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IS-54-B

EIA/TIA INTERIM STANDARD

Cellular System Dual-Mode Mobile Station - Base Station Compatibility Standard

IS-54-B

(Revision of IS/54-A)

APRIL 1992

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

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PREFACE

These technical requirements form a compatibility standard for cellular mobile telecommunications systems. Their purpose is to ensure that a mobile station can obtain service in any cellular system manufactured according to this standard. These requirements do not address the quality or reliability of that service, nor do they cover equipment performance or measurement procedures.

To ensure compatibility (see Note 1), it is essential that both radio-system parameters and call-processing procedures be specified. The equipment and interface parameters commonly encountered in two-way radio systems have been updated and expanded to reflect the unique radio plan upon which cellular systems are based. The sequence of call processing steps that the dual-mode mobile stations and base stations execute to establish calls has been specified along with the digital control messages and analog signals that are exchanged between the two stations.

The base station is subject to fewer compatibility requirements than the dual-mode mobile station. Radiated power levels, both desired and undesired, are fully specified for dual-mode mobile stations to control the RF interference that one mobile station can cause another. Base stations are fixed in location and their interference is controlled by proper layout and operation of the system in which the station operates. Detailed call-processing procedures are specified for mobile stations to ensure a uniform response to all base stations. Base station call procedures, like power levels, are not specified in detail because they are a part of the overall design of the individual land system. This approach to writing the compatibility specification provides the land system designer with sufficient flexibility to respond to local service needs and to account for local topography and propagation conditions.

The basic radio-system parameters and call-processing procedures for analog mode of operation embodied in the compatibility specification were originally derived from the Chicago and Baltimore-Washington developmental cellular systems and include certain additions and modifications gained by experience with the operation of commercial systems. The basic radio system parameters and call-processing procedures embodied in the dual-mode specification were derived by due process within EIA/TIA TR45.3, but have not been subject to field trial.

As commercial systems evolve there may be a need for additional capabilities primarily in the area of call-processing procedures and new system features. It is important that evolutionary changes be readily accommodated. To that end, these technical requirements have been organized into six general sections. Alterations to 2 and 3 can affect fundamental mobile station - base station compatibility. All other sections may be altered without affecting basic compatibility.

The following is a summary of each section:

1. **General.** This section comprises a list of brief explanations of terms, processes, and functions used in these requirements. Since it is the intention of these requirements to permit great latitude of system configurations and the implementation of system features, only those items required for compatibility have strict definitions. Other items may be interpreted to fit the needs of manufacturers and system operators. For example, control channels may be implemented with either combined paging/access functions or as separate paging and access channels. In addition, the section provides a description of the digital traffic channel structure.

2. Dual-Mode Mobile Station Compatibility Requirements. This section comprises the fundamental signaling compatibility requirements of dual-mode mobile stations. If strictly adhered to, a mobile station technically will be able to signal a base station. This section assures communications only if service is not otherwise restricted by operational or RF signal level constraints. For example, service may be denied for reasons of subscriber credit or because the mobile station is out of the effective range of a base station. In general, changes or alterations to this section will affect fundamental dual-mode mobile station - base station compatibility and the ability of dual-mode mobile stations to signal base stations irrespective of operational or RF signal level conditions.

3. Base Station Compatibility Requirements. This section comprises the fundamental signaling compatibility requirements of base stations and is organized in a manner similar to 2. (In fact, 2 and 3 should be read together for a clearer understanding of the bi-directional signaling protocol.) If strictly adhered to, a base station technically will be able to signal a dual-mode mobile station. As in 2, communications are assured only if not otherwise restricted by factors such as RF signal levels or operational limitations. In general, changes or alterations to this section will affect fundamental dual-mode mobile station - base station compatibility and the ability of dual-mode mobile stations to signal base stations irrespective of operational or RF signal level conditions.

4. Requirements for Mobile Station Options. This section states requirements for use of optional functions and features by dual-mode mobile stations. It is concerned with evolutionary changes which do not affect fundamental compatibility but which require strict definition to ensure uniform recognition and implementation of such factors as the order qualifier definitions, extended message protocols, feature coding recommendations, etc. Requirements in this section do not affect the operation of existing mobile stations. Also unaffected is the ability of mobile stations incorporating any of these options to communicate with existing base stations.

5. Requirements for Base Station Options. This section states requirements for use of optional functions and features by base stations. This section is in general organized to follow the sequence of items listed in 4. The reader may thus review the changes in both mobile stations and base stations by referring to corresponding paragraphs in 4 and 5. Similar to the requirements for mobile station options, this section defines changes that require strict definition to ensure uniform recognition and utilization of such factors as reserved bits, order qualifier definitions, extended message protocols, feature coding recommendations, etc. Requirements in this section do not affect the operation of existing mobile stations. Also unaffected is the ability of existing mobile stations to communicate with base stations incorporating any of these options.

6. Change History. This section traces all changes to these technical requirements beginning with the initial release of this standard. A brief description of each change as well as a reference to the affected section(s) are provided.

NOTES

1. Compatibility, as used in connection with these standards, is understood to mean: Any dual-mode mobile station is able to place and receive calls in any cellular system. Conversely all systems are able to place and receive calls for any mobile station. In a subscriber's home system, all call placement must be automatic. It is preferable that call placement be automatic when a mobile station is in roam status.

2. The term "dual-mode mobile station" is defined as one capable of analog or digital operation.

3. This compatibility specification is based upon the specific US spectrum allocation for cellular systems.

4. Technical details are included for the operation of two systems in a geographic area, System A and System B, each with a separate set of control channels.

5. EIA IS-55, "Recommended Minimum Performance Standards for 800 MHz Dual-Mode Mobile Stations," and EIA IS-56, "Recommended Minimum Performance Standards for 800 MHz Base Stations Supporting Dual-Mode Mobile Stations" provide specifications and measurement methods for cellular equipment.

6. Each cellular system is identified by a unique 15-bit digital code, the SID code (see 2.3.8). The Federal Communications Commission assigns SID codes when cellular system construction permits are issued.

7. Each dual-mode mobile station is assigned a unique 32-bit binary serial number which cannot be changed by the subscriber without rendering the mobile station inoperative. (see 2.3.2).

8. In the message formats used between the dual-mode mobile stations and base stations, some bits are marked as reserved (RSVD). Some or all of these reserved bits may be used in the future for additional messages. Therefore, all dual-mode mobile stations and base stations must set all bits that they are programmed to treat as reserved bits to "0" (zero) in all messages that they transmit. All mobile stations and base stations must ignore the state of all bits that they are programmed to treat as reserved bits in all messages that they receive.

9. Reserved.

10. RF Emissions. Minimum advisory standards of ANSI and the processing guidelines of FCC are contained in ANSI C95.1-1982 Advisory Standards and FCC Rules and Regulations respectively. Members should also take notice of the more stringent exposure criteria for the general public and for radio frequency carriers with low frequency amplitude modulation as given in NCRP Report No. 86.

11. For the optional extended protocol feature (see 4.2 and 5.2), the assignment of message type codes (MST words) will be made using procedures developed under authority of the Engineering Department of the EIA. This will ensure that the feature will be implemented in an orderly manner.

12. Reserved.

13. The allocation of SID numbers is under review by EIA/TIA TR45 for potential revision to accommodate international requirements. Utilization of SID numbers must be coordinated.

14. Although the analog mode of operation draws upon EIA/TIA 553, some modifications have been made.

15. All lines added or modified during the transition from IS-54-A to IS-54-B are denoted by a single vertical bar (|) in the left-hand margin.

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1. GENERAL

1.1 Definitions

A-key. A secret, 64-bit pattern stored in the mobile station. It is used to generate/update the mobile station's Shared Secret Data. The A-key is used in the mobile station authentication process.

Abbreviated Alert. The abbreviated alert order is used to remind the user that previously selected alternative routing features are still active.

Analog Access Channel. An analog control channel used by a mobile station to access a system to obtain service.

Analog Color Code. An analog signal (see Supervisory Audio Tone) transmitted by a base station on an analog voice channel and used to detect capture of a mobile station by an interfering base station or the capture of a base station by an interfering mobile station.

Analog Control Channel. A channel used for the transmission of digital control information from a base station to a mobile station or from a mobile station to a base station.

Analog Paging Channel. A forward analog control channel that is used to page mobile stations and send orders.

Analog Voice Channel. A channel on which a voice conversation occurs and on which brief digital messages may be sent from a base station to a mobile station or from a mobile station to a base station.

AUTH. A 1-bit field in the System Parameter Overhead Message. When set to 1, it signifies that the system supports the authentication procedures.

Authentication. A procedure used by base stations to validate a mobile station's identity at system access.

Authentication Response (AUTHR). An 18-bit output of the authentication algorithm. It is used to validate mobile station registrations, originations and terminations.

Base Station. A station in the Domestic Public Cellular Radio Telecommunications Service, other than a mobile station, used for radio communications with mobile stations.

Base Station Authentication Response (AUTHBS). An 18-bit pattern generated by the authentication algorithm. AUTHBS is used to confirm the validity of base station orders to update the Shared Secret Data.

Base Station Random Variable (RANDBS). A 32-bit random number generated by the mobile station for use in authenticating base station orders to update the Shared Secret Data.

BCH Code. Bose-Chaudhuri-Hocquenghem Code

Busy-Idle Bits. The portion of the data stream transmitted by a base station on a forward analog control channel that is used to indicate the current busy-idle status of the corresponding reverse analog control channel.

Channel Quality Measurement (CQM). A digital message in two parts in which the results of mobile channel quality measurements are sent to a base station over the FACCH or the SACCH.

Coded Digital Verification Color Code (CDVCC). A 12-bit data field containing the 8-bit DVCC and 4 protection bits, sent in each time slot to and from mobile stations and base stations. It is used to indicate that the correct rather than co-channel data is being decoded.

Continuous Transmission. A mode of operation in which Discontinuous Transmission is not permitted.

Control Mobile Attenuation Code (CMAC). A 3-bit field in the Control-Filler Message that specifies the maximum authorized power level for a mobile transmitting on a reverse control channel.

Cyclic Redundancy Check (CRC). A process in which a desired sequence of bits is encoded in a prescribed manner to enable detection and correction of bit errors. In this Standard, certain critical bit sequences are encoded using specified polynomials and procedures which use CRC-16 (CCITT) and BCH code structures.

Dedicated Control Channels. A channel used for the transmission of digital control information from either a base station or a mobile station.

Digital Color Code (DCC). A digital signal transmitted by a base station on a forward analog control channel that is used to detect capture of a base station by an interfering mobile station.

Digital Verification Color Code (DVCC). A digital 8-bit code that is sent by the base station to the mobile station and is used for the generation of the CDVCC.

Discontinuous Transmission (DTX). A mode of operation in which a mobile-station transmitter autonomously switches between two transmitter power levels while the mobile station is in the conversation state on an analog voice channel or a digital traffic channel.

Extended Protocol. An optional expansion of the signaling messages between the base station and mobile station to allow for the addition of new system features and operational capabilities.

Fast Associated Control Channel (FACCH). A blank-and-burst channel used for signaling message exchange between the base station and the mobile station.

Flash Request. An indication sent on an analog voice channel from a mobile station to a base station indicating that a user desires to invoke special processing.

Flash with Information. A message sent over the digital traffic channel in either direction to indicate that special processing is required.

Forward Analog Control Channel (FOCC). An analog control channel used from a base station to a mobile station.

Forward Analog Voice Channel (FVC). An analog voice channel used from a base station to a mobile station.

Forward Digital Traffic Channel (FDTC). A digital channel from a base station to a mobile station used to transport user information and signaling. There are two separate control channels associated with the FDTC: the Fast Associated Control Channel (FACCH) and the Slow Associated Control Channel (SACCH).

Group Identification. A subset of the most significant bits of the system identification (SID) that is used to identify a group of cellular systems.

Handoff. The act of transferring a mobile station from one channel to another.

Home Mobile Station. A mobile station that operates in the cellular system from which service is subscribed.

Home System. The system which is transmitting a SID which is recognized by the mobile station as the "Home" SID.

Location Registration (LREG). A 1-bit field used to indicate the location area ID registration status.

Mean Output Power. The calorimetric power measured during the active part of transmission.

Message. There are 2 types of messages sent between base stations and mobile stations: order messages and acknowledgement messages. An order message commands or requests the recipient to take some action. In some cases, the recipient acknowledges an order message by returning an acknowledgement message. In other cases, no acknowledgement message is returned. If a message has "Ack" as part of its name, it is an Ack Message; otherwise, it is an Order Message. The following are examples of valid order-message names: Send Burst DTMF, Send Burst DTMF Order, Send Burst DTMF Order Message, and Send Burst DTMF Message. The following are examples of valid acknowledgement-message names: Send Burst DTMF Ack, Send Burst DTMF Ack Message, Measurement Order Ack, and Measurement Order Ack Message.

Mobile Assisted Handoff (MAHO). A process where a mobile in digital mode, under direction from a base station, measures signal quality of specified RF channels. These measurements are forwarded to the base station upon request to assist in the handoff process.

Mobile Protocol Capability Indicator (MPCI). A 2-bit field used to indicate the mobile station's capabilities.

Mobile Identification Number (MIN). The 34-bit number that is a digital representation of the 10-digit directory telephone number assigned to a mobile station.

Mobile Station. A station in the Domestic Public Cellular Radio Telecommunications Service intended to be used while in motion or during halts at unspecified points. It is assumed that mobile stations include portable units (e.g., hand-held personal units) and units installed in vehicles.

Mobile Station Class. Mobile station classes are defined in Table 2.1.2-1.

Power Down Registration (PDREG). A 1-bit field used to indicate the power down registration status.

Power Up Registration (PUREG). A 1-bit field used to indicate the power up registration status.

Numeric Information. Numeric information is used to describe the operation of the mobile station. The following subscripts are used to clarify the use of the numeric information:

- "s" to indicate a value stored in a mobile station's temporary memory,
    - "sv" to indicate a stored value that varies as a mobile station processes various tasks,
    - "sl" to indicate the stored limits on values that vary,
- "r" to indicate a value received by a mobile station over a forward analog control channel,
- "p" to indicate a value set in a mobile station's permanent security and identification memory, and
- "s-p" to indicate a value stored in a semi-permanent security and identification memory.

The numeric **indicators** are:

- $ACCOLC_p$. A four-bit number used to identify which overload class field controls access attempts.
- BIS_s. Identifies whether a mobile station must check for an idle-to-busy transition on a reverse analog control channel when accessing a system.

- CCLIST$_s$. The list of analog control channels to be scanned by a mobile station processing the Directed-Retry Task (see 2.6.3.14).
- CMAX$_s$. The maximum number of channels to be scanned by a mobile station when accessing a system.
- COUNT$_{s\text{-}p}$. A modulo-64 count held in the mobile station. COUNT$_{s\text{-}p}$ is maintained during power off.
- CPA$_s$. Identifies whether the access functions are combined with the paging functions on the same set of analog control channels.
- DCC$_s$. A DCC value stored in a mobile station's temporary memory.
- DTX$_s$. Identifies in what way the mobile station is permitted to use the discontinuous transmission mode on the analog voice channel.
- DVCC$_s$. A DVCC value stored in a mobile station's temporary memory.
- DVCC$_r$. A DVCC value received by a mobile station over the forward digital traffic channel.
- E$_s$. The stored value of the E field sent on the forward analog control channel. E$_s$ identifies whether a home mobile station must send only MIN1$_p$ or both MIN1$_p$ and MIN2$_p$ when accessing the system.
- EX$_p$. Identifies whether home mobile stations must send MIN1$_p$ or both MIN1$_p$ and MIN2$_p$ when accessing the system. EX$_p$ differs from E$_s$ in that the information is stored in the mobile station's security and identification memory.
- FIRSTCHD$_s$. The number for the first channel used as a dedicated control channel.
- FIRSTCHA$_s$. The number of the first analog control channel used for accessing a system.
- FIRSTCHP$_{p\text{-}pri}$. The number of the first paging channel used as a primary paging channel in the mobile station's "home" system.
- FIRSTCHP$_s$. The number of the first analog control channel used for paging mobile stations.
- FIRSTCHP$_{p\text{-}sec}$. The number of the first paging channel used as a secondary paging channel in the mobile station's "home" system.
- LASTCHA$_s$. The number of the last analog control channel used for accessing a system.
- LASTCHD$_s$. The number for the last channel used as a dedicated control channel.
- LASTCHP$_s$. The number of the last analog control channel used for paging mobile stations.
- LOCAID$_{s\text{-}p}$. Identifies the current location area.
- LOCAID$_s$. The received location area identity.
- LREG$_s$. The stored value of the LREG field received in the most recent Location Area Global Action Message.
- LT$_s$. Identifies whether the next access attempt is required to be the last try.
- MIN1$_p$. The 24-bit number that corresponds to the 7-digit directory telephone number assigned to a mobile station.

- $MIN2_p$. The 10-bit number that corresponds to the 3-digit area code assigned to a mobile station.
- $MAXBUSY_{sl}$. The maximum number of busy occurrences allowed on a reverse analog control channel.
- $MAXSZTR_{sl}$. The maximum number of seizure attempts allowed on a reverse analog control channel.
- N_s . The number of analog paging channels that a mobile station must scan.
- $NBUSY_{sv}$. The number of times a mobile station attempts to seize a reverse analog control channel and finds the reverse control channel busy.
- $NSZTR_{sv}$. The number of times a mobile station attempts to seize a reverse analog control channel and fails.
- $NXTREG_{s-p}$. Identifies when a mobile station must make its next registration to a system.
- PCI_s. The stored value of the PCI field in the System Parameter Overhead Message.
- $PDREG_s$. The stored value of the PDREG field received in the most recent Location Area Global Action Message.
- PL_s. The mobile station RF power level.
- $PUREG_s$. The stored value of the PUREG field received in the most recent Location Area Global Action Message.
- $PUREG_{s-p}$. The semi-permanent value of $PUREG_s$.
- R_s. Indicates whether registration is enabled or not.
- $RAND_s$. The stored value of RAND.
- RCF_s. Identifies whether the mobile station must read a Control-Filler Message before accessing a system on a reverse analog control channel.
- $REGID_s$. The stored value of the last registration number ($REGID_r$) received on a forward analog control channel.
- $REGINCR_s$. Identifies increments between registrations by a mobile station.
- S_s. Identifies whether the mobile station must send its serial number when accessing a system.
- SCC_s. A digital number that is stored and used to identify which SAT frequency a mobile station should be receiving.
- $SDCC1_s$. The SDCC value stored in a mobile station's temporary memory.
- $SDCC2_s$. The SDCC value stored in a mobile station's temporary memory.
- SID_p. The home system identification stored in the mobile station's permanent security and identification memory.
- SID_{s-p}. Identifies the system of current (last successful) registration.
- SID_r. The system identification received on a forward analog control channel.
- SID_s. The stored system identification.
- $WFOM_s$. Identifies whether a mobile station must wait for an Overhead Message Train before accessing a system on a reverse analog control channel.

Order. See definition for Message.

Overload Control (OLC). A means to restrict reverse control channel accesses by mobiles. Mobiles are assigned one (or more) of sixteen control levels. Access is selectively restricted by a base station setting one or more OLC bits in the Overload Control Global Action Message.

Paging. The act of seeking a mobile station when an incoming call has been placed to it.

Personal Identification Number (PIN). A secret number managed by the system operator for each subscriber. The PIN is intended primarily for use in authenticating the subscriber.

Physical Layer Control. A digital-mode-base-station control message to initiate or change certain mobile parameters such as traffic channel power, time alignment, and whether discontinuous transmission (DTX) is permitted.

Primary Paging Channels. A forward analog control channel that is used to page mobile stations and send orders, and is supported by both EIA-553 and IS-54 compatible mobiles.

Privacy Mode (PM). A one-bit parameter used to refer to the voice privacy status: '0' = "off", '1' = "on".

Protocol Capability Indicator (PCI). A 1-bit field in the first word of the System Parameter Overhead Message that when set to one indicates the base station is capable of digital operation.

Random Variable (RAND). A 32-bit random number issued periodically by the base station in two, 16-bit pieces: RAND1_A and RAND1_B. The mobile station stores and uses the most recent version of RAND in the authentication process.

Random Variable Confirmation (RANDC). A 8-bit number used to confirm the last RAND received by the mobile station.

Registration. The steps by which a mobile station identifies itself to a base station as being active in the system at the time the message is sent to the base station.

Release Request. A message sent from a mobile station to a base station indicating that the user desires to disconnect the call.

Reverse Analog Control Channel (RECC). The analog control channel used from a mobile station to a base station.

Reverse Analog Voice Channel (RVC). The analog voice channel used from a mobile station to a base station.

Reverse Digital Traffic Channel (RDTC). A digital channel from a mobile station to a base station used to transport user information and signaling. There are two separate control channels associated with the RDTC: the Fast Associated Control Channel (FACCH) and the Slow Associated Control Channel (SACCH.)

Roamer. A mobile station that operates in a cellular system other than the one from which service is subscribed.

Scan of Channels. The procedure by which a mobile station examines the signal strength of each forward analog control channel.

Secondary Control Channels. A supplementary set of analog control channels developed specifically for IS-54 compatible mobile stations. Such channels are used for the transmission of digital control information from either the base or mobile stations.

Secondary Paging Channels. In addition to the primary paging channels, a supplementary set of analog control channels developed specifically for IS-54 compatible mobile stations. Such channels are used to page mobile stations and send orders.

Seizure Precursor. The initial digital sequence transmitted by a mobile station to a base station on a reverse analog control channel.

Signaling Tone. A 10-kHz tone transmitted by a mobile station on an analog voice channel to: 1) confirm orders, 2) signal flash requests, and 3) signal release requests.

Shared Secret Data (SSD). A 128-bit pattern stored in the mobile station (in semi-permanent memory) and known by the base station. SSD is a concatenation of two 64-bit subsets: SSD-A, which is used to support the authentication procedures, and SSD-B, which serves as one of the inputs to the voice privacy mask generation process. Shared Secret Data is maintained during power off.

Shared Secret Data Random Variable (RANDSSD). A 56-bit random number generated by the mobile station's home system. RANDSSD is used in conjunction with the mobile station's A-key and ESN to generate its Shared Secret Data.

Slow Associated Control Channel (SACCH) is a continuous channel used for signaling message exchange between the base station and the mobile station. A fixed number of bits are allocated to the SACCH in each TDMA slot.

Status Information. The following status information is used in this section to describe mobile station operation:

- Serving-System Status. Indicates whether a mobile station is tuned to channels associated with System A or System B.
- First Registration ID Status. A status variable used by the mobile station in association with its processing of received Registration ID messages.
- First Location Area ID Status. A status variable used by the mobile station in association with its processing of received Location Area ID messages.
- Location Registration ID Status. A status variable used by the mobile station in association with its processing of power up registrations and location-based registrations.
- First Idle ID Status. A status variable used by the mobile station in association with its processing of the Idle task.
- Local Control Status. Indicates whether a mobile station must respond to local control messages.
- Roam Status. Indicates whether a mobile station is in its home system.
- Termination Status. Indicates whether a mobile station must terminate the call when it is on an analog voice channel.

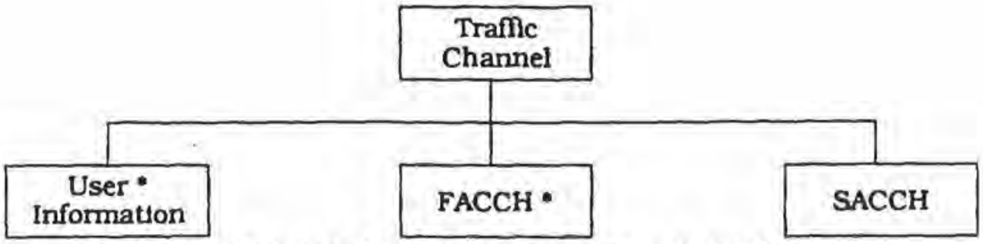
Supervisory Audio Tone (SAT). One of three tones in the 6-kHz region that are transmitted by a base station and transponded by a mobile station.

Supplementary Digital Color Code (SDCC1, SDCC2). Additional bits assigned to increase the number of color codes from four to sixty four, transmitted on the forward analog control channel.

Symbol. In the $\frac{\pi}{4}$ DQPSK modulation scheme specified, each symbol carries 2 bits of information.

System Identification (SID). A digital identification associated with a cellular system; each system is assigned a unique number.

Traffic Channel. That portion of the digital information transmitted between the base station and the mobile station, or between the mobile station and the base station, that is dedicated to the transport of user and signaling information as depicted in the figure below.



* FACCH and user information cannot be sent simultaneously.

Unique Challenge Authentication Response (AUTHU). An 18-bit pattern generated by the authentication algorithm. AUTHU is used to support the Unique Challenge-Response procedure.

Unique Challenge-Response Procedure. An exchange of information between a mobile station and a base station for the purpose of confirming the mobile station's identity. The procedure is initiated by the base station and is characterized by the use of a challenge-specific random number (i.e., RANDU) instead of the random variable broadcast globally (RAND).

Unique Random Variable (RANDU). A 24-bit random number generated by the base station in support of the Unique Challenge-Response procedure.

Voice Mobile Attenuation Code (VMAC). A 3-bit field in the Extended Address Word commanding the initial mobile power level when assigning a mobile station to an analog voice or traffic channel.

Voice Privacy. The process by which user voice transmitted over a digital traffic channel is afforded a modest degree of cryptographic protection against eavesdropping in the mobile station - base station segment of the connection.

Digital Mobile Attenuation Code (DMAC). A 4-bit field commanding the initial mobile power level when assigning a mobile station to a digital traffic channel.

Wait-for-Overhead Message (WFOM). A 1-bit field in the Control-Filler Message that when set to one causes the mobile to wait for an overhead message before transmitting on a reverse control channel.

1.2 Digital Traffic Channel Structure

This diagram depicts the frame structure:

Figure 1.2–1

One Frame = 1944 bits (972 Symbols) = 40 ms. (25 frames per second)

Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6
				One Slot	

Figure 1.2–2

6	6	16	28	122	12	12	122
G	R	DATA	SYNC	DATA	SACCH	CDVCC	DATA

SLOT FORMAT MOBILE STATION TO BASE STATION

28	12	130	12	130	12
SYNC	SACCH	DATA	CDVCC	DATA	RSVD = 00...00

SLOT FORMAT BASE STATION TO MOBILE STATION

INTERPRETATION OF THE DATA FIELDS IS AS FOLLOWS:

G – Guard Time (see 1.2.3)
R – Ramp Time (see 1.2.3)
DATA – User Information or FACCH
RSVD – Reserved

All numbers indicate bits.

SACCH – Slow Associated Control Channel (see 2.7.3.1.2 and 3.7.3.1.2)
CDVCC – Coded Digital Verification Color Code (see 1.2.5, 2.4.3, and 3.4.3)
SYNC – Synchronization and Training (see 1.2.4)

1.2.1 Frame Length

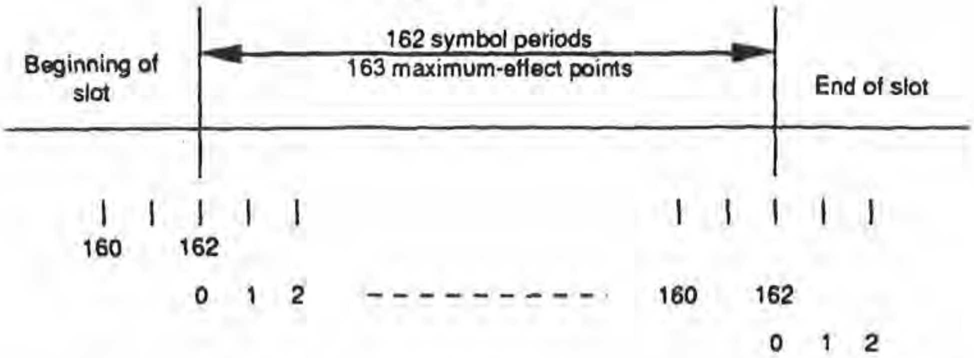
The frame length on each digital TDMA RF channel shall be 40 milliseconds. Each frame shall consist of six equally sized time slots (1–6), exactly 162 symbols in length. Each full rate traffic channel shall utilize two equally spaced time slots of the frame (1&4, 2&5, or 3&6). Each half rate traffic channel shall utilize one time slot of the frame.

At the mobile station, the offset between the reverse and forward frame timing, with no time advance applied, is one time slot plus 45 symbols (207 symbol periods). Time slot 1 of frame N in the forward direction occurs 207 symbol periods after time slot 1 of frame N in the reverse direction, with no time advance.

The relation between data modulation and the above definition of time slots is as follows:

The modulation timing within a forward time slot shall be such that the first modulated symbol to be used by the mobile receiving that time slot (the first symbol of the sync word) shall have maximum effect on the signal transmitted from the base antenna coincident with the beginning of the time slot as shown in Figure 1.2.1–1.

Figure 1.2.1-1

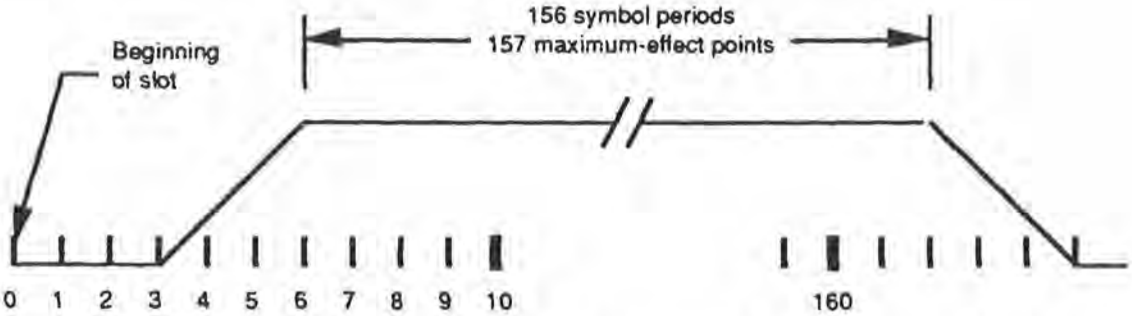


The maximum effect point is defined to be the point in time at which the pulse shaping function associated with the modulation is at a maximum for the symbol of interest (refer to section 2.1.3.3.1 for a description of the pulse shaping function). The relation between the maximum effect point and the associated symbol period is such that the maximum effect point is defined to occur at the end of the symbol period.

The first maximum effect point for the forward channel is at point 0. Decoding the phase change from point 0 to point 1 provides the first two bits of data. Decoding the phase change from point 161 to point 162 provides the last two bits of data. Point 0 is the same maximum effect point as point 162 of the previous time slot.

The modulation timing within a reverse time slot shall be such that the first modulated symbol has maximum effect on the signal transmitted at the antenna by the mobile 6.0 symbol periods after the beginning of the reverse time slot, as shown in Figure 1.2.1-2.

Figure 1.2.1-2

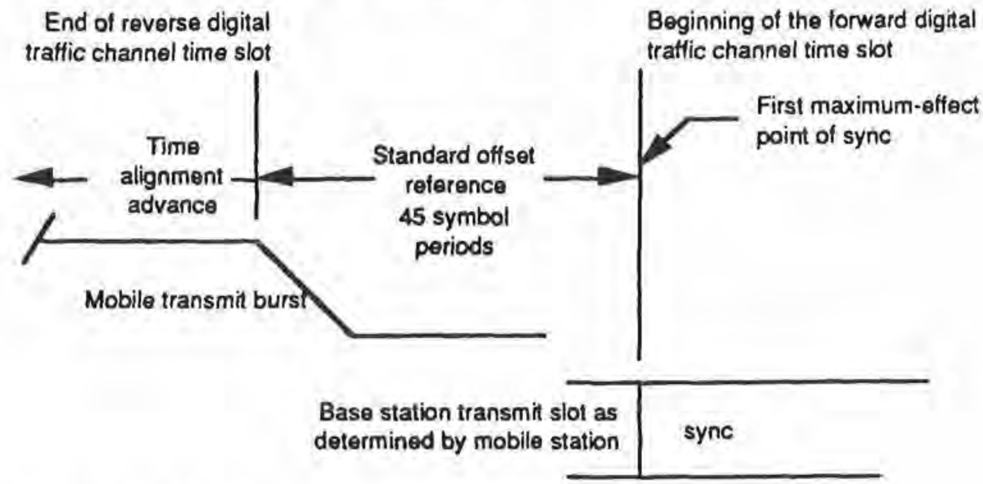


The first maximum-effect for the reverse channel is at point 6. Decoding the phase change from point 6 to point 7 provides the first two bits of data.

1.2.1.1 Standard Offset Reference

Figure 1.2.1.1-1 depicts the relationship between transmit and receive as specified for the mobile station (full-rate).

Figure 1.2.1.1-1



1.2.2 Gross Rate for the Traffic Channel

The gross data rate for a full-rate digital traffic channel shall be 13.0 kbit/s.

1.2.3 Guard and Power Ramp Up Interval

The interval of each (i.e. Guard & Power Ramp Up) is 3 symbols in duration.

1.2.4 Synchronization Word/Time Slot Identifier

The synchronization word/time slot identifier is a 14 symbol field which is used for slot synchronization, equalizer training, and time slot identification. For its location refer to Figure 1.2-2. Six unique synchronization sequences are defined.

The synchronization word has good autocorrelation properties to facilitate synchronization and training.

Six time slot identifiers are defined, which have good cross correlation properties. The actual synchronization sequences are defined in Table 1.2.4-2.

Line 8 from Table 1.2.4-1 identifies the sync word for a channel fully assigned to full rate users.

Line 1 from Table 1.2.4-1 identifies the sync word for a channel fully assigned to half rate users.

Lines 2 through 7 identify the sync word order for a mixture of full and half rate users, such that only one sync word is assigned per user.

Unassigned slots are indicated by the base station as half-rate user slots in the Time Slot Identifier field.

The mobile station uses its assigned sync word on the RDTC.

Table 1.2.4–1

line \ time slot	1	2	3	4	5	6
1	1	2	3	4	5	6
2	1	2	3	1	5	6
3	1	2	3	4	2	6
4	1	2	3	4	5	3
5	1	2	3	1	2	6
6	1	2	3	1	5	3
7	1	2	3	4	2	3
8	1	2	3	1	2	3

The preferred assignment by base station of sync identity is from the table above. However, the base station, upon appropriate signaling, may assign other sync word ordering.

The preferred assignment shall be used for a particular traffic channel unless the mobile station supports extended modulation and framing in accordance with Table 3.7.1–1.

Table 1.2.4–2 Synchronization Sequences

The sync words are specified by the following <u>phase changes</u> in radians:

Sync 1	$-\frac{\pi}{4}$	$-\frac{\pi}{4}$	$-\frac{\pi}{4}$	$3\frac{\pi}{4}$	$\frac{\pi}{4}$	$3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-\frac{\pi}{4}$	$3\frac{\pi}{4}$	$\frac{\pi}{4}$	$-\frac{\pi}{4}$	$-\frac{\pi}{4}$
Sync 2	$-\frac{\pi}{4}$	$-\frac{\pi}{4}$	$-\frac{\pi}{4}$	$3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$3\frac{\pi}{4}$	$\frac{\pi}{4}$	$3\frac{\pi}{4}$	$\frac{\pi}{4}$	$-\frac{\pi}{4}$	$3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-\frac{\pi}{4}$	$-\frac{\pi}{4}$
Sync 3	$-3\frac{\pi}{4}$	$\frac{\pi}{4}$	$3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-\frac{\pi}{4}$	$\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$\frac{\pi}{4}$	$\frac{\pi}{4}$	$\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$\frac{\pi}{4}$
Sync 4	$\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$3\frac{\pi}{4}$	$\frac{\pi}{4}$	$\frac{\pi}{4}$	$-\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$\frac{\pi}{4}$	$\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$\frac{\pi}{4}$	$-3\frac{\pi}{4}$
Sync 5	$\frac{\pi}{4}$	$3\frac{\pi}{4}$	$\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-\frac{\pi}{4}$	$\frac{\pi}{4}$	$-\frac{\pi}{4}$	$\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$3\frac{\pi}{4}$	$\frac{\pi}{4}$	$3\frac{\pi}{4}$
Sync 6	$-3\frac{\pi}{4}$	$3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$\frac{\pi}{4}$	$\frac{\pi}{4}$	$-\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$-\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$\frac{\pi}{4}$	$\frac{\pi}{4}$	$3\frac{\pi}{4}$	$-3\frac{\pi}{4}$	$3\frac{\pi}{4}$

Note: The current specification is based on the best available information at the time of writing. As such, it is subject to revision.

1.2.5 Coded Digital Verification Color Code (CDVCC)

This is a 12-bit field, permitting 255 distinct values of CDVCC. The same CDVCC may be used for all base and mobile transmissions in the same cell (or sector, where this is appropriate).

DVCC is an 8-bit word which is coded using a (15,11) Hamming code shortened to a (12,8) code to form a 12-bit Coded Digital Verification Color Code (CDVCC). The following coding procedure defines the relationship between the 8-bit DVCC and the 12-bit CDVCC, and does not imply an implementation. Bit d7 is the most significant bit of DVCC and is received earliest in time in the mobile station control message.

DVCC (8-bits) = (d7,d6,d5,d4,d3,d2,d1,d0)

1. Form DVCC Information Word polynomial a(X):

   $$d7X^7 + d6X^6 + d5X^5 + d4X^4 + d3X^3 + d2X^2 + d1X^1 + d0X^0$$

2. Multiply a(X) by X^4.

3. Obtain the remainder b(X) from dividing $X^4a(X)$ by $X^4 + X + 1$.

   Where $$\frac{a(X)X^4}{X^4 + X + 1} = q(X) + \frac{b(X)}{X^4 + X + 1}$$

4. CDVCC (12-bits) is defined as (d7,d6,d5,d4,d3,d2,d1,d0,b3,b2,b1,b0).

   CDVCC bit d7 is transmitted first.

1.3 Timing Tolerances

Unless otherwise specified, all call-processing timers and call-processing timing values have a tolerance of ±10%. Tolerances of other parameters are provided for guidance only. Refer to IS-55, "Recommended Minimum Performance Standards for 800-MHz Dual-Mode Mobile Stations", and IS-56, "Recommended Minimum Performance Standards for 800-MHz Base Stations Supporting Dual-Mode Mobile Stations", for minimum standards, definitions, tolerances, and measurement methods.

2. MOBILE STATION

(See also §4. for Mobile Station Options)

2.1 Transmitter

2.1.1 Frequency Parameters

2.1.1.1 Channel Spacing and Designation

Channel spacing shall be 30 kHz and the dual-mode mobile station transmit channel at 825.030 MHz (and the corresponding base station transmit channel at 870.030 MHz) shall be termed channel number 1. The 20 MHz range of channels 1 through 666 as shown in Table 2.1.1.1-1 for System A and System B is basic. The additional 5 MHz of channels 667 through 799 and (wrap-around) 991 through 1023 for extending System A (A', A") and B (B') is mandatory. The station class mark (SCM, see 2.3.3) shall be set appropriately.

Table 2.1.1.1-1 Channel Numbers and Frequencies

System	Bandwidth (MHz)	Number of Channels	Boundary Channel Number	Transmitter Center Frequency (MHz)	
				Mobile	Base
(Not used)		1	(990)	(824.010)	(869.010)
A"	1	33	991 1023	824.040 825. 000	869.040 870. 000
A	10	333	1 333	825.030 834.990	870.030 879.990
B	10	333	334 666	835.020 844.980	880.020 889.980
A'	1.5	50	667 716	845.010 846.480	890.010 891.480
B'	2.5	83	717 799	846.510 848.970	891.510 893.970

In the above, the center frequency in MHz corresponding to the channel number (expressed as N) is calculated as follows.

Transmitter	Channel Number	Center Frequency (MHz)
Mobile	$1 \le N \le 799$	$0.030\ N + 825.000$
	$990 \le N \le 1023$	$0.030\ (N - 1023) + 825.000$
Base	$1 \le N \le 799$	$0.030\ N + 870.000$
	$990 \le N \le 1023$	$0.030\ (N - 1023) + 870.000$

2.1.1.2 Frequency Tolerance

2.1.1.2.1 Frequency Tolerance for Analog Mode Operation

The dual-mode mobile station carrier frequency must be maintained within ±2.5 parts per million (ppm) of any assigned channel frequency, except during channel switching (see 2.1.2.1). This tolerance must be maintained over the ambient temperature range of –30°C to +60°C, and over the supply voltage range of ±15 percent from the nominal value.

2.1.1.2.2 Frequency Tolerance for Digital Mode Operation

The dual-mode mobile station transmit carrier frequency must track within ±200 Hz of a frequency value 45.0 MHz lower than the frequency of the corresponding base station transmit signal, as measured at the mobile receiver, except during channel switching or MAHO channel scanning (ref: section 2.4.5). This tolerance must be maintained over the ambient temperature range of –30°C to +60°C and over the supply voltage range of ±15 percent from the nominal value.

2.1.2 Power Output Characteristics

2.1.2.1 Carrier On/Off Conditions

2.1.2.1.1 Constant Envelope Conditions

The carrier-off condition is defined as a power output at the transmitting antenna connector not exceeding –60 dBm. When commanded to the carrier-on condition on a reverse control channel, a mobile station transmitter must come to within 3 dB of the specified output power (see 2.1.1.2.1) and to within the required stability (see 2.1.1.2) within 2 ms. Conversely, when commanded to the carrier-off condition, the transmit power must fall to a level not exceeding –60 dBm within 2 ms. Whenever a transmitter is more than 1 kHz from its initial or final value during channel switching, the transmitter carrier must be inhibited to a power output level not greater than –60 dBm.

2.1.2.1.2 $\frac{\pi}{4}$ Shifted DQPSK Conditions

The carrier-off condition is defined as a power output at the transmitting antenna connector not exceeding –60 dBm. The steady-state carrier-on condition is defined in 2.1.2.2. The acceptable instantaneous variation in power output level is defined in 2.1.3.3.1.3.3. The first 3 symbol periods of the TDMA burst are assigned to guard time (see 1.2). During the 3 symbol periods of guard time the carrier remains in the carrier-off condition. Symbol periods 4 through 6 are assigned to the power ramp time. The carrier-on command for the reverse traffic channel occurs at the beginning of symbol period 4. By the end of symbol period 6 the transmit power must be sufficiently stable to permit the conditions of 2.1.3.3.1.3.3 to be met. The beginning time of symbol period 1 is established by the time alignment procedure described in 2.1.3.3.5. Conversely, when commanded to the carrier-off condition the mobile station transmit power must fall to a level not exceeding –60 dBm within 3 symbol periods. The spectrum profile of the ramp up and ramp down must conform to the adjacent and alternate channel emission requirements given in section 2.1.4.1.2. During the information bearing portion of the message the transmitter frequency accuracy must be within the required stability (see 2.1.1.2.2).

2.1.2.2 Power Output and Power Control

The mean effective radiated power (ERP) with respect to a half wave dipole for any class mobile station transmitter shall not exceed 8 dBW (6.3 Watts). An inoperative antenna assembly must not degrade the spurious emission levels as defined in 2.1.4.2. The nominal ERP (average burst power in digital mode) for each class of mobile station transmitter is: Class I 6 dBW (4.0 Watts), Class II 2 dBW (1.6 Watts), Class III –2 dBW (0.6 Watts), and Class IV –2 dBW (0.6 Watts). Class V, Class VI, Class VII, and Class VIII are reserved for future definition. Class IV is available only in dual-mode mobiles.

All mobile station transmitters must be capable of reducing or increasing power on command from a base station specifying the power level 0 to 7. Mobiles in classes IV through VIII must further be able to change power to levels in the range of power levels 0 to 10 by a Physical Layer Control Message (Power Change) from the base station. Only mobiles assigned a digital traffic channel can operate below power level 7 (see 2.7 and 3.7). The nominal levels are given in Table 2.1.2–1.

The power levels 0 to 7 must be maintained within the range of +2dB/–4dB of its nominal level over the ambient temperature range of –30°C to +60°C, and over the supply voltage range of ±10 percent from the nominal value, accumulative. A power change command will raise or lower power in increments of 4dB. (See Table 2.1.2–1 for tolerances).

For power levels 8 through 10, RF power emission must be maintained within the range +2dB/–6dB of the initial power level unless a Physical Layer Control Message (Power Change) is received, over the same temperature and supply voltage conditions stated above. A commanded increase of the power level number (PL) must never result in an increase of output power.

All classes of mobile will respond to a CMAC, DMAC or a VMAC command by setting their transmit power to the appropriate Mobile Station Power Level, regardless of prior Mobile Station Power Level. Mobile station power levels 8 through 10 are not allowed on analog signaling or voice channels.

Table 2.1.2–1 MOBILE STATION NOMINAL POWER LEVELS

Mobile Station Power Level (PL)	Mobile Attenuation Code (MAC)	Nominal ERP (dBW) for Mobile Station Power Class							
		I	II	III	IV	V	VI	VII	VIII
0	0000	6	2	− 2	−2	•	•	•	•
1	0001	2	2	− 2	−2	•	•	•	•
2	0010	− 2	− 2	− 2	−2	•	•	•	•
3	0011	− 6	− 6	− 6	−6	•	•	•	•
4	0100	−10	−10	−10	−10	•	•	•	•
5	0101	−14	−14	−14	−14	•	•	•	•
6	0110	−18	−18	−18	−18	•	•	•	•
7	0111	−22	−22	−22	−22	•	•	•	•
DUAL MODE ONLY									
8	1000	−22	−22	−22	−26 ± 3dB	•	•	•	•
9	1001	−22	−22	−22	−30 ± 6dB	•	•	•	•
10	1010	−22	−22	−22	−34 ± 9dB	•	•	•	•

Note: The three least significant bits of MAC are used in the CMAC/VMAC field. All four bits of MAC are used in the DMAC field.

2.1.3 Modulation Characteristics

2.1.3.1 Analog Voice Signals

The modulator is preceded by the following five voice-processing stages (in the order listed):

- Transmit Audio Level Adjustment
- Compressor
- Pre-Emphasis
- Deviation Limiter
- Post Deviation-Limiter Filter

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks.

Transmit Level Adjustment

The transmit audio sensitivity shall be adjusted such that the same reference input level used to generate a state of $R_0 = 21$ in the VSELP coder results in a ±2.9 kHz peak frequency deviation of the transmitted carrier measured with a 1 kHz sinusoidal tone.

2.1.3.1.1 Compressor

This stage is the compressor portion of a 2:1 syllabic compandor. For every 2 dB change in input level to a 2:1 compressor within its operating range, the change in output level is a nominal 1 dB. The compressor must have a nominal attack time of 3 ms and a nominal recovery time of 13.5 ms as defined by the CCITT (Reference: Recommendation G162, CCITT Plenary Assembly, Geneva, May-June 1964, Blue Book, Vol. 111, P. 52). The nominal reference input level to the compressor is that corresponding to a 1000 Hz acoustic tone at the expected nominal speech volume level (IS-55). This level must produce a nominal ±2.9 kHz peak frequency deviation of the transmitted carrier.

2.1.3.1.2 Pre-Emphasis

The pre-emphasis characteristic must have a nominal +6 dB/octave response between 300 and 3000 Hz.

2.1.3.1.3 Deviation Limiter

For audio (voice) inputs applied to the transmitter voice-signal processing stages, a dual-mode mobile station operating in analog mode must limit the instantaneous frequency deviation to ±12 kHz. This requirement excludes supervision signals (see 2.4) and wideband data signals (see 2.1.3.2).

2.1.3.1.4 Post Deviation-Limiter Filter

The deviation limiter must be followed by a low-pass filter whose characteristics are:

Frequency Band	**Attenuation Relative to 1000 Hz**
3000 - 5900 Hz	≥ 40 log (f/3000) dB
5900 - 6100 Hz	≥ 35 dB
6100 - 15000 Hz	≥ 40 log (f/3000) dB
above 15000 Hz	≥ 28 dB

2.1.3.2 Wideband Analog Data Signals

2.1.3.2.1 Encoding

The reverse control channel (RECC) and reverse voice channel (RVC) wideband data streams (see 2.7) must be further encoded such that each nonreturn-to-zero binary one is transformed to a zero-to-one transition, and each nonreturn-to-zero binary zero is transformed to a one-to-zero transition.

2.1.3.2.2 Modulation and Polarity

The filtered wideband data stream must then be used to modulate the transmitter carrier using direct binary frequency shift keying. A one (i.e., high state) into the modulator must correspond to a nominal peak frequency deviation 8 kHz above the carrier frequency, and a zero into the modulator must correspond to a nominal peak frequency deviation 8 kHz below the carrier frequency.

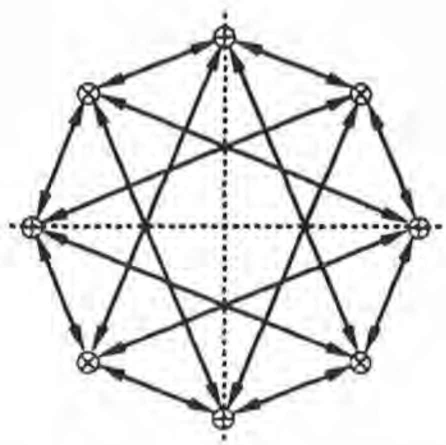
2.1.3.3 Digital Voice and Data Signals

2.1.3.3.1 Modulation

The modulation method used is known as $\frac{\pi}{4}$ shifted, differentially encoded quadrature phase shift keying.

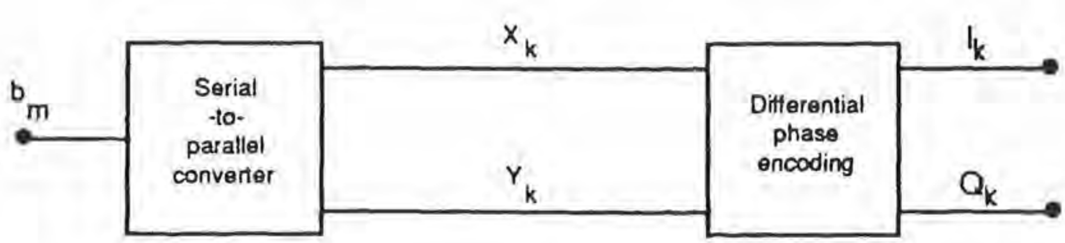
The modulation scheme uses the phase constellation shown in Figure 2–1. Note that Gray code is used in the mapping; two di-bit symbols corresponding to adjacent signal phases differ only in a single bit. Since most probable errors due to noise result in the erroneous selection of an adjacent phase, most di-bit symbol errors contain only a single bit error. Note also, the rotation by $\frac{\pi}{4}$ of the basic QPSK constellation for odd (denoted ⊕) and even (denoted ⊗) symbols.

Figure 2–1



The information is differentially encoded; symbols are transmitted as changes in phase rather than absolute phases. A block diagram of the differential encoder is shown in Figure 2–2. The binary data stream entering the modulator, b_m, is converted by a serial-to-parallel converter into two separate binary streams (X_k) and (Y_k). Starting from bit 1 in time of stream b_m, all odd numbered bits form stream X_k and all even numbered bits form stream Y_k.

Figure 2–2



The digital data sequences $\{X_k\}$ and $\{Y_k\}$ are encoded onto $\{I_k\}$ and $\{Q_k\}$ according to:

$$I_k = I_{k-1}\cos[\Delta\Phi(X_k,Y_k)] - Q_{k-1}\sin[\Delta\Phi(X_k,Y_k)]$$

$$Q_k = I_{k-1}\sin[\Delta\Phi(X_k,Y_k)] + Q_{k-1}\cos[\Delta\Phi(X_k,Y_k)]$$

where I_{k-1}, Q_{k-1} are the amplitudes at the previous pulse time. The phase change $\Delta\Phi$ is determined according to the following table:

X_k	Y_k	$\Delta\Phi$
1	1	$\frac{-3\pi}{4}$
0	1	$\frac{3\pi}{4}$
0	0	$\frac{\pi}{4}$
1	0	$\frac{-\pi}{4}$

The signals I_k,Q_k at the output of the differential phase encoding block can take one of five values, 0, ± 1, $\pm\frac{1}{\sqrt{2}}$, resulting in the constellation shown in Figure 2–1.

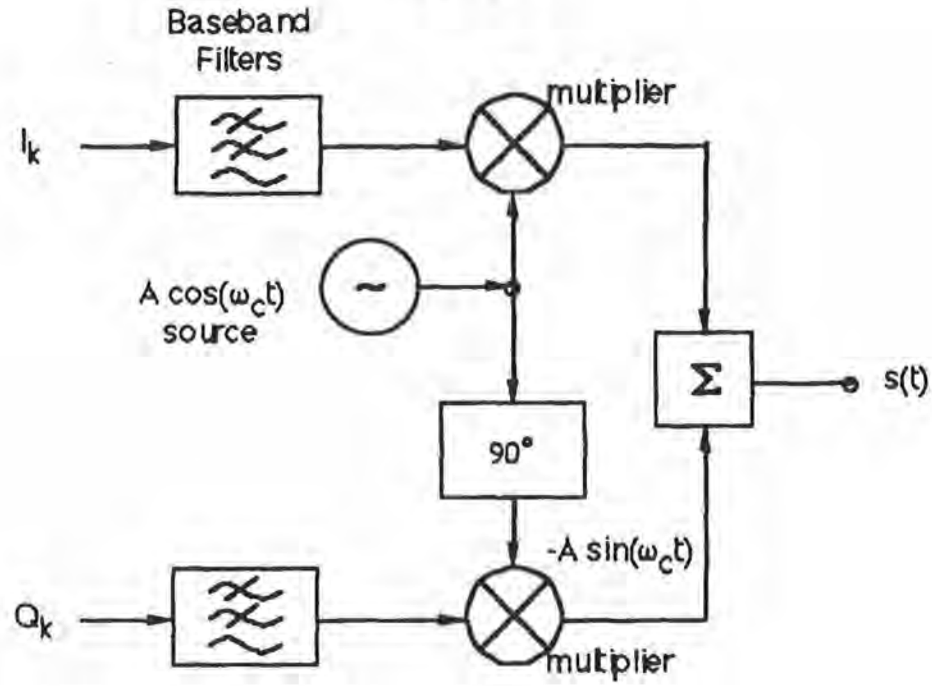
Impulses I_k, Q_k are applied to the inputs of the I & Q base-band filters. The base-band filters shall have linear phase and square root raised cosine frequency response of the form:

$$|H(f)| = \begin{cases} 1 & 0 \le f \le \frac{(1-\alpha)}{2T} \\ \sqrt{\frac{1}{2}\left\{1 - \sin\left[\frac{\pi(2fT-1)}{2\alpha}\right]\right\}} & \frac{(1-\alpha)}{2T} \le f \le \frac{(1+\alpha)}{2T} \\ 0 & f > \frac{(1+\alpha)}{2T} \end{cases}$$

where T is the symbol period. The roll-off factor, α, determines the width of the transition band, and is 0.35.

Figure 2–3 is for explanatory purposes and does not prescribe a specific implementation.

Figure 2–3



The resultant transmitted signal s(t) is given by :

$$s(t) = \sum_n g(t - nT)\cos\Phi_n \cos\omega_c t - \sum_n g(t - nT)\sin\Phi_n \sin\omega_c t$$

where g(t) is the pulse shaping function, ω_c is the radian carrier frequency, T is the symbol period, and Φ_n is the absolute phase corresponding to the n^{th} symbol interval.

The Φ_n which results from the differential encoding is:

$$\Phi n = \Phi n{-}1 + \Delta\Phi n.$$

Any method which generates the specified s(t) using the cited phase table may be used.

2.1.3.3.1.1 (Intentionally Left Blank)

2.1.3.3.1.2 (Intentionally Left Blank)

2.1.3.3.1.3 Modulation Accuracy

2.1.3.3.1.3.1 Description Of The Technique Used To Specify The Modulation Accuracy Requirement

The modulation accuracy requirement is specified by setting limits on the RMS difference between the actual transmitted signal waveform and the ideal signal waveform. The ideal waveform is derived mathematically from the specification of modulation in sections 2.1.3.3.1. The specified requirement is error vector magnitude.

2.1.3.3.1.3.2 Average Frequency Error Definition

For this measurement, frequency accuracy shall meet the requirements of section 2.1.1.2.2. (and 3.1.1.2.2) prior to measurement.

The average carrier frequency error is the difference between the average carrier frequency of the actual transmitted waveform and the average signal waveform carrier frequency.

2.1.3.3.1.3.3 Error Vector Magnitude Requirement

The ideal modulation is defined in 2.1.3.3.1. The definition is such that, observing an ideal transmitter through an ideal root raised-cosine receiver filter at the correct sampling instants one symbol apart would result in the sequence of values given by:

$$S(k) = S(k-1)e^{j[\pi/4 + B(k) \bullet \pi/2]}$$

where B(k) = 0,1,2, 3 according to the following table:

X_k	Y_k	B(k)
0	0	0
0	1	1
1	1	2
1	0	3

In the forward channel, S(k) forms part of a continuous data stream. In the reverse channel, the transmit bursts from the mobile are truncated by power up and down ramping. In this case, S(6) is the first sample that enters into demodulation, which yields the first two information bits by comparing S(6) with S(7). The last two information bits lie in the comparison of S(162) and S(161).

The ideal transmit and receive filters in cascade form a raised cosine Nyquist filter having an impulse response going through zero at symbol period intervals, so there is no inter-symbol interference at the ideal sampling points. The ideal signal samples therefore, take on one of the eight values defined above, at the output of the receive filter.

This section defines how the output signal from a transmitter is to be evaluated against the ideal signal.

Let Z(k) be the complex vectors produced by observing the real transmitter through an ideal measuring receiver filter at instants k, one symbol period apart. With S(k) defined as above, the transmitter is modelled as:

$$Z(k) = [C0 + C1 \bullet [S(k) + E(k)]] \bullet W^k$$

where:

$W = e^{dr + jda}$ accounts for both a frequency offset giving "da" radians per symbol phase rotation and an amplitude changes of "dr" nepers per symbol;

C0 is a constant origin offset representing quadrature modulator imbalance,

C1 is a complex constant representing the arbitrary phase and output power of the transmitter, and

E(k) is the residual vector error on sample S(k).

The sum square vector error is then:

$$\sum_{k=MIN}^{k=MAX} \left| E(k) \right|^2 = \sum_{k=MIN}^{k=MAX} \left| \left\{ \left[Z(k) \cdot W^{-k} - C0 \right] / C1 \right\} - S(k) \right|^2 ;$$

C0, C1 and W shall be chosen to minimize this expression and are then used to compute the individual vector errors E(k) on each symbol. The symbol timing phase of the receiver output samples used to compute the vector error shall also be chosen to give the lowest value.

The values of MAX and MIN for the reverse channel (mobile transmitter) are:

MIN	=	6	(the vector in the last of the three ramp-up symbol periods)
MAX	=	162	(the vector in the first of the three ramp-down symbol periods)

The RMS vector error is then computed as the square root of the sum-square vector divided by the number of symbols in the slot, 162 in the forward direction and 157 in the reverse direction.

The RMS vector error in any burst shall be less than 0.125.

In addition, the normalized error vector magnitude during the first 10 symbols (20 bits) of a mobile TDMA burst following the ramp-up, must have an RMS value of less than 0.25 when averaged over 10 bursts within a 1 minute interval.

Note: The value of origin offset for minimum performance referred to in section 2.1.3.3.1.3.3 will be addressed, if deemed necessary, in IS-55 and IS-56.

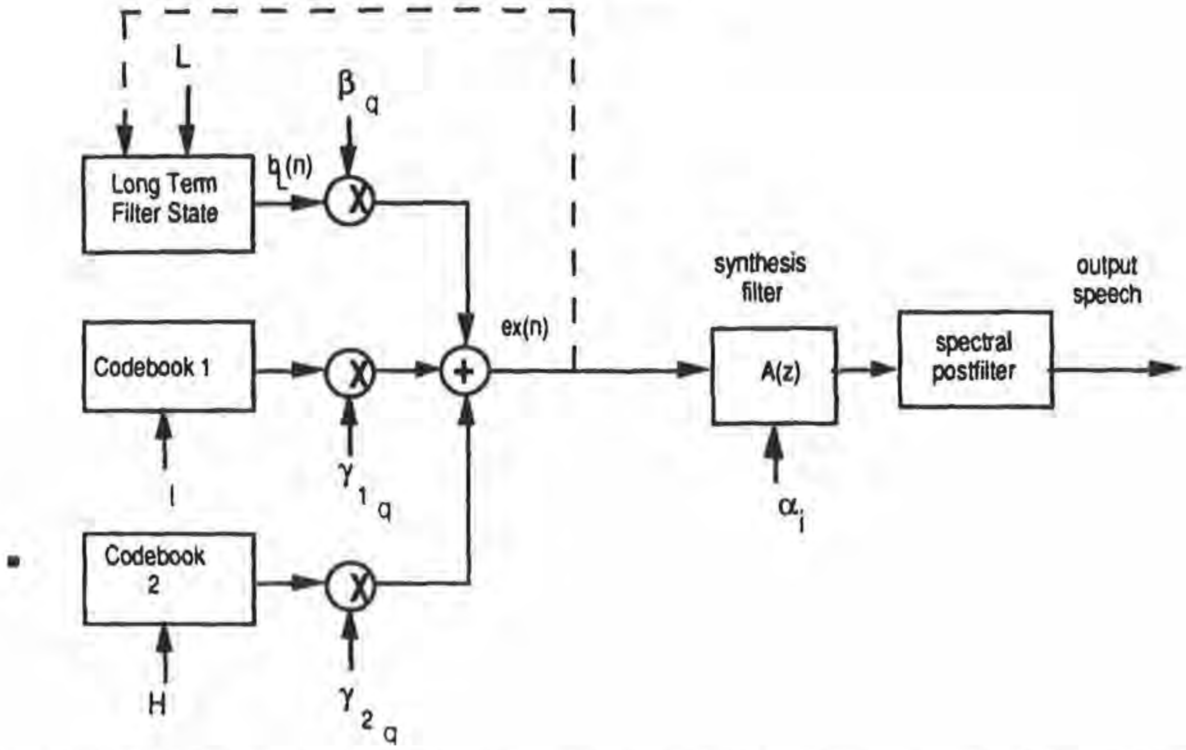
2.1.3.3.2 Speech Coding (Full Rate)

The speech coding algorithm is a member of a class of speech coders known as Code Excited Linear Predictive Coding (CELP), Stochastic Coding or Vector Excited Speech Coding. These techniques use codebooks to vector quantize the excitation (residual) signal. The speech coding algorithm is a variation on CELP called Vector-Sum Excited Linear Predictive Coding (VSELP). VSELP uses a codebook which has a predefined structure such that the computations required for the codebook search process can be significantly reduced.

2.1.3.3.2.1 Definitions and Basic Coder Parameters

Figure 2.1.3.3.2.1-1 shows a block diagram of the speech decoder. This figure indicates the various parameters which must be determined and encoded by the speech coder.

Fig. 2.1.3.3.2.1-1



The speech decoder utilizes two VSELP excitation codebooks. The two codebooks each have their own gain. The two codebook excitations are each multiplied by their corresponding gains and summed to create a combined codebook excitation. The following are the basic parameters for the 7950 bps speech coder and decoder.

	sampling rate	8 kHz
N_F	frame length	160 samples (20 msec)
N	subframe length	40 samples (5 msec)
N_P	short term predictor order	10
	# of taps for long term predictor	1
M_1	# of bits in codeword 1 (# of basis vectors)	7
M_2	# of bits in codeword 2 (# of basis vectors)	7

The basic data rate of the speech coder is 7950 bps. There are 159 bits per speech frame (20 msec) for the speech coder. These 159 bits are allocated as follows:

short-term filter coefficients, α_i's		38 bits/frame
frame energy, R(0)		5 bits/frame
lag, L	7 bits/subframe	28 bits/frame
codewords, I, H	7+7 bits/subframe	56 bits/frame
gains $\beta, \gamma_1, \gamma_2$	8 bits/subframe	32 bits/frame

The following is a list of all the parameter codes transmitted for each 20 msec. speech frame. The codes are:

R0	5 bits	frame energy
LPC1	6 bits	1st reflection coefficient
LPC2	5 bits	2nd reflection coefficient
LPC3	5 bits	3rd reflection coefficient
LPC4	4 bits	4th reflection coefficient
LPC5	4 bits	5th reflection coefficient
LPC6	3 bits	6th reflection coefficient
LPC7	3 bits	7th reflection coefficient
LPC8	3 bits	8th reflection coefficient
LPC9	3 bits	9th reflection coefficient
LPC10	2 bits	10th reflection coefficient
LAG_1	7 bits	lag for first subframe
LAG_2	7 bits	lag for second subframe
LAG_3	7 bits	lag for third subframe
LAG_4	7 bits	lag for fourth subframe
CODE1_1	7 bits	1st codebook code, I, for first subframe
CODE1_2	7 bits	1st codebook code, I, for second subframe
CODE1_3	7 bits	1st codebook code, I, for third subframe
CODE1_4	7 bits	1st codebook code, I, for fourth subframe
CODE2_1	7 bits	2nd codebook code, H, for first subframe
CODE2_2	7 bits	2nd codebook code, H, for second subframe
CODE2_3	7 bits	2nd codebook code, H, for third subframe
CODE2_4	7 bits	2nd codebook code, H, for fourth subframe
GSP0_1	8 bits	{GS, P0, P1} code for first subframe
GSP0_2	8 bits	{GS, P0, P1} code for second subframe
GSP0_3	8 bits	{GS, P0, P1} code for third subframe
GSP0_4	8 bits	{GS, P0, P1} code for fourth subframe

2.1.3.3.2.2 Audio Interface

Due to the delays inherent in the air interface specification, which may exceed 100 msec, the implementer is cautioned that echo control measures are necessary.

The function of the audio interface at the mobile transmitter is to convert the analog speech signal to uniform PCM format with a minimum resolution of 13 bits for further processing by the speech coder.

The speech coder is preceded by the following voice processing stages.

- Level adjustment
- Bandpass Filter

- Analog to Digital Converter

The characteristics of these stages are described in the following sections.

2.1.3.3.2.2.1 Transmit Level Adjustment

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks.

The transmit audio sensitivity of the mobile station shall meet the requirements stated in EIA/TIA IS-55 under "Digital Transmitter Audio Sensitivity".

2.1.3.3.2.2.2 Bandpass Filter

The function of the filter is to avoid aliasing distortion of the input signal. The attenuation of the filter shall comply with CCITT Red Book G.714 sending filter.

2.1.3.3.2.2.3 Analog to Digital converter

The A/D function shall be performed according to either of the following:

- by direct conversion analog to a uniform PCM format with a minimum resolution of 13 bits.
- or by converting analog to an 8-bit/μlaw format followed by a μlaw/uniform code conversion.

The A/D conversion is based on the standard 8-bit/μlaw codec specified in CCITT Red Book G.711.

The μlaw/uniform code conversion is performed according to definition in CCITT Red Book G.721 section 4.2.1 sub-block EXPAND. The parameter LAW shall be set to LAW=0.

2.1.3.3.2.2.4 Echo Return Loss

The echo return loss of the mobile station shall have a minimum value of 45 dB, measured in accordance with the procedure given in IEEE 269-1990, Section 7.10.2, condition 3, using the continuous-spectrum signal method; and calculated using the technique described in TIA SP-1920A, Section 4.4.1.1. This requirement must be met by all types of mobile stations at their nominal volume setting.

2.1.3.3.2.3 Pre-Processing

It may be desirable in some instances to provide additional high-pass filtering after analog to digital conversion. A fourth order Chebyshev type II highpass with a filter response which is 3 dB down at 120 Hz and 40 dB down at 60 Hz may be used. The transfer function of the high-pass filter is given by:

$$H_{hp}(z) = \frac{\sum_{i=0}^{4} a_i z^{-i}}{1 - \sum_{i=1}^{4} b_i z^{-i}} \qquad (2.1.3.3.2.3\text{–}1)$$

where:

$a_0 =$	0.898025036		
$a_1 =$	−3.59010601	$b_1 =$	3.78284979
$a_2 =$	5.38416243	$b_2 =$	−5.37379122
$a_3 =$	−3.59010601	$b_3 =$	3.39733505
$a_4 =$	0.898024917	$b_4 =$	−0.806448996

2.1.3.3.2.4 Short-Term Predictor Coefficients

The short-term filter is equivalent to the traditional LPC synthesis filter. The transfer function for the short-term filter is given by.

$$A(z) = \frac{1}{1 - \sum_{i=1}^{N_p} \alpha_i z^{-i}} \qquad (2.1.3.3.2.4\text{–}1)$$

The short term predictor parameters are the α_i's of the short term or synthesis filter. These are standard LPC direct form filter coefficients. The short term predictor parameters are computed from the input speech. No pre-emphasis is used. This analysis interval should be centered with respect to the center of the fourth subframe of each frame. The order of the predictor is 10 ($N_P = 10$).

2.1.3.3.2.4.1 Solution for Reflection Coefficients

An efficient fixed point covariance lattice algorithm, FLAT, may be used for determination of the short-term filter coefficients. Let the samples of the input speech which fall in the analysis interval be represented by $s(n)$; $0 \le n \le N_A - 1$. The analysis length used for computation of the parameters is 170 samples ($N_A = 170$).

Since FLAT is a lattice algorithm one can view the technique as trying to build an optimum (that which minimizes residual energy) inverse lattice filter stage by stage.

Defining $b_j(n)$ to be the backward residual out of stage j of the inverse lattice filter and $f_j(n)$ to be the forward residual out of stage j of the inverse lattice filter we can define:

$$F_j(i,k) = \sum_{n=N_P}^{N_A-1} f_j(n-i) f_j(n-k) \qquad (2.1.3.3.2.4.1\text{–}1)$$

the autocorrelation of $f_j(n)$;

$$B_j(i,k) = \sum_{n=N_P}^{N_A-1} b_j(n-i-1) b_j(n-k-1) \qquad (2.1.3.3.2.4.1\text{–}2)$$

the autocorrelation of $b_j(n-1)$ and:

$$C_j(i,k) = \sum_{n=N_P}^{N_A-1} f_j(n-i) b_j(n-k-1) \qquad (2.1.3.3.2.4.1\text{–}3)$$

the cross correlation between $f_j(n)$ and $b_j(n-1)$.

Let r_j represent the reflection coefficient for stage j of the inverse lattice. Then:

$$F_j(i,k) = F_{j-1}(i,k) + r_j\left(C_{j-1}(i,k) + C_{j-1}(k,i)\right) + r_j^2 B_{j-1}(i,k) \qquad (2.1.3.3.2.4.1\text{–}4)$$

and

$$B_j(i,k) = B_{j-1}(i+1,k+1) + r_j\left(C_{j-1}(i+1,k+1) + C_{j-1}(k+1,i+1)\right) + r_j^2 F_{j-1}(i+1,k+1) \qquad (2.1.3.3.2.4.1\text{-}5)$$

and

$$C_j(i,k) = C_{j-1}(i,k+1) + r_j\left(B_{j-1}(i,k+1) + F_{j-1}(i,k+1)\right) + r_j^2 C_{j-1}(k+1,i) \qquad (2.1.3.3.2.4.1\text{-}6)$$

r_j can be expressed as:

$$r_j = -2\frac{C_{j-1}(0,0) + C_{j-1}(N_P - j, N_P - j)}{F_{j-1}(0,0) + B_{j-1}(0,0) + F_{j-1}(N_P - j, N_P - j) + B_{j-1}(N_P - j, N_P - j)} \qquad (2.1.3.3.2.4.1\text{–}7)$$

The FLAT algorithm can now be stated as follows.

1. First compute the covariance (autocorrelation) matrix from the input speech:

   $$\phi(i,k) = \sum_{n=N_P}^{N_A-1} s(n-i)\, s(n-k) \qquad (2.1.3.3.2.4.1\text{–}8)$$

   for $0 \le i,k \le N_P$.

   (Note: see also 2.1.3.3.2.4.2).

2. $F_0(i,k) = \phi(i,k)$ $\quad 0 \le i,k \le N_P-1$ $\quad$ (2.1.3.3.2.4.1–9)
   $B_0(i,k) = \phi(i+1,k+1)$ $\quad 0 \le i,k \le N_P-1$ $\quad$ (2.1.3.3.2.4.1–10)
   $C_0(i,k) = \phi(i,k+1)$ $\quad 0 \le i,k \le N_P-1$ $\quad$ (2.1.3.3.2.4.1–11)

3. set $j = 1$

4. Compute r_j using (2.1.3.3.2.4.1–7)

5. Quantize r_j (see section 2.1.3.3.2.4.3)

6. If $j = N_P$ then done.

7. Compute $F_j(i,k)$ $\quad 0 \le i,k \le N_P-j-1$ $\quad$ using (2.1.3.3.2.4.1–4)
   Compute $B_j(i,k)$ $\quad 0 \le i,k \le N_P-j-1$ $\quad$ using (2.1.3.3.2.4.1–5)
   Compute $C_j(i,k)$ $\quad 0 \le i,k \le N_P-j-1$ $\quad$ using (2.1.3.3.2.4.1–6)

8. $j = j+1$; go to 4.

This algorithm can be simplified by noting that the ϕ, F and B matrices are symmetric such that only the upper triangular part of the matrices need to be computed or updated. In addition $\phi(i,j)$ can be efficiently computed from $\phi(i-1,j-1)$. Also, if step 7 is done so that $F_j(i,k)$, $B_j(i-1,k-1)$, $C_j(i,k-1)$, and $C_j(k,i-1)$ are updated together, then common terms can be computed once and the recursion can be done in place.

2.1.3.3.2.4.2 Bandwidth Expansion

The speech coder should provide for a small amount of bandwidth expansion of the short-term filter coefficients prior to quantization. Windowing of the autocorrelations prior to the solution of the reflection coefficients is one technique which may be used.

Prior to solving for the reflection coefficients, the ϕ array is modified by windowing the autocorrelation functions:

$$\phi'(i,k) = \phi(i,k)w(|i-k|) \qquad (2.1.3.3.2.4.2\text{–}1)$$

The window used is a binomial window with an effective bandwidth of 80 Hz. The values of w(i) are:

w(0)	1.000000
w(1)	0.999644
w(2)	0.998577
w(3)	0.996802
w(4)	0.994321
w(5)	0.991141
w(6)	0.987268
w(7)	0.982710
w(8)	0.977478
w(9)	0.971581
w(10)	0.965032

(2.1.3.3.2.4.2-2)

2.1.3.3.2.4.3 Quantization and Encoding of Coefficients

As stated in 2.1.3.3.2.4.1, the quantization of the reflection coefficients may be done within the FLAT recursion.

The reflection coefficients are quantized using codebooks designed for each reflection coefficient. The bit allocations for the reflection coefficient quantizers are:

r_1	6 bits
r_2	5 bits
r_3	5 bits
r_4	4 bits
r_5	4 bits
r_6	3 bits
r_7	3 bits
r_8	3 bits
r_9	3 bits
r_{10}	2 bits

The 10 reflection coefficients ($r_1 - r_{10}$) which represent the short term predictor parameters are each independently quantized. Table 2.1.3.3.2.4.3–1 provides the 10 codebooks for quantization of the 10 reflection coefficients to provide codes LPC1 through LPC10. The quantization may be performed by finding the codebook value which is closest (minimum absolute error) from the unquantized reflection coefficient. The code for that codebook entry (which appears in the left column) is the code for that reflection coefficient. Note that no transformation (such as log area ratio or arc sine) of the reflection coefficients is required during the quantization process.

Table 2.1.3.3.2.4.3-1

64 QUANTIZATION LEVELS FOR r_1 FOLLOW:

0	−0.9867044091E+00	32	−0.6262212992E+00
1	−0.9810330868E+00	33	−0.5971570611E+00
2	−0.9762308002E+00	34	−0.5684631467E+00
3	−0.9711073637E+00	35	−0.5378258228E+00
4	−0.9655630589E+00	36	−0.5058867931E+00
5	−0.9597059488E+00	37	−0.4740323126E+00
6	−0.9536622763E+00	38	−0.4414438009E+00
7	−0.9471911192E+00	39	−0.4054017663E+00
8	−0.9406521916E+00	40	−0.3682330251E+00
9	−0.9339897037E+00	41	−0.3293099701E+00
10	−0.9266145825E+00	42	−0.2894666791E+00
11	−0.9190770388E+00	43	−0.2428349406E+00
12	−0.9110740423E+00	44	−0.1948891282E+00
13	−0.9032388926E+00	45	−0.1466629505E+00
14	−0.8951876163E+00	46	−0.9152601659E-01
15	−0.8865973353E+00	47	−0.2692181431E-01
16	−0.8775991797E+00	48	0.3727672249E-01
17	−0.8679655194E+00	49	0.1093522757E+00
18	−0.8578169942E+00	50	0.1758577228E+00
19	−0.8468435407E+00	51	0.2397777289E+00
20	−0.8350597620E+00	52	0.3001485765E+00
21	−0.8232460022E+00	53	0.3555985391E+00
22	−0.8109311461E+00	54	0.4108347893E+00
23	−0.7979614735E+00	55	0.4679426551E+00
24	−0.7842678428E+00	56	0.5202128887E+00
25	−0.7699828744E+00	57	0.5746787190E+00
26	−0.7545526624E+00	58	0.6337370872E+00
27	−0.7377604842E+00	59	0.6966888309E+00
28	−0.7188396454E+00	60	0.7613552213E+00
29	−0.6990101337E+00	61	0.8211135268E+00
30	−0.6768131256E+00	62	0.8759805560E+00
31	−0.6533866525E+00	63	0.9311733246E+00

32 QUANTIZATION LEVELS FOR r_2 FOLLOW:

0	-0.7547348738E+00	16	0.5302551389E+00
1	-0.5826729536E+00	17	0.5760165453E+00
2	-0.4569368660E+00	18	0.6193220615E+00
3	-0.3481135964E+00	19	0.6593915224E+00
4	-0.2492762953E+00	20	0.6967787147E+00
5	-0.1585778296E+00	21	0.7315257788E+00
6	-0.7726432383E-01	22	0.7650170326E+00
7	-0.5096863955E-02	23	0.7966732979E+00
8	0.6527176499E-01	24	0.8267812133E+00
9	0.1329884380E+00	25	0.8543012142E+00
10	0.1978287548E+00	26	0.8798117638E+00
11	0.2600678802E+00	27	0.9037305117E+00
12	0.3186267912E+00	28	0.9251338840E+00
13	0.3747462034E+00	29	0.9448361397E+00
14	0.4288900495E+00	30	0.9636774063E+00
15	0.4810178876E+00	31	0.9816107750E+00

32 QUANTIZATION LEVELS FOR r_3 FOLLOW:

0	-0.8606231213E+00	16	-0.1760748774E+00
1	-0.8046579361E+00	17	-0.1370347440E+00
2	-0.7523136735E+00	18	-0.9637858719E-01
3	-0.7056827545E+00	19	-0.5570860580E-01
4	-0.6582847834E+00	20	-0.1342663728E-01
5	-0.6130494475E+00	21	0.2913235873E-01
6	-0.5684005022E+00	22	0.7243801653E-01
7	-0.5247684717E+00	23	0.1183170006E+00
8	-0.4832728207E+00	24	0.1668847799E+00
9	-0.4436871707E+00	25	0.2185972333E+00
10	-0.4048590660E+00	26	0.2741918266E+00
11	-0.3659544587E+00	27	0.3353714645E+00
12	-0.3276270330E+00	28	0.4032742083E+00
13	-0.2901176810E+00	29	0.4797808230E+00
14	-0.2521926463E+00	30	0.5761802793E+00
15	-0.2139451057E+00	31	0.6969622374E+00

16 QUANTIZATION LEVELS FOR r_4 FOLLOW:

0	-0.4505536556E+00	8	0.3864109516E+00
1	-0.2582354248E+00	9	0.4573097229E+00
2	-0.1276191175E+00	10	0.5282919407E+00
3	-0.1891620830E-01	11	0.5986876488E+00
4	0.7355944812E-01	12	0.6679506302E+00
5	0.1581759751E+00	13	0.7368153930E+00
6	0.2381238639E+00	14	0.8054329753E+00
7	0.3138437271E+00	15	0.8715001345E+00

16 QUANTIZATION LEVELS FOR r_5 FOLLOW:

0	-0.6570090652E+00	8	-0.1441930979E-01
1	-0.5339469314E+00	9	0.4928108677E-01
2	-0.4366474450E+00	10	0.1149446666E+00
3	-0.3503953516E+00	11	0.1853068322E+00
4	-0.2729992270E+00	12	0.2629969418E+00
5	-0.2044571489E+00	13	0.3558021188E+00
6	-0.1395732164E+00	14	0.4658669233E+00
7	-0.7738068700E-01	15	0.6091661453E+00

8 QUANTIZATION LEVELS FOR r_6 FOLLOW:

0	-0.3351013660E+00	4	0.2685563564E+00
1	-0.1157702208E+00	5	0.3836385608E+00
2	0.3265872598E-01	6	0.5067840815E+00
3	0.1545225680E+00	7	0.6525010467E+00

8 QUANTIZATION LEVELS FOR r_7 FOLLOW:

0	-0.5834863186E+00	4	-0.5848890170E-01
1	-0.4363777936E+00	5	0.5718512833E-01
2	-0.3007811308E+00	6	0.1880214661E+00
3	-0.1750739664E+00	7	0.3601035774E+00

8 QUANTIZATION LEVELS FOR r_8 FOLLOW:

0	-0.3832900822E+00	4	0.1637183726E+00
1	-0.2111644298E+00	5	0.2812094688E+00
2	-0.7242984325E-01	6	0.4174390733E+00
3	0.4901395738E-01	7	0.5824319720E+00

8 QUANTIZATION LEVELS FOR r_9 FOLLOW:

0	-0.5373110771E+00	4	-0.2935140580E-01
1	-0.3927696943E+00	5	0.8255130798E-01
2	-0.2594878078E+00	6	0.2107033432E+00
3	-0.1391013712E+00	7	0.3958446980E+00

4 QUANTIZATION LEVELS FOR r_{10} FOLLOW:

0	-0.1508204788E+00	2	0.1958054304E+00
1	0.4652437568E-01	3	0.3621688187E+00

2.1.3.3.2.4.4 (Intentionally Left Blank)

2.1.3.3.2.4.5 Conversion to Direct Form Coefficients

The quantized reflection coefficients must be converted to direct form filter coefficients, α_i's.

2.1.3.3.2.4.6 Interpolation of Coefficients

The speech coder linearly interpolates the α_i's for the first, second and third subframes of each frame. The fourth subframe uses the uninterpolated α_i's for that frame. For all α_i's:

$$\alpha_i = .75\alpha_{i(previous)} + .25\alpha_{i(current)} \quad \text{for subframe 1}$$
$$\alpha_i = .5\alpha_{i(previous)} + .5\alpha_{i(current)} \quad \text{for subframe 2}$$
$$\alpha_i = .25\alpha_{i(previous)} + .75\alpha_{i(current)} \quad \text{for subframe 3}$$
$$\alpha_i = \alpha_{i(current)} \quad \text{for subframe 4}$$

(2.1.3.3.2.4.6-1)

where $\alpha_{i(previous)}$ is the i^{th} direct form coefficient from the previous frame and $\alpha_{i(current)}$ is the i^{th} direct form coefficient from the current frame.

For interpolated subframes, the α_i's are converted to reflection coefficients to check for filter stability. If the resulting filter is unstable (any reflection coefficient having a magnitude equal to or greater than 1.0,) then uninterpolated coefficients are used for that subframe. The uninterpolated coefficients used for subframe 1 are the previous frame's coefficients. The uninterpolated coefficients used for subframe 3 are the current frame's coefficients. Subframe 2 uses either the previous frame or the current frame's coefficients, choosing those coefficients which correspond to the frame with the higher energy. If both frames have the same energy (R(0)) then subframe 2 uses the previous frame's coefficients.

2.1.3.3.2.5 Frame Energy

An energy value is computed and encoded once per frame. This energy value, R(0), reflects the average signal power in the input speech over a 20 msec. interval which is centered with respect to the middle of the fourth subframe.

2.1.3.3.2.5.1 Computation of Frame Energy

R(0), may be computed during the computation of the short term predictor parameters.

$$R(0) = \frac{\phi(0,0)+\phi(N_P,N_P)}{2\,(N_A - N_P)} \qquad (2.1.3.3.2.5\text{-}1)$$

where $\phi(i,k)$ is defined by (2.1.3.3.2.4.1–8). Equation 2.1.3.3.2.5–1 can be rewritten as:

$$R(0) = \frac{\phi(0,0)+\phi(10,10)}{320} \qquad (2.1.3.3.2.5\text{–}2)$$

2.1.3.3.2.5.2 Quantization and Encoding of Frame Energy

R(0) is converted into dB relative to full scale (full scale, R_{max}, is defined as the square of the maximum sample amplitude).

$$R_{dB} = 10 \log_{10}(R(0) / R_{max}) \qquad (2.1.3.3.2.5.2\text{–}1)$$

R_{dB} is then quantized to 32 levels. A code of zero for R0 corresponds to an energy of 0 (R(0) = 0). This code can be used to totally silence the speech decoder. The remaining 31 quantized values for R_{dB} range from a minimum of –64 (corresponding to a code of 1 for R0) to a maximum of –4 (corresponding to a code of 31 for R0). The step size of the quantizer is 2 (2 dB steps). R0 is chosen as:

minimize (for R0=1 to 31) $|abs(R0-(R_{dB} + 66)/2)|$	if $R_{dB} \ge -72$	(2.1.3.3.2.5.2–2a)
else R0 = 0	if $R_{dB} < -72$	(2.1.3.3.2.5.2–2b)

where R0 can take on the integer values from 0 to 31 corresponding to the 32 codes for R0.

The quantized value of R(0), $R_q(0)$ is given by:

$R_q(0) = R_{max}(10.$ ** (((2 * R0) – 66) / 10))	if R0 ≠ 0	(2.1.3.3.2.5.2–3a)
$R_q(0) = 0$	if R0 = 0	(2.1.3.3.2.5.2–3b)

2.1.3.3.2.5.3 Interpolation of Frame Energy

Define $R'_q(0)$ to be the quantized value of R(0) to be used for the subframe and $R_q(0)$ to be the quantized value of R(0). Then:

$R'_q(0) = R_q(0)_{\text{previous frame}}$	for subframe 1	(2.1.3.3.2.5.3–1a)
$R'_q(0) = R_q(0)_{\text{current frame}}$	for subframes 3 and 4	(2.1.3.3.2.5.3–1b)
$R'_q(0) = \sqrt{R_q(0)_{\text{previous frame}} \; R_q(0)_{\text{current frame}}}$	for subframe 2	(2.1.3.3.2.5.3–1c)

2.1.3.3.2.6 Subframe Processing

The 20 msec. speech frame is subdivided into four 5 msec. subframes. For each subframe the speech coder must determine and code the long-term predictor lag, L, the two codewords, I and H, and the gains, β, γ_1 and γ_2.

2.1.3.3.2.6.1 Weighting of Input Speech

The speech coder utilizes a perceptual noise weighting filter of the form:

$$W(z) = \frac{1-\sum_{i=1}^{N_p} \alpha_i z^{-i}}{1-\sum_{i=1}^{N_p} \alpha_i \lambda^i z^{-i}} \qquad (2.1.3.3.2.6.1\text{–}1)$$

where α_i's are the filter coefficients for the subframe (see 2.1.3.3.2.4.6) and λ is the noise weighting parameter. A value of $\lambda = .8$ may be used. The input speech for the subframe must be filtered by the perceptual weighting filter. The filter may be implemented as a cascade of a 10^{th} order inverse (all zero) direct form filter corresponding to the numerator of equation 2.1.3.3.2.6.1–1, followed by a 10^{th} order (all pole) direct form filter corresponding to the denominator. The filter coefficients will change for each subframe. The states of the filters should be preserved from one subframe to the next. (Note: other weighting filter implementations may adversely affect performance. Consequently, care must be taken to achieve or exceed the performance level that is realized by the above filter configuration.)

2.1.3.3.2.6.2 Subtraction of Zero Input Response

The speech encoder is an analysis by synthesis coding system. Therefore a version of the speech decoder is used in the speech encoder. The form of the synthesis filter used in the speech encoder is given by:

$$H(z) = \frac{1}{1 - \sum_{i=1}^{N_p} \alpha_i \lambda^i z^{-i}} \qquad (2.1.3.3.2.6.2\text{–}1)$$

Note that the synthesis filter used in the speech encoder is different than that used in the speech decoder. The synthesis for the speech encoder includes the same noise weighting parameter, λ, as the weighting filter in section 2.1.3.3.2.6.1. The synthesis filter used in the speech coder is therefore called the weighted synthesis filter. A weighted synthesis filter is used to match the weighting applied to the input speech. The weighted synthesis filter will have a filter state associated with it at the start of each subframe. In order to remove the effects of the weighted synthesis filter's initial state from the subframe parameter determinations, the zero input response of the weighted synthesis filter shall be computed and subtracted from the weighted input speech for the subframe. The weighted synthesis filter should be implemented with a direct form filter.

2.1.3.3.2.6.3 Long Term Predictor Lag

The speech coder uses the closed loop approach to choosing the long term predictor lag. In the closed loop case the lag is determined from only past output from the long term filter and the current input speech. The long term filter response can be expressed as:

$$B_n(z) = \frac{1}{1 - \beta z^{-\left\lfloor \frac{n+L}{L} \right\rfloor L}} \qquad (2.1.3.3.2.6.3\text{–}1)$$

where $\lfloor x \rfloor$ is the floor function of x which evaluates to the largest integer $\leq x$ and n is the sample in the subframe; $0 \leq n \leq N-1$. The lag L is always used as the delay for the first L samples of the subframe. If $L < N$ then for samples $n = L$ to $2L-1$, a delay of $2L$ is used, etc. In this way the delay is always greater than n so that only long term filter states existing at the start of the subframe are used.

Fig. 2.1.3.3.2.6.3–1
Analysis by Synthesis Procedure for
Long Term Predictor Lag and Code Search

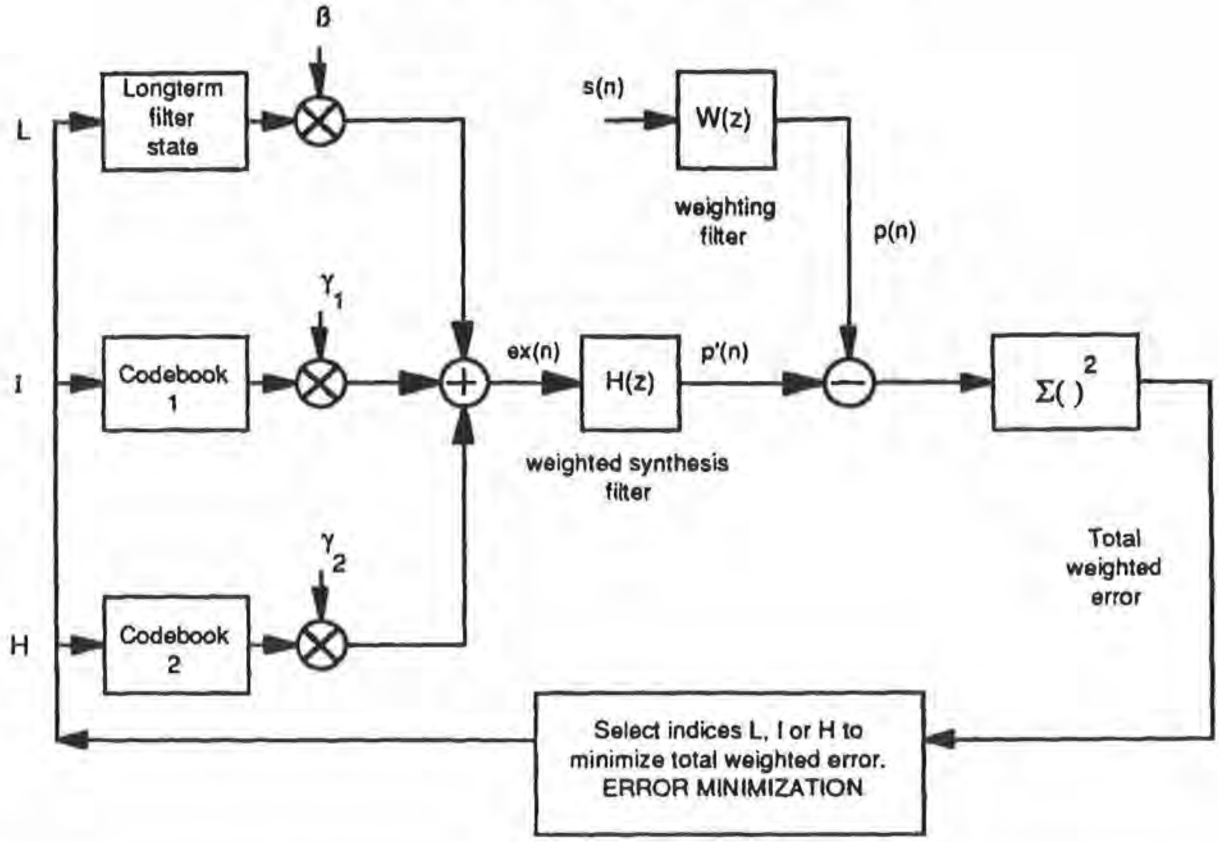


Fig. 2.1.3.3.2.6.3–1 illustrates how the long term predictor lag search and code search can be formulated utilizing the long term filter just described. The input p(n) in this case is the weighted input speech for the subframe minus the zero input response of the weighted synthesis filter, H(z). The long term lag optimization looks just like a codebook search where the codebook is defined by the long term filter state and the specific vector in the codebook is specified by the long term predictor lag, L. These three "codebooks" (the long term predictor state and the two excitation codebooks) are searched sequentially. The long term predictor lag is determined first assuming no input from the excitation codebooks.

2.1.3.3.2.6.3.1 Computation of Lag

defining:

- L_{min} minimum possible value for long term lag L (L_{min} = 20)
- r(n) long term filter state; n < 0 (past outputs of long term filter)
- $b_L(n)$ output of long term filter state "codebook" for lag L
- h(n) impulse response of H(z)
- $b'_L(n)$ $b_L(n)$ filtered by H(z) (convolved with h(n))

$$G_L = \sum_{n=0}^{N-1} (b'_L(n))^2 \qquad (2.1.3.3.2.6.3.1\text{–}1)$$

$$C_L = \sum_{n=0}^{N-1} b'_L(n)\, p(n) \qquad (2.1.3.3.2.6.3.1\text{–}2)$$

Then the lag, L, which will minimize the total weighted error (with optimal β) should be chosen as that which maximizes

$$(C_L)^2 / G_L \qquad (2.1.3.3.2.6.3.1\text{–}3)$$

Since we are restricting β to be positive, only lags with positive C_L are considered. L is coded with 7 bits and can take on a value from 20 to 146. One of the 128 coded lag values is reserved to indicate that the long term predictor is not used. This allows the long term predictor to be disabled when a positive correlation cannot be found. In order for this search to be efficient, $b'_L(n)$ must be computed efficiently. This may be done as follows:

define:

$$z_L(n) = \sum_{i=0}^{\min(n,L-1)} r(i-L)\, h(n-i) \qquad (2.1.3.3.2.6.3.1\text{–}4)$$

then:

$$b'_L(n) = \sum_{i=0}^{\left\lfloor \frac{n}{L} \right\rfloor} z_L(n-iL) \qquad (2.1.3.3.2.6.3.1\text{–}5)$$

where $\lfloor x \rfloor$ is the floor function of x which evaluates to the largest integer ≤ x

$z_L(n)$ can be computed from $z_{L-1}(n)$ in a very efficient manner using (2.1.3.3.2.6.3.1–6) and (2.1.3.3.2.6.3.1–7).

$$z_L(n) = z_{L-1}(n-1) + r(-L)h(n) \qquad (2.1.3.3.2.6.3.1\text{–}6)$$

for $1 \le n \le N-1$ and

$$z_L(0) = r(-L)h(0) \qquad (2.1.3.3.2.6.3.1\text{–}7)$$

A further computational reduction can be achieved if a truncated impulse response is used in the computations associated with the long term lag determination process. The truncated impulse response can be written as:

$$h'(n) = \begin{cases} h(n) & , 0 \le n \le N_T - 1 \\ 0 & , N_T \le n \end{cases} \qquad (2.1.3.3.2.6.3.1\text{–}8)$$

A value of 21 for N_T, corresponding to a truncated impulse response 21 samples long, may be used.

Replacing h(n) with h'(n) in equations 2.1.3.3.2.6.3.1-4 and 2.1.3.3.2.6.3.1-6 results in a number of zero products that can be eliminated from the equations. These equations can be replaced by the following set of equations

$$z_{L_{min}}(n) = \sum_{i=\max(0,\, n - N_T + 1)}^{\min(n,\, L_{min} - 1)} r(i-L_{min})\, h(n-i) \qquad (2.1.3.3.2.6.3.1\text{–}9)$$

$$z_L(n) = \begin{cases} z_{L-1}(n-1) + r(-L)h(n) & , 1 \le n \le N_T - 1 \\ z_{L-1}(n-1) & , N_T \le n \le N-1 \end{cases} \qquad (2.1.3.3.2.6.3.1\text{–}10)$$

Equation 2.1.3.3.2.6.3.1–9 is computed only for the minimum lag value and the array $z_L(n)$ for all other values of L is computed using 2.1.3.3.2.6.3.1–10.

Further computational reduction is possible when L > N–1 since then equation 2.1.3.3.2.6.3.1–5 reduces to

$$b'_L(n) = z_L(n) \qquad (2.1.3.3.2.6.3.1\text{–}11)$$

and computation of the energy term, G_L, in equation 2.1.3.3.2.6.3.1–1 simplifies to

$$G_L = E_L + \sum_{n=0}^{N_T-1} z_L^2(n) \qquad (2.1.3.3.2.6.3.1\text{–}12)$$

where

$$E_L = E_{L-1} + z_{L-1}^2(N_T - 1) - z_{L-1}^2(N-1) \qquad (2.1.3.3.2.6.3.1\text{–}13)$$

and

$$E_N = \sum_{n=N_T}^{N-1} z_N^2(n) \qquad (2.1.3.3.2.6.3.1\text{–}14)$$

These equations are used to determine G_L and C_L and the determination of the long term predictor lag, L, is based on maximizing equation 2.1.3.3.2.6.3.1–3. Once the lag is determined, the untruncated impulse response, h(n), is used to compute the weighted long term lag vector, $b'_L(n)$. This is done by computing $b'_L(n)$ as the zero state response of H(z) to $b_L(n)$ where $b_L(n)$ is:

$$b_L(n) = r(n - \lfloor (n+L)/L \rfloor L) \quad 0 \le n \le 39 \qquad (2.1.3.3.2.6.3.1\text{–}15)$$

2.1.3.3.2.6.3.2 Encoding of Lag

The lag, L, for each of the four subframes can take on the value of 20 to 146. This corresponds to 127 possible codes. Seven bits are used to encode each lag. The 128th code is used to indicate that the pitch predictor for that subframe is deactivated. The lag value is converted to the lag code as follows:

$LAG\_x = L - 19$ if predictor not deactivated

$LAG\_x = 0$ if predictor deactivated

where x is the numerals 1 through 4 for the 4 subframes.

(2.1.3.3.2.6.3.2–1)

2.1.3.3.2.6.4 Codebook Excitation

The VSELP coder uses two excitation codebooks each of 2^M code vectors which are constructed from two sets of M basis vectors, where M = 7. Defining $v_{k,m}(n)$ as the m^{th} basis vector of the k^{th} codebook and $u_{k,i}(n)$ as the i^{th} code vector in the k^{th} codebook, then:

$$u_{k,i}(n) = \sum_{m=1}^{M} \theta_{im} v_{k,m}(n) \qquad (2.1.3.3.2.6.4\text{–}1)$$

where k = 1 for the first codebook and k = 2 for the second codebook and where $0 \le i \le 2^M - 1$; $0 \le n \le N-1$.

In other words, each code vector in the codebook is constructed as a linear combination of the M basis vectors. The linear combinations are defined by the θ parameters. θ_{im} is defined as:

$\theta_{im} = +1$ if bit m of codeword i = 1
$\theta_{im} = -1$ if bit m of codeword i = 0

The codebook construction for the VSELP coder can restated as follows. Code vector i is constructed as the sum of the M basis vectors where the sign (plus or minus) of each basis vector is determined by the state of the corresponding bit in codeword i. Note that if we complement all the bits in codeword i, the corresponding code vector is the negative of code vector i. Therefore, for every code vector, its negative is also a code vector in the codebook. These pairs are called complementary code vectors since the corresponding codewords are complements of each other. The basis vectors $(v_{k,m}(n))$ which specify the two VSELP codebooks are given in Table 2.1.3.3.2.6.4–1.

Table 2.1.3.3.2.6.4–1

Format in which the Basis Vector Samples are Given

1	2	3	4
5	6	7	8
.	.	.	.
.	.	.	.
.	.	.	.
33	34	35	36
37	38	39	40

BASIS VECTOR # 1 FROM CODEBOOK # 1

0.3451242149E+00	-0.1908946037E+00	-0.1863791049E+00	-0.2809082866E+00
-0.5949888006E-01	-0.2898133993E+00	-0.2007001042E+00	-0.2624697983E+00
-0.2319182009E+00	-0.1809999943E+00	0.3789095208E-01	-0.2147784978E+00
0.1241798997E+00	-0.1218566000E+00	0.2359705418E-01	0.2713254094E+00
0.1632671058E+00	-0.4970406741E-01	0.1902845949E+00	-0.1335213892E-01
0.9223834425E-01	-0.5935087055E-01	0.2032784373E-01	-0.2071827054E+00
0.2095990814E-01	-0.1549381018E+00	-0.2140610069E+00	-0.2329927981E+00
-0.3249342367E-01	-0.1220064014E+00	0.1809466928E+00	0.6742917746E-01
0.1195665970E+00	0.3998436928E+00	0.2750256956E+00	0.1396846026E+00
-0.2264889032E+00	0.2459658980E+00	-0.1478482038E+00	0.1349629015E+00

BASIS VECTOR # 2 FROM CODEBOOK # 1

-0.1649273038E+00	-0.1280633956E+00	0.2084657997E+00	0.2897260711E-01
-0.1229320988E+00	0.9742700309E-01	0.5553475767E-01	0.3294681013E+00
-0.1346358955E+00	0.1256469041E+00	-0.1168436036E+00	0.6231806241E-02
0.7953327894E-01	0.3193782866E+00	-0.2746013105E+00	-0.1363205444E-01
-0.1766237020E+00	-0.1918185949E+00	-0.1746349931E+00	-0.2069617957E+00
-0.1570205986E+00	-0.2679320872E+00	-0.2100628428E-01	-0.2031996995E+00
-0.2044696063E+00	-0.4844427574E-02	-0.1820494980E+00	-0.7023712248E-01
-0.5200922117E-01	-0.1236483976E+00	0.1006868035E+00	-0.4063146114E+00
0.1314809024E+00	-0.1702741603E-02	0.3849417865E+00	0.3761824071E+00
0.1832554936E+00	0.2255230993E+00	0.3952260017E+00	0.1965305060E+00

BASIS VECTOR # 3 FROM CODEBOOK # 1

0.1222262010E+00	-0.2443725429E-01	0.9521071613E-01	0.2051250041E+00
-0.2647739053E+00	-0.4311279953E-01	-0.2744256854E+00	0.4825744405E-01
-0.1441915929E+00	0.1775548011E+00	0.2227558941E+00	0.4199514985E+00
0.3407743871E+00	0.3164913058E+00	0.1395058036E+00	-0.2050642073E+00
0.6457627565E-01	-0.3537886143E+00	-0.5985410511E-01	-0.2940579951E+00
0.1644386053E+00	-0.9712598473E-01	0.2345167994E+00	-0.1141005009E+00
0.3247086108E+00	-0.7059235126E-01	-0.1467435956E+00	-0.1093520969E+00
0.1290429980E+00	-0.3067413867E+00	0.6985686719E-01	0.3380126059E+00
0.1060701013E+00	0.4212953150E-02	0.2529056966E+00	-0.5316415336E-02
-0.9389756620E-01	-0.1408378035E+00	-0.1945132017E+00	-0.3807552159E-01

BASIS VECTOR # 4 FROM CODEBOOK # 1

-0.2002453059E+00	0.3095070124E+00	0.1193293035E+00	0.2501963079E+00
0.7344523072E-01	0.2895031869E+00	0.4940271005E-01	-0.1672842950E+00
0.1761247963E+00	0.7341763377E-01	-0.1781246960E+00	0.4386122897E-01
-0.4659612477E-01	-0.7253613323E-01	-0.2906739116E+00	-0.6229455397E-01
-0.1309871972E+00	0.7658090442E-01	0.1743921936E+00	0.1855054945E+00
0.3523846865E+00	0.1146479025E+00	0.1589893997E+00	0.2222200036E+00
-0.1127394941E-01	-0.2681927979E+00	-0.3662436008E+00	-0.3717831075E+00
0.2991584130E-01	-0.3533985913E+00	-0.4226866737E-01	0.6729383767E-01
-0.3311626986E-01	0.3588928878E+00	-0.2317036986E+00	0.1110844016E+00
-0.1048915014E+00	0.6802166253E-01	0.3553674743E-01	0.2772972547E-01

BASIS VECTOR # 5 FROM CODEBOOK # 1

-0.6483641267E+00	-0.1471579727E-01	-0.3926123083E+00	-0.3888195008E-01
0.2079516463E-01	0.1957547069E+00	-0.9889058024E-01	0.3825030029E+00
0.8439254016E-01	0.3003462851E+00	0.1768756062E+00	0.2268030941E+00
0.3840109110E+00	-0.1217688024E+00	0.1454651952E+00	-0.5188317969E-01
0.1141197011E+00	-0.2478182875E-01	0.9596040845E-01	0.1432708949E+00
-0.5413892493E-01	0.3947615623E-02	-0.2586893141E+00	-0.2089742571E-01
-0.2101484984E+00	-0.6067659706E-01	-0.2703967504E-01	0.6947388500E-01
0.1313298047E+00	0.6357792765E-01	0.2391532250E-01	0.6551270187E-01
0.5597909912E-01	-0.4799355194E-01	-0.6142149866E-01	-0.3112792969E+00
-0.3918431103E+00	-0.8220961690E-01	0.2932965523E-02	-0.1451980025E+00

BASIS VECTOR # 6 FROM CODEBOOK # 1

0.3414244056E+00	0.2305835932E+00	-0.1154242009E+00	0.4631759599E-01
-0.6643511355E-01	0.8361395448E-01	-0.9363006055E-01	-0.2741353214E-01
0.7112574577E-01	-0.1254739016E+00	0.7751072943E-01	0.1796556264E-01
0.5026462078E+00	0.7896416634E-01	0.4279431999E+00	0.2176973969E+00
0.2289295048E+00	0.4618147761E-01	0.1656796932E+00	-0.5426255241E-01
0.1128297970E+00	-0.3721603751E-01	0.7740236074E-01	-0.2443609983E+00
-0.1894937009E+00	0.1477535069E+00	-0.5043362975E+00	0.2714478597E-01
-0.1350484043E+00	-0.3649033234E-01	-0.1041088998E+00	-0.2749828100E+00
-0.5220643431E-01	-0.3343094885E+00	-0.3461129069E+00	-0.3607497364E-01
0.8886242658E-01	-0.2545958944E-01	0.4283397645E-01	-0.6496996619E-02

BASIS VECTOR # 7 FROM CODEBOOK # 1

-0.9914957881E+00	-0.4214186221E-01	-0.2065369934E+00	-0.6139709428E-01
-0.2154099382E-01	0.1004114971E+00	0.1811787933E+00	0.5004148930E-01
0.2562974095E+00	-0.1523203999E+00	-0.2674589306E-01	-0.1296720058E+00
0.4938440397E-01	0.1061969027E+00	0.1991406977E+00	0.2695614994E+00
-0.2002000436E-01	0.2905817032E+00	-0.3127651755E-02	0.1016449034E+00
0.1299401969E+00	0.2303000987E+00	0.2902364135E+00	0.1896886975E+00
0.3253236115E+00	0.2585191838E-01	-0.2631102223E-02	-0.7936273515E-01
-0.9870006144E-01	-0.1658474952E+00	-0.1042916998E+00	-0.1593011022E+00
0.7002063841E-01	0.9161889553E-02	0.5557846278E-02	-0.2852319553E-01
0.4387573805E-02	-0.7425554097E-01	-0.1108988002E+00	-0.1056471020E+00

BASIS VECTOR # 1 FROM CODEBOOK # 2

-0.1078469992E+01	0.3220184147E+00	0.3572095037E+00	0.6032103896E+00
0.3291260004E+00	-0.2068174034E+00	-0.7850720733E-01	0.7766201347E-01
-0.5539268255E+00	-0.4499691129E+00	-0.2874793112E+00	0.1191606000E+00
-0.1273895055E+00	0.2862497866E+00	0.2214280069E+00	0.2592194974E+00
-0.1962423027E+00	-0.5959221721E-01	0.1745598018E+00	-0.8334506303E-02
-0.1402842999E+00	-0.2419897020E+00	0.9168544412E-01	-0.2495622039E+00
-0.2419583052E+00	0.1644829959E+00	-0.2559731901E+00	0.5646622181E+00
-0.2104290761E-01	0.9073065221E-01	-0.3278034925E+00	0.2478367984E+00
0.2951978147E+00	0.2485664934E+00	-0.1241953000E+00	-0.5802686140E-01
-0.3626115024E+00	-0.3764331713E-01	-0.8315514028E-01	-0.1295665950E+00

BASIS VECTOR # 2 FROM CODEBOOK # 2

-0.6171314716E+00	0.1042459980E+00	0.1904276013E+00	-0.2003915012E+00
0.2364176959E+00	-0.3931302130E+00	-0.7451597601E-01	-0.1113720983E+00
-0.3296768069E+00	0.5505855009E-01	-0.2221453041E+00	0.6063252091E+00
0.1949710995E+00	-0.9999454767E-01	-0.2479213029E+00	-0.1112871021E+00
0.7108733803E-01	-0.3127546236E-01	-0.3499733284E-02	0.4116210938E+00
0.6289582253E+00	-0.1262892317E-01	0.3541105092E+00	-0.2191990018E+00
-0.4144948125E+00	0.3219327331E-01	0.1044111997E+00	0.1266452968E+00
0.4700252116E+00	0.2069593072E+00	0.2521953881E+00	0.5423704535E-01
-0.1685699970E+00	-0.5957524776E+00	0.1484079063E+00	0.3758538067E+00
0.3699175119E+00	0.2625274956E+00	-0.2196810991E+00	0.2226922959E+00

BASIS VECTOR # 3 FROM CODEBOOK # 2

-0.7037442923E+00	0.1780209988E+00	0.1386262029E+00	0.1773904264E-01
0.3194114864E+00	-0.8156231046E+00	-0.3730263934E-01	0.1182738021E+00
-0.4221254960E-01	0.1008443981E+00	0.3434633017E+00	-0.3526256084E+00
-0.2351640016E+00	-0.2203640044E+00	-0.3177471692E-02	0.1706431061E+00
0.7822614908E-01	-0.5083335042E+00	-0.2581757903E+00	-0.5118042827E+00
0.2634621859E+00	0.3051618934E+00	0.1222215965E+00	-0.1114903986E+00
-0.3546279967E+00	-0.8888566494E-01	-0.1979334950E+00	-0.4040746093E+00
0.1048382279E-01	0.6411200762E-01	0.2749992907E+00	0.3400909901E+00
-0.2861019596E-01	-0.3443039060E+00	-0.4039180875E+00	-0.3798497021E+00
0.3202857077E+00	-0.2101213932E+00	0.4261999130E+00	0.3337397873E+00

BASIS VECTOR # 4 FROM CODEBOOK # 2

0.7885073125E-01	0.1641726047E+00	0.2769562006E+00	0.3139050007E+00
-0.1808016002E+00	-0.6696839929E+00	0.2347880006E+00	0.4427241981E+00
0.3996557891E+00	0.5498163104E+00	-0.1858830005E+00	-0.2986466885E+00
0.9812835604E-01	-0.4205571115E+00	0.4010680914E+00	0.3347500414E-01
0.2540239990E+00	0.4309037924E+00	0.1113025993E+00	0.2318263054E+00
-0.2789230049E+00	-0.1045858022E-01	0.1381077021E+00	-0.4480378926E+00
0.8657258004E-01	-0.2983936071E+00	0.1923187971E+00	0.2231222987E+00
0.6417953223E-01	-0.1814893037E+00	0.2403858006E+00	0.3521871194E-01
0.2641254067E+00	0.2590672076E+00	-0.1733974181E-01	0.1440864950E+00
0.5846006870E+00	-0.1969480067E+00	-0.2235774994E+00	-0.3034487963E+00

BASIS VECTOR # 5 FROM CODEBOOK # 2

0.4358376190E-01	-0.5805857107E-01	0.4501081109E+00	-0.2082135975E+00
-0.3582383990E+00	-0.2613596022E+00	-0.6745511889E+00	0.5382819176E+00
-0.1477800962E-01	-0.5667730793E-01	0.1898874938E+00	0.3535073102E+00
0.4257721826E-01	-0.2010733038E+00	-0.3887566030E+00	-0.3210910857E+00
0.7393498719E-01	0.4713085890E+00	-0.7108450681E-01	-0.1935663968E+00
0.1660837978E+00	-0.3511838615E-01	0.1417755932E+00	-0.2500975132E+00
-0.1513005942E+00	0.1157625020E+00	0.4493466914E+00	0.2846056968E-01
-0.2096074969E+00	-0.3893598020E+00	-0.2374109030E+00	-0.6184939742E+00
-0.3851557076E+00	0.4619333148E+00	0.9302373976E-01	-0.3500598073E+00
0.1615410298E-01	-0.1559370011E+00	-0.1810939014E+00	-0.1666457951E+00

BASIS VECTOR # 6 FROM CODEBOOK # 2

0.6736537218E+00	0.1836300045E+00	-0.1169203967E+00	-0.2385098040E+00
-0.3071058728E-01	0.3613345921E+00	0.4077064991E+00	0.2359752059E+00
0.4120293260E-01	-0.1880857050E+00	-0.1632833034E+00	-0.6836611032E-01
-0.4735979810E-01	-0.3098683432E-01	0.1077236980E+00	0.2860186100E+00
-0.3181805015E+00	0.2275553942E+00	-0.5157095194E+00	0.1487997267E-01
0.1960210055E+00	0.5612939000E+00	-0.2136532962E+00	-0.1722970009E+00
-0.3482623994E+00	-0.2468501031E+00	-0.2466483414E-01	-0.2039584070E+00
0.5595381260E+00	-0.1073065028E+00	-0.3460974619E-01	0.5144857243E-01
0.1268441975E+00	-0.2642670870E+00	0.6754587889E+00	0.1380926967E+00
-0.4250771999E+00	-0.6028810143E+00	-0.1822202951E+00	-0.2909131944E+00

BASIS VECTOR # 7 FROM CODEBOOK # 2

-0.6942132115E+00	0.1113955006E+00	0.6013740897E+00	0.1951819062E+00
0.5133929253E+00	0.1132920980E+00	0.1437312961E+00	-0.2392677963E+00
-0.4471820891E+00	0.3258281052E+00	0.4280638099E+00	0.1897481978E+00
-0.1792849004E+00	-0.2804139853E+00	-0.4632335901E-01	0.5034636855E+00
0.1647147983E+00	0.1746135056E+00	0.2235112935E+00	-0.4559667110E+00
0.3063598871E+00	-0.4095937014E+00	-0.2687213123E+00	-0.3071638942E+00
0.2464583963E+00	0.1107138991E+00	0.5172047019E-01	-0.1779457927E+00
-0.4489682913E+00	0.4342001975E+00	-0.3757492900E+00	0.7282961905E-01
-0.4642477930E+00	0.8351081610E-01	0.2392690927E+00	0.3020069003E+00
0.1004394703E-01	-0.3548842967E+00	-0.2936468124E+00	-0.9987259656E-01

The excitation codebook search procedure takes place after the long term predictor lag, L, has been determined. The codebook search procedure sequentially chooses one code vector from the first VSELP codebook and then chooses one code vector from the second VSELP codebook. Define:

I = code word selected from first VSELP codebook

H = codeword selected from the second VSELP codebook

2.1.3.3.2.6.4.1 Filtering of Basis Vectors

To perform the codebook searches, the zero state response of each basis vector to H(z) must be computed for both codebooks. Define $q_{k,m}(n)$ to be the zero state response of H(z) to basis vector $v_{k,m}(n)$; $0 \le n \le N-1$. From the definition of the VSELP codebook (2.1.3.3.2.6.4-1), the zero state response of each code vector $f_{k,i}(n)$, can be expressed as:

$$f_{k,i}(n) = \sum_{m=1}^{M} \theta_{im} \, q_{k,m}(n) \qquad (2.1.3.3.2.6.4.1\text{-}1)$$

2.1.3.3.2.6.4.2 Orthogonalization of Filtered Basis Vectors

The selection of the code vector from the first codebook must account for the previous selection of the long term predictor lag, L. The selection of the code vector from the second codebook must account for the selection of both the long term predictor lag, L, and the codeword selected from the first codebook, I. One technique which may be employed uses orthogonalization procedures to decouple the selection process for the codebook excitation vectors from previously determined excitation components.

2.1.3.3.2.6.4.2.1 Orthogonalization for Codebook 1

Prior to the first codebook search each filtered basis vector for the first codebook, $q_{1,m}(n)$, may be made orthogonal to $b'_L(n)$, the zero state response of H(z) to the long term prediction vector $b_L(n)$.

Defining:

$$\Gamma = \sum_{n=0}^{N-1} \left(b'_L(n)\right)^2 \qquad (2.1.3.3.2.6.4.2.1\text{–}1)$$

and

$$\Psi_m = \sum_{n=0}^{N-1} b'_L(n)\, q_{1,m}(n) \qquad (2.1.3.3.2.6.4.2.1\text{–}2)$$

for $1 \le m \le M$; then $q'_{1,m}(n)$, the orthogonalized filtered basis vectors, can be computed by:

$$q'_{1,m}(n) = q_{1,m}(n) - \left(\frac{\Psi_m}{\Gamma}\right) b'_L(n) \qquad (2.1.3.3.2.6.4.2.1\text{–}3)$$

for $1 \le m \le M$ and $0 \le n \le N-1$.

The orthogonalized filtered code vectors can now be expressed as:

$$f'_{1,i}(n) = \sum_{m=1}^{M} \theta_{im}\, q'_{1,m}(n) \qquad (2.1.3.3.2.6.4.2.1\text{–}4)$$

for $0 \le i \le 2^M-1$ and $0 \le n \le N-1$.

Using the orthogonalized filtered codebook vectors, $f'_{1,i}(n)$, the expression to be minimized is:

$$E'_{1,i} = \sum_{n=0}^{N-1} \left(p(n) - \gamma'_1 f'_{1,i}(n)\right)^2 \qquad (2.1.3.3.2.6.4.2.1\text{–}5)$$

where γ'_1 is optimized for each code vector i.

2.1.3.3.2.6.4.2.2 Orthogonalization for Codebook 2

The filtered basis vectors for the second codebook may be orthogonalized to both $b'_L(n)$ and $f_{1,I}(n)$. This can be done by first orthogonalizing the $q_{2,m}(n)$ vectors with respect to $b'_L(n)$ in the same manner as for the first codebook. The resulting vectors are then orthogonalized with respect to $f'_{1,I}(n)$ using a similar procedure. Since $f'_{1,I}(n)$ is orthogonal to $b'_L(n)$, the resulting vectors, $q'_{2,m}(n)$, will be orthogonal to both $b'_L(n)$ and $f_{1,I}(n)$ (this is an implementation of Gram-Schmidt orthogonalization).

The orthogonalized filtered code vectors for the second codebook can now be expressed as:

$$f'_{2,i}(n) = \sum_{m=1}^{M} \theta_{im}\, q'_{2,m}(n) \qquad (2.1.3.3.2.6.4.2.2\text{–}1)$$

for $0 \le i \le 2^M-1$ and $0 \le n \le N-1$.

Using the decorrelated filtered codebook vectors, $f'_{2,i}(n)$, the expression to be minimized for the second codebook search is:

$$E'_{2,i} = \sum_{n=0}^{N-1} (p(n) - \gamma'_2\, f'_{2,i}(n))^2 \qquad (2.1.3.3.2.6.4.2.2\text{–}2)$$

2.1.3.3.2.6.4.3 VSELP Codebook Search

The codebook search procedure should find the codeword i which minimizes:

$$E'_{k,i} = \sum_{n=0}^{N-1} (p(n) - \gamma'_k\, f'_{k,i}(n))^2 \qquad (2.1.3.3.2.6.4.3\text{–}1)$$

where k =1 for the first codebook and k =2 for the second codebook and where γ'_k is optimal for each code vector i. In the rest of this section the subscript k indicating the first or second codebook will be dropped. Once we have the filtered and orthogonalized basis vectors, the actual codebook search procedures are identical.

Defining :

$$C_i = \sum_{n=0}^{N-1} f'_i(n)\, p(n) \qquad (2.1.3.3.2.6.4.3\text{–}2)$$

and

$$G_i = \sum_{n=0}^{N-1} (f'_i(n))^2 \qquad (2.1.3.3.2.6.4.3\text{–}3)$$

then the code vector shall be chosen as the one which maximizes :

$$\frac{(C_i)^2}{G_i} \qquad (2.1.3.3.2.6.4.3\text{–}4)$$

The search process should evaluate (2.1.3.3.2.6.4.3–4) for each code vector. The code vector which maximizes (2.1.3.3.2.6.4.3–4) is then chosen. Using properties of the VSELP codebook construction, the computations required for computing C_i and G_i can be greatly simplified.

defining:

$$R_m = 2\sum_{n=0}^{N-1} q'_m(n)\, p(n) \qquad (2.1.3.3.2.6.4.3\text{–}5)$$

for $1 \le m \le M$ and

$$D_{mj} = 4\sum_{n=0}^{N-1} q'_m(n)\, q'_j(n) \qquad (2.1.3.3.2.6.4.3\text{–}6)$$

for $1 \le m \le j \le M$

C_i can be expressed as:

$$C_i = \frac{1}{2}\sum_{m=1}^{M} \theta_{im} R_m \qquad (2.1.3.3.2.6.4.3\text{–}7)$$

and G_i can be expressed as:

$$G_i = \frac{1}{2}\sum_{j=2}^{M}\sum_{m=1}^{j-1} \theta_{im}\,\theta_{ij}\,D_{mj} + \frac{1}{4}\sum_{j=1}^{M} D_{jj} \qquad (2.1.3.3.2.6.4.3\text{–}8)$$

Assuming that codeword u differs from codeword i in only one bit position, say position v such that $\theta_{uv} = -\theta_{iv}$ and $\theta_{um} = \theta_{im}$ for $m \ne v$ then:

$$C_u = C_i + \theta_{uv} R_v \qquad (2.1.3.3.2.6.4.3\text{–}9)$$

and

$$G_u = G_i + \sum_{j=1}^{v-1} \theta_{uj}\,\theta_{uv}\,D_{jv} + \sum_{j=v+1}^{M} \theta_{uj}\,\theta_{uv}\,D_{vj} \qquad (2.1.3.3.2.6.4.3\text{–}10)$$

If the codebook search is structured such that each successive codeword evaluated differs from the previous codeword in only one bit position, then (2.1.3.3.2.6.4.3–9) and (2.1.3.3.2.6.4.3–10) can be used to update C_i and G_i in a very efficient manner. Sequencing of the codewords in this manner is accomplished using a binary Gray code.

Note that complementary codewords (see 2.1.3.3.2.6.4) will have equivalent values for (2.1.3.3.2.6.4.3–4). Therefore only half of the code vectors need to be evaluated. Once the code vector which maximizes (2.1.3.3.2.6.4.3–4) is found, the sign of C_i for that code vector will determine whether that code vector or its complement will yield a positive gain. If C_i is positive than i is the selected codeword, if C_i is negative the ones complement of i is selected as the codeword.

2.1.3.3.2.6.4.4 Encoding of Excitation Codewords

The code value for the first codebook, CODE1_x, is the codeword I as derived by the codebook search procedure in section 4. The least significant bit corresponds to the first basis vector for the codebook.

The code value for the second codebook, CODE2_x, is the codeword H as derived by the codebook search procedure in section 4. The least significant bit corresponds to the first basis vector for the codebook.

2.1.3.3.2.6.5 Quantization of Gains

The weighted error per sample in a subframe is given by

$$e(n) = p(n) - \beta\, c'_0(n) - \gamma_1\, c'_1(n) - \gamma_2\, c'_2(n) \quad 0 \le n \le N-1 \qquad (2.1.3.3.2.6.5\text{–}1)$$

where

$p(n)$	is the weighted input to be matched, minus zero input response of $H(z)$
$c'_0(n)$	is the weighted long term prediction vector – $b'_L(n)$
$c'_1(n)$	is the weighted code vector selected from codebook 1– $f_{1,I}(n)$
$c'_2(n)$	is the weighted code vector selected from codebook 2– $f_{2,H}(n)$
β	is the long term predictor coefficient
γ_1	is the gain scaling the code vector from codebook 1
γ_2	s the gain scaling the code vector from codebook 2

Consequently the total weighted error squared for a subframe is given by

$$E = \sum_{n=0}^{N-1} e^2(n) = \sum_{n=0}^{N-1} (p(n) - \beta\, c'_0(n) - \gamma_1 c'_1(n) - \gamma_2 c'_2(n))^2 \qquad (2.1.3.3.2.6.5\text{–}2)$$

To simplify the error equation , E may be expressed in terms of correlations among vectors $p(n)$, $c'_0(n)$, $c'_1(n)$, and $c'_2(n)$.

Let

$$R_{pp} = \sum_{n=0}^{N-1} p(n)p(n) \qquad (2.1.3.3.2.6.5\text{–}3)$$

$$R_{pc}(k) = \sum_{n=0}^{N-1} p(n)c'_k(n) \quad k = 0, 2 \qquad (2.1.3.3.2.6.5\text{–}4)$$

$$R_{cc}(k,j) = \sum_{n=0}^{N-1} c'_k(n)\, c'_j(n) \quad k = 0, 2; \quad j = k, 2 \qquad (2.1.3.3.2.6.5\text{–}5)$$

$$R_{cc}(k,j) = R_{cc}(j,k) \qquad (2.1.3.3.2.6.5\text{–}6)$$

Incorporating the correlations into the error expression yields

$$E = R_{pp} - 2\,\beta R_{pc}(0) - 2\sum_{j=1}^{2} \gamma_j R_{pc}(j) + 2\beta \sum_{j=1}^{2} \gamma_j R_{cc}(0,j) + 2\gamma_1\gamma_2 R_{cc}(1,2) + \beta^2 R_{cc}(0,0) + \sum_{j=1}^{2} \gamma_j^2 R_{cc}(j,j) \qquad (2.1.3.3.2.6.5\text{–}7)$$

Minimizing the weighted error consists of jointly optimizing β, the long term predictor coefficient, with γ_1 and γ_2, the gain terms to minimize 2.1.3.3.2.6.5–7.

2.1.3.3.2.6.5.1 Transformation of Gains to GS, P0 and P1

Define ex(n) to be the excitation function at a given subframe. ex(n) is a linear combination of the long term predictor vector scaled by β, the long term predictor coefficient, and of the code vectors scaled by γ_1 and γ_2, their respective gains.

$$ex(n) = \beta\, c_0(n) + \gamma_1\, c_1(n) + \gamma_2\, c_2(n) \quad 0 \le n \le N\text{-}1 \qquad (2.1.3.3.2.6.5.1\text{–}1)$$

where $c_0(n)$ is the unweighted long term prediction vector, $b_L(n)$
$c_1(n)$ is the unweighted code vector selected from codebook 1, $u_{1,I}(n)$
$c_2(n)$ is the unweighted code vector selected from codebook 2, $u_{2,H}(n)$

The energy in each excitation vector is given by

$$R_x(k) = \sum_{n=0}^{N-1} c_k^2(n) \qquad k = 0, 2 \qquad (2.1.3.3.2.6.5.1\text{–}2)$$

Let RS be the approximate residual energy at a given subframe. RS is a function of N, R'q(0), and of the normalized prediction gain of the LPC filter.

$$RS = N\, R'_q(0) \prod_{i=1}^{N_p} (1 - r_i^2) \qquad (2.1.3.3.2.6.5.1\text{–}3)$$

where r_i is the i^{th} reflection coefficient for the subframe corresponding to the set of direct form filter coefficients (α_i's) for the subframe.

GS, the energy offset parameter, is a coded parameter which adjusts the estimated value of RS. Define:

$$R = GS\, RS \qquad (2.1.3.3.2.6.5.1\text{–}4)$$

Define P0, the energy contribution of the long term prediction vector as a fraction of the total excitation energy at a subframe, as

$$P0 = \frac{\beta^2 R_x(0)}{R} \qquad \text{where } 0 \le P0 \le 1 \qquad (2.1.3.3.2.6.5.1\text{–}5)$$

Similarly, P1, the energy contribution of the code vector selected from the first codebook as a fraction of the total excitation energy at a subframe, is defined as:

$$P1 = \frac{\gamma_1^2 R_x(1)}{R} \qquad \text{where } P0 + P1 \le 1 \qquad (2.1.3.3.2.6.5.1\text{–}6)$$

Thus β, γ_1, and γ_2 are replaced by three new parameters: P0, P1, and GS. The transformations relating β, γ_1, and γ_2 to GS, P0, and P1 are given by

$$\beta = \sqrt{\frac{RS\; GS\; P0}{R_x(0)}} \qquad (2.1.3.3.2.6.5.1\text{–}7)$$

$$\gamma_1 = \sqrt{\frac{RS\ GS\ P1}{R_x(1)}} \qquad (2.1.3.3.2.6.5.1\text{–}8)$$

$$\gamma_2 = \sqrt{\frac{RS\ GS\ (1\text{-}P0\text{-}P1)}{R_x(2)}} \qquad (2.1.3.3.2.6.5.1\text{–}9)$$

2.1.3.3.2.6.5.2 Vector Quantization and Encoding of GS, P0 and P1

Replacing the β, γ_1, and γ_2 in (2.1.3.3.2.6.5–7) by the equivalent expressions in terms of GS, P0, P1, and $R_x(k)$ results in the updated weighted error equation

$$\begin{aligned} E = R_{pp} &- a\sqrt{GS\ P0} - b\sqrt{GS\ P1} - c\sqrt{GS\ (1\text{-}P0\text{-}P1)} + d\ GS\sqrt{P0\ P1} \\ &+ e\ GS\sqrt{P0\ (1\text{-}P0\text{-}P1)} + f\ GS\sqrt{P1\ (1\text{-}P0\text{-}P1)} \\ &+ g\ GS\ P0 + h\ GS\ P1 + i\ GS\ (1\text{-}P0\text{-}P1) \end{aligned} \qquad (2.1.3.3.2.6.5.2\text{–}1)$$

where

$$a = 2R_{pc}(0)\sqrt{\frac{RS}{R_x(0)}} \qquad (2.1.3.3.2.6.5.2\text{–}2)$$

$$b = 2R_{pc}(1)\sqrt{\frac{RS}{R_x(1)}} \qquad (2.1.3.3.2.6.5.2\text{–}3)$$

$$c = 2R_{pc}(2)\sqrt{\frac{RS}{R_x(2)}} \qquad (2.1.3.3.2.6.5.2\text{–}4)$$

$$d = \frac{2R_{cc}(0,1)\ RS}{\sqrt{R_x(0)R_x(1)}} \qquad (2.1.3.3.2.6.5.2\text{–}5)$$

$$e = \frac{2R_{cc}(0,2)\ RS}{\sqrt{R_x(0)R_x(2)}} \qquad (2.1.3.3.2.6.5.2\text{–}6)$$

$$f = \frac{2R_{cc}(1,2)\ RS}{\sqrt{R_x(1)R_x(2)}} \qquad (2.1.3.3.2.6.5.2\text{–}7)$$

$$g = \frac{R_{cc}(0,0)\ RS}{R_x(0)} \qquad (2.1.3.3.2.6.5.2\text{–}8)$$

$$h = \frac{R_{cc}(1,1)\,RS}{R_x(1)} \qquad (2.1.3.3.2.6.5.2\text{–}9)$$

$$i = \frac{R_{cc}(2,2)\,RS}{R_x(2)} \qquad (2.1.3.3.2.6.5.2\text{–}10)$$

GS, P0 and P1 are vector quantized. The first step in quantizing vector (GS, P0, P1) consists of calculating the parameters required by the error equation:

$R_{cc}(k,j)$ $k = 0, 2;\ j = k, 2$
$R_x(0), R_x(1), R_x(2)$
RS
$R_{pc}(k)$ $k = 0, 2$
a, b, c, d, e, f, g, h, i

Next (2.1.3.3.2.6.5.2–1) is evaluated for each vector in the (GS, P0, P1)codebook, and the vector which minimizes the weighted error is selected. The (GS, P0, P1) codebook is given in Table 2.1.3.3.2.6.5.2–1.

Table 2.1.3.3.2.6.5.2-1

INDEX #	GS	P0	P1
0	0.1674511004E-02	0.1628413945E+00	0.5090150237E+00
1	0.1334269880E-02	0.5378435850E+00	0.2362515032E+00
2	0.3112269565E-02	0.1365114003E+00	0.7425394058E+00
3	0.3868540749E-02	0.3757469952E+00	0.5166236758E+00
4	0.3916129004E-02	0.3697459996E+00	0.1677096933E+00
5	0.2203964163E-02	0.6928331256E+00	0.2034170032E+00
6	0.6334181409E-02	0.5041198730E+00	0.2782799006E+00
7	0.6364202593E-02	0.7150015831E+00	0.9318676591E-01
8	0.6032689475E-02	0.1773163974E+00	0.4278650880E+00
9	0.8498853073E-02	0.2549907863E+00	0.1608013064E+00
10	0.1103511825E-01	0.2339199036E+00	0.4263555110E+00
11	0.1213169005E-01	0.4288598895E+00	0.1452523023E+00
12	0.1125547010E-01	0.5531352162E+00	0.2692165077E+00
13	0.1499444060E-01	0.6825100780E+00	0.1179910004E+00
14	0.1991050877E-01	0.5739204288E+00	0.2914825976E+00
15	0.2668176405E-01	0.7299969792E+00	0.1241495013E+00
16	0.1216377132E-01	0.2081580013E+00	0.6651288867E+00
17	0.1665616408E-01	0.2399802953E+00	0.5246518254E+00
18	0.2211280540E-01	0.5327664316E-01	0.5560309887E+00
19	0.4146175086E-01	0.4332519695E-01	0.3001616001E+00
20	0.1824236475E-01	0.4052976966E+00	0.2251251936E+00
21	0.2846666984E-01	0.2728624940E+00	0.7517775893E-01
22	0.4009734094E-01	0.2904489934E+00	0.1128304973E+00
23	0.3304062411E-01	0.5624005198E+00	0.1144611016E+00
24	0.3026418947E-01	0.4282687008E+00	0.2743416131E+00
25	0.4202774912E-01	0.4557394087E+00	0.2395865023E+00
26	0.3683714196E-01	0.6080287099E+00	0.2409482002E+00
27	0.4296181723E-01	0.7553868294E+00	0.1563764066E+00
28	0.5061166734E-01	0.5004783869E+00	0.1042283028E+00
29	0.6330294907E-01	0.6044433713E+00	0.9549445659E-01
30	0.5410422012E-01	0.8002007008E+00	0.5705973133E-01
31	0.7002255321E-01	0.8490940928E+00	0.8035162836E-01
32	0.2551996335E-01	0.2582708895E+00	0.5111098289E+00
33	0.3739386052E-01	0.1589131057E+00	0.5667265058E+00
34	0.3554347903E-01	0.1742120981E+00	0.3600822091E+00
35	0.4851049930E-01	0.2376495004E+00	0.3000344038E+00
36	0.6062155217E-01	0.5450420082E-01	0.4720115960E+00
37	0.1110351011E+00	0.4298216850E-01	0.2424717993E+00
38	0.7409280539E-01	0.2410012931E+00	0.3175866902E+00
39	0.1102432981E+00	0.2211526036E+00	0.1535796970E+00
40	0.4073541611E-01	0.3339963853E+00	0.5350126028E+00
41	0.5102888495E-01	0.3695037961E+00	0.3936882913E+00

42	0.5682564899E-01	0.3825046122E+00	0.2120109946E+00
43	0.7335599512E-01	0.4522989094E+00	0.2309546024E+00
44	0.5556463450E-01	0.5706608891E+00	0.2843337059E+00
45	0.6869171560E-01	0.6323106885E+00	0.2636449933E+00
46	0.8424820751E-01	0.6379644871E+00	0.1834726036E+00
47	0.9327419102E-01	0.7574281096E+00	0.1561726928E+00
48	0.8650545031E-01	0.4290732145E+00	0.1055454984E+00
49	0.9788852930E-01	0.4905169904E+00	0.1626531035E+00
50	0.1121798009E+00	0.5697429776E+00	0.6549628824E-01
51	0.1267466992E+00	0.6473875046E+00	0.7873713970E-01
52	0.9539756179E-01	0.5148016214E+00	0.2657338977E+00
53	0.1166627035E+00	0.5716524720E+00	0.2173192054E+00
54	0.1064478979E+00	0.6332104802E+00	0.2814091146E+00
55	0.1370353997E+00	0.7724838853E+00	0.1699541062E+00
56	0.7964644581E-01	0.6711853147E+00	0.9912785143E-01
57	0.9281945974E-01	0.7759063840E+00	0.6934114546E-01
58	0.1014161035E+00	0.8620666265E+00	0.3112772666E-01
59	0.1022674963E+00	0.9087637067E+00	0.5598694459E-01
60	0.1174440011E+00	0.7431836128E+00	0.1049233973E+00
61	0.1427710056E+00	0.7971041203E+00	0.9140700102E-01
62	0.1335725933E+00	0.8768588901E+00	0.4184054211E-01
63	0.1557984948E+00	0.9022567868E+00	0.6620954722E-01
64	0.6495805830E-01	0.6296302378E-01	0.7413570881E+00
65	0.9106755257E-01	0.8545581996E-01	0.6011378765E+00
66	0.7078369707E-01	0.3166824877E+00	0.5017414093E+00
67	0.8891370893E-01	0.3859643042E+00	0.3850632012E+00
68	0.1122341007E+00	0.1393730044E+00	0.6837037206E+00
69	0.1487948000E+00	0.1515955031E+00	0.6527392864E+00
70	0.1860724986E+00	0.2641281486E-01	0.5289260149E+00
71	0.3097940087E+00	0.4747741669E-01	0.3588519990E+00
72	0.1144608036E+00	0.1517399997E+00	0.4133580029E+00
73	0.1507880986E+00	0.1906109005E+00	0.3410502076E+00
74	0.1706172973E+00	0.2265263945E+00	0.1259271950E+00
75	0.2289942056E+00	0.3038589060E+00	0.5896532163E-01
76	0.1143215969E+00	0.3475125134E+00	0.4705806077E+00
77	0.1365052015E+00	0.3987742960E+00	0.3133349121E+00
78	0.1365693957E+00	0.5241140723E+00	0.3406164050E+00
79	0.1702775955E+00	0.5960590243E+00	0.2761180103E+00
80	0.1696981043E+00	0.2615928054E+00	0.4811651111E+00
81	0.1853505969E+00	0.3369044960E+00	0.3201222122E+00
82	0.2397855967E+00	0.2163629979E+00	0.3759418130E+00
83	0.2480811030E+00	0.3784976900E+00	0.3057712913E+00
84	0.2192613930E+00	0.2088246047E+00	0.2205650955E+00
85	0.2986275852E+00	0.2121827006E+00	0.1468642056E+00

86	0.3383885026E+00	0.2949447036E+00	0.1601980031E+00
87	0.3737956882E+00	0.4145816863E+00	0.1163380966E+00
88	0.1759153008E+00	0.4035001099E+00	0.4613820016E+00
89	0.2228980958E+00	0.4619579017E+00	0.3872157931E+00
90	0.2172852010E+00	0.6011435986E+00	0.2250604033E+00
91	0.2496989071E+00	0.6760768294E+00	0.2467515022E+00
92	0.2739233971E+00	0.4865092933E+00	0.3028185964E+00
93	0.3398965895E+00	0.5414069891E+00	0.2644341886E+00
94	0.3390182853E+00	0.5252041817E+00	0.3680981100E+00
95	0.4163025916E+00	0.6538612843E+00	0.2602193952E+00
96	0.1315259039E+00	0.4091641009E+00	0.1912034005E+00
97	0.1607993990E+00	0.5165988207E+00	0.1835025996E+00
98	0.1879366040E+00	0.4849447012E+00	0.8831258863E-01
99	0.2067928016E+00	0.6063880920E+00	0.1208055019E+00
100	0.1528825015E+00	0.6418548822E+00	0.1632298976E+00
101	0.1782497019E+00	0.7136489749E+00	0.1472460032E+00
102	0.1950799972E+00	0.7978122234E+00	0.1000023037E+00
103	0.2166976035E+00	0.8509386778E+00	0.1027066037E+00
104	0.1565562040E+00	0.6794986725E+00	0.5061172321E-01
105	0.1849167049E+00	0.7903293967E+00	0.2766529471E-01
106	0.1756449044E+00	0.8734303117E+00	0.4561759904E-01
107	0.1827957928E+00	0.9436277747E+00	0.1549258269E-01
108	0.2184236050E+00	0.8266959786E+00	0.3775115311E-01
109	0.2439989001E+00	0.8668105006E+00	0.4946492240E-01
110	0.2295816988E+00	0.9242373705E+00	0.2596106380E-01
111	0.2636404037E+00	0.9466627836E+00	0.3032221086E-01
112	0.2556335926E+00	0.5659329891E+00	0.3311180696E-01
113	0.2362577021E+00	0.7178587914E+00	0.5643908307E-01
114	0.3040370047E+00	0.6967657208E+00	0.4607859254E-01
115	0.3047299087E+00	0.7958889008E+00	0.6132747978E-01
116	0.2486615032E+00	0.7239356041E+00	0.1274670959E+00
117	0.2704665959E+00	0.8301647902E+00	0.1037508994E+00
118	0.3247472048E+00	0.8424968719E+00	0.7406390458E-01
119	0.3339362144E+00	0.8971030712E+00	0.7224391401E-01
120	0.2825644910E+00	0.8350514174E+00	0.1852613129E-01
121	0.3211824000E+00	0.8924705982E+00	0.1794643141E-01
122	0.3117949069E+00	0.9256172776E+00	0.3072093800E-01
123	0.3341934979E+00	0.9692093730E+00	0.1217324380E-01
124	0.3961125910E+00	0.8843719959E+00	0.1469997689E-01
125	0.3869144917E+00	0.9570943117E+00	0.1347938739E-01
126	0.4470236897E+00	0.9570295811E+00	0.9546336718E-02
127	0.4775207937E+00	0.9821900129E+00	0.6872606464E-02
128	0.2058212012E+00	0.6196407974E-01	0.7798926234E+00
129	0.2518475056E+00	0.1279000044E+00	0.5915088058E+00

130	0.2544569075E+00	0.3105351925E+00	0.5829390883E+00
131	0.3156026006E+00	0.3249501884E+00	0.4639602900E+00
132	0.3772808015E+00	0.4402553663E-01	0.6654961705E+00
133	0.4207046032E+00	0.8673334122E-01	0.4119533002E+00
134	0.5295364857E+00	0.1508532017E+00	0.3733662069E+00
135	0.8137475252E+00	0.1406006068E+00	0.2279590964E+00
136	0.3151867092E+00	0.2598291039E+00	0.3530336022E+00
137	0.3418394029E+00	0.3817451894E+00	0.2589038014E+00
138	0.4035350084E+00	0.3584713042E+00	0.3537184894E+00
139	0.5077272058E+00	0.3992733955E+00	0.2898977101E+00
140	0.4722937942E+00	0.2965064943E+00	0.2139941007E+00
141	0.5662766099E+00	0.4028589129E+00	0.1497109979E+00
142	0.6893994808E+00	0.3969871104E+00	0.1982202977E+00
143	0.8628751040E+00	0.4853290021E+00	0.1307560951E+00
144	0.4045999944E+00	0.1813627034E+00	0.6773204803E+00
145	0.4689007103E+00	0.2662957013E+00	0.4910367131E+00
146	0.4937984943E+00	0.4234876931E+00	0.4420625865E+00
147	0.6434162855E+00	0.5166773796E+00	0.3720596135E+00
148	0.6337016821E+00	0.1006304994E+00	0.6432744861E+00
149	0.7272452116E+00	0.2273804992E+00	0.4609940946E+00
150	0.6628788114E+00	0.3772400916E+00	0.3294067085E+00
151	0.8595455885E+00	0.4418708980E+00	0.3302043974E+00
152	0.4765160978E+00	0.5293753147E+00	0.2594738901E+00
153	0.5636020899E+00	0.6010723114E+00	0.1951211989E+00
154	0.5510414243E+00	0.6588652730E+00	0.2373663932E+00
155	0.6402565241E+00	0.7532817721E+00	0.1749967039E+00
156	0.7472360134E+00	0.5478879809E+00	0.2225959003E+00
157	0.8277941942E+00	0.6562498212E+00	0.2030532956E+00
158	0.1119096041E+01	0.6475703120E+00	0.2262544930E+00
159	0.1122905016E+01	0.7757607102E+00	0.1542932987E+00
160	0.2242027968E+00	0.4361718893E+00	0.1964779049E+00
161	0.2674177885E+00	0.5595858097E+00	0.1660642028E+00
162	0.3104830980E+00	0.5457221270E+00	0.9627965093E-01
163	0.3328841031E+00	0.6755965948E+00	0.1057367995E+00
164	0.3720475137E+00	0.5095406771E+00	0.1847946048E+00
165	0.4265367091E+00	0.5779184103E+00	0.1757698953E+00
166	0.4357596040E+00	0.6473218799E+00	0.1036375985E+00
167	0.4856935143E+00	0.7093607187E+00	0.1225507036E+00
168	0.3159776032E+00	0.6743202209E+00	0.1763204038E+00
169	0.3529244959E+00	0.7572814226E+00	0.1405256987E+00
170	0.4068664014E+00	0.7727342844E+00	0.1524548978E+00
171	0.4181675911E+00	0.8476157784E+00	0.1214092970E+00
172	0.4287396073E+00	0.7954624295E+00	0.8431659639E-01
173	0.4728245139E+00	0.8548663855E+00	0.7520925999E-01

174	0.5418804288E+00	0.8417572975E+00	0.1007888988E+00
175	0.5576245785E+00	0.9113693237E+00	0.6275516003E-01
176	0.3971770108E+00	0.7196612954E+00	0.4043109342E-01
177	0.3923479021E+00	0.8275126219E+00	0.4315078631E-01
178	0.4840024114E+00	0.7903401852E+00	0.3052827716E-01
179	0.5030732155E+00	0.8705636859E+00	0.3875757754E-01
180	0.3900350034E+00	0.8867447972E+00	0.4544848204E-01
181	0.4045810103E+00	0.9283564091E+00	0.4342215508E-01
182	0.4665615857E+00	0.9232664108E+00	0.3089918755E-01
183	0.4797903001E+00	0.9536154866E+00	0.2980542555E-01
184	0.4771012068E+00	0.8924021721E+00	0.1256007701E-01
185	0.5173798800E+00	0.9331367016E+00	0.1438540779E-01
186	0.5575615764E+00	0.9366083145E+00	0.2553104609E-01
187	0.5714020729E+00	0.9634227157E+00	0.2135989256E-01
188	0.5851451159E+00	0.9320334792E+00	0.8649736643E-02
189	0.5510594845E+00	0.9707422256E+00	0.6941570900E-02
190	0.6335691810E+00	0.9735900760E+00	0.5166618619E-02
191	0.5969625115E+00	0.9864069819E+00	0.7369614672E-02
192	0.4779720008E+00	0.4981344938E+00	0.5844748393E-01
193	0.6348072290E+00	0.5891370773E+00	0.3766107932E-01
194	0.6167864203E+00	0.6059731841E+00	0.1244375035E+00
195	0.8251013160E+00	0.6318687797E+00	0.9435034543E-01
196	0.5646904111E+00	0.7259691954E+00	0.6244398281E-01
197	0.6031528711E+00	0.7809702158E+00	0.8972237259E-01
198	0.5980842113E+00	0.8440924287E+00	0.5054383352E-01
199	0.5895571709E+00	0.8967409134E+00	0.4768311605E-01
200	0.7048380971E+00	0.7237101793E+00	0.1033923998E+00
201	0.8334618211E+00	0.7786496282E+00	0.7027542591E-01
202	0.7637972236E+00	0.7895383239E+00	0.1180671006E+00
203	0.8420091271E+00	0.8581050038E+00	0.9375898540E-01
204	0.7073963284E+00	0.8697832823E+00	0.5842054635E-01
205	0.6991103888E+00	0.9158318043E+00	0.6012412533E-01
206	0.8318998814E+00	0.9036728740E+00	0.4429496452E-01
207	0.8849071264E+00	0.9387481213E+00	0.3935790807E-01
208	0.6044886708E+00	0.8107022047E+00	0.2025584877E-01
209	0.6730198264E+00	0.8731182814E+00	0.1431398839E-01
210	0.6342272758E+00	0.9009475112E+00	0.2692351677E-01
211	0.6683933735E+00	0.9305152893E+00	0.3192029893E-01
212	0.6766291261E+00	0.9417983294E+00	0.1271538995E-01
213	0.6850581169E+00	0.9629445076E+00	0.2146667801E-01
214	0.7299829721E+00	0.9634938836E+00	0.6568749901E-02
215	0.7426728010E+00	0.9863529205E+00	0.5142178852E-02
216	0.7833564281E+00	0.8852707744E+00	0.2286950313E-01
217	0.8246064782E+00	0.9266918898E+00	0.1838962547E-01

218	0.7951936722E+00	0.9550110102E+00	0.1876292750E-01
219	0.8614364862E+00	0.9694117904E+00	0.1849077269E-01
220	0.8687235117E+00	0.9521716833E+00	0.6444055587E-02
221	0.9092599750E+00	0.9828807712E+00	0.6192821544E-02
222	0.1090209961E+01	0.9633936286E+00	0.8265390992E-02
223	0.1166924953E+01	0.9859452248E+00	0.6158319302E-02
224	0.1000375986E+01	0.1854172051E+00	0.5423095226E+00
225	0.1570129037E+01	0.2168993950E+00	0.4258900881E+00
226	0.1075256944E+01	0.3578406870E+00	0.2021154016E+00
227	0.1512421966E+01	0.4072645903E+00	0.1910302043E+00
228	0.1027004004E+01	0.4538662136E+00	0.3981646895E+00
229	0.1506876945E+01	0.5409070253E+00	0.3729160130E+00
230	0.1685479045E+01	0.5329133272E+00	0.2578333914E+00
231	0.2448146105E+01	0.6229693294E+00	0.1946762949E+00
232	0.1146139979E+01	0.6132298708E+00	0.1224573031E+00
233	0.1672626972E+01	0.6349121928E+00	0.8354412764E-01
234	0.1636142015E+01	0.7288373113E+00	0.1244362965E+00
235	0.1811290979E+01	0.8061832190E+00	0.1446519941E+00
236	0.2685538054E+01	0.3550836146E+00	0.3155787885E+00
237	0.1071245956E+02	0.4264922142E+00	0.2618879080E+00
238	0.2574728966E+01	0.8001124859E+00	0.7955052704E-01
239	0.4390925884E+01	0.8128105998E+00	0.1211687997E+00
240	0.8725733757E+00	0.7602546811E+00	0.2738693357E-01
241	0.1000702977E+01	0.8445605040E+00	0.2932630666E-01
242	0.1025166988E+01	0.8316953182E+00	0.7419369370E-01
243	0.1113782048E+01	0.8983482718E+00	0.6792701036E-01
244	0.1019778013E+01	0.9057493806E+00	0.1808738336E-01
245	0.9740859270E+00	0.9485203028E+00	0.1788486727E-01
246	0.1141852975E+01	0.9295607805E+00	0.3048870526E-01
247	0.1114433050E+01	0.9626024961E+00	0.2363116853E-01
248	0.1463426948E+01	0.7795253992E+00	0.4330257326E-01
249	0.1333399057E+01	0.8801984191E+00	0.3900365904E-01
250	0.1495571017E+01	0.9150947928E+00	0.3560945764E-01
251	0.1602329969E+01	0.9379981756E+00	0.4199227318E-01
252	0.1346436977E+01	0.9428874254E+00	0.1151810307E-01
253	0.1516757011E+01	0.9776836038E+00	0.8404225111E-02
254	0.1893331051E+01	0.9280338287E+00	0.2603170462E-01
255	0.2636862040E+01	0.9607506990E+00	0.1253264863E-01

Note that in conducting the code search Rpp correlation may be ignored in (2.1.3.3.2.6.5.2–1), since it is a constant, thus eliminating the need to compute it. β_q, the quantized long term predictor coefficient, and γ_{lq}, the quantized gain for the code vector selected from the l-th codebook (l = 1,2), are reconstructed from

$$\beta_q = \sqrt{\frac{RS\ GS_{vq}\ P0_{vq}}{R_x(0)}} \qquad (2.1.3.3.2.6.5.2\text{–}11)$$

$$\gamma 1_q = \sqrt{\frac{RS\ GS_{vq}\ P1_{vq}}{R_x(1)}} \qquad (2.1.3.3.2.6.5.2\text{–}12)$$

$$\gamma 2_q = \sqrt{\frac{RS\ GS_{vq}(1\text{-}P0_{vq}\text{-}P1_{vq})}{R_x(2)}} \qquad (2.1.3.3.2.6.5.2\text{–}13)$$

where GS_{vq}, $P0_{vq}$, and $P1_{vq}$ are the elements of the vector chosen from the (GS, P0, P1) codebook. The index of the corresponding codebook entry selected is then assigned to GSP0_x, where x is the current subframe number (1 to 4).

A special case occurs when the long term predictor is disabled for a certain subframe. This occurs when no positive correlation is found during the lag search, or when the state of the long term predictor is populated entirely by zeroes (e.g., at the first subframe).

When the long term predictor is deactivated, a modified form of (2.1.3.3.2.6.5.2–1) is used:

$$E \equiv R_{pp} - b\sqrt{GS\ P1} - c\sqrt{GS\ (1\text{-}P1\text{-}P0)} + f\ GS\sqrt{P1(1\text{-}P1\text{-}P0)}$$
$$+ h\ GS\ P1 + i\ GS\ (1\text{-}P1\text{-}P0) \qquad (2.1.3.3.2.6.5.2\text{–}14)$$

For this case the quantized code vector gains are:

$$\beta_q = 0 \qquad (2.1.3.3.2.6.5.2\text{–}15)$$

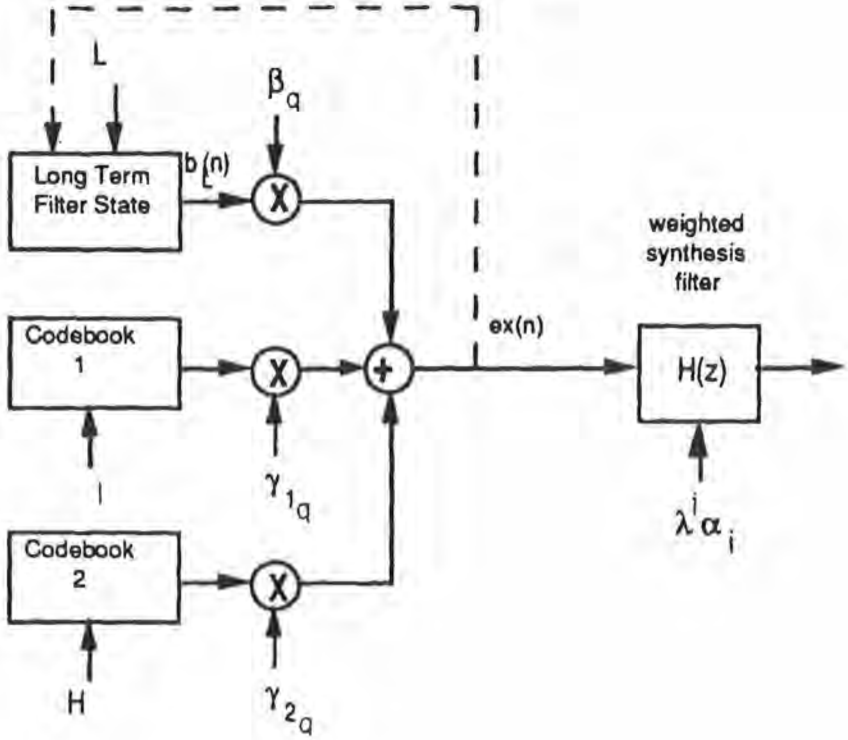
$$\gamma 1_q = \sqrt{\frac{RS\ GS_{vq}\ P1_{vq}}{R_x(1)}} \qquad (2.1.3.3.2.6.5.2\text{–}16)$$

$$\gamma 2_q = \sqrt{\frac{RS\ GS_{vq}\ (1\text{-}P1_{vq}\text{-}P0_{vq})}{R_x(2)}} \qquad (2.1.3.3.2.6.5.2\text{–}17)$$

2.1.3.3.2.6.6 Update Filter States

After all subframe parameters have been determined and quantized, the long term filter state and the weighted synthesis filter state must be updated in preparation for processing the next subframe. Figure 2.1.3.3.2.6.6–1 shows the weighted synthesizer employed in the speech encoder.

Fig. 2.1.3.3.2.6.6–1



The combined excitation, ex(n), shall be computed as:

$$ex(n) = \beta_q b_L(n) + \gamma_{1q} u_{1,I}(n) + \gamma_{2q} u_{2,H}(n) \qquad (2.1.3.3.2.6.6\text{–}1)$$
$$\text{for } 0 \le n \le 39$$

The long term predictor state, r(n), is updated by:

$$r(n) = r(n+40) \quad \text{for } -146 \le n \le -41 \qquad (2.1.3.3.2.6.6\text{–}1a)$$
$$r(n) = ex(n+40) \quad \text{for } -40 \le n \le -1 \qquad (2.1.3.3.2.6.6\text{–}1b)$$

The weighted synthesis filter is updated by inputting the 40 samples of ex(n) into the weighted synthesis filter. The state of the weighted synthesis filter should reflect the filter's state at the end of the previous subframe processing prior to filtering the excitation, ex(n), for the current subframe. A direct form filter should be used for the weighted synthesis filter.

2.1.3.3.3 Channel Coding

The channel error control for the speech coder data employs three mechanisms for the mitigation of channel errors. The first is to use a rate one-half convolutional code to protect the more vulnerable bits of the speech coder data stream. The second technique interleaves the transmitted data for each speech coder frame over two time slots to mitigate the effects of Rayleigh fading. The third technique employs the use of a cyclic redundancy check over some the most perceptually significant bits of the speech coder. After the error correction is applied at the receiver, these cyclic redundancy bits are checked to see if the most perceptually significant bits were received properly.

2.1.3.3.3.1 Definition of Terms, Nomenclature, and Assumptions

a(X)	– the eleventh order input polynomial to the CRC
a'(X)	– the eleventh order CRC input polynomial at the receiver which may include the effects of channel errors.
b(X)	– the sixth order CRC parity polynomial.
b'(X)	– the sixth order CRC parity polynomial received which may include the effects of channel errors.
bit position	– in speech coder parameters the lsb is bit 0, the msb is bit n–1 where there are n bits in the parameter. i.e. the speech parameter R0 has 5 bits, the msb is bit 4, the lsb is bit 0.
bit channel position	– bits are transmitted from low to high. The first bit transmitted is bit 0, the last transmitted bit of the frame is bit 259.
bit position class1	– bit 0 , cl1[0] is the first bit to be encoded, bit 88 , cl1[88] the last.
$cc_0[i]$	– the output of $g_0(D)$ to input bit i, cl1[i].
$cc_1[i]$	– the output of $g_1(D)$ to input bit i, cl1[i].
CL1[i]	– Input bit array to the convolutional encoder where i = 0..88.
CL2[i]	– class 2 bits (unencoded bits) where i ranges from 0 to 81
class 1	– those bits which are convolutionally encoded.
class 2	– those bits which are not convolutionally encoded.
crc[a'(X)]	– the sixth order CRC parity polynomial generated from the received input bits (a'(X))
CRC	– Cyclic Redundancy Checking code.
CRC generator	– the CRC generator polynomial
CRC's	– the CRC parity bits, b(X).
frame X	– the first of the two speech coder frames.
frame Y	– the speech coder frame occurring after frame X.
$g_0(D)$	– the first of the two convolutional code generator polynomials (65 octal) $g_0(D) = 1 + D + D^3 + D^5$.
$g_1(D)$	– the second of the two convolutional code generator polynomials 57 octal, $g_1(D) = 1 + D^2 + D^3 + D^4 + D^5$.
$g_{crc}(X)$	– the CRC generator polynomial. $g_{crc}(X) = 1 + X + X^2 + X^4 + X^5 + X^7$.
interleaving	– ordering of the bits on the channel.
memory order, m	– memory order of the convolutional code, where 2^m = the number of convolutional states. For this system, m = 5.
parameter names	– the subframe information can be deciphered as follows: code2_3 is the second code vector for subframe 3.

q(X) – the CRC quotient

subframe – one of the four subdivisions of a speech frame, each subframe is 5 milliseconds in duration. For each subframe, the speech coder generates 4 parameters: CODE1_X, CODE2_X, LAG_X and GSP0_X where X refers to the subframe number Refer to 2.1.3.3.2.1).

2.1.3.3.3.2 Speech Data Classes

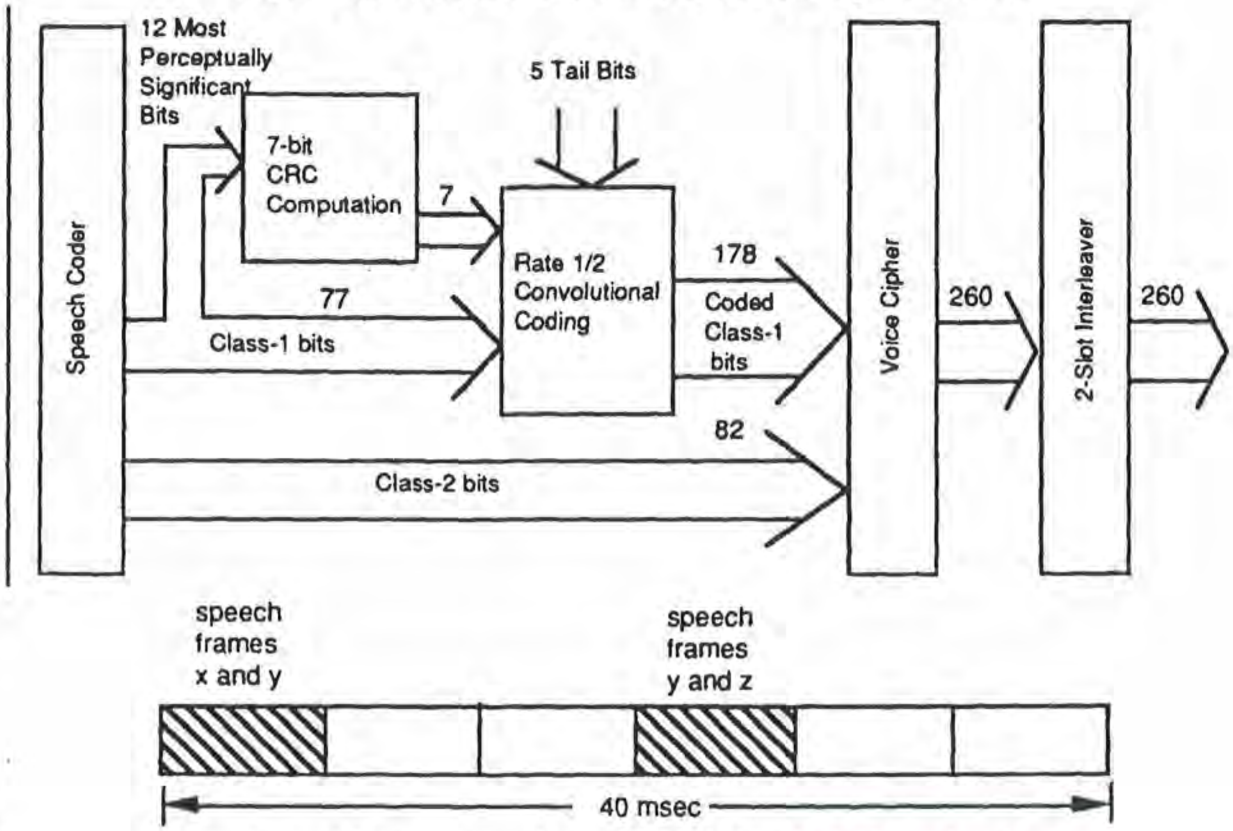
The first step in the error correction process is the separation of the 159 bit speech coder frame's information into class 1 and class 2 bits. There are 77 class 1 bits and 82 class 2 bits in the 159 bit speech coder frame. The class 1 bits represent that portion of the speech data stream to which the convolutional coding is applied. A 7-bit CRC is used for error detection purposes and is computed over the 12 most perceptually significant bits of the class 1 bits for each frame. Class 2 bits are transmitted without any error protection. The process is depicted in figure 2.1.3.3.3.2–1. Table 2.1.3.3.3.2–1 describes the bit allocation among the classes for the parameter bits of the speech coder.

Table 2.1.3.3.3.2–1: Speech Coder Parameter Class Bit Assignments

(Note: The number in the Class 1 and most perceptually significant columns refer to the number of most significant bits of a codeword while the Class 2 column refers to the number of least significant bits of a codeword) See Figure 2.1.3.3.3.2–1.

Parameter	Total Codeword Bits	Class 1 Bits	Class 2 Bits	Most Perceptually Significant Bits
R0	5	4	1	3
LPC1	6	4	2	3
LPC2	5	3	2	2
LPC3	5	3	2	2
LPC4	4	2	2	1
LPC5	4	1	3	1
LPC6	3	0	3	0
LPC7	3	0	3	0
LPC8	3	0	3	0
LPC9	3	0	3	0
LPC10	2	0	2	0
LAG_1	7	7	0	0
CODE1_1	7	0	7	0
CODE2_1	7	0	7	0
GSP0_1	8	8	0	0
LAG_2	7	7	0	0
CODE1_2	7	0	7	0
CODE2_2	7	0	7	0
GSP0_2	8	8	0	0
LAG_3	7	7	0	0
CODE1_3	7	0	7	0
CODE2_3	7	0	7	0
GSP0_3	8	8	0	0
LAG_4	7	7	0	0
CODE1_4	7	0	7	0
CODE2_4	7	0	7	0
GSP0_4	8	8	0	0

Figure 2.1.3.3.3.2-1: Error Correction For Speech Coder



Class 1 bits are convolutionally coded and interleaved with
class 2 bits and transmitted over two time slots.

2.1.3.3.3.3 Cyclic Redundancy Check (CRC)

A 7-bit CRC is computed for the 12 most perceptually significant bits in the frame.

The generator polynomial for the CRC is

$$g_{crc}(X) = 1 + X + X^2 + X^4 + X^5 + X^7 \qquad (2.1.3.3.3.3\text{–}1)$$

The twelve most perceptually significant bits of the frame are identified in Table 2.1.3.3.3.2–1 and they form the input polynomial. This input polynomial is defined as

$$a(X) = CL1[80]X^{11} + CL1[4]X^{10} + CL1[79]X^9 + CL1[5]X^8 + CL1[78]X^7 + CL1[6]X^6 + CL1[77]X^5 + CL1[7]X^4 + CL1[76]X^3 + CL1[8]X^2 + CL1[75]X^1 + CL1[9]X^0 \qquad (2.1.3.3.3.3\text{-}2)$$

The parity polynomial b(X) is the remainder of a the division of the input polynomial and the generator polynomial, i.e. :

$$\frac{a(X) \bullet X^7}{g_{crc}(X)} = q(X) + \frac{b(X)}{g_{crc}(X)} \qquad (2.1.3.3.3.3\text{–}3)$$

Where q(X) is the quotient of the division, b(X) the remainder. The quotient here is discarded and only the parity bits identified in the polynomial b(X) are encoded for transmission. To facilitate the convolutional encoding of these parity bits, they are placed into the array of Class 1 bits, CL[i]. The placement of the parity bits into CL[i] is determined by the following identification for b(X):

$$b(X) = CL1[0]\,X^6 + CL1[83]\,X^5 + CL1[1]\,X^4 + CL1[82]\,X^3 + CL1[2]\,X^2 + CL1[81]\,X^1 + CL1[3]\,X^0 \qquad (2.1.3.3.3.3\text{-}4)$$

2.1.3.3.3.4 Convolutional Encoding

There are 89 bits which are input to the convolutional coder. Of these 89 bits, 77 are class 1 bits from the speech coder which are placed into CL1[4] through CL1[80]. Bits CL1[0] through CL1[3] and CL1[81] through CL1[83] are reserved for the CRC for the frame and bits CL1[84] through CL1[88] are filled with zeros corresponding to the 5 tail bits.

The bits are rearranged in the array CL1[i] as shown in Table 2.1.3.3.3.4–2. The first column indicates the location in the array where a particular bit for a parameter is to be placed starting with CL1[0]. The second column indicates the parameter and the last column indicates the bit of the parameter where bit 0 is the least significant bit.

The convolutional encoding used is a rate 1/2, memory order 5 code (R = 1/2, m=5). There are 32 states in this code, five memory elements. Table 2.1.3.3.3.4–1 shows all the states and their outputs to a given input. The notation for the generator polynomials, $g_0(D)$ and $g_1(D)$, follow that defined by Shu Lin and Daniel Costello in **Error Control Coding: Fundamentals and Applications**, Prentice-Hall, April 1983 on page 330.

The polynomials are defined as

$$g_0(D) = 1 + D + D^3 + D^5 \qquad (2.1.3.3.3.4\text{–}1)$$

$$g_1(D) = 1 + D^2 + D^3 + D^4 + D^5 \qquad (2.1.3.3.3.4\text{–}2)$$

The output from the convolutional coder alternates between these two polynomials starting with $g_0(D)$ being the first in each time slot. The free coefficient in the above equations is the MSB.

TABLE 2.1.3.3.3.4–1: Input - Output Relationship of Convolutional Coder

	INPUT = 0		INPUT = 1			INPUT = 0		INPUT = 1	
state	g0	g1	g0	g1	state	g0	g1	g0	g1
0	0	0	1	1	16	1	1	0	0
1	1	0	0	1	17	0	1	1	0
2	0	1	1	0	18	1	0	0	1
3	1	1	0	0	19	0	0	1	1
4	1	1	0	0	20	0	0	1	1
5	0	1	1	0	21	1	0	0	1
6	1	0	0	1	22	0	1	1	0
7	0	0	1	1	23	1	1	0	0
8	0	1	1	0	24	1	0	0	1
9	1	1	0	0	25	0	0	1	1
10	0	0	1	1	26	1	1	0	0
11	1	0	0	1	27	0	1	1	0
12	1	0	0	1	28	0	1	1	0
13	0	0	1	1	29	1	1	0	0
14	1	1	0	0	30	0	0	1	1
15	0	1	1	0	31	1	0	0	1

The convolutional encoding process may be viewed in the following manner. Initially the encoder's memory elements are cleared, i.e. the encoder starts at state 0, the bits in the class 1 buffer are read in starting at CL1[0] and concluding with bit CL1[88]. Sequentially the output from $g_0(D)$ and $g_1(D)$ are referred to as $cc_0[i]$ and $cc_1[i]$, respectively. For each input bit, CL1[i], the two output bits, $cc_0[i]$ and $cc_1[i]$, are produced. The order, i, the bits are placed into CL1[i] is indicated in Table 2.1.3.3.3.4–2.

Table 2.1.3.3.3.4–2: Bit Ordering Into Convolutional Coder
(Note: All the tail bits, numbered 0 through 4, are equal to 0.)

Order, i	Parameter	Bit Number	Order, i	Parameter	Bit Number
0	CRC	6	44	GSP0_3	1
1	CRC	4	45	GSP0_1	1
2	CRC	2	46	GSP0_3	2
3	CRC	0	47	GSP0_1	2
4	R0	3	48	GSP0_3	3
5	R0	2	49	GSP0_1	3
6	LPC3	4	50	GSP0_3	4
7	LPC4	3	51	GSP0_1	4
8	LPC1	3	52	LPC2	2
9	LPC5	3	53	GSP0_4	5
10	LAG_2	6	54	GSP0_2	5
11	LAG_4	6	55	LPC4	2
12	LAG_2	5	56	GSP0_4	6
13	LAG_4	5	57	GSP0_2	6
14	LAG_2	4	58	GSP0_4	0
15	LAG_4	4	59	LAG_3	0
16	LAG_2	3	60	LAG_1	0
17	LAG_4	3	61	LAG_3	1
18	GSP0_2	7	62	LAG_1	1
19	GSP0_4	7	63	LAG_3	2
20	LAG_2	2	64	LAG_1	2
21	LAG_4	2	65	GSP0_3	7
22	LAG_2	1	66	GSP0_1	7
23	LAG_4	1	67	LAG_3	3
24	LAG_2	0	68	LAG_1	3
25	LAG_4	0	69	LAG_3	4
26	GSP0_1	6	70	LAG_1	4
27	GSP0_3	6	71	LAG_3	5
28	R0	1	72	LAG_1	5
29	GSP0_1	5	73	LAG_3	6
30	GSP0_3	5	74	LAG_1	6
31	LPC1	2	75	LPC3	3
32	LPC3	2	76	LPC2	3
33	GSP0_2	4	77	LPC1	4
34	GSP0_4	4	78	LPC2	4
35	GSP0_2	3	79	LPC1	5
36	GSP0_4	3	80	R0	4
37	GSP0_2	2	81	CRC	1
38	GSP0_4	2	82	CRC	3
39	GSP0_2	1	83	CRC	5
40	GSP0_4	1	84	Tail	0
41	GSP0_2	0	85	Tail	1
42	GSP0_3	0	86	Tail	2
43	GSP0_1	0	87	Tail	3
44	GSP0_3	1	88	Tail	4

2.1.3.3.4 Interleaving

Before transmission, the encoded speech data is interleaved over two time slots with the speech data from adjacent speech frames. Stated another way, each time slot contains information from two speech coder frames. The speech data is placed into a rectangular interleaving array as shown in Figure 2.1.3.3.4–1. The speech data is entered into the interleaving array column-wise. The two speech frames are referred to as x and y where x is the previous speech frame and y is the present or most recent speech frame.

Figure 2.1.3.3.4–1

0x	26x	52x	78x	104x	130x	156x	182x	208x	234x
1y	27y	53y	79y	105y	131y	157y	183y	209y	235y
2x	28x	54x	80x	106x	132x	158x	184x	210x	236x
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
12x	38x	64x	90x	116x	142x	168x	194x	220x	246x
13y	39y	65y	91y	117y	143y	169y	195y	221y	247y
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
24x	50x	76x	102x	128x	154x	180x	206x	232x	258x
25y	51y	77y	103y	129y	155y	181y	207y	233y	259y

The data (ciphered or plain text) is placed into the interleaving array in a manner that intermixes the class 2 bits from the speech coder with the convolutionally coded class 1 bits. The class 2 bits are sequentially placed into the array and occupy the following numbered locations in the interleaving array:

0, 26, 52, 78

93 through 129

130, 156, 182, 208

223 through 259

The coded class 1 bits occupy the remainder of the interleaving array and also are sequentially placed into the array. The placement of the class 1 and class 2 bits in the array is shown in Figure 2.1.3.3.4–2. Figure 2.1.3.3.4–1 indicates the frame from which each bit in Figure 2.1.3.3.4–2 is taken.

Figure 2.1.3.3.4–2

CL2[0]	CL2[1]	CL2[2]	CL2[3]	CL2[15]	CL2[41]	CL2[42]	CL2[43]	CL2[44]	CL2[56]
cc0[0]	cc1[12]	cc0[25]	cc1[37]	CL2[16]	cc1[44]	cc0[57]	cc1[69]	cc0[82]	CL2[57]
cc1[0]	cc0[13]	cc1[25]	cc0[38]	CL2[17]	cc0[45]	cc1[57]	cc0[70]	cc1[82]	CL2[58]
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
cc1[6]	cc0[19]	cc1[31]	cc0[44]	CL2[29]	cc0[51]	cc1[63]	cc0[76]	cc1[88]	CL2[70]
cc0[7]	cc1[19]	cc0[32]	CL2[4]	CL2[30]	cc1[51]	cc0[64]	cc1[76]	CL2[45]	CL2[71]
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
cc1[11]	cc0[24]	cc1[36]	CL2[13]	CL2[39]	cc0[56]	cc1[68]	cc0[81]	CL2[54]	CL2[80]
cc0[12]	cc1[24]	cc0[37]	CL2[14]	CL2[40]	cc1[56]	cc0[69]	cc1[81]	CL2[55]	CL2[81]

The bits in this array are then transmitted row-wise using the following algorithm:

```
do row=0,25
    do colm=0,9
        transmit(array(row,colm))
    end do
end do
```

The ordering of the bits into the CL2[i] array is shown in Table 2.1.3.3.4–1.

Table 2.1.3.3.4–1: Bit Ordering Into Class 2 Array

Order, i	Parameter	Number	Order, i	Parameter	Number
0	CODE2_4	0	41	LPC6	1
1	CODE2_4	1	42	LPC5	0
2	CODE2_4	2	43	LPC5	1
3	CODE2_4	3	44	LPC5	2
4	CODE2_4	4	45	LPC4	0
5	CODE2_4	5	46	LPC4	1
6	CODE2_4	6	47	LPC3	0
7	CODE1_4	0	48	LPC3	1
8	CODE1_4	1	49	LPC2	0
9	CODE1_4	2	50	LPC2	1
10	CODE1_4	3	51	LPC1	0
11	CODE1_4	4	52	LPC1	1
12	CODE1_4	5	53	R0	0
13	CODE1_4	6	54	CODE2_2	0
14	CODE2_3	0	55	CODE2_2	1
15	CODE2_3	1	56	CODE2_2	2
16	CODE2_3	2	57	CODE2_2	3
17	CODE2_3	3	58	CODE2_2	4
18	CODE2_3	4	59	CODE2_2	5
19	CODE2_3	5	60	CODE2_2	6
20	CODE2_3	6	61	CODE1_2	0
21	CODE1_3	0	62	CODE1_2	1
22	CODE1_3	1	63	CODE1_2	2
23	CODE1_3	2	64	CODE1_2	3
24	CODE1_3	3	65	CODE1_2	4
25	CODE1_3	4	66	CODE1_2	5
26	CODE1_3	5	67	CODE1_2	6
27	CODE1_3	6	68	CODE2_1	0
28	LPC6	2	69	CODE2_1	1
29	LPC10	0	70	CODE2_1	2
30	LPC10	1	71	CODE2_1	3
31	LPC9	0	72	CODE2_1	4
32	LPC9	1	73	CODE2_1	5
33	LPC9	2	74	CODE2_1	6
34	LPC8	0	75	CODE1_1	0
35	LPC8	1	76	CODE1_1	1
36	LPC8	2	77	CODE1_1	2
37	LPC7	0	78	CODE1_1	3
38	LPC7	1	79	CODE1_1	4
39	LPC7	2	80	CODE1_1	5
40	LPC6	0	81	CODE1_1	6

2.1.3.3.5 Time Alignment

2.1.3.3.5.1 Time Alignment Process

Time alignment is the process of controlling the time of TDMA time slot burst transmission from the mobile by advancing or retarding the mobile transmit burst so that it arrives at the base station receiver in the proper time relationship to other time slot burst transmissions. An error in time alignment is caused by the arrival of power from two different mobile transmitters simultaneously at the base station receiver. This in turn causes errors in both signals. This overlap will occur at the head or tail of a time slot. The mechanism for detection of overlap is left to the implementor and is not subject to standardization. Upon detecting an overlap condition, the base station must send an appropriate time alignment message to the mobile station using the appropriate forward signaling channel.

The format of the physical layer control message is described in 3.7.3.1.3.2.5. The time adjustment parameter in that message provides for advancing or retarding the time of the mobile transmit burst in units of 1/2 Symbols. Upon receipt of a Time Alignment message, the mobile station shall change its timing in one adjustment.

2.1.3.3.5.2 Shortened Burst Transmission

At certain times it is necessary for a mobile station while operating on a digital traffic channel to transmit during its slot interval a sequence 324 bits long, defined as a SHORTENED BURST, so as to avoid collisions at the base station between the mobile station's burst and the burst of a neighboring slot. This collision of neighboring bursts at the base station is due to the mobile station not having the proper Time Alignment information corresponding to its distance from the base station.

As part of System Access 2.6.3 the mobile station receives an Initial Traffic Channel Designation (ITCD) message (Table 3.7.1-1) and moves to a traffic channel. The mobile station first synchronizes to the forward traffic channel as described in 2.6.5.2. The mobile station then transmits at the standard offset reference position the SHORTENED BURST defined in 2.1.3.3.5.2.1. The mobile station continues to transmit a SHORTENED BURST at the standard offset reference position until it receives a Time Alignment message from the base station or the mobile station is directed to stop transmission due the timeout of its fade timer, (see section 2.6.5.1). If the mobile station receives a Time Alignment message, it adjusts its transmission timing and transmits during the next available slot a time aligned full duration slot burst.

A mobile HANDOFF message contains estimated Time Alignment information. For smaller diameter cells, this estimated Time Alignment information will be used to adjust the mobile station transmit timing so that there will be no burst collisions at the base station. For systems with sector to sector handoff, the estimated time alignment information will also be used to adjust the mobile station transmit timing so that there will be no burst collisions at the base station. For larger diameter cells, however, this estimated Time Alignment information may not be accurate enough to avoid burst collisions at the base station.

Analog to Digital and Digital to Digital HANDOFF messages contain a Shortened Burst Indicator (SBI) field, (see 2.7.3.1.3.3). This field indicates to the mobile station which of the following three handoff conditions exist:

SBI=00

A handoff to a small diameter cell: The mobile station first synchronizes to the forward traffic channel. The mobile station's first transmission is a full duration burst transmitted at the time derived from Timeslot Indicator and Time Alignment information received during the handoff message. All further transmissions to the current base station should also be full duration bursts. The mobile station adjusts its transmission timing according to 2.1.3.3.5.1 whenever it receives Time Alignment information from the base station.

SBI=01

A handoff sector to sector (within the same cell.) The mobile station first synchronizes to the forward traffic channel . The mobile station's first transmission is a full duration burst transmitted at the time derived from Timeslot Indicator and Time Alignment information received during the handoff message. All further transmissions to the current base station should also be full duration bursts. The mobile station adjusts its transmission timing according to 2.1.3.3.5.1 whenever it receives Time Alignment information from the base station.

SBI=10

A handoff to a large diameter cell. The mobile station first synchronizes to the forward traffic channel. The mobile station then transmits at the standard offset reference position the SHORTENED BURST defined in 2.1.3.3.5.2.1. The mobile station continues to transmit a SHORTENED BURST at the standard offset reference position until it receives a Time Alignment message from the base station or the mobile station is directed to stop transmission due the timeout of its fade timer, (see section 2.6.5.1). If the mobile station receives a Time Alignment message, it adjusts its transmission timing and transmits during the next available slot a time aligned full slot duration burst.

2.1.3.3.5.2.1 Shortened Burst Definition

The Shortened Burst format is shown in the following figure:

G1	R S D S D V S D W S D X S D Y S	G2

The Shortened Burst contains:

G1: 3 symbol length guard time.

R: 3 symbol length Ramp time.

S: 14 symbol length Sync Word; The mobile station uses its assigned sync word.

D: 6 symbol length CDVCC; The mobile station uses its assigned DVCC.

G2: 22 Symbol length guard time.

The fields V,W,X,Y contain bits as follows:

V = 0000

W = 00000000

X = 000000000000

Y = 0000000000000000

The above format allows determination by the base of Timing Alignment after detection of any 2 or more sync words of the Shortened Burst. This is because the symbol interval between any two sync words in the above format is unique to the 2 sync words detected. Determination of the number of symbols between two detected sync words uniquely defines the location of the detected sync words within the received Shortened Burst.

2.1.3.3.6 Synchronization and Timing

The mobile station shall derive timing for the transmit symbol and TDMA frame and slot clocks from a common source which shall track the base station symbol rate as perceived at the mobile receiver. The frequency tracking shall be maintained over all specified operating conditions.

2.1.4 Limitations on Emissions

2.1.4.1 Bandwidth Occupied

2.1.4.1.1 Analog Transmitters

Modulation products outside the region ±20 kHz from the carrier shall not exceed a level of 26 dB below the unmodulated carrier. Modulation products outside the region of ±45 kHz from the carrier shall not exceed a level of 45 dB below the unmodulated carrier. Modulation products outside the region of ±90 kHz from the carrier shall not exceed a level of (a) 60 dB below the unmodulated carrier, or (b) 43 plus 10 $\log_{10}$ (mean output power in Watts) dB below the unmodulated carrier, whichever is the higher level of power. Measurement techniques are defined in the current EIA IS-19, "Recommended Minimum Standards for 800-MHz Cellular Subscriber Units", and EIA/TIA IS-55, "Recommended Minimum Standards for 800-MHz Dual-Mode Mobile Stations."

2.1.4.1.2 Digital Transmitters

The emission power in either adjacent channel, centered ± 30 kHz from the center frequency, shall not exceed a level of 26 dB below the mean output power. The emission power in either alternate channel, centered ± 60 kHz from the center frequency, shall not exceed a level of 45 dB below the mean output power. The emission power in either 2^{nd} alternate channel centered ± 90 kHz from the center frequency, shall not exceed a level of 45 dB below the mean output power or -13 dBm, whichever is the lower power.

2.1.4.2 Conducted Spurious Emissions

Refer to EIA/TIA - IS-55.

2.1.4.3 Radiated Spurious Emissions

Refer to EIA/TIA - IS-55.

2.2 Receiver

2.2.1 Frequency Parameters

2.2.1.1 Channel Spacing and Designation

Channel spacing shall be 30 kHz and the dual-mode mobile station receive channel at 870.030 MHz (and the corresponding base station receive channel at 825.030 MHz) shall be termed channel number 1. The 20 MHz range of channels 1 through 666 as shown in Table 2.1.1.1-1 for System A and System B is basic. The additional 5 MHz of channels 667 through 799 and (wrap-around) 991 through 1023 for extending Systems A and B is mandatory. In either case, the station class mark (SCM, see 2.3.3) shall be set appropriately.

2.2.2 Demodulation Characteristics

2.2.2.1 Analog Voice Signals

The demodulator is followed by the following three voice-signal processing stages:

- Receive Audio Level Adjustment
- De-emphasis
- Expandor

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks.

Audio Level Adjustment

The receive audio sensitivity shall be adjusted such that a 1 kHz modulated carrier with a ±2.9 kHz peak frequency deviation produces the same output as results from a state of R_0 = 21 in the VSELP coder.

2.2.2.1.1 De-Emphasis

The de-emphasis characteristic must have a nominal –6 dB per octave response between 300 and 3000 Hz.

2.2.2.1.2 Expandor

This stage is the expandor portion of a 2:1 syllabic compandor. For every 1 dB change in input level to a 1:2 expandor, the change in output level is a nominal 2 dB. The signal expansion must follow all other demodulation signal processing (including the 6 dB/octave de-emphasis and filtering). The expandor must have a nominal attack time of 3 ms and a nominal recovery time of 13.5 ms as defined by the CCITT (Reference: Recommendation G162, CCITT Plenary Assembly, Geneva, May-June 1964, Blue Book, Vol. 111, P. 52). The nominal reference input level to the expandor is that corresponding to a 1000 Hz tone from a carrier with a ±2.9 kHz peak frequency deviation.

2.2.2.2 Digital Voice and Data Signals

2.2.2.2.1 Demodulation

$\frac{\pi}{4}$ shifted, differentially encoded quadrature phase shift keying is amenable to a number of different demodulation techniques.

2.2.2.2.2 De-Interleaving

The data from the channel must first be de-interleaved (complying with the interleaving specified in Section 2.1.3.3.4). Each time slot contains the interleaved information from part of two speech coder frames. The nomenclature at the decoder is slightly different from the encoder, now frame x is the present speech coder frame and frame y is the next speech coder frame. Each time slot contains data for both speech frames. The received data is placed row-wise into a 26 x 10 de-interleaving array. The frame that each bit belongs to is indicated in Figure 2.1.3.3.4–1. The location in the Class 2 and Coded Class 1 arrays (CL2[i], cc0[i] and cc1[i]) that each bit in the array belongs to is shown in Figure 2.1.3.3.4–2. The correspondence between the bits in Class 2 array, CL2[i], and bits in the parameter codes is shown in Table 2.1.3.3.4–1. Once the data from the timeslot is used to fill the de-interleaving array, all the data for frame x is available and the data for that frame can be decoded.

2.2.2.2.3 Convolutional Decoding

After de-interleaving, data for one entire speech coder frame becomes available. The de-interleaved data that was convolutionally encoded must now be decoded. Any known decoding technique for convolutional codes may be used. (Refer to 2.1.3.3.3.4). (May be decoded using Viterbi algorithm in conjunction with the use of soft channel information.)

2.2.2.2.3.1 Cyclic Redundancy Check (CRC)

After decoding the class 1 bits, the received CRC bits are checked to determine if an error has been detected in the 12 most perceptually significant bits in each frame. A second CRC polynomial is generated at the receiver over the most perceptually significant bits, and compared to the received CRC polynomial. The second CRC polynomial is generated using received information and the CRC generator polynomial. The CRC's generator polynomial is

$$g_{crc}(X) = 1 + X + X^2 + X^4 + X^5 + X^7 \qquad (2.2.2.2.3.1\text{–}1)$$

The decoded twelve most perceptually significant bits of the frame form the input polynomial. This decoded input polynomial is defined as

$$a'(X) = CL1[80]X^{11} + CL1[4]X^{10} + CL1[79]X^9 + CL1[5]X^8 + CL1[78]X^7 + CL1[6]X^6 + CL1[77]X^5 + CL1[7]X^4 + CL1[76]X^3 + CL1[8]X^2 + CL1[75]X^1 + CL1[9]X^0 \qquad (2.2.2.2.3.1\text{–}2)$$

Where CL1[i] are the decoded Class 1 bits. The input polynomial is divided by the CRC generator polynomial yielding a quotient and remainder polynomial:

$$\frac{a'(X) \bullet X^7}{g_{crc}(X)} = q(X) + \frac{crc[a'(X)]}{g_{crc}(X)} \qquad (2.2.2.2.3.1\text{–}3)$$

Where q(x) is the quotient of the division, crc[a'(X)] the remainder. The quotient is discarded leaving the remainder crc[a'(X)], the parity polynomial. The received CRC polynomial b'(X) is derived from the decoded class 1 array using the following formula.

$$b'(X) = CL1[0]X^6 + CL1[83]X^5 + CL1[1]X^4 + CL1[82]X^3 + CL1[2]X^2 + CL1[81]X^1 + CL1[3]X^0 \qquad (2.2.2.2.3.1\text{-}4)$$

The received CRC for the frame, b'(X), is compared with crc[a'(X)]. If the two differ then an error has been detected in the twelve most perceptually significant bits for that speech frame.

2.2.2.2.3.2 Bad Frame Masking

Based on the CRC comparison, an error in the 12 most perceptually significant bits of the speech frame may be detected. This CRC comparison failure can occur because the data was corrupted by channel errors or because a FACCH message was transmitted in place of the speech data. In either case, use of this received data for the generation of the speech signal can cause severe degradation to the speech quality. To prevent this problem, a bad frame masking strategy could be employed. The strategy described in this section may be employed.

The bad frame masking system is based on a 6 state machine. On every decode of a speech frame, the state machine can change state. State 0 occurs most often and implies that the CRC comparison was successful. State 6 implies that there were at least 6 consecutive frames which failed the CRC check. The action taken at each of these states varies as well. At state 0 no action is taken. States 1 and 2 are simple frame repeats. States 3,4 and 5 repeat and attenuate the speech. State 6 completely mutes the speech.

The state count, with one exception, indicates how many consecutive frames had CRC comparison failures. For example, state 5 indicates 5 consecutive frames (including the current frame) have failed the comparison. The only exception is state 6 which may be preceded by indefinitely many corrupted frames. In any state (except state 6) agreement between the received and regenerated CRC's returns the state machine to the starting state, state 0. State 6 requires two contiguous correct decodes to return to state 0. This is used to provide additional protection during prolonged intervals of very poor channel conditions which might cause the CRC to occasionally falsely indicate a valid speech data.

State 0 - error free state is the normal state of the system. The state machine stays at this state unless a CRC error is detected where CRC error is defined as a disagreement of the regenerated CRC, crc[a'(X)], and the received CRC, b'(X). On each successive speech frame detected in error, the state machine moves to the next higher numbered state. As soon as the CRC detects no error for a speech frame, the machine returns to state 0 unless it was in state 6. If the machine is in state 6, two successive frames with no detected errors will cause the state machine to return to state 0 otherwise the state machine stays in state 6. In each state the following actions are followed:

State 0 – No CRC error is detected. The received decoded speech data is used.

State 1 – A CRC error has been detected in the frame. The parameter values for R(0) and the LPC bits are replaced with the corresponding values from the last frame that was in state 0. The remaining decoded bits for the frame are passed to the speech decoder without modification.

State 2 – same action is taken as in state 1.

State 3 – As in state 1 and 2, a frame repeat is done, except that the value of R(0) is modified. A 4 dB attenuation is applied to the R(0) parameter, i.e. if R0 of the last state 0 frame is greater than 2, then R0 is decremented by 2 and repeated at this lower level.

State 4 – same as state 3. R(0) is again attenuated by 4 dB, so now the level is as much as 8 dB from the original value of the R(0).

State 5 – R(0) is attenuated an additional 4 dB.

State 6 – Again the frame is repeated, but this time R(0) is set to zero, totally muting the output speech. Alternatively, comfort noise could be inserted in place of the speech signal.

2.2.2.2.4 Speech Decoding

The speech decoder takes the 7950 bps data from the channel decoder and generates the received speech signal. The speech decoder must operate correctly in conjunction with the speech coder described in 2.1.3.3.2.

2.2.2.2.4.1 Definitions and Basic Definitions and Basic Decoder Parameters

See 2.1.3.3.2.1.

2.2.2.2.4.2 Short Term Predictor Coefficients

The short-term filter is equivalent to the traditional LPC synthesis filter. The transfer function for the short-term filter is given by.

$$A(z) = \frac{1}{1 - \sum_{i=1}^{N_p} \alpha_i z^{-i}} \qquad (2.2.2.2.4.2\text{–}1)$$

The short term predictor parameters are the α_i's of the short term or synthesis filter. These are standard LPC direct form filter coefficients.

2.2.2.2.4.2.1 Decoding of Coefficients

The short term predictor coefficients are coded as quantized reflection coefficients. These codes (LPC1 – LPC10) can be decoded into the 10 reflection coefficients (r_1 – r_{10}) using the Table 2.1.3.3.2.4.3–1.

2.2.2.2.4.2.2 Conversion to Direct Form Coefficients

See 2.1.3.3.2.4.5

2.2.2.2.4.2.3 Interpolation of Coefficients

See 2.1.3.3.2.4.6

2.2.2.2.4.3 Frame Energy

An energy value is computed and encoded once per frame. This energy value, R(0), reflects the average signal energy in the input speech over a 20 msec. interval which is centered with respect to the middle of the fourth subframe.

DECODING OF FRAME ENERGY

The quantized value of R(0), $R_q(0)$, is determined from R0 (the transmitted code for $R_q(0)$) using equations 2.1.3.3.2.5.2–3.

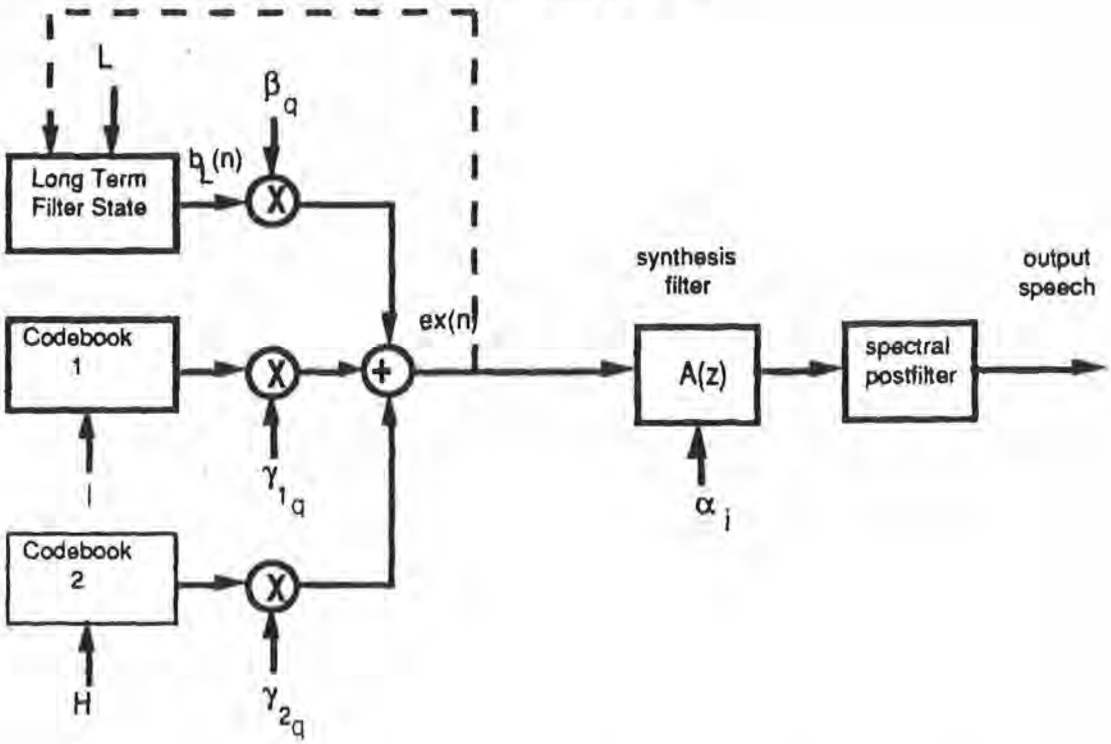
INTERPOLATION OF FRAME ENERGY

See 2.1.3.3.2.5.3

2.2.2.2.4.4 Subframe Processing

Figure 2.2.2.2.4.4–1 is a block diagram of the speech decoder.

Figure 2.2.2.2.4.4–1



2.2.2.2.4.4.1 Decoding of Lag

The lag, L, for subframe x can be determined from the code LAG_x as follows:

$$L = LAG\_x + 19 \qquad \text{if } LAG\_x \neq 0 \qquad (2.2.2.2.4.4.1\text{–}1)$$

long term predictor deactivated if LAG_x = 0

2.2.2.2.4.4.2 Decoding of Excitation Codewords

See 2.1.3.3.2.6.4.4

2.2.2.2.4.4.3 Decoding of GS, P0 and P1

The GSP0_x code for subframe x is decoded in GS, P0 and P1 using Table 2.1.3.3.2.6.5.2–1.

2.2.2.2.4.4.4 Transformation of GS, P0 and P1 to gains

GS, P0 and P1 are transformed into β_q, γ_{1q}, and γ_{2q} using equations 2.1.3.3.2.6.5.2–11, 2.1.3.3.2.6.5.2–12 and 2.1.3.3.2.6.5.2–13 if the long term predictor is activated. If the long term predictor is deactivated equations 2.1.3.3.2.6.5.2–15, 2.1.3.3.2.6.5.2–16 and 2.1.3.3.2.6.5.2–17 are used.

2.2.2.2.4.4.5 Generation of Combined Excitation

The combined excitation, ex(n), shall be computed as:

$$ex(n) = \beta_q \, b_L(n) + \gamma 1_q \, u_{1,I}(n) + \gamma 2_q \, u_{2,H}(n) \quad \text{for } 0 \le n \le 39 \qquad (2.2.2.2.4.4.5\text{–}1)$$

where $b_L(n)$ is defined by 2.1.3.3.2.6.3.1–14 and the codebook excitation vectors, $u_{1,I}(n)$ and $u_{2,H}(n)$ are defined by 2.1.3.3.2.6.4–1 where I and H are the decoded codewords for the first and second codebooks.

2.2.2.2.4.4.6 Update Long Term Filter State

The long term predictor state, r(n), is updated by:

$$r(n) = r(n+40) \quad \text{for } -146 \le n \le -41 \qquad (2.1.3.3.2.6.6\text{–}1a)$$

$$r(n) = ex(n+40) \quad \text{for } -40 \le n \le -1 \qquad (2.1.3.3.2.6.6\text{–}1b)$$

2.2.2.2.4.4.7 Synthesis Filter

The combined excitation, ex(n), is filtered by the synthesis filter to generate the speech signal. The synthesis filter is a tenth order all pole filter. The filter coefficients for the subframe are the α_i's defined in 2.2.2.2.4.2.3. The filter coefficients will change from subframe to subframe. The filter state must be preserved from subframe to subframe. A direct form filter should be used for the synthesis filter.

2.2.2.2.4.4.8 Adaptive Spectral Postfilter

The perceptual quality of the synthetic speech may be enhanced by using an adaptive spectral postfilter as the final processing step. The form of the postfilter is

$$\hat{H}(z) = \frac{1 - \sum_{i=1}^{10} \eta_i z^{-i}}{1 - \sum_{i=1}^{10} v^i \alpha_i z^{-i}} \; , \; 0 \le v < 1 \qquad (2.2.2.2.4.4.8\text{–}1)$$

where the α_i's are the coefficients of the synthesis filter.

The numerator polynomial in 2.2.2.2.4.4.8–1 is a spectrally smoothed version of the denominator polynomial.

To derive the numerator coefficients, the autocorrelation of the impulse response of the all pole filter corresponding to the denominator of 2.2.2.2.4.4.8–1 is calculated for lags 0 through 10. The autocorrelation sequence is then windowed by a binomial window and the numerator coefficients (η_i for i = 1 to 10) are calculated from the windowed autocorrelation sequence via the Levinson recursion. Alternatively, the autocorrelation coefficients may be computed directly from the direct form coefficients via a recursion related to Levinson's recursion.

To have more control over postfiltered speech "brightness", a first order filter is used of the form:

$$\tilde{H}(z) = 1 - u \, z^{-1} \qquad (2.2.2.2.4.4.8\text{–}2)$$

This filter is cascaded with filter 2.2.2.2.4.4.8–1 and is considered part of the adaptive spectral postfilter.

The following postfilter parameters may be used. Note that B_{eq} is the bandwidth expansion factor which specifies the degree of smoothing which is performed on the denominator, to generate the numerator.

$$v = 0.8$$

$$B_{eq} = 1200\text{Hz}$$

$$u = 0.4$$

The spectral smoothing coefficients (autocorrelation window), wp(i), for 1200 Hz are:

wp(0)	1.000000
wp(1)	0.923077
wp(2)	0.725275
wp(3)	0.483516
wp(4)	0.271978
wp(5)	0.127990
wp(6)	0.049774
wp(7)	0.015718
wp(8)	0.003930
wp(9)	0.000748
wp(10)	0.000102

(2.2.2.2.4.4.8–3)

In order to reduce the computations needed to compute the spectrally smoothed numerator coefficients, one may perform the spectral smoothing operation once per frame on the denominator coefficients corresponding to the uninterpolated coefficients. This will yield the coefficients for the numerator of the spectral postfilter for subframe four. The numerator coefficients for subframes one, two, and three are interpolated using the same interpolation scheme that is used for the LPC synthesis coefficients as described in 2.1.3.3.2.4.6.

To ensure unity power gain between the input, $\hat{s}(n)$, and the output, $\hat{s}_p(n)$, of the spectral postfilter, a gain scale factor is computed and is used to scale the spectral postfiltered signal. S_{scale}, the postfilter scale factor, is

$$S_{scale} = \sqrt{\frac{\sum_{n=0}^{N-1} \hat{s}^2(n)}{\sum_{n=0}^{N-1} \hat{s}_p^{\,2}(n)}} \qquad (2.2.2.2.4.4.8\text{–}4)$$

The scale factor, S_{scale}, is the square root of the ratio of the input signal energy to output signal energy over the subframe. This scale factor is not used directly. The scale factor is passed through a first order low pass filter. This filtering is given by :

$$S'_{scale}(n) = (.9875 * S'_{scale}(n-1)) + (.0125 * S_{scale}) \qquad (2.2.2.2.4.4.8\text{–}5)$$

The output of the spectral postfilter, $\hat{s}_p(n)$, is then multiplied by S'_{scale} as the last step in reconstructing the speech signal in the speech decoder.

2.2.2.2.4.5 Audio Interface

The function of the audio interface at the mobile receiver is to convert the signal from the speech decoder to an analog speech signal.

The speech coder shall be succeeded by the following voice processing stages.

- Digital to Analog Converter
- Reconstruction filter
- Receive Level Adjustment

The characteristics of these stages are described in the following sections.

2.2.2.2.4.5.1 Digital to Analog Converter

The D/A converter shall be performed according to either of the following.

- by direct conversion from PCM to analog
- or by making an uniform/μlaw code conversion succeeded by a standard codec D/A converter.

The uniform/μlaw code conversion is performed according to definition in CCITT Red Book G.721, section 4.2.7 sub-block COMPRESS. The parameter LAW shall be set to LAW=0. The D/A conversion is based on the standard specified in CCITT Red Book G.711.

2.2.2.2.4.5.2 Reconstruction Filter

The function of the filter is to reconstruct the analog band-limited speech signal from the D/A converter. The attenuation of the filter shall comply with CCITT Red Book G.714 receiving filter.

Note: The filter specification in G.714 is concerned with PCM equipment. In some cases more attenuation will be needed in a terminal equipment.

2.2.2.2.4.5.3 Receive Level Adjustment

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks.

The receive audio sensitivity of the mobile station in the digital mode shall meet the requirements stated in EIA/TIA IS-55 under "Digital Receiver Audio Sensitivity".

2.2.2.2.5 Delay Interval Requirements

The mobile stations and the base station shall, as a default on a digital traffic channel, provide for delay interval compensation of up to 1 symbol length. The Delay Interval Compensation (DIC) function can then be turned on or off in the mobile station by a Physical Layer Control message from the base station. The delay interval, as previously defined, is defined as the difference in μsec between the first and last ray, using a two-ray model, where both rays are of equal magnitude.

(Note: The current specification is based on incomplete information on delay spread profiles found in existing cellular systems. As such, it is subject to revision and change in the future, if this is found to be necessary in light of further data.)

2.2.3 Limitations on Emissions

2.2.3.1 Conducted Spurious Emissions

2.2.3.1.1 Suppression Inside Cellular Band

Any RF signals emitted in the mobile station's receive band must not exceed –80 dBm, as measured at the antenna connector. Additionally, signals in the mobile station's transmit band must not exceed –60 dBm, as measured at the antenna connector.

2.2.3.1.2 Suppression Outside Cellular Band

Refer to EIA/TIA IS-55.

2.2.3.2 Radiated Spurious Emissions

Refer to EIA/TIA IS-55.

2.2.4 Other Receiver Parameters

System performance is predicated upon receivers meeting EIA IS-19 "Recommended Minimum Standards for 800 MHz Cellular Subscriber Units" and EIA/TIA IS-55 "Recommended Minimum Performance Standards for 800-MHz Dual-Mode Mobile Stations".

2.3 Security and Identification

2.3.1 Mobile Identification Number

A 34-bit binary mobile identification number (MIN) is derived from the dual-mode mobile station's 10-digit directory telephone number by the following procedure.

	$MIN2_p$	$MIN1_p$		
	NPA	NXX	X	XXX
bits	10	10	4	10

(1) The first three digits are mapped into 10 bits (corresponding to ($MIN2_p$)) by the following coding algorithm:

(a) Represent the 3-digit field as $D_1D_2\,D_3$ with the digit 0 having the value 10.

(b) Compute $100D_1 + 10D_2 + D_3 - 111$.

(c) Convert the result in step (b) to binary by a standard decimal-to-binary conversion (see table below).

(2) The second three digits are mapped into the 10 most significant bits of $MIN1_p$ by the coding algorithm described in (1).

(3) The last four digits are mapped into the 14 least-significant bits of $MIN1_p$ as follows:

(a) The thousands digit should be mapped into four bits by a Binary-Coded-Decimal (BCD) conversion, as specified in the table below.

(b) The last three digits are mapped into 10 bits by the coding algorithm described in (1).

DECIMAL-TO-BINARY CONVERSION	
Decimal Number	Binary Number
1	0000000001
2	0000000010
3	0000000011
4	0000000100
998	1111100110
999	1111100111

THOUSANDS-DIGIT BCD MAPPING PROCEDURE	
Thousands Digit	Binary Sequence
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
0	1010

In the following example the 10-digit directory telephone number 321-456-7890 is encoded into MIN2 and MIN1 using the procedure described above:

- MIN2. The 10-bit MIN2 is derived from the first three digits of the telephone number (i.e., 321):

  (a) $D_1 = 3$; $D_2 = 2$; $D_3 = 1$.

  (b) $100 D_1 + 10 D_2 + D_3 - 111 = 100(3) + 10(2) + (1) - 111 = 210$.

  (c) 210 in binary is '00 1101 0010'.

Therefore MIN2 is '00 1101 0010'.

- MIN1. The 10 most significant bits of MIN1 are derived from the second three digits of the telephone number (i.e., 456):

  (a) $D_1 = 4$; $D_2 = 5$; $D_3 = 6$

  (b) $100 D_1 + 10 D_2 + D_3 - 111 = 100(4) + 10(5) + (6) - 111 = 345$.

  (c) 345 in binary is '0101 0110 01'.

The next four most significant bits of MIN1 are derived from the thousands digit of the telephone number (i.e., 7) by BCD conversion:

  (a) 7 in BCD is '0111'.

The 10 least significant bits of MIN1 are derived from the last three digits of the telephone number (i.e., 890):

  (a) $D_1 = 8$; $D_2 = 9$; $D_3 = 10$.

  (b) $100 D_1 + 10 D_2 + D_3 - 111 = 100(8) + 10(9) + (10) - 111 = 789$.

  (c) 789 in binary is '11 0001 0101'.

Therefore MIN1 is '0101 0110 0101 1111 0001 0101'.

2.3.2 Electronic Serial Number (ESN)

The ESN is a 32-bit binary number that uniquely identifies the mobile station to any cellular system. It must be factory-set and not readily alterable in the field. Modification of the ESN will require a special facility not normally available to subscribers. The circuitry that provides the ESN must be isolated from fraudulent contact and tampering. Electronic storage devices mounted in sockets or connected with a cable are deemed not to comply with this requirement. Attempts to change the ESN circuitry must render the mobile station inoperative.

The bit allocation of the ESN shall be as follows:

Bits	31 – 24	23 – 18	17 – 0
	MFR Code	Reserved	Serial Number
	ESN		

At the time of issuance of initial type acceptance, the manufacturer shall be assigned a Manufacturer's (MFR) Code within the eight most-significant bits (bit 31 through bit 24) of the 32-bit serial number. Bits 23 through 18 shall be reserved (initially all zero), and bits 17 through 0 shall be uniquely assigned by each manufacturer. When a manufacturer has used substantially all possible combinations of serial numbers within bits 17 through 0, the manufacturer may submit notification to the FCC. The FCC will allocate the next sequential binary number within the reserve block (bits 23 through 18).

2.3.3 Station Class Mark

Class-of-station information referred to as the station class mark (SCM_p) must be stored in a mobile station. The digital representation of this class mark is specified in the table below.

STATION CLASS MARKS (BITS 4-0)

Power Class (see 2.1.2.2)	SCM_p	Transmission (see 2.3.11)	SCM_p	Bandwidth (see 2.1.1.1 and 2.2.1.1)	SCM_p
Class I	0XX00	Continuous	XX0XX	20 MHz	X0XXX
Class II	0XX01	Discontinuous	XX1XX	25 MHz	X1XXX
Class III	0XX10				
Class IV	0XX11				
Class V	1XX00				
Class VI	1XX01				
Class VII	1XX10				
Class VIII	1XX11				

Note: In order to maintain compatibility between dual-mode mobile stations and EIA/TIA-553 base stations, dual-mode mobile stations with power classes IV - VIII must set the power class bits of the SCM to look like a Power Class III mobile station (i.e. SCM(4-0) = 0XX10) when PCI = 0 in the System Parameter Overhead Message (3.7.1.2.1).

2.3.4 Registration Memory

2.3.4.1 Autonomous Registration Memory

A single 21-bit (20 data bits plus an overflow bit) next registration indicator ($NXTREG_{s-p}$) and corresponding 15-bit system identification indicator (SID_{s-p}) pair must be retained when the mobile station power is turned off. The data retention time under power-off condition must be longer than 48 hours. If the integrity of the stored data can not be guaranteed after the mobile station is disconnected from the vehicle battery, then the memory must be set to zero when power is re-applied to the mobile station.

2.3.4.2 Location Area Memory

A 12-bit location area identifier ($LOCAID_{s-p}$) must be stored in the mobile station and used to identify changes in location area (see 2.6.2.1). The $LOCAID_{s-p}$ value must be retained when the mobile station power is turned off. The data retention time under power-off condition must be longer than 48 hours. If the integrity of the stored data cannot be guaranteed after the mobile station is disconnected from the vehicle battery, then the memory must be set to zero when power is re-applied to the mobile station.

A 1-bit power-up registration identifier ($PUREG_{s-p}$) must be stored in the mobile station and used to identify changes in the power-up registration flag (see 2.6.2.1). The $PUREG_{s-p}$ value must be retained when the mobile station power is turned off. The data retention time under power-off condition must be longer than 48 hours. If the integrity of the stored data cannot be guaranteed after the mobile station is disconnected from the vehicle battery, then the memory must be set to zero when power is re-applied to the mobile station.

2.3.5 Access Overload Class

A four-bit number indicator ($ACCOLC_p$) must be stored in the mobile station and used to identify which overload class field controls access attempts by the mobile station (see 2.6.3.4).

2.3.6 Extended Address Method

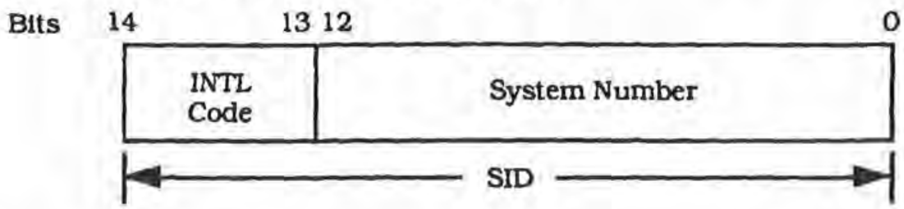
A one-bit access method indicator (EX_p) must be stored in the mobile station and used to determine if the extended address word must be included in all access attempts (see 2.6.3.7).

2.3.7 First Paging Channel

Contains two eleven-bit first paging channels ($FIRSTCHP_{p-pri}$ and $FIRSTCHP_{p-sec}$) which must be stored in the mobile station and used to identify the channel number of the first paging channel when the mobile station is "home" (see 2.6.1.1.2).

2.3.8 Home System Identification

A 15-bit system identification indicator (SID_p) must be stored in the mobile station and used to identify the mobile station's home system (see 2.6.1.1.2). The bit allocation of the system identification indicator (SID) shall be as follows:



The international (INTL) codes (bits 14 and 13) shall be allocated as follows:

BIT 14	BIT 13	
0	0	United States
0	1	Other countries
1	0	Canada
1	1	Mexico

Bits 12 through 0 will be assigned to each U.S. system by the FCC. (See note 13 in preface.)

2.3.9 Local Control Option

A means must be provided within the mobile station to enable or disable the local control option.

2.3.10 Preferred-System Selection

A means must be provided within the mobile station to identify the preferred system as either System A or System B.

2.3.11 Discontinuous Transmission

Discontinuous transmission refers to the ability of certain mobile stations to switch autonomously between two transmitter power-level states ("DTX-high" and "DTX-low").

2.3.11.1 Discontinuous Transmission on an Analog Voice Channel

In the DTX-high state, the transmitter radiates at the power level indicated by the most recent power-controlling order (initial-voice-channel-designation, handoff, or power-change order) received by the mobile station. In this state the mobile station must transpond SAT at all times, except for the normal suspensions of SAT covered in 2.4.1.

In the DTX-low state, the transmitter radiates at a power level determined by the DTX-high-state power level ("DTX-high level") and the DTX_s indicator that is copied from the DTX field in Word 2 of the System Parameter Overhead Message (see 3.7.1.2.1). If the DTX_s indicator is set to '10', the DTX-low level must equal or exceed a level that is 8 dB below the DTX-high level. If the DTX_s indicator is set to '11', no minimum applies to the DTX-low level; that is, the transmitter may be turned off or it may be turned on at any level up to the DTX-high level. In the DTX-low state, the mobile station must not transpond SAT. If the DTX_s indicator is set to '00', only the DTX-high state (that is "continuous transmission") is permitted. The DTX_s indicator setting of '01' is reserved.

When a mobile station switches from the DTX-high state to the DTX-low state, it must pass through a transition state in which the transmitted power is at the DTX-high level but SAT is not transponded. The sequence must be as follows: starting in the DTX-high state, enter the transition state; remain in the transition state 300 ms; enter the DTX-low state.

When a mobile station switches from the DTX-low state to the DTX-high state, it must begin transponding SAT immediately after changing the power level, except for the normal suspensions of SAT covered in 2.4.1. Each time that the mobile station enters the DTX-high state, it must remain in that state for at least 1.5 seconds, unless it enters the DTX-high state in response to an audit order in which case it must remain in that state for at least 5 seconds. (Note that any requirement for the mobile station to remain in the DTX-high state for a certain minimum time interval does not prohibit the mobile station from leaving the conversation state before the interval ends.)

2.3.11.2 Discontinuous Transmission on a Digital Traffic Channel

In the DTX-high state, the transmitter radiates at a power level indicated by the most recent power-controlling order (initial-traffic-channel-designation, handoff, or physical layer control message) received by the mobile station. In this state the mobile station will send CDVCC at all times.

In the DTX-low state, the transmitter will remain off and the CDVCC will not be sent except for the transmission of FACCH messages. All SACCH messages to be transmitted by the mobile station while in the DTX-low state will be sent as an FACCH message after which the transmitter will return to the off state unless discontinuous transmission has been otherwise inhibited.

When a mobile station switches from the DTX-high state to the DTX-low state, it must pass through a transition state in which the transmitted power is at the DTX-high level until all pending FACCH and SACCH messages in the mobile station have been entirely transmitted.

2.3.12 Authentication, Encryption of Signaling Information/User Data and Voice Privacy

Note: Messages received during the authentication procedures that are unrelated to the authentication process shall also be processed.

2.3.12.1 Authentication

The term "authentication" refers to the process during which information is exchanged between a mobile station and the base station for the purposes of enabling the base station to confirm the identity of the mobile station. In short, a successful outcome of the authentication process occurs only when it can be demonstrated that the mobile station and base station possess identical sets of Shared Secret Data (SSD).

2.3.12.1.1 Shared Secret Data (SSD)

SSD is a 128-bit pattern stored in the mobile station (in semi-permanent memory) and readily available to the base station. As depicted in Figure 2.3.12.1-1, SSD is partitioned into two distinct subsets. Each subset is used to support a different process.

Figure 2.3.12.1.1-1
Partitioning of SSD

Contents	SSD-A	SSD-B
Length (bits)	64	64

Specifically,

SSD-A is used to support the authentication procedures; and

SSD-B is used to support voice privacy and message confidentiality.

SSD is generated according to the procedure specified in 2.3.12.1.8.

2.3.12.1.2 Random Challenge Memory (RAND)

A 32 bit value held in the mobile station. It is the concatenation of the last RAND1_A and RAND1_B values received in Random Challenge A and Random Challenge B Global Action Messages appended to the overhead message train. Both RAND1_A and RAND1_B must be received on the same control channel and in the same Overhead Message Train in order for a valid RAND to exist. $RAND_s$ is used in conjunction with SSD-A and other parameters, as appropriate, to authenticate mobile station originations, terminations and registrations.

2.3.12.1.3 Call History Parameter ($COUNT_{s-p}$)

A modulo-64 count held in the mobile station. $COUNT_{s-p}$ is updated at the mobile upon receipt of a Parameter Update Order (see Table 3.7.1–1) on the FVC or the Parameter Update Message on the FDTC (see 3.7.3.1.3.2.15).

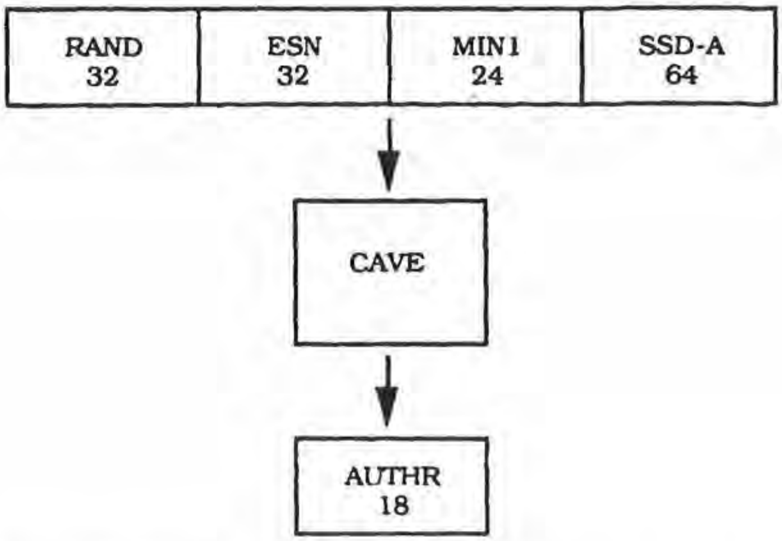
2.3.12.1.4 Authentication of Mobile Station Registrations

When the information element AUTH in the System Parameter Overhead Message is set to 1, and the mobile station attempts to register, the following authentication-related procedures shall be performed:

- In the mobile station,
  - initialize the authentication algorithm (CAVE) as illustrated in Figure 2.3.12.1.4–1;
  - execute the CAVE procedure (see 2.3.12.1.9);
  - set AUTHR equal to the 18 bits of CAVE algorithm output;
  - send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{s-p}$ to the base station (Authentication Word C of RECC Autonomous Registration Order Message).
- At the base station,
  - compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MIN1/ESN;
  - compute AUTHR as described above, except use the internally stored value of SSD-A; and
  - compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If any of the comparisons by the base station fail, the base station may deem the registration attempt unsuccessful, initiate the Unique Challenge-Response procedure (see 2.3.12.1.5), or commence the process of updating the SSD (see 2.3.12.1.8).

Figure 2.3.12.1.4-1
Computation of AUTHR for Authentication of Mobile Station Registrations



2.3.12.1.5 Unique Challenge-Response Procedure

The Unique Challenge-Response Procedure is initiated by the base station and can be carried out over any combination of control, traffic and/or voice channels.

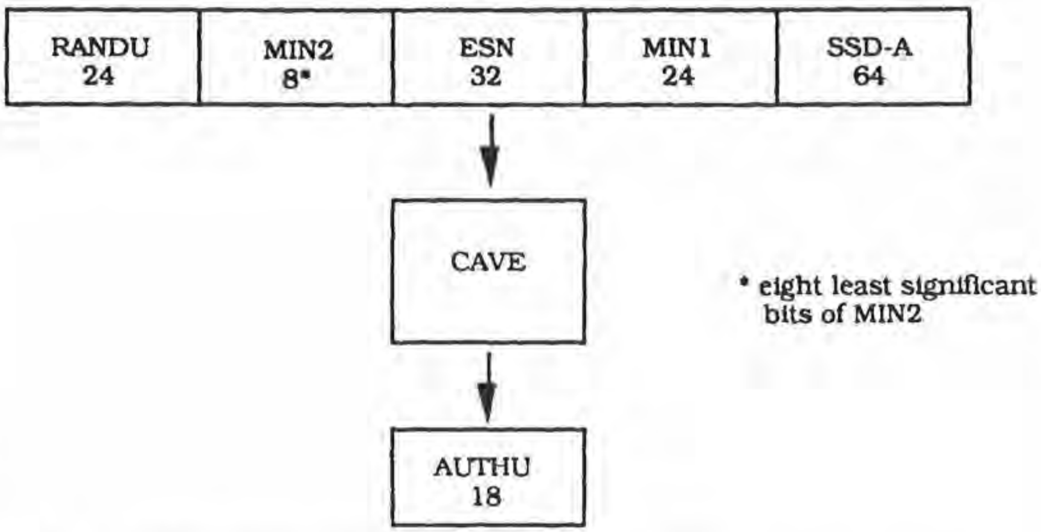
More specifically:

- At the base station,
    - a 24-bit, random pattern referred to as RANDU is generated and sent to the mobile station via:
        - the FOCC in Word 3-Unique Challenge Order Word of a mobile station control message if the procedure is to be initiated on a forward control channel (see 3.6.2.3 and 3.7.1.1); or
        - the FDTC in a Unique Challenge Order FACCH message if the mobile station has been assigned to a digital traffic channel (see 3.6.5 and 3.7.3.1.3.2.17); or
        - the FVC in Word 2-Unique Challenge Order Word of a mobile station control message (see 3.6.4 and 3.7.2.1).
    - initialize CAVE as illustrated in Figure 2.3.12.1.5-1;
    - execute the CAVE algorithm (see 2.3.12.1.9);
    - set AUTHU equal to the 18 bits of the CAVE algorithm output.
- At the mobile station,
    - compute AUTHU as described above using the received RANDU and its internally stored values for the remaining input parameters;
    - send AUTHU to the base station via:
        - the RECC in WORD C-Unique Challenge Order Confirmation Word of an order confirmation message if the mobile station is not tuned to an analog voice or digital traffic channel (see 2.6.2.3 and 2.7.1.1); or

- the FDTC in a Unique Challenge Order Confirmation FACCH message if the mobile station is tuned to a digital traffic channel (see 3.6.5 and 2.7.3.1.3.2.16); or
- the RVC in a Unique Challenge Order Confirmation message if the mobile station is tuned to an analog voice channel.

Upon receipt of the Unique Challenge Order Confirmation from the mobile station, the base station compares the received value for AUTHU to that generated/stored internally. If the comparison fails, the base station may deny further access attempts by the mobile station, drop the call in progress, or initiate the process of updating the SSD (see 2.3.12.1.8).

Figure 2.3.12.1.5-1
Computation of AUTHU for Unique Challenge-Response Procedure



2.3.12.1.6 Authentication of Mobile Station Originations

When the information element AUTH in the System Parameter Overhead Message is set to 1, and the mobile station attempts to originate a call, the following authentication-related procedures shall be performed:

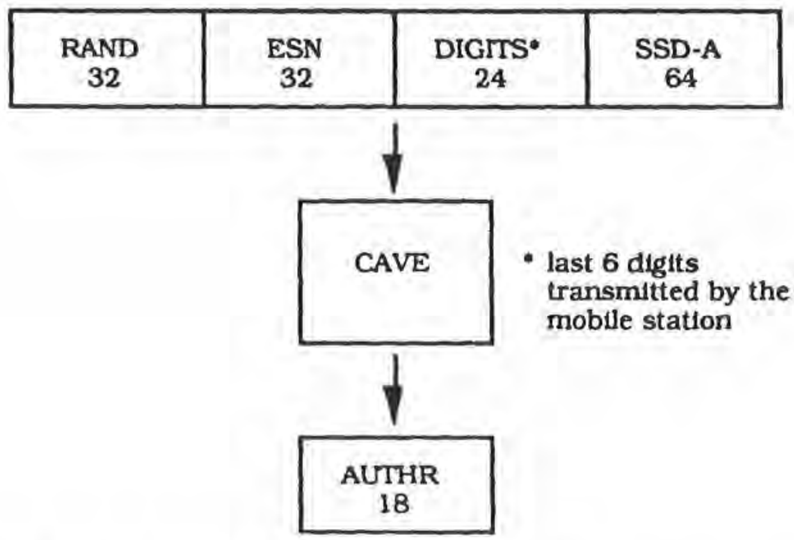
- In the mobile station,
  - initialize CAVE as illustrated in Figure 2.3.12.1.6–1;
  - execute the CAVE algorithm (see 2.3.12.1.9);
  - set AUTHR equal to the 18 bits of the CAVE algorithm output.
  - send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{s-p}$ to the base station (Authentication Word C of the RECC Origination Message);
- At the base station,
  - compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MIN1/ESN;
  - compute AUTHR as described above, except use the internally stored value of SSD-A; and

- compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If the comparisons at the base station are successful, the appropriate channel assignment procedures are commenced. Once assigned to an analog voice or digital traffic channel, the base station may, at the discretion of the system operator, issue a Parameter Update Order (see Table 3.7.1-1) to the mobile station on the FVC or a Parameter Update Message (see 3.7.3.1.3.2.15) on the FDTC. Mobile stations confirm the receipt of Parameter Update Orders by sending Parameter Update Confirmations on the RVC, and acknowledge receipt of Parameter Update Messages via Parameter Update ACK messages sent on the RDTC.

If any of the comparisons by the base station fail, the base station may deny service, initiate the Unique Challenge-Response procedure (see 2.3.12.1.5), or commence the process of updating the SSD (see 2.3.12.1.8).

Figure 2.3.12.1.6-1
Computation of AUTHR forAuthentication of Mobile Station Originations



2.3.12.1.7 Authentication of Mobile Station Terminations

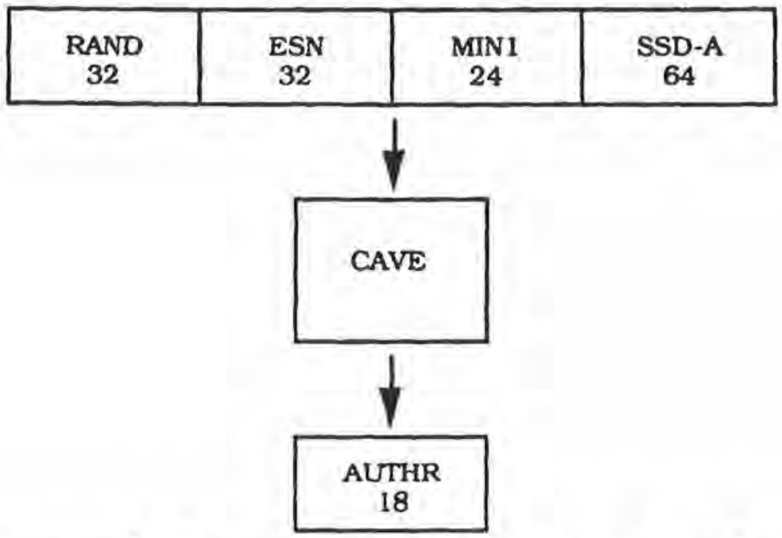
When the information element AUTH in the System Parameter Overhead Message is set to 1, and a "Page Match" occurs, the following authentication-related procedures shall be performed:

- In the mobile station,
  - initialize CAVE as illustrated in Figure 2.3.12.1.7-1;
  - execute the CAVE algorithm (see 2.3.12.1.9);
  - set AUTHR equal to the 18 bits of the CAVE algorithm output.
  - send AUTHR together with RANDC (eight most significant bits of RAND) and $COUNT_{s\text{-}p}$ to the base station (Authentication Word C of the RECC Page Response Message);
- At the base station,
  - compare the received values for RANDC, and optionally COUNT, with the internally stored values associated with the received MIN1/ESN;

- compute AUTHR as described above, except use the internally stored value of SSD-A; and
- compare the value for AUTHR computed internally with the value of AUTHR received from the mobile station.

If the comparisons at the base station are successful, the appropriate channel assignment procedures are commenced. Once assigned to an analog voice or digital traffic channel, the base station may, at the discretion of the system operator, issue a Parameter Update Order (see Table 3.7.1–1) to the mobile station on the FVC or a Parameter Update Message (see 3.7.3.1.3.2.15) on the FDTC. Mobile stations confirm the receipt of Parameter Update Orders by sending Parameter Update Confirmations on the RVC, and acknowledge receipt of Parameter Update Messages via Parameter Update ACK messages sent on the RDTC.

Figure 2.3.12.1.7-1
Computation of AUTHR for Authentication of Mobile Station Terminations



If any of the comparisons by the base station fail, the base station may deny service, initiate the Unique Challenge procedure (see 2.3.12.1.5), or commence the process of updating the SSD (see 2.3.12.1.8).

2.3.12.1.8 Updating the Shared Secret Data (SSD)

Updating the SSD involves the application of CAVE (2.3.12.1.9), initialized with mobile station specific information, random data and the mobile station's A-key.

The A-key is:

- 64 bits long;
- assigned to the mobile station;
- stored in the mobile station's permanent security and identification memory; and
- is known only to the mobile station and its associated HLR/AC.

Notes:

1. The last item in the above list is intended to enhance the security of the mobile station's secret data by eliminating the need to pass the A-key itself from system to system as the subscriber roams. As a consequence, SSD updates are carried out only in the mobile station and its associated HLR/AC, not in the serving system. The serving system obtains a copy of the SSD computed by the HLR/AC via intersystem communication (see EIA/TIA IS-41) with the mobile station's HLR/AC.
2. Since the SSD Update procedure involves multiple transactions and can be started on one channel and completed on another channel, call processing and signaling text above and beyond that normally included in this portion of the document has been included here for the sake of added clarity.

An A-key must be entered into the mobile station. See Appendix A for details.

More specifically, updating the SSD in the mobile station proceeds as follows (refer to Figure 2.3.12.1.8–1):

- At the base station,
  - send an SSD Update Order, with the RANDSSD field set to the same 56-bit random number used in the HLR/AC computations, to the mobile station on the:
    - FOCC in Word 3-First SSD Update Order Word, Word 4-Second SSD Update Order Word and Word 5-Third SSD Update Order Word of a mobile station control message if the mobile station has not been assigned to an analog voice or digital traffic channel (see 3.6.2.3 and 3.7.1.1); or
    - FDTC in a FACCH message if the mobile station has been assigned to a digital traffic channel (see 3.6.5 and 3.7.3.1.3.2.18); or
    - FVC in Word 2-First SSD Update Order Word and Word 3-Second SSD Update Order Word of a mobile station control message if the mobile station has been assigned to an analog voice channel (see 3.6.4 and 3.7.2.1).
- In the mobile station,
  - upon receipt of the SSD Update Order, initialize CAVE as illustrated in Figure 2.3.12.1.8–2;
  - execute the CAVE algorithm (see 2.3.12.1.9);
  - set SSD-A_NEW equal to the 64 most significant bits of the CAVE algorithm output, and SSD-B_NEW to the 64 least significant bits of the CAVE algorithm output;
  - select a 32-bit random number, RANDBS, and send it to the base station in a Base Station Challenge Order on the:
    - RECC in Word C-Base Station Challenge Word if the mobile station is not tuned to an analog voice or digital traffic channel (see 2.6.2.3 and 2.7.1.1); or
    - RDTC in a FACCH message if the mobile station is tuned to a digital traffic channel (see 2.6.5 and 2.7.3.1.3.2.15); or
    - RVC in Words 1 and 2 of a Base Station Challenge Order message if the mobile station is tuned to an analog voice channel (see 2.6.4 and 2.7.2.1).
  - re-initialize CAVE as illustrated in Figure 2.3.12.1.8–3;
  - execute the CAVE algorithm (see 2.3.12.1.9); and
  - set AUTHBS equal to the 18 bits of the CAVE algorithm output.

Figure 2.3.12.1.8-1
SSD Update Message Flow

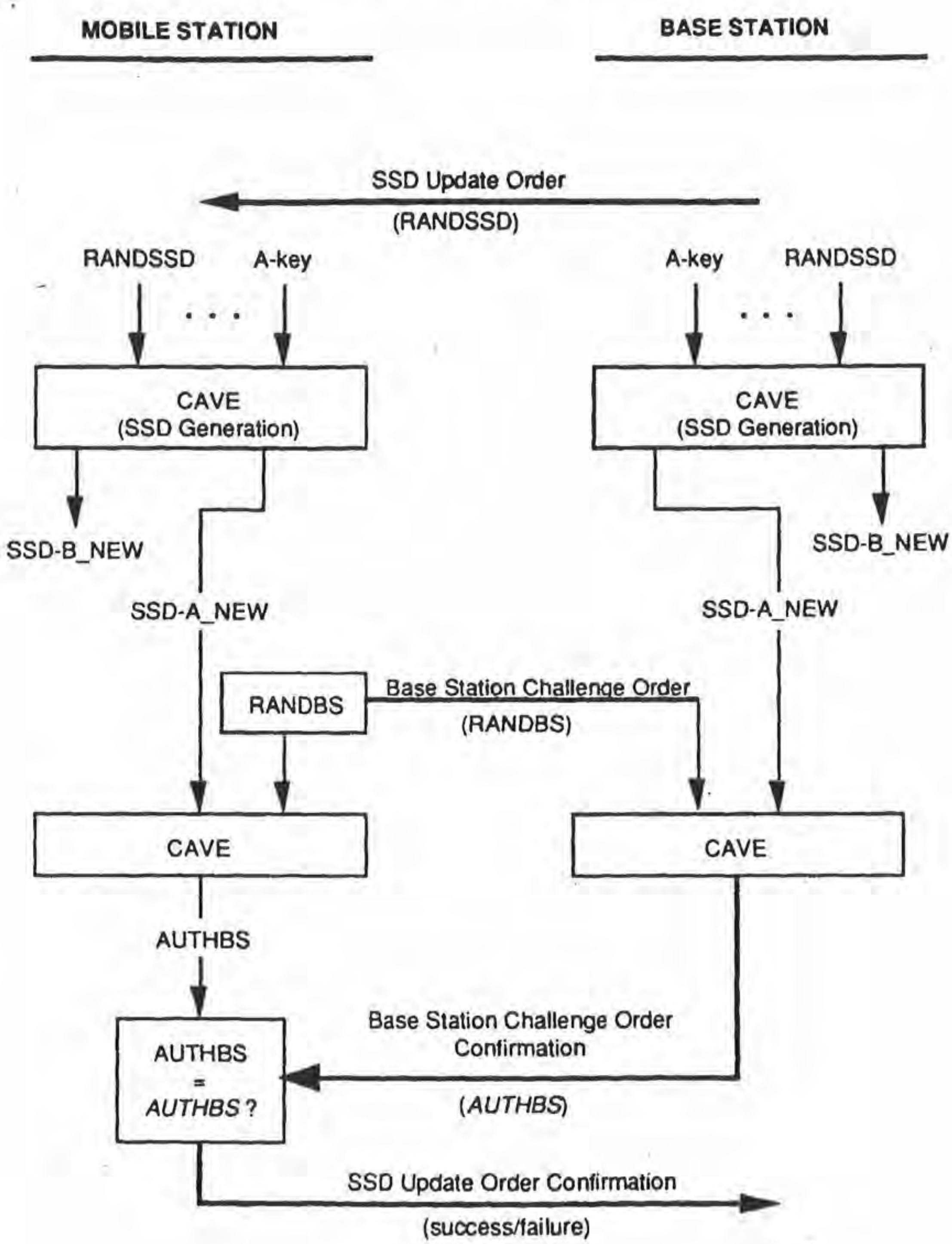


Figure 2.3.12.1.8-2
Computation of Shared Secret Data (SSD)

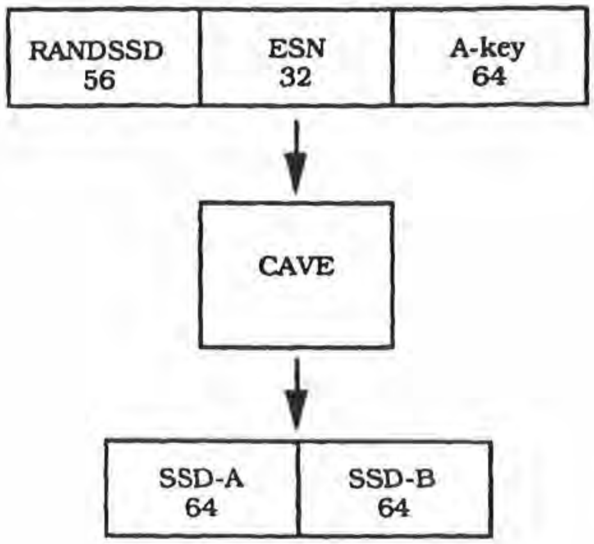
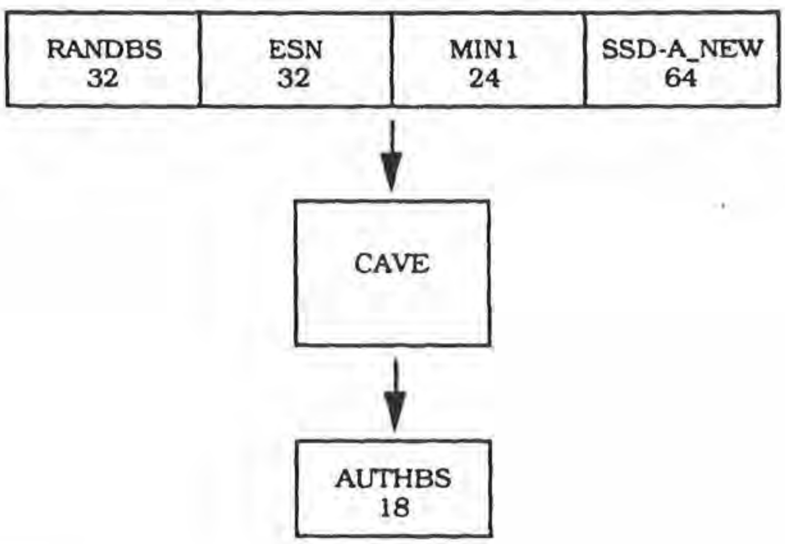


Figure 2.3.12.1.8-3
Computation of AUTHBS



- In the base station,
    - upon receipt of the Base Station Challenge Order, initialize CAVE as illustrated in Figure 2.3.12.1.8-3, where RANDBS is set to the value received in the Base Station Challenge Order;
    - execute the CAVE algorithm (see 2.3.12.1.9);
    - set AUTHBS equal to the 18 bits of the CAVE algorithm output; and

- acknowledge receipt of the Base Station Challenge Order by including AUTHBS in the Base Station Challenge Order Confirmation message, which is sent on the:
    - FOCC in Word 3-Base Station Challenge Order Confirmation Word of a mobile station control message if the mobile station has not yet been assigned to an analog voice or digital traffic channel (see 3.6.2.3, 3.6.3.3 and 3.7.1.1); or
    - FDTC in a FACCH message if the mobile station has been assigned to a digital traffic channel (see 3.6.5 and 3.7.3.1.3.2.19); or
    - FVC in Word 2-Base Station Challenge Order Confirmation of a mobile station control message if the mobile station has been assigned to an analog voice channel (see 3.6.4 and 3.7.2.1).

- In the mobile station,
    - upon receipt of the Base Station Challenge Order Confirmation, compare the AUTHBS received to that generated internally;
    - acknowledge receipt of the SSD Update Order as follows:
        - if the comparison at the mobile station is successful, set SSD-A and SSD-B to SSD-A_NEW and SSD-B_NEW, respectively, and:
            - if the mobile station is not tuned to an analog voice or digital traffic channel:
                - send an order confirmation message to the base station on the RECC with:
                    - the "T" field in Word A-Abbreviated Address Word set to '0' to identify the message as an Order Confirmation;
                    - the "ORDER" field in Word B-Extended Address Word set to '10101' to signify confirmation of the SSD Update Order;
                    - the "ORDQ" field in Word B-Extended Address Word set to '001' to denote the successful completion of the SSD Update process; and
                    - all other fields set as described in 2.7.1.1 and in the references cited therein.
            - if the mobile station is tuned to a digital traffic channel,
                - send an SSD Update Order Confirmation message to the base station on the RDTC-FACCH with the SSD_UPDATE Information Element set to '1' and all other parameters set as described in 2.7.3.1.3.2.14 and 2.7.3.1.3.3.
            - if the mobile station is tuned to an analog voice channel,
                - send an Order Confirmation message to the bast station on the RVC with:
                    - the "T" field set to '1' to identify the message as an order confirmation;
                    - the "ORDER" field set to '10101' to signify confirmation of the SSD Update order;
                    - the "ORDQ" field set to '001' to denote the successful completion of the SSD Update process; and

- all other fields set as described in 2.7.2.1 and in the references cited therein.
- If the comparison at the mobile station fails, discard SSD-A_NEW and SSD-B_NEW, and:
  - if the mobile station is not tuned to an analog voice or digital traffic channel,
    - send an order confirmation message to the base station on the RECC with:
      - the "T" field in Word A-Abbreviated Address Word set to '0' to identify the message as an Order Confirmation;
      - the "ORDER" field in Word B-Extended Address Word set to '10101' to signify confirmation of the SSD Update Order;
      - the "ORDQ" field in Word B-Extended Address Word set to '000' to denote the unsuccessful completion of the SSD Update process; and
      - all other fields set as described in 2.7.1.1 and in the references cited therein.
  - if the mobile station is tuned to a digital traffic channel,
    - send an SSD Update Order Confirmation message to the base station on the RDTC-FACCH with the SSD_UPDATE Information Element set to '0' and all other parameters set as described in 2.7.3.1.3.2.14 and 2.7.3.1.3.3.
  - if the mobile station is tuned to an analog voice channel,
    - send an Order Confirmation message to the bast station on the RVC with:
      - the "T" field set to '1' to identify the message as an order confirmation;
      - the "ORDER" field set to '10101' to signify confirmation of the SSD Update order;
      - the "ORDQ" field set to '000' to denote the unsuccessful completion of the SSD Update process; and
      - all other fields set as described in 2.7.2.1 and in the references cited therein.

In the base station, if the SSD Update Confirmation received from the mobile station indcates a success, set SSD-A and SSD-B to the values received from the HLR/AC (see EIA/TIA IS-41).

2.3.12.1.9 CAVE Algorithm

The availability of CAVE algorithm information is governed under the U.S. International Traffic and Arms Regulation (ITAR) and the Export Administration Regulations. TIA will act as the focal point and facilitator for making such information available. Procedures for distribution of this information are contained in the Technology Transfer Control Plan which applies to Appendix A of IS-54 Rev.B. The Technology Transfer Control Plan is available from TIA.

2.3.12.2 Signaling Message Encryption

In an effort to enhance the authentication process, and to protect sensitivite subscriber information (e.g., PINs), provisions have been made to allow for the encryption of a select subset of FVC, RVC, FDTC and RDTC signaling messages. Note that some fields of the messages subject to encryption are always transmitted as plain text. Order/Message Type fields, for example, are never encrypted.

Consult Appendix A for the list of messages subject to encryption, the details of the encryption algorithm and a description of how the algorithm is initialized and applied.

2.3.12.2.1 Signaling Message Encryption Control

Signaling message encryption is controlled on a per-call basis. The default value is "off". To activate signaling message encryption, the base station must initiate one of the following transactions:

- For mobile stations assigned to a digital traffic channel:
  - on the FOCC,
    - set MEM to '1' in the Initial Digital Traffic Channel Designation Message (3.7.1.1).
  - on the FDTC,
    - send a Status Request message to the mobile station with the Message Encryption Mode Information Element set to '1'; or
    - hand the mobile station off to a Digital Traffic Channel with the MEM field set to '1'.
- For mobile stations assigned to an Analog Voice Channel:
  - on the FVC,
    - send a Message Encryption Mode Order with the Order Qualifier field set to '001'; or
    - hand the mobile station off to a Digital Traffic Channel with the MEM field set to '1'.

Note that regardless of when signaling message encryption is activated, the data used to initialize the algorithm is computed based on parameters in effect at the time the AUTHR appended to the origination/page response message was computed (see 2.3.12.1.6 and 2.3.1.12.1.7).

Once activated, signaling message encryption can be deactivated by the base station as follows:

- For mobile stations assigned to Digital Traffic Channels:
  - on the FDTC,
    - send a Status Request message to the mobile station with the Message Encryption Mode Information Element set to '0'; or
    - hand the mobile station off to a Digital Traffic Channel with the MEM field set to '0'.
- For mobile stations assigned to an Analog Voice Channel:
  - on the FVC,
    - send a Message Encryption Mode Order with the Order Qualifier field set to '000'; or

- hand the mobile station off to a Digital Traffic Channel with the MEM field set to '0'.

In all cases both the base station and mobile station shall continue to operate in their present mode until the message sent to the mobile station has been properly acknowledged.

2.3.12.3 Voice Privacy

The term "voice privacy" refers to the process by which user voice transmitted over a digital traffic channel is afforded a modest degree of cryptographic protection against eavesdropping in the mobile station - base station segment of the connection.

Note that regardless of when voice privacy is activated, the data used to initialize the algorithm is computed based on parameters in effect at the time the AUTHR appended to the origination/page response message was computed (see 2.3.12.1.6 and 2.3.1.12.1.7).

2.3.12.3.1 Voice Privacy Control

Requests to activate/deactivate the voice privacy feature may be made during the call setup process or while the mobile station is in the conversation state. In either case, however, the decision to honor the request lies with the base station. Furthermore, the mobile station must not act under the assumption that the request has been granted until it receives positive verification from the base station.

2.3.12.3.1.1 Voice Privacy Control During Call Establishment

2.3.12.3.1.1.1 Mobile Station Originations

To request activation of voice privacy on mobile station originations, a digital-privacy specification is included in Word B of the RECC Origination message (Order Code = 00000, Order Qualifier = 100, Message Type = XXX1X or XX1XX).

Voice privacy is activated in the mobile station only when the PM field in the First Digital Channel Assignment Word (3.7.1) is set to 1.

2.3.12.3.1.1.2 Mobile Station Terminations

To request activation of voice privacy on mobile station terminations, a digital-privacy specification is included in Word B of the RECC Page Response message (Order Code = 00000, Order Qualifier = 100, Message Type = XXX1X or XX1XX).

Voice privacy is activated in the mobile station only when the PM field in the First Digital Channel Assignment Word (3.7.1) is set to 1.

2.3.12.3.1.2 Voice Privacy Control After Initial Channel Assignment

To request a change in the privacy mode after the mobile station has been assigned to a Digital Traffic Channel, a Status message with the Privacy Mode Information Element set to the requested value (0=privacy off, 1=privacy on) is sent to the base station on the RDTC. The mobile station continues to operate in its current mode until it receives a Base Station Ack message with the Message Type parameter set to "Status" on the FDTC.

To request voice privacy after the mobile station has been assigned to an Analog Voice Channel, a Page Response message with the Order Qualifier field set to the '100' and the Message Type field set to 'XXX1X' or 'XX1XX' is sent to the base station on the RVC. The mobile station continues to operate in its current mode until it receives the corresponding Call Mode Ack message on the FVC and is subsequently handed off to a Digital Traffic Channel where the PM field in the First Digital Channel Assignment Word has been set to '1'.

2.3.12.3.2 Cipher Placement

Enciphering shall take place after error correction coding and before interleaving. In particular, note that user voice is enciphered while still represented as bits rather than quaternary symbols. Similarly, deciphering occurs after deinterleaving.

2.3.12.3.3 Voice Privacy Algorithm

The availability of this information is governed under the U.S. International Traffic and Arms Regulation (ITAR) and the Export Administration Regulations. TIA will act as the focal point and facilitator for making such information available. Procedures for distribution of this information are contained in the Technology Transfer Control Plan which applies to Appendix A of IS-54 Rev.B. The Technology Transfer Control Plan is available from TIA.

2.4 Supervision

For supervising the connection on the traffic channel

- if the mobile station is on an analog voice channel the Supervisory Audio Tone (see 2.4.1) and the Signaling Tone (see 2.4.2) are used.
- if the mobile station is on a digital traffic channel the Digital Verification Color Code (see 2.4.3) is used.

2.4.1 Supervisory Audio Tone

The supervisory audio tone (SAT) will be one of three frequencies: 5970, 6000, or 6030 Hz. The SAT is added to the voice transmission by a base station (see 3.4.1). A mobile station must detect, filter, and modulate the transmitted voice channel carrier with this tone. Transmission of the SAT by a mobile station must be suspended during transmission of wideband data on the reverse voice channel (see 2.7.2), but must not be suspended when signaling tone is sent (see 2.4.2).

While a valid SAT is detected and the measured SAT determination does not agree with the SAT color code (SCCr) received in the mobile station control message (see 3.7.1.1 and 3.7.2), the receiver audio must be muted.

2.4.1.1 SAT Detection

A mobile station must make the following decisions to determine which SAT, if any, is present:

Measured Frequency of Incoming Signal	Measured SAT Determination	Where
$f \leq f_1$	No valid SAT	f_1 = 5955 ±5Hz
$f_1 \leq f < f_2$	SAT = 5970	f_2 = 5985 ±5Hz
$f_2 \leq f < f_3$	SAT = 6000	f_3 = 6015 ±5Hz
$f_3 \leq f < f_4$	SAT = 6030	f_4 = 6045 ±5 Hz
$f_4 \leq f$	No valid SAT	
No SAT Received	No valid SAT	

The determination of SAT is not required to be made continuously but should be performed at least every 250 ms.

2.4.1.2 SAT Transmission

The transmission requirements for the SAT signal, including time delays in the transmitter, receiver, and any equalization circuits, are summarized as follows:

Condition	Requirement
Steady-state phase difference between received and transmitted SAT at 5970, 6000, and 6030 Hz	May have any average phase but must remain within a ±10° band
Phase Step Response	Settle to within 10° of final steady state phase difference in ≤250 ms
Tone Modulation Index	1/3 radian ±10% (Δf ~ ±2 kHz)

2.4.1.3 Fade Timing Status

When an SAT determination is made a mobile station must perform the following:

- If no valid SAT is detected or the measured SAT determination does not agree with the SAT color code (SCCr) received in the mobile station control message (See 3.7.2.1 and 3.7.2), the fade timing status must be enabled (See 2.6.5.1).
- Otherwise, the fade timing status must be disabled (See 2.6.5.1).

2.4.2 Signaling Tone

Signaling tone must be 10 kHz ±1 Hz and produce a nominal frequency deviation of ±8 kHz.

2.4.3 Digital Verification Color Code

Digital channels are marked with a Coded Digital Verification Color Code, CDVCC. The CDVCC is used to distinguish the current traffic channel from traffic co-channels.

Each slot contains the CDVCC field both from mobile station to base station and base station to mobile station. The number of different Color Codes is 255 (0 is not used), corresponding to 8 bits. A DVCC of 8 bits is coded with a (15,11) Hamming code shortened to (12,8) giving a CDVCC of 12 bits (see 1.2.5).

2.4.3.1 Digital Verification Color Code, DVCC, Detection

CDVCC is present in every slot that is transmitted by the base station. In the mobile station the received CDVCC is decoded ($DVCC_r$) and is compared to the DVCC ($DVCC_s$) that has been received in the Traffic Channel Designation message or Handoff message.

At the time Traffic Channel Designation is received, the DVCC status is disabled. The subsequent detection and setting of DVCC status that must be performed by the mobile station involves the following steps:

- for each slot assemble the bits that correspond to the channel CDVCC.
- decode the field to retrieve the 8-bit DVCC. The current value of DVCC is denoted $DVCC_r$.
- the following conditions define when DVCC status changes:
  - if the 2 latest consecutive $DVCC_r = DVCC_s$ then DVCC status is enabled.
  - if the 5 latest consecutive $DVCC_r \neq DVCC_s$ then DVCC status is disabled.

2.4.3.2 DVCC Transmission

A mobile station on a digital traffic channel must in each burst set CDVCC to the coded value of $DVCC_s$, irrespective of whether DVCC status is enabled or disabled.

2.4.3.3 Fade Timing Status

A mobile station on a digital traffic channel must perform the following:

- If DVCC status is disabled the fade timing status must be enabled (see 2.6.5.1).
- Otherwise, the fade timing status must be disabled (see 2.6.5.1).

2.4.4 Supervision

2.4.4.1 Fast Associated Control Channel (FACCH)

The FACCH is a signaling channel for the transmission of control and supervision messages between the base station and mobile.

The FACCH replaces the user information block whenever system considerations deem it appropriate to do so. The FACCH is distinguished from the user information block as described in 2.7.3.1.1.5.

2.4.4.2 Slow Associated Control Channel (SACCH)

The SACCH is a signaling channel in parallel with the speech path used for transmission of control and supervision messages between the base station and the mobile.

Certain messages may be sent over either the SACCH or the FACCH. The information field structure for the messages is identical, however, the forward error correcting methods differ.

The SACCH is present in all slots transmitted over the channel whether these contain voice or FACCH information.

2.4.5 Mobile Assisted Handoff

2.4.5.1 Mobile General Operational Description

The Mobile Assisted Handoff (MAHO) function requires a mobile station to furnish RF-channel signal-quality information to its serving base station. There are two types of channels upon which the mobile performs signal quality measurements: the current forward traffic channel and any other forward RF channels.

- The current forward traffic channel is used to transmit information from the base station to the mobile during a call. Channel quality measurements consist of the mobile received signal strength (RSSI) and Bit Error Rate (BER) information.
- The forward RF channel can be any RF channel. Channel quality measurements on these RF channels consist of measured RSSI levels.

The base station identifies in the Measurement Order Message, those forward RF channels that the mobile shall measure.

2.4.5.2 Mobile Assisted Handoff Messages

MAHO consists of the following messages:

- Start Measurements order
    - Measurement Order Message
      (base station to mobile)
    - Measurement Order Acknowledge Message
      (mobile to base station)
- Stop measurements order
    - Stop Measurement Order
      (base to mobile station)
    - Mobile Ack
      (mobile to base station)
- Channel Quality Message (mobile to base station only)

2.4.5.2.1 Procedures to Start Channel Quality Measurements and Reporting

The mobile begins channel quality measurements with the reception of the start measurements order. This message identifies those forward RF channels which the base station requires the mobile to measure.

Upon receipt of this message, the mobile shall begin measurements on the current traffic channel and all forward RF channels identified in the Measurement Order Message and the mobile shall begin reporting the measurement results to the base station in the exact order specified by the Measurement Order Message (See 3.7.3.1.3.2.2).

2.4.5.2.2 Procedures to Stop Channel Quality Measurements and Reporting

A Stop Measurement Order Message terminates all channel quality measurements and reports.

2.4.5.2.3 Reporting of Measurement Results

The mobile normally reports measurement results by transmitting the information to the base station on the SACCH. The base station does not acknowledge reception of a Channel Quality Message. Conditions for transmission on FACCH are given in 2.4.5.3.

2.4.5.2.4 Measurement Status After Handoff

There is no change in measurement history after a handoff. When a new measurement order list is specified, the mobile station will maintain continuity of the time averaging process on all RF channel frequencies which are in the same positions on both the old and new lists. RF channel frequencies which are only in the new list are re-initialized.

2.4.5.3 MAHO Operations With DTX Operation

The mobile transmits the signal quality information over either the SACCH or the FACCH. In the case of continuous transmission, the mobile transmits over the SACCH. In the case of Discontinuous Transmission (DTX), the mobile transmits channel quality information over the SACCH whenever the mobile is in the DTX high state. If the mobile is in the DTX low state, the data is sent from the mobile to the base station by going to the DTX high state and transmitting the information over the FACCH.

2.4.5.4 Mobile Measurement Procedures

2.4.5.4.1 Current Traffic Channel

When MAHO procedures are activated, the mobile will measure signal strength (RSSI) and Bit Error Rate (BER) channel conditions on the current traffic channel.

2.4.5.4.1.1 Bit Error Rate (BER)

The mobile will determine an estimate of bit error information by monitoring the correctness of the data stream at the input to the channel decoder.

2.4.5.4.1.1.1 BER Measurement Technique

The mobile BER information will be derived using the following algorithm, for all types of frames.

1. Upon receipt of the Measurement Order, the mobile will clear the content of AVE_BER_SUM (average bit error summation buffer).

2. The contents of buffer AVE_BER_FR is cleared at the beginning of each frame decode. As each frame (40 ms) is decoded, the number of bit errors divided by the number of bits over which the measurement was performed is accumulated in AVE_BER_FR.
3. At the completion of each frame decode, the content of AVE_BER_FR is added to the content of AVE_BER_SUM until 25 frames of any type have been measured.
4. Once the bit errors for 25 frames have been measured, the AVE_BER value in the Channel Quality Message is derived by dividing AVE_BER_SUM by 25.
5. For frames after 25 frames have been measured, a new AVE_BER_FR is calculated according to the procedure in item 2. The new AVE_BER_SUM is calculated by multiplying the old AVE_BER_SUM by the ratio (24/25), and adding the result to the new value of AVE_BER_FR.
6. At the time a measurement message is generated, the reported bit error rate is encoded using the current AVE_BER value (in percent) as given in table 2.4.5.1-1 .

The estimated BER information shall be reported as a 3-bit pattern in the Channel Quality Message, as given in table 2.4.5.1-1.

TABLE 2.4.5.1-1

Bit pattern	AVE_BER interval (%)
000	< 0.01
001	0.01 to less than 0.1
010	0.1 to less than 0.5
011	0.5 to less than 1.0
100	1.0 to less than 2.0
101	2.0 to less than 4.0
110	4.0 to less than 8.0
111	≥ 8.0

The estimated BER shall not differ from the actual BER by more than 25% over ten reporting periods.

2.4.5.4.1.2 Signal Strength

The mobile will determine an estimate of signal strength information by monitoring the RSSI indicator.

2.4.5.4.1.2.1 Signal Strength Measurement Technique

The mobile signal strength information will be derived using the following algorithm. All calculations are in dB.

1. Upon receipt of the Measurement Order, the mobile will clear the contents of buffers RSSI_SUM (RSSI summation buffer) for each new designated channel.
2. The content of buffer RSSI_FR is cleared at the beginning of each frame decode. As a frame (40 msec) on the current channel is received, one RSSI sample will be taken and the result stored in the RSSI_FR buffer.
3. At the completion of the sampling process, the content of RSSI_FR buffer will be added to the content of RSSI_SUM buffer until 25 frames have been measured.

4. Once the the RSSI for 25 frames have been measured, the average will be taken by dividing the content RSSI_SUM by 25. This value is then stored in the RSSI_AVE buffer.

5. For frames after 25 frames have been measured:

   a. Once the RSSI sample is stored in RSSI_FR, the content of RSSI_AVE is subtracted from RSSI_SUM.

   b. The content of RSSI_FR is then added to the content of RSSI_SUM.

   c. A new RSSI_AVE value is determined by dividing RSSI_SUM by 25 and storing the result in RSSI_AVE.

6. The value of RSSI_AVE contained in the Channel Quality Message is derived by encoding the value contained in the RSSI_AVE buffer as defined in Table 2.4.5.1-2. This encoding function is performed when the Channel Quality Message is generated.

The estimated RSSI information shall be reported as a 5-bit pattern in the Channel Quality Message, as given in table: 2.4.5.1-2. An RSSI value of -113 dBm or less is reported as binary '0', above that in steps of 2 dB until -51 dBm or higher that is reported as binary '11111'.

TABLE 2.4.5.1-2

Bit pattern	RSSI_AVE interval
00000	-113 dBm or less
00001	-111 dBm
00010	-109 dBm
00011	-107 dBm
.	.
.	.
.	.
11110	-53 dBm
11111	-51 dBm or greater

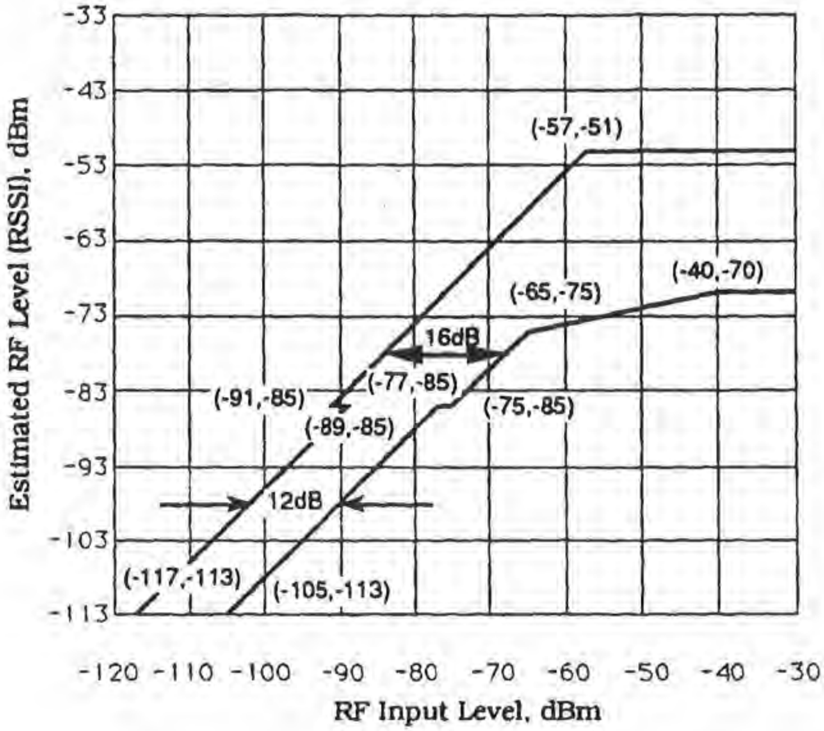
The RSSI shall increase monotonically with received RF signal strength.

The absolute accuracy of RSSI is specified in Figure 2.4.5.1-1.

The relative accuracy, defined as the error in dB, between the difference of two estimated RF levels and the difference between the corresponding RF input levels, is ±3dB in the range -105 to -85dBm of estimated RF levels. In addition, if the estimated RF levels spans a wider rage, from -105 to -75dBm, the relative accuracy shall be ±5dB.

Over the temperature range -30°C to +60°C, the above accuracies shall hold.

Figure 2.4.5.1-1 Absolute RSSI Accuracy



2.4.5.4.2 Measurement Procedures for R.F. Channels Other Than the Current Channel

When Mobile Assisted Handoff procedures are activated, the mobile will measure the RSSI of one entry of the measurement order channel list during an idle time slot each 20 msec. interval (1/2 frame).

The sequence designated in the Measurement Order Message will be used to determine which entry will be measured during a specific frame. The mobile station will start with the first entry in the list, and the sequence will repeat until the reception of a Stop Measurement Order or a null set Measurement Order. The RSSI sampling and averaging are the same as those for the current channel except that the minimum number of samples per channel is 4. The number of samples is determined by the number of channels designated in the Measurement Order and is an integer obtained by dividing 50 by the number of channels sent in the order. The reporting interval is determined by the current channel operation as described in section 2.4.5.4.1.2.1 and 2.4.5.4.3.

2.4.5.4.3 Reporting Interval Determination

At the receipt of a Measurement Order Message, the mobile will clear the FR_CNT buffer associated with that traffic channel. Upon reception of each frame (40 msec.) this count will be incremented. When the count reaches 25, a flag, CQM_RDY is set. The Channel Quality Message is generated as described in section 2.4.5.4.1.2. At that time the FR_CNT buffer and CQM_RDY flag are reset and the procedure is repeated until a Stop Measurement Order or a Disconnect Message is received or a Disconnect Message is generated.

2.5 Malfunction Detection

2.5.1 Malfunction Timer

A timer separate from and independent of all other functions must be running continuously whenever power is applied to the transmitter of a mobile station. If the mobile station is software-controlled, sufficient reset commands must be interspersed throughout the mobile station logic program to ensure that the timer never expires as long as the proper sequence of operations is taking place; similar means must be provided, as appropriate, in hardware-controlled designs. If the timer expires, a malfunction must be assumed and the mobile station must be inhibited from transmitting. The maximum time allowed for expiration of the timer is 60 seconds.

This supersedes the requirement for a transmitter carrier-on indicator.

2.5.2 False Transmission

A protection circuit must be provided to minimize the possibility of false transmitter operation caused by component failure within the mobile station.

2.6 Call Processing

The following sections describe mobile station operation as controlled by a base station. Frequent references are made to the corresponding sections in the base station section and to the messages that flow between a base station and a mobile station. It is helpful to read 2.6 and 3.6 in parallel and examine the message formats in 2.7 and 3.7 at the same time.

When power is applied to a mobile station, it should enter Initialization at the Retrieve System Parameters task.

2.6.1 Initialization

2.6.1.1 Retrieve System Parameters

If this task has been entered as a result of a power up condition the mobile station shall set the Location-Registration ID status to enabled, set the First-Idle ID status to enabled and shall set $PUREG_S = 0$, $PDREG_S = 0$, $LREG_S = 0$, and $RAND_s = 0$.

If the preferred system is System A, set the serving system-status to enabled; if the preferred system is System B, set the serving-system status to disabled.

The mobile station must then enter the Scan Primary Set Of Dedicated Control Channels task (see 2.6.1.1.1).

2.6.1.1.1 Scan Primary Set of Dedicated Control Channels

If the serving system status is enabled, a mobile station must:

- Set $FIRSTCHD_S$ to the first dedicated control channel for System A (834.990 MHz/879.990 MHz).
- Set $LASTCHD_S = FIRSTCHD_S - 21 + 1$.

If the serving-system status is disabled, a mobile station must:

- Set $FIRSTCHD_S$ to the first dedicated control channel for System B (835.020 MHz/880.020 MHz).
- Set $LASTCHD_S = FIRSTCHD_S + 21 - 1$.

The mobile station examines the signal strength on each of the channels $FIRSTCHD_S$ TO $LASTCHD_S$.

The mobile station must then enter the Update Digital Overhead Information task (see 2.6.1.1.2).

2.6.1.1.2 Update Digital Overhead Information

Overhead messages are sent in a group called an overhead message train. The mobile station must use the value given in the NAWC (number of additional words coming) field of the System Parameter Overhead Message in the train to determine that all messages of the train have been received. The END field must be used as a cross-check. For NAWC counting purposes, inserted control filler messages must not be counted as part of the overhead message train.

If the mobile station receives a correctly decoded but unrecognizable System Parameter Overhead Message, the mobile station must count that message as part of the train for NAWC counting purposes, but must not attempt to execute the message.

The mobile station must tune to the strongest dedicated control channel and, within 3 seconds, receive a System Parameter Overhead Message (see 3.7.1.2) and update the following numeric information:

- System identification (SID_s). Set the 14 most significant bits of SID_s to the value of the SID 1 field. Set the least significant bit of SID_s to '1' if the serving-system status is enabled otherwise, set the bit to '0'.
- Protocol Capability Indicator. Set PCI_s to the value of the PCI field.
- Number of paging channels (N_s). Set N_s to 1 plus the value of the N - 1 field.
- First paging channel ($FIRSTCHP_s$). Set $FIRSTCHP_s$ according to the following algorithm:
  - If $SID_s = SID_p$, $FIRSTCHP_s = FIRSTCHP_{p\text{-}pri}$
  - If $SID_s \neq SID_p$, $FIRSTCHP_s = FIRSTCHD_s$
- Last paging channel ($LASTCHP_s$). Set $LASTCHP_s$ according to the following algorithm:
  - If the serving-system status is enabled, $LASTCHP_s = FIRSTCHP_s - N_s+1$.
  - If the serving-system status is disabled, $LASTCHP_s = FIRSTCHP_s + N_s-1$.

The mobile station must:

- Set registration increment ($REGINCR_s$) to its default value of 450.
- Set the first registration ID status to enabled and set the first-location-area ID status to enabled.

If PCI_s indicates Analog Only the mobile station may enter the Scan Secondary Set Of Dedicated Control Channel task (see 2.6.1.3).

If PCI_s indicates Digital Capability the mobile station shall enter the Primary Paging Channel Selection task (see 2.6.1.2).

If the mobile station cannot complete this task on the strongest dedicated control channel, it shall tune to the second strongest dedicated control channel and attempt to complete this task within a second 3-second interval. If it cannot complete this task on either of the two strongest control channels, the mobile station may check the serving-system status: If the serving-system is enabled, it may be disabled: if the serving-system status is disabled, it may be enabled. The mobile station must then enter the Scan Primary Set of Dedicated Control Channels (see 2.6.1.1.1)

2.6.1.2 Primary Paging Channel Selection

2.6.1.2.1 Scan Paging Channels

The mobile station must examine the signal strength on each of channels $FIRSTCHP_s$ to $LASTCHP_s$ (see 2.6.1.1.1)

The mobile station must then enter the Verify Overhead Information task (see 2.6.1.5).

2.6.1.3 Scan Secondary Set of Dedicated Control Channels

If the serving-system status is enabled, a mobile station must:

- Set $FIRSTCHD_s$ to the first dedicated control channel in the second set of control channels for System A (846.240MHz/891.240MHz).

- Set $LASTCHD_S = FIRSTCHD_S - 21 + 1$.

If the serving-system status is disabled, a mobile station must

- Set $FIRSTCHD_S$ to the first dedicated control channel in the second set of control channels for System B (847.110MHz/892.110MHz).
- Set $LASTCHD_S = FIRSTCHD_S + 21 - 1$.

The mobile station must then examine the signal strength on each of the channels $FIRSTCHD_S$ to $LASTCHD_S$.

The mobile station must then enter the Update Secondary Control Channels task (see 2.6.1.3.1).

2.6.1.3.1 Update Secondary Control Channels

Overhead messages are sent in a group called an overhead message train. The mobile station must use the value given in the NAWC (number of additional words coming) field of the system parameter overhead message in the train to determine that all messages of the train have been received. The END field must be used as a cross- check. For NAWC counting purposes, inserted control filler messages must not be counted as part of the overhead message train.

If the mobile station receives a correctly decoded but unrecognizable System Parameter Overhead Message, the mobile station must count that message as part of the train for NAWC counting purposes, but must not attempt to execute the message.

The mobile station must tune to the strongest dedicated control channel and, within 3 seconds, receive a system parameter message (see 3.7.1.2) and update the following numeric information:

- System identification (SID_S). Set the 14 most significant bits of SID_S to the value of the SID1 field. Set the least significant bit of SID_S to '1' if the serving-system status is enabled otherwise, set the bit to '0'.
- Protocol Capability Indicator. Set PCI_S to the value of the PCI field.
- Number of paging channels (N_S). Set N_S to 1 plus the value of the N - 1 field.
- First paging channel ($FIRSTCHP_S$). Set $FIRSTCHP_S$ according to the following algorithm:
  - If $SID_S = SID_p$, $FIRSTCHP_S = FIRSTCHP_{p\text{-}sec}$
  - If $SID_S \neq SID_p$, $FIRSTCHP_S = FIRSTCHD_S$
- Last paging channel ($LASTCHP_S$). Set $LASTCHP_S$ according to the following algorithm:
  - If the serving-system status is enabled, $LASTCHP_S = FIRSTCHP_S - N_S + 1$.
  - If the serving-system status is disabled, $LASTCHP_S = FIRSTCHP_S + N_S - 1$.

The mobile station must:

- Set registration increment ($REGINCR_S$) to its default value of 450.
- Set the first registration ID status to enabled and set the first-location-area ID status to enabled.

The mobile station must enter the Secondary Paging Channel Selection task (see 2.6.1.4).

If the mobile station cannot complete this task on the strongest dedicated control channel, it may tune to the second strongest dedicated control channel and attempt to complete this task within a second 3-second interval. If it cannot complete this task on either of the two strongest control channels, the mobile station must enter the Primary Paging Channel Selection (see 2.6.1.2)

2.6.1.4 Secondary Paging Channel Selection

2.6.1.4.1 Scan Paging Channels

The mobile station must examine the signal strength on each of the channels $FIRSTCHP_s$ to $LASTCHP_s$ (see 2.6.1.3)

The mobile station must then enter the Verify Overhead Information task (see 2.6.1.5).

2.6.1.5 Verify Overhead Information

The mobile station must set the Wait-for-Overhead-Message bit ($WFOM_s$) to '0'; the mobile station must then tune to the strongest paging channel and, within 3 seconds, receive an overhead message train (see 3.7.1.2) and update the following:

- *System identification*: Set the 14 most significant bits of SID_r to the value of the SID1 field. Set the least significant bit of SID_r to '1' if the serving-system status is enabled; otherwise, set the bit to '0'.
- ROAM *status*: The mobile station must compare the received system identification (SID_r) with the stored system identification (SID_s). If $SID_r = SID_s$, the mobile station must compare SID_s with SID_p. If $SID_p = SID_s$, the mobile station must set the ROAM status to disabled. If $SID_p \neq SID_s$, the mobile station must set the ROAM status to enabled. If $SID_r \neq SID_s$, the mobile station must enter the Retrieve System Parameters task (see 2.6.1.1).
- *Local control status*: If the local control option is enabled within the mobile station (see 2.3.9) and the bits of the home system identification (SID_p) that comprise the group identification match the corresponding bits of SID_s, then the local control status must be enabled. Otherwise, the local control status must be disabled.

The mobile station must then enter Idle at the Response to Overhead Information task (see 2.6.2.1).

If the mobile station cannot complete this task on the strongest paging channel, it may tune to the second strongest paging channel and attempt to complete this task within a second 3- second interval. If it cannot complete this task on either of the two strongest paging channels, the mobile station may check the serving-system status: If the serving-system status is enabled, it may be disabled; if the serving-system status is disabled, it may be enabled. The mobile station must then enter the Scan Primary Set of Dedicated Control Channels task (see 2.6.1.1.1).

2.6.2 Idle

During the Idle task, a mobile station must execute each of the following four (sub)tasks (see 2.6.2.1, 2.6.2.2, 2.6.2.3, and 2.6.2.4) at least every 46.3 ms, the periodicity of word blocks on the forward control channel. If the mobile station is not listening to a control channel of the preferred system, it may exit this task and enter Initialization at the Retrieve System Parameters task (see 2.6.1.1).

2.6.2.1 Response to Overhead Information

Whenever a mobile station receives an overhead message train (see 3.7.1.2), the mobile station must compare SID_s with SID_r. If $SID_s \neq SID_r$, the mobile station must exit the Idle task and enter the Initialization task at Retrieve System Parameters (see 2.6.1).

If $SID_s = SID_r$, the mobile station must set the random challenge received status to disabled and update the following numeric values using information contained in the system parameter overhead message:

- *Serial number bit* (S_s): Set S_s to the value in the S field.
- *Registration bit* (R_s): If the roam status is disabled, set R_s to the value of the REGH field; if the roam status is enabled, set R_s to the value of the REGR field.
- *Extended address bit* (E_s): Set E_s to the value in the E field.
- *Authentication bit* ($AUTH_s$): Set $AUTH_s$ to the value in the AUTH field.
- *Discontinuous transmission bit* (DTX_s): Set DTX_s to the value of the DTX field.
- *Number of paging channels* (N_s): Set N_s to 1 plus the value of the N-1 field.
- *Read-control-filler bit* (RCF_s): Set RCF_s to the value of the RCF field.
- *Combined paging/access bit* (CPA_s): Set CPA_s to the value of the CPA field.
- *Number of access channels* ($CMAX_s$): Set $CMAX_s$ to 1 plus the value of the CMAX-1 field.
- Determine control channel boundaries for accessing the system ($FIRSTCHA_s$ and $LASTCHA_s$) by using the following algorithm:
    - If the serving-system status is enabled,
        - If $CPA_s = 1$, set $FIRSTCHA_s$ to $FIRSTCHP_s$ for System A.
        - If $CPA_s = 0$, set $FIRSTCHA_s$ to $FIRSTCHP_s$ for System A minus N_s
        - $LASTCHA_s = FIRSTCHA_s - CMAX_s + 1$.
    - If the serving-system status is disabled,
        - If $CPA_s = 1$, set $FIRSTCHA_s$ to $FIRSTCHP_s$ for System B.
        - If $CPA_s = 0$, set $FIRSTCHA_s$ to $FIRSTCHP_s$ for System B plus N_s
        - $LASTCHA_s = FIRSTCHA_s + CMAX_s - 1$.

If CPA is set to 0, each dual-mode mobile, regardless of the mode it is operating in, must perform all the paging functions described in 2.6.2.2 to 2.6.3.14 on the nominal Access Channel and all the access functions described in 2.6.2.2 to 2.6.3.14 on the nominal Paging Channel. A dual-mode mobile station will immediately select the strongest nominal Access Channel to wait for paging messages after the current overhead message train.

If $SID_S = SID_{S-p}$, $PUREG_{S-p} = 1$ and the first-idle ID status is enabled the mobile station shall initiate an autonomous registration by entering the System Access task (see 2.6.3) with a "registration" indication.

The mobile station must then respond as indicated to each of the following messages, if received in the overhead message train. The order in which the mobile station must respond to the messages, if two or more are received, is given by their order in the following list:

1. *Local Control Messages:* If the local control status is enabled (see 2.6.1.5) the mobile station must respond to the Local Control Messages.
2. New Access Channel Set Message:
   - The mobile station must set $FIRSTCHA_s$ to the value of the NEWACC field of the message.
   - The mobile station must set $LASTCHA_s$ according to the following algorithm:
     - If the serving-system status is enabled, $LASTCHA_s = NEWACC_r - CMAX_s + 1$.
     - If the serving-system status is disabled, $LASTCHA_s = NEWACC_r + CMAX_s - 1$.
3. *Registration Increment Message:* The mobile station must set $REGINCR_s$ to the value of the REGINCR field in the message.
4. *Location Area Message:* The mobile station must set $PUREG_S$, $PDREG_S$, $LREG_S$ and $LOCAID_S$ to the values contained in the corresponding fields of the received message and then set $PUREG_{S-p}$ equal to $PUREG_S$.
   - If $PUREG_S = 1$ and the location -registration ID status is enabled the mobile station must set the first-registration ID status to enabled (see 2.6.1.1.2) and set first-location-area ID status to disabled (see 2.6.1.1.2). The mobile station must then initiate an autonomous registration by entering the System Access task (see 2.6.3) with a "registration" indication.
   - If $LOCAID_{S-p} \neq LOCAID_S$ and $LREG_S = 1$ the mobile station must do the following:
     - If the first-location-area ID status is disabled the mobile station must set the first-registration ID status to enabled (see 2.6.1.1.2) and then initiate an autonomous registration by entering the System Access task (2.6.3) with a "registration" indication.
     - If the first-location-area ID status is enabled and $PUREG_{S-p}=1$, the mobile station must set the first-location-area ID status to disabled (see 2.6.1.1.2) and then enter the Autonomous Registration Update task (see 2.6.3.11), supplying a "success" indication.
     - If the first-location-area ID status is enabled and $PUREG_{S-p}=0$, the mobile station must set the first-location-area ID status to disabled (see 2.6.1.1.2) and then initiate an autonomous registration by entering the System Access task (see 2.6.3) with a "registration" indication.

     Otherwise, the mobile station shall set set the first-location-area ID status to disabled (see 2.6.1.1.2).
   - The mobile station shall continue to process messages in the overhead message train.
5. *Random Challenge A Message:* The mobile station must set the corresponding portion of its internal $RAND1_s$ to the value of the RAND1_A field in the Global Action Message (see 2.3.12.1.2 for updating of RAND)

6. *Random Challenge B Message:* The mobile station must set the corresponding portion of its internal $RAND1_s$ to the value of the RAND1_B field in the Global Action Message (see 2.3.12.1.2 for updating of RAND). The mobile station must also set the random challenge received status to enabled.
7. *Registration ID Message:* The mobile station must perform the following:
   - The mobile station must set $REGID_s$ to the value of the REGID field of the received message. If the first-registration ID status is enabled and the location-registration ID status is disabled the mobile station must do the following:
     - set the first-registration ID status to disabled (see 2.6.1.1.2).
     - if autonomous registration is enabled, the mobile station must enter the Autonomous Registration Update task (see 2.6.3.11), supplying a "success" indication.
     - the mobile station shall continue to process information in the overhead message stream.

     Otherwise, the mobile station shall set the first-registration ID status to disabled (see 2.6.1.1.2) and proceed as folows
   - If SID_s equals the $SID_{s\text{-}p}$ value stored in the registration memory, the mobile station must perform the following:
     - The mobile station must use the following (or an equivalent) algorithm to review the $NXTREG_{s\text{-}p}$ associated with the $SID_{s\text{-}p}$ to determine if $REGID_s$ has cycled through zero:
       - If $NXTREG_{s\text{-}p}$ is greater than or equal to $REGID_s + REGINCR_s + 5$, then $NXTREG_{s\text{-}p}$ must be replaced by the greater of 0 or $NXTREG_{s\text{-}p} - 2^{20}$.
       - Otherwise do not change $NXTREG_{s\text{-}p}$.
     - The mobile station must then compare $REGID_s$ with the $NXTREG_{s\text{-}p}$ associated with the $SID_{s\text{-}p}$.
       - If $REGID_s$ is greater than or equal to $NXTREG_{s\text{-}p}$ and autonomous registration is enabled, the mobile station must set the first-registration ID status to disabled (see 2.6.1.1.2) and then enter the System Access task with a "registration" indication (see 2.6.3).
       - If $REGID_s$ is greater than or equal to $NXTREG_{s\text{-}p}$ and autonomous registration is not enabled, then set $NXTREG_{s\text{-}p}$ equal to $REGID_s$.
       - Otherwise, the mobile station must ignore the message and continue to process messages in the overhead message train.
   - If SID_s is not equal to the $SID_{s\text{-}p}$ value stored in the registration memory, the mobile station must perform the following:
     - If autonomous registration is enabled, the mobile station must set the first-registration ID status to disabled (see 2.6.1.1.2), and if the random challenge received status is disabled, the mobile station must set $RAND_s = 0$. The mobile station must then enter the System Access task with a "registration" indication supplied (see 2.6.3).
     - Otherwise, the mobile station must ignore the message and continue to process messages in the overhead message train.
8. *Rescan Message:* The mobile station must immediately exit this task and enter the Initialization task (see 2.6.1).
9. *Any Other Message:* Ignore message.

2.6.2.2 Page Match

The mobile station must monitor mobile station control messages for page messages (see 3.7.1.1).

- If the ROAM status is disabled, the mobile station must attempt to match $MIN1_p$ to $MIN1_r$ for one-word messages and both $MIN1_p$ and $MIN2_p$ to $MIN1_r$ and $MIN2_r$, respectively, for two-word messages. All decoded MIN bits must match to cause the mobile station to respond to the message.
- If the ROAM Status is enabled, the mobile station must attempt to match both $MIN1_p$ and $MIN2_p$ to $MIN1_r$ and $MIN2_r$, respectively. All decoded MIN bits must match to cause the mobile station to respond to the order.

When a match occurs, the mobile station must enter the System Access task with a "page response" indication (see 2.6.3).

2.6.2.3 Order

The mobile station must monitor mobile station control messages for orders and must attempt to match both $MIN1_p$ and $MIN2_p$ to $MIN1_r$ and $MIN2_r$, respectively. All decoded MIN bits must match to cause the mobile station to respond to the order. The responses to the following orders are:

- *Abbreviated Alert:* The mobile station must enter the System Access Task (see 2.6.3) with an "order confirmation" indication.
- *Audit order:* The mobile station must enter the System Access task (see 2.6.3) with an "order confirmation" indication.
- *Local control order:* The action to be taken depends on the local control field.
- *SSD update order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. The mobile station must then enter the System Access Task (see 2.6.3) with a "base station challenge" indication.
- *Unique challenge order:* The mobile station executes the Unique Challenge procedure as in 2.3.12.1.5. The mobile station must then enter the System Access Task (see 2.6.3) with an "order confirmation" indication.
- *Message waiting order:* If the mobile station is capable of performing Message Waiting Notification, the mobile station shall indicate the presence of messages waiting based on the information contained in the message type field of the Message Waiting order (i.e., 0 for clear or no messages, other non-zero values indicate the number of messages waiting). The mobile station then enters the System Access Task (see 2.6.3) with an "order confirmation" indication.
- *Any other order:* Ignore order.

2.6.2.4 Call Initiation

When the user initiates a call, the System Access task (see 2.6.3) must be entered with an "origination" indication.

2.6.2.5 Non-Autonomous Registration Initiation

If R_6=1, the mobile station may initiate a non-autonomous registration by entering the System Access task (see 2.6.3) with a "registration" indication.

2.6.2.6 Power Down

If the mobile station is intentionally removed from the air interface while in the Idle task and $PDREG_S = 1$ the mobile station must initiate an autonomous registration by entering the System Access task (see 2.6.3) with a "power down registration" indication.

2.6.3 System Access

2.6.3.1 Set Access Parameters

If a mobile station power down occurs during a system access and $PDREG_S$ = 1 the mobile station must terminate its access procedures and initiate an autonomous registration by entering the System Access task (see 2.6.3) with a "power down registration" indication.

When the System Access task is started, a timer, called the access timer, must be set as follows:

- If this is an origination, to a maximum of 12 seconds.
- If this is a page response, to a maximum of 6 seconds.
- If this is an order response, to a maximum of 6 seconds.
- If this is a registration other than power down registration, to a maximum of 6 seconds.
- If this is a power down registration, to a maximum of 3 seconds.
- If this is a Base Station Challenge, to a maximum of 6 seconds.

The mobile station must set the last-try code (LT_S) to '0' and then enter the Scan Access Channels task (see 2.6.3.2).

2.6.3.2 Scan Access Channels

The mobile station must examine the signal strength on each of the channels $FIRSTCHA_s$ to $LASTCHA_s$ and choose up to two channels with the strongest signals. See 2.6.2.1 Response to Overhead Information task for access channel set determination.

The mobile station must then tune to the strongest access channel and enter the Retrieve Access Attempts Parameters task (see 2.6.3.3).

2.6.3.3 Retrieve Access Attempt Parameters

The mobile station must set the maximum-number-of-seizure-attempts allowed ($MAXSZTR_{sl}$) to a maximum of 10, and the maximum-number- of-busy-occurrences ($MAXBUSY_{sl}$) to a maximum of 10.

The mobile station must then initialize the following to zero:

- Number of busy occurrences ($NBUSY_{sv}$)
- Number of unsuccessful seizure attempts ($NSZTR_{sv}$)

The mobile station must then examine the read control-filler bit (RCF_s).

- If RCF_s = 0, the mobile station must then within 400 ms (+ 100 ms, -0 ms) set DCC_s to the value in the DCC field of a received message, set $SDCC1_s$ and $SDCC2_s$ to 0, and set the power level (PL_s) to 0.
- If RCF_s = 1, the mobile station must then within 1000 ms (+ 100 ms, -0 ms) read a control-filler message, set DCC_S, $WFOM_S$, $SDCC1_s$ and $SDCC2_s$ to the values in the DCC, WFOM, SDCC1 and SDCC2 fields of the message, respectively, and set PL_s to the power level given by Table 2.1.2-1 for the value of the CMAC field of the message and the mobile station power class (see 2.1.2.2, 2.3.3, and 3.7.1.2.4).

If the DCC field or the control-filler message is not received within the time allowed, then the mobile station must examine the access timer. If the access timer has expired, the mobile station must enter the Serving-System Determination task (see 2.6.3.12). If the access timer has not expired, the mobile station must enter the Alternate Access Channel task (see 2.6.3.13).

The mobile station must then set BIS_s to '1' and examine the $WFOM_s$ bit.

- If $WFOM_s = 1$, the mobile station must enter the Update Overhead Information task (see 2.6.3.4).
- If $WFOM_s = 0$, the mobile station must wait a random delay. Each time it waits a random delay, a random delay must be generated with the time uniformly distributed in the interval 0 to 92 ±1 ms and, if quantized, with granularity no more than 1 ms. The mobile station must then enter the Seize Reverse Control Channel task (see 2.6.3.5).

2.6.3.4 Update Overhead Information

If this task is not completed within 1.5 seconds, the mobile station must exit this task and enter the Serving-System Determination task (see 2.6.3.12). If the Update Overhead Information task is completed, the mobile station must enter the Seize Reverse Control Channel task (see 2.6.3.5)

The mobile station must receive an overhead message train (see 3.7.1.2)

If the access is a registration access, the mobile station shall perform the following:

- Update System Identification (SID_r). Set the 14 most significant bits of SID_r to the value of the SID1 field. Set the least significant bit of SID_r to "1" if the serving-system status is enabled; otherwise, set the bit to "0".
- The mobile station must then compare SID_r with SID_s. If $SID_r \neq SID_s$, the mobile station must exit the Update Overhead Information task and enter the Serving System Determination task (see 2.6.3.12). Otherwise, the mobile station shall continue to process this task.

The mobile station must act as indicated below in response to the following global action messages, if received in the message train:

- *Overload Control Message.*
  - If this access is an origination, the mobile station must examine the value of the overload class field (OLC) identified by $ACCOLC_p$. If the identified OLC field is set to '0', the mobile station must exit this task and enter the Serving-System Determination task (see 2.6.3.12); if the identified OLC field is set to '1', the mobile station must continue to respond to messages in the overhead message train.
  - Otherwise, the mobile station must continue to respond to messages in the overhead message train.
- *Access Type Parameters Message:* The busy-idle status bit (BIS_s) must be set to the value of the BIS field of the received message.
- *Random Challenge A Message:* The mobile station must set the corresponding portion of its internal $RAND1_s$ to the value of the RAND1_A field in the Global Action Message (see 2.3.12.1.2 for updating of RAND).
- *Random Challenge B Message:* The mobile station must set the corresponding portion of its internal RAND1s to the value of the RAND1_B field in the Global Action Message (see 2.3.12.1.2 for updating of RAND).

- *Access Attempt Parameters Message*: The mobile station must update the following parameters:
  - If this access is a page response,
    - Maximum number of seizure tries allowed ($MAXSZTR_{sl}$) must be set to the value of the MAXSZTR-PGR field of the received message.
    - Maximum number of busy occurrences allowed ($MAXBUSY_{sl}$) must be set to the value of the MAXBUSY-PGR field of the received message.
  - Otherwise,
    - Maximum number of seizure tries allowed ($MAXSZTR_{sl}$) must be set to the value of the MAXSZTR-OTHER field of the received message.
    - Maximum number of busy occurrences allowed ($MAXBUSY_{sl}$) must be set to the value of the MAXBUSY-OTHER field of the received message.

If the access is a registration access, the mobile station must respond as indicated to the registration identification message, if received in the overhead message train:

- The mobile station must set $REGID_s$ to the value of the REGID field in the message.

After the overhead message train is received and processed as required above, the mobile station must wait a random time. Each time this task is executed, a different random delay must be generated, distributed uniformly in the interval 0 to 750 ms, and if quantized, with granularity no greater than 1 ms. At the end of the delay, the mobile station must enter the Seize Reverse Control Channel task (see 2.6.3.5).

2.6.3.5 Seize Reverse Control Channel

The mobile station must read the busy-idle bits of the channel (see 3.7.1).

- If the channel is busy, the mobile station must increment $NBUSY_{sv}$ by 1.
  - If $NBUSY_{sv}$ exceeds $MAXBUSY_{sl}$, then the mobile station must exit this task and enter the Serving-System Determination task (see 2.6.3.12).
  - If $NBUSY_{sv}$ does not exceed $MAXBUSY_{sl}$, then the mobile station must exit this task and the Delay After Failure task must be executed (see 2.6.3.6).
- If the channel is idle, then the mobile station must set $NBUSY_{sv}$ to zero, turn on the transmitter at the power level indicated by PL_s (see 2.6.3.3 and 2.1.2.2), waits the proper delay (see 2.1.2.1) until the transmitter is within 3 dB of the required power level, and then starts to send the message to the base station (see 2.7.1).

If $BIS_s = 0$, then the mobile station must enter the Service Request task (see 2.6.3.7); if $BIS_s = 1$, then upon starting to send the message, the mobile station must continuously monitor the busy-idle bits of the channel.

- If the channel becomes busy before the first 56 bits of the message are sent, the mobile station must immediately stop sending the message and turn off the transmitter.
- If the channel fails to change to busy by the time the mobile station has sent 104 bits, then the mobile station must immediately stop sending the message and turn off the transmitter.

  In either of these cases, the mobile station must then increment the count of seizure failures $NSZTR_{sv}$) by 1 and compare the result with the maximum number of seizure attempts allowed ($MAXSZTR_{sl}$).

  - If $NSZTR_{sv}$ exceeds $MAXSZTR_{sl}$, the mobile station must exit this task and enter the Serving-System Determination task (see 2.6.3.12).

- If $NSZTR_{sv}$ does not exceed $MAXSZTR_{sl}$, the mobile station must exit this task and enter the Delay After Failure task (see 2.6.3.6).
- If the busy-idle status changes to busy after 56 bits and before 104 bits are sent, then the mobile station must enter the Service Request task (see 2.6.3.7).

2.6.3.6 Delay After Failure

The mobile station must examine the access timer. If the access timer has expired, the mobile station must enter the Serving-System Determination task (see 2.6.3.12). If the access timer has not expired, the mobile station must wait a random time. Each time it enters this task, it must generate a random time, uniformly distributed in the interval 0 to 200 ms, and if quantized, with granularity no greater than 1 ms. The mobile station must then enter the Seize Reverse Control Channel task (see 2.6.3.5).

2.6.3.7 Service Request

The mobile station must continue to send its message to the base station. The information that must be sent is as follows (with the formats given in 2.7.1):

- Word A must always be sent.
- If:
  - $E_S = 1$, or
  - $LT_S = 1$, or
  - $AUTH_S = 1$, or
  - the ROAM status is enabled, or
  - the ROAM status is disabled and $EX_p = 1$, or
  - the access is an "order confirmation", or
  - the access is a "registration", or
  - the access is a "base station challenge", or
  - digital traffic channel capability is requested, or
  - the mobile station was paged with a two-word mobile station control message, or
  - RCF = 1.

  Word B must be sent.
- Word C must be sent as per the following table:

S_S Bit	Type of System Access			
	Registration, Origination or Page Response where $AUTH_S = 0$	Registration, Origination or Page Response where $AUTH_S = 1$	Unique Challenge Order Confirmation	Base Station Challenge
0	Send no Word C	Send Authentication Word C	Send Unique Challenge Order Confirmation Word C	Send Base Station Challenge Word C
1	Send Serial Number Word C	Send Serial Number Word C and Authentication Word C	Send Serial Number Word C and Unique Challenge Order Confirmation Word C	Send Serial Number Word C and Base Station Challenge Word C

- If the access is an "origination",
  word D must be sent.
- If the access is an "origination" and 9 to 16 digits were dialed,
  word E must be sent.

When the mobile station has sent its complete message, it must continue to send unmodulated carrier for a nominal duration of 25 ms and then turn off the transmitter.

The next task to be entered depends on the type of access by the mobile station:

- If the access is an order confirmation, the mobile station must enter the Serving-System Determination task (see 2.6.3.12).
- If the access is an origination, the mobile station must enter the Await Message Task (see 2.6.3.8).
- If the access is a page response, the mobile station must enter the Await Message Task (see 2.6.3.8).
- If the access is a registration request other than a power down registration the mobile station must enter the Await Registration Confirmation task (see 2.6.3.9). If the registration is a power down registration the mobile station shall power down.
- If the access is a base station challenge, the mobile station must enter the Await Message Task (see 2.6.3.8).

2.6.3.8 Await Message

If this task is not completed within 5 seconds, the mobile station must exit this task and enter the Serving System Determination task (see 2.6.3.12).

The mobile station must monitor mobile station control messages (see 3.7.1.1). If the mobile station sent Word B as part of the Service Request (see 2.6.3.7), then the mobile station must attempt to match $MIN1_p$ and $MIN2_p$ to $MIN1_r$ and $MIN2_r$, respectively; otherwise, the mobile station must attempt to match only $MIN1_p$ to $MIN1_r$.

The mobile station must respond as indicated to any of the following messages if all decoded MIN bits match.

If the access is an origination or page response:

- *Initial Voice Channel Designation Message* (see 3.7.1.1): The mobile station must update the parameters as set in the message. If $R_s = 1$ the mobile station must enter the Autonomous Registration Update task (see 2.6.3.11), supplying a "success" indication. Then enter the Confirm Initial Voice Channel task (see 2.6.4.2).
- *Initial Traffic Channel Designation Message* (see 3.7.1.1): The mobile station must update the parameters as set in the message. If $R_s = 1$ the mobile station must enter the Autonomous Registration Update task (see 2.6.3.11), supplying a "success" indication. Then enter the Confirm Initial Traffic Channel task (see 2.6.5.2).
- *Directed-Retry Message* (see 3.7.1.1): If the mobile station is equipped for directed retry, it must respond to the directed-retry message as follows:

  If the mobile station encounters the start of a new message before it receives all four words of the directed-retry message, it must exit this task and enter the Serving-System Determination task (see 2.6.3.12).

  The mobile station must set the last-try code (LT_s) according to the ORDQ field of the message:

  - If ORDQ = '000', set LT_s to '0'.
  - If ORDQ = '001', set LT_s to '1'.

  The mobile station must then clear $CCLIST_s$ and examine each CHANPOS field in Words 3 and 4 of the message. For each nonzero CHANPOS field, the mobile station must calculate a corresponding channel number according to the following algorithm:

  - If the serving-system status is enabled, subtract CHANPOS from $FIRSTCHA_s$ + 1.
  - If the serving-system status is disabled, add CHANPOS to $FIRSTCHA_s$ - 1.

The mobile station must then determine whether each channel number is within the set allocated to cellular systems, and if so, list the channel number in $CCLIST_s$.

After completing its response to the directed-retry message, the mobile station must examine the access timer. If the access timer has expired, the mobile station must enter the Serving-System Determination task (see 2.6.3.12). If the access timer has not expired, the mobile station must enter the Directed-Retry task (see 2.6.3.14).

If the access is an origination:

- *Intercept*: The mobile station must enter the Serving-System Determination task (see 2.6.3.12).
- *Reorder*: The mobile station must enter the Serving-System Determination task (see 2.6.3.12).

If the access is a page response:

- *Release:* The mobile station must enter the Serving-System Determination task (see 2.6.3.12).

If the access is a Base Station Challenge:

- *Base Station Challenge Order Confirmation:* The mobile station compares the AUTHBS received in the Base Station Challenge Order Confirmation message to that computed internally. The mobile station must then acknowledge receipt of the SSD Update Order with a success or failure indication as described in 2.3.12.1.8 by entering the System Access task (see 2.6.3) with an "order response" indication (see 2.6.3.1). If the mobile station fails to receive the Base Station Challenge Order Confirmation within 5 seconds of when the Base Station Challenge Order was transmitted, terminate the SSD update process.

If the access is an origination and the user terminates a call during this task, the termination status must be enabled so that the call can be released on a voice channel (see 2.6.4.4) or Digital Traffic Channel (see 2.6.5.4) instead of on a control channel.

2.6.3.9 Await Registration Confirmation

If this task is not completed within 5 seconds, the mobile station must exit this task and enter the Action on Registration Failure task (see 2.6.3.10).

The mobile station must monitor mobile station control messages (see 3.7.1.1). If the mobile station sent Word B as part of the Service Request (see 2.6.3.7), then the mobile station must attempt to match $MIN1_p$ and $MIN2_p$ to $MIN1_r$ and $MIN2_r$, respectively; otherwise, the mobile station must attempt to match only $MIN1_p$ to $MIN1_r$.

The mobile station must respond as indicated to any of the following messages if all decoded MIN bits match:

- *Release Order* (see 3.7.1.1): The mobile station must exit this task and enter the Action on Registration Failure task (see 2.6.3.10).
- *Order Confirmation* (see 3.7.1.1): If autonomous registration is enabled or $PUREG_{S-p}=1$, or $LREG_S=1$, the mobile station must enter the Autonomous Registration Update task (see 2.6.3.11), supplying a "success" indication; the mobile station must then enter the Serving-System Determination task (see 2.6.3.12). Otherwise, the mobile station must enter the Serving-System Determination task (see 2.6.3.12).

2.6.3.10 Action on Registration Failure

If autonomous registration is enabled or $PUREG_{s\text{-}p}$=1 or $LREG_s$=1, the mobile station must enter the Autonomous Registration Update task (see 2.6.3.11), supplying a "failure" indication; the mobile station must then enter the Serving-System Determination task (see 2.6.3.12). Otherwise, the mobile station must enter the Serving-System Determination task (see 2.6.3.12).

2.6.3.11 Autonomous Registration Update

If the first-location area ID status is enabled, the first-registration ID status is enabled, the first-idle ID status is enabled and if a "success" indication was supplied to this task, the mobile station must set the location-registration ID status to disabled.

If the first-location-area ID status is disabled and a "success" indication was supplied to this task, the mobile station must set $LOCAID_{s\text{-}p}$ equal to $LOCAID_s$ and must set location - registration ID status to disabled.

If the first-registration ID status is disabled and a "success" indication was supplied to this task, the mobile station must set $SID_{s\text{-}p}$ equal to SID_s, set $NXTREG_{s\text{-}p}$ equal to $REGID_s$ + $REGINCR_s$ and set location -registration ID status to disabled.

If the first-registration ID status is disabled and a "failure" indication was supplied to this task, the mobile station must do the following:

- generate a random number ($NRANDOM_{sv}$). Each time this step is executed, a random number must be generated, uniformly distributed in the interval 0 to 10, and with granularity no more than 1.
- set $NXTREG_{s\text{-}p}$ equal to $REGID_s$+ $NRANDOM_{sv}$.

The mobile station must set the first-idle ID status to disabled and then return to the invoking task.

2.6.3.12 Serving-System Determination

If this task is entered as a result of a power down registration attempt the mobile station must immediately power down. Otherwise, the mobile station shall proceed as follows:

- If the serving-system status does not correspond to the preferred system, the mobile station may enter the Retrieve System Parameters task (see 2.6.1.1); otherwise, it must enter the Scan Primary Dedicated Control Channels task (see 2.6.1.1.1).

2.6.3.13 Alternate Access Channel

If the mobile station is tuned to the strongest access channel, it may tune to the second strongest channel and then enter the Retrieve Access Attempt Parameters task (see 2.6.3.3). Otherwise, it must enter the Serving-System Determination task (see 2.6.3.12).

2.6.3.14 Directed Retry

The mobile station must examine the signal strength on each of the channels listed in $CCLIST_s$ and choose up to two channels with the strongest signals. The mobile station must then tune to the strongest access channel and enter the Retrieve Access Attempts Parameters task (see 2.6.3.3).

2.6.4 Mobile Station Control on the Analog Voice Channel

2.6.4.1 Loss of Radio-Link Continuity

While the mobile station is tuned to a voice channel, it must monitor the fade timing status (see 2.4.1.3). If the fade timing status is enabled, a fade timer must be started; each time the fade timing status is disabled, the timer must be reset. If the timer counts to 5 seconds, the mobile station must turn off its transmitter; and enter the Serving-System Determination task (see 2.6.3.12).

2.6.4.2 Confirm Initial Voice Channel

Within 100 ms of the receipt of the Initial Voice Channel Designation Message (see 3.7.1.1), the mobile station must determine whether the channel number is within the set allocated to cellular systems, and

- If it is within the allocated set, the mobile station must tune to the designated voice channel, turn on the transmitter at the power level indicated by the VMAC field of the Initial Voice Channel Designation Message (see 2.1.2.2 and 3.7.1.1), turn on the SAT transponder (see 2.4.1), and set the stored SAT Color Code (SCC_s) to the value of the SCC field of the initial voice channel message (see 3.7.1.1). Discontinuous transmission (see 2.3.11) is prohibited while the mobile station is in this task. That is, a mobile station capable of discontinuous-transmission operation must remain in the DTX-high state.
  - If this is an origination access, the mobile station then must enter the Conversation task (see 2.6.4.4).
  - If this is a page response access, the mobile station then must enter the Waiting for Order task (see 2.6.4.3.1).
- Otherwise, the mobile station must enter the Serving-System Determination task (see 2.6.3.12).

2.6.4.3 Alerting

2.6.4.3.1 Waiting for Order

Discontinuous transmission (see 2.3.11) is prohibited while the mobile station is in this task. That is, a mobile station capable of discontinuous transmission operation must remain in the DTX-high state. When this task is entered, an order timer must be set to 5 seconds. The following may occur:

- If the order timer expires the mobile station must turn off the transmitter; then the mobile station must enter the Serving-System Determination task (see 2.6.3.12).
- The mobile station may spontaneously transmit the Page Response message to indicate a change in preferred call mode or privacy mode, as indicated in the message type and order qualifier fields of the message. (See Table 3.7.1-1). The mobile station must remain in the Waiting For Order task.
- The mobile station may receive a Base Station Challenge Order Confirmation as part of the SSD Update process (see 2.3.12.1.8). The mobile station must compare the AUTHBS received in the Base Station Challenge Order Confirmation message with that computed internally. The mobile station must then acknowledge receipt of the SSD Update Order with a success or failure indication as described in 2.3.12.1.8. If the mobile station fails to receive the Base Station Challenge Order Confirmation within 5 seconds of when the Base Station Challenge Order was transmitted, terminate the SSD update process. Reset the order timer to 5 seconds and remain in the Waiting for Order task.

- Within 100 ms of the receipt of any of the orders listed below (see 3.7.2), the mobile station must compare SCC_S to the present SAT color code (PSCC) field in the received message. If $SCC_S \neq PSCC$, the order must be ignored. If $SCC_S = PSCC$, the action to be taken for each order is as follows:
  - *Handoff (to Analog Voice Channel)*: Turn on signaling tone for 50 ms, turn off signaling tone, turn off transmitter, adjust power level, tune to new channel, adjust to new SAT, set SCC_S to the value of the SCC field of the message (see 2.4.1), turn on transmitter, reset fade timer, remain in the Waiting for Order task, and reset the order timer to 5 seconds. A dual-mode mobile station may spontaneously transmit the Page Response message (without receiving the Page message) to indicate the preferred call mode.
  - *Handoff (to Digital Traffic Channel)*. Turn on signaling tone for 50 ms, turn off signaling tone, turn off transmitter, adjust power level, tune to new channel, set stored $DVCC_S$ to the DVCC field of the received message, set the transmitter and receiver to digital mode, set the transmit and receive rate to that indicated by the message type field, set timeslot to that indicated by the Message Type field, configure voice codec to the rate indicated by the message type field, set the time alignment offset to the value indicated by the TA field of the received message, set the voice privacy and message encryption modes to that indicated in the message, once synchronized turn on transmitter, reset fade timer, enter the Waiting for Order task of the Digital Voice Channel, and reset the order timer to 5 seconds.

    If the Handoff Order indicated the use of shortened burst, the mobile station must transmit shortened bursts on the channel until a Physical Layer Control Order containing a time alignment setting is received.
  - *Alert* and *Alert With Info:* Turn on signaling tone, wait 500 ms, and enter the Waiting for Answer task (see 2.6.4.3.2).
  - *Release*: Enter Release task (see 2.6.4.5).
  - *Audit*: Send order confirmation message to base station (see 2.7.2), remain in the Waiting for Order task, and reset the order timer to 5 seconds.
  - *Message waiting order:* If the mobile station is capable of performing Message Waiting Notification, the mobile station shall indicate the presence of messages waiting based on the information contained in the message type field of the Message Waiting order (i.e., 0 for clear or no messages, other non-zero values indicate the number of messages waiting). The mobile station must send an order confirmation to the base station (see 2.7.2), reset the order timer to 5 seconds and remain in the Waiting for Order task.
  - *Maintenance*: Turn on signaling tone, wait 500 ms, and enter the Waiting for Answer task (see 2.6.4.3.2).
  - *Change Power*: Adjust the transmitter to the power level indicated by the order qualification code (see 3.7.1.1 and 2.1.2.2) and send order confirmation message to base station (see 2.7.2). Remain in the Waiting for Order task, and reset the order timer to 5 seconds.
  - *Local Control*: If the local control status is enabled (see 2.6.1.5) and a local control order is received, the local control field must be examined to determine the action and confirmation to take.
  - *Page:* Reply with Page Response with the Message type and order qualifier fields indicating the preferred call mode of the mobile station (including privacy mode). The mobile station must remain in the Waiting for Order task and reset the order timer to 5 seconds.

- *Serial Number Request:* Reply with Serial Number Response message. The mobile station must remain in the Waiting for Order task, and reset the order timer to 5 seconds.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station must reply with a Base Station Challenge Order. Remain in the Waiting for Order task and reset the order timer to 5 seconds.
- *Unique Challenge Order:* The mobile station executes the Unique Challenge procedure as in 2.3.12.1.5. Within 5 seconds, the mobile station must send an "order confirmation" message to the base station (see 2.7.2). Remain in the current task and reset the order timer to 5 seconds.
- *Message Encryption Mode Order:* The base station is activating/deactivating signaling message encryption. If the order qualifier field in the received message is set to '001', activate signaling message encryption. If the order qualifier field in the received message is set to '000', deactivate signaling message encryption. In either case, send an "order confirmation" message to the base station (see 2.7.2), remain in the Waiting for Order task and reset the order timer to 5 seconds.
- *Call Mode Ack:* The base station is either confirming a change in the preferred call mode or indicating the privacy mode that is permissible. In either case, remain in the Waiting for Order task and reset the order timer to 5 seconds.
- *Parameter Update Order:* Increment $COUNT_{S-P}$ (see 2.3.12.1.3), send an order confirmation message to the base station (see 2.7.2) and reset the order timer to 5 seconds. Remain in the Waiting for Order task.
- *Any other order:* Ignore order.

2.6.4.3.2 Waiting for Answer

Discontinuous transmission (see 2.3.11) is prohibited while the mobile station is in this task. That is, a mobile station capable of discontinuous- transmission operation must remain in the DTX-high state. When this task is entered, an alert timer must be set to 65 seconds (-0, +20%). The following may occur:

- If the alert timer expires the mobile station must turn off the transmitter; then the mobile station must enter the Serving-System Determination task (see 2.6.3.12).
- If the user answers, signaling tone must be turned off and the Conversation task (see 2.6.4.4) must be entered.
- The mobile station may spontaneously transmit the Page Response message to indicate a change in preferred call mode or privacy mode, as indicated in the message type and or order qualifier fields of the message. (See Table 3.7.1-1). The mobile station must remain in the Waiting For Answer task.
- The mobile station may receive a Base Station Challenge Order Confirmation as part of the SSD Update process (see 2.3.12.1.8). The mobile station must compare the AUTHBS received in the Base Station Challenge Order Confirmation message with that computed internally. The mobile station must then acknowledge receipt of the SSD Update Order with a success or failure indication as described in 2.3.12.1.8. If the mobile station fails to receive the Base Station Challenge Order Confirmation within 5 seconds of when the Base Station Challenge Order was transmitted, terminate the SSD update process. Remain in the Waiting for Answer task.
- Within 100 ms of the receipt of any of the orders listed below, the mobile station must compare SCC_s to the PSCC field in the received message. If $SCC_s \neq PSCC$, the order must be ignored. If $SCC_s = PSCC$, the action to be taken for each order is as follows:

- *Handoff (to Analog Voice Channel)*: Turn off signaling tone for 500 ms, turn on signaling tone for 50 ms, turn off signaling tone, turn off transmitter, adjust power level, tune to new channel, adjust to new SAT, set SCC_S to the value of the SCC field of the message (see 2.4.1), turn on transmitter, reset fade timer, and turn on signaling tone. Then remain in the Waiting for Answer task. A dual-mode mobile station may spontaneously transmit the Page Response message (without receiving the Page message) to indicate the preferred call mode.
- *Handoff (to Digital Traffic Channel)*. Turn off signaling tone for 500ms, turn on signaling tone for 50 ms, turn off signaling tone, turn off transmitter, adjust power level, tune to new channel, set stored $DVCC_S$ to the DVCC field of the received message, set the transmitter and receiver to digital mode, set the transmit and receive rate to that indicated by the message type field, set timeslot to that indicated by the message type field, configure voice codec to the rate indicated by the message type field, set the time alignment offset to the value indicated by the TA field of the received message, set the voice privacy and message encryption modes to that indicated in the message, once synchronized turn on transmitter, reset fade timer, enter the Waiting for Answer task of the Digital Traffic Channel.

  If the Handoff Order indicated the use of shortened burst, the mobile station must transmit shortened bursts on the channel until a Physical Layer Control Order containing a time alignment setting is received.
- *Alert and Alert With Info:* Remain in the Waiting for Answer task, and reset the alert timer to 65 seconds.
- *Stop Alert*: Turn off signaling tone, and enter the Waiting for Order task (see 2.6.4.3.1).
- *Release:* Turn off signaling tone, wait 500 ms, and then enter the Release task (see 2.6.4.5).
- *Audit*: Send order confirmation message to base station (see 2.7.2) and remain in the Waiting for Answer task.
- *Message Waiting:* If the mobile station is capable of performing Message Waiting Notification, the mobile station shall indicate the presence of messages waiting based on the information contained in the message type field of the Message Waiting order (i.e., 0 for clear or no messages, other non-zero values indicate the number of messages waiting). The mobile station must send an order confirmation to the base station (see 2.7.2) and remain in the Waiting for Answer task.
- *Maintenance:* Remain in the Waiting for Answer task, and reset the alert timer to 65 seconds.
- *Change Power:* Adjust the transmitter to the power level indicated by the order qualification code (see 3.7.1.1 and 2.1.2.2) and send order confirmation message to base station (see 2.7.2). Remain in the Waiting for Answer task.
- *Local Control:* If the local control status is enabled (see 2.6.1.5) and a local control order is received, the local control field must be examined to determine the action and confirmation to take.
- *Page:* Reply with Page Response with the Message type and order qualifier fields indicating the preferred call mode of the mobile station (including privacy mode). The mobile station must remain in the Waiting for Answer task.
- *Serial Number Request*: Reply with Serial Number Response message. The mobile station must remain in the Waiting for Answer task.

- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station must then reply with a Base Station Challenge Order. Remain in the Waiting for Answer task.
- *Unique Challenge Order:* The mobile station executes the Unique Challenge procedure as in 2.3.12.1.5. Within 5 seconds, the mobile station must send an "order confirmation" message to the base station (see 2.7.2). Remain in the current task.
- *Message Encryption Mode Order:* The base station is activating/deactivating signaling message encryption. If the order qualifier field in the received message is set to '001', activate signaling message encryption. If the order qualifier field in the received message is set to '000', deactivate signaling message encryption. In either case, send an "order confirmation" message to the base station (see 2.7.2) and remain in the Waiting for Answer task.
- *Call Mode Ack:* The base station is either confirming a change in the preferred call mode or indicating the privacy mode that is permissible. In either case, remain in the Waiting for Answer task.
- *Parameter Update Order:* Increment $COUNT_{s-p}$ (see 2.3.12.1.3) and send an order confirmation message to the base station (see 2.7.2). Remain in the Waiting for Answer task.
- *Any other order:* Ignore order.

2.6.4.4 Conversation

When this task is entered, a release-delay timer must be set to 500 ms. If the termination status is enabled (see 2.6.3.8), the mobile station must set the termination status to disabled, wait 500 ms and then enter the Release task (see 2.6.4.5).

Discontinuous transmission (see 2.3.11) must be inhibited for 1.5 seconds after the mobile station enters this task. That is, for at least 1.5 seconds after entering this task, a mobile station capable of discontinuous-transmission operation must remain in the DTX-high state.

In the conversation state; the following may occur:

- If the user terminates the call, the release-delay timer must be examined. If the timer has expired, the Release task must be entered (see 2.6.4.5). If the timer has not expired, the mobile station must wait until the timer expires and then enter the Release task.
- If the user requests a flash, the mobile station must take the following steps. Mobile stations capable of discontinuous-transmission operation (see 2.3.11) must inhibit discontinuous transmission for 1.5 seconds; that is, for at least 1.5 seconds the mobile station must remain in the DTX-high state. Immediately following the flash, a mobile station not capable of discontinuous transmission or a mobile station capable of discontinuous transmission but in the DTX-high state must turn on signaling tone for 400 ms.

  If the mobile station is capable of discontinuous transmission and is in the DTX-low state or the transition state when the flash occurs, the mobile station must enter the DTX-high state and wait 200 ms. Then it must turn on signaling tone for 400 ms. If a valid order (one that is not ignored) is received while processing a flash, the flash must be terminated immediately and the order must be processed. Flashes so terminated are not considered valid.

- The mobile station may spontaneously transmit the Page Response message to indicate a change in preferred call mode or privacy mode, as indicated in the message type and or order qualifier fields of the message. (See Table 3.7.1-1). The mobile station must remain in the Conversation task.

- The mobile station may receive a Base Station Challenge Order Confirmation as part of the SSD Update process (see 2.3.12.1.8). The mobile station must compare the AUTHBS received in the Base Station Challenge Order Confirmation message with that computed internally. The mobile station must then acknowledge receipt of the SSD Update Order with a success or failure indication as described in 2.3.12.1.8. If the mobile station fails to receive the Base Station Challenge Order Confirmation within 5 seconds of when the Base Station Challenge Order was transmitted, terminate the SSD update process. Remain in the Conversation task.

- Within 100 ms of the receipt of any of the orders listed below, the mobile station must compare SCC_S to the PSCC field in the received message. If $SCC_S \neq PSCC$, the order must be ignored. If $SCC_S = PSCC$, the mobile station must take the following steps. Except for the audit order, mobile stations capable of discontinuous-transmission operation (see 2.3.11) must inhibit discontinuous transmission for 1.5 seconds; that is, for at least 1.5 seconds the mobile station must remain in the DTX-high state. Upon receipt of the audit order, mobile stations capable of discontinuous transmission must inhibit discontinuous transmission for at least 5 seconds. Immediately after determining that $SCC_S = PSCC$ a mobile station not capable of discontinuous transmission or a mobile station capable of discontinuous transmission but in the DTX-high state must take the actions specified below for each order.

  If the mobile station is capable of discontinuous transmission and is in the DTX-low state or the transition state when the order arrives, the mobile station must enter the DTX-high state and wait 200 ms. Then it must take the actions specified below for each order.

  - *Handoff (to Analog Voice Channel)*: Turn on signaling tone for 50 ms, turn off signaling tone, turn off transmitter, adjust power level, tune to new channel, adjust to new SAT, set SCC_S to the value of the SCC field of the message (see 2.4.1), turn on transmitter, reset fade timer, and remain in the Conversation task. A dual-mode mobile station may spontaneously transmit the Page Response message (without receiving the Page message) to indicate the preferred call mode.

  - *Handoff (to Digital Traffic Channel)*. Turn on signaling tone for 50 ms, turn off signaling tone, turn off transmitter, adjust power level, tune to new channel, set stored $DVCC_S$ to the DVCC field of the received message, set the transmitter and receiver to digital mode, set the transmit and receive rate to that indicated by the message type field, set timeslot to that indicated by the message type field, configure voice codec to the rate indicated by the message type field, set the time alignment offset to the value indicated by the TA field of the received message, set the voice privacy and message encryption modes to that indicated in the message, once synchronized turn on transmitter, reset fade timer, enter the Conversation task of the Digital Traffic Channel.

    The mobile station shall start transmitting speech (or user data) blocks immediately unless the Handoff Order indicated the use of shortened burst. In that case the mobile station must suspend the transmission of speech (or user data) blocks and transmit shortened bursts on the channel until a PHYSICAL LAYER CONTROL order containing a time alignment setting is received.

- *Send Called-Address:*
  - If received within 10 seconds of the completion of the last valid flash, send the called-address to the base station (see 2.7.2) and remain in the Conversation task.
  - Otherwise, ignore the order and remain in the Conversation task.
- *Disable DTMF Order:* Send an order confirmation message to the base station (see 2.7.2). The mobile station must then disable its DTMF tone generator until the Called Address message sent to the base station in response to the next Send Called-Address message received by the mobile station has been completely transmitted. The mobile station must remain in the Conversation task.
- *Alert and Alert With Info:* Turn on signaling tone, wait 500 ms, and then enter the Waiting for Answer task (see 2.6.4.3.2).
- *Release:* Examine the release-delay timer. If the timer has expired, the mobile station must enter the Release task (see 2.6.4.5). If the timer has not expired, the mobile station must wait until the timer expires and then enter the Release task.
- *Audit:* Send order confirmation message to base station (see 2.7.2) and remain in the Conversation task.
- *Flash With Info:* Send order confirmation message to the base station (see 2.7.2) and remain in the conversation task.
- *Message Waiting:* If the mobile station is capable of performing Message Waiting Notification, the mobile station shall indicate the presence of messages waiting based on the information contained in the message type field of the Message Waiting order (i.e., 0 for clear or no messages, other non-zero values indicate the number of messages waiting). The mobile station must send an order confirmation to the base station (see 2.7.2) and remain in the Conversation task.
- *Maintenance:* Turn on signaling tone, wait 500 ms, and then enter the Waiting for Answer task (see 2.6.4.3.2).
- *Change Power:* Adjust the transmitter to the power level indicated by the order qualification code (see 3.7.1.1 and 2.1.2.2) and send order confirmation message to base station (see 2.7.2). Remain in the Conversation task. If the mobile station is capable of discontinuous transmission and is in the DTX-low state or the transition state when this order arrives, the mobile station must immediately enter the DTX-high state at the power level indicated in the order.
- *Local Control:* If the local control status is enabled (see 2.6.1.5) and a local control order is received, the local control field must be examined to determine the action and confirmation to take.
- *Page:* Reply with a Page Response with the Message Type and Order Qualifier fields indicating the preferred call and privacy modes. The mobile station must remain in the Conversation task.
- *Serial Number Request:* Reply with Serial Number Response message. The mobile station must remain in the Conversation task.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station must then reply with a Base Station Challenge Order. Remain in the Conversation task.

- *Unique Challenge Order:* The mobile station executes the Unique Challenge procedure as in 2.3.12.1.5. Within 5 seconds, the mobile station must send an "order confirmation" message to the base station (see 2.7.2). Remain in the Conversation task.
- *Message Encryption Mode Order:* The base station is activating/deactivating signaling message encryption. If the order qualifier field in the received message is set to '001', activate signaling message encryption. If the order qualifier field in the received message is set to '000', deactivate signaling message encryption. In either case, send an "order confirmation" message to the base station (see 2.7.2) and remain in the Conversation task.
- *Call Mode Ack:* The base station is either confirming a change in the preferred call mode or indicating the privacy mode that is permissible. In either case, remain in the Conversation task.
- *Parameter Update Order:* Increment $COUNT_{s-p}$ (see 2.3.12.1.3) and send an order confirmation message to the base station (see 2.7.2). Remain in the Conversation task.
- *Any other order:* Ignore order.

2.6.4.5 Release

Discontinuous transmission (see 2.3.11) is prohibited while the mobile station is in this task. That is, a mobile station capable of discontinuous-transmission operation must remain in the DTX-high state. Any mobile station in the DTX-low state must immediately enter the DTX-high state, wait 200 ms. While in the DTX-high state, the mobile station shall do the following:

- Send signaling tone for 1.8 seconds. If a flash (see 2.6.4.4) was being sent when this task was entered, signaling tone must continue to be sent for no more than 1.8 seconds.
- Stop sending signaling tone.
- Turn off the transmitter.

The mobile station must then enter the Serving-System Determination Task (see 2.6.3.12).

2.6.4.6 Power Down

If the mobile station is intentionally removed from the air interface while it is tuned to an analog voice channel the mobile station must immediately prohibit discontinuous transmission (see 2.3.11). That is, a mobile station capable of discontinuous transmission operation must remain in the DTX-high state. Any mobile station in the DTX-low state must immediately enter the DTX-high state, wait 200 ms. While in the DTX-high state, the mobile station shall do the following:

- If $PDREG_s = 1$ the mobile station must send an autonomous registration message with a power down indication on the reverse voice channel.
- Send signaling tone for 1.8 seconds. If a flash (2.6.4.4) was being sent when this task was entered, signaling tone must continue to be sent for no more than 1.8 seconds.
- Stop sending signaling tone, turn off the transmitter and then power down.

2.6.5 Mobile Station Control on the Digital Traffic Channel

2.6.5.1 Loss of Radio-Link Continuity

While the mobile is tuned to a traffic channel, it must monitor the fade timing status (see 2.4.3.3). If the fade timing status is enabled, a fade timer must be started; each time the fade timing status is disabled, the timer must be reset. If the timer counts to 5 seconds, the mobile must turn off its transmitter; and enter the Serving-System Determination task (see 2.6.3.12).

2.6.5.2 Confirm Initial Traffic Channel

Within 100 ms of the receipt of the initial Traffic Channel Designation (see 3.7.1.1), the mobile must determine whether the channel number is within the set allocated to cellular systems. The Delay Interval Compensation (DIC) function shall by default be turned on.

- If it is within the allocated set, the mobile must tune to the designated RF channel, set $DVCC_s$ to the DVCC field of the received message, set the transmit and receive rate to that indicated by the message type field, set the time slot to that indicated by the message type field, configure the voice coder to the rate indicated by the message type field, set the time alignment offset to the standard offset reference, set the voice privacy and message encryption modes to that indicated in the received message, and once synchronized turn on the transmitter in the DTX-high state at the power level indicated by the DMAC field of the initial Traffic Channel Designation Message (see 2.1.2.2 and 3.7.1.1). Discontinuous transmission (see 2.3.11) is prohibited while the mobile is in this task. That is, a mobile capable of discontinuous transmission operation must remain in the DTX-high state. The voice coder is in the "off" state during this task.

  The mobile station must transmit shortened bursts on the channel until a Physical Layer Control Message containing a time alignment setting is received. If no Physical Layer Control Message is received within 5 seconds, the mobile station must turn off its transmitter and then enter the Serving System Determination task (see 2.6.3.12).

- Within 100ms of the receipt (on either FACCH or SACCH) of a valid message (see 2.7.3.1.3.1) containing any of the orders listed below the action to be taken for each order is as follows:

  - Physical Layer Control: Send Physical Layer Control Ack Message containing data that reflects the state of the mobile station after the order has taken effect as follows:

    - If a change in power was requested send a Physical Layer Control Ack containing the information element giving the power level which the mobile station is set to as a result of the request.

    - If the message contains a Time Alignment order then adjust the timing for the transmitted time slot as indicated by the order. Include data for the Time Alignment field in the ack message.

    - If the message contains a DTX allowed order then change DTX mode accordingly. Retain this DTX mode for the duration of the call, or until another Physical Layer Control message with a DTX allowed field is received. Include data for the DTX allowed field in the ack message.

    - If the message contains a DIC mode order, then change the Compensation mode accordingly. Retain this information for the duration of the call or until another Physical Layer Control message with a DIC Mode field is received. Include data for the DIC Mode field in the Ack message.

  - If this is an origination access, the mobile then must enter the Conversation task (see 2.6.5.4).
  - If this is a page response access, the mobile then must enter the Waiting for Order task (see 2.6.5.3.1).
- Otherwise, the mobile must enter the Serving-System Determination task (see 2.6.3.12).

2.6.5.3 Alerting

2.6.5.3.1 Waiting for Order

Discontinuous transmission (see 2.3.11) must be inhibited for 1.5 seconds after the mobile station enters this task. That is, for at least 1.5 seconds after entering this task a mobile station capable of discontinuous transmission operation must remain in the DTX-high state.

When this task is entered, an order timer must be set to 5 seconds. The following may occur:

- If the order timer expires the mobile must turn off the transmitter; then the mobile must enter the Serving-System Determination task (see 2.6.3.12).
- If the mobile is in the DTX-low state and a message is received then the response must be sent on the FACCH.
- The mobile station may receive a Base Station Challenge Order Confirmation as part of the SSD Update process (see 2.3.12.1.8). The mobile station must compare the AUTHBS received in the Base Station Challenge Order Confirmation message with that computed internally. The mobile station must then acknowledge receipt of the SSD Update Order with a success or failure indication as described in 2.3.12.1.8. If the mobile station fails to receive the Base Station Challenge Order Confirmation within 5 seconds of when the Base Station Challenge Order was transmitted, terminate the SSD update process. Reset the order timer to 5 seconds and remain in the Waiting for Order task.
- Within 100 ms of the receipt (on either FACCH or SACCH) of a valid message (see 2.7.3.1.3.1) containing any of the orders listed below the action to be taken for each order is as follows:
  - *Alert with Info:* Send Mobile Ack, and enter the Waiting for Answer task (see 2.6.5.3.2).
  - *Measurement Order:* (for the overall measurement activity in the mobile see 2.4.5). Send Measurement Order Ack. Start measurements of Channel Quality and send Channel Quality Messages continuously. If a mobile station capable of DTX operation is in DTX low state, the messages must be sent on FACCH, otherwise the messages must be sent on the SACCH. The default state is no measurements (prior to any Measurement Order).
    - If the RF channel list of the Measurement Order contains no more than 6 RF channels then only CQM1 (current channel and RF channels 1 thru 6) messages are sent.
    - If the RF channel list of the Measurement Order contains more than 6 RF channels then both CQM1 (current channel and RF channels 1 thru 6) and CQM2 (RF channels 7 up to 12) messages are sent.

    Remain in the Waiting for Order task, and reset the order timer to 5 seconds.
  - *Stop Measurements Order:* Send Mobile Ack message, terminate all Channel Quality measurements, as well as the sending of CQM messages.

- *Physical Layer Control:* Send Physical Layer Control Ack Message containing data that reflects the state of the mobile after the order has taken effect, as follows:
    - If a change in power was requested send a Physical Layer Control Ack containing the information element giving the power level which the mobile station is set to as a result of the request.
    - If the message contains a Time Alignment order then adjust the timing for the transmitted time slot as indicated by the order. Include data for the Time Alignment field in the Ack message.
    - If the message contains a DTX allowed order then change DTX mode accordingly. Retain this DTX mode for the duration of the call or until another Physical Layer Control message with a DTX allowed field is received. Include data for the DTX allowed field in the Ack message.
    - If the message contains a DIC mode order, then change the Compensation mode accordingly. Retain this information for the duration of the call or until another Physical Layer Control message with a DIC Mode field is received. Include data for the DIC Mode field in the Ack message.

    Remain in the Waiting for Order task, and reset the order timer to 5 seconds.
- *Release:* Enter Release task (see 2.6.5.5).
- *Maintenance:* Send Mobile Ack and enter the Waiting for Answer task (see 2.6.5.3.2).
- *Audit:* Inhibit discontinuous transmission for 5 seconds, send Mobile Ack, remain in the Waiting for Order task, and reset the order timer to 5 seconds.
- *Local Control:* If the local control status is enabled (see 2.6.1.5) and a local control order is received, the local control field must be examined to determine the action and confirmation to take.
- *Handoff (to Digital Traffic Channel).* Send Mobile Ack, turn off transmitter, adjust power level, tune to new RF channel, set stored $DVCC_s$ to the DVCC field of the received message, set the transmitter and receiver to digital mode, set the transmit and receive rate to that indicated by the message type field, set the time slot to that indicated by the message type field, configure the voice codec to the the rate indicated by the message type field, set the time alignment offset to the value indicated by the time alignment field of the received message, set the voice privacy and message encryption modes to that indicated in the received message, once synchronized, turn on transmitter, reset fade timer, inhibit discontinuous transmission for 1.5 seconds, remain in the Waiting For Order task, and reset the order timer to 5 seconds.

    If the Handoff Order indicated the use of shortened burst, the mobile station must transmit shortened bursts on the channel until a Physical Layer Control Order containing a time alignment setting is received.
- *Handoff (to Analog Voice Channel).* Send Mobile Ack, turn off transmitter, terminate all channel quality measurements, adjust power level, tune to new channel, adjust to new SAT, set SCC_s to the value of the SCC field of the message (see 2.4.1), turn on transmitter, and reset fade timer. Then enter the Waiting for Order task for analog channel (See 2.6.4.3.1) and reset order timer to 5 seconds.

- *Status Request:* If the base station indicates a change in the privacy mode, the mobile station must send a Status message with the Privacy Mode Information Element set to the indicated value (0=privacy off, 1=privacy on) to the base station on the RDTC. The mobile station takes the requested action with respect to turning the voice privacy on /off. Remain in the Waiting for Order task and reset the order timer to 5 seconds.

  If the base station is attempting to activate/deactivate signaling message encryption, activate signaling message encryption if the Message Encryption Mode Information Element in the received message is set to '1'. Deactivate signaling message encryption if the Message Encryption Mode Information Element in the received message is set to '0'. In either case, send a Status message to the base station with the Message Encryption Mode Information Element set to the value indicated in the Status Request message, remain in the Waiting for Order task and reset the order timer to 5 seconds.

  For all other types of Status Requests, send Status Message and remain in the Waiting for Order task and reset order timer to 5 seconds.

- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station must reply with a Base Station Challenge Order and reset the order timer to 5 seconds. Remain in the Waiting for Order task.

- *Unique Challenge Order:* The mobile station executes the Unique Challenge procedure as in 2.3.12.1.5. Within 5 seconds, the mobile station must send an "order confirmation" message to the base station (see 2.7.3). Remain in the current task and reset the order timer to 5 seconds.

- *Parameter Update Message:* Increment $COUNT_{s-p}$ (see 2.3.12.1.3), send a Parameter Update Ack message to the base station (see 2.7.3) and reset the order timer to 5 seconds. Remain in the Waiting for Order task.

- *Any other order.* Ignore order.

- If the user requests a change in the privacy mode, the mobile station must send a Status message with the Privacy Mode Information Element set to the requested value (0=privacy off, 1=privacy on) to the base station on the RDTC. The mobile station continues to operate in its current mode until it receives a Base Station Ack message with the Message Type parameter equal to "Status" on the FDTC. If a Base Station Ack message with Message Type parameter equal to "Status" is not received within the Timeout Interval (see 2.6.5.6.2) on the channel on which the Status Message was sent, then the Status Message is sent up to a maximum of 3 times.

- If the preferred call mode is changed as a result of direct or indirect user action, the mobile station must send the Status Message to indicate such change. If a Base Station Ack Message with Message Type parameter equal to "Status" is not received within the Timeout Interval (see 2.6.5.6.2) on the channel on which the Status Message was sent, then the Status Message is sent up to a maximum of 3 times.

2.6.5.3.2 Waiting for Answer

Discontinuous transmission (see 2.3.11) must be inhibited for 1.5 seconds after the mobile station enters this task. That is, for at least 1.5 seconds after entering this task a mobile station capable of discontinuous transmission operation must remain in the DTX-high state.

When this task is entered, an alert timer must be set to 65 seconds (-0, +20%). The following may occur:

- If the alert timer expires the mobile must turn off the transmitter; then the mobile must enter the Serving-System Determination task (see 2.6.3.12).

- If the user answers, the Connect Message must be transmitted. On receipt of a Base Station Ack message the Conversation task (see 2.6.5.4) must be entered. If a Base Station Ack Message is not received within the Ack timeout interval (See 2.6.5.6.2) the Connect Message is sent up to a maximum of 3 times.
- The mobile station may receive a Base Station Challenge Order Confirmation as part of the SSD Update process (see 2.3.12.1.8). The mobile station must compare the AUTHBS received in the Base Station Challenge Order Confirmation message with that computed internally. The mobile station must then acknowledge receipt of the SSD Update Order with a success or failure indication as described in 2.3.12.1.8. If the mobile station fails to receive the Base Station Challenge Order Confirmation within 5 seconds of when the Base Station Challenge Order was transmitted, terminate the SSD update process. Remain in the Waiting for Answer task.
- If the mobile is in the DTX-low state and a message is received then the response must be sent on the FACCH.
- Within 100 ms of the receipt (on either FACCH or SACCH) of a valid message containing any of the orders listed below the action to be taken for each order is as follows:
    - *Alert with Info:* Send Mobile Ack. Remain in the Waiting for Answer task, and reset the alert timer to 65 seconds.
    - *Measurement Order:* for the overall measurement activity in the mobile see 2.4.5). Send Measurement Order Ack. Start measurements of Channel Quality and send Channel Quality Messages (CQM) continuously. If a mobile station capable of DTX operation is in DTX low state, the CQM must be sent on FACCH, otherwise the CQM must be sent on the SACCH. The default state is no measurements (prior to any Measurement Order).
        - If the RF channel list of the Measurement Order contains no more than 6 RF channels then only CQM1 (current channel and RF channels 1 thru 6) is sent.
        - If the RF channel list of the Measurement Order contains more than 6 RF channels then both CQM1 (current channel and RF channels 1 thru 6) and CQM2 (RF channels 7 up to 12) are sent.

      Remain in the Waiting for Answer task.
    - *Stop Measurements Order:* Send Mobile Ack message, terminate all Channel Quality measurements, as well as the sending of CQM messages. Remain in the Waiting for Answer task.
    - *Physical Layer Control:* Send Physical Layer Control Ack Message containing data that reflects the state of the mobile after the order has taken effect, as follows:
        - If a change in power was requested send a Physical Layer Control Ack containing the information element giving the power level which the mobile station is set to as a result of the request.
        - If the message contains a Time Alignment order then adjust the timing for the transmitted time slot as indicated by the order. Include data for the time alignment field in the ack message.
        - If the message contains a DTX Allowed order then change DTX mode accordingly. Retain this DTX mode for the duration of the call, or until another Physcial Layer Control Message with a DTX allowed field is received. Include data for the DTX allowed field in the ack message.

  - If the message contains a DIC mode order, then change the Compensation mode accordingly. Retain this information for the duration of the call or until another Physical Layer Control message with a DIC Mode field is received. Include data for the DIC Mode field in the Ack message.

  Remain in the Waiting for Answer task.

- *Release:* Enter the Release task (see 2.6.5.5).
- *Maintenance*: Send Mobile Ack. Remain in the Waiting for Answer task, and reset the alert timer to 65 seconds.
- *Audit:* Inhibit discontinuous transmission for 5 seconds, send Mobile Ack, and remain in the Waiting for Answer task.
- *Local Control:* If the local control status is enabled (see 2.6.1.5) and a local control order is received, the local control field must be examined to determine the action and confirmation to take.
- *Handoff (to Digital Traffic Channel):* Send Mobile Ack, turn off transmitter, adjust power level, tune to new RF channel, set stored $DVCC_s$ to the DVCC field of the received message, set the transmitter and receiver to digital mode, set the transmit and receive rate to that indicated by the message type field, set the time slot to that indicated by the message type field, configure the voice codec to the the rate indicated by the message type field, set the time alignment offset to the value indicated by the time alignment field of the received message, set the voice privacy and message encryption modes to that indicated in the received message, once synchronized turn on transmitter, reset fade timer, inhibit discontinuous transmission for 1.5 seconds, remain in the Waiting For Answer task. If the Handoff Order indicated the use of shortened burst, the mobile station must transmit shortened bursts on the channel until a Physical Layer Control Order containing a time alignment setting is received.
- *Handoff (to Analog Voice Channel):* Send Mobile Ack, turn off transmitter, terminate all channel quality measurements, adjust power level , tune to new channel, adjust to new SAT, set SCC_s to the value of the SCC field of the message (see 2.4.1), turn on transmitter, turn on signaling tone and reset fade timer. Then enter Waiting for Answer task for analog channel (See 2.6.4.3.2).
- *Status Request:* If the base station indicates a change in the privacy mode, the mobile station must send a Status message with the Privacy Mode Information Element set to the indicated value (0=privacy off, 1=privacy on) to the base station on the RDTC. The mobile station takes the requested action with respect to turning the voice privacy on /off. Remain in the Waiting for Answer task.

  If the base station is attempting to activate/deactivate signaling message encryption, activate signaling message encryption if the Message Encryption Mode Information Element in the received message is set to '1'. Deactivate signaling message encryption if the Message Encryption Mode Information Element in the received message is set to '0'. In either case, send a Status Message to the base station with the Message Encryption Mode Information Element set to the value indicated in the Status Request message and remain in the Waiting for Answer task.

  For all other types of Status Requests, send Status Message and remain in the Waiting For Answer task.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station must reply with a Base Station Challenge Order. Remain in the Waiting for Answer task.

- *Unique Challenge Order:* The mobile station executes the Unique Challenge procedure as in 2.3.12.1.5. Within 5 seconds, the mobile station must send an "order confirmation" message to the base station (see 2.7.3). Remain in the current task.
- *Parameter Update Message:* Increment $COUNT_{s-p}$ (see 2.3.12.1.3) and send a Parameter Update Ack message to the base station (see 2.7.3). Remain in the Waiting for Answer task.
- *Any other order:* Ignore order.

- If the user requests a change in the privacy mode, the mobile station must send a Status message with the Privacy Mode Information Element set to the requested value (0=privacy off, 1=privacy on) to the base station on the RDTC. The mobile station continues to operate in its current mode until it receives a Base Station Ack message on the FDTC. If a Base Station Ack message with message Type Parameter equal to "Status" is not received within the Timeout Interval (see 2.6.5.6.2) on the channel on which the Status Message was sent, then the Status Message is sent up to a maximum of 3 times.
- If the preferred call mode is changed as a result of direct or indirect user action, the mobile station must send the Status Message to indicate such change. If a Base Station Ack message with message Type Parameter equal to "Status" is not received within the Timeout Interval (see 2.6.5.6.2) on the channel on which the Status Message was sent, then the Status Message is sent up to a maximum of 3 times.

2.6.5.4 Conversation

Upon entering the Conversation task, the mobile station shall turn on its voice coder and engage the appropriate voice privacy mode.

Discontinuous transmission (see 2.3.11) must be inhibited for 1.5 seconds after the mobile enters this task. That is, for at least 1.5 seconds after entering this task, a mobile capable of discontinuous transmission operation must remain in the DTX-high state.

In the conversation state; the following may occur:

Release:

- If the user terminates the call the Release task must be entered (see 2.6.5.5).

Flash with Info:

- If the user issues a flash, the mobile must transmit the Flash with Info Message, including all digits (see 2.7.3.1.3.2.8). If a Flash with Info Ack Message is not received within the Ack timeout interval (see 2.6.5.6.2), then the Flash is sent without changing the request number, to a maximum of 3 times.

Send Burst DTMF:

- If the user requests Send Burst DTMF (see 2.7.3.1.3.2.9), then the mobile must send the Send Burst DTMF Message, including all digits. If a Send Burst DTMF Ack Message is not received within the Ack timeout interval (See 2.6.5.6.2) then the Send Burst DTMF Message is sent without changing the request number, up to a maximum of 3 times.

Send Continuous DTMF:

- If the user requests Send Continuous DTMF (see 2.7.3.1.3.2.10), then the mobile must send the Send Continuous DTMF Message with the appropriate digit. If a Send Continuous DTMF Ack is not received within the Ack timeout interval (See 2.6.5.6.2) then the Send Continuous DTMF Message is sent without changing the request number, up to a maximum of 3 times.

- When the user request is terminated the mobile must send the Send Continuous DTMF Message with a null digit. If a Send Continuous DTMF Ack Message is not received within the Ack timeout interval (See 2.6.5.6.2) then the Send Continuous DTMF is sent without changing the request number, up to a maximum of 3 times.

Change of Privacy Mode:

- If the user requests a change in the privacy mode, the mobile station must send a Status message with the Privacy Mode Information Element set to the requested value (0=privacy off, 1=privacy on) to the base station on the RDTC. The mobile station continues to operate in its current mode until it receives a Base Station Ack message on the FDTC. If a Base Station Ack message with message Type Parameter equal to "Status" is not received within the Timeout Interval (see 2.6.5.6.2) on the channel on which the Status Message was sent, then the Status Message is sent up to a maximum of 3 times.

Change of Preferred Service:

- If the preferred call mode is changed as a result of direct or indirect user action, the mobile station must send the Status Message to indicate such change. If a Base Station Ack message with message Type Parameter equal to "Status" is not received within the Timeout Interval (see 2.6.5.6.2) on the channel on which the Status Message was sent, then the Status Message is sent up to a maximum of 3 times.

SSD Update Process:

- The mobile station may receive a Base Station Challenge Order Confirmation as part of the SSD Update process (see 2.3.12.1.8). The mobile station must compare the AUTHBS received in the Base Station Challenge Order Confirmation message with that computed internally. The mobile station must then acknowledge receipt of the SSD Update Order with a success or failure indication as described in 2.3.12.1.8. If the mobile station fails to receive the Base Station Challenge Order Confirmation within 5 seconds of when the Base Station Challenge Order was transmitted, terminate the SSD update process. Remain in the Conversation task.

Message:

- If the mobile is in the DTX-low state and a message is received on the SACCH then the response must be sent on the FACCH.
- Within 100 ms of the receipt (on either FACCH or SACCH) of a valid message (see 2.7.3.1.3) containing any of the orders listed below the action to be taken for each order is as follows:
    - *Alert with Info:* Send Mobile Ack. Then enter the Waiting for Answer task.
    - *Measurement Order:* (For the overall measurement activity in the mobile see 2.4.5). Send Measurement Order Ack. Start measurements of channel quality and send Channel Quality Messages (CQM) continuously. If a mobile station capable of DTX operation is in the DTX low state, the CQM must be sent on the FACCH, otherwise the CQM must be sent on the SACCH. The default state is no measurements (prior to any Measurement Order).
        - If the RF channel list of the Measurement Order contains no more than 6 RF channels then only CQM1 (current channel and RF channels 1 thru 6) is sent.
        - If the RF channel list of the Measurement Order contains more than 6 RF channels then both CQM1 (current channel and RF channels 1 thru 6) and CQM2 (RF channels 7 up to 12) are sent.

      Remain in the Conversation task.

- *Stop Measurement Order:* Send Mobile Ack. Terminate all channel quality measurements, as well as the transmission of CQM messages. Remain in the Conversation task.
- *Physical Layer Control:* Send Physical Layer Control Ack Message containing data that reflects the state of the mobile after the order has taken effect, as follows:
    - If a change in power was requested send a Physical Layer Control Ack containing the information element giving the power level which the mobile station is set to as a result of the request.
    - If the message contains a Time Alignment order then adjust the timing for the transmitted time slot as indicated by the order. Include data for the time alignment field in the ack message.
    - If the message contains a DTX Allowed order then change DTX mode accordingly. Retain this DTX mode for the duration of the call, or until another Physical Layer Control Message with a DTX allowed field is received. Include data for the DTX allowed field in the ack message.
    - If the message contains a DIC mode order, then change the Compensation mode accordingly. Retain this information for the duration of the call or until another Physical Layer Control message with a DIC Mode field is received. Include data for the DIC Mode field in the Ack message.

  Remain in the Conversation task.
- *Release:* The mobile must enter the Release task (see 2.6.5.5).
- *Maintenance:* Send Mobile Ack. Then enter the Waiting For Answer task (see 2.6.5.3.2).
- *Audit:* Inhibit discontinuous transmission for 5 seconds. Send Mobile Ack and remain in the Conversation task.
- *Local Control:* If the local control status is enabled (see 2.6.1.5) and a local control order is received, the local control field must be examined to determine the action and confirmation to take.
- *Handoff (to Digital Traffic Channel):* Send Mobile Ack, turn off transmitter, adjust power level, tune to new RF channel, set stored $DVCC_s$ to the DVCC field of the received message, set the transmitter and receiver to digital mode, set the transmit and receive rate to that indicated by the message type field, set the time slot to that indicated by the message type field, configure the voice codec to the the rate indicated by the message type field, set the time alignment offset to the value indicated by the time alignment field of the received message, set the voice privacy and message encryption modes to that indicated in the received mesage, once synchronized turn on transmitter, reset fade timer, inhibit discontinuous transmission for 1.5 seconds, remain in the Conversation task. If the Handoff Order indicated the use of shortened burst, the mobile station must transmit shortened bursts on the channel until a Physical Layer Control Order containing a time alignment setting is received.
- *Handoff (to Analog Voice Channel):* Send Mobile Ack, turn off transmitter, turn off voice codec, terminate all channel quality measurements, adjust power level, tune to new channel, adjust to new SAT, set SCC_s to the value of the SCC field of the message (see 2.4.1), turn on transmitter, and reset fade timer. Then enter the Conversation task for analog channel (See 2.6.4.4).
- *Flash with Info:* Send Flash with Info Ack. Remain in the Conversation task.

- *Status Request:* If the base station indicates a change in the privacy mode, the mobile station must send a Status message with the Privacy Mode Information Element set to the indicated value (0=privacy off, 1=privacy on) to the base station on the RDTC. The mobile station takes the requested action with respect to turning the voice privacy on /off.

  If the base station is attempting to activate/deactivate signaling message encryption, activate signaling message encryption if the Message Encryption Mode Information Element in the received message is set to '1'. Deactivate signaling message encryption if the Message Encryption Mode Information Element in the received message is set to '0'. In either case, send a Status Message to the base station with the Message Encryption Mode Information Element set to the value indicated in the Status Request message and remain in the Conversation task.

  The mobile station must remain in the conversation state. For all other types of Status Requests, send status message and remain in the Conversation task.

- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station must then reply with a Base Station Challenge Order. Remain in the Conversation task.

- *Unique Challenge Order:* The mobile station executes the Unique Challenge procedure as in 2.3.12.1.5. Within 5 seconds, the mobile station must send an "order confirmation" message to the base station (see 2.7.3). Remain in the conversation task.

- *Parameter Update Message:* Increment $COUNT_{s\text{-}p}$ (see 2.3.12.1.3) and send a Parameter Update Ack message to the base station (see 2.7.3). Remain in the Conversation task.

- *Any other order:* Ignore order.

2.6.5.5 Release

Upon entering the Release task, the mobile station shall turn off its voice coder.

Discontinuous transmission (see 2.3.11) is prohibited while the mobile station is in this task. That is, a mobile station capable of discontinuous-transmission operation must remain in the DTX-high state. Any mobile station in the DTX-low state must immediately enter the DTX-high state.

- If the Release task is entered as a result of a power down condition and $PDREG_s = 1$ the mobile station must send a Release message with a "power down" indication and then power down.

- Otherwise, if the user has terminated this call then the mobile station must send a Release Message with a "normal" indication.

  If the mobile station receives a valid message on FACCH containing any of the orders listed below the indicated action shall be taken. The action to be taken for each order is as follows:

- *Base Station Ack (Release):* Turn off the transmitter and enter the Serving System Determination task (see 2.6.3.12).

- *Alert:* Send Mobile Ack, and enter Waiting For Answer task (see 2.6.5.3.2).

- *Any other order:* Ignore order.

If no Base Station Ack or Alert is received within 500 ms, after the sending of the Release, then the Release Message is sent up to a maximum of 3 times. If still no Release Ack or Alert has been received then the mobile station must turn off the transmitter, and enter the Serving System Determination task (see 2.6.3.12).

- If the mobile has received a Release Message from the base station then the mobile must send a Mobile Ack Message to the base station on the FACCH, turn off the transmitter and enter the Serving System Determination task (see 2.6.3.12).

2.6.5.6 General Rules for Message Exchange on Digital Traffic Channel

2.6.5.6.1 Transmission of Messages

A mobile station may transmit a message on either the FACCH or the SACCH. Some messages transmitted require an acknowledgement from the base station. If the retransmission time out expires before an acknowledgement corresponding to the message is received, the mobile station must retransmit the message on the same associated control channel. After a number of retransmissions caused by the same message (as stated in table 2.7.3.1.3.2-1), the mobile station must abort the transmission of that message.

After transmitting a message which requires an acknowledgement from the base station, the mobile must wait for the corresponding acknowledgement from the base station before transmitting another message. However, the Channel Quality Message may be transmitted in the absence of an acknowledgement of the previous message. Acknowledgements to messages received from the base station may be transmitted while a mobile is waiting for acknowledgement from the base station for a message transmitted earlier.

2.6.5.6.2 Acknowledgement of Received Messages

The timeout interval for Ack response to a message requiring an Ack begins after the last bit of the message is transmitted. The timeout interval is determined by the channel on which the message requiring an Ack was transmitted, regardless of which channel may be used to respond with the Ack. The timeout interval values are shown below.

	FACCH	SACCH
Full Rate	200msec	1200 msec
Half rate	Requires further study.	

2.6.5.6.3 Encoding Messages into Words

The mobile station must observe the following rules when assembling messages into words:

- A message may span multiple words.
- No part of another message or the filler code may be inserted between segments of a message.
- If the first octet of a word contains the first octet of a message or the filler octet, the continuation bit must be set to 0, otherwise, the continuation bit must be set to 1.
- The filler octet may be inserted as many times as desired in front of a message or following the end of a message.
- A word may not contain parts of more than one message.

2.6.5.6.4 Decoding Words into Messages

The mobile station must decode words into messages using the following rules:

- A filler octet does not convey any information and shall not affect the state of the mobile station.

- If the message type code of the current message is not a recognizable type code, the mobile must ignore the current message, all subsequent octets in the current word, and all immediate consecutive words with continuation bits set to 1. See 3.6.5.5.1
- If the decoded message length disagrees with the word continuation bit, the mobile station must decode according to the word continuation bit. (i.e. the continuation bit takes precedence over the message length.)
- If a word contains the end of a message the rest of the word following the end of the message may be ignored.

2.6.5.6.5 Encoding and Decoding of Information Elements

The mobile station must decode variable length messages with optional information elements using the following rules:

- A mobile station must be able to decode all information elements defined in this standard.
- In decoding a message with a valid message type code, if a parameter type for an optional information element is not recognizable, the mobile station must ignore that information element and the those that follow it. However, the mobile station must attempt to interpret the current message with all the properly decoded information elements.
- New information elements defined for existing messages after the first release of this standard must be transmitted in the order of the standard releases in which the information elements are defined.

2.6.5.7 Power Down

If the mobile station is intentionally removed from the air interface while it is tuned to a digital traffic channel, the mobile station must enter the Release task (see 2.6.5.5).

2.7 Signaling Formats

In the message formats used between the mobile stations and base stations, some bits are marked as reserved (RSVD). Some or all of these reserved bits may be used in the future for additional messages. Therefore, all mobile stations and base stations must set all bits that they are programmed to treat as reserved bits to "0" (zero) in all messages that they transmit. All mobile stations and base stations must ignore the state of all bits that they are programmed to treat as reserved bits in all messages that they receive.

2.7.1 Reverse Analog Control Channel (RECC)

The reverse analog control channel (RECC) is a wideband data stream sent from the mobile station to the base station. This data stream must be generated at a 10 kbps ±1 bit/second rate. Figure 2.7.1-1 depicts the format of the RECC data stream.

Figure 2.7.1-1
REVERSE ANALOG CONTROL CHANNEL MESSAGE STREAM (Mobile-to-Base)

Information element	Length (bits)	
DOTTING = 1010...010	30	Seizure Precursor
WORD SYNC = 11100010010	11	
CODED DCC [Coded per Table 2.7.1-1]	7	
1st Word Repeated 5 times	240	
2nd Word Repeated 5 times	240	
3rd Word Repeated 5 times	240	
...		

All messages begin with the RECC seizure precursor that is composed of a 30-bit dotting sequence (1010...010), an 11-bit word sync sequence (11100010010), and the coded digital color code (DCC). The 7-bit coded DCC is obtained by translating the received DCC according to Table 2.7.1-1.

Table 2.7.1-1
CODED DIGITAL COLOR CODE

Received DCC	7-Bit Coded DCC
00	0000000
01	0011111
10	1100011
11	1111100

Each word contains 48 bits, including parity, and is repeated five times; it is then referred to as a word block. A word is formed by encoding 36 content bits into a (48, 36) BCH code that has a distance of 5, (48, 36; 5). The left-most bit (i.e., earliest in time) shall be designated the most-significant bit. The 36 most-significant bits of the 48-bit field shall be the content bits. The generator polynomial for the code is the same as for the (40, 28; 5) code used on the forward control channel (see 3.7.1).

2.7.1.1 Reverse Analog Control Channel (RECC) Messages

Each RECC message can consist of one to six words. The types of messages to be transmitted over the reverse control channel are:

- Page Response Message
- Origination Message
- Order Confirmation Message
- Order Message

These messages are made up of combinations of the following words:

Word A - Abbreviated Address Word

Information element	Length (bits)
F	1
NAWC	3
T	1
S	1
E	1
ER	1
SCM (3-0)	4
MIN1	24
P	12

Word B - Extended Address Word

Information element	Length (bits)
F = 0	1
NAWC	3
LOCAL/MSG TYPE	5
ORDQ	3
ORDER	5
LT	1
EP	1
SCM(4)	1
MPCI	2
SDCC1	2
SDCC2	2
$MIN2_{33-24}$	10
P	12

Word C - Serial Number Word

Information element	Length (bits)
F = 0	1
NAWC	3
ESN	32
P	12

Word C - Authentication Word

Information element	Length (bits)
F = 0	1
NAWC	3
COUNT	6
RANDC	8
AUTHR	18
P	12

Word C - Unique Challenge Order Confirmation Word

Information element	Length (bits)
F = 0	1
NAWC	3
RSVD = 0...0	14
AUTHU	18
P	12

Word C - Base Station Challenge Word

Information element	Length (bits)
F = 0	1
NAWC	3
RANDBS	32
P	12

Word D - First Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC	3
1st DIGIT	4
2nd DIGIT	4
3rd DIGIT	4
4th DIGIT	4
5th DIGIT	4
6th DIGIT	4
7th DIGIT	4
8th DIGIT	4
P	12

Word E - Second Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC = 0	3
9th DIGIT	4
10th DIGIT	4
11th DIGIT	4
12th DIGIT	4
13th DIGIT	4
14th DIGIT	4
15th DIGIT	4
16th DIGIT	4
P	12

The interpretation of the data fields is as follows:

F – First word indication field. Set to '1' in first word and '0' in subsequent words.

NAWC – Number of additional words coming field.

T – T field. Set to '1' to identify the message as an origination or an order; set to '0' to identify the message as an order response or page response.

S – Send serial number field. If the serial number word is sent, set to '1'; if the serial number word is not sent, set to '0'.

E – Extended address field. If the extended address word is sent, set to '1'; if the extended address word is not sent, set to '0'.

EP – The Extended Protocol (EP) bit is used to indicate to the system that the mobile station is capable of using the Extended Protocol.

ER	–	The Extended Protocol Reverse Channel (ER) bit is used to indicate that the current message is in the Extended Protocol. If the ER bit is a "zero" (0), the message format of 2.7.1.1 above, is being used. If the ER bit is a "one" (1), the Extended Protocol message format is being used.
COUNT	–	A modulo-64 count maintained by the mobile station and used for authentication and anti-fraud purposes
RANDC	–	An 8-bit number used to confirm the last RAND received by the mobile station
SCM(4-0)	–	The station class mark field (see 2.3.3).
MPCI	–	'00' indicates EIA-553 or IS-54-A mobile station '01' indicates EIA/TIA IS–54-B dual mode mobile station '10' reserved '11' reserved
SDCC1	–	Supplementary Digital Color Codes
SDCC2	–	Supplementary Digital Color Codes
ORDER	–	Order field. Identifies the order type (See Table 3.7.1–1).
ORDQ	–	Order qualifier field. Qualifies the order confirmation to a specific action (see Table 3.7.1–1).
LOCAL	–	Local control field. This field is specific to each system. The ORDER field must be set to local control (see Table 3.7.1–1) for this field to be interpreted.
MESSAGE TYPE	–	Message type field. Qualifies the order to a specific action (see Table 3.7.1-1)
LT	–	Last-try code field (see 2.6.3.8).
MIN1	–	First part of the mobile identification number field (see 2.3.1).
MIN2	–	Second part of the mobile identification number field (see 2.3.1).
ESN	–	Electronic Serial Number field. Identifies the electronic serial number of the mobile station (see 2.3.2).
DIGIT	–	Digit field (see Table 2.7.1–2).
AUTHR	–	Output response of the authentication algorithm.
AUTHU	–	Output of the authentication algorithm when responding to a Unique Challenge order (see 2.3.12.1.5).
RANDBS	–	Random number used in the SSD update procedure (see 2.3.12.1.8)
RSVD	–	Reserved for future use; all bits must be set as indicated.
P	–	Parity field.

Table 2.7.1-2. DIGIT CODE

Digit	Code	Digit	Code
1	0001	7	0111
2	0010	8	1000
3	0011	9	1001
4	0100	0	1010
5	0101	*	1011
6	0110	#	1100
		Null	0000

Notes:

1. The digit 0 is encoded as binary "ten"; not binary "zero."
2. The code 0000 is the null code, indicating no digit present.
3. All other four-bit sequences are reserved, and must not be transmitted.

Examples of encoding called-address information into the called-address words are given below:

1. If the number 2# is entered, the word is:

Information element	Value	Length (bits)
F = 0	note	1
NAWC	note	3
1st DIGIT	0010	4
2nd DIGIT	1100	4
3rd DIGIT	0000	4
4th DIGIT	0000	4
5th DIGIT	0000	4
6th DIGIT	0000	4
7th DIGIT	0000	4
8th DIGIT	0000	4
P		12

II. If the number 13792640 is entered, the word is:

Information element	Value	Length (bits)
F = 0	note	1
NAWC	note	3
1st DIGIT	0001	4
2nd DIGIT	0011	4
3rd DIGIT	0111	4
4th DIGIT	1001	4
5th DIGIT	0010	4
6th DIGIT	0110	4
7th DIGIT	0100	4
8th DIGIT	1010	4
P		12

III. If the number *24273258 is entered, the words are:

Word D - First Word of the Called-Address

Information element	Value	Length (bits)
F = 0	note	1
NAWC	note	3
1st DIGIT	1011	4
2nd DIGIT	0010	4
3rd DIGIT	0100	4
4th DIGIT	0010	4
5th DIGIT	0111	4
6th DIGIT	0011	4
7th DIGIT	0010	4
8th DIGIT	0101	4
P		12

Word E - Second Word of the Called-Address

Information element	Value	Length (bits)
F = 0	note	1
NAWC = 0	note	3
9th DIGIT	1000	4
10th DIGIT	0000	4
11th DIGIT	0000	4
12th DIGIT	0000	4
13th DIGIT	0000	4
14th DIGIT	0000	4
15th DIGIT	0000	4
16th DIGIT	0000	4
P		12

note: These four bits depend on the type of message.

2.7.2 Reverse Analog Voice Channel (RVC)

The reverse voice channel (RVC) is a wideband data stream sent from the mobile station to the base station. This data stream must be generated at a 10 kbps ±1 bps rate. Figure 2.7.2-1 depicts the format of the RVC data stream.

Figure 2.7.2-1. RVC MESSAGE STREAM (Mobile-to-Base)

Information element	Length (bits)
DOTTING	101
W.S.	11
Repeat 1 of WORD 1	48
dotting	37
W.S.	11
Repeat 2 of WORD 1	48
dotting	37
W.S.	11
...	...
Repeat 5 of WORD 1	48
dotting	37
W.S.	11
Repeat 1 of WORD 2	48
dotting	37
W.S.	11
...	...
Repeat 5 of WORD 2	48

DOTTING = 1010....101

W.S. (WORD SYNC) = 11100010010

A 37-bit dotting sequence (1010....101) and an 11-bit word sync sequence (11100010010) are sent to permit base stations to achieve synchronization with the incoming data, except at the first repeat of word 1 of the message where a 101-bit dotting sequence is used. Each word contains 48 bits, including parity, and is repeated five times together with the 37-bit dotting and 11-bit word sync sequences; it is then referred to as a word block. For a multi-word message, the second word block is formed the same as the first word block including the 37-bit dotting and 11-bit word sync sequences. A word is formed by encoding the 36 content bits into a (48, 36) BCH code that has a distance of 5, (48, 36; 5). The left-most bit (i.e., earliest in time) shall be designated the most-significant bit. The 36 most-significant bits of the 48-bit field shall be the content bits. The generator polynomial for the code is the same as for the (40, 28; 5) code used on the forward control channel (see 3.7.1).

2.7.2.1 Reverse Analog Voice Channel (RVC) Messages

Each RVC message can consist of one or two words. Formats are shown for the following RVC message types:

- Order Confirmation Message
- Called-Address Message
- Serial Number Response Message
- Page Response
- Unique Challenge Order Confirmation
- Base Station Challenge Order Message

Order Confirmation Message

Information element	Length (bits)
F = 1	1
NAWC = 00	2
T = 1	1
LOCAL/MSG TYPE	5
ORDQ	3
ORDER	5
RSVD = 000 ... 000	19
P	12

Called-Address Message:

Word 1 - First Word of the Called-Address

Information element	Length (bits)
F = 1	1
NAWC	2
T = 0	1
1st DIGIT	4
2nd DIGIT	4
3rd DIGIT	4
4th DIGIT	4
5th DIGIT	4
6th DIGIT	4
7th DIGIT	4
8th DIGIT	4
P	12

Word 2 - Second Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC = 00	2
T = 0	1
9th DIGIT	4
10th DIGIT	4
11th DIGIT	4
12th DIGIT	4
13th DIGIT	4
14th DIGIT	4
15th DIGIT	4
16th DIGIT	4
P	12

Serial Number Response Message:

Word 1 of Serial Number Response Message

Information element	Length (bits)
F = 1	1
NAWC = 01	2
T = 1	1
LOCAL/MSG TYPE=00000	5
ORDQ	3
ORDER	5
RSVD = 000 ... 000	19
P	12

Word 2 of Serial Number response message

Information element	Length (bits)
F = 0	1
NAWC = 00	2
T = 1	1
ESN	32
P	12

Page Response

Information element	Length (bits)
F = 1	1
NAWC = 00	2
T = 1	1
MSG TYPE	5
ORDQ	3
ORDER = 00000	5
RSVD = 000 ... 000	19
P	12

Unique Challenge Order Confirmation Message

Information element	Length (bits)
F = 1	1
NAWC = 00	2
T = 1	1
LOCAL/MSG TYPE = 0...0	5
ORDQ	3
ORDER	5
AUTHU	18
RSVD = 0	1
P	12

Base Station Challenge Order Message

Word 1 of Base Station Challenge Order Message

Information element	Length (bits)
F = 1	1
NAWC = 01	2
T = 1	1
LOCAL/MSG TYPE = 0...0	5
ORDQ	3
ORDER	5
RSVD = 000 ... 000	19
P	12

Word 2 of Base Station Challenge Order Message

Information element	Length (bits)
F = 0	1
NAWC = 00	2
T = 1	1
RANDBS	32
P	12

The interpretation of the data fields is as follows:

- F – First word field. Set to '1' in first word and '0' in second word.
- NAWC – Number of additional words coming field.
- T – T field. Set to '1' to identify the message as an order or order confirmation. Set to '0' to identify the message as a called-address.
- DIGIT – Digit field (see Table 2.7.1–2).
- ORDER – Order field. Identifies the order type (see Table 3.7.1–1).
- ORDQ – Order qualifier field. Qualifies the order confirmation to a specific action (See Table 3.7.1–1).
- LOCAL – Local Control field. This field is specific to each system. The ORDER field must be set to local control (see Table 3.7.1–1) for this field to be interpreted.
- MSG TYPE – Message Type field. Qualifies the order (see Table 3.7.1–1).
- RSVD – Reserved for future use; all bits must be set as indicated.
- AUTHU – Output of the authentication algorithm when responding to a Unique Challenge order (see 2.3.12.1.5)
- RANDBS – Random number used in the SSD update procedure (see 2.3.12.1.8)
- ESN – Electronic Serial Number field. Identifies the electronic serial number of the mobile station (see 2.3.2).
- P – Parity field.

2.7.3 Reverse Digital Traffic Channel (RDTC)

The Reverse Digital Traffic Channel (RDTC) is a digital channel from a mobile station to a base station used to transport user information and signaling. It has associated with it two separate control channels: the Fast Associated Control Channel (FACCH) and the Slow Associated Control Channel (SACCH). The FACCH is a blank and burst channel. The SACCH is a continuous channel.

2.7.3.1 Protocol Structure for the Traffic Channel

2.7.3.1.1 Fast Associated Control Channel (FACCH)

The FACCH is a signaling channel for transmission of control and supervision messages between the system and the mobile.

2.7.3.1.1.1 Data Stream Format (FACCH)

The FACCH block replaces (is used in place of) the user information block whenever it is to be transmitted. Each block is regarded as one signaling word. A FACCH message can consist of more than one such word. Messages that span multiple FACCH words can be interspersed with one or more transmissions containing user information.

2.7.3.1.1.2 Interleaving

FACCH is interleaved over 2 consecutive bursts in the same manner as speech. More precisely, the mapping of bits from the two bursts to bits presented sequentially to the input of the convolutional decoding process shall be exactly the same for the FACCH as for the coded speech bits.

Label the coded FACCH bits from 0 to 259 with the following definition:

Index	Bit	
0	P1	from first quadruple out of the encoder
1	P2	"
2	P3	"
3	P4	"
4	P1	from second quadruple out of the encoder
5	P2	"
.	.	
.	.	
.	.	
258	P3	from 65 quadruple out of the encoder
259	P4	"

Sequential FACCH bits number 0 to 259 in the order they emerge from rate 1/4 convolutional encoder are placed in the interleaving array using first those positions otherwise occupied by coded class 1 speech bits, and in the same order.

When all positions normally occupied by coded speech bits have been used, the positions normally used by uncoded speech bits are then filled up, but in a different order.

Bits 0 to 259 are interleaved according to Table 2.7.3.1.1.2–1.

The bits are transmitted from the interleaving array along rows from left to right, using only odd numbered rows from this frame alternately with even numbered rows of the previous frame, which may be a similar speech or FACCH block.

The even numbered rows of an interleaved FACCH block constructed this frame will be transmitted in the next burst, alternating with odd numbered rows from the following block, which may also be speech or FACCH.

Table 2.7.3.1.1.2–1 FACCH Interleaving

ROW NUMBER										
0	215	256	223	258	230	219	257	227	259	189
1	0	25	50	75	231	89	114	139	164	190
2	1	26	51	76	232	90	115	140	165	191
3	2	27	52	77	233	91	116	141	166	192
4	3	28	53	78	234	92	117	142	167	193
5	4	29	54	79	235	93	118	143	168	194
6	5	30	55	80	236	94	119	144	169	195
7	6	31	56	81	237	95	120	145	170	196
8	7	32	57	82	238	96	121	146	171	197
9	8	33	58	83	239	97	122	147	172	198
10	9	34	59	84	240	98	123	148	173	199
11	10	35	60	85	241	99	124	149	174	200
12	11	36	61	86	242	100	125	150	175	201
13	12	37	62	87	243	101	126	151	176	202
14	13	38	63	88	244	102	127	152	177	203
15	14	39	64	216	245	103	128	153	178	204
16	15	40	65	217	246	104	129	154	179	205
17	16	41	66	218	247	105	130	155	180	206
18	17	42	67	220	248	106	131	156	181	207
19	18	43	68	221	249	107	132	157	182	208
20	19	44	69	222	250	108	133	158	183	209
21	20	45	70	224	251	109	134	159	184	210
22	21	46	71	225	252	110	135	160	185	211
23	22	47	72	226	253	111	136	161	186	212
24	23	48	73	228	254	112	137	162	187	213
25	24	49	74	229	255	113	138	163	188	214

2.7.3.1.1.3 Error Detection and DVCC Identifier

The 8-bit DVCC precedes the 49 information (1 Continuation + 48 Message) bits (see 2.7.3.1.1.5) when calculating the 16-bit Cyclic Redundancy Check (CRC) code. The CRC code is the standard CCITT CRC-16 code. The 16-bit CRC is placed after the 49 information bits.

DVCC (8-bits) = (d7,d6,d5,d4,d3,d2,d1,d0)

$$\text{Let } a(X) = d7X^{56} + d6X^{55} + d5X^{54} + d4X^{53} + d3X^{52} + d2X^{51} + d1X^{50} + d0X^{49} + (\text{continuation flag})X^{48} + (\text{message}[0])X^{47} + (\text{message}[1])X^{46} + \ldots + (\text{message}[47])X^{0}$$

Message[0] and d7 are the most significant bits respectively (see 1.2.5 and 2.1.3.3.3.4), where message[n] is the n-th bit of the message field in a FACCH word.

The parity polynomial is the remainder of the division of the input polynomial a(X) and the generator polynomial. i.e.:

$$\frac{a(X)X^{16}}{X^{16} + X^{12} + X^{5} + 1} = q(X) + \frac{b(X)}{X^{16} + X^{12} + X^{5} + 1}$$

Where q(X) is the quotient of the division, b(X) the remainder. The quotient here is discarded and only the parity bits are sent. The generator polynomial is the generator polynomial for the standard CCITT CRC-16 code (see definition in 1.1).

$$\text{Let } c(X) = C[0]X^{64} + C[1]X^{63} + C[2]X^{62} + \ldots + C[64]X^{0}$$

$$= (\text{continuation flag})X^{64} + (\text{message}[0])X^{63} + \ldots + (\text{message}[47])X^{16} + b(X)$$

Where message[n] is the n-th bit of the message field in a FACCH word.

The coefficients of the polynomial c(X) are fed sequentially to the convolutional encoder in the order C[0], C[1], ... C[64].

2.7.3.1.1.4 Convolutional Coding

The FACCH data is error protected by means of a rate 1/4 convolutional code. The coding uses the same start and end bit (tail-biting), instead of extra tail bits, to avoid the overhead introduced with explicit tail bits.

The data bits to be encoded are shifted through a coding circuit. Each new data bit shifted in results in four parity bits out of the coder that are designated (P1,P2,P3,P4). One such bit quadruple is produced as a result of shifting in one new data bit. Each of the four parity bits is a different logical function of the new data bit and the five data bits previously shifted in. Denoting the new data bit by D(i) and earlier data bits by D(i-1),D(i-2),D(i-3), D(i-4) and D(i-5), the defining equations for (P1,P2,P3,P4) are:

$$P1 = D(i) + D(i-1) + D(i-3) + D(i-4) + D(i-5)$$

$$P2 = D(i) + D(i-1) + D(i-2) + D(i-5)$$

$$P3 = D(i) + D(i-1) + D(i-2) + D(i-3) + D(i-5)$$

$$P4 = D(i) + D(i-2) + D(i-4) + D(i-5)$$

where + stands for modulo 2 addition (XOR).

The channel coder memory is initialized with the first 6 bits according to the following:

D(i)	D(i-1)	D(i-2)	D(i-3)	D(i-4)	D(i-5)	
C[5]	C[4]	C[3]	C[2]	C[1]	C[0]	bit

The first bit quadruple (P1,P2,P3,P4) is then generated and extracted. The input bits are then shifted though the coder memory so that bit C[0] shifts out, bit C[1] replaces bit C[0], bit C[5] replaces bit C[4] and a new bit (bit C[6]) replaces bit C[5] in D(i). After this shift the memory content is as follows:

D(i)	D(i-1)	D(i-2)	D(i-3)	D(i-4)	D(i-5)	
C[6]	C[5]	C[4]	C[3]	C[2]	C[1]	bit

Another bit quadruple (P1,P2,P3,P4) is then extracted and likewise after every subsequent shift until after 59 shifts the state of the encoder is as follows:

D(i)	D(i-1)	D(i-2)	D(i-3)	D(i-4)	D(i-5)	
C[64]	C[63]	C[62]	C[61]	C[60]	C[59]	bit

Then the bits with index 0 to 4 are used again in that order, shifting in to the coder from the left with extraction of a bit quadruple after every shift.

After these five last shifts the encoder memory contains:

D(i)	D(i-1)	D(i-2)	D(i-3)	D(i-4)	D(i-5)	
C[4]	C[3]	C[2]	C[1]	C[0]	C[64]	bit

Thus after one more shift the encoder state would have returned to the starting state. The data bits can be visualized as stored in a 65-stage circular buffer which is then rotated one revolution so that every bit successively appears in the position corresponding to D(i-5).

2.7.3.1.1.5 Word Format

The fields are presented to the FACCH convolutional coder described in 2.7.3.1.1.4 in the order starting from the signaling word header. Bits within a field are presented to the coder in the order most significant bit first.

Each word is formatted as follows:

Field	Description	Length (bits)
Signaling Word Header	Continuation Flag	1
Contents	Message and/or Filler	48
CRC	Cyclic Redundancy Check	16

Signaling Word Header

The word header consists of a continuation flag of one bit. The flag indicates to the receiver whether a word is the first word in a message or if it is a subsequent word.

Description	Code
First word of a message	0
Subsequent word of a multiple-word message	1

Contents

The Contents field may consist of either a message part as described in 2.7.3.3 and/or Filler Octets. If the Contents field contains a message or message part of less than 48 bits, then the Contents field is completed by inserting up to two zero bits followed by as many Filler Octets as needed. Truncate, if necessary, the last Filler Octet to complete the Contents field. If no message or message part is included in the Contents field then the field contains six Filler Octets.

DVCC — DVCC is the 8-bit color code distinguishing a designated traffic channel from its co-channels. It is used as address information for a traffic channel connection, thus both as destination address to a particular receiver and originating address from a transmitter. The DVCC is included and precedes the 49 data bits for determining the CRC.

CRC — The 49 data bits in a FACCH word is appended with a 16-bit CRC to detect the presence of channel errors in the data as well as providing a mechanism for distinguishing the FACCH data from speech data. The CRC is computed over the entire 49 bit data as well as the DVCC. (See 2.7.3.1.1.3).

For explanatory purposes, one method of differentiating between speech blocks and FACCH blocks is to utilize the information present in the respective CRC fields.

2.7.3.1.2 Slow Associated Control Channel (SACCH)

The SACCH is a signaling channel for transmission of control and supervision messages between the digital mobile and the system. The SACCH uses twelve coded bits per TDMA burst.

2.7.3.1.2.1 Interleaving

Before transmission, the output of the convolutional coder is diagonally interleaved so that the twelve coded bits are transmitted over 12 time slots. The order in which the bits are output from the convolutional coder in time slot m (where m is reset on startup, increases once every transmitted time slot and continues indefinitely) is $cc_0[m,0]$, $cc_1[m,0]$, $cc_0[m,1]$, $cc_1[m,1]$,...., $cc_0[m,5]$, $cc_1[m,5]$. These 12 encoded bits are read into a 12 x 12 array along the diagonal and then the first column of the array is transmitted. The columns are then shifted left by one from the diagonal and the data for the next time slot is used to fill the diagonal.

The algorithm governing the transmitting order for the encoded bits at time slot m can be also be expressed as follows:

```
do i = 0,5
    do k = 0,1
        n = m - 2i - k
        output cc_k [n,i]
    enddo k
enddo i
```

The total delay going through the interleaver and deinterleaver is 12 transmitted time slots.

2.7.3.1.2.2 Forward Error Correction

The SACCH data stream on a full rate channel is error protected by means of a rate 1/2 convolutional code. The coding is continuous and requires no start bits, tail bits or other form of block synchronization. The decoder can,however, be reset when the handoff command is executed to realign the SACCH format more rapidly to the new base, which may be unsynchronized.

Once every 20 ms, six new SACCH data bits are encoded by applying the data to the convolutional coder. For each input data bit into the convolutional coder, two output parity are shifted out of the coder. After the six SACCH data bits are input to the convolutional coder, twelve parity bits are output from the convolutional coder.

The convolutional encoding used is a rate 1/2, memory order 5 code. There are 32 states in this code, five memory elements. The generator polynomials, $g_0(D)$ and $g_1(D)$, are defined as:

$$g_0(D) = 1+D+D^3+D^5$$

$$g_1(D) = 1+D^2+D^3+D^4+D^5$$

The output alternates between the two polynomials with the output from g0(D) being the first in each time slot (See 2.1.3.3.3.4).

On handoff, the encoder memory elements are cleared; that is, the encoder starts at state 0.

Sequentially the outputs from $g_0(D)$ and $g_1(D)$ at time slot m are referred to as $cc_0[m,i]$ and $cc_1[m,i]$, respectively, for $0 \le i \le 5$.

2.7.3.1.2.3 Word Synchronization

For ease of SACCH word synchronization, the position of the first bit (Continuation Flag) should be linked to the transmission of a 12-bit SACCH burst. This link is obtained by demanding that when the Continuation Flag is placed in the position of D^0 (in $g_0(D)$ and $g_1(D)$, see 2.7.3.1.2.2), this shall always happen at an instance when the value of i in $cc_k[n,i]$ (see 2.7.3.1.2.1) is equal to zero.

2.7.3.1.2.4 Word Format

The fields are presented to the SACCH convolutional coder described in 2.7.3.1.2.2 in the order starting from the signaling word header. Bits within a field are presented to the coder in the order most significant bit first.

Each word is formatted as follows:

Field	Description	Length (bits)
Signaling Word Header	Continuation Flag	1
Reserved	Set to zero	1
Contents	Message and/or Filler	48
CRC	Cyclic Redundancy Check	16

Signaling Word Header

The word header consists of a continuation flag of one bit. The flag indicates to the receiver whether a word is the first word in a message or if it is a subsequent word.

Description	Code
First word of a message	0
Subsequent word of a multiple-word message	1

Contents

The Contents field may consist of either a message part as described in 2.7.3.3 and/or Filler Octets. If the Contents field contains a message or message part of less than 48 bits, then the Contents field is completed by inserting up to two zero bits followed by as many Filler Octets as needed. Truncate, if necessary, the last Filler Octet to complete the Contents field. If no message or message part is included in the Contents field then the field contains six Filler Octets.

DVCC

DVCC is the 8-bit color code distinguishing a designated traffic channel from its co-channels. It is used as address information for a traffic channel connection, thus both as destination address to a particular receiver and originating address from a transmitter. The DVCC is included and precedes the 50 data bits for determining the CRC.

CRC

The 50 data bits in a SACCH word is appended with a 16-bit CRC code to detect the presence of channel errors in the data. The CRC code is computed over the entire 50 bit data as well as the DVCC. (See 2.7.3.1.1.3).

2.7.3.1.3 Messages

2.7.3.1.3.1 Message Structure

Figure 2.7.3–1 shows the message format for FACCH and SACCH.

Figure 2.7.3–1 Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	Mandatory	2
Message Type	Mandatory	8
Mandatory Fixed Information Elements	Mandatory	
Mandatory Variable Information Elements	Mandatory	
Remaining Length [Note 1]	Mandatory	6
Optional Variable Information Elements	Optional	

Notes

1. To produce an integer number of octets following *Remaining Length*, zeros shall be inserted, as necessary, after the optional information elements.

Protocol Discriminator shall be the first information element in all messages. *Message Type* shall follow *Protocol Discriminator* in all messages. Where required by a specific message, other information elements shall be sent from top to botton in the order shown. If the message contains optional variable information elements, *Remaining Length* shall be included. *Remaining Length* indicates the number of octets that follow it, i.e., if the remaining length is zero, there are no optional information elements.

Variable information elements have two formats as shown in Figures 2.7.3–2 and 2.7.3–3. Format 1 is used when fixed-length fields are not required and each value can be efficiently coded using less than 8 bits. Format 2 is used when fixed-length fields are required and each value must be one octet in length. For both formats, fields shall be sent in the order shown.

Figure 2.7.3–2 Information Element Format 1

Information Element Field	Length (bits)
Parameter Type	4
Number of Values	6
Value [Note 1]	
Notes 1. 0 to 63 instances may be sent.	

Figure 2.7.3–3 Information Element Format 2

Information Element Field	Length (bits)
Parameter Type	4
Remaining Length [Note 1]	6
Fixed-Length Fields [Note 2]	
Octet Value [Note 3]	8
Notes 1. The total length of fixed-length fields and octet values shall not exceed 63 octets. 2. Fixed-length fields must total an integer number of octets. 3. 0 to 63 instances may be sent, subject to Note 1.	

For a message to be considered as valid, all words containing any part of a message must be received without any CRC failures. Note also that if after inserting zeros to fill the remaining length of a message to an integer number of octets the last word contains only zeros and filler, it too must be sent.

2.7.3.1.3.2 Message Functional Definition

Each definition includes:

- a brief description of the message use.
- a table listing the information elements contained in the message.
- parameter-type codes.

For each information element, the table indicates:

- Whether inclusion is mandatory 'M' or optional 'O'. Words containing only unused optional fields must not be sent .
- The length in bits.

Information elements shall be coded into the Message field of the FACCH or SACCH words starting from the top as they appear in the following tables. The coding shall be done in the following order: the more-significant bits of an information element shall be coded into the more-significant bits of the Message field.

Table 2.7.3.1.3.2-1 summarizes the messages on the RDTC.

Table 2.7.3.1.3.2-1 Messages on the RDTC.

Call connect messages	Max.Transmissions	Channel
CONNECT	3	FACCH

Call information phase messages	Max. Transmissions	Channel
MEASUREMENT ORDER ACK	1	FACCH
CHANNEL QUALITY MESSAGE 1	1	FACCH/ SACCH
CHANNEL QUALITY MESSAGE 2	1	FACCH/ SACCH

Call release message	Max. Transmissions	Channel
RELEASE	3	FACCH

Miscellaneous messages	Max. Transmissions	Channel
MOBILE ACK	1	FACCH/SACCH
FLASH WITH INFO	3	FACCH
FLASH WITH INFO ACK	1	FACCH
SEND BURST DTMF	3	FACCH
SEND CONTINUOUS DTMF	3	FACCH
PHYSICAL LAYER CONTROL ACK	1	FACCH/SACCH
STATUS	3/1 [Note 1]	FACCH
PARAMETER UPDATE ACK	1	FACCH
SSD UPDATE ORDER CONFIRMATION	1	FACCH
BASE STATION CHALLENGE ORDER	3	FACCH
UNIQUE CHALLENGE ORDER CONFIRMATION	1	FACCH

Notes

1. When the STATUS message is sent spontaneously by the mobile station, it may be repeated up to three times. When the STATUS message is sent by the mobile station as a response to a STATUS REQUEST message, it is sent only once.

2.7.3.1.3.2.1 Connect

This message is sent to indicate a call answer by the mobile subscriber.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8

2.7.3.1.3.2.2 Measurement Order Ack

This message acknowledges the start of the channel quality measurement in the mobile station.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
RF Channel	O	10-142

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
RF Channel	0001

2.7.3.1.3.2.3 Channel Quality Message 1

CHANNEL QUALITY MESSAGE 1 contains the measurement report for the 1st RF channel to the 6th RF channel from the mobile station.

Note: The values carried in the information element "RSSI of 1st RF ch" shall correspond to values measured on the RF channel designated as "1st RF Channel" in the Measurement Order. The same applies for the 2nd to the 6th RF Channel. The values carried in the information element "RSSI of 1st RF ch" "RSSI of 2nd RF ch" etc. is set to zero if not used.

Channel: FACCH/SACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
BER of current ch	M	3
RSSI of current ch	M	5
RSSI of 1st RF ch	M	5
RSSI of 2nd RF ch	M	5
RSSI of 3rd RF ch	M	5
RSSI of 4th RF ch	M	5
RSSI of 5th RF ch	M	5
RSSI of 6th RF ch	M	5

2.7.3.1.3.2.4 Channel Quality Message 2

The CHANNEL QUALITY MESSAGE 2 contains the measurement report for the 7th RF channel to the 12th RF channel from the mobile station.

Note: The values carried in the information element "RSSI of 7th RF ch" shall correspond to values measured on the RF channel designated as "7th RF Channel" in the Measurement Order. The same applies for the 8th to the 12th RF Channel. The values carried in the information element "RSSI of 7th RF ch", "RSSI of 12 RF ch" etc. is set to zero if not used.

Channel: FACCH/SACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
RSSI of 7th RF ch	M	5
RSSI of 8th RF ch	M	5
RSSI of 9th RF ch	M	5
RSSI of 10th RF ch	M	5
RSSI of 11th RF ch	M	5
RSSI of 12th RF ch	M	5

2.7.3.1.3.2.5 Physical Layer Control Ack

This message is used to acknowledge the PHYSICAL LAYER CONTROL message. This message must contain all the optional information elements in the PHYSICAL LAYER CONTROL message it is acknowledging. The DMAC,Time Alignment, DTX Allowed and Delay Interval Compensation Mode information elements must reflect the current value after the last PHYSICAL LAYER CONTROL message.

Channel: FACCH/SACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Remaining Length	M	6
Power Change	O	14
Time Alignment	O	15
DTX Allowed	O	11
Delay Interval Compensation Mode	O	11

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Reserved	0001
Power Change	0010
Time Alignment	0011
DTX Allowed	0100
Delay Interval Compensation Mode	0101

2.7.3.1.3.2.6 Release

This message informs the base station that a call currently established is terminated.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Remaining Length	M	6
Release Reason	O	14

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Release Reason	0001

2.7.3.1.3.2.7 Mobile Ack

This message acknowledges messages of the following message types. (For message type codes, refer to 2.7.3.1.3.3).

Ack Message Type	Ack Channel
ALERT WITH INFO	FACCH
STOP MEASUREMENT ORDER	FACCH/SACCH
RELEASE	FACCH
MAINTENANCE	FACCH
AUDIT	FACCH/SACCH
LOCAL CONTROL	FACCH/SACCH
HANDOFF	FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Ack Message Type	M	8
Remaining Length	M	6
Last Decoded Parameter	O	14

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Last Decoded Parameter	0001

2.7.3.1.3.2.8 Flash With Info

This message is sent from a mobile station to the base station indicating that a user desires to invoke a special service.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4
Remaining Length	M	6
Feature Indicator [Note 1]	O	10–14
Keypad Facility [Note 1]	O	10–266
Calling Party Number [Note 1]	O	26–146
Called Party Number [Note 1]	O	18–138

Notes

1. The total number of optional octets shall not exceed 63.

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Reserved for compatibility with IS–54–A	0001
Feature Indicator	0010
Keypad Facility	0011
Calling Party Number	0100
Called Party Number	0101

2.7.3.1.3.2.9 Send Burst DTMF

This message requests the sending of DTMF tones on the land line.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4
Remaining Length	M	6
Digits	O	10–262

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Digits	0001

2.7.3.1.3.2.10 Send Continuous DTMF

This message requests the sending of continuous DTMF tones on the land line. The sending of a DTMF tone is stopped when the null digit is sent.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4
Digit	M	4

2.7.3.1.3.2.11 Status Message

This message is used either as a reply to the STATUS Request message or as a spontaneous message from the mobile station to inform the base station of a change in status. When the STATUS message is used as a reply to the STATUS Request, it must contain all the corresponding optional parameters that appeared in the STATUS Request message.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Remaining Length	M	6
Serial Number	O	42
Call Mode	O	15
Terminal Information	O	42
Voice Privacy Mode	O	11
Message Encryption Mode	O	11

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Serial Number	0001
Call Mode	0010
Terminal Information	0011
Voice Privacy Mode	0100
Message Encryption Mode	0101

2.7.3.1.3.2.12 Flash with Info Ack

This message acknowledges a flash with info order from the base station.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4
Remaining Length	M	6
Last Decoded Parameter	O	14

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Last Decoded Parameter	0001

2.7.3.1.3.2.13 Parameter Update Ack

This message acknowledges a mobile station's update of its internal call history parameter.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4

2.7.3.1.3.2.14 SSD Update Order Confirmation

This message contains an indication of the success or failure of the SSD update procedure (see 2.3.12.1.8).

Channel: FACCH

Message Format

Information Element	**Type**	**Length (bits)**
Protocol Discriminator	M	2
Message Type	M	8
SSD_UPDATE	M	1

2.7.3.1.3.2.15 Base Station Challenge Order

This message contains the random number RANDBS used in the SSD update procedure (see 2.3.12.1.8).

Channel: FACCH

Message Format

Information Element	**Type**	**Length (bits)**
Protocol Discriminator	M	2
Message Type	M	8
RANDBS	M	32

2.7.3.1.3.2.16 Unique Challenge Order Confirmation

This message contains the response to the Unique Challenge order.

Channel: FACCH

Message Format

Information Element	**Type**	**Length (bits)**
Protocol Discriminator	M	2
Message Type	M	8
AUTHU	M	18

2.7.3.1.3.3 Information Element Description

Information elements are listed in alphabetical order.

AUTHU

This 18-bit information element is the output of the authentication algorithm when responding to a Unique Challenge order (see 2.3.12.1.5).

Bit Error Rate of current channel

This 3-bit information element contains a bit error rate value coded as defined in Table 2.4.5.1-1 .

Called Party Number

This information element identifies the called party's number.

Field	Length (bits)
Parameter Type (Called Party Number)	4
Remaining Length	6
Type of Number	3
Numbering Plan Identification	4
Spare (Set to '0')	1
Character [Note 1]	8

Notes

1. 0 to 15 instances may be sent.

Calling Party Number

This information element identifies the calling party's number.

Field	Length (bits)
Parameter Type (Calling Party Number)	4
Remaining Length	6
Type of Number	3
Numbering Plan Identification	4
Spare (Set to '0')	5
Presentation Indicator	2
Screening Indicator	2
Character [Note 1]	8

Notes

1. 0 to 15 instances may be sent.

Call Mode

This information element indicates the preferred call mode.

Field	Length (bits)
Parameter Type (Call Mode)	4
Number of Values	6
Call Mode	5

1

Digits

This information element contains dialed digits.

Field	Length (bits)
Parameter Type (Digits)	4
Remaining Length	6
Digit [Note 1]	4
Notes 1. 0 to 63 instances may be sent.	

2

DTX Allowed

This information element indicates whether the mobile station can use discontinuous transmission.

Field	Length (bits)
Parameter Type (DTX Allowed)	4
Number of Values	6
DTX Allowed	1

3

Delay Interval Compensation Mode (DIC)

This information element commands the mobile station to turn its Delay Interval Compensation function on or off.

Field	Length (bits)
Parameter Type (DIC Mode)	4
Number of Values	6
DIC Mode	1

4

Feature Indicator

This information element allows the user to invoke supplementary services and features.

Field	Length (bits)
Parameter Type (Feature Indicator)	4
Number of Values	6
Feature Indicator	4

5

Filler Octet

An octet with the binary value of 00001110. It is used in positions surrounding valid messages. It is not a message and shall not affect the call processing state. The full eight bits are not required when the filler position overlaps the end of the CRC information block.

1

Keypad Facility

This information element allows the user to convey characters entered via a keypad or other such terminal.

Field	Length (bits)
Parameter Type (Keypad Facility)	4
Number of Values	6
Character [Note 1]	8
Notes 1. Up to 32 instances may be sent.	

2

Last Decoded Parameter

This information element indicates the last information element decoded by the recipient.

Field	Length (bits)
Parameter Type (Last Decoded Parameter)	4
Number of Values	6
Last Decoded Parameter	4

3

Message Encryption Mode

This information element indicates the mobile station's message encryption mode.

Field	Length (bits)
Parameter Type (Message Encryption Mode)	4
Number of Values	6
Message Encryption Mode	1

4

Message Type

This 8-bit information element identifies the function of the message being sent. The message types are coded as follows:

Call Establishment Messages	Code
ALERT WITH INFO	00110001
CONNECT	11000001
PARAMETER UPDATE	10100010

5

Call Information Phase Messages	Code
HANDOFF	11011100
CHANNEL QUALITY MESSAGE 1	01010001
CHANNEL QUALITY MESSAGE 2	10100111
MEASUREMENT ORDER	01010010
MEASUREMENT ORDER ACK	11000010
STOP MEASUREMENT ORDER	11000111
PHYSICAL LAYER CONTROL	11110010
PHYSICAL LAYER CONTROL ACK	10010001

Call Release Messages	Code
RELEASE	11011010

Miscellaneous Messages	Code
MOBILE ACK/BASE STATION ACK	01010100
MAINTENANCE	01100010
AUDIT	01100001
LOCAL CONTROL	00110010
FLASH WITH INFO	11110001
FLASH WITH INFO ACK	10100001
SEND BURST DTMF	10010010
SEND BURST DTMF ACK	00110111
SEND CONTINUOUS DTMF	01100111
SEND CONTINUOUS DTMF ACK	01010111
STATUS REQUEST	11110111
STATUS	10010111
PARAMETER UPDATE ACK	00110100
UNIQUE CHALLENGE ORDER CONFIRMATION	00000001
BASE STATION CHALLENGE ORDER	00000011
SSD UPDATE ORDER CONFIRMATION	00000101
UNIQUE CHALLENGE ORDER	00000111
BASE STATION CHALLENGE ORDER CONFIRMATION	00001000
SSD UPDATE ORDER	00001001

Message Waiting

This information element conveys to the user the number of messages waiting.

Field	Length (bits)
Parameter Type (Msg Waiting)	4
Number of Values	6
Number of Messages Waiting	6

1

Power Change

This information element indicates the RF transmit power the mobile station must use.

Field	Length (bits)
Parameter Type (Power Change)	4
Number of Values	6
DMAC	4

2

Protocol Discriminator

This 2-bit information element defines the protocol used for the message.

Description	Code
Protocol defined by 2.7.3.1.3	00
Reserved	01
Reserved	10
Reserved	11

3

RANDBS

This 32-bit information element, is a random number used in the SSD update procedure (see 2.3.12.1.8)

4

Release Reason

This information element indicates the reason the release message was sent.

Field	Length (bits)
Parameter Type (Release Reason)	4
Number of Values	6
Release Reason	4

5

Remaining Length

This 6-bit information element indicates the number of octets following this element in a message.

Description	Code
none	000000
1 octet	000001
2 octets	000010
...	...
63 octets	111111

1

Request number

This 4-bit information element is used to determine that retransmission due to the lack of acknowledgement of a request has occurred. For every retransmission due to lack of an acknowledgement, the request number is not incremented. However, for each new request, the request number is incremented by one (modulo 16). Each request number shall be incremented and a comparison made on an individual basis for each message type.

2

RF Channel

This information element indicates the RF channel number.

Field	Length (bits)
Parameter Type (RF Channel)	4
Number of Values	6
RF Channel [Note 1]	11
Notes 1. 0 to 12 instances may be sent.	

3

RSSI of current channel

This 5-bit information element contains a received signal strength value coded as defined in Table 2.4.5.1-2 .

4

RSSI of 1st RF channel , RSSI of 2nd RF...etc

This 5-bit information element contains a received signal strength value coded as defined in Table 2.4.5.1-2 .If this information element is sent but not used it is filled with zeros.

5

Serial Number

This information element indicates the electronic serial number of the mobile station.

Field	Length (bits)
Parameter Type (Serial Number)	4
Number of Values	6
Electronic Serial Number	32

6

Signal

This information element allows the network to convey information to a user via tones and other alerting signals.

Field	Length (bits)
Parameter Type (Signal)	4
Number of Values	6
Signal	8

1

SSD _UPDATE

This 1-bit information element indicates the outcome of the SSD update procedure

Description	Code
SSD update failure	0
SSD update success	1

2

Terminal Information

This information element provides information on the sending mobile station.

Field	Length (bits)
Parameter Type (Terminal Information)	4
Number of Values	6
Terminal Information	32

3

Time Alignment

This information element commands the mobile station to set itself to an absolute timing offset from the standard reference position.

Field	Length (bits)
Parameter Type (Time Alignment)	4
Number of Values	6
Time Alignment	5

4

Voice Privacy Mode

This information element indicates the mobile station's voice-privacy mode.

Field	Length (bits)
Parameter Type (Voice Privacy Mode)	4
Number of Values	6
Privacy Mode	1

5

1 2.7.3.1.3.3.1 Information Element Field Description

2 Fields are listed in alphabetical order.

3

Ack Message Type — This 8-bit information element contains a message type code. This code is always the same as in the message type field of the message being acknowledged.

4

Call Mode — This 5-bit field uses the same code as the analog voice channel mobile initiation message message-type code (see 3.7.1-1).

5

Color Code SAT/DVCC — This 8-bit field defines the color code to be used. The interpretation of this information element is dependent of the value of the information element Timeslot Indicator.

If Timeslot Indicator = 000 the two least significant bits of SAT/DVCC shall be coded according to Table 3.7.1-2 SAT Color Code and the other 6 bits set to zero.

If Timeslot Indicator ≠ 000 the 8 bits of the SAT/DVCC shall be interpreted as the DVCC of the new traffic channel .

6

Character — Each character is an 8-bit field coded as follows:

- The most-significant bit is set to '0'.
- The remaining seven bits represent an ASCII character as defined in ANSI X3.4.

7

Delay Interval Compensation (DIC) Mode — This 1-bit field indicates if the delay interval compensation function in the mobile station should be turned on or off.

Description	Code
Turn off DIC function	0
Turn on DIC function Delay Interval Compensation is turned on unless otherwise stated. [Default setting]	1

8

Digit

This 4-bit field indicates a dialed digit.

Description	Code
[NULL]	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
0	1010
*	1011
#	1100
Reserved	1101
Reserved	1110
Reserved	1111

1

DMAC/VMAC

This field indicates the mobile station power level to be used on the new traffic or voice channel. For handoff from a digital traffic channel to an analog voice channel, the mobile station shall interpret the last three significant bits of codes 0000 through 0111 as VMAC.

Description	Code
Go to power level 0	0000
Go to power level 1	0001
...	...
Go to power level 9	1001
Go to power level 10	1010
Reserved for future use	1011
Reserved for future use	1100
Reserved for future use	...
Reserved for future use	1111

2

DTX Allowed

This 1-bit field indicates if DTX is allowed.

Description	Code
DTX is disabled	0
DTX is enabled unless otherwise stated. [Default setting]	1

3

Electronic Serial Number This 32-bit field contains the 32-bit electronic serial number (ESN) assigned by the mobile manufacturer.

Feature Indicator This 4-bit field indicates the feature that is to be invoked.

Last Decoded Parameter This 4-bit field indicates the bit pattern of the last decoded information element parameter-type field.

Local Control This 5-bit field indicates what kind of customized operation the mobile is to perform.

Message Encryption Mode This one-bit field indicates message encryption mode.

Description	Code
Message encryption mode off	0
Message encryption mode on	1

Number of Messages Waiting This 6-bit field indicates the number of messages waiting at the base station.

Description	Code
none	000000
1 message	000001
2 messages	000010
...	...
63 messages	111111

Number of Values This 6-bit field indicates the number of values contained in the variable length parameter field.The number of bits the value consists of is defined by the parameter type.

Description	Code
none	000000
1 value	000001
2 values	000010
...	...
63 values	111111

1

Numbering Plan Identification

As defined in ANSI T1.607 §4.5.9, this 4-bit field indicates the numbering plan used for calling or called numbers.

Description	Code
Unknown	0000
ISDN/Telephony numbering plan (CCITT E.164 and E.163)	0001
Data numbering plan (CCITT X.121)	0011
Telex numbering plan (CCITT F.69)	0100
Private numbering plan	1001
Reserved for extension	1111
All other values are reserved.	

2

Parameter Type

This 4-bit field indicates the type of optional parameter that follows. Parameter-type codes are specific to the message type.

3

Presentation Indicator

As defined in ANSI T1.607 §4.5.9, this 2-bit field indicates whether or not the calling number should be displayed.

Description	Code
Presentation allowed	00
Presentation restricted	01
Number not available	10
Reserved	11

4

Privacy Mode

This one-bit field indicates privacy mode.

Description	Code
Privacy mode off	0
Privacy mode on	1

5

Rate

This 1-bit field indicates the rate of the designated traffic channel .

Description	Code
Full-Rate Channel	0
Half-Rate Channel	1

1 **Release Reason**

This 4-bit field indicates the reason a release message was sent.

Description	Code
Normal release	0000
Power-down release	1111
All other values are reserved.	

2 **Remaining Length**

This 6-bit field indicates the number of octets to follow.

Description	Code
None	000000
1 octet to follow	000001
...	...
63 octets to follow	111111

3 **RF Channel**

This 11-bit field contains an RF channel number as defined in paragraph 2.1.1.1.

Description	Code
[NULL]	00000000000
Channel Number 1	00000000001
Channel Number 2	00000000010
...	...
Channel Number 1023	01111111111
Reserved	10000000000
Reserved	...
Reserved	11111111111

4 **Screening Indicator**

As defined in ANSI T1.607 §4.5.9, this 2-bit field indicates how the calling number was screened.

Description	Code
User-provided, not screened	00
User-provided, verified and passed	01
User-provided, verified and failed	10
Network-provided	11

1

Shortened Burst Indicator

This 2-bit field defines whether the mobile station shall use shortened burst initially on the new traffic channel. It also indicates if the handoff is within the same cell.

Description	Code
Transmit normal burst after cell-to-cell handoff	00
Transmit normal burst after handoff within cell	01
Transmit shortened burst after cell-to-cell handoff	10
Reserved	11

2

Signal

This 8-bit field comprises two subfields: pitch, the two most-significant bits, and cadence, the six least-significant bits. Pitch represents a distinction between tones, usually based on frequency. Cadence is the on/off pattern of the tones. *Standard Alert* is "00000001." If the mobile station supports distinctive alerting with pitches and cadences, it should generate the pitches and cadences recommended in the following tables.

Recommended pitches and their corresponding codes are as follows:

Description	Code
Medium pitch	00
High pitch	01
Low pitch	10
Reserved	11

3

Recommended cadences and their corresponding codes are as follows:

Description	Code
No Tone: Off	000000
Long: 2.0 s on, 4.0 s off, repeating	000001
Short-Short: 0.8 s on, 0.4 s off, 0.8 s on, 4.0 s off, repeating	000010
Short-Short-Long: 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.8 s on, 4.0 s off, repeating	000011
Short-Short-2: 1.0 s on, 1.0 s off, 1.0 s on, 3.0 s off, repeating.	000100
Short-Long-Short: 0.5 s on, 0.5 s off, 1.0 s on, 0.5 s off, 0.5 s on, 3.0 s off, repeating.	000101
Short-Short-Short-Short: 0.5 s on, 0.5 s off, 0.5 s on, 0.5 s off, 0.5 s on, 0.5 s off, 0.5 s on, 2.5 s off, repeating.	000110
PBX Long: 1.0 s on, 2.0 s off, repeating.	000111
PBX Short-Short: 0.4 s on, 0.2 s off, 0.4 s on, 2.0 s off, repeating.	001000
PBX Short-Short-Long: 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.8 s on, 1.0 s off, repeating.	001001
PBX Short-Long-Short: 0.4 s on, 0.2 s off, 0.8 s on, 0.2 s off, 0.4 s on, 1.0 s off, repeating.	001010
PBX Short-Short-Short-Short: 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.4 s on, 0.2 s off, 0.4 s on, 0.8 s off, repeating.	001011
Reserved	001100
...	...
Reserved	111111

Terminal Information

A 32-bit field used to identify/verify mobile station terminal-specific information and feature settings.

The "EIA/TIA IS-54 Version Number" indicates the EIA/TIA standard for which the mobile station is complying. For IS-54 Revision A, the four bits should be set to 0000. For IS-54 Revision B, the four bits should be set to 0001. All other values are reserved for future use.

The "Model Number of Mobile" is defined by each mobile station manufacturer for their own mobile stations. All mobile station models from the same manufacturer must have a different "Model Number of Mobile". All possible values between 00000000 and 11111111 are valid.

The "Firmware Vintage of Mobile" is defined by each mobile station manufacturer for their own firmware releases. All firmware vintages of the same mobile station model must have a different "Firmware Vintage of Mobile" number. All possible values between 000000 and 111111 are valid.

Subfield	Length (Bits)
EIA/TIA IS-54 Version Number	4
MFR Code	8
Model Number of Mobile	8
Firmware Vintage of Mobile	6
Access Overload Class from NAM	4
Local Control Status of Mobile (enabled=1, disabled=0)	1
Registration bit (R_S)	1

Time Alignment

This 5-bit field indicates the absolute timing offset (see 2.1.3.3.5.1) from the standard offset reference (SOR) position (see 1.2.1.1).

Description	Code
Timing offset = SOR	00000
Timing offset = 1 unit from SOR	00001
Timing offset = 2 units from SOR	00010
Timing offset = 3 units from SOR	00011
...	...
Timing offset = 28 units from SOR	11100
Timing offset = 29 units from SOR	11101
Timing offset = 30 units from SOR	11110
Maintain current timing offset	11111

Timeslot Indicator

This 3-bit field indicates the timeslot of the designated traffic channel .

Description	**Code**
Analog channel	000
Timeslot 1	001
Timeslot 2	010
Timeslot 3	011
Timeslot 4	100
Timeslot 5	101
Timeslot 6	110
Reserved	111

Type of Number

As defined in ANSI T1.607 §4.5.9, this 3-bit field indicates the type of calling or called number.

Description	**Code**
Unknown	000
International number	001
National number	010
Network-specific number	011
Subscriber number	100
Reserved	101
Abbreviated number	110
Reserved for extension	111

2.7.3.2 Protocol Structure For Enhanced Services

Requires further study.

3. Base Station

(See also §5. for Base Station Options.)

3.1 Transmitter

3.1.1 Frequency Parameters

3.1.1.1 Channel Spacing and Designation

Channel spacing shall be 30 kHz and the base station transmit channel at 870.030 MHz (and the corresponding dual-mode mobile station transmit channel at 825.030 MHz) shall be termed channel number 1. The 20 MHz range of channels 1 through 666 as shown in Table 2.1.1.1-1 for System A and System B is basic. The additional 5 MHz of channels 667 through 799 and (wrap-around) 991 through 1023 for extending Systems A and B is mandatory. The station class mark (SCM, see 2.3.3) of a mobile station must be taken into account in the consideration of assignment of a channel in this extended band.

3.1.1.2 Frequency Tolerance

3.1.1.2.1 Frequency Tolerance for Analog Mode Operation

The base station carrier frequency must be maintained within ±1.5 parts per million (ppm) of any assigned channel frequency.

3.1.1.2.2 Frequency Tolerance for Digital Mode Operation

The base station transmit carrier frequency must be maintained within ±0.25 parts per million (ppm) of any assigned channel frequency.

3.1.2 Power Output Characteristics

Maximum effective radiated power (ERP) and antenna height above average terrain (HAAT) must be coordinated locally on an ongoing basis. For digital mode operation, the base station output power shall be maintained at a constant level for the full duration of the frame if any slot is occupied.

3.1.3 Modulation Characteristics

3.1.3.1 Analog Voice Signals

The (FM) modulator is preceded by the following five voice-processing stages (in the order listed):

- Transmit Audio Level Adjustment
- Compressor
- Pre-Emphasis
- Deviation Limiter
- Post Deviation-Limiter Filter

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks:

The transmit audio sensitivity shall be adjusted such that the same reference input level used to generate a state of $R_0 = 21$ in the VSELP encoder results in a ±2.9 kHz peak frequency deviation of the transmitted carrier measured with a 1 kHz sinusoidal tone.

3.1.3.1.1 Compressor

This stage is the compressor portion of a 2:1 syllabic compandor. For every 2 dB change in input level to a 2:1 compressor within its operating range, the change in output level is a nominal 1 dB. The compressor must have a nominal attack time of 3 ms and a nominal recovery time of 13.5 ms as defined by the CCITT. (Reference: Recommendation G162, CCITT Plenary Assembly, Geneva, May-June 1964, Blue Book, Vol. 111, P. 52.) The nominal reference input level to the compressor is that corresponding to a 1000 Hz acoustic tone at the expected nominal speech volume level. This level must produce a nominal ±2.9 kHz peak frequency deviation of the transmitted carrier.

3.1.3.1.2 Pre-emphasis

The pre-emphasis characteristic must have a nominal +6 dB/octave response between 300 and 3000 Hz.

3.1.3.1.3 Deviation Limiter

For audio (voice) inputs applied to the transmitter analog voice-signal processing stages, a base station must limit the instantaneous frequency deviation to ±12 kHz. This requirement excludes supervision signals (see 3.4) and wideband data signals (see 3.1.3.2).

3.1.3.1.4 Post Deviation-Limiter Filter

The deviation limiter must be followed by a low-pass filter whose characteristics are:

Frequency Band	Attenuation Relative to 1000 Hz
3000 - 15000 Hz	≥ 40 log (f/3000) dB
above 15000 Hz	≥ 28 dB

3.1.3.2 Wideband Analog Data Signals

3.1.3.2.1 Encoding

The forward control channel (FOCC) and forward voice channel (FVC) wideband data streams (see 3.7) must be further encoded such that each nonreturn-to-zero binary one is transformed to a zero-to-one transition, and each nonreturn-to-zero binary zero is transformed to a one-to-zero transition.

3.1.3.2.2 Modulation and Polarity

The filtered wideband data stream must then be used to modulate the transmitter carrier using direct binary frequency shift keying. A one (i.e., high state) into the modulator must correspond to a nominal peak frequency deviation 8 kHz above the carrier frequency, and a zero into the modulator must correspond to a nominal peak frequency deviation 8 kHz below the carrier frequency.

3.1.3.3 Digital Voice and Data Signals

3.1.3.3.1 Modulation

The standard modulation method used is known as $\frac{\pi}{4}$ shifted, differentially encoded quadrature phase shift keying. A description is found in Section 2.1.3.3.1.

If any time slot is assigned to a mobile station that is using the standard modulation then all time slots whether assigned or not sharing the same RF carrier shall use the same modulation method. Each time slot must contain a sync word as defined in 1.2.4.

3.1.3.3.2 Speech Coding

See 2.1.3.3.2 with the exception of 2.1.3.3.2.2.

3.1.3.3.2.1 Audio Interface

Due to the delays inherent in the air interface specification, which may exceed 100 msec, the implementer is cautioned that echo control measures are necessary.

The function of the audio interface at the base station transmitter is to code convert a 8 bit/μ-law PCM signal from the PSTN to a uniform 14 bit format. This 14 bit uniform signal is the input to the speech coder.

The characteristics of this code conversion is described in the following sections.

3.1.3.3.2.1.1 Transmit Audio Level Adjustment

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks:

The transmit audio sensitivity shall be adjusted so that a level of -18 dBm0 on the digital trunk network (0 dBr) shall be equivalent to the state $R_0 = 21$ in the VSELP encoder measured using a speech-like signal or a 1 kHz sinusoidal tone whose level is adjusted to be equivalent.

3.1.3.3.2.1.2 Mulaw to 14 bit uniform format conversion

The μ-law to uniform format conversion shall be performed according to the definition in the CCITT Red Book G.721 section 4.2.1 sub-block EXPAND. The parameter LAW shall be set to LAW=0.

3.1.3.3.2.1.3 Echo Control

When a mobile station is operating in a digital mode for speech transmission, echo-return-loss enhancement shall be provided on the outgoing trunk, by means of an echo canceler, to remove echoes returned to the mobile user. The echo canceler shall provide a minimum echo return loss enhancement (ERLE) of 20 dB, and it shall be capable of providing this loss enhancement on any echo path having an impulse response length of 48 ms or less.

3.1.3.3.3 Channel Coding

See 2.1.3.3.3.

3.1.3.3.4 Interleaving

See 2.1.3.3.4.

3.1.3.3.5 Time Alignment

See 2.1.3.3.5.

3.1.3.3.6 Synchronization and Timing

The base station transmit symbol and TDMA frame and slot timing shall be derived from a common source with an absolute frequency tolerance of ±5 parts per million (ppm).

3.1.4 Limitations on Emissions

3.1.4.1 Bandwidth Occupied

3.1.4.1.1 Analog Transmitter

Modulation products outside the region ±20 kHz from the carrier shall not exceed a level of 26 dB below the unmodulated carrier. Modulation products outside the region of ±45 kHz from the carrier shall not exceed a level of 45 dB below the unmodulated carrier. Modulation products outside the region of ±90 kHz from the carrier shall not exceed a level of (a) 60 dB below the unmodulated carrier, or (b) 43 plus 10 Log_{10} (mean output power in Watts) dB below the unmodulated carrier. Measurement techniques are defined in the current EIA/TIA IS-20, "Recommended Minimum Standards for 800 MHz Cellular Land Stations," and IS-56, "Recommended Minimum Performance Standards for 800 MHz Base Stations Supporting Dual-Mode Mobile Stations".

3.1.4.1.2 Digital Transmitter

The emission power in either adjacent channel, centered ±30 kHz from the nominal center frequency, shall not exceed a level of 26 dB below the mean output power. The emission power in either alternate channel, centered ±60 kHz from the nominal center frequency, shall not exceed a level of 45 dB below the mean output power. For output powers 50 W or less, the emission power in either second alternate channel, centered ±90 kHz from the nominal center frequency, shall not exceed a level of 45 dB below the mean output power or -13 dBm, whichever is the lower power. For output powers greater than 50 W, the emission power in either second alternate channel, centered ±90 kHz from the nominal center frequency, shall not exceed a level of 60 dB below the mean output power.

3.1.4.2 Conducted Spurious Emissions

Refer to EIA/TIA - IS-56.

3.1.4.3 Radiated Spurious Emissions

Refer to EIA/TIA - IS-56.

3.1.4.4 Intermodulation

Radiated products from co-located transmitters shall not exceed FCC spurious and harmonic level requirements that would apply to any of the transmitters operated singly.

3.2 Receiver

3.2.1 Frequency Parameters

3.2.1.1 Channel Spacing and Designation

Channel spacing shall be 30 kHz and the base station receive channel at 825.030 MHz (and the corresponding dual-mode mobile station receive channel at 870.030 MHz) shall be termed channel number 1. The 20 MHz range of channels 1 through 666 as shown in Table 2.1.1.1-1 for System A and System B is basic. The additional 5 MHz of channels 667 through 799 and (wrap-around) 991 through 1023 for extending Systems A and B is mandatory. The station class mark (SCM, see 2.3.3) of a mobile station must be taken into account in the consideration of assignment of a channel in this extended band.

3.2.2 Demodulation Characteristics

3.2.2.1 Analog Voice Signals

The demodulator is followed by the following three voice-signal processing stages:

- Receive Audio Level Adjustment
- De-Emphasis
- Expandor

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks:

The receive audio sensitivity shall be adjusted so that a 1 kHz modulated carrier with ±2.9 kHz peak frequency deviation results in a level of -18 dBm0 on the digital trunk network (0 dBr).

3.2.2.1.1 De-emphasis

The de-emphasis characteristic must have a nominal -6 dB per octave response between 300 and 3000 Hz.

3.2.2.1.2 Expandor

This stage is the expandor portion of a 2:1 syllabic compandor. For every 1 dB change in input level to a 1:2 expandor, the change in output level is a nominal 2 dB. The signal expansion must follow all other demodulation signal processing (including the 6 dB/octave de-emphasis and filtering). The expandor must have a nominal attack time of 3 ms and a nominal recovery time of 13.5 ms as defined by the CCITT. (Reference: Recommendation G162, CCITT Plenary Assembly, Geneva, May-June 1964, Blue Book, Vol. 111, P. 52.)

The nominal reference input level to the expandor is that corresponding to a 1000 Hz tone from a carrier with a ±2.9 kHz peak frequency deviation.

3.2.2.2 Digital Voice and Data Signals

3.2.2.2.1 Demodulation

$\frac{\pi}{4}$ shifted, differentially encoded quadrature phase shift keying is amenable to a number of different demodulation techniques.

3.2.2.2.2 De-interleaving

See 2.2.2.2.2.

3.2.2.2.3 Convolutional Decoding

See 2.2.2.2.3.

3.2.2.2.4 Speech Decoding

See 2.2.2.2.4 with the exception of 2.2.2.2.4.5.

3.2.2.2.4.1 Audio Interface

The function of the audio interface at the base station receiver is to code convert a 14 bit uniform format signal from the speech decoder to 8 bit/μ-law signal as the input to the PSTN.

The characteristics of this code conversion is described in the following sections.

3.2.2.2.4.1.1 Receive Audio Level Adjustment

Pending the generation of a complete speech transmission plan for dual-mode cellular systems, the following requirements shall be met to ensure compatibility with the transmission plan for fixed digital speech networks:

The receive audio sensitivity shall be adjusted so that the state $R_0 = 21$ in the VSELP encoder measured with a speech-like signal or a 1 kHz tone whose level is adjusted to be equivalent results in a level of -18 dBm0 on the digital trunk network (0 dBr).

3.2.2.2.4.1.2 Uniform to 8 bit/μ-law code conversion

The 14 bit uniform to 8 bit/μ-law code conversion shall be performed according to definition in CCITT Red Book G.721 section 4.2.7. sub-block COMPRESS. The parameter LAW shall be set to LAW=0.

3.2.2.2.5 Delay Interval Requirements

The base station shall provide for delay interval compensation of up to 1 symbol length. The delay interval is defined as the difference in microseconds between the first and last ray, using a two-ray model, where both rays are of equal magnitude

(Note: The current specification is based on incomplete information on delay spread profiles found in existing cellular systems. As such, it is subject to revision and change in the future, if this is found to be necessary in light of further data.)

3.2.3 Limitations on Emissions

Refer to EIA/TIA IS-56.

3.2.4 Other Receiver Parameters

System performance is predicated upon receivers meeting EIA/TIA IS-20, "Recommended Minimum Standards for 800 MHz Cellular Land Stations", and EIA/TIA IS-56, "Recommended Minimum Performance Standards for 800 MHz Base Stations Supporting Dual-Mode Mobile Stations.

3.3 Security and Identification

3.3.1 Authentication

The term "authentication" refers to the process during which information is exchanged between a mobile station and the base station for the purposes of enabling the base station to confirm the identity of the mobile station. In short, a successful outcome of the authentication process occurs only when it can be demonstrated that the mobile station and base station possess identical sets of Shared Secret Data (SSD). Details of the procedures are given in 2.3.12.

3.3.2 Voice Privacy

See 2.3.12.3.

3.4 Supervision

For supervising the connection on the traffic channel

- if the base station is operating on an analog voice channel the Supervisory Audio Tone (see 2.4.1) and the Signaling Tone (see 2.4.2) are used.
- if the base station is operating on a digital traffic channel the Digital Verification Color Code (see 2.4.3) is used.

3.4.1 Supervisory Audio Tone

3.4.1.1 SAT Detection (reserved)

3.4.1.2 SAT Transmission

Whenever a base station transmitter is active on a voice channel, one of the following tones must be modulated on the carrier with a frequency deviation of ±2 kHz ±10 percent:

- 5970 Hz.
- 6000 Hz.
- 6030 Hz.

The frequency tolerance of the tone must be ±1 Hz.

3.4.1.3 Fade Timing Status

Reserved.

3.4.2 Signaling Tone Detection

Reserved.

3.4.3 Digital Verification Color Code

See 1.2.5 and 2.4.3.

3.4.4 Time Slot Identifier

See 1.2.4.

3.4.5 Supervisory Channel

See 2.4.4.

3.4.6 Mobile Assisted Handoff

3.4.6.1 Base Station General Operational Description

Mobile Assisted Handoff (MAHO) is a function in which the mobile supplies the base station with signal quality information pertaining to RF channels in the cellular network.

There are two types of channels upon which the mobile performs signal quality measurements: the current forward traffic channel and any other forward RF channels.

- The current forward traffic channel is used to transmit information from the base station to the mobile during a call. Channel quality measurements consist of the mobile received signal strength indicator (RSSI) and Bit Error Rates.
- The forward RF channel can be any RF channel. Channel quality measurements on these RF channels consist of measured RSSI levels.

The base station identifies in the measurement order message those RF channels that the mobile shall measure. When time alignment control has advanced mobile transmit time alignment by 30 units (units are in $\frac{1}{2}$ symbols), the Stop Measurement Order or the Start Measurement Order with only the current channel shall be sent.

3.4.6.2 Mobile Assisted Handoff Message Sets

MAHO consists of the following messages:

Start Measurements order

- MEASUREMENT ORDER message (base station to mobile)
- MEASUREMENT ORDER acknowledge message (mobile to base station)

Stop measurements order

- STOP MEASUREMENT order message (base station to mobile)
- MOBILE ACK message (mobile to base station)

CHANNEL QUALITY MESSAGE (mobile to base station only)

3.4.6.2.1 Procedures to Start Channel Quality Measurements

The base station initiates MAHO operation by sending start measurements order to the mobile. This message identifies those forward RF channels which the base station requires the mobile to measure.

Upon receipt of this message, the mobile shall begin measurements on the current traffic channel and all forward RF channels identified in the measurement order message and the mobile shall begin reporting the measurement results to the base station in the exact order specified by the measurement order message (See 3.7.3.1.3.2.2).

3.4.6.2.2 Procedures to Stop Channel Quality Measurements

A stop measurement message terminates all channel quality measurements and reports.

3.4.6.2.3 Reporting of Measurement Results

The mobile normally reports the measurement results by transmitting the information to the base station on the SACCH. The base station does not acknowledge the reception of a channel quality message.

3.4.6.2.4 Measurement Status After Handoff

There is no change in measurement history after a handoff. When a new measurement order list is specified, the mobile station will maintain continuity of the time averaging process on all unchanged RF channel frequencies which are in the same positions in both the old and new lists. RF channel frequencies which are only in the new list are reinitialized.

3.4.6.3 MAHO Operations With DTX Operation

The mobile transmits the signal quality information over either the SACCH or the FACCH. In the case of continuous transmission, the mobile transmits over the SACCH. In the case of Discontinuous Transmission (DTX), the mobile transmits channel quality information over the SACCH whenever the mobile is in the DTX High state. If the mobile is in the DTX Low state, the data is sent from the mobile to the base station by going to the DTX High state and transmitting the information over the FACCH.

3.5 Malfunction Detection

Reserved.

3.6 Call Processing

The following sections describe the base station operation to control the mobile station. Frequent references are made to the corresponding sections in the mobile section and to the messages that flow between the base station and the mobile station. It is helpful to read 2.6 and 3.6 in parallel and examine the message formats in 2.7 and 3.7 at the same time.

3.6.1 Overhead Functions for Mobile Station Initiation

To control mobile stations executing the Initialization Task (see 2.6.1), the following information must be sent in the overhead message train (see 3.7.1.2 for the formats of the messages):

- First part of the system identification (SID1).
- Number of paging channels (N).

3.6.2 Mobile Station Control on the Control Channel

3.6.2.1 Overhead Information

To control mobile stations monitoring a control channel, the following overhead information must be sent in the system parameter overhead message (see 3.7.1.2 for the message formats):

- First part of the system identification (SID1).
- *Protocol Capability Indicator (PCI).* Set to 1 if the control channel can assign digital traffic channels.
- *Authentication (AUTH).* To permit the mobile station to use the authentication procedures described in 2.3.12 and 3.3.1, set this bit to 1.
- *Serial number (S).* To require that all mobile stations send their serial numbers during a system access, the S field must be set to '1'; otherwise it must be set to '0'.
- *Registration (REGH, REGR).* To enable registration for home mobile stations, the REGH field must be set to '1'; otherwise it must be set to '0'. To enable registration for roaming mobile stations, The REGR field must be set to '1'; otherwise it must be set to '0'. If registration is enabled, the base station must support both autonomous and non-autonomous registration by mobile stations.
- *Extended Address (E).* To require that all mobile stations send both MIN1 and MIN2 during a system access, the E field must be set to '1'; otherwise it must be set to '0'.
- *Discontinuous transmission (DTX).* To permit mobile stations to use the discontinuous transmission mode on the voice channel, the DTX field must be set to '10' or '11'; otherwise it must be set to '00'. A setting of '10' indicates that the DTX-low level must equal or exceed a level 8 dB below the DTX-high level. A setting of '11' indicates that no minimum applies to the DTX-low level. (See 2.3.11.) This field controls the operation of Discontinuous Transmission on an analog voice channel only. All digital traffic channels will support discontinuous transmission as described in 2.3.11.2.
- *Number of paging channels (N).*
- *Read control-filler message (RCF).* To require that all mobile stations read a control-filler message before accessing a system on a reverse control channel, the RCF field must be set to '1'; otherwise it must be set to '0'.

- *Combined paging/access (CPA).* If the access functions are combined with the paging functions on the same set of control channels, the CPA field must be set to '1'. If the access functions are not on the same set of channels as the paging functions, the CPA field must be set to '0'.
- *Number of access channels (CMAX).*

The following overhead information is sent as required in messages appended to a system parameter overhead message (see 3.7.1.2 for messages formats):

- *Local control.* A system may customize operation for home mobile stations and for those roaming mobile stations whose home systems are members of a group by sending local control global action messages.
- *New Access channels.* If the access channel set is not the default set (see 2.6.2.1), the new access channel global action message must be sent with the NEWACC field set to the first access channel.
- *Registration increment.* Each time a mobile station with autonomous registration enabled registers, it increments its next registration ID by a fixed value ($REGINCR_s$; see 2.6.3.11). To change this value, the registration increment global action message must be sent with the REGINCR field appropriately set.
- *Registration ID.* The registration ID message must be sent in order to require that all mobile stations with autonomous registration enabled and with a given or lower next registration ID ($NXTREG_{s-p}$) register.
- *Rescan.* To require that all mobile stations enter the Initialization Task and scan the dedicated control channels, the rescan global action message must be sent.
- *RAND1_A.* Used by a mobile station to construct the 16 most significant bits of the 32 bit RAND value.
- *RAND1_B.* Used by a mobile station to construct the 16 least significant bits of the 32 bit RAND value.

3.6.2.2 Page

To page a mobile station, a mobile station control message must be sent (see 3.7.1.1). Home mobile stations may be paged with a one-word or a two-word message. Roaming mobile stations must be paged with a two-word message.

When CPA is set to 0 in a cell's overhead message train, paging for dual-mode mobiles stations will be performed on the nominal Access channel, and paging for analog mobiles will be performed on the nominal Paging channel.

3.6.2.3 Order

Orders and order confirmations must be sent to mobile stations with a multi-word mobile station control message (See 3.7.1.1). The following orders and order confirmations may be transmitted:

- Audit.
- Local control.
- Message Waiting
- Abbreviated Alert
- SSD Update order
- Unique Challenge order
- Base Station Challenge order confirmation

3.6.2.4 Local Control

A cellular system may customize operation for home mobile stations, and for those roaming mobile stations whose home systems are members of a group, by sending local orders with the order field set to local control (which informs the mobile station to examine the local control field), and by sending one or both of two local control global action overhead messages (see 3.7.1.1, 3.7.1.2.2, and 3.7.2).

A group of systems could be formed by participating systems agreeing to a common set of local control protocols and whose system identifications (SID) are recognized by mobile stations as a common group.

3.6.3 Base Station Support of System Access by Mobile Stations

3.6.3.1 Overhead Information

The following information must be sent on a forward control channel to support system access by mobile stations (see 3.7.1.2 for message formats):

- *Digital color code* (DCC). The DCC, SDCC1, and SDCC2 are transmitted from the base station to the mobile station. The mobile station then uses the DCC, SDCC1, and SDCC2 to identify to the base station which base station transmitter the mobile station is receiving.
- *Control mobile attenuation code* (CMAC). The CMAC must be transmitted from the base station to the mobile station in the control-filler message if the mobile station must adjust its transmitter power level before accessing a system on a reverse control channel. The translation of the CMAC field to transmitter power level depends on the mobile station's power class as indicated by its station class mark (SCM_p) (see 2.1.2.2 and 2.3.3). When not required, the CMAC field must be set to '000'. To require that mobile stations read a control-filler message prior to system access, the RCF field must be set to '1' in the system parameter overhead message.
- *Wait-for-overhead-message* (WFOM). If the mobile station must wait for an overhead message train before accessing a system on a reverse control channel, then the WFOM field must be set to '1' in the control-filler message; otherwise it must be set to '0'.
- *Overload control* (OLC). If the mobile stations assigned to one or more of the 16 overload classes must not access the system for originations on the reverse control channel, the overload control global action message must be appended to a system parameter overhead message. When this message is appended, the overload class fields corresponding to the restricted overload classes must be set to '0', and the remaining overload class fields must be set to '1'.
- *Access type parameters*. If a mobile station must not check for an idle-to-busy status transition on the reverse control channel when accessing a system, then the access type parameters global action message with the BIS field set to '0' must be appended to a system parameter overhead message; otherwise the BIS field must be set to '1' whenever the message is appended.
- *Access attempt parameters*. If the default values for the number of seizure attempts or the limit on the number of busy occurrences for mobile stations accessing the reverse control channel must not be used, then the access attempt parameters global action message must be appended to a system parameter overhead message.

3.6.3.2 Reverse Control Channel Seizure by Mobile Stations

If mobile stations are required to check for an idle-to-busy transition of the busy-idle bits in the corresponding FOCC when accessing a system (i.e., the BIS field is set to '1'), then whenever the base station receives a seizure precursor (see 2.7.1) that matches its encoded form of the DCC with 1 or no bit errors, it must begin transmitting busy-idle bits as busy on the FOCC between 0.8 ms and 2.9 ms, inclusive, after the reception of the last bit of the mobile station's precursor (i.e., bit times 56 through 77 of the mobile station's message). The busy-idle bits must remain busy until the 30 ms after the last bit of the last word of the mobile station's message has been received, if this can be determined; otherwise, until the time equal to (24N + 55) ms after transmitting the first busy- idle bit as busy, where N is the maximum number of words the base station has been designed to receive.

3.6.3.3 Response to Mobile Station Messages

Whenever the mobile station sends a message to the base station, it is not required that the base station respond to the message. During periods of overload or high usage, it may be desirable to permit mobile stations to "time-out" rather than sending release or other orders that use system capacity.

The following responses to mobile station messages may be sent:

- *Origination message.* Send one of the following orders:
    - Initial voice channel designation,
    - Directed retry,
    - Intercept,
    - Reorder,
    - Traffic channel designation.
- *Page response message.* Send one of the following orders:
    - Initial voice channel designation,
    - Directed retry
    - Release,
    - Traffic channel designation.
- *Order message.* When the base station receives a Base Station Challenge Order from the mobile station, it should perform the authentication procedure as defined in 2.3.12.1.8. The base must then send the order confirmation to the mobile containing the algorithm output. For all other orders, the base station should send one of the following orders:
    - Order confirmation,
    - Release.
- *Order confirmation message.* No message is sent.

3.6.4 Mobile Station Control on Voice Channel

Whenever the mobile station is transmitting on a voice channel, changes in the status of the supervisory audio tone (SAT) and signaling tone (ST) are used to signal the occurrence of certain events during the progress of a call. These events include confirming orders, sending a release request, sending a flash request, and loss of radio-link continuity. The mobile station will signal these events by changing in a prescribed manner (see 2.6.4) the status of the SAT and ST, abbreviated in the following sections (SAT,ST) where SAT and ST have the value '0' when not present and '1' when present. These status changes must be detected by the base station and interpreted within the context of the task the base station is in as a message that identifies the event signaled by the mobile station. Requirements concerning these base station actions are described below. In the following sections, the (0,1) status shall always be treated as the (0,0) status.

In addition to the analog signaling to and from the mobile station, digital messages can be sent to the mobile station and received from the mobile station. The response to a digital message sent to the mobile station will be either be a digital message or a status change of SAT and ST.

3.6.4.1 Loss of Radio-Link Continuity

Reserved.

3.6.4.2 Initial Voice Channel Confirmation

Confirmation that a mobile station has successfully tuned to its initial designated voice channel will be received by the base station as a change in the SAT, ST status from (0,0) to (1,0).

If the confirmation is not received, the base station must either resend the message or turn off the voice channel transmitter.

Following confirmation, if the mobile station was paged, the base station must enter the Waiting for Order Task (see 3.6.4.3.1); otherwise, the base station must enter the Conversation Task (see 3.6.4.4).

3.6.4.3 Alerting

3.6.4.3.1 Waiting for Order

When the mobile station confirms the initial voice channel designation after having been paged, it enters this task. The following orders can be sent to the mobile station, with the resultant confirmation and action to be taken as follows:

- *Handoff (to Analog Voice Channel).* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1) with the (1,1) status held for 50 ms. The base station must remain in the Waiting for Order Task.
- *Handoff (to Digital Traffic Channel).* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1) with the (1,1) status held for 50 ms. The base station Call Control of the new Digital Traffic Channel must enter the Waiting for Order Task.
- *Alert* and *Alert with Info.* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1). The base station must then enter the Waiting for Answer Task (see 3.6.4.3.2).

- *Release.* The mobile station confirms the order by a change of the SAT, ST status from (1,0) to (1,1) with the (1,1) status held for 1.8 seconds. The base station must then turn off the transmitter.
- *Audit.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Waiting for Order Task.
- *Message Waiting.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Waiting for Order task.
- *Maintenance.* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1). The base station must then enter the Waiting for Answer Task (see 3.6.4.3.2).
- *Change power.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Waiting for Order Task.
- *Serial Number Request.* The mobile station confirms the order by a Serial Number Response message. The base station must remain in the Waiting for Order Task.
- *Page.* The mobile station confirms the order by a Page Response message with the preferred call mode indicated in the message type field. The base station must remain in the Waiting for Order Task.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station will reply with a Base Station Challenge Order. Process the order as described below and remain in the Waiting for Order Task.
- *Unique Challenge Order.* The mobile executes the Unique Challenge Response Procedure (see 2.3.12.1.5) and within 5 seconds must respond with a confirmation containing the output of the Authentication Process. The base station must remain in the Waiting for Order Task.
- *Parameter Update Order.* The mobile station executes the parameter updating procedure (see 2.3.12.1.3 and 2.3.12.1.7) and confirms the order by sending a Parameter Update Confirmation. The base station must remain in the Waiting for Order Task.
- *Message Encryption Mode Order.* The mobile station puts enables or disables the message encryption mode as indicated in the order (see 2.3.12.2.1) and confirms the order with a digital message (see 2.7.2). The base station must remain in the Waiting for Order Task.
- *Local control.* The confirmation and action depend on the message.

In addition, the following message can be received autonomously from the mobile station:

- *Page Response.* The mobile station signals a change in preferred call mode or privacy mode by transmitting a Page Response message with the order qualifier and message type field indicating the combination of preferred call mode and privacy mode. If the base station honors such a request, it must reply with a Call Mode Ack message indicating the new permissible call and privacy mode given to the mobile station.
- *Base Station Challenge Order:* When the base station receives a Base Station Challenge Order it must process the RANDBS contained in the order as described in 2.3.12.1.8, and within 5 seconds, send the result (AUTHBS) back to the mobile station in the associated order confirmation. The base station shall remain in the Waiting for Order Task.

3.6.4.3.2 Waiting for Answer

When this task is entered, an alert timer may be set. The following orders can be sent with the confirmation and action to be taken as follows:

- *Handoff (to Analog Voice Channel).* The mobile station confirms the order by changing the SAT, ST status from (1,1) to (1,0) for 500 ms followed by a change in the status from (1,0) to (1,1), with the (1,1) status held for 50 ms on the old channel. Then a (1,1) status is sent on the new channel. The base station must remain in the Waiting for Answer Task.
- *Handoff (to Digital Traffic Channel).* The mobile station confirms the order by changing the SAT, ST status from (1,1) to (1,0) for 500 ms followed by a change in the status from (1,0) to (1,1), with the (1,1) status held for 50 ms on the old channel. The base station Call Control of the new Digital Traffic Channel must enter the Waiting for Answer Task.
- *Alert* and *Alert with Info.* No Confirmation is received. The base station may reset the alert timer and remain in the Waiting for Answer Task.
- *Stop alert.* The mobile station confirms the order by a change in the SAT, ST status from (1,1) to (1,0). The base station must then enter the Waiting for Order Task.
- *Release.* The mobile station confirms the order by a change in the SAT, ST status from (1,1) to (1,0) for 500 ms followed by a change in the status from (1,0) to (1,1), with the (1,1) status held for 1.8 seconds. The base station must then turn off the transmitter.
- *Audit.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Waiting for Answer Task.
- *Message Waiting.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Waiting for Answer task.
- *Maintenance.* No confirmation is received. The base station may reset the alert timer and remain in the Waiting for Answer Task.
- *Change power.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Waiting for Answer Task.
- *Serial Number Request.* The mobile station confirms the order by a Serial Number Response message. The base station must remain in the Waiting for Answer Task.
- *Page.* The mobile station confirms the order by a Page Response message with the preferred call mode indicated in the message type field. The base station must remain in the Waiting for Answer Task.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station will reply with a Base Station Challenge Order. Process the order as described below and remain in the Waiting for Answer Task.
- *Unique Challenge Order.* The mobile executes the Unique Challenge Response Procedure (see 2.3.12.1.5) and within 5 seconds must respond with a confirmation containing the output of the Authentication Process. The base station must remain in the Waiting for Answer Task.
- *Parameter Update Order.* The mobile station executes the parameter updating procedure (see 2.3.12.1.3 and 2.3.12.1.7) and confirms the order by sending a Parameter Update Confirmation. The base station must remain in the Waiting for Answer Task.

- *Message Encryption Mode Order.* The mobile station puts enables or disables the message encryption mode as indicated in the order (see 2.3.12.2.1) and confirms the order with a digital message (see 2.7.2). The base station must remain in the Waiting for Answer Task.
- *Local control.* The confirmation and action depend on the message.

In addition, the following message can be received autonomously from the mobile station:

- *Page Response.* The mobile station signals a change in preferred call mode or privacy mode by transmitting a Page Response message with the order qualifier and message type field indicating the combination of preferred call mode and privacy mode. If the base station honors such a request, it must reply with a Call Mode Ack message indicating the new permissible call and privacy mode given to the mobile station.
- *Base Station Challenge Order:* When the base station receives a Base Station Challenge Order it must process the RANDBS contained in the order as described in 2.3.12.1.8, and within 5 seconds, send the result (AUTHBS) back to the mobile station in the associated order confirmation. The base station shall remain in the Waiting for Answer Task.

The mobile station signals an answer by a change in the SAT, ST status from (1,1) to (1,0). The base station must then enter the Conversation Task (see 3.6.4.4).

3.6.4.4 Conversation

While the base station is in the Conversation Task, the following orders can be sent to the mobile station, with confirmation and action to be taken as follows:

- *Handoff (to Analog Voice Channel).* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1), with the (1,1) status held for 50 ms. The base station must remain in the Conversation Task.
- *Handoff (to Digital Traffic Channel).* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1) with the (1,1) status held for 50 ms. The base station Call Control of the new Digital Traffic Channel must enter the Conversation Task.
- *Send called address.* The mobile station confirms the order by a digital message with the called-address information (see 2.7.2). The action to be taken will depend on the called-address information.
- *Alert* and *Alert with Info.* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1). The base station must then enter the Waiting for Answer Task (see 3.6.4.3.2).
- *Release.* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1), with the (1,1) status held for 1.8 seconds. The base station must turn off the transmitter.
- *Audit.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Conversation Task.
- *Flash with Info.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Conversation Task.
- *Message Waiting.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Conversation task.
- *Maintenance.* The mobile station confirms the order by a change in the SAT, ST status from (1,0) to (1,1). The base station must then enter the Waiting for Answer Task (see 3.6.4.3.2).

- *Change power.* The mobile station confirms the order by a digital message (see 2.7.2). The base station must remain in the Conversation Task.
- *Serial Number Request.* The mobile station confirms the order by a Serial Number Response message. The base station must remain in the Conversation Task.
- *Page.* The mobile station confirms the order by a Page Response message with the preferred call mode indicated in the message type field. The base station must remain in the Conversation Task.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station will reply with a Base Station Challenge Order. Process the order as described below and remain in the Conversation Task.
- *Unique Challenge Order.* The mobile executes the Unique Challenge Response Procedure (see 2.3.12.1.5) and within 5 seconds must respond with a confirmation containing the output of the Authentication Process. The base station must remain in the Conversation Task.
- *Parameter Update Order.* The mobile station executes the parameter updating procedure (see 2.3.12.1.3 and 2.3.12.1.7) and confirms the order by sending a Parameter Update Confirmation. The base station must remain in the Conversation Task.
- *Disable DTMF Order.* The mobile station confirms the order by a digital message (see 2.7.2). The Mobile disables the DTMF tone generator upon receipt of this order until the Called Address Message is transmitted. The base station must remain in the Conversation Task.
- *Message Encryption Mode Order.* The mobile station puts enables or disables the message encryption mode as indicated in the order (see 2.3.12.2.1) and confirms the order with a digital message (see 2.7.2). The base station must remain in the Conversation Task.
- *Local control.* The confirmation and action depend on the message.

In addition, the following messages can be received autonomously from the mobile station:

- *Flash request.* The mobile station signals a flash by a change in the SAT, ST status from (1,0) to (1,1) with the (1,1) status held for 400 ms followed by a transition to the (1,0) status.
- *Release.* The mobile station signals a release by a change in the SAT, ST status from (1,0) to (1,1) with the (1,1) status held for 1.8 seconds. The base station must turn off the transmitter.
- *Page Response.* The mobile station signals a change in preferred call mode or privacy mode by transmitting a Page Response message with the order qualifier and message type field indicating the combination of preferred call mode and privacy mode. If the base station honors such a request, it must reply with a Call Mode Ack message indicating the new permissible call and privacy mode given to the mobile station.
- *Base Station Challenge Order:* When the base station receives a Base Station Challenge Order it must process the RANDBS contained in the order as described in 2.3.12.1.8, and within 5 seconds, send the result (AUTHBS) back to the mobile station in the associated order confirmation. The base station shall remain in the Conversation Task.

3.6.5 Mobile Station Control on the Digital Traffic Channel

Signaling to and from the mobile station is done on the FACCH and the SACCH.

3.6.5.1 Loss Of Radio Link Continuity

Reserved.

3.6.5.2 Confirm Initial Traffic Channel

Confirmation that a mobile station has successfully tuned to its initial designated traffic channel will be received by the base station as a change in the DVCC status.

If the confirmation is not received, the base station may either retransmit the message or turn off the transmitter.

Following confirmation, if the mobile station was paged, the base station must enter the Waiting For Order task (see 3.6.5.3.1); otherwise, the base station must enter the Conversation task (see 3.6.5.4).

3.6.5.3 Alerting

3.6.5.3.1 Waiting For Order

The mobile station enters this task after it confirms the initial traffic channel designation after having been paged. The following orders can be sent to the mobile station, with the resultant acknowledgement and action to be taken as follows:

- *Handoff (to Analog Voice Channel)*. The mobile station acknowledges the order by sending a Mobile Ack message. The base station call control of the new analog voice channel must enter the Analog Voice Channel Waiting for Order Task (See 3.6.4.3.1).
- *Handoff (to Digital Traffic Channel)*. The mobile station acknowledges the order by sending a Mobile Ack message. The base station must remain in the Digital Traffic Channel Waiting for Order Task.
- *Alert with Info*. The mobile station acknowledges the order. The base station must then enter the Waiting For Answer Task (see 3.6.5.3.2).
- *Release*. The mobile station acknowledges the order. The base station may then turn off the transmitter.
- *Audit*. The mobile station acknowledge the order. The base station must remain in the Waiting for Order Task.
- *Maintenance*. The mobile station acknowledges the order. The base station must then enter the Waiting for Answer Task (see 3.6.5.3.2).
- *Physical Layer Control*. The mobile station acknowledges the order. The base station must remain in the Waiting for Order Task.
- *Local Control*. The acknowledgement and action depend on the message.
- *Measurement Order*. The mobile station acknowledges the order. The base station must remain in the Waiting for Order Task.
- *Stop Measurement Order*. The mobile station acknowledges the order. The base station must remain in the Waiting for Order Task.
- *Status Request*. The mobile station replies to the order with a Status Message. The base station must remain in the Waiting For Order Task.

- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station will reply with a Base Station Challenge Order. Process the order as described below and remain in the Waiting for Order Task.
- *Unique Challenge Order.* The mobile executes the Unique Challenge Response Procedure (see 2.3.12.1.5) and within 5 seconds must respond with a confirmation containing the output of the Authentication Process. The base station must remain in the Waiting for Order Task.
- *Parameter Update Order.* The mobile station executes the parameter updating procedure (see 2.3.12.1.7) and confirms the order by sending a Parameter Update ACK. The base station must remain in the Waiting for Order Task.

In addition, the following messages can be received autonomously from the mobile station:

- *Status.* The base station shall respond with one of the following actions:
  - Change of Privacy Mode. The mobile station requests a change in privacy mode with a Status Message that has the Privacy Mode Information Element set to the requested value (0=privacy off, 1=privacy on). If the base station honors a request to change voice privacy mode, it must reply with a Base Station Ack message with Message Type Parameter equal to "Status". The base station must remain in the Waiting for Order Task.
  - *Base Station Challenge Order:* When the base station receives a Base Station Challenge Order it must process the RANDBS contained in the order as described in 2.3.12.1.8, and within 5 seconds, send the result (AUTHBS) back to the mobile station in the associated order confirmation. The base station shall remain in the Waiting for Order Task.
  - Other actions taken by the base station are system dependent.

3.6.5.3.2 Waiting For Answer

When this task is entered, an alert timer may be set. The following orders can be sent with the acknowledgement and action to be taken as follows:

- *Handoff (to Analog Voice Channel).* The mobile station acknowledges the order by sending a Mobile Ack message. The base station call control of the new analog voice channel must enter the Analog Voice Channel Waiting for Answer Task (See 3.6.4.3.2).
- *Handoff (to Digital Traffic Channel).* The mobile station acknowledges the order by sending a Mobile Ack message. The base station must remain in the Digital Traffic Channel Waiting for Answer Task.
- *Alert with Info.* The mobile station acknowledges the order. The base station may reset the alert timer. The base station must remain in the Waiting for Answer Task.
- *Release.* The mobile station acknowledges the order. The base station may then turn off the transmitter.
- *Audit.* The mobile station acknowledges the order. The base station may reset the alert time. The base station must remain in the Waiting for Answer Task.
- *Physical Layer Control.* The mobile station acknowledges the order. The base station must remain in the Waiting for Answer Task.
- *Local Control* . The acknowledgement and action depend on the message.
- *Measurement Order.* The mobile station acknowledges the order. The base station must remain in the Waiting for Answer Task.

- *Stop Measurement Order.* The mobile station acknowledges the order. The base station must remain in the Waiting for Answer Task.
- *Status Request.* The mobile station replies to the order with a Status Message. The base station must remain in the Waiting For Answer Task.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station will reply with a Base Station Challenge Order. Process the order as described below and remain in the Waiting for Answer Task.
- *Unique Challenge Order.* The mobile executes the Unique Challenge Response Procedure (see 2.3.12.1.5) and within 5 seconds must respond with a confirmation containing the output of the Authentication Process. The base station must remain in the Waiting for Answer Task.
- *Parameter Update Order.* The mobile station executes the parameter updating procedure (see 2.3.12.1.7) and confirms the order by sending a Parameter Update ACK. The base station must remain in the Waiting for Answer Task.

In addition, the following messages can be received autonomously from the mobile station:

- *Connect.* Send Base Station Ack. The base station must then enter the Conversation Task (see 3.6.5.4).
- *Status.* The base station shall respond with one of the following actions:
  - Change of Privacy Mode. The mobile station requests a change in privacy mode with a Status Message that has the Privacy Mode Information Element set to the requested value (0=privacy off, 1=privacy on). If the base station honors a request to change voice privacy mode, it must reply with a Base Station Ack message with Message Type Parameter equal to "Status". The base station must remain in the Waiting for Answer Task.
  - *Base Station Challenge Order:* When the base station receives a Base Station Challenge Order it must process the RANDBS contained in the order as described in 2.3.12.1.8, and within 5 seconds, send the result (AUTHBS) back to the mobile station in the associated order confirmation. The base station shall remain in the Waiting for Answer Task.
  - Other actions taken by the base station are system dependent.

3.6.5.4 Conversation

If the voice privacy feature is active during the Conversation Task, then the base station must treat the forward and reverse digital traffic channel in accordance with the procedures described in 2.3.12.3. While the base station is in the Conversation Task, the following orders can be sent to the mobile station, with acknowledgement and action to be taken as follows:

- *Handoff (to Analog Voice Channel).* The mobile station acknowledges the order by sending a Mobile Ack message. The base station call control of the new analog voice channel must enter the Analog Voice Channel Conversation Task (See 3.6.4.4).
- *Handoff (to Digital Traffic Channel).* The mobile station acknowledges the order by sending a Mobile Ack message. The base station must remain in the Digital Traffic Channel Conversation Task.
- *Alert with Info.* The mobile station acknowledges the order. The base station must then enter the Waiting for Answer Task (see 3.6.5.3.2).

- *Release.* The mobile station acknowledges the order. The base station may then turn off the transmitter.
- *Audit.* The mobile station acknowledges the order. The base station must remain in the Conversation Task.
- *Maintenance.* The mobile station acknowledges the order. The base station must then enter the Waiting for Answer Task (see 3.6.5.3.2).
- *Physical Layer Control.* The mobile station acknowledges the order. The base station must remain in the Conversation Task.
- *Local Control.* The acknowledgement and action depend on the message.
- *Measurement Order.* The mobile station acknowledges the order. The base station must remain in the Conversation Task.
- *Stop Measurement Order.* The mobile station acknowledges the order. The base station must remain in the Conversation Task.
- *Flash with Info.* The mobile station acknowledges the order. The base station must remain in the Conversation Task.
- *Status Request.* The mobile station replies to the order with a Status Message. The base station must remain in the Conversation Task.
- *SSD Update Order:* The mobile station computes SSD-A_NEW and SSD-B_NEW and selects a RANDBS as described in 2.3.12.1.8. Within 5 seconds, the mobile station will reply with a Base Station Challenge Order. Process the order as described below and remain in the Conversation Task.
- *Unique Challenge Order.* The mobile executes the Unique Challenge Response Procedure (see 2.3.12.1.5) and within 5 seconds must respond with a confirmation containing the output of the Authentication Process. The base station must remain in the Conversation Task.
- *Parameter Update Order.* The mobile station executes the parameter updating procedure (see 2.3.12.1.7) and confirms the order by sending a Parameter Update ACK. The base station must remain in the Conversation Task.

In addition, the following messages can be received autonomously from the mobile station:

- *Flash with Info.* Send Flash with Info Ack. The base station must remain in the Conversation Task.
- *Send Burst DTMF.* Send "Send Burst DTMF Ack". The base station must remain in the Conversation Task.
- *Send Continuous DTMF.* Send "Send Continuous DTMF Ack". The base station must remain in Conversation Task.
- *Connect.* Send Base Station Ack. The base station must remain in the Conversation Task.
- *Release.* The base station shall respond with one of the following actions:
    - Send Base Station Ack. The base station may then turn off the transmitter.
    - Alert with Info. The mobile station acknowledges the order. The base station must then enter the Waiting for Answer Task (see 3.6.5.3.2).
- *Status.* The base station shall respond with one of the following actions:

- Change of Privacy Mode. The mobile station requests a change in privacy mode with a Status Message that has the Privacy Mode Information Element set to the requested value (0=privacy off, 1=privacy on). If the base station honors a request to change the voice privacy mode, it must reply with a Base Station Ack message with the Message Type Parameter equal to "Status". The base station must remain in the Conversation Task. If the voice privacy feature is active during the Conversation Task, then the base station must treat the forward and reverse digital traffic channel in accordance with the procedures described in 2.3.12.3.
- Change of Preferred Call Mode. The mobile station requests a change in preferred call mode with a Status Message indicating the change. If the base station decides to honor such a request, it must reply with a Base Station Ack message with the Message Type Parameter equal to "Status".
- *Base Station Challenge Order:* When the base station receives a Base Station Challenge Order it must process the RANDBS contained in the order as described in 2.3.12.1.8, and within 5 seconds, send the result (AUTHBS) back to the mobile station in the associated order confirmation. The base station shall remain in the Conversation Task.
- Other actions taken by the base station are system dependent.

NOTE: DTMF tones in the forward direction are sent in-band.

3.6.5.5 General Rules for Message Exchange on Digital Traffic Channel

3.6.5.5.1 Encoding of Information Elements

The base station must encode variable length messages with optional information elements using the following rule:

- New information elements defined for existing messages after the first release of this standard must be transmitted in the order of the standard releases in which the information elements are defined.

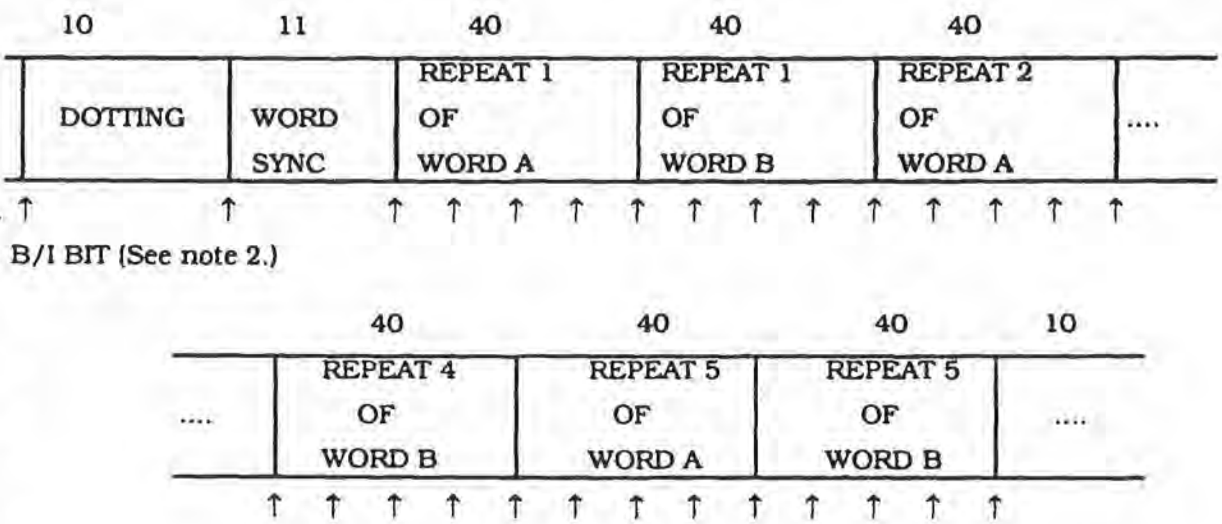
3.7 Signaling Formats

In the message formats used between the mobile stations and base stations, some bits are marked as reserved (RSVD). Some or all of these reserved bits may be used in the future for additional messages. Therefore, all mobile stations and base stations must set all bits that they are programmed to treat as reserved bits to '0' (zero) in all messages that they transmit. All mobile stations and base stations must ignore the state of all bits that they are programmed to treat as reserved bits in all messages that they receive.

3.7.1 Forward Analog Control Channel

The forward analog control channel (FOCC) is a continuous wideband data stream sent from the base station to the mobile station. This data stream must be generated at a 10 kilobit/second ±0.1 bit/second rate. Figure 3.7.1-1 depicts the format of the FOCC data stream.

Figure 3.7.1-1. FORWARD ANALOG CONTROL CHANNEL MESSAGE STREAM (Base-to-Mobile)



DOTTING = 1010101010

WORD SYNC = 11100010010

NOTES:

1. A given mobile reads only one of the two interleaved messages (A or B).
2. Busy-Idle bits are inserted at each arrow.

Each forward analog control channel consists of three discrete information streams, called stream A, stream B, and busy-idle stream, that are time-multiplexed together. Messages to mobile stations with the least significant bit of their mobile identification number (see 2.3.1) equal to '0' are sent on stream A, and those with the least-significant bit of their mobile identification number equal to '1' are sent on stream B.

The busy-idle stream contains busy-idle bits, which are used to indicate the current status of the reverse control channel. The reverse control channel is busy if the busy-idle bit is equal to '0' and idle if the busy-idle bit is equal to '1'. A busy-idle bit is located at the beginning of each dotting sequence, at the beginning of each word sync sequence, at the beginning of the first repeat of word A, and after every 10 message bits thereafter.

A 10-bit dotting sequence (1010101010) and an 11-bit word sync sequence (11100010010) are sent to permit mobile stations to achieve synchronization with the incoming data. Each word contains 40 bits, including parity, and is repeated five times; it is then referred to as a word block. For a multi-word message, the second word block and subsequent word blocks are formed the same as the first word block including the 10-bit dotting and 11-bit word sync sequences. A word is formed by encoding 28 content bits into a (40, 28) BCH code that has a distance of 5, (40, 28; 5). The left-most bit (i.e., earliest in time) shall be designated the most-significant bit. The 28 most-significant bits of the 40-bit field shall be the content bits. The generator polynomial for the (40, 28; 5) BCH code is:

$$g_B(x) = X^{12} + X^{10} + X^8 + X^5 + X^4 + X^3 + X^0 .$$

The code, a shortened version of the primitive (63, 51; 5) BCH code, is a systematic linear block code with the leading bit as the most significant information bit and the least-significant bit as the last parity-check bit.

Each FOCC message can consist of one or more words. The types of messages to be transmitted over the forward control channel are:

- Mobile station control message
- Overhead message
- Control-Filler message

Control-filler messages may be inserted between messages and between word blocks of a multi-word message.

The following sections contain descriptions of the message formats that the base station transmits over either stream A or B. For purposes of format presentation and explanation, the busy-idle bits have been deleted in the discussion of the message formats.

3.7.1.1 Mobile Station Control Message

The mobile station control message can consist of one to five words.

Word 1 - Abbreviated Address Word

Information element	Length (bits)
T_1T_2	2
DCC	2
$MIN1_{23-0}$	24
P	12

Word 2 - Extended Address Word

Information element		Length (bits)	
$T_1T_2 = 10$		2	
SCC		2	
SCC = 11		SCC ≠ 11	
Information element	Length (bits)	Information element	Length (bits)
$MIN2_{33-24}$	10	$MIN2_{33-24}$	10
EF	1	VMAC	3
LOCAL/MSG Type	5	CHAN	11
ORDQ	3	P	12
ORDER	5		
P	12		

Word 3 - First Digital Channel Assignment Word

Information element	Length (bits)
$T_1T_2 = 10$	2
RSVD = 0	1
MEM	1
DVCC	8
PM	1
DMAC	4
CHAN	11
P	12

Word 3 - First Directed-Retry Word

Information element	Length (bits)
$T_1T_2 = 10$	2
SCC = 11	2
CHANPOS	7
CHANPOS	7
CHANPOS	7
RSVD = 000	3
P	12

Word 3 - Base Station Challenge Order Confirmation Word

Information element	Length (bits)
T_1T_2 = 10	2
SCC = 11	2
RSVD = 00	2
AUTHBS	18
RSVD = 0..0	4
P	12

Word 3 - Unique Challenge Order Word

Information element	Length (bits)
T_1T_2 = 10	2
SCC = 11	2
RANDU	24
P	12

Word 3 - First SSD Update Order Word

Information element	Length (bits)
T_1T_2 = 10	2
SCC = 11	2
RANDSSD_1	24
P	12

Word 4 - Second Directed-Retry Word

Information element	Length (bits)
T_1T_2 = 10	2
SCC = 11	2
CHANPOS	7
CHANPOS	7
CHANPOS	7
RSVD = 000	3
P	12

Word 4- Second SSD Update Order Word

Information element	Length (bits)
$T_1T_2 = 10$	2
SCC = 11	2
RANDSSD_2	24
P	12

Word 5- Third SSD Update Order Word

Information element	Length (bits)
$T_1T_2 = 10$	2
SCC = 11	2
RSVD = 0..0	12
RANDSSD_3	8
RSVD = 0..0	4
P	12

The interpretation of the data fields is as follows:

- T_1T_2 - Type field. If only Word 1 is sent, set to '00' in Word 1. If a multiple-word message is sent, set to '01' in Word 1 and set to '10' in each additional word.
- DCC - Digital color code field.
- DVCC - Digital Verification Color Code
- EF - Extended Protocol (Forward Channel) indicator (See 5.2);
- MSG. TYPE - Message type field. Qualifies the order to a specific action. See Table 3.7.1-1.
- MIN1 - First part of the mobile identification number field (see 2.3.1).
- MIN2 - Second part of the mobile identification number field (see 2.3.1).
- SCC - SAT color code (see Table 3.7.1-2).
- ORDER - Order field. Identifies the order type (see Table 3.7.1-1).
- ORDQ - Order qualifier field. Qualifies the order to a specific action (See Table 3.7.1-1).
- LOCAL - Local control field. This field is specific to each system. The ORDER field must be set to local control (see Table 3.7.1-1) for this field to be interpreted.
- VMAC - Voice mobile attenuation code field. Indicates the mobile station power level associated with the designated analog voice channel. VMAC is made of the three least significant bits of MAC in Table 2.1.2-1.
- DMAC - Digital mobile attenuation code field. Indicates the mobile station power level associated with the designated digital traffic channel. DMAC is made from all four bits of MAC in Table 2.1.2-1.

PM - Privacy Mode indicator. Set to '1' if voice privacy is activated on the assigned Digital Traffic Channel. Set to '0' if voice privacy is not activated on the assigned Digital Traffic Channel.

CHAN - Channel number field. Indicates the designated RF channel (see 2.1.1.1 and 2.3.3).

CHANPOS - Channel position field. Indicates the position of a control channel relative to the first access channel (FIRSTCHA).

RANDU - The 24 bit random number issued by the base in the Unique Challenge Order.

RANDSSD_1 - The most significant 24 bits of the random number issued by the base in the SSD Update Order.

RANDSSD_2 - The subsequent 24 bits (following RANDSSD_1) of the random number issued by the base in the SSD Update Order.

RANDSSD_3 - The least significant 8 bits of the random number issued by the base in the SSD Update Order.

AUTHBS - Output response of the authentication algorithm initiated by the Base Station Challenge Order.

MEM - Message Encryption Mode. A 1 bit value that is set to '0' to indicate that encrypted signaling is disabled, and set to '1' to indicate that encrypted signaling is enabled. See 2.3.12.2.1.

RSVD - Reserved for future use, all bits must be set as indicated.

P - Parity field.

Table 3.7.1-1 ORDER AND ORDER QUALIFICATION CODES

Order Code	Qual Code	Message Type	Function
00001	000	00000	Alert
00001	001	00000	Abbreviated Alert
10001	000	00000	Alert With Info
10010	000	00000	Flash With Info
00011	000	00000	Release
00100	000	00000	Reorder
00101	000	XXXXX	Message Waiting (Type field indicates # of messages)
00110	000	00000	Stop Alert
00111	000	00000	Audit
01000	000	00000	Send Called-address
01001	000	00000	Intercept
01010	000	00000	Maintenance
01011	000	00000	Change Power to Power Level 0 (see 2.1.2.2)
01011	001	00000	Change Power to Power Level 1
01011	010	00000	Change Power to Power Level 2
01011	011	00000	Change Power to Power Level 3
01011	100	00000	Change Power to Power Level 4
01011	101	00000	Change Power to Power Level 5
01011	110	00000	Change Power to Power Level 6
01011	111	00000	Change Power to Power Level 7
01100	000	00000	Directed Retry - not last try
01100	001	00000	Directed Retry - last try
01101	000	00000	Non-autonomous Registration - Do not make whereabouts known, Authentication Word C not included
01101	001	00000	Non-autonomous Registration - Make whereabouts known, Authentication Word C not included
01101	010	00000	Autonomous Registration - Do not make whereabouts known, Authentication Word C not included
01101	011	00000	Autonomous Registration - Make whereabouts known, Authentication Word C not included
01101	011	00001	Autonomous Registration - Power Down, Authentication Word C not included

Table 3.7.1-1 (Cont) ORDER, ORDER QUALIFICATION, AND MESSAGE TYPE CODES

Order Code	Qual Code	Message Type	Function
11000	000	00000	Non-autonomous Registration - Do not make whereabouts known, Authentication Word C included
11000	001	00000	Non-autonomous Registration - Make whereabouts known, Authentication Word C included
11000	010	00000	Autonomous Registration - Do not make whereabouts known, Authentication Word C included
11000	011	00000	Autonomous Registration - Make whereabouts known, Authentication Word C included
11000	011	00001	Autonomous Registration - Power Down, Authentication Word C included
11110	000	XXXXX	local control
[Base station initiated messages only - Page and Call Mode Ack messages]			
00000	000	00000	Page Message
10000	000	XXXX0	Call Mode Ack: Analog Voice channel permissible
10000	000	XXXX1	Call Mode Ack: Analog Voice channel not permissible
10000	000	XXX0X	Call Mode Ack: Full-rate digital traffic channel not permissible
10000	000	XXX1X	Call Mode Ack: Full -rate digital traffic channel permissible, voice privacy off
10000	100	XXX1X	Call Mode Ack: Full -rate digital traffic channel permissible, voice privacy on
10000	000	XX0XX	Call Mode Ack: Half-rate digital traffic channel not permissible
10000	000	XX1XX	Call Mode Ack: Half-rate digital traffic channel permissible, voice privacy off
10000	100	XX1XX	Call Mode Ack: Half-rate digital traffic channel permissible, voice privacy on
10000	000	X0XXX	Call Mode Ack: Other DQPSK channel not permissible
10000	000	X1XXX	Call Mode Ack: Other DQPSK channel permissible
10000	000	0XXXX	Call Mode Ack: Other voice coding not permissible
10000	000	1XXXX	Call Mode Ack: Other voice coding permissible
10000	001	XXXXX	Call Mode Ack: Extended modulation and framing permissible

Table 3.7.1-1 (Cont) ORDER, ORDER QUALIFICATION, AND MESSAGE TYPE CODES

Order Code	Qual Code	Message Type	Function
[Mobile station initiated messages only - Origination and Page Response messages]			
00000	000	XXXX0	Analog Voice channel acceptable, Authentication Word C not included
00000	000	XXXX1	Analog Voice channel not acceptable, Authentication Word C not included
00000	000	XXX0X	Full-rate digital traffic channel not acceptable, Authentication Word C not included
00000	000	XXX1X	Full-rate digital traffic channel acceptable (voice privacy off), Authentication Word C not included
00000	100	XXX1X	Full-rate digital traffic channel acceptable (voice privacy on), Authentication Word C not included
00000	000	XX0XX	Half-rate digital traffic channel not acceptable, Authentication Word C not included
00000	000	XX1XX	Half-rate digital traffic channel acceptable (voice privacy off), Authentication Word C not included
00000	100	XX1XX	Half-rate digital traffic channel acceptable (voice privacy on), Authentication Word C not included
00000	000	X0XXX	Other DQPSK channel not acceptable, Authentication Word C not included
00000	000	X1XXX	Other DQPSK channel acceptable, Authentication Word C not included
00000	000	0XXXX	Other voice coding not acceptable, Authentication Word C not included
00000	000	1XXXX	Other voice coding acceptable, Authentication Word C not included
00000	001	XXXXX	Extended Modulation and Framing, Authentication Word C not included

Table 3.7.1-1 (Cont) ORDER, ORDER QUALIFICATION, AND MESSAGE TYPE CODES

Order Code	Qual Code	Message Type	Function
[Mobile station initiated messages only - Origination and Page Response messages]			
00010	000	XXXX0	Analog Voice Channel (AVC) acceptable, Authentication Word C included
00010	000	XXXX1	AVC not acceptable, Auth. Word C included
00010	000	XXX0X	Full-rate digital traffic channel not acceptable, Authentication Word C included
00010	000	XXX1X	Full-rate digital traffic channel acceptable (voice privacy off), Authentication Word C included
00010	100	XXX1X	Full-rate digital traffic channel acceptable (voice privacy on), Authentication Word C included
00010	000	XX0XX	Half-rate digital traffic channel not acceptable, Authentication Word C included
00010	000	XX1XX	Half-rate digital traffic channel acceptable (voice privacy off), Authentication Word C included
00010	100	XX1XX	Half-rate digital traffic channel acceptable (voice privacy on), Authentication Word C included
00010	000	X0XXX	Other DQPSK channel not acceptable, Authentication Word C included
00010	000	X1XXX	Other DQPSK channel acceptable, Authentication Word C included
00010	000	0XXXX	Other voice coding not acceptable, Authentication Word C included
00010	000	1XXXX	Other voice coding acceptable, Authentication Word C included
00010	001	XXXXX	Extended Modulation and Framing, Authentication Word C included
[Base station initiated messages only - Initial Traffic Channel Designation message]			
01110	000	Digital Traffic Channel Assignment for Minimum Dual Mode	
		00001	Assigned to timeslot 1, full rate.
		01001	Assigned to timeslot 1, half rate.
		00010	Assigned to timeslot 2, full rate.
		01010	Assigned to timeslot 2 , half rate.
		00011	Assigned to timeslot 3, full rate.
		01011	Assigned to timeslot 3, half rate.
		01100	Assigned to timeslot 4, half rate.
		01101	Assigned to timeslot 5, half rate.
		01110	Assigned to timeslot 6, half rate.
01110	001	XXXXX	Digital Traffic Channel Assignment with Extended Modulation and Framing.
01111	000	00000	Parameter Update Order/Confirmation
01111	001	00000	Serial Number Request / Response

Table 3.7.1-1 (Cont) ORDER, ORDER QUALIFICATION, AND MESSAGE TYPE CODES

Order Code	Qual Code	Message Type	Function
[Base station initiated messages only - Mobile Station Authentication and Privacy]			
10011	000	00000	Base Station Challenge Order Confirmation
10100	000	00000	Unique Challenge Order
10101	000	00000	SSD Update Order
10110	000	00000	Disable DTMF Order
10111	000	00000	Message Encryption Mode Order with disable indication
10111	001	00000	Message Encryption Mode Order with enable indication
[Mobile station initiated messages only - Mobile Station Authentication and Privacy]			
10011	000	00000	Base Station Challenge Order
10100	000	00000	Unique Challenge Order Confirmation
10101	000	00000	SSD Update Order Confirmation with failure indication
10101	001	00000	SSD Update Order Confirmation with success indication
(All other codes are reserved)			

Note 1: Digital Traffic Channel assignments to timeslots 4, 5, and 6 are not allowed on full-rate channels.

Note 2: In order to maintain compatibility between dual-mode mobile stations and EIA/TIA-553 base stations, a dual-mode mobile station must set the message type to 00000 and the Order Qualification Code to 000 when Order Code = 00000 (Mobile Page Response or Mobile Origination) and PCI = 0 in the System Parameter Overhead Message (3.7.1.2.1).

Table 3.7.1-2. SAT COLOR CODE (SCC)

Bit Pattern	SAT Frequency
00	5970 Hz
01	6000 Hz
10	6030 Hz
11	(Not an analog channel designation)

3.7.1.2 Overhead Message

A three-bit OHD field is used to identify the overhead message types. Overhead message type codes are listed in Table 3.7.1-3, and are grouped into the following functional classes:

- System parameter overhead message,
- Global action overhead message,
- Registration identification message,
- Control-filler message.

Overhead messages are sent in a group called an overhead message train. The first message of the train must be the system parameter overhead message. The desired global action messages or a registration ID message must be appended to the end of the system parameter overhead message. The total number of words in an overhead message train is one more than the value of the NAWC field contained in the first word of the system parameter overhead message. The last word in the overhead message train is identified by a '1' in the END field of that word; the END field of all other words in the train must be set to '0'. For NAWC- counting purposes, inserted control-filler messages (see 3.7.1) must not be counted as part of the overhead message train.

The system parameter overhead message must be sent every 0.8 ±0.3 seconds on each of the following control channels:

- All dedicated control channels (see 2.6.1.1.1).
- Combined paging-access forward control channel (i.e., CPA = 1, see 3.7.1.2.1),
- Separate paging forward control channel (i.e., CPA = 0).
- Separate access forward control channel (i.e., CPA = 0) when the control-filler message is sent with the WFOM bit set to '1' (see 3.7.1.2.4).

The global action messages and the registration identification message are sent on an as needed basis.

Table 3.7.1-3. OVERHEAD MESSAGE TYPES

Code	Order
000	Registration ID
001	Control-filler
010	Reserved
011	Reserved
100	Global action
101	Reserved
110	Word 1 of system parameter message
111	Word 2 of system parameter message

3.7.1.2.1 System Parameter Overhead Message

The system parameter overhead message consists of two words.

Word 1

Information element	Length (bits)
$T_1T_2 = 11$	2
DCC	2
SID1	14
EP	1
AUTH	1
PCI	1
NAWC	4
OHD = 110	3
P	12

Word 2

Information element	Length (bits)
$T_1T_2 = 11$	2
DCC	2
S	1
E	1
REGH	1
REGR	1
DTX	2
N - 1	5
RCF	1
CPA	1
CMAX - 1	7
END	1
OHD = 111	3
P	12

The interpretation of the data fields is as follows:

T_1T_2 - Type field. Set to '11' indicating an overhead word.

OHD - Overhead message type field. The OHD field of word 1 is set to '110' indicating the first word of the system parameter overhead message. The OHD field of word 2 is set to '111' indicating the second word of the system parameter overhead message.

EP - Extended Protocol Capability Indicator

DCC - Digital color code field.

SID1 - First part of the system identification field.

AUTH - Set to 1 if the base station supports the authentication procedures described in sections 2.3.12 and 3.3.1.

PCI - Set to 1 if Control Channel can assign digital traffic channels.

NAWC - Number of additional words coming field. In word 1 this field is set to one fewer than the total number of words in the overhead message train.

S - Serial number field.

E - Extended address field.

REGH - Registration field for home stations.

REGR - Registration field for roaming stations.

DTX - Discontinuous transmission field.

N-1 - N is the number of paging channels in the system.

RCF - Read-control-filler field.

CPA - Combined paging/access field.

CMAX-1 - CMAX is the number of access channels in the system.

END - End indication field. Set to '1' to indicate the last word of the overhead message train; set to '0' if not last word.

RSVD - Reserved for future use, all bits must be set as indicated.

P - Parity field.

3.7.1.2.2 Global Action Overhead Message

Each global action overhead message consists of one word. The global action message types are listed in Table 3.7.1-4. Any number of global action messages can be appended to a system parameter overhead message.

The formats for the global action commands are as follows:

Rescan Global Action Message

Information element	Length (bits)
$T_1T_2 = 11$	2
DCC	2
ACT = 0001	4
RSVD = 00...0	16
END	1
OHD = 100	3
P	12

Registration Increment Global Action Message

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
ACT = 0010	4
REGINCR	12
RSVD = 0000	4
END	1
OHD = 100	3
P	12

Location Area Global Action Message

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
ACT = 0011	4
PUREG	1
PDREG	1
LREG	1
RSVD = 0	1
LOCAID	12
END	1
OHD = 100	3
P	12

New Access Channel Set Global Action Message

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
ACT = 0110	4
NEWACC	11
RSVD = 00000	5
END	1
OHD = 100	3
P	12

Overload Control Global Action Message

Information element	Length (bits)
$T_1T_2 = 11$	2
DCC	2
ACT = 1000	4
OLC 0	1
OLC 1	1
OLC 2	1
OLC 3	1
OLC 4	1
OLC 5	1
OLC 6	1
OLC 7	1
OLC 8	1
OLC 9	1
OLC 10	1
OLC 11	1
OLC 12	1
OLC 13	1
OLC 14	1
OLC 15	1
END	1
OHD = 100	3
P	12

Access Type Parameters Global Action Message

Information element	Length (bits)
$T_1T_2 = 11$	2
DCC	2
ACT = 1001	4
BIS	1
RSVD = 000000000000000	15
END	1
OHD = 100	3
P	12

Access Attempt Parameters Global Action Message

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
ACT = 1010	4
MAXBUSY-PGR	4
MAXSZTR-PGR	4
MAXBUSY-OTHER	4
MAXSZTR-OTHER	4
END	1
OHD = 100	3
P	12

Random Challenge A Global Action Message

Information element	Length (bits)
T_1T_2	2
DCC	2
ACT = 0111	4
RAND1_A	16
END	1
OHD = 100	3
P	12

Random Challenge B Global Action Message

Information element	Length (bits)
T_1T_2	2
DCC	2
ACT = 1011	4
RAND1_B	16
END	1
OHD = 100	3
P	12

Local Control 1 Message

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
ACT = 1110	4
LOCAL CONTROL	16
END	1
OHD = 100	3
P	12

Local Control 2 Message

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
ACT = 1111	4
LOCAL CONTROL	16
END	1
OHD = 100	3
P	12

The interpretation of the data fields is as follows:

T_1T_2 - Type field. Set to '11' indicating an overhead word.

ACT - Global action field. See Table 3.7.1-4.

BIS - Busy-idle status field.

DCC - Digital color code field.

OHD - Overhead message type field. Set to '100' indicating the global action message.

REGINCR - Registration increment field.

NEWACC - New access channel starting point field.

MAXBUSY-PGR - Maximum busy occurrences field (page response).

MAXBUSY-OTHER - Maximum busy occurrences field (other accesses).

MAXSZTR-PGR - Maximum seizure tries field (page response).

MAXSZTR-OTHER - Maximum seizure tries field (other accesses).

OLC N - Overload class field (N = 0 to 15). (See NOTE for recommended overload control bit assignments.)

END - End indication field. Set to '1' to indicate the last word of the overhead message train; set to '0' if not last word.

RAND1_A - The 16 most significant bits of the 32 bit RAND variable stored by a mobile for use in the authentication process.

RAND1_B - The 16 least significant bits of the 32 bit RAND variable stored by a mobile for use in the authentication process.

LOCAID - Location area identity field.

RSVD - Reserved for future use, all bits must be set as indicated.

LOCAL CONTROL - May be set to any bit pattern.

PUREG - Power up registration status field (enabled = 1, disabled = 0).

PDREG - Power down registration Status field (enabled = 1, disabled = 0).

LREG - Location area ID registration status field (enabled = 1, disabled = 0).

P - Parity field.

NOTE: The recommended overload control bit assignments are:

Uniform distribution assigned to normal subscribers = OLC 0 through OLC 9

Test mobiles = OLC 10

Emergency mobiles = OLC 11

Reserved = OLC 12 through OLC 15

For more information, refer to EIA Telecommunications Systems Bulletin No. 16 (March 1985), "Assignment of Access Overload Classes in the Cellular Telecommunications Services".

3.7.1.2.3 Registration ID Message

The registration ID message consists of one word. When sent, the message must be appended to a system parameter overhead message in addition to any global action messages.

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
REGID	20
END	1
OHD = 000	3
P	12

The interpretation of the data fields is as follows:

T_1T_2 - Type field. Set to '11' indicating overhead word.

DCC - Digital color code field.

OHD - Overhead message type field. Set to '000' indicating the registration ID message.

REGID - Registration ID field.

END - End indication field. Set to '1' to indicate last word of the overhead message train; set to '0' if not last word.

P - Parity field.

Table 3.7.1-4. GLOBAL ACTION MESSAGE TYPES

Action Code	Type
0000	Reserved
0001	Rescan paging channels
0010	Registration increment
0011	Location Area
0100	Reserved
0101	Reserved
0110	New access channel set
0111	Random Challenge A
1000	Overload control
1001	Access type parameters
1010	Access attempt parameters
1011	Random Challenge B
1100	Reserved
1101	Reserved
1110	Local control 1
1111	Local Control 2

3.7.1.2.4 Control-Filler Message

The control-filler message consists of one word. It is sent whenever there is no other message to be sent on the forward control channel. It may be inserted between messages as well as between word blocks of a multi-word message. The control-filler message is chosen so that when it is sent, the 11-bit word sync sequence (11100010010) will not appear in the message stream, independent of the busy-idle bit status.

The control-filler message is also used to specify a control mobile attenuation code (CMAC) for use by mobile stations accessing the system on the reverse control channel, a wait-for-overhead-message bit (WFOM) indicating whether or not mobile stations must read an overhead message train before accessing the system, and read the supplementary digital color code which mobile stations will return in Word B of the reverse control channel message when mobile stations are requested to read control-filler before system access in the system parameter overhead message.

Information element	Length (bits)
T_1T_2 = 11	2
DCC	2
010111	6
CMAC	3
SDCC1	2
11	2
SDCC2	2
1	1
WFOM	1
1111	4
OHD = 001	3
P	12

The interpretation of the data fields is as follows:

T_1T_2 - Type field. Set to '11' indicating overhead word.

DCC - Digital color code field.

CMAC - Control mobile attenuation field. Indicates the mobile station power level associated with the reverse control channel (see Table 2.1.2-1).

SDCC1, SDCC2 - Supplementary digital color codes

WFOM - Wait-for-overhead-message field.

OHD - Overhead message type field. Set to '001' indicating the control-filler word.

P - Parity field.

3.7.1.3 Data Restrictions

The 11-bit word-sync sequence (11100010010) is shorter than the length of a word, and therefore can be embedded in a word. Normally, embedded word-sync will not cause a problem because the next word to be sent will not have the word-sync sequence embedded in it. There are, however, three cases in which the word-sync sequence may appear periodically in the FOCC stream. They are:

- The overhead message,
- The control-filler message,
- Mobile station control messages with pages to mobile stations with certain central office codes.

These three cases are handled by 1) restricting the overhead message transmission rate to about once per second, 2) designing the control-filler message to exclude the word-sync sequence, taking into account the various busy-idle bits, and 3) restricting the use of certain central office codes.

Table 3.7.1-5. TROUBLESOME CENTRAL OFFICE CODES

		Bit Pattern Thousands			Central Office Code	Digit
T_1T_2	DCC	NXX	X	XXX		
00	ZZ	111110(0)0100	10YY	...	007	0,8,9
00	ZZ	111011(1)0001	0010	...	056	2
00	ZZ	111100(0)1001	0ZZZ	...	070	1-7
00	ZZ	000011(1)0001	0010	...	150	2
00	ZZ	000111(1)0001	0010	...	224	2
00	ZZ	000111(0)0010	010Z	...	225	4,5
00	ZZ	001011(1)0001	0010	...	288	2
00	ZZ	001110(0)0100	10YY	...	339	0,8,9
00	ZZ	001111(1)0001	0010	...	352	2
00	ZZ	001111(0)0010	010Z	...	353	4,5
00	ZZ	010011(1)0001	0010	...	416	2
00	ZZ	010111(1)0001	0010	...	470	2
00	ZZ	010111(0)0010	010Z	...	481	4,5
00	ZZ	011111(1)0001	0010	...	508	2
00	ZZ	011111(0)0010	010Z	...	509	4,5
00	ZZ	011011(1)0001	0010	...	544	2
00	ZZ	011100(0)1001	0ZZZ	...	568	1-7
00	ZZ	011110(0)0100	10YY	...	595	0,8,9
00	11	100010(0)1000	....	...	663	0-9
00	11	100010(0)1001	....	...	664	0-9
00	11	100010(0)1010	....	...	665	0-9
00	11	100010(0)1011	....	...	666	0-9
00	ZZ	100011(1)0001	0010	...	672	2
00	ZZ	100111(1)0001	0010	...	736	2
00	ZZ	100111(0)0010	010Z	...	737	4,5
00	ZZ	101011(1)0001	0010	...	790	2
00	ZZ	101110(0)0100	10YY	...	851	0,8,9
00	ZZ	101111(1)0001	0010	...	864	2
00	ZZ	101111(0)0010	010Z	...	865	4,5
00	Z1	110001(0)0101	....	...	890	0-9
00	Z1	110001(0)0100	....	...	899	0-9
00	ZZ	111000(1)0010	....	...	909	0-9

00	ZZ	110011(1)0001	0010	...	928	2
00	ZZ	110111(1)0001	0010	...	992	2
00	ZZ	110111(0)0010	010Z	...	993	4,5
00	ZZ	111111(0)0010	010Z	...	---	4,5*
00	ZZ	111111(1)0001	0010	...	---	2*

Notes:

1) YY-bits can be '0', but both cannot be '1' at the same time.
2) Z represents a bit that may be '1' or '0'.
3) The bit in parentheses is the busy-idle bit.
4) * - Central Office Code above 999.
5) Central Office Codes beginning with '1' and '0' have been included for completeness.

If the mobile station control message (see 3.7.1.1) is examined with the MIN1 separated into NXX-X-XXX as described in 2.3.1 (where NXX is the central office code, N represents a number from 2-9, and X represents a number from 0-9), Table 3.7.1-5 identifies the central office codes that are troublesome when used in the 1-word page mode. Use of the 2-word page mode alleviates the possibility of improper word-sync when using troublesome central office codes. For completeness, all 3-digit combinations that may be troublesome are shown even though they may be unrealistic, e.g., beginning with 0 or 1.

3.7.2 Forward Analog Voice Channel

The forward voice channel (FVC) is a wideband data stream sent by the base station to the mobile station. This data stream must be generated at a 10 kilobit/second ±0.1 bit/second rate. Figure 3.7.2-1 depicts the format of the FVC data stream.

A 37-bit dotting sequence (1010....101) and an 11-bit word sync sequence (11100010010) are sent to permit mobile stations to achieve synchronization with the incoming data, except at the first repeat of the word, where the 101-bit dotting sequence is used. Each word contains 40 bits, including parity, and is repeated eleven times together with the 37-bit dotting and 11-bit word sync sequences; it is then referred to as a word block. A word is formed by encoding the 28 content bits into a (40, 28) BCH code that has a distance of 5, (40, 28; 5). The left-most bit (i.e., earliest in time) shall be designated the most- significant bit. The 28 most-significant bits of the 40-bit field shall be the content bits. The generator polynomial is the same as that used for the forward control channel (see 3.7.1).

Figure 3.7.2-1. FORWARD ANALOG VOICE CHANNEL MESSAGE STREAM (Base-to-Mobile)

Information element	Length (bits)
DOTTING = 1010...101	101
W.S. = 11100010010	11
Repeat 1 of WORD1	40
DOTTING = 1010...101	37
W.S. = 11100010010	11
Repeat 2 of WORD1	40
...	
DOTTING = 1010...101	37
W.S. = 11100010010	11
Repeat 10 of WORD1	40
DOTTING = 1010...101	37
W.S. = 11100010010	11
Repeat 11 of WORD1	40

Information element	Length (bits)
DOTTING = 1010...101	101
W.S. = 11100010010	11
Repeat 1 of WORD2	40
DOTTING = 1010...101	37
W.S. = 11100010010	11
Repeat 2 of WORD2	40
...	
DOTTING = 1010...101	37
W.S. = 11100010010	11
Repeat 10 of WORD2	40
DOTTING = 1010...101	37
W.S. = 11100010010	11
Repeat 11 of WORD2	40

3.7.2.1 Mobile Station Control Message

The mobile station control message is the only message transmitted over the forward voice channel. The mobile station control message consists of one or more words.

Mobile Station Control Message Word 1

Information element		Length (bits)	
$T_1T_2 = 10$		2	
SCC		2	
SCC = 11		SCC ≠ 11	
Information element	Length (bits)	Information element	Length (bits)
PSCC	2	PSCC	2
EF	1	EF	1
RSVD = 00000000/ DVCC	8	RSVD = 0000000	7
LOCAL/MSG TYPE	5	VMAC	3
ORDQ	3	CHAN	11
ORDER	5	P	12
P	12		

Word 2 - Digital Channel Assignment

Information element	Length (bits)
$T_1T_2 = 01$	2
MEM	1
PM	1
PSCC	2
SBI	2
TA	5
DMAC	4
CHAN	11
P	12

Word 2- Base Station Challenge Order Confirmation

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	4
AUTHBS	18
RSVD = 0000	4
P	12

Word 2- Unique Challenge Order Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
RANDU	24
P	12

Word 2- First SSD Update Order Word

Information element	Length (bits)
T_1T_2 = 01	2
RANDSSD_1	24
RSVD = 0...0	2
P	12

Word 2- First Alert With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RL_W	5
SIGNAL	8
CPN_RL	6
PI	2
SI	2
RSVD=000	3
P	12

Word 2- First Flash With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RL_W	5
CPN_RL	6
PI	2
SI	2
RSVD=0...0	11
P	12

Word 3- Second SSD Update Order Word

Information element	Length (bits)
T_1T_2 = 01	2
RANDSSD_2	24
RSVD = 0...0	2
P	12

Word 3- Second Alert With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

Word 3- Second Flash With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

Word 4- Third SSD Update Order Word

Information element	Length (bits)
T_1T_2 = 01	2
RANDSSD_3	8
RSVD = 0...0	18
P	12

Word 4- Third Alert With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

Word 4- Third Flash With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

Word 5- Fourth Alert With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

Word 5- Fourth Flash With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

•

•

•

Word N- (N-1)th Alert With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

Word N- (N-1)th Flash With Info Word

Information element	Length (bits)
T_1T_2 = 01	2
RSVD = 00	2
CHARACTER	8
CHARACTER	8
CHARACTER	8
P	12

The interpretation of the data fields is as follows:

T_1T_2	-	Type field. Set to '10' in Word 1. Set to '01' in Word 2 and all subsequent Words. Word 2 is sent after Word 1 only when the order is '01110', a digital traffic channel assignment, or one of the following orders or order confirmations: • Base Station Challenge Order Confirmation • Unique Challenge Order • SSD Update Order • Alert With Info • Flash With Info
SCC	-	SAT color code for new channel (see Table 3.7.1-2).
PSCC	-	Present SAT color code. Indicates the SAT color code associated with the present channel.
DVCC	-	Digital Verification Color Code
EF	-	Extended Protocol Forward Channel Indicator (See 5.2)
MSG. TYPE	-	Message type field. Qualifies the order to a specific action. See Table 3.7.1-3
ORDER	-	Order field. Identifies the order type (see Table 3.7.1- 1).
ORDQ	-	Order Qualifier field. Qualifies the order to a specific action (See Table 3.7.1-1).
LOCAL	-	Local Control field. This field is specific to each system. The ORDER field must be set to local control (see Table 3.7.1-1) for this field to be interpreted.
SBI	-	Shortened Burst Indication: 00 = Transmit normal burst after cell to cell handoff 01 = Transmit normal burst after handoff within cell 10 = Transmit shortened burst after cell to cell handoff 11 = Reserved
TA	-	Time Alignment Offset
VMAC	-	Voice mobile attenuation code field. Indicates the mobile station power level associated with the designated analog voice channel. VMAC is made of the three least significant bits of MAC in Table 2.1.2-1.
DMAC	-	Digital mobile attenuation code field. Indicates the mobile station power level associated with the designated digital traffic channel. DMAC is made from all four bits of MAC in Table 2.1.2-1.
PM	-	Privacy Mode indicator. Set to '1' if voice privacy is activated on the assigned Digital Traffic Channel. Set to '0' if voice privacy is not activated on the assigned Digital Traffic Channel.
CHAN	-	Channel number field. Indicates the designated RF channel (see 2.3.3).
RSVD	-	Reserved for future use; all bits must be set as indicated.
RANDU	-	The 24 bit random number issued by the base in the Unique Challenge Order.

RANDSSD_1 -	The most significant 24 bits of the random number issued by the base in the SSD Update Order.
RANDSSD_2 -	The subsequent 24 bits (following RANDSSD-1) of the random number issued by the base in the SSD Update Order.
RANDSSD_3 -	The least significant 8 bits of the random number issued by the base in the SSD Update Order.
AUTHBS -	Output response of the authentication algorithm initiated by the Base Station Challenge Order.
MEM -	Message Encryption Mode. A 1 bit value that is set to '0' to indicate that encrypted signaling is disabled, and set to '1' to indicate that encrypted signaling is enabled. See 2.3.12.2.1.
RL_W -	The remaining length, in 'Words', of the Alert With Info or Flash With Info order.
SIGNAL -	An 8 bit information element that causes the mobile station to generate tones and alerting signals to the user, coded as specified in 2.7.3.1.3.3
CPN_RL -	A 6 bit field used to indicate the number of CHARACTERs in the first instance of the Calling Party Number.
PI -	Presentation indicator. A 2 bit field used to indicate whether or not the calling number should be displayed. See 2.7.3.1.3.3.1 for coding rules.
SI -	Screening Indicator. A 2 bit field indicating how the calling number was screened. See 2.7.3.1.3.3.1 for coding rules.
CHARACTER -	An 8 bit representation of an ASCII character, coded as described in 2.7.3.1.3.4 and the references cited therein. Note that in the absence of a sufficient number of characters to completely fill the last Alert With Info or Flash With Info Word, null characters (00000000) are to be used as filler.
P -	Parity field.

3.7.3 Forward Digital Traffic Channel (FDTC)

The Forward Digital Traffic Channel (FDTC) is a digital channel from a base station to a mobile station used to transport user information and signaling. It has associated with it two separate control channels: the Fast Associated Control Channel (FACCH) and the Slow Associated Control Channel (SACCH). The FACCH is a blank and burst channel. The SACCH is a continuous channel.

3.7.3.1 Protocol Structure for the Traffic Channel

3.7.3.1.1 Fast Associated Control Channel (FACCH)

The FACCH is a signaling channel for transmission of control and supervision messages between the base station and the mobile. See 2.7.3.1.1 for data stream format and word format.

3.7.3.1.2 Slow Associated Control Channel (SACCH)

The SACCH is a signaling channel for transmission of control and supervision messages between the base station and a mobile.

The SACCH is obtained by including twelve coded bits in every TDMA slot. See 2.7.3.1.2 for data stream format and word format.

3.7.3.1.3 Messages

3.7.3.1.3.1 Message Structure

See 2.7.3.1.3.1 for message structure description.

See 2.7.3.1.3.3 for information element description.

3.7.3.1.3.2 Message Functional Definition

Each definition includes:

- a brief description of the message use.
- a table listing the information elements contained in the message.
- parameter-type codes.

For each information element, the table indicates:

1) Whether inclusion is mandatory 'M' or optional 'O'. Words containing only unused optional fields must not be sent.
2) The length in bits.

Information elements shall be coded into the Message field of the FACCH or SACCH words starting from the top as they appear in the following tables. The coding shall be done in the following order: the more-significant bits of an information element shall be coded into the more-significant bits of the Message field.

Table 3.7.3.1.3.2-1 summarizes the messages on the FDTC.

1 **Table 3.7.3.1.3.2-1 Messages on the FDTC.**

Call establishment messages	Number of Transmissions	Channel
Alert With Info	Multiple	FACCH

2

Call information phase messages	Number of Transmissions	Channel
Measurement Order	Multiple	FACCH
Stop Measurement Order	Multiple	FACCH/SACCH
Handoff	Multiple	FACCH
Physical Layer Control	Multiple	FACCH/SACCH

3

Call Release messages	Number of Transmissions	Channel
Release	Multiple	FACCH

4

Miscellaneous messages	Number of Transmissions	Channel
Base Station Ack	Single	FACCH
Maintenance	Multiple	FACCH
Audit	Multiple	SACCH
Local Control	Multiple	SACCH
Flash With Info Ack	Single	FACCH
Send Burst DTMF Ack	Single	FACCH
Send Continuous DTMF Ack	Single	FACCH
Flash With Info	Multiple	FACCH
Parameter Update	Multiple	FACCH
Status Request	Multiple	FACCH
Base Station Challenge Confirmation	Multiple	FACCH
SSD Update Order	Multiple	FACCH
Unique Challenge Order	Multiple	FACCH

3.7.3.1.3.2.1 Alert With Info

The Alert With Info message is sent by the base station to the mobile to cause audible or visual signaling to the subscriber relating to the initiation of a mobile terminated call, and to convey such related information as indicated by the parameter names. If the message does not include the optional information element *Signal*, the mobile station shall use *Standard Alert*.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Remaining Length	M	6
Signal	O	10–18
Calling Party Number [Note 1]	O	26–146
Notes 1. 0 to 2 instances may be sent		

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Signal	0001
Reserved for compatibility with IS-54-A	0010
Reserved for compatibility with IS-54-A	0011
Calling Party Number	0100

3.7.3.1.3.2.2 Measurement Order

This message informs the mobile station that it shall begin the channel quality measurements and reporting.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
RF Channel [Note 1]	O	10–142
Notes 1. 0 to 12 instances may be sent.		

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
RF Channel	0001

3.7.3.1.3.2.3 Stop Measurement Order

This message informs the mobile station that it shall terminate the channel quality measurements and reporting.

Channel: FACCH/SACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8

3.7.3.1.3.2.4 Handoff

This message is sent from the base station to the mobile station to order the mobile station from one traffic channel to another.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
RF Channel	M	11
Rate	M	1
Timeslot Indicator	M	3
Color code SAT/DVCC	M	8
DMAC/VMAC	M	4
Time Alignment	M	5
Shortened Burst	M	2
Voice Privacy Mode	M	1
Message Encryption Mode	M	1

3.7.3.1.3.2.5 Physical layer control

This message is used to control the physical layer in the mobile station. The parameters control output power level, time alignment value, if DTX is allowed and the delay interval compensation mode.

Channel: FACCH/SACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Remaining Length	M	6
Power Change	O	14
Time Alignment	O	15
DTX Allowed	O	11
Delay Interval Compensation Mode	O	11

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Reserved	0001
Power Change	0010
Time Alignment	0011
DTX Allowed	0100
Delay Interval Compensation Mode	0101

3.7.3.1.3.2.6 Release

This message informs the mobile station that the currently established call is terminated.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8

3.7.3.1.3.2.7 Base Station Ack

This message acknowledges messages of the following message types (for message type codes, refer to 2.7.3.1.3.3).

Ack Message Type	Ack Channel
CONNECT	FACCH
RELEASE	FACCH
STATUS	FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Ack Message Type	M	8
Remaining Length	M	6
Last Decoded Parameter	O	14

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Last Decoded Parameter	0001

3.7.3.1.3.2.8 Maintenance

This message is sent by a base station in order to check the operation of a mobile station.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8

3.7.3.1.3.2.9 Audit

This message is sent by the base station to determine if a mobile is active in a system.

Channel: SACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8

3.7.3.1.3.2.10 Local Control

This message is sent by the base station to customize the operation of a mobile station.

Channel: SACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Local Control	M	5

3.7.3.1.3.2.11 Flash with Info Ack

This message acknowledges a flash with info order from the mobile station. The flash with info order indicates to the base station that a user desires to invoke a special service.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4
Remaining Length	M	6
Last Decoded Parameter	O	14

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Last Decoded Parameter	0001

3.7.3.1.3.2.12 Send Burst DTMF Ack

This message acknowledges the Send Burst DTMF request.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4
Remaining Length	M	6
Last Decoded Parameter	O	14

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Last Decoded Parameter	0001

3.7.3.1.3.2.13 Send Continuous DTMF Ack

This message acknowledges the Send Continuous DTMF request.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4

3.7.3.1.3.2.14 Flash With Info

The Flash With Info message is sent by the base station to convey appropriate data to the mobile station, as is indicated by the name of the relevant parameters.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4
Remaining Length	M	6
Message Waiting	O	10-16
Signal	O	10–18
Calling Party Number [Note 1]	O	26–146
Notes 1. 0 to 2 instances may be sent		

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Message Waiting	0001
Reserved for compatibility with IS-54-A	0010
Signal	0011
Calling Party Number	0100

3.7.3.1.3.2.15 Parameter Update

This message causes the mobile to update its internal call history parameter that is used in the authentication process.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Request Number	M	4

3.7.3.1.3.2.16 Status Request Message

This message is used to query a mobile station for its status, confirm its request for a change in the voice privacy mode, and/or to inform the mobile station that the the base station has unilaterally decided to effect a change in the voice privacy mode.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
Remaining Length	M	6
Serial Number	O	10
Call Mode	O	10
Terminal Information	O	10
Voice Privacy Mode	O	11
Message Encryption Mode	O	11

Parameter-Type Codes for Optional Info Elements

Parameter Type	Code
Serial Number	0001
Call Mode	0010
Terminal Information	0011
Voice Privacy Mode	0100
Message Encryption Mode	0101

3.7.3.1.3.2.17 Unique Challenge Order

This message causes the mobile to execute the authentication algorithm.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
RANDU	M	24

3.7.3.1.3.2.18 SSD Update Order

This message causes the mobile to execute the authentication algorithm.

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
RANDSSD	M	56

3.7.3.1.3.2.19 Base Station Challenge Order Confirmation

This message is a response to the Base Station Challenge Order and contains the authentication algorithm outputs .

Channel: FACCH

Message Format

Information Element	Type	Length (bits)
Protocol Discriminator	M	2
Message Type	M	8
AUTHBS	M	18

3.7.3.1.3.3 Information Element Description

Refer to section 2.7.3.1.3.3 for information element description.

3.7.3.2 Protocol Structure for Enhanced Services

Requires further study.

4. REQUIREMENTS FOR MOBILE STATION OPTIONS

Mobile stations may be equipped with the following optional capabilities:

4.1 32-Digit Dialing

The following optional changes to 2.6.3.7 and 2.7 permit mobile stations to send up to 32 dialed digits to a base station on the reverse control channel in an origination message, and on the reverse voice channel in a called-address message.

4.1.1 Service Request - Requirement for 32-Digit Dialing Option

The mobile station must continue to send its message to the base station. The information that must be sent is as follows (with the formats given in 4.1.2):

- Word A must always be sent.
- If:
  - E_S = 1, or
  - LT_S = 1, or
  - $AUTH_S$ = 1, or
  - the ROAM status is enabled, or
  - the ROAM status is disabled and EX_p = 1, or
  - the access is an "order confirmation", or
  - the access is a "registration", or
  - the access is a "base station challenge", or
  - digital traffic channel capability is requested, or
  - the mobile station was paged with a two-word mobile station control message, or
  - RCF = 1,

  Word B must be sent.

- Word C must be sent as per the following table:

S_S Bit	Type of System Access			
	Registration, Origination or Page Response where $AUTH_S = 0$	Registration, Origination or Page Response where $AUTH_S = 1$	Unique Challenge Order Confirmation	Base Station Challenge
0	Send no Word C	Send Authentication Word C	Send Unique Challenge Order Confirmation Word C	Send Base Station Challenge Word C
1	Send Serial Number Word C	Send Serial Number Word C and Authentication Word C	Send Serial Number Word C and Unique Challenge Order Confirmation Word C	Send Serial Number Word C and Base Station Challenge Word C

- If the access is an "origination",
  Word D must be sent.
- If the access is an "origination" and 9 to 16 digits were dialed, Word E must be sent.
- If the access is an "origination" and 17 to 24 digits were dialed, Word F must be sent.
- If the access is an "origination" and 25 to 32 digits were dialed, Word G must be sent.

When the mobile station has sent its complete message, it must continue to send unmodulated carrier for a nominal duration of 25 ms and then turn off the transmitter.

The next task to be entered depends on the type of access by the mobile station:

- If the access is an order confirmation, the mobile station must enter the Serving-System Determination Task (see 2.6.3.12).
- If the access is an origination, the mobile station must enter the Await Message Task (see 2.6.3.8).
- If the access is a page response, the mobile station must enter the Await Message Task (see 2.6.3.8).
- If the access is a registration request other than a power down registration the mobile station must enter the Await Registration Confirmation task (see 2.6.3.9). If the registration is a power down registration the mobile station shall power down.
- If the access is a base station challenge, the mobile station must enter the Await Message Task (see 2.6.3.8).

4.1.2 Signaling Formats - Requirements for 32-Digit Dialing Option

In the message formats used between the mobile stations and base stations, some bits are marked as reserved (RSVD). Some or all of these reserved bits may be used in the future for additional messages. Therefore, all mobile stations and base stations must set all bits that they are programmed to treat as reserved bits to "0" (zero) in all messages that they transmit. All mobile stations and base stations must ignore the state of all bits that they are programmed to treat as reserved bits in all messages that they receive.

4.1.2.1 Reverse Analog Control Channel (RECC) - Requirement for 32-Digit Dialing Option

The reverse analog control channel (RECC) is a wideband data stream sent from the mobile station to the base station. This data stream must be generated at a 10 kbps ±1 bps rate. Figure 4.1.2.1-1 depicts the format of the RECC data stream.

Figure 4.1.2.1-1. Reverse Analog Control Channel Message Stream (Mobile-to-Base)

Information element	Length (bits)	
DOTTING = 1010...010	30	Seizure Precursor
WORD SYNC = 11100010010	11	Seizure Precursor
CODED DCC *	7	Seizure Precursor
1st Word Repeated 5 times	240	
2nd Word Repeated 5 times	240	
3rd Word Repeated 5 times	240	
...		

* DIGITAL COLOR CODE - Coded per Table 4.1.2-1.

All messages begin with the RECC seizure precursor that is composed of a 30-bit dotting sequence (1010...010), an 11-bit word sync sequence (11100010010), and the coded digital color code (DCC). The 7-bit coded DCC is obtained by translating the received DCC according to Table 4.1.2-1.

Table 4.1.2-1. Coded Digital Color Code

Received DCC	7-Bit Coded DCC
00	0000000
01	0011111
10	1100011
11	1111100

Each word contains 48 bits, including parity, and is repeated five times; it is then referred to as a word block. A word is formed by encoding 36 content bits into a (48, 36) BCH code that has a distance of 5, (48, 36; 5). The left-most bit (i.e., earliest in time) shall be designated the most-significant bit. The 36 most-significant bits of the 48-bit field shall be the content bits. The generator polynomial for the code is the same as for the (40, 28; 5) code used on the forward control channel (see 3.7.1).

4.1.2.2 RECC Messages

Each RECC message can consist of one to eight words. The types of messages to be transmitted over the reverse control channel are:

- Page Response Message
- Origination Message
- Order Confirmation Message
- Order Message

These messages are made up of combinations of the following words:

Word A - Abbreviated Address Word

Information element	Length (bits)
F	1
NAWC	3
T	1
S	1
E	1
ER	1
SCM (3-0)	4
MIN1	24
P	12

Word B - Extended Address Word

Information element	Length (bits)
F = 0	1
NAWC	3
LOCAL/MSG TYPE	5
ORDQ	3
ORDER	5
LT	1
EP	1
SCM(4)	1
MPCI	2
SDCC1	2
SDCC2	2
$MIN2_{33-24}$	10
P	12

Word C - Serial Number Word

Information element	Length (bits)
F = 0	1
NAWC	3
ESN	32
P	12

Word C - Authentication Word

Information element	Length (bits)
F = 0	1
NAWC	3
COUNT	6
RANDC	8
AUTHR	18
P	12

Word C - Unique Challenge Order Confirmation Word

Information element	Length (bits)
F = 0	1
NAWC	3
RSVD = 0...0	14
AUTHU	18
P	12

Word C - Base Station Challenge Word

Information element	Length (bits)
F = 0	1
NAWC	3
RANDBS	32
P	12

Word D - First Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC	3
1st DIGIT	4
2nd DIGIT	4
3rd DIGIT	4
4th DIGIT	4
5th DIGIT	4
6th DIGIT	4
7th DIGIT	4
8th DIGIT	4
P	12

Word E - Second Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC = 0	3
9th DIGIT	4
10th DIGIT	4
11th DIGIT	4
12th DIGIT	4
13th DIGIT	4
14th DIGIT	4
15th DIGIT	4
16th DIGIT	4
P	12

Word F - Third Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC = 0	3
17th DIGIT	4
18th DIGIT	4
19th DIGIT	4
20th DIGIT	4
21st DIGIT	4
22nd DIGIT	4
23rd DIGIT	4
24th DIGIT	4
P	12

Word G - Fourth Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC = 0	3
25th DIGIT	4
26th DIGIT	4
27th DIGIT	4
28th DIGIT	4
29st DIGIT	4
30th DIGIT	4
31st DIGIT	4
32nd DIGIT	4
P	12

4.1.3 Reverse Analog Voice Channel - Requirement for 32-Digit Dialing Option

The reverse analog voice channel (RVC) is a wideband data stream sent from the mobile station to the base station. This data stream must be generated at a 10 kbps ±1 bps rate. Figure 4.1.3-1 depicts the format of the RVC data stream.

Figure 4.1.3-1. Reverse Analog Voice Channel Message Stream (Mobile-to-Base)

Information element	Length (bits)
DOTTING	101
W.S.	11
Repeat 1 of WORD1	48
DOTTING	37
W.S.	11
Repeat 2 of WORD 1	48
DOTTING	37
W.S.	11
Repeat 3 of WORD 1	48
DOTTING	37
W.S.	11
Repeat 4 of WORD 1	48
DOTTING	37
W.S.	11
Repeat 5 of WORD 1	48
DOTTING	37
W.S.	11
Repeat 1 of WORD 2	48
...	

DOTTING = 1010....101
W.S. (WORD SYNC) = 11100010010

A 37-bit dotting sequence (1010...01) and an 11-bit word sync sequence (11100010010) are sent to permit base stations to achieve synchronization with the incoming data, except at the first repeat of word 1 of the message where a 101-bit dotting sequence is used. Each word contains 48 bits, including parity, and is repeated five times together with the 37-bit dotting and 11-bit word sync sequences; it is then referred to as a word block. For a multi-word message, each additional word block is formed the same as the first word block including the 37-bit dotting and 11-bit word sync sequences. A word is formed by encoding the 36 content bits into a (48, 36) BCH code that has a distance of 5, (48, 36; 5). The left-most bit (i.e., earliest in time) shall be designated the most-significant bit. The 36 most-significant bits of the 48-bit field shall be the content bits. The generator polynomial for the code is the same as for the (40, 28; 5) code used on the forward control channel.

4.1.3.1 RVC Messages

Each RVC message can consist of one to four words. The types of messages to be transmitted over the reverse voice channel are:

- Order Confirmation Message
- Called-Address Message
- Serial Number Response Message
- Page Response
- Unique Challenge Order Confirmation
- Base Station Challenge Order Message

The message formats are as follows:

Order Confirmation Message

Information element	Length (bits)
F = 1	1
NAWC = 00	2
T = 1	1
LOCAL/MSG TYPE	5
ORDQ	3
ORDER	5
RSVD = 000 ... 000	19
P	12

Called-Address Message:

Word 1 - First Word of the Called-Address

Information element	Length (bits)
F = 1	1
NAWC	2
T = 0	1
1st DIGIT	4
2nd DIGIT	4
3rd DIGIT	4
4th DIGIT	4
5th DIGIT	4
6th DIGIT	4
7th DIGIT	4
8th DIGIT	4
P	12

Word 2 - Second Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC	2
T = 0	1
9th DIGIT	4
10th DIGIT	4
11th DIGIT	4
12th DIGIT	4
13th DIGIT	4
14th DIGIT	4
15th DIGIT	4
16th DIGIT	4
P	12

Word 3 - Third Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC	2
T = 0	1
17th DIGIT	4
18th DIGIT	4
19th DIGIT	4
20th DIGIT	4
21st DIGIT	4
22nd DIGIT	4
23rd DIGIT	4
24th DIGIT	4
P	12

Word 4 - Fourth Word of the Called-Address

Information element	Length (bits)
F = 0	1
NAWC = 00	2
T = 0	1
25th DIGIT	4
26th DIGIT	4
27th DIGIT	4
28th DIGIT	4
29th DIGIT	4
30th DIGIT	4
31st DIGIT	4
32nd DIGIT	4
P	12

Serial Number Response Message:

Word 1 of Serial Number Response Message

Information element	Length (bits)
F = 1	1
NAWC = 01	2
T = 1	1
LOCAL/MSG TYPE	5
ORDQ	3
ORDER	5
RSVD = 000 ... 000	19
P	12

Word 2 of Serial Number response message.

Information element	Length (bits)
F = 0	1
NAWC = 00	2
T = 1	1
ESN	32
P	12

Page Response

Information element	Length (bits)
F = 1	1
NAWC = 00	2
T = 1	1
MSG TYPE	5
ORDQ = 000	3
ORDER = 00000	5
RSVD = 000 ... 000	19
P	12

Unique Challenge Order Confirmation Message

Information element	Length (bits)
F = 1	1
NAWC = 00	2
T = 1	1
LOCAL/MSG TYPE = 0...0	5
ORDQ	3
ORDER	5
AUTHU	18
RSVD = 0	1
P	12

Base Station Challenge Order Message

Word 1 of Base Station Challenge Order Message

Information element	Length (bits)
F = 1	1
NAWC = 01	2
T = 1	1
LOCAL/MSG TYPE = 0...0	5
ORDQ	3
ORDER	5
RSVD = 000 ... 000	19
P	12

1 Word 2 of Base Station Challenge Order Message

Information element	Length (bits)
F = 0	1
NAWC = 00	2
T = 1	1
RANDBS	32
P	12

2 The interpretation of the data fields is as follows:

F – First word field. Set to '1' in first word and '0' in second word.

NAWC – Number of additional words coming field.

T – T field. Set to '1' to identify the message as an order or order confirmation. Set to '0' to identify the message as a called-address.

DIGIT – Digit field (see Table 2.7.1–2).

ORDER – Order field. Identifies the order type (see Table 3.7.1–1).

ORDQ – Order qualifier field. Qualifies the order confirmation to a specific action (See Table 3.7.1–1).

LOCAL – Local Control field. This field is specific to each system. The ORDER field must be set to local control (see Table 3.7.1–1) for this field to be interpreted.

MSG TYPE – Message Type field. Qualifies the order (see Table 3.7.1–1).

RSVD – Reserved for future use; all bits must be set as indicated.

AUTHU – Output of the authentication algorithm when responding to a Unique Challenge order (see 2.3.12.1.5)

RANDBS – Random number used in the SSD update procedure (see 2.3.12.1.8)

ESN – Electronic Serial Number field. Identifies the electronic serial number of the mobile station (see 2.3.2).

P – Parity field.

4.2 Mobile Station Extended Protocol (See also 5.2)

The following optional additions to Section 2 provide the structure and signaling procedures to allow new messages and data to be sent to or transmitted by mobile stations. The term "mobile stations" is used in the generic sense as indicated in Note 2 and includes transportable, hand-held and fixed station units as well as mobiles mounted in vehicles.

The purpose of this option is to extend the signaling capabilities of the Base station/Mobile Station interface to allow new features and operational capabilities to be added to existing and future cellular systems.

The Extended Protocol structure and signaling have been designed to allow all four of the following combinations of systems and mobile stations to be simultaneously operational:

1. Old systems operating with old mobile stations;
2. Old systems operating with new mobile stations;
3. New systems operating with old mobile stations;
4. New systems operating with new mobile stations;

where "old" means a version that does not include this optional capability, and "new" means a version that does.

4.2.1 RECC Extended Protocol Messages

Each Extended Protocol message starts with a message header. In all cases, the message headers contain among other information:

- Message Length (MSL) indicator;
- Message Type (MST) indicator; and
- Extended Protocol (ER) indicator.

In the RECC, each message header always consists of two words.

Header Word A

Information element	Bit Assignment	Length (bits)
F1	11	2
RSVD	00	2
T	X	1
S	0	1
E	1	1
ER	X	1
SCM	XXXX	4
MIN1	X...X	24
P	X...X	12

Header Word B

Information element	Bit Assignment	Length (bits)
F2	10	2
RSVD	00	2
MSL	X...X	5
MST	X...X	8
LT	X	1
EP	1	1
SCM(4)	X	1
MPCI	XX	2
SDCC1	XX	2
SDCC2	XX	2
MIN2	X...X	10
P	X...X	12

The interpretation of the data fields is as follows:

F1 = Start of Header, first word;
RSVD = Reserved (new bit assignments);
T = message class, i.e., order or response;
S = serial number (not used);
E = extended address (Word B to be sent);
ER = Extended Protocol (Reverse Channel) ;
SCM = Station Class Mark (unchanged);
MIN1 = subscriber coded directory number (7 digits);
P = cyclic redundancy code;
F2 = Second word of header;
MSL = Message Length (former LOCAL field) ;
MST = Message Type (former ORDQ and ORDER fields) ;
MIN2 = 3 most significant digits of subscriber directory number;
LT = Last Try;
EP = Extended Protocol Capability indicator;
MPCI = Multiple Protocol Capability Indicator;
'00' indicates EIA 553 and IS-54-A mobile stations
'01' indicates an EIA/TIA IS-54-B dual-mode mobile station
'10' reserved
'11' reserved
SDCC1 = Supplementary Digital Color Code;

SDCC2 = Supplementary Digital Color Code;

X..X = variable bit field depending on the message.

The following are expanded definitions of the new fields.

MSL - The Message Length (MSL) field makes use of the former 5 bit LOCAL field to allow up to 31 Message Data Words to be appended to a message header to form a complete message.

An all zero MSL field (MSL = 00000) means that there are no Message Data Words appended. The header words are not included in the message length count.

MST - The Message Type (MST) field defines the type of message and, by implication, the form and format of any appended Message Data Words. (See Note 11)

EP - The Extended Protocol (EP) bit is used to indicate to the system that the mobile station is capable of using the Extended Protocol.

ER - The Extended Protocol Reverse Channel (ER) bit is used to indicate that the current message is in the Extended Protocol. If the ER bit is a "zero" (0), the message format of 2.7.1.1 above, is being used. If the ER bit is a "one" (1), the Extended Protocol message format is being used.

The generic formats of Message Data Words used are as follows:

Message Data Word 1 to N-1

Information element	Bit Assignment	Length (bits)
F3	01	2
Message Data	X...X	34
P	X...X	12

Message Data Word N

Information element	Bit Assignment	Length (bits)
F4	00	2
Message Data	X...X	34
P	X...X	12

The F1, F2, F3 and F4 fields are used as follows:

F1 = 11 = the first header word, Header Word A

F2 = 10 = the second header word, Header Word B

F3 = 01 = the 1st to N-1 Message Data Word

F4 = 00 = the last (Nth) Message Data Word

4.2.2 RVC Extended Protocol Messages

In the RVC, each message header consists of one word whose format is shown below.

RVC Header Word

Information element	Bit Assignment	Length (bits)
F1	11	2
RSVD	0	1
T	X	1
MSL	X..X	5
MST	X..X	8
ER	X	1
EP	1	1
RSVD	0...0	17
P	X..X	12

The interpretation of the fields is as follows:

F1 = Start of header (Header Word);
T = message class, i.e., order or response;
MSL = Message Length indicator;
MST = Message Type indicator;
ER = Extended Protocol Reverse Channel indicator;
EP = Extended Protocol Capability indicator;
P = cyclic redundancy code;
RSVD = reserved field.

When ER is set to "zero" (0), the message format and field definitions areas defined in 4.2.1 above. When ER is set to a "one" (1), the message format and field definitions are as shown for the Extended Protocol RVC Header Word.

Message Data Words that are appended to RVC Header Word are formatted in accordance with the generic formats shown in 4.2.1, above.

5. REQUIREMENTS FOR BASE STATION OPTIONS

Base stations may be equipped with the following optional capabilities:

5.1 32-Digit Dialing

No changes to 3 are required to permit mobile stations to send up to 32 dialed digits to a base station on the reverse control channel in an origination message, and on the reverse voice channel in a called-address message.

Note: Base stations that do not have 32-digit dialing capability must not malfunction if a mobile station sends a called-address message that includes three or four called-address words.

5.2 Base Station Extended Protocol (See also 4.2)

Refer to 4.2.

5.2.1 Extended Protocol Mobile Station Control Message

Each message header always consists of two words as follows:

Word 1

Information element	Bit Assignment	Length (bits)
T_1T_2	01	2
DCC	XX	2
MIN 1	X...X	24
P	X...X	12

Word 2

Information element	Bit Assignment	Length (bits)
T_1T_2	10	2
SCC	11	2
MIN 2	X...X	10
EF	X	1
MSL	X...X	5
MST	X...X	8
P	X...X	12

The interpretation of the fields is as follows:

T_1T_2 = Type field;
DCC = Digital Color Code;
MIN1 = subscriber coded directory number (7 digits);
P = cyclic redundancy code;
SCC = SAT Color Code = 11 = not a channel designation message;
MIN2 = 3 most significant digits of subscriber directory number;
EF = Extended Protocol (Forward Channel) indicator;
MSL = Message Length (former LOCAL);
MST = Message Type (former ORDQ and ORDER; and
X..X = variable bit field depending on message.

The generic format of Message Data Words on the FOCC are as follows:

Message Data Word 1 to N-1

Information element	Bit Assignment	Length (bits)
T_1T_2	01	2
DCC	XX	2
Message Data	X...X	24
P	X...X	12

Message Data Word N

Information element	Bit Assignment	Length (bits)
T_1T_2	00	2
DCC	XX	2
Message Data	X...X	24
P	X...X	12

5.2.2 Extended Protocol Overhead Message

One of the formerly reserved (RSVD) bits in Word 1 of the SYSTEM PARAMETER overhead message is used to indicate to mobile stations that the cellular system is equipped to use the Extended Protocol. (See 3.7.1.2.1.)

Word 1

Information element	Bit Assignment	Length (bits)
T_1T_2	11	2
DCC	XX	2
SID 1	X...X	14
EP	1	1
AUTH	X	1
PCI	X	1
NAWC	X...X	4
OHD	110	3
P	X...X	12

All other words of the System Overhead Parameter Message are as defined in 3.7.1.2.1 through 3.7.1.2.4, above.

5.2.3 FVC Extended Protocol Message

In the FVC each message header consists of one word whose format is shown below.

Word 1 (Control Message)

Information element	Bit Assignment	Length (bits)
T_1T_2	10	2
SCC	11	2
PSCC	XX	2
EF	X	1
RSVD	0...0	8
MSL	X...X	5
MST	X..X	8
P	X...X	12

The interpretation of the data fields is as follows:

T_1T_2 = Type field (bit assignment unchanged);
SCC = Digital Color Code = 11 = not a channel designation message;
PSCC = Present SAT Color Code (unchanged);
EF = Extended Protocol Forward Channel indicator;
MSL = Message Length indicator;
MST = Message Type indicator; and
P = cyclic redundancy code.

The generic format of Message Data Words used in the FVC are as follows:

Message Data Word 1 to N-1

Information element	Bit Assignment	Length (bits)
T_1T_2	01	2
Message Data	X...X	26
P	X...X	12

Message Data Word N

Information Element	Bit Assignment	Length (bits)
T_1T_2	00	2
Message Data	X...X	26
P	X...X	12

6. CHANGE HISTORY

6.1. Chronology Of Revisions For IS-54-A

ADOPTED	SECTION(S)	CHANGE
4-12-90	2	Clarifications to speech coder text.
4-12-90	2, 3	Improved time alignment procedure.
4-12-90	2	Removal of ambiguities in channel coding text.
5-17-90	2, 3	Introduction of delay interval compensation control function.
5-17-90	1	Clarification of text addressing tolerances.
5-17-90	2	Improved SACCH coding procedure.
5-17-90	2	Enhanced physical layer control procedure.
5-17-90	2	Corrections to address inconsistencies in the text describing the order of bit transmission.
5-17-90	4	Re-format of entire section.
5-17-90	5	Re-format of entire section.
6-20-90	1	Enhanced definition of "maximum effect point".
6-20-90	2, 3	Modifications to ensure compatibility between dual-mode mobile stations and EIA/TIA-553 base stations.
6-20-90	2	Clarification of text describing the coding of DVCCs.
6-20-90	2	Clarification of "Abbreviated Alert" order call processing.
6-20-90	2	Enhanced definition/specification of absolute RSSI accuracy.
7-26-90	2, 3	Streamlined mobile station output power control procedure.
7-26-90	2,3	Reverse position of "Message Type" and "Protocol Discriminator" fields in message headers.
7-26-90	1	Improved synchronization sequences.
7-26-90	2, 3	Changes to facilitate geographic-based auto-registration.
8-29-90	2, 3	Addition of "Terminal Information" feature.
8-30-90	2, 3	Addition of "Distinctive Alert" feature.
8-30-90	3	Clarification to text regarding the use of extended modulation.
8-30-90	2, 3	Revised procedure for the handling of DTMF tones.

11-8-90	2, 3	Editorial changes to address discrepancies reported during the IS-54-A letter-ballot process.
12-13-90	2	Corrections to the text describing the interleaving of coded speech data.
12-13-90	2	Clarification of the procedure for handling partially decoded FDTC and RDTC messages.
12-13-90	2	Clarification of BER measurement procedures for MAHO.
12-13-90	3	Clarification of the interpretation of the "T1T2" field in FVC messages.
12-13-90	2	Clarification of the bad frame masking procedure.
1-24-91	2	Clarification of the use of filler octets in constructing FACCH and SACCH messages.
1-24-91	2, 3	Removal of ambiguities in the coding of "Terminal Information".
1-24-91	PREFACE	Editorial change to "Change History".
1-24-91	NOTES	Editorial change to Note 5.
1-24-91	NOTES	Addition of Note 15.
1-24-91	6	Summary of changes from IS-54 to IS-54-A.

6.2. Chronology Of Revisions For IS-54-B

ADOPTED	SECTION(S)	CHANGE
10-4-90	2	Modified conditions for transmit power during power ramp time.
11-08-90	2, 3	Introduction of echo return loss and control requirements.
12-13-90	1, 2, 4	Addition of Mobile Protocol Capability Indicator.
12-13-90	2, 3	Support for "minimum implementation" of G-3 FAX and asynchronous data services.
1-24-91	2	Update "Terminal Information" field of "Terminal Information" information element.
4-4-91	1, 2, 3	Introduction of power up/down auto-registration.
5-9-91	1	Revised Note to Table 1.2.4-1.
7-12-91	2, 3	Addition of analog voice channel Message Waiting Indicator capability.
7-12-91	1, 2, 3	Addition of authentication, voice privacy and signaling message encryption capabilities.
8-13-91	2, 3	Revised format for "Alert w/Info" and "Flash w/Info" messages to support CNIP, CNIR and Call Trace.
8-13-91	2, 3	Addition of analog voice channel "Alert w/Info" and "Flash w/Info" messages.
8-13-91	2, 3	Revised requirements for transmit and receive levels.
8-13-91	1, 2, 3, 4, 5	Enhancements/clarifications to authentication, voice privacy and signaling message encryption procedures/text.
8-13-91	NOTES	Editorial Change to Note 15.
8-13-91	NOTES 2, 3	Removal of all text suggesting that mobile station support for auto-registration is optional.
8-19-91	2, 3	Re-format of text and tables describing FDTC and RDTC message structures.
8-19-91	6	Summary of changes from IS-54-A to IS-54-B.
1-9-92	1,2,3,4,5,6	Clarifications to address discrepancies reported during the letter-ballot process.

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