UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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NOKIA OF AMERICA CORP.,

Petitioner

v.

ADAPTIVE SPECTRUM AND SIGNAL ALIGNMENT, INC.,

Patent Owner

_____

Case: IPR2025-00492

U.S. Patent No. 7,593,458

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DECLARATION OF DR. MARC MOONEN IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,593,458

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I, Dr. Marc Moonen, declare that:

I. INTRODUCTION

1. I have been retained by Petitioner Nokia of America Corp. (to whom I will refer to as Petitioner) for this *inter partes* review proceeding (which I may refer to a times as an "IPR").

2. I have been asked to consider whether certain references disclose, teach, and/or suggest the features recited in Claims 1, 2, 4-5, 7, 9-12, and 14-15 of U.S. Patent No. 7,593,458 (the "'458 patent").

3. I understand that the '458 patent is assigned to Adaptive Spectrum and Signal Alignment Inc.

4. I have been asked to provide an independent analysis of the '458 patent in view of the asserted prior art publications cited in the Petition. This Declaration is limited to those issues.

5. I am not, and never have been, an employee of Adaptive Spectrum and Signal Alignment Inc. I am not receiving compensation for this Declaration beyond my normal hourly fees based on my time actually spent analyzing and documenting my opinions herein on the '458 patent, the asserted prior art publications cited in this Declaration and in the Petition, and the issues related thereto. My compensation is not related to the outcome of this proceeding, and I will not receive any additional

compensation based on the outcome of any IPR or other proceeding involving the ’458 patent.

6. I have personal knowledge of the facts and opinions stated herein and, if called as a witness, could and would testify competently to them under oath.

II. QUALIFICATIONS

7. All of my opinions stated in this Declaration are based on my own personal knowledge and professional judgment. In forming my opinions, I have relied on my knowledge and experience in the field of digital signal processing and digital communications.

8. I have been a Full Professor at KU Leuven, Belgium, since 2004. I obtained a PhD degree from KU Leuven in 1990, and have been a PhD- and postdoctoral visiting researcher at the University of Stanford, University of Minnesota, and Delft University of Technology, and visiting professor at ALaRI, University of Lugano. I served as President of EURASIP (European Association for Signal Processing, first term 2007-2008, second term 2011-2012), and as IEEE Signal Processing Society Vice President-Publications (2021-2023). I am a Fellow of the IEEE (2007), Fellow of EURASIP (2018), recipient of the EURASIP Meritorious Service Award (2020), the IEEE Signal Processing Society Claude Shannon-Harry Nyquist Technical Achievement Award (2024), and co-recipient of

the EU/CELTIC Excellence Award (for EU/CELTIC Project 'BANITS', 2008) as well as 10 journal/conference best paper awards.

9. For over 25 years I headed a team of 15+ PhD- and postdoctoral researchers in the field of numerical algorithms and signal processing for digital communications, digital audio- and speech processing. I have supervised/co-supervised 60 defended PhD-theses, authored/co-authored 300+ journal papers (of which 175+ in IEEE journals) and 400+ international conference papers (of which 150+ in IEEE conferences). **Link Google Scholar: https://scholar.google.com/citations?user=OX95yYsAAAAJ.**

10. My research has consistently had a strong industry focus, e.g., with over twenty years of ongoing cooperation in the area of digital subscriber lines (DSL) with Nokia Bell Labs (formerly Alcatel/Alcatel-Bell/Alcatel-Lucent), which has resulted in 10+ patents/patent applications as well as several (DSL) standardization contributions. **Link Nokia Bell Labs Collaboration: https://www.bell-labs.com/institute/blog/ku-leuven-professor-reflects-20-years-collaboration-bell-labs/.** I am also a co-founder of conneXounds, a company developing BYOD audio technology for hybrid meeting environments. **Link conneXounds: www.connexounds.com.**

11. Around the time of filing the '458 patent, my DSL-related research was focused on Dynamic Spectrum Management (DSM). DSM exploits the multi-user

aspect of the DSL network in an attempt to mitigate the negative effects of crosstalk. On a spectral level DSM involves modifying the power spectral densities (PSD) of the different modems in a network to prevent multiple modems from transmitting in bands where crosstalk is significant, while at the same time a minimum quality of service must be guaranteed for all users. Together with Raphael Cendrillon (PhD candidate working under my supervision), an algorithm was developed that finds the optimal solution to the spectrum management problem, referred to as Optimal Spectrum Management (OSM). OSM solves the problem with a reasonable complexity and leads to significant increases in data-rate (up to 300%) over existing state-of-the-art (heuristic) DSM algorithms. OSM has been the subject of several conference and journal publications as well as an Alcatel patent, and has been agreed for inclusion in the American DSL standards.

III. COMPENSATION

12. I am being compensated for my work on this matter at the rate of €300 per hour, plus expenses. My fees are not contingent upon the outcome of this litigation.

IV. MATERIALS CONSIDERED

13. I have reviewed the materials listed below.

Exhibit	Short Name	Description
Ex. 1001	’458 patent	U.S. Patent No. 7,593,458

Exhibit	Short Name	Description
Ex. 1002	Moonen Declaration	Declaration of Dr. Marc Moonen
Ex. 1003	CV	*Curriculum Vitae* of Dr. Marc Moonen
Ex. 1004	'458 File History	File History of U.S. Patent No. 7,593,458
Ex. 1005	Rezvani	U.S. Patent No. 7,356,049 to Rezvani
Ex. 1006	Cendrillon I	"Partial Crosstalk Cancellation Exploiting Line and Tone Selection in VDSL"
Ex. 1007	G.992.3	ITU-T Recommendation G.992.3 (07/2002)
Ex. 1008	Cendrillon II	"Partial Crosstalk Cancellation for Upstream VDSL"
Ex. 1009	Cendrillon III	"Partial crosstalk precompensation in downstream VDSL"
Ex. 1010	Marzetta	"BLAST Training: Estimating Channel Characteristics for High Capacity Space-Time Wireless" by Marzetta
Ex. 1011	Simplified Waterfilling	"Simplified Waterfilling for Power Allocation in MIMO-DSL"
Ex. 1012	Linear Zero-Forcing Crosstalk Canceler	"The Linear Zero-Forcing Crosstalk Canceler is Near-optical DSL Channels"
Ex. 1013	Low Complexity Crosstalk Cancellation	"Low Complexity Crosstalk Cancellation Through Line Selection in Upstream VDSL"
Ex. 1014	Distributed Multiuser Power Control	"Distributed Multiuser Power Control for Digital Subscriber Lines"
Ex. 1015	Simplified Power Allocation	"Simplified Power Allocation for the DSL Multi-Access Channel through Column-wise Diagonal Dominance"
Ex. 1016	T1E1.4/2003-325	T1E1.4/2003-325, "On the Optimality of Iterative Waterfilling"
Ex. 1017		[*Reserved*]
Ex. 1018	Saleheen	U.S. Patent Application Publication No. 2002/0186428 to Saleheen

Exhibit	Short Name	Description
Ex. 1019	Amrany	U.S. Patent No. 6,999,504 to Amrany et al.
Ex. 1020	Barrass	U.S. Patent No. 7,154,845 to Barrass et al.
Ex. 1021	Tzannes	U.S. Patent No. 6,778,596 to Tzannes
Ex. 1022	Hall-Ellis Declaration	Declaration of Sylvia Hall-Ellis
Ex. 1023	Docket Control Order	Docket Control Order, *Adaptive Spectrum and Signal Alignment, Inc. v. AT&T Inc., et al.*, Case No. 2:24-cv-00029-JRG-RSP (E.D. Tex. July 22, 2024) ECF No. 84.
Ex. 1024	Order Focusing Claims	Order Focusing Patent Claims and Prior Art to Reduce Costs, *Adaptive Spectrum and Signal Alignment, Inc. v. AT&T Inc., et al.*, Case No. 2:24-cv-00029-JRG-RSP (E.D. Tex. Oct. 23, 2024), ECF No. 104.
Ex. 1025	Motion to Transfer	Defendants' Motion to Transfer Venue Based on the Parties' Contractual Forum-Selection Clause, and Alternatively, Motion to Stay Case Pending Arbitration, *Adaptive Spectrum and Signal Alignment, Inc. v. AT&T Inc., et al.*, Case No. 2:24-cv-00029-JRG-RSP (E.D. Tex. Oct. 23, 2024), ECF No. 92 (*Redacted*).

14. I have also relied on my own education, knowledge, and experience in the relevant art.

15. I have also considered the understanding of a person of ordinary skill around the time of the invention of the '458 patent.

V. LEGAL STANDARDS

16. I am not an attorney and do not offer opinions on the law in this Declaration.

17. In forming my analyses and conclusions expressed here in this Declaration, I have applied the legal principles described in the following paragraphs, which were provided to me by counsel for the Petitioners.

18. I used my understanding of the following legal principles set forth in this section in reaching my opinions.

19. I understand that, in this proceeding, Petitioners have the burden of proving that the challenged claims are invalid by a preponderance of the evidence.

A. Obviousness

20. I have been informed that a claim is invalid as obvious under 35 U.S.C. § 103 (pre-AIA) if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention to a person of ordinary skill in the art. I have been informed that the following matters are relevant to determining whether the claimed invention would have been obvious: (1) the scope and content of the prior art, (2) the difference or differences between the patent claim and the prior art, (3) the level of ordinary skill in the art at the time the invention of the patent, and (4) any secondary considerations or objective indicia of non-obviousness.

21. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. When a claim simply arranges prior art elements with each

performing the same function it had been known to perform and yields no more than one would expect from such an arrangement, then such a combination is obvious. When a patent claims a structure already known in the prior art altered by the mere substitution of one element for another known in the field, the combination is likely to be obvious unless the combination yields an unpredictable result.

22. I have been informed that when a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation, such a variation is likely unpatentable. For the same reason, if a technique has been used to improve one device, and one of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. One question to consider is whether the improvement is more than predictably using prior art elements according to their established functions.

23. I have been informed that it may often be necessary, in a validity analysis, to consider whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue. This can be accomplished by looking to interrelated teachings of multiple patents or other publications or pieces of prior art; the effects of demands known to the design community or present in the

marketplace; and the background knowledge possessed by one of ordinary skill in the art.

24. I have been informed that a validity analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim; it is appropriate to take account of the inferences and creative steps that a person of ordinary skill in the art would employ. I have been informed that a person of ordinary skill in the art is a person of ordinary creativity, not an automaton.

25. I have been informed that a claim composed of several elements is not proved obvious merely by demonstrating that each element was, independently, known in the prior art. I have been informed that it can be important to identify a reason that would have prompted a person of ordinary skill in the art in the relevant field to combine the elements in the way the claimed new invention does. I am told that one way that subject matter can be proved obvious is by noting there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims. I have been informed that any need or problem known in the field of endeavor at the time of the claimed invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

26. I have been informed that one should not assume that a person of ordinary skill in the art attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem. Instead, I have been

informed that since familiar items may have obvious uses beyond their primary purposes, in many cases a person of ordinary skill in the art will be able to fit the teachings of multiple prior art references together like pieces of a puzzle.

27. I have been informed that, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, persons of ordinary skill in the art have good reason to pursue the known options within their technical grasp. If this leads to the anticipated success, the product was likely not accomplished by innovation but by using ordinary skill and common sense. I have been informed that, in such an instance, the fact that the combination was obvious to try may show that the combination was obvious.

28. I have been informed that, when determining whether a claimed combination would have been obvious, the correct analysis is not whether a person of ordinary skill in the art, writing on a blank slate, would have chosen the particular combination of elements described in the claim. Instead, I have been informed that the correct analysis considers whether one of ordinary skill, facing the wide range of needs created by developments in the field of endeavor, would have seen a benefit to selecting the combination claimed.

29. I have been informed that, when determining whether a claimed invention is obvious, any "secondary considerations" of non-obviousness identified

by the patentee should also be considered. These secondary considerations can include:

- commercial success of the invention, causally related to the invention itself rather than to companion factors, such as advertising or attractive packaging;
- the invention taught away from the technical direction followed by those skilled in the art;
- a long-felt but unsatisfied need for the invention while the needed implementing arts and elements had long been available;
- the invention achieves results unexpected to those skilled in the art;
- copying of the invention by competitors as distinguished from their independent development;
- unsuccessful attempts by those skilled in the art to make the invention;
- acquiescence by the industry to the patent's validity by honoring the patent through taking licenses or not infringing the patent, or both; and
- skepticism, disbelief in or incredulity by those skilled in the art that the patentee's approach worked.

30. I have been informed that, for the above information to impact the obviousness of a patent claim, there must be a nexus between the alleged secondary considerations and the claims. In addition, I have been informed that the burden of introducing evidence of secondary considerations generally is on the Patent Owner. If the Patent Owner or its expert should assert secondary considerations of non-obviousness, I reserve the right to provide a Declaration addressing assertions of non-obviousness due to secondary considerations.

B. Claim Construction

31. I have been informed that claim terms are typically given their plain and ordinary meanings, as would have been understood by a person of ordinary skill in the art at the time of the earliest alleged priority date. I have further been informed that when considering the meaning of any terms in the challenged claims of the '458 patent, I should apply the plain and ordinary meaning of those terms. I have further been informed that in considering the meaning of the claims, one must consider the language of the claims, the specification, and the prosecution history of record.

32. I have been informed that, in general, a preamble limits the invention if it recites essential structure or steps, or if it is necessary to give life, meaning, and vitality to the claim. I have further been informed that a preamble is not limiting where a patentee defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for the invention. I have

further been informed that dependence on a particular disputed preamble phrase for antecedent basis may limit claim scope because it indicates a reliance on both the preamble and claim body to define the claimed invention. I have further been informed that clear reliance on the preamble during prosecution to distinguish the claimed invention from the prior art transforms the preamble into a claim limitation because such reliance indicates use of the preamble to define, in part, the claimed invention.

VI. PERSON OF ORDINARY SKILL IN THE ART

33. Assuming that the ’458 patent is entitled to its earliest alleged priority date of May 18, 2004 (*see* Ex. 1001, 1), based on my knowledge and experience, I was a person of ordinary skill in the art as of May 18, 2004, and can provide opinions regarding the knowledge of a person of ordinary skill in the art as of that time. My opinions herein are, where appropriate, based on my understandings as to a person of ordinary skill in the art at that time.

34. I understand that factors that are pertinent to a determination of the level of ordinary skill in the art include: (1) the educational level of the inventor; (2) the type of problems encountered in the art; (3) the prior art solutions to those problems; (4) the rapidity with which innovations are made; (5) the sophistication of the technology; and (6) and the educational level of workers active in the field.

35. Based on the materials and information I have reviewed and based on my experience in the technical areas relevant to the '458 patent, a person of ordinary skill in the art at the time of the alleged invention of the '458 patent would have had at least a Bachelor's Degree in electrical engineering, computer engineering, or similar discipline and had approximately two years of experience with electronic communication systems and familiarity with standards governing DSL systems. A person with a different degree but with additional relevant experience could still qualify if the additional experience compensates for the different educational background.

VII. SUMMARY OF OPINIONS

36. I have been asked to consider whether the claims of the '458 patent are obvious over certain prior art references. As explained in detail in the following sections, it is my opinion that:

- Ground 1: Claims 1, 2, 4-5, 7, 9-10, 12, and 14-15 are rendered obvious by U.S. Patent No. 7,356,049 ("Rezvani") in view of *Partial Crosstalk Cancellation Exploiting Line and Tone Selection in VDSL* ("Cendrillon I").
- Ground 2: Claim 11 is rendered obvious by Rezvani in view of Cendrillon I and ITU-T Recommendation G.992.3 ("G.992.3").

37. The following table is a summary of the above enumerate grounds:

Ground	Prior Art	Claims
1	Rezvani and Cendrillon I	1, 2, 4-5, 7, 9-10, 12, and 14-15
2	Rezvani, Cendrillon I, and G.992.3	11

VIII. OVERVIEW OF THE '458 PATENT

38. The claims of the '458 patent that are being challenged, and that I have been asked to evaluate, are Claims 1, 2, 4-5, 7, 9-12, and 14-15. I have reproduced the challenged claims below:

Claim	Recitation
1[pre]	A method of evaluating operational characteristics of a multi-line, vectored Digital Subscriber Line (DSL) system having a plurality of crosstalking lines in a common communication channel (channel), the method comprising:
1[a]	exciting the plurality of crosstalking lines in the channel with a known sequence of input symbols applied to the crosstalking lines;
1[b]	acquiring output data from a primary line among the plurality of lines in the channel, the output data comprising the known sequence of input symbols after having been affected by crosstalk coupling among the plurality of crosstalking lines in the channel;
1[c]	ordering the crosstalking lines based on a comparison between the known sequence of input symbols used to excite the crosstalking lines and the output data acquired from the primary line;
1[d]	generating a data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines based on the ordering of the crosstalking lines; and

1[e]	sending instructions to one or more modems communicatively interfaced with the plurality of crosstalking lines in the channel based on the data quantity generated.
2	The method of claim 1, wherein the instructions sent to the one or more modems comprise instructions to implement: operational condition values, a maximum data rate limit, upstream transmission frequency band limits, transmit power levels, and coding/latency requirements.
4	The method of claim 1, wherein the output data from the primary line is collected over time on a periodic basis.
5	The method of claim 1, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) that is a decibel-magnitude value representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.
7	The method of claim 5, wherein the DSM-data quantity Xlog(u,n) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.
9[a]	The method of claim 1, wherein the output data further comprises far-end crosstalk (FEXT) and/or near-end crosstalk (NEXT) transfer functions between the primary line and each of the crosstalking lines; and
9[b]	further wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) that is a decibel-magnitude value of the insertion loss equivalent of the FEXT and/or NEXT transfer functions.
10	The method of claim 1, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlin(u,n) that is representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.
11[a]	The method of claim 10, wherein Xlin(u,n) is represented in a linear format by a scale factor scale(u) and a normalized

	complex number a(u,n)+j*b(u,n), where n is a subcarrier index n=0, . . . , NSC, wherein NSC is a number of carriers used, u is an index of a line transfer function between a one of the crosstalking lines and the primary line, and further wherein a(u,n) and b(u,n) are coded as 16-bit 2's complement signed integers, and
11[b]	further wherein the value of Xlin(u,n) is defined as $Xlin(u,n)=scale(u)/2^{15})*(a(u,n)+j*b(u,n)/2^{15}$.
12	The method of claim 1, wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.
14	The method of claim 1, wherein the plurality of crosstalking lines are allocated to a single customer.
15	The method of claim 14, wherein generating the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises generating a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) representing line transfer functions between crosstalking line u and the primary line at a subcarrier index n.

A. Prosecution History

39. The '458 patent was filed as U.S. Patent Application No. 11/122,365 ("the '365 Application") on May 5, 2005, with original Claims 1-46. Ex. 1004, pp. 181-245.

40. A first non-final office action was mailed on April 9, 2008. Ex. 1004, pp. 139-145. The Examiner stated that a restriction was required under 35 U.S.C. § 121 to either Claims 1-32, drawn to methods of ordering crosstalking lines, or Claims 33-46, drawn to methods of obtaining and combining NEXT and FEXT interferences. Ex. 1004, 141-142. The Examiner stated that during a telephone call on April 1, 2008, the Applicant made a provisional election without traverse to

prosecute Claims 1-32. Ex. 1004, pp. 141-142. Accordingly, the Examiner indicated that Claims 33-46 were withdrawn from further consideration by the Examiner. Ex. 1004, pp. 141-142. Additionally, Claims 1-32 were objected to for informalities. Ex. 1004, pp. 142-143. The Examiner also proposed amending Claim 25 to add "when executed by a machine" "to overcome any possible rejections under 35 U.S.C. § 101. Ex. 1004, p. 143. Notwithstanding these objections, the Examiner indicated that Claims 1-32 were allowable subject matter. Ex. 1004, p. 144.

41. The Applicant responded on June 9, 2008, affirming the Applicant's provisional election of Claims 1-32 for prosecution and withdrawing Claims 33-46 from further consideration. Ex. 1004, pp. 124-135. The Applicant also amended Claims 1, 2, 7, 8, 14, 16, 21, and 25 to address informalities, as indicated below. Ex. 1004, pp. 125-132.

Claims 1, 8, 16, and 25 - Definition of DSL and DSM:

In accordance with the Examiner's recommendation, Applicant has amended claims 1, 8, 16, and 25 to recite the full definition of DSL and DSM (Digital Subscriber Line and Dynamic Spectrum Management respectively) upon the first occurrence of each acronym.

Claim 2 - Function of m(u,n):

In accordance with the Examiner's recommendation, Applicant has amended claim 2 to recite "Xlog(u,n) is **a function of** a 10-bit unsigned integer m(u,n) …" to overcome any potential indefiniteness in the definition of "Xlog(u,n)." Claim 21, which was not objected to, has been amended in a similar manner.

Claims 7 and 14 – Term "DSM-data quantity" already defined:

In accordance with the Examiner's recommendation, Applicant has amended dependent claims 7 and 14 to recite, "**the** DSM-data quantity," as the term is already defined in a parent to each dependent claim.

Claim 25 – Examiner's suggested amendment:

In accordance with the Examiner's suggested amendment, Applicant has amended claim 25 to recite "the program instructions, **when executed by a machine** …" so as to overcome any potential rejection under 35 U.S.C. § 101.

Accordingly, Applicant respectfully requests the Examiner to withdraw the objections to claims 1-32.

42. A second non-final office action was mailed on July 29, 2008. Ex. 1004, 113. The Examiner stated that a supplementary restriction of the previously presented claims was required to either Claims 1-26, drawn to methods of ordering crosstalking lines, or Claims 27-32, drawn to methods of obtaining and combining NEXT and FEXT interferences. Ex. 1004, pp. 115-116. The Examiner stated that during a telephone call on July 24, 2008, the Applicant made a provisional election without traverse to prosecute Claims 1-26. Ex. 1004, pp. 115-116. Accordingly, the Examiner indicated that Claims 27-32 were withdrawn from further consideration by the Examiner. Ex. 1004, pp. 115-116. Claims 3-5, 10-12, 14, and 17 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicant regarded as the invention. Ex. 1004, pp. 116-117. Claims 1, 3-8, 10-14, 16-19, 24, 25, and 26 were rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent Publication No. 2002/0041565 ("Valenti"). Ex. 1004, p. 118. Additionally, the Examiner indicated that Claims 2, 9, 15, and 20-23 were objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Ex. 1004, p. 122.

43. The Applicant responded on October 29, 2008, affirming the Applicant's provisional election of Claims 1-26 for prosecution and withdrawing

Claims 27-32 from further consideration. Ex. 1004, pp. 106-107. In response to the rejection under 35 U.S.C. § 112, the Applicant canceled Claims 3-5, 10-12, 14, and 17 and submitted new Claims 47-92, which the Applicant stated "provide[] sufficient descriptive language sufficient for patentability under 35 U.S.C. § 112." Ex. 1004, p. 107. In response to the rejection under 35 U.S.C. § 102, the Applicant stated that during an interview with the Examiner, "a general agreement as to subject matter for an independent claim that would be patentable over the prior art of record" was reached. Accordingly, the Applicant stated that "new independent claims 47, 64, and 76 . . . specifically set forth the use of 'a known sequence of input symbols.'" Ex. 1004, pp. 107-108.

44. A third non-final office action was mailed on January 14, 2009. Ex. 1004, p. 86. Claims 47-92 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicant regarded as the invention. Ex. 1004, p. 88. The Applicant amended the claims as indicated below to overcome the rejection. Ex. 1004, pp. 51-63.

Listing of Claims:

1-46. (Canceled).

47. (Currently amended) A method of evaluating operational characteristics of a multi-line, vectored Digital Subscriber Line (DSL) system having a plurality of lines in a common communication channel (channel), the method comprising:

exciting a plurality of crosstalking lines in the channel ~~of the DSL system~~ with a known sequence of input symbols applied to the crosstalking lines;

acquiring output data from ~~one or more~~ a primary line[[s]] among the plurality of lines in the channel, ~~of the DSL system,~~ the output data comprising the known sequence of input symbols after having propagated through the crosstalking lines ~~each respective line~~ and having been affected by crosstalk coupling within the plurality of crosstalking lines in the channel; ~~within a communications channel common to the plurality of lines;~~

ordering the ~~plurality of~~ crosstalking lines based on a comparison between the known sequence of input symbols ~~as applied to the respective line~~ used to excite the crosstalking lines and based further on the output data acquired from the ~~one or more~~ primary line[[s]];

generating~~, for each of the lines,~~ a data quantity representative of the ~~lines excited with the known sequence of input symbols, determined to have been most affected by crosstalk coupling within the communications channel~~ crosstalk coupling between the primary line and each of the crosstalking lines based on the ordering of the ~~plurality~~ crosstalking lines; and

sending instructions to one or more modems communicatively interfaced with the plurality of lines in the channel ~~DSL system~~ based on the data quantity generated.

48. (Previously presented) The method of claim 47, wherein the instructions sent to the one or more modems comprise instructions to implement: operational condition values, a maximum data rate limit, upstream transmission frequency band limits, transmit power levels, and coding/latency requirements.

49. (Currently amended) The method of claim 47, further comprising zeroing all inputs into the ~~plurality of~~ crosstalking lines ~~of the DSL system~~ to eliminate other crosstalk among the plurality of lines in the channel prior to exciting the crosstalking lines.

50. (Currently amended) The method of claim 47, wherein the output data from the primary line ~~one or more primary lines of the DSL system~~ is collected over time on a periodic basis.

51. (Currently amended) The method of claim 47, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines ~~determined to have been most affected by crosstalk coupling within the communications channel~~ comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) that is a decibel-magnitude value representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line ~~respective line~~ within the ~~communications~~ channel.

52. (Previously presented) The method of claim 51, wherein the DSM-data quantity Xlog(u,n) is a function of a 10-bit unsigned integer m(u,n) such that Xlog(u,n) = 6 - (m(u,n)/10).

53. (Previously presented) The method of claim 51, wherein the DSM-data quantity Xlog(u,n) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

54. (Previously presented) The method of claim 51, wherein the DSM-data quantity Xlog(u,n) is a function of a 10-bit unsigned integer m(u,n) such that Xlog(u,n) = 6 - (m(u,n)/10) and further wherein Xlog(u,n) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

55. (Currently amended) The method of claim 47, wherein the output data further comprises FEXT and/or NEXT transfer functions between the ~~one or more~~ primary line[[s]] and each of the ~~plurality of~~ crosstalking lines; and

further wherein the DSM-data quantity Xlog(*u,n*) is a decibel-magnitude value of the insertion loss equivalent of the acquired FEXT and/or NEXT transfer functions.

56. (Currently amended) The method of claim 47, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines ~~determined to have been most affected by crosstalk coupling within the communications channel~~ comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlin(*u,n*) that is a decibel-magnitude value representative of the extent of crosstalk coupling associated with each of the crosstalking lines ~~respective line~~ within the ~~communications~~ channel.

57. (Previously presented) The method of claim 56, wherein Xlin(*u,n*) is represented in a linear format by a scale(u) factor and a normalized complex number a(u,n) + *j***b*(*u,n*), where *n* is the subcarrier index *n*=0, …, NSC, wherein NSC is the number of carriers used and

further wherein *a(u,n)* and *b(u,n)* are coded as 16-bit 2's complement signed integers, and further wherein the value of Xlin(u,n) is defined as Xlin(u,n) = (scale(u)/2^{15})*(a*(u,n)* + *j*b(u,n)*)/2^{15}; and

further wherein the scale factor is chosen such that *max(|a(u,n)|, |b(u,n)|)* over all n is equal to 2^{15}-1.

58. (Previously presented) The method of claim 56, wherein the DSM-data quantity Xlin(*u,n*) is a linear version of Xlog(u,n).

59. (Currently amended) The method of claim 47, wherein the DSL system comprises a multi-line one-sided vectored communication system, wherein transmit signals on ~~multiple~~ the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.

60. (Currently amended) The method of claim 47, wherein the DSL system comprises a multi-line double-sided vectored communication system, wherein transmit signals on ~~multiple~~ the plurality of lines are co-generated with a common clock and processor at each of a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system and at a Customer Premises Equipment (CPE) end of the DSL system.

61. (Currently amended) The method of claim 47, wherein the DSL system comprises a multi-line bonded vectored communication system, wherein ~~multiple~~ the plurality of lines are allocated to a single customer.

62. (Currently amended) The method of claim 61, wherein generating the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines ~~determined to have been most affected by crosstalk coupling within the communications channel~~ comprises generating a Dynamic Spectrum Management data

(DSM-data) quantity Xlog(u,n) for u=1, …, U, ~~$2n-1$,~~ representing line transfer[[s]] functions between U ~~among n~~ lines in the multi-line bonded vectored communication system and the primary line at subcarrier index n.

63. (Currently amended) The method of claim 56, further comprising:

acquiring a value representative of insertion loss for the ~~each of the one or more~~ primary line[[s]], including any transmitter and receiver filter effects; and

assigning the value to index $u=0$ so that the value is identified as Xlin($0,n$).

64. (Currently amended) A controller communicably interfaced with a Digital Subscriber Line (DSL) system having a plurality of lines in a common communication channel (channel), comprising:

means for exciting a plurality of crosstalking lines in the channel ~~of the DSL system~~ with a known sequence of input symbols applied to the crosstalking lines;

means for acquiring output data from ~~one or more~~ a primary line[[s]] among the plurality of lines in the channel, ~~of the DSL system,~~ the output data comprising the known sequence of input symbols after having propagated through the crosstalking lines ~~each respective line~~ and having been affected by crosstalk coupling within the plurality of crosstalking lines in the channel; ~~within a communications channel common to the plurality of lines;~~

means for ordering the ~~plurality of~~ crosstalking lines based on a comparison between the known sequence of input symbols ~~as applied to the respective line~~ used to excite the crosstalking lines and based further on the output data acquired from the ~~one or more~~ primary line[[s]];

means for generating~~, for each of the lines,~~ a data quantity representative of the ~~lines excited with the known sequence of input symbols, determined to have been most affected by~~

~~crosstalk coupling within the communications channel~~ crosstalk coupling between the primary line and each of the crosstalking lines based on the ordering of the ~~plurality~~ crosstalking lines; and

means for sending instructions to one or more modems communicatively interfaced with the plurality of lines in the channel ~~DSL system~~ based on the data quantity generated.

65. (Previously presented) The controller of claim 64, wherein the instructions sent to the one or more modems comprise instructions to implement: operational condition values, a maximum data rate limit, upstream transmission frequency band limits, transmit power levels, and coding/latency requirements.

66. (Currently amended) The controller of claim 64, further comprising means for zeroing all inputs into the crosstalking ~~plurality of~~ lines ~~of the DSL system~~ to eliminate other crosstalk among the plurality of lines in the channel prior to exciting the crosstalking lines.

67. (Currently amended) The controller of claim 64, wherein the output data from the ~~one or more~~ primary line[[s]] ~~of the DSL system~~ is collected over time on a periodic basis.

68. (Previously presented) The controller of claim 64, wherein the DSL system comprises a multi-line, vectored DSL system.

69. (Currently amended) The controller of claim 64, wherein the output data further comprises FEXT and/or NEXT transfer functions between the ~~one or more~~ primary line[[s]] and each of the ~~plurality of~~ crosstalking lines; and

further wherein the data quantity representative of crosstalk coupling between the primary line and each of the crosstalking lines ~~the lines determined to have been most affected by crosstalk coupling within the communications channel~~ is the insertion loss equivalent of

the acquired FEXT and/or NEXT transfer functions.

70. (Currently amended) The controller of claim 64, wherein the data quantity representative of crosstalk coupling between the primary line and each of the crosstalking lines comprises ~~the lines determined to have been most affected by crosstalk coupling within the communications channel is~~ at least one of the following:

Xlog(u,n), wherein Xlog(u,n) is a decibel-magnitude value representative of crosstalk coupling between the primary line n and each ~~potential crosstalking~~ crosstalking line; and

Xlin(u,n), wherein Xlin(u,n) is the linear version of Xlog(u,n).

71. (Currently amended) The controller of claim 70, wherein Xlin(u,n) is represented in a linear format by a scale(u) factor and a normalized complex number $a(u,n) + j*b(u,n)$, where n is the subcarrier index n=0,…, NSC, wherein NSC is the number of used carriers, ~~and~~ further wherein $a(u,n)$ and $b(u,n)$ are coded as 16-bit 2's complement signed integers, and further wherein the value of Xlin(u,n) is defined as $\text{Xlin}(u,n) = (\text{scale}(u)/2^{15})*(a(u,n) + j*b(u,n))/2^{15}$; and ~~further~~

wherein the scale factor is chosen such that $max(|a(u,n)|, |b(u,n)|)$ over all n is equal to 2^{15}-1.

72. (Previously presented) The controller of claim 70, wherein the quantity Xlog(u,n) is a function of a 10-bit unsigned integer m(u,n) such that Xlog(u,n) = 6 - (m(u,n)/10).

73. (Currently amended) The controller of claim 70, further comprising:

means for acquiring a value representative of insertion loss for ~~each of the one or more~~ the primary line[[s]], including any transmitter and receiver filter effects; and

means for assigning the value to index $u=0$ so that the value is identified as Xlin($0,n$).

74. (Currently amended) The controller of claim 70, further comprising:

means for acquiring a value representative of insertion loss for the ~~each of the one or more~~

the acquired FEXT and/or NEXT transfer functions.

70. (Currently amended) The controller of claim 64, wherein the data quantity representative of crosstalk coupling between the primary line and each of the crosstalking lines comprises ~~the lines determined to have been most affected by crosstalk coupling within the communications channel is~~ at least one of the following:

Xlog(u,n), wherein Xlog(u,n) is a decibel-magnitude value representative of crosstalk coupling between the primary line n and each ~~potential crosstalking~~ crosstalking line; and

Xlin(u,n), wherein Xlin(u,n) is the linear version of Xlog(u,n).

71. (Currently amended) The controller of claim 70, wherein Xlin(u,n) is represented in a linear format by a scale(u) factor and a normalized complex number $a(u,n) + j*b(u,n)$, where n is the subcarrier index n=0,…, NSC, wherein NSC is the number of used carriers, ~~and~~ further wherein $a(u,n)$ and $b(u,n)$ are coded as 16-bit 2's complement signed integers, and further wherein the value of Xlin(u,n) is defined as $\text{Xlin}(u,n) = (\text{scale}(u)/2^{15})*(a(u,n) + j*b(u,n))/2^{15}$; and ~~further~~

wherein the scale factor is chosen such that $max(|a(u,n)|, |b(u,n)|)$ over all n is equal to 2^{15}-1.

72. (Previously presented) The controller of claim 70, wherein the quantity Xlog(u,n) is a function of a 10-bit unsigned integer m(u,n) such that Xlog(u,n) = 6 - (m(u,n)/10).

73. (Currently amended) The controller of claim 70, further comprising:

means for acquiring a value representative of insertion loss for ~~each of the one or more~~ the primary line[[s]], including any transmitter and receiver filter effects; and

means for assigning the value to index $u=0$ so that the value is identified as Xlin($0,n$).

74. (Currently amended) The controller of claim 70, further comprising:

means for acquiring a value representative of insertion loss for the ~~each of the one or more~~

and

sending instructions to one or more modems communicatively interfaced with the plurality of lines in the channel ~~DSL system~~ based on the data quantity generated.

77. (Previously presented) The computer-readable medium of claim 76, wherein the instructions sent to the one or more modems comprise instructions to implement: operational condition values, a maximum data rate limit, upstream transmission frequency band limits, transmit power levels, and coding/latency requirements.

78. (Currently amended) The computer-readable medium of claim 76, wherein the method further comprises zeroing all inputs into the ~~plurality of~~ crosstalking lines ~~of the DSL system~~ to eliminate other crosstalk among the plurality of lines in the channel prior to exciting the crosstalking lines.

79. (Currently amended) The computer-readable medium of claim 76, wherein the output data from the ~~one or more~~ primary line[[s]] ~~of the DSL system~~ is collected over time on a periodic basis.

80. (Currently amended) The computer-readable medium of claim 76, wherein the data quantity representative of crosstalk coupling between the primary line and each of the crosstalking lines ~~representing the extent of crosstalk coupling associated with each respective line~~ within the ~~communications~~ channel comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) that is a decibel-magnitude value representative of the extent of crosstalk coupling between the primary line and ~~associated with~~ each of the crosstalking lines ~~respective line~~ within the ~~communications~~ channel.

81. (Previously presented) The computer-readable medium of claim 80, wherein the DSM-data quantity Xlog(u,n) is a function of a 10-bit unsigned integer m(u,n) such that Xlog(u,n) =

6 - (m(u,n)/10).

82. (Previously presented) The computer-readable medium of claim 80, wherein the DSM-data quantity Xlog(u,n) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

83. (Previously presented) The computer-readable medium of claim 80, wherein the DSM-data quantity Xlog(u,n) is a function of a 10-bit unsigned integer m(u,n) such that Xlog(u,n) = 6 - (m(u,n)/10) and further wherein Xlog(u,n) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

84. (Currently amended) The computer-readable medium of claim 76, wherein the output data further comprises FEXT and/or NEXT transfer functions between the ~~one or more~~ primary line[[s]] and each of the ~~plurality of~~ crosstalking lines; and

further wherein the DSM-data quantity Xlog(*u,n*) is a decibel-magnitude value of the insertion loss equivalent of the acquired FEXT and/or NEXT transfer functions.

85. (Currently amended) The computer-readable medium of claim 76, wherein the data quantity representative of crosstalk coupling between the primary line and each of the crosstalking lines ~~the lines determined to have been most affected by crosstalk coupling within the communications channel~~ comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlin(*u,n*) that is a decibel-magnitude value representative of the extent of crosstalk coupling between the primary line and each of the crosstalking lines ~~associated with each respective line~~ within the ~~communications~~ channel.

86. (Currently amended) The computer-readable medium of claim 85, wherein Xlin(*u,n*) is represented in a linear format by a scale(u) factor and a normalized complex number a(u,n) + *j***b*(*u,n*), where *n* is the subcarrier index *n*=0, …, NSC, wherein NSC is the

number of carriers used and further wherein *a(u,n)* and *b(u,n)* are coded as 16-bit 2's complement signed integers, and ~~further~~ wherein the value of Xlin(u,n) is defined as $Xlin(u,n) = (scale(u)/2^{15})*(a(u,n) + j*b(u,n))/2^{15}$; and ~~further~~ wherein

the scale factor is chosen such that $max(|a(u,n)|, |b(u,n)|)$ over all n is equal to 2^{15}-1.

87. (Previously presented) The computer-readable medium of claim 85, wherein the DSM-data quantity Xlin(*u,n*) is a linear version of Xlog(u,n).

88. (Currently amended) The computer-readable medium of claim 76, wherein the DSL system comprises a multi-line one-sided vectored communication system, wherein transmit signals on ~~multiple~~ the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.

89. (Currently amended) The computer-readable medium of claim 76, wherein the DSL system comprises a multi-line double-sided vectored communication system, wherein transmit signals on ~~multiple~~ the plurality of lines are co-generated with a common clock and processor at each of a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system and at a Customer Premises Equipment (CPE) end of the DSL system.

90. (Currently amended) The computer-readable medium of claim 76, wherein the DSL system comprises a multi-line bonded vectored communication system, wherein ~~multiple~~ the plurality of lines are allocated to a single customer.

91. (Currently amended) The computer-readable medium of claim 90, wherein generating the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines ~~determined to have been most affected by crosstalk coupling within the communications channel~~ comprises generating a Dynamic Spectrum

number of carriers used and further wherein *a(u,n)* and *b(u,n)* are coded as 16-bit 2's complement signed integers, and ~~further~~ wherein the value of Xlin(u,n) is defined as $Xlin(u,n) = (scale(u)/2^{15})*(a(u,n) + j*b(u,n))/2^{15}$; and ~~further~~ wherein

the scale factor is chosen such that $max(|a(u,n)|, |b(u,n)|)$ over all n is equal to 2^{15}-1.

87. (Previously presented) The computer-readable medium of claim 85, wherein the DSM-data quantity Xlin(*u,n*) is a linear version of Xlog(u,n).

88. (Currently amended) The computer-readable medium of claim 76, wherein the DSL system comprises a multi-line one-sided vectored communication system, wherein transmit signals on ~~multiple~~ the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.

89. (Currently amended) The computer-readable medium of claim 76, wherein the DSL system comprises a multi-line double-sided vectored communication system, wherein transmit signals on ~~multiple~~ the plurality of lines are co-generated with a common clock and processor at each of a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system and at a Customer Premises Equipment (CPE) end of the DSL system.

90. (Currently amended) The computer-readable medium of claim 76, wherein the DSL system comprises a multi-line bonded vectored communication system, wherein ~~multiple~~ the plurality of lines are allocated to a single customer.

91. (Currently amended) The computer-readable medium of claim 90, wherein generating the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines ~~determined to have been most affected by crosstalk coupling within the communications channel~~ comprises generating a Dynamic Spectrum

45. The Examiner issued a Notice Allowance along with an Examiner's Amendment on May 20, 2009. Ex. 1004, pp. 28-42. The Applicant agreed to amend Claims 47, 49, 52-57, 59-64, 66, 69-74, 76, 78, 81-86, and 88-92 as follows to place the claims in condition for allowance. Ex. 1004, pp. 32-41.

47. A method of evaluating operational characteristics of a multi-line, vectored Digital Subscriber Line (DSL) system having a plurality of crosstalking lines in a common communication channel (channel), the method comprising:

exciting ~~a~~ the plurality of crosstalking lines in the channel with a known sequence of input symbols applied to the crosstalking lines;

acquiring output data from a primary line among the plurality of lines in the channel, the output data comprising the known sequence of input symbols after having ~~propagated through the crosstalking lines and having~~ been affected by crosstalk coupling ~~within~~ among the plurality of crosstalking lines in the channel;

ordering the crosstalking lines based on a comparison between the known sequence of input symbols used to excite the crosstalking lines and ~~based further on~~ the output data acquired from the primary line;

generating a data quantity representative of the crosstalk coupling between the primary line and

each of the crosstalking lines based on the ordering of the crosstalking lines; and

sending instructions to one or more modems communicatively interfaced with the plurality of crosstalking lines in the channel based on the data quantity generated.

49. The method of claim 47, further comprising zeroing all inputs ~~into~~ of the crosstalking lines to eliminate other crosstalk among the plurality of lines in the channel prior to exciting the crosstalking lines.

52. The method of claim 51, wherein the DSM-data quantity ~~Xlog(u,n)~~ Xlog(*u,n*) is a function of a 10-bit unsigned integer ~~m(u,n)~~ m(*u,n*) such that ~~Xlog(u,n)~~ Xlog(*u,n*) = 6 - (~~m(u,n)~~ m(*u,n*)/10).

53. The method of claim 51, wherein the DSM-data quantity ~~Xlog(u,n)~~ Xlog(*u,n*) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

54. The method of claim 51, wherein the DSM-data quantity ~~Xlog(u,n)~~ Xlog(*u,n*) is a function of a 10-bit unsigned integer ~~m(u,n)~~ m(*u,n*) such that ~~Xlog(u,n)~~ Xlog(*u,n*) = 6 - (~~m(u,n)~~ m(*u,n*)/10) and further wherein ~~Xlog(u,n)~~ Xlog(*u,n*) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

55. The method of claim 47, wherein the output data further comprises far-end crosstalk (FEXT) ~~FEXT~~ and/or near-end crosstalk (NEXT) ~~NEXT~~ transfer functions between the primary line and each of the crosstalking lines; and

further wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) ~~the DSM-data~~ quantity Xlog(*u,n*) that is a decibel-magnitude value of the insertion loss equivalent of the ~~acquired~~ FEXT and/or NEXT transfer functions.

56. The method of claim 47, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlin(*u,n*) that is ~~a decibel-magnitude~~

~~value~~ representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.

57. The method of claim 56, wherein Xlin(u,n) is represented in a linear format by a scale ~~scale(u)~~ factor scale(u) and a normalized complex number ~~a(u,n)~~ $a(u,n)$ + $j*b(u,n)$, where n is a ~~the~~ subcarrier index n=0, …, NSC, wherein NSC is ~~the~~ a number of carriers used, u is an index of a line transfer function between a one of the crosstalking lines and the primary line, and further wherein $a(u,n)$ and $b(u,n)$ are coded as 16-bit 2's complement signed integers, and

further wherein the value of ~~Xlin(u,n)~~ Xlin(u,n) is defined as ~~Xlin(u,n)~~ Xlin(u,n) = (~~scale(u)~~ scale(u)/2^{15})*(a(u,n) + $j*b(u,n)$)/2^{15}~~; and~~

~~further wherein the scale factor is chosen such that $max(|a(u,n)|, |b(u,n)|)$ over all n is equal to $2^{15}-1$.~~

58. (CANCELLED) ~~The method of claim 56, wherein the DSM-data quantity Xlin(u,n) is a linear version of Xlog(u,n).~~

59. The method of claim 47, ~~wherein the DSL system comprises a multi-line one-sided vectored communication system,~~ wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.

60. The method of claim 47, ~~wherein the DSL system comprises a multi-line double-sided vectored communication system,~~ wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at each of a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system and at a Customer Premises Equipment (CPE) end of the DSL system.

61. The method of claim 47, ~~wherein the DSL system comprises a multi-line bonded vectored communication system,~~ wherein the plurality of crosstalking lines are allocated to a single customer.

~~value~~ representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.

57. The method of claim 56, wherein Xlin(u,n) is represented in a linear format by a scale ~~scale(u)~~ factor scale(u) and a normalized complex number ~~a(u,n)~~ $a(u,n)$ + $j*b(u,n)$, where n is a ~~the~~ subcarrier index n=0, …, NSC, wherein NSC is ~~the~~ a number of carriers used, u is an index of a line transfer function between a one of the crosstalking lines and the primary line, and further wherein $a(u,n)$ and $b(u,n)$ are coded as 16-bit 2's complement signed integers, and

further wherein the value of ~~Xlin(u,n)~~ Xlin(u,n) is defined as ~~Xlin(u,n)~~ Xlin(u,n) = (~~scale(u)~~ scale(u)/2^{15})*(a(u,n) + $j*b(u,n)$)/2^{15}~~; and~~

~~further wherein the scale factor is chosen such that $max(|a(u,-n)|, |b(u,n)|)$ over all n is equal to $2^{15}-1$.~~

58. (CANCELLED) ~~The method of claim 56, wherein the DSM-data quantity Xlin(u,n) is a linear version of Xlog(u,n).~~

59. The method of claim 47, ~~wherein the DSL system comprises a multi-line one-sided vectored communication system,~~ wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.

60. The method of claim 47, ~~wherein the DSL system comprises a multi-line double-sided vectored communication system,~~ wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at each of a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system and at a Customer Premises Equipment (CPE) end of the DSL system.

61. The method of claim 47, ~~wherein the DSL system comprises a multi-line bonded vectored communication system,~~ wherein the plurality of crosstalking lines are allocated to a single customer.

prior to exciting the crosstalking lines.

69. The controller of claim 64, wherein the output data further comprises far-end crosstalk (FEXT) ~~FEXT~~ and/or near-end crosstalk (NEXT) ~~NEXT~~ transfer functions between the primary line and each of the crosstalking lines; and

further wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines is the insertion loss equivalent of the ~~acquired~~ FEXT and/or NEXT transfer functions.

70. The controller of claim 64, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises at least one of the following:

~~Xlog(u,n)~~ Xlog(*u,n*), wherein ~~Xlog(u,n)~~ Xlog(*u,n*) is a decibel-magnitude value representative of crosstalk coupling between the primary line n and each of the crosstalking ~~line~~ lines; and

~~Xlin(u,n)~~ Xlin(*u,n*), wherein ~~Xlin(u,n)~~ Xlin(*u,n*) is the linear version of ~~Xlog(u,n)~~ Xlog(*u,n*).

71. The controller of claim 70, wherein Xlin(*u,n*) is represented in a linear format by a scale ~~scale(u)~~ factor scale(*u*) and a normalized complex number $a(u,n) + j*b(u,n)$, where *n* is ~~the~~ a subcarrier index n=0,…, NSC, wherein NSC is ~~the~~ a number of used carriers, *u* is an index of a line transfer function between a one of the crosstalking lines and the primary line, ~~further wherein~~ $a(u,n)$ and $b(u,n)$ are coded as 16-bit 2's complement signed integers, and further wherein the value of ~~Xlin(u,n)~~ Xlin(*u,n*) is defined as ~~Xlin(u,n)~~ Xlin(*u,n*) = (~~scale(u)~~ scale(*u*) $/2^{15}$)*($a(u,n) + j*b(u,n)$)$/2^{15}$~~; and~~

~~wherein the scale factor is chosen such that $max(|a(u,n)|, |b(u,n)|)$ over all n is equal to $2^{15}-1$~~.

72. The controller of claim 70, wherein the quantity ~~Xlog(u,n)~~ Xlog(*u,n*) is a function of a 10-bit unsigned integer ~~m(u,n)~~ m(*u,n*) such that ~~Xlog(u,n)~~ Xlog(*u,n*) = 6 - (~~m(u,n)~~ m(*u,n*)/10).

73. The controller of claim 70, further comprising:

means for acquiring a value representative of insertion loss including any transmitter and receiver filter effects for the primary line~~, including any transmitter and receiver filter effects~~; and

means for assigning the value to index *u=0* of Xlin(*u,n*) ~~so that the value is identified as Xlin(*0,n*)~~.

74. The controller of claim 70, further comprising:

means for acquiring a value representative of insertion loss including any transmitter and receiver filter effects for the primary line~~, including any transmitter and receiver filter effects~~; and

means for assigning the value to index *u=0* of Xlog(*u,n*) ~~so that the value is identified as Xlog(*0,n*)~~.

76. A computer-readable medium having executable program code stored thereon that, when executed by a processor in a Digital Subscriber Line (DSL) system having a plurality of crosstalking lines in a common communication channel (channel), the executable program code causes the DSL system to perform a method comprising:

exciting ~~a~~ the plurality of crosstalking lines in the channel with a known sequence of input symbols applied to the crosstalking lines;

acquiring output data from a primary line among the plurality of lines in the channel, the output data comprising the known sequence of input symbols after having ~~propagated through the crosstalking lines and having~~ been affected by crosstalk coupling ~~within~~ among the plurality of crosstalking lines in the channel;

ordering the crosstalking lines based on a comparison between the known sequence of input symbols used to excite the crosstalking lines and ~~based further on~~ the output data acquired from the primary line;

generating a data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines based on the ordering of the crosstalking lines; and

sending instructions to one or more modems communicatively interfaced with the plurality of crosstalking lines in the channel based on the data quantity generated.

78. The computer-readable medium of claim 76, wherein the method further comprises zeroing all inputs ~~into~~ of the plurality of crosstalking lines to eliminate other crosstalk among the plurality of lines in the channel prior to exciting the plurality of crosstalking lines.

81. The computer-readable medium of claim 80, wherein the DSM-data quantity ~~Xlog(u,n)~~ Xlog(*u,n*) is a function of a 10-bit unsigned integer ~~m(u,n)~~ m(*u,n*) such that ~~Xlog(u,n)~~ Xlog(*u,n*) = 6 - (~~m(u,n)~~ m(*u,n*)/10)

82. The computer-readable medium of claim 80, wherein the DSM-data quantity ~~Xlog(u,n)~~ Xlog(*u,n*) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

83. The computer-readable medium of claim 80, wherein the DSM-data quantity ~~Xlog(u,n)~~ Xlog(*u,n*) is a function of a 10-bit unsigned integer ~~m(u,n)~~ m(*u,n*) such that ~~Xlog(u,n)~~ Xlog(*u,n*) = 6 - (~~m(u,n)~~ m(*u,n*)/10) and further wherein ~~Xlog(u,n)~~ Xlog(*u,n*) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.

84. The computer-readable medium of claim 76, wherein the output data further comprises far-end crosstalk (FEXT) ~~FEXT~~ and/or near-end crosstalk (NEXT) ~~NEXT~~ transfer functions between the primary line and each of the crosstalking lines; and

further wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) ~~the DSM-data~~ quantity Xlog(*u,n*) that is a decibel-magnitude value of the insertion loss equivalent of the ~~acquired~~ FEXT and/or NEXT transfer functions.

85. The computer-readable medium of claim 76, wherein the data quantity representative of crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlin(*u,n*) that is ~~a decibel-magnitude value~~ representative of the extent of crosstalk coupling between the primary line and each of the crosstalking lines and the primary line within the channel.

86. The computer-readable medium of claim 85, wherein Xlin(*u,n*) is represented in a linear format by a scale ~~scale(u)~~ factor scale(*u*) and a normalized complex number ~~a(u,n)~~ *a(u,n)* + *j*b*(*u,n*), where *n* is the subcarrier index *n*=0, …, NSC, wherein NSC is ~~the~~ a number of carriers used, *u* is an index of a line transfer function between a one of the

crosstalking lines and the primary line, and further wherein *a(u,n)* and *b(u,n)* are coded as 16-bit 2's complement signed integers, and

further wherein the value of ~~Xlin(u,n)~~ Xlin(*u,n*) is defined as ~~Xlin(u,n)~~ Xlin(*u,n*) = (~~scale(u)~~ scale(*u*)/2^{15})*(a*(u,n)* + *j*b(u,n)*)/2^{15}~~; and wherein~~

~~the scale factor is chosen such that *max(|a(u,n)|, |b(u,n)|)* over all n is equal to 2^{15}-1~~.

87. (CANCELLED) ~~The computer-readable medium of claim 85, wherein the DSM-data quantity Xlin(*u,n*) is a linear version of Xlog(u,n).~~

88. The computer-readable medium of claim 76, ~~wherein the DSL system comprises a multi-line one-sided vectored communication system,~~ wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.

89. The computer-readable medium of claim 76, ~~wherein the DSL system comprises a multi-line double-sided vectored communication system,~~ wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at each of a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system and at a Customer Premises Equipment (CPE) end of the DSL system.

90. The computer-readable medium of claim 76, ~~wherein the DSL system comprises a multi-line bonded vectored communication system,~~ wherein the plurality of crosstalking lines are allocated to a single customer.

91. The computer-readable medium of claim 90, wherein generating the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises generating a Dynamic Spectrum Management data (DSM-data) quantity Xlog(*u,n*) ~~for *u*=1, …, U,~~ representing line transfer functions between ~~U lines~~ crosstalking line *u* ~~in the multi-line bonded vectored communication system~~ and the primary line at a subcarrier index *n*.

92. The computer-readable medium of claim 85, wherein the method further comprises:

acquiring a value representative of insertion loss including any transmitter and receiver filter effects for the primary line~~, including any transmitter and receiver filter effects~~; and

assigning the value to index *u=0* of Xlin(*u*,*n*) ~~so that the value is identified as Xlin(*0*,*n*)~~.

B. Priority Date

46. I understand that the '458 patent has a filing date of May 5, 2005. Ex. 1001, 1. I understand that the '458 patent claims priority to provisional application No. 60/572,051 filed on May 18, 2004. For purposes of this Declaration, I have assumed that the earliest alleged priority date of the '458 patent is not earlier than May 18, 2004.

C. The '458 Patent's Specification

47. In describing the state of the art, the '458 patent explains that X-DSL technologies "provide potentially large bandwidth for digital communications for existing telephone subscriber lines." Ex. 1001, 1:40-42. As an example, "asymmetric DSL (ADSL) can adjust to the characteristics of the subscriber line by using a discrete multitone (DMT) line code that assigns a number of bits to each tone (or sub-carrier), which can be adjusted to channel conditions as determined during training and initialization of the modems . . . at each end of the subscriber line." Ex. 1001, 1:43-50. However, in an attempt to ensure compatibility between X-DSL technologies, "[u]nreasonable static limits" or "mandated spectrum masks" have been placed on DSL operation. Ex. 1001, 1:54-56, 2:6-11. In practice, these limits "have frustrated efforts to improve service to users." Ex. 1001, 1:54-56.

48. For example, the ’458 patent explains that “crosstalk, which increases with wider spectrum use and thus higher data rates, dominates the achievable performance of DSL systems.” Ex. 1001, 1:61-63. The ’458 patent further describes two types of common crosstalk interference, including “FEXT interference (far-end crosstalk)” and “NEXT interference (near-end crosstalk).” Ex. 1001, 1:26-38. “Measurement of crosstalk, especially FEXT interference, allows that interference to be removed from signals sent on various DSL lines.” Ex. 1001, 2:12-14. The ’458 patent acknowledges that “[a] variety of systems, techniques and methods have been developed for measuring and removing FEXT interference,” including methods discussed in ANSI standard T1.417-2003. Ex. 1001, 2:14-16. However, the methods for modeling crosstalk specified in ANSI T1.417-2003 are “based on worst-case, generally inapplicable transmission situations.” *See* Ex. 1001, 1:51-67.

49. The ’458 patent teaches a method of collecting operational data from DSL modems[1] and determining FEXT interference based on the collected

[1] The ’458 patent teaches that the foregoing “embodiments of the present invention typically use ADSL systems (for example, ADSL1 and ADSL2 systems) and/or VDSL systems (for example, VDSL1 and VDSL2 systems) as exemplary communication systems.” Ex. 1001, 8:13-17. “However, as will be appreciated by

operational data Ex. 1001, 1:28-33, 4:66-5:12, 8:13-17, FIG. 1. The ’458 patent suggests two functions can describe crosstalk interference detected on a given DSL line in a manner similar to insertion-loss quantities Hlog(n) and Hlin(n) for a DSL line, stating “[c]rosstalk interference relating to FEXT interference is determined using either an Xlog(u,n) or Xlin(u,n) quantity.” Ex. 1001, 4:3-5. “The Xlog(u,n) quantity is a decibel-magnitude representation of the insertion-loss equivalent of the FEXT transfer functions specified in one or more DSL standards and is defined as the ratio of a line u's source power into matched load of 100 Ohms when no binder is present to the power at the output of the subject line when line u is excited with the same source and the binder is present. Xlin(u,n) is the linear equivalent of Xlog(u,n).” Ex. 1001, 4:8-15. The ’458 patent explains that Xlog(u,n) and Xlin(u,n) describe the amount of crosstalk interference on a subject line caused by U other

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those skilled in the art, embodiments of the present invention may be applied to various communication systems, and the invention is not limited to any particular system. The present invention can be used in any data transmission system in which determination and use of crosstalk-type interference is useful, especially where such information can be used to improve system performance.” Ex. 1001, 8:20-27.

lines (for u=1,2,3,…U) on each of N tones (for n=1,2,3,…N).[2] Ex. 1001, 9:52-58, FIG. 3. The '458 patent explains that "[q]uantities Xlog, and Xlin typically are level-3 data DSM-compliant insertion-loss measures for multi-line one-sided vectored situations, though their compliance and use may vary." Ex. 1001, 8:28-31.

50. "A method according to one embodiment of the present invention relating to Xlog(u,n) and Xlin(u,n) is shown in FIG. 3." Ex. 1001, 11:17-19, FIG. 3. After selecting the subject line and tone/frequency, "[p]ossible crosstalking lines are identified at 320." Ex. 1001, 11:20-21. The '458 patent explains that these crosstalking lines are typically in the same binder. Ex. 1001, 11:21-22. Then, "[t]he ratio P_s:P_o is calculated for each and every frequency or tone n" for every possible crosstalking line. Ex. 1001, 11:27-32. The ratio P_s:P_o, where: P_s is line u's (a crosstalking line) source power into a matched load of 100 Ohms when no binder is present; and P_o is the power at the output of the primary line when line u is excited with the same source power and the binder is present. Ex. 1001, 8:65-9:5. Once all R of the potential crosstalking lines have been evaluated and their ratios P_s:P_o

[2] I note that the '458 patent specification inconsistency uses "n" to refer to "the derived logarithmic magnitude Xlog (u, n) for any line n" (Ex. 1001, 9:52-55), however the most consistent usage of variables defines u=index of crosstalking lines and n=index of frequency throughout the '458 patent.

calculated for each tone, a subset of those crosstalking lines (denoted as U) are selected at 370. Ex. 1001, 11:33-35. For example, the selection may be based on U of the crosstalking lines having ratios that exceeded a threshold crosstalk value or may select the U worst crosstalking lines. Ex. 1001, 11:36-38. At 380 the U crosstalking lines are ordered according to the degree of crosstalk they induce in the primary line. Ex. 1001, 11:38-40. The worst (most severe) crosstalking line is assigned index u=1 with the progressively less severe crosstalking lines being assigned progressively higher indexes u=2, 3,…,U. Ex. 1001, 11:41-42. The ’458 patent describes one method for ranking the crosstalking lines, uses a max function to assign a u value for each crosstalking line:

$$\max_{i,n}\{Xlog[i,n]\}$$

Ex. 1001, 9:15.

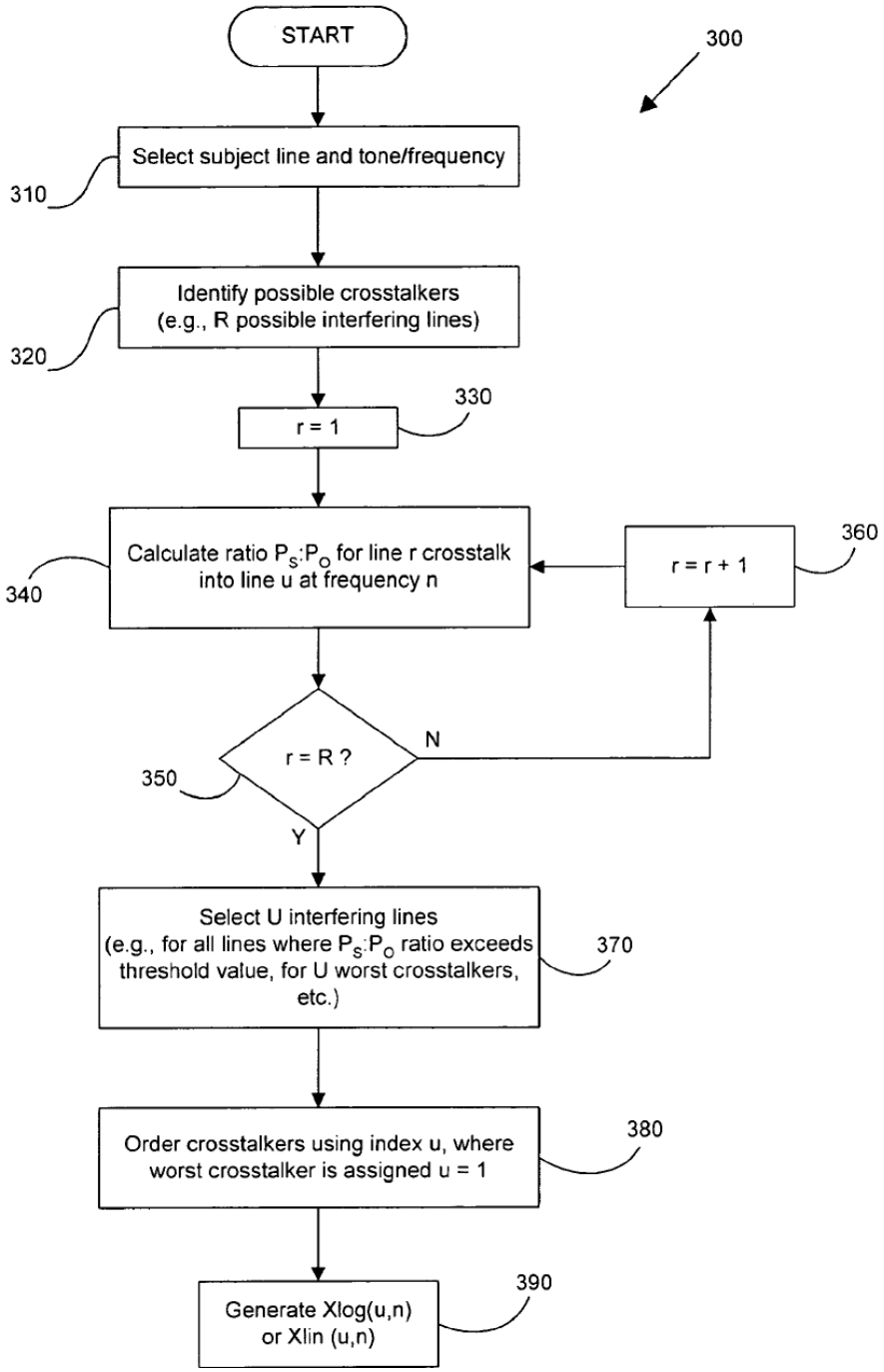
51. The crosstalking line having the highest maximum value is assigned u=1, and each progressively less severe crosstalking line is assigned progressively higher indexes. Ex. 1001, 9:9-11. The ’458 patent gives a further example for assigning u=2 to another crosstalking line using the following formula:

$$\max_{i\neq 1,n}\{Xlog[i,n]\}$$

Ex. 1001, 9:6-35.

52. Finally, after ordering the U crosstalking lines, matrices Xlog(u,n) and/or Xlin(u,n) can be generated at 390 and used in the DSL system. Ex. 1001, 11:42-46. This method is illustrated in FIG. 3 of the '458 patent below.

Ex. 1001, FIG. 3



IX. SUMMARY OF THE PRIOR ART

A. Rezvani (Ex. 1005)

53. U.S. Patent No. 7,356,049 to Rezvani was filed on December 30, 2002, and issued on April 8, 2008. Ex. 1005, 1. I understand from counsel that Rezvani is prior art to the ’458 patent based on its filing date. I understand that Rezvani has been attached as Ex. 1005. *See* Ex. 1005. Rezvani was not cited and was not considered during prosecution.

54. Rezvani is directed to “a method and apparatus for optimizing channel capacity of multi-line multi-tone communications such as X-DSL among subscriber lines which are bundled together.” Ex. 1005, 2:36-40, Abstract.

55. Rezvani explains that various X-DSL standards, such as G.Lite, ADSL, VDSL, SDSL, MDSL, RADSL, and HDSL, “have been developed to increase the effective bandwidth of existing subscriber line connections, without requiring the installation of new fiber optic cable.” Ex. 1005, 1:42-47. The various X-DSL standards implement several modulation protocols, such as discrete multi-tone (DMT) modulation, to increase bandwidth and reduce signal interference. Ex. 1005, 1:54-56. “DMT modulation involves establishing a communication channel with a

plurality of sub-channels each with a center frequency a.k.a. carrier tone.[3] The sub-channels are frequency division multiplexed across the available bandwidth. Each sub-channel uses quadrature amplitude modulation (QAM) to modulate information." Ex. 1005, 1:56-62.

56. As additional background, Rezvani further explains that "XDSL modems are typically installed in pairs, with one of the modems installed in a home and the other in the telephone compan[y's] central office (CO) switching office servicing that home. This provides a direct dedicated connection to the home from a line card at the central office on which the modem is implemented through the

[3] I note that Rezvani uses the term "sub-channel" as a synonym for "tone," "carrier," "subcarrier," and "frequency," whereas the '458 patent uses the term "channel" as a synonym for "the plurality of lines in a common communication channel (channel)." *See, e.g.*, Ex. 1001, cl. 1. For purposes of this Declaration, it should be understood that the term "sub-channel" is used interchangeably with "tone," "carrier," "subcarrier," and "frequency." Additionally, the terms "primary line," "subject line," and "interferee line" to refer to the DSL subscriber line being affected by interference, whereas the terms "crosstalking line," "crosstalker," and "interferer line" to refer to the DSL subscriber lines introducing interference into the primary/subject/interferee line.

subscriber line or local loop." Ex. 1005, 1:64-2:3. Referring to FIG. 1, which "shows an overall communication environment in which to practice the current invention including dynamic spectrum management of bundled subscriber lines," Rezvani explains that multiple subscriber lines or loops may be bundled together in a binder, also referred to as a bundle. Ex. 1005, 4:23-27, FIG. 1. "Each of the subscriber lines in a bundle shields or interferes with other lines in the bundle in varying amounts across the time and/or frequency domains." Ex. 1005, 5:25-27. Revani discloses that Near End Cross-Talk (NEXT) and Far End Cross-talk (FEXT) are two types of such interference. "NEXT is defined as cross-talk effected between a transmitting path and a receiving path of transceivers at the same end of two different subscriber loops within the same bundle." Ex. 1005, 6:37-40. "FEXT is defined as cross talk between a transmitting path and a receiving path of transceivers at opposite ends of two different subscriber loops within the same bundle." Ex. 1005, 6:48-51.

57. Rezvani discloses that there are two known approaches for addressing interference: individual subscriber line approaches and aggregate subscriber line approaches. Individual subscriber line approaches include "various forms of forward error correction (FEC)," "carefully regulated band plans," and "capped transmission levels, a.k.a. power spectral densities (PSD) masks which limit interference between subscriber lines in a bundle by uniformly reducing bandwidth on all channels," regardless of the channel's actual spectral profile. Ex. 1005, 2:11-21. On the other

hand, "[a]ggregate subscriber line approaches involve vector cancellation applied to all the subscriber lines in a bundle with the training necessary to calculate vectors accomplished during the initialization of all lines." Ex. 1005, 2:21-25.

58. Accordingly, Rezvani discloses a method and spectrum manager "for optimizing channel capacity of multi-line multi-tone communications such as X-DSL among subscriber lines which are bundled with one another." Ex. 1005, 2:36-39. Rezvani explains that the disclosed method "alters the prior art methodology by managing subscriber lines in the aggregate rather than individually." Ex. 1005, 5:35-37. "The current invention manages a bundle of subscriber lines by determining the spectral characteristics, interference profile, and the subscriber requirements associated with each subscriber line and then setting the transmission characteristics of each subscriber line accordingly. Transmission characteristics include: bit-loading, PSD mask, and band-plan for each sub-channel on each subscriber line." Ex. 1005, 5:39-46.

59. Rezvani teaches that the spectrum manager may perform the following steps or phases to optimize channel capacity and determine for each subscriber line in the bundle: a spectral profiling phase, an interference determination phase, a demand determination phase, and a spectral allocation phase. *See* Ex. 1005, 4:14-18, 17:47-51, FIG. 12. FIG. 12 describes each of these phases, which "may be carried out on initialization of the first and subsequent subscriber lines, as well as after all

lines have been initialized and have entered showtime." Ex. 1005, 21:28-31. "During the spectral profiling phase, the spectrum manager determines the relative lengths of each of the subscriber lines based either on bit loading levels in each of the sub-channels or on an actual comparison of transmit and receive power levels and the attenuation of same across the entire spectrum. Either of these parameters are already part of the existing X-DSL specifications and are exchanged between modem pairs during initialization." Ex. 1005, 13:64-14:5. After a spectral profile for each subscriber line is determined, the spectrum manager initiates an interference determination phase. Ex. 1005, FIG. 12. "The interference determination phase is designed to allow a more precise allocation of revised spectral profile targets based on detailed co-interference parameters between subscriber lines determined during the interference determination phase." Ex. 1005, 14:35-39; *see also id.* at 18:14-19. "A training sequence is sent by the interference module 934 on selected sub-channels of successively selected subscriber lines while interference on the same sub-channels is monitored on the receive path of all of the other lines in the bundle. This is continued until all subscriber lines have performed as both interferer and interferee and the corresponding data accumulated." Ex. 1005, 14:41-47; *see also id.* at 18:32-42. "Based on this data an interference matrix is calculated . . . [that] shows for each sub-channel on each subscriber line the relative interference in terms of noise injected from all other subscriber lines." Ex. 1005, 14:47-51; *see also id.* at 18:42-

46. The data included in this matrix is shown graphically in FIG. 6A, reproduced below. FIG. 6A depicts an interference profile of a single subject line from the calculated interference matrix. Ex. 1005, 7:23-26. Particularly, FIG. 6A shows the amount of interference on line 202 caused by crosstalking Lines 206, 210, and 212, expressed in terms of signal strength vs. frequency, that is detected on Line k=202. Ex. 1005, 7:23-37, FIG. 6A. In other words, FIG. 6A shows the cumulative level of interference caused by each interferer line at multiple frequencies (f_1, f_2, f_3, etc.).

Ex. 1005, FIG. 6A.

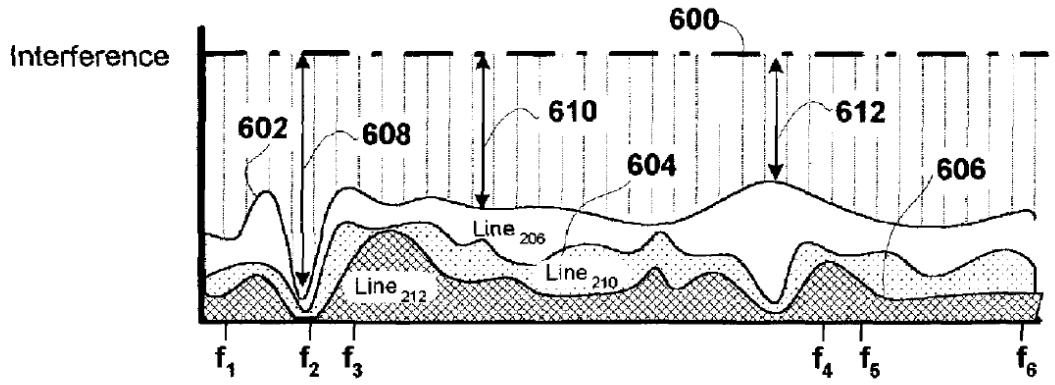


FIG. 6A **Interference Profile on a Line k=202 from Other Lines$_{1..N}$ in Bundle**

60. After the interference determination phase, the spectrum manager initiates a demand profiling phase. Ex. 1005, 18:60-66. In the demand profiling phase, the spectrum manager "determines subscriber demand profiles which includes at least one of subscription bandwidth levels, guarantees, QOS, caps or usage patterns and demand profiles," such as "data rates in both the upstream and

downstream direction." Ex. 1005, 18:65-19:1, 19:10-15. "Subscriber demand profiles may be accumulated by the spectral manager directly by maintaining a rolling history of subscriber demand on each of the subscriber lines to which the spectrum manager is coupled or by access to subscription data maintained by the Telco or other subscriber line provider." Ex. 1005, 19:4-9.

61. After the demand profiling phase, the spectrum manager initiates a spectral allocation phase. Ex. 1005, FIG. 12. "The spectral allocation phase commences with process 1218 in which depending on the capabilities of the spectrum manager either of four paths of operation will be provided." Ex. 1005, 19:17-19. These four paths are represented by processes 1232-1234, processes 1228-1230, processes 1224-1226, and processes 1220-1222 in FIG. 12. Ex. 1005, FIG. 12. "Generally all paths of operation allocate spectrum to each of the subscriber lines based at least on spectral profiling and where available the interference determination and demand phases of operation as well." Ex. 1005, 19:20-23. Depending upon the particular embodiment, "[a]llocation [may be] based both on dropping underutilized sub-channels of each subscriber line based either on bit-loading or low demand profiles, generating new PSD masks with higher transmit power levels in the dropped sub-channels for the same or other subscriber lines in the bundle adding tunnel tones where appropriate and revising the band plans for those subscriber lines with high demand profiles." Ex. 1005, 21:10-17. "After all

these determinations are made the new spectral profile target parameters are downloaded by the spectrum manager to the appropriate modules on the transmit path of the DSP and the effected channels are subject to another round of initialization. The parameters downloaded may include: designated tunnel tones, revised band plans, PSD masks, gain tables, or tone loading for the effected subscriber lines and sub-channels thereof." Ex. 1005, 21:17-25. After re-initialization, a.k.a. spectral optimization, . . . showtime operation is continued or commenced." Ex. 1005, 21:26-28.

Ex. 1005, FIG. 12

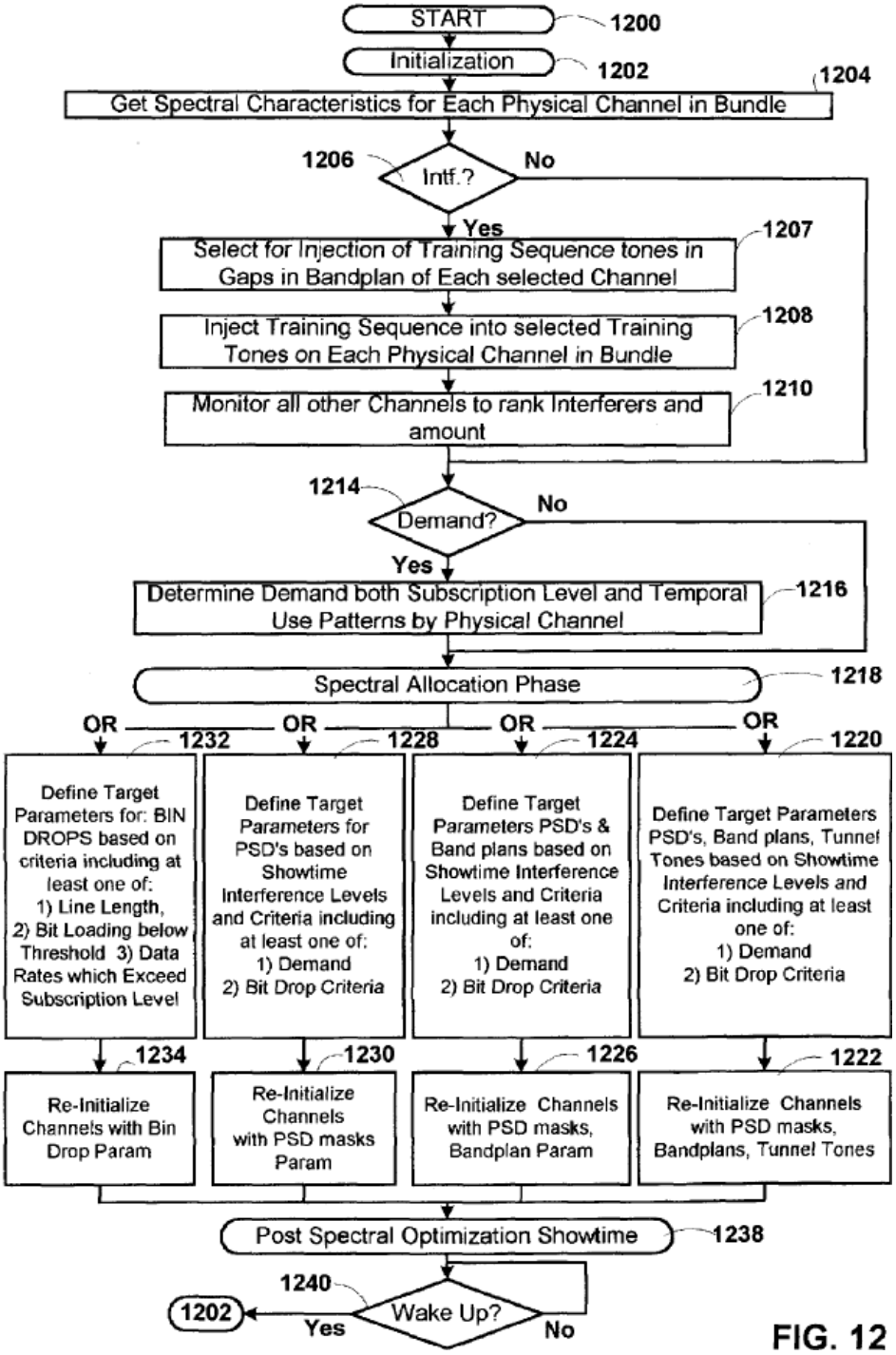


FIG. 12

B. Cendrillon I (Ex. 1006)

62. "Partial Crosstalk Cancellation Exploiting Line and Tone Selection in VDSL", authored by myself and Raphael Cendrillon, among others, was first published in the *Proceedings of the 6th Baiona Workshop on Signal Processing in Communications*, pages 229-234, on October 1, 2003. *See* Ex. 1022, ¶¶56-63. I have personal knowledge that Cendrillon I was published prior to the earliest priority date of the '458 patent. Thus, I understand that Cendrillon I is prior art to the '458 patent based on its publication date. I understand that Cendrillon I has been attached as Ex. 1006. *See* Ex. 1006. Cendrillon I was not cited and was not considered during prosecution.

63. Cendrillon I is directed to "partial crosstalk cancellation for upstream VDSL." Ex. 1006, p. 1. Cendrillon I explains that multiple subscriber lines "are distributed within large *binder-groups*." Ex. 1006, p. 1. "As a result of the close distance between twisted-pairs within binders and the high frequencies used in VDSL transmission there is significant electromagnetic coupling between near-by pairs. This electromagnetic coupling leads to interference or *crosstalk* between the different systems operating within a binder." Ex. 1006, p. 1. Cendrillon I explains that one type of crosstalk affecting DSL systems is far-end crosstalk (FEXT), which is "*the* dominant source of performance degradation in VDSL." Ex. 1006, p. 1.

Removing this crosstalk leads to significant performance benefits, crosstalk cancellation techniques can be extremely complex. Ex. 1006, p. 1.

64. Accordingly, Cendrillon I teaches "a crosstalk cancellation scheme with scalable complexity." Ex. 1006, p. 1. More specifically, Cendrillon I teaches partial crosstalk cancellation that "exploit[] the space and frequency-selective nature of crosstalk channels." Ex. 1006, p. 1. This takes advantage of the fact that the majority of the effects of crosstalk are limited to small number of crosstalkers and tones. Ex. 1006, pp. 3, 6. Stated differently, partial crosstalk cancellation provides similar performance gains as full crosstalk cancellation by cancelling only the largest crosstalkers on each tone. Ex. 1006, pp. 1, 6. In this regard, Cendrillon I teaches three separate algorithms for crosstalk cancellation exploiting space- and/or frequency- selectivity: Algorithm 1, which employs only line selection; Algorithm 2, which employs only tone selection; and Algorithm 3, which employs simple tone-line section. *See* Ex. 1006, pp. 4-5.

Ex. 1006, Algorithm 1

Algorithm 1 Line Selection Only

$$\mathbb{M}_k^n = \{q_{k,n}(1), \ldots, q_{k,n}(c)\}, \forall n, k$$

Ex. 1006, Algorithm 2

Algorithm 2 Tone Selection Only

$$\mathbb{M}_k^n = \begin{cases} \{1, \ldots, n-1,\ n+1, \ldots, N+1\}, \\ \quad k \in \{k_n(1), \ldots, k_n(cK/N)\} \\ \emptyset, \text{ otherwise} \end{cases}$$

Ex. 1006, Algorithm 3

Algorithm 3 Simple Line-Tone Selection

$$\mathbb{M}_k^n = \{m : \ (m,k) \in \{d_n(1), \ldots, d_n(cK)\}\}$$

C. G.992.3 (Ex. 1007)

65. G.992.3 is a Recommendation submitted to the Telecommunication Standardization Sector of ITU (ITU-T) that was approved on July 29, 2003, and was posted for public inspection by November 11, 2003. *See* Ex. 1022, ¶¶64-70; Ex. 1007, p. 5. Thus, I understand that G.992.3 is prior art to the '458 patent based on its publication date. The G.992.3 recommendation is referred to as the ADSL2 standard that describes "ADSL transceivers on a metallic twisted pair." Ex. 1007, p. i.

66. Among other things, G.992.3 describes procedures for transporting a bitstream over twisted pairs of copper wires. Ex. 1007, p. 52. Those procedures include processes for determining channel characteristics as a function of subcarrier (or tone). Ex. 1007, pp. 92-93. The characteristics are provided in two formats, according to G.992.3: (1) Hlin(f): a format providing complex values in linear scale;

and (2) Hlog(f): a format providing magnitude values in a logarithmic scale. Ex. 1007, p. 93.

67. The channel characteristics function Hlin (i × Δf) is represented in linear format by a *scale* factor and a normalized complex number *a(i) + j × b(i)*, where *i* is the subcarrier index and Δf is the spacing between the subcarrier central frequencies. Ex. 1007, pp. 93-94. G.992.3 specifies that the scale factor is coded as a 16-bit unsigned integer and both *a(i)* and *b(i)* are coded as 16-bit 2's complement signed integer. Ex. 1007, p. 94.

68. The value of Hlin (i × Δf) is defined as Hlin (i × Δf)=$(scale/2^{15}) \times (a(i) + j \times b(i))/2^{15}$. G.992.3 specifies that to maximize precision, the scale factor shall be chosen such that $max(|a(i)|, |b(i)|)$ over all *i* is equal to 2^{15}-1. Ex. 1007, p. 94.

69. The channel characteristics function Hlog(f) is represented in logarithmic format by an integer number *m(i)*, where *i* is the subcarrier index and *m(i)* is coded as a 10-bit unsigned integer. The value of Hlog (i × Δf)=*6-(m(i)/10)*. Ex. 1007, p. 94.

X. OPINIONS

70. The '458 patent contains 44 claims, of which Claims 1, 17, and 29 are independent and recite analogous limitations. Claim 1 is directed to a method. Claim 17 is directed to an apparatus. Claim 29 is directed to a computer program product. The Challenged Claims are disclosed and/or taught by the prior art.

A. Ground 1: Claims 1, 2, 4-5, 7, 9-10, 12, and 14-15 are rendered obvious over Rezvani in view of Cendrillon I.

71. Rezvani in view of Cendrillon I renders obvious all of the limitations of Claims 1, 2, 4-5, 7, 9-10, 12, and 14-15.

1. Motivation to combine.

72. A POSITA would have been motivated to modify Rezvani with the teachings of Cendrillon I to apply Cendrillon I's partial crosstalk cancellation methods to Rezvani's DSL system to thereby improve signaling on DSL lines with improved efficiency over complete crosstalk cancellation. Rezvani and Cendrillon I are both directed towards optimizing channel performance by mitigating or cancelling interference among bundled DSL subscriber lines. Ex. 1005, 2:4-49; Ex. 1006, p. 1. Rezvani discloses a typical DSL deployment in which "opposing sets of modems coupled to one another by corresponding subscriber lines within a bundle." Ex. 1005, 4:44-50, FIG. 2A; *see also id.* at 1:64-67 ("XDSL modems are typically installed in pairs, with one of the modems installed in a home and the other in the telephone companies central office (CO) switching office servicing that home."). To address crosstalk interference among the bundled lines, Rezvani describes "a method and apparatus for optimization of channel capacity in multi-line multi-tone communications" such as XDSL lines (encompassing ADSL, VDSL, and other standards) which are bundled with one another." Ex. 1005, Abstract, 1:42-51. Rezvani explains that crosstalk interference can be mitigated using spectrum

coordination and/or "cross channel interference cancellation techniques . . . to optimize channel capacity." Ex. 1005, 8:42-48. Rezvani's crosstalk mitigation methods use a spectrum manager that "determines both the initial spectral characteristics of a line as well as interference profiles between lines, in order to efficiently allocate one or more of the following: bit-loading, PSD mask and band plans for each subscriber line to maximize dataflow through the bundle of subscriber lines." Ex. 1005, 7:52-57. The spectrum manager determines these interference profiles by injecting training sequences of data into one or more tones transmitted on each subscriber line and monitoring the output of the multiple bundled subscriber lines to characterize the level of crosstalk between the bundled lines at each of the one or more frequencies, and to calculate an interference matrix that may be used for "either cross channel interference cancellation techniques or less granular energy balancing techniques." Ex. 1005, 8:26-48. Cendrillon I also discusses a method for mitigating the effects of crosstalk interference among lines in a typical VDSL deployment having opposing sets of VDSL modems located at the CP and CO. *See* Ex. 1006, pp. 1-2. Cendrillon I teaches that by applying partial crosstalk cancellation techniques and targeting specific tones or lines, the system can achieve similar channel performance improvements to full crosstalk cancellation with less complexity. Ex. 1006, p. 1.

73. More specifically, both Rezvani and Cendrillon I recognize efficiencies in only mitigating or canceling crosstalk on the specific subscriber lines or tones most effected by interference. Rezvani explains that NEXT and FEXT are two categories of interference impairing bundled DSL subscriber lines, Ex. 1005, 6:33-60, but that most of the interference experienced on a subject line originates from a subset of all crosstalking lines. *See* Ex. 1005, 7:46-50 (referring to FIG. 6A and explaining that "[i]n each sub-channel the contribution to the total interference by each interferor will vary" and "[t]hus in the sub-channel(s) 612 experiencing the highest aggregate interference most of that interference is due to interference from subscriber line 206"). Rezvani ranks the interferers for a subject line in order of importance to identify the interfering lines contributing the highest amount of interference to the subject line based on a determined interference matrix calculated for each subject line. Ex. 1005, 8:42-48, FIG. 6A. Using the interference matrix, "cross channel interference cancellation techniques or less granular energy balancing techniques can be used to optimize channel capacity." Ex. 1005, 8:46-48.

74. Cendrillon I teaches partial crosstalk cancellation techniques which similarly exploit differences in importance of contributors of crosstalking lines to "exploit both space and frequency-selectivity" of the crosstalk channel. Ex. 1006, 4. Cendrillon I also explains that FEXT is one category of interference impairing bundled DSL subscriber lines and that the amount of crosstalk may vary between

each tone of each subscriber line. Ex. 1006, p. 1. More particularly, because "[t]he majority of the effects of crosstalk are limited to a small number of crosstalkers and tones," "partial crosstalk cancellation exploits this by only performing crosstalk cancellation on the tones and lines where it gives the most benefit." Ex. 1006, p. 6.

75. Given Cendrillon I's discussion of efficiency gains by performing only partial crosstalk cancellation while achieving similar levels of signal improvements as full crosstalk cancellation, a POSITA would have been motivated to modify Rezvani's crosstalk mitigation methods that use a ranking of importance of crosstalking lines to utilize Cendrillon I's partial crosstalk cancellation method to cancel crosstalk from a subset of the highest-contributing crosstalking lines for a subject line. *See* Ex. 1005, 8:46-48; Ex. 1006, p. 6 (describing the "combinations of partial crosstalk cancellation with dynamic spectrum management"). A POSITA would understand that Rezvani's training phase for generating an interference matrix would enable Cendrillon I's partial crosstalk cancellation method to only cancel crosstalk from the crosstalking lines contributing the most interference to a subject line. *See* Ex. 1005, 8:46-48; Ex. 1006, p. 6.

76. Furthermore, a POSITA would have had a reasonable expectation of success in combining Rezvani and Cendrillon I because both references characterize the crosstalk interference contributions among bundled DSL lines, and selectively cancel or otherwise mitigate crosstalk from a subset of the largest contributors of

crosstalk interference to improve the performance of a subject line. *See* Ex. 1005, 2:4-25, 8:46-48; Ex. 1006, p. 6. A POSITA would be familiar with DSM techniques for mitigating or cancelling crosstalk and that DSM techniques are distinguished by "levels." *See, e.g.*, Ex. 1001, 8:28-53. Accordingly, a POSITA would have understood that DSM Level 2 (spectrum coordination) jointly manages the transmit powers of different lines to mitigate or avoid crosstalk, whereas DSM Level 3 (signal coordination or vectoring) jointly manages subscriber lines by coordinating transmissions on the signal level to cancel crosstalk. *See* Ex. 1016, pp. 1-2, 11 (describing "Dynamic Spectrum Management (DSM)" techniques for adapting transmit spectra as "Level 2"), Ex. 1006, p. 1 (explaining that "crosstalk cancellation" requires "signal level co-ordination"). A POSITA would have understood that Rezvani's interference matrix could be used to determine how to selectively cancel crosstalk interference from other lines. Specifically, Rezvani's interference matrix could be used to determine the highest contributors of crosstalk interference, to use Cendrillon I's partial crosstalk cancellation method to cancel crosstalk interference from only the highest contributors of crosstalk interference. *See* Ex. 1005, 2:4-25, 8:46-48; Ex. 1006, p. 6. Moreover, a POSITA would have had a reasonable expectation of success because a POSITA would have been familiar with both spectrum coordination and signal coordination, and that the training phase of Rezvani's spectrum coordination would not conflict with crosstalk cancellation

provided by Cendrillon I's signal coordination process. *See* Ex. 1005, 2:4-25, 8:46-48; Ex. 1006, p. 6.

2. Claim 1

1[pre]: A method of evaluating operational characteristics of a multi-line, vectored Digital Subscriber Line (DSL) system having a plurality of crosstalking lines in a common communication channel (channel), the method comprising:

77. To the extent the preamble is limiting, Rezvani teaches 1[pre]. Rezvani teaches "a method and apparatus for optimizing channel capacity of multi-line multi-tone communications such as X-DSL among subscriber lines which are bundled together." Ex. 1005, 2:36-40, Abstract; *see also id.* at 3:1-4 (teaching a method "for spectral management of multi-tone communications effected across a plurality of subscriber lines"), 16:10-12 (stating that "subscriber lines 202, 208, 210, 212 . . . occupy a common bundle 200").

78. First, it should be noted that the term "operational characteristics" is not defined in and appears only once in the '458 patent (in the preamble of Claim 1). However, the '458 patent broadly describes "operational data" as data relating to two or more DSL lines that is used "to enhance system operation, for example, to reduce crosstalk between lines in a common binder." Ex. 1001, 3:61-64. Operational data "may include such data as is normally available from a DSL or other communication systems during normal operation" or "data specifically requested,

prompted and/or ordered by the controller for use in connection with the present invention." Ex. 1001, 4:28-33. Additionally, "operational data may relate to measurements and/or values obtained from a DSLAM, ONU/LT device, RT device or any other suitable component in the DSL system." Ex. 1001, 13:19-22; *see also id.* at 8:10-12 ("Various types of operational data and/or information available from an ADSL NMS can be found therein; others may be known to those skilled in the art."). As such, a POSITA would understand that the broadest reasonable interpretation of "operational characteristics" would include information relating to two or more DSL lines that is used to enhance system performance.

79. A POSITA would understand that Rezvani teaches "***evaluating operational characteristics***." Rezvani teaches a method for "optimizing channel capacity of multi-line multi-tone communications such as X-DSL among subscriber lines which are bundled with one another" where "[c]hannel capacity optimization is effected with knowledge of one or more of: the spectral profiles of all subscriber lines, the interference profiles of all subscriber lines with one another, the subscriber demand profiles and or data rates for all subscriber lines." Ex. 1005, 5:39-46; *see also id.* at 7:52-57 ("The spectrum manager of the current invention determines both the initial spectral characteristics of a line as well as interference profiles between lines, in order to efficiently allocate [transmission characteristics.]"). Rezvani further teaches that the spectral profiles, interference profiles, and subscriber demand

profiles may be obtained "from the at least one of the opposing sets of modems," and/or determined "from a number of parameters provided by the modems." Ex. 1005, 2:55-59, 17:57-65. A POSITA would understand the spectral profiles, interference profiles, and/or subscriber demand profiles to be information relating to two or more DSL lines that is used to enhance system performance. *See* Ex. 1005, 2:35-49. Moreover, Rezvani teaches that "from one or more of these datum [the spectrum manager] determines how best to optimize the spectrum accorded to each subscriber line in the bundle including: dropping or adding sub-channels, altering PSD masks, and or band plans." Ex. 1005, 10:37-43. A POSITA would understand that the spectral profiles, interference profiles, and/or subscriber demand profiles are evaluated to optimize performance. Ex. 1005, 2:35-49. Thus, Rezvani teaches "evaluating operational characteristics."

80. Further, Rezvani teaches "evaluating operational characteristics ***of a multi-line, vectored Digital Subscriber Line (DSL) system***." As described above, Rezvani teaches "optimizing channel capacity of multi-line multi-tone communications such as X-DSL among subscriber lines which are bundled with one another." Ex. 1005, 5:39-46. Moreover, by the time of the priority date of the '458 patent, a POSITA would have been familiar with vectored DSL systems. *See* Ex. 1005, 2:21-25. For example, in discussing background, Rezvani discloses aggregate subscriber line approaches, which mitigate crosstalk in DSL systems by applying

"vector cancellation . . . to all the subscriber lines in a bundle," were known in the art. Ex. 1005, 2:21-25. Thus, a POSITA would understand that Rezvani teaches "evaluating operational characteristics of a multi-line, vectored Digital Subscriber Line (DSL) system having a plurality of crosstalking lines in a common communication channel (channel)."

1[a]: exciting the plurality of crosstalking lines in the channel with a known sequence of input symbols applied to the crosstalking lines;

81. Rezvani teaches element 1[a]. First, a POSITA would understand that in XDSL systems, modems perform training procedures to measure or estimate channel characteristics for optimizing system performance accordingly. *See* Ex. 1001, 1:43-48; Ex. 1005, 2:21-25; Ex. 1007, pp. 98-99; Ex. 1019, 10:13-22. Rezvani teaches that during the spectrum manager's interference determination phase, "[a] training sequence is sent by the interference module 934 on selected sub-channels of successively selected subscriber lines." Ex. 1005, 14:41-47; *see also id.* at 18:19-25 (discussing "the injection of training sequences into successive ones of the subscriber lines . . . to determine the interference profiles"). A POSITA would recognize that training sequencies applied to the crosstalking lines necessarily include "known input symbols" so that they can be detected and compared to output. As the training sequences are injected into each subscriber line, "interference on the same sub-channels is monitored on the receive path of all of the other lines in the

bundle. This is continued until all subscriber lines have performed as both interferer and interferee and the corresponding data accumulated." Ex. 1005, 14:41-47. A POSITA would understand that the injected training sequences excite the subscriber lines so that any resulting crosstalk can be monitored and measured. *See, e.g.*, Ex. 1001, 12:53-67; Ex. 1010, pp. 5-6. A POSITA would understand that injecting training sequences into subscriber lines to determine the crosstalk interference of each subscriber line teaches the claimed step of "exciting the plurality of crosstalking lines with a known sequence of input symbols applied to the crosstalking lines."

82. The '458 patent confirms this understanding. The '458 patent acknowledges that DSL systems "can adjust to the characteristics of the subscriber line by using a discrete multitone (DMT) line code that assigns a number of bits to each tone (or sub-carrier), which can be adjusted to ***channel conditions as determined during training*** and initialization of the modems." Ex. 1001, 1:43-48 (emphasis added). In this regard, "[m]easurements of crosstalk, especially FEXT interference, allows that interference to be removed from signals sent on various DSL lines." Ex. 1001, 2:12-14. In a first example, the '458 patent states that NEXT and Hlin values "are obtained by measuring after ***exciting the respective channels with a known input sequence of symbols, say TRAIN(n,k)***, where k is a time-symbol index, and then observing several corresponding channel outputs OUT(n,k)." Ex. 1001, 12:53-67 (emphasis added). As is apparent from its name, a

POSITA would understand "a known input sequence of symbols" or "TRAIN(n,k)" to be a training sequence.

1[b]: acquiring output data from a primary line among the plurality of lines in the channel, the output data comprising the known sequence of input symbols after having been affected by crosstalk coupling among the plurality of crosstalking lines in the channel;

83. Rezvani teaches element 1[b]. As discussed above with respect to 1[a], a POSITA would understand that in XDSL systems, modems perform training procedures to measure, calculate, or estimate channel characteristics for optimizing system performance accordingly. *See* Ex. 1001, 1:43-48; Ex. 1005, 2:21-25; Ex. 1007, pp. 98-99; Ex. 1019, 10:13-22. Rezvani teaches that training sequences are injected "into successive ones of the subscriber lines . . . to determine the interference profiles" or "relative interference" of each subscriber line. of Ex. 1005, 18:19-25, 18:44-46. Particularly, after injecting a training sequence of a known sequence of input symbols on selected sub-channels of a selected subscriber line, "interference on the same sub-channels is monitored on the receive path of all of the other lines in the bundle," demonstrating that the symbols are detected in output data on the other lines after having been affected by crosstalk coupling. Ex. 1005, 14:41-47; *see also id.* at 18:34-39. "This is continued until all subscriber lines have performed as both interferer and interferee and the corresponding data accumulated." Ex. 1005, 14:41-47; *see also id.* at 18:39-46. In other words, each selected subscriber line is a primary

line with respect to the remaining plurality of subscriber lines. A POSITA would understand that interference being monitored is the training sequence distorted by the crosstalk coupling between subscriber lines. *See, e.g.*, Ex. 1001, 12:53-67; Ex. 1010, 5-6. And as discussed above, a training sequence is equivalent to "a known sequence of input symbols." Further, a POSITA would understand that the corresponding data that is accumulated from monitoring the interference or crosstalk coupling of the selected subscriber line teaches "acquiring output data from a primary line among the plurality of lines in the channel."

84. Indeed, the '458 patent discloses that the "output data" is acquired in the same way that Rezvani teaches accumulating the "corresponding data" during a training process. For example, the '458 patent explains that NEXT and Hlin values "are obtained by measuring after exciting the respective channels with a known input sequence of symbols, say TRAIN(n,k) . . . and then observing several corresponding channel outputs OUT(n,k)." Ex. 1001, 12:53-67.

1[c]: ordering the crosstalking lines based on a comparison between the known sequence of input symbols used to excite the crosstalking lines and the output data acquired from the primary line;

85. Rezvani alone or Rezvani in view of Cendrillon I teaches element 1[c]. As discussed above with respect to 1[a] and 1[b], Rezvani teaches exciting crosstalking lines by injecting a known training sequence of symbols into each subscriber line at various frequencies. Crosstalk within the other remaining

subscriber lines within a bundle is identified by detecting that same known training sequence of symbols within the output of those remaining subscriber lines. Ex. 1005, 18:32-42. Specifically, it is identified by comparing the training sequence detected in the output against the known training sequence injected into the crosstalking lines. *See* Ex. 1005, 14:30-56, FIG. 6A.

86. Rezvani explains that the interference levels contributed by each crosstalking line can be expressed in terms of a signal strength of the training sequence detected in the output of a primary line at each of the various frequencies. Ex. 1005, 7:23-30. FIG. 6A, reproduced below, illustrates the cumulative levels of interference (in terms of signal strength) that are contributed by lines 206, 210, and 212, at multiple frequences (f_1-f_6) into line 202.

Ex. 1005, FIG. 6A

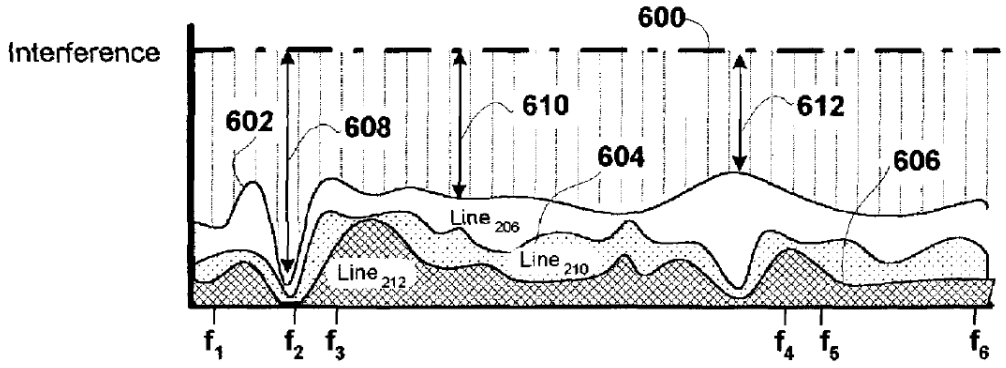


FIG. 6A

87. Rezvani explains that "[o]nce the information is recovered for any given line it [sic] ***the interferer channels can be ranked in order of importance*** within each sub-channel." Ex. 1005, 8:42-45 (emphasis added); *see also id*., 18:32-43, FIG. 12 (illustrated step 1210 states "Monitor all other Channels to rank Interferers and amount."). Rezvani explains that "[a]ll other lines in the bundle inject varying amounts of interference into every other line with which they are bundled" and "[t]he susceptibility of a line to interference from other lines depends on factors including the degree of the electromagnetic coupling between interferor and interferee lines as well as the signal strength of the interferor on each sub-channel." Ex. 1005, 7:23-34. Rezvani's ranking in "order of importance" for a particular subject line thereby characterizes which lines inject the greatest amount of interference into the particular subject line. *See* Ex. 1005, 7:23-57, 8:42-44, FIG. 6A. A POSITA would recognize that the "order of importance" as stated in Rezvani could be determined based on the signal strength of the known training sequence detected in the output of the primary line at each of the various frequencies. *See* Ex. 1005, 7:23-57, 8:42-44, FIG. 6A. For example, a POSITA would recognize that a maximum overall signal strength of the known training sequence detected on the subject line would provide an appropriate mechanism of ordering the "importance"

of each crosstalking line.[4] *See* 1005, 7:23-57, FIG. 6A; Ex. 1006, p. 3; Ex. 1008, p. 1526; Ex. 1009, p. 2011.

88. To the extent it is argued that Rezvani alone does not teach element 1[c], Rezvani in view of Cendrillon I does. Cendrillon I specifically teaches that in DSL systems, "the majority of the crosstalk that a particular user experiences comes from only a few of the other users within the system." Ex. 1006, p. 3. Thus, rather than applying crosstalk cancellation techniques to all crosstalking lines, by selecting only the largest crosstalkers and applying crosstalk cancellation to only those tones or lines, the DSL system can achieve greater performance without the complexity of complete crosstalk cancellation of all crosstalk contributing lines. Ex. 1006, p. 6. For example, in implementing partial crosstalk cancellation Algorithm 1, Cendrillon I explains that "[m]aximizing $SINR_k^n$ and thus rate c_k^n corresponds to minimizing the

[4] I note that this claim limitation does not specify a criterion for "ordering" the crosstalking lines, such as a max function as discussed in the '458 patent specification. *See* Ex. 1001, 9:6-35. However, as mentioned here, Rezvani teaches using signal strength to characterize the interferers, and a POSITA would recognize that "ordering" the interfering lines based on maximum interference signal strength would be a reasonable criterion to use for comparing each of the interfering lines to create a ranked ordering.

amount interference in the set M_k^n. Ex. 1006, pp. 3-4. Cendrillon I then teaches that "to maximize rate c_k^n we simply choose M_k^n ," the subset of lines at the CO when detecting user *n*, "***to contain the largest crosstalkers*** of user *n* on tone *k*, where "the indices of the crosstalkers of user *n* on tone *k* [are] ***sorted in order of crosstalk strength***." Ex. 1006, p. 3 (emphasis added).

1[d]: generating a data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines based on the ordering of the crosstalking lines; and

89. Rezvani alone or Rezvani in view of Cendrillon I teaches 1[d]. As discussed above with respect to 1[a], 1[b], and 1[c], Rezvani teaches calculating and thereby generating an interference matrix that "shows for each sub-channel on each subscriber line the relative interference in terms of noise injected from all other subscriber lines." Ex. 1005, 14:47-51. This interference matrix is a data quantity that represents the crosstalk coupling between the primary line and each of the crosstalking lines. The data included in this matrix is shown graphically in FIG. 6A, which depicts an interference profile of a single subject line from the calculated interference matrix. Ex. 1005, 14:31-49, FIG. 6A. Particularly, FIG. 6A shows the cumulative amount of interference caused by crosstalking lines 206, 210, and 212, expressed in terms of signal strength vs. frequency, that is detected on line k=202 at varying frequencies. Ex. 1005, 7:23-37, FIG. 6A. A POSITA would understand the amount of interference caused by crosstalking Lines 206, 210, and 212 into Line

k=202, shown in FIG. 6A, to be representative of the crosstalk coupling between the primary line (Line k=202) and each of the crosstalking lines (Lines 206, 210, and 212). *See* Ex. 1005 7:23-57, FIG. 6A.

Ex. 1005, FIG. 6A

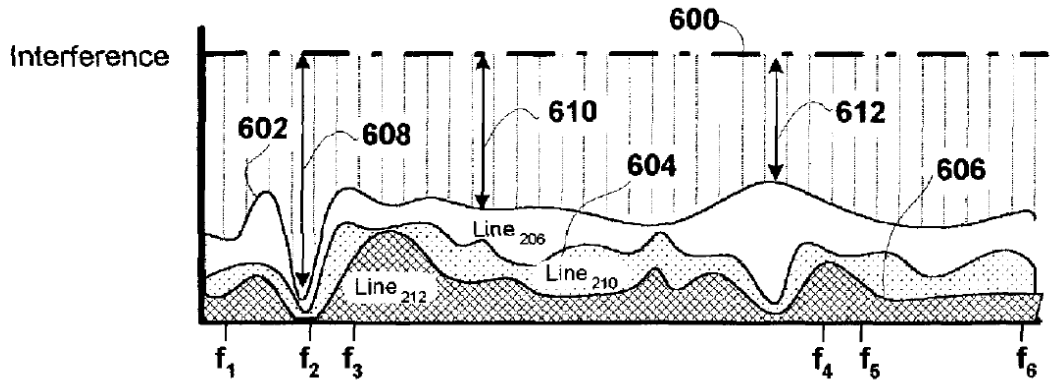


FIG. 6A

90. Further, Rezvani teaches generating the interference matrix "based on the ordering of the crosstalking lines." For example, Rezvani teaches that during the interference determination phase, "the interferer channels can be ranked in order of importance within each sub-channel." Ex. 1005, 8:42-45. As discussed above with respect to 1[c], Rezvani's ranking in "order of importance" for a particular subject line thereby characterizes which lines inject the greatest amount of interference into the particular subject line. *See* Ex. 1005, 7:23-57, 8:42-44, FIG. 6A. Indeed, FIG. 6A of Rezvani shows which lines inject the greatest amount of interference in each sub-channel of a particular subject line k=202. Ex. 1005, FIG. 6A. For example, "in

the sub-channel[] 612 experiencing the highest aggregate interference most of that interference is due to interference from subscriber line 206." Ex. 1005, 7:48-50. A POSITA would recognize that once the "ordering" of importance is determined, this would conveniently be reflected in the interference matrix generated for characterizing the crosstalk interference on a primary line. By incorporating this ordering of crosstalking lines in the interference matrix, the system could implement mechanisms for mitigating crosstalk interference from the most important crosstalk lines (e.g., highest sources of interference).

91. To the extent it is argued that Rezvani alone does not teach 1[c], Rezvani in view of Cendrillon I does. Cendrillon I explains that Equation 1 below is the basic model for all DSM techniques, i.e., for both spectrum coordination and signal coordination. Ex. 1006, p. 1; *see also* Ex. 1008, p. 1521 (showing the same equation, but in matrix format). Equation 1 models crosstalk independently on each tone for N+1 users within the binder group, where "x_k^n and y_k^n denote the symbols transmitted and received, respectively by user *n* on tone *k*," "$h_k^{(n,n)}$ is the direct channel of user *n* at tone *k*," "$h_k^{(n,m)}$ is the crosstalk channel from user *m* into user *n*," and "z_k^n represents the additive noise experienced by user *n* on tone *k*." Ex. 1006, p. 1; Ex. 1008, p. 1521. As shown below, the channel transfer matrix H_k is a data quantity comprising $h_k^{(n,m)}$ values which represent the crosstalk channel from user *m* into user *n*. Moreover, Cendrillon I discusses the benefits of *partial* crosstalk

cancellation focusing on the subset of lines that are, "***the largest crosstalkers*** of user *n* on tone *k*, where "the indices of the crosstalkers of user *n* on tone *k* [are] ***sorted in order of crosstalk strength***." Ex. 1006, p. 3 (emphasis added). To identify the "largest crosstalkers," a POSITA would understand that the crosstalking lines are ordered, and this ordering would be conveniently reflected in the resulting data quantity (e.g., channel transfer matrix), such as by only including values corresponding to the crosstalkers deemed to be the "largest crosstalkers." This would enable Cendrillon I's *partial* crosstalk cancellation techniques to be applied to those "largest crosstalkers" that are represented in the data quantity.

Ex. 1006, p. 1.

$$\mathbf{y}_k = \mathbf{H}_k \mathbf{x}_k + \mathbf{z}_k$$

Ex. 1008, p. 1521, Equation 1.

$$\begin{bmatrix} y_k^1 \\ \vdots \\ y_k^{N+1} \end{bmatrix} = \begin{bmatrix} h_k^{(1,1)} & \cdots & h_k^{(1,N+1)} \\ \vdots & \ddots & \vdots \\ h_k^{(N+1,1)} & \cdots & h_k^{(N+1,N+1)} \end{bmatrix} \begin{bmatrix} x_k^1 \\ \vdots \\ x_k^{N+1} \end{bmatrix} + \begin{bmatrix} z_k^1 \\ \vdots \\ z_k^{N+1} \end{bmatrix},$$

$$\mathbf{y}_k = \mathbf{H}_k \mathbf{x}_k + \mathbf{z}_k. \qquad (1)$$

1[e]: sending instructions to one or more modems communicatively interfaced with the plurality of crosstalking lines in the channel based on the data quantity generated.

92. Rezvani teaches 1[e]. Rezvani teaches that "[t]he current invention manages a bundle of subscriber lines by determining the spectral characteristics, interference profile, and the subscriber requirements associated with each subscriber line" in order to "***set[] the transmission characteristics of each subscriber line accordingly***," such as "bit-loading, PSD mask, and band-plan for each sub-channel on each subscriber line." Ex. 1005, 5:39-46 (emphasis added).

93. Rezvani teaches a series of steps or phases in order to send instructions for revised spectral profile targets to each modem based on the interference matrix (data quantity): a spectral profiling phase, an interference determination phase, a demand determination phase, and a spectral allocation phase. *See* Ex. 1005, 5:39-46. During the spectral profiling phase, the spectrum manager determines the spectral characteristics or profiles of each subscriber line, which are required to determine the revised spectral profile targets. *See* Ex. 1005, 10:37-43. The spectral profiles may be used in the subsequent phases to further revise the new spectral profile targets.

94. For example, the interference determination phase "is designed to allow a more precise allocation of revised spectral profile targets based on detailed co-interference parameters between subscriber lines determined during the interference determination phase." Ex. 1005, 14:33-39. Similarly, during the demand

determination phase, the spectrum manager determines demand profiles "to determine on which subscriber lines additional sub-channels can be dropped and on which subscriber lines band plans can be revised." Ex. 1005, 19:1-4.

95. The allocation phase also relies on the initial spectral profiles to allocate revised spectral profile targets. Ex. 1005, 15:38-47. Notably, "[t]his later determination results directly from the interference parameters determined during the interference determination phase." Ex. 1005, 14:67-15:3. "After all these determinations are made the new spectral profile target parameters are downloaded by the optimizer module of the spectrum manager to the appropriate modules on the transmit path of the DSP." Ex. 1005, 15:47-50. In other words, by downloading the new spectral profile target parameters to the appropriate modules, Rezvani teaches sending instructions to one or more modems to implement the new spectral profile target parameters, which are determined from, for example, the calculated interference matrix.

3. Claim 2: The method of claim 1, wherein the instructions sent to the one or more modems comprise instructions to implement: operational condition values, a maximum data rate limit, upstream transmission frequency band limits, transmit power levels, and coding/latency requirements.

96. Rezvani teaches Claim 2 for at least the reasons discussed with respect to 1[e]. *See supra*, § X.A.2.1[e]. First, it should be noted that the term "***operational condition values***" is not defined in and appears only once in the '458 patent (other

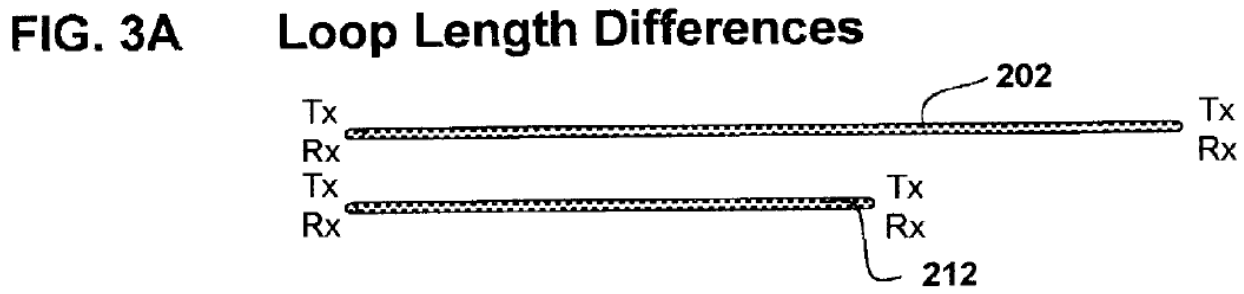
than the claims) when discussing what the instructions may include. Ex. 1001, 14:15-22 ("These instructions may include operational condition values, maximum data rate limits, upstream transmission frequency band limits, compliance instructions or other instructions regarding transmit power levels, coding and latency requirements, etc. The instructions may be generated before or after the controller 510 determines a given line's compliance with any set operational conditions in the communication system."). However, the '458 patent broadly describes "operational data" as data relating to two or more DSL lines that is used to enhance system performance and "may include such data as is normally available from a DSL or other communication systems during normal operation," or "data specifically requested, prompted and/or ordered by the controller for use in connection with the present invention." Ex. 1001, 3:61-64, 4:24-39. Additionally, "operational data may relate to measurements and/or values obtained from a DSLAM, ONU/LT device, RT device or any other suitable component in the DSL system." Ex. 1001, 13:19-22; *see also id.* at 8:10-12 ("Various types of operational data and/or information available from an ADSL NMS can be found therein; others may be known to those skilled in the art."). As such, a POSITA would understand that the broadest reasonable interpretation of "operational condition values" would include measurements or values indicative of channel conditions of two or more DSL lines during operation.

97. Rezvani teaches sending instructions to one or more modems to implement "***operational condition values***." Rezvani teaches a series of steps or phases to send instructions for revised spectral profile targets or parameters to each modem. *See* Ex. 1005, 5:39-46. The parameters downloaded may include, for example, gain tables. *See, e.g.*, Ex. 1005, 15:8-11, 15:53-55, 17:25-27. Rezvani further teaches that "[w]hen a change in gain table for a particular channel is called for the core processor sends instructions regarding the change in the header of the device packet for that channel . . . and writes the new gain table to a memory which can be accessed by the appropriate module in the receive path." Ex. 1005, 12:16-21. Thus, a POSITA would understand that sending instructions to implement gain tables teaches sending instructions to implement "operational condition values."

98. Rezvani further teaches sending instructions to one or more modems to implement "***a maximum data rate limit***." As discussed above, Rezvani teaches sending instructions for implementing transmission characteristics, such as the band plan for each sub-channel on each subscriber line. Ex. 1005, 5:39-46. More specifically, Rezvani teaches that the spectrum manager "determines both the initial spectral characteristics of a line as well as interference profiles between lines, in order to efficiently allocate one or more of the following: bit-loading, PSD mask and band plans for each subscriber line to maximize dataflow through the bundle of subscriber lines." Ex. 1005, 7:52-57. The initial spectral characteristics may include,

for example, loop length. Ex. 1005, 13:53-59. In this regard and with respect to FIG. 3A, a POSITA would understand that transmissions from the shorter line 121 may interfere with transmissions from the longer line 202. *See* Ex. 1005, 5:47-6:7, FIG. 3A. Thus, it would be obvious to a POSITA that setting a maximum data rate limit for the shorter line 121 would mitigate interference from shorter line 121 into longer line 202. *See* Ex. 1005, 5:47-6:7.

Ex. 1005, FIG. 3A



99. Rezvani further teaches sending instructions to one or more modems to implement "***upstream transmission frequency band limits***." As discussed above, Rezvani teaches sending instructions for implementing transmission characteristics, such as bit-loading or revised band plans for each sub-channel on each subscriber line. Ex. 1005, 5:39-46. Rezvani further teaches that the spectrum manager may implement revised band plans providing high frequency sub-channels dedicated to upstream communications. *See* Ex. 1005, 9:41-54. A POSITA would understand that these (revised) band plans of Rezvani teach "upstream transmission frequency band limits."

100. Rezvani further teaches sending instructions to one or more modems to implement "***transmit power levels***." As discussed above, Rezvani teaches sending instructions for implementing transmission characteristics, such as PSD masks for each sub-channel on each subscriber line. Ex. 1005, 5:39-46. More specifically, Rezvani teaches that the spectrum manager "determines both the initial spectral characteristics of a line as well as interference profiles between lines, in order to efficiently allocate one or more of the following: bit-loading, PSD mask and band plans for each subscriber line to maximize dataflow through the bundle of subscriber lines." Ex. 1005, 7:52-57. Rezvani further teaches that the "PSD mask for each subscriber line" "***sets the maximum transmit power*** for each of the sub-channels." Ex. 1005, 5:8-10 (emphasis added). Thus, it would be obvious to a POSITA that Rezvani teaches sending instructions to implement "transmit power levels." *See* Ex. 1005, 9:37-48.

101. Rezvani further teaches sending instructions to one or more modems to implement "***coding/latency requirements***." First, it should be noted that the "coding/latency requirements" are not defined in and appear only once in the '458 patent (other than the claims) when discussing what the instructions may include. Ex. 1001, 14:15-22 ("These instructions may include operational condition values, maximum data rate limits, upstream transmission frequency band limits, compliance instructions or other instructions regarding transmit power levels, coding and latency

requirements, etc."). However, Rezvani discloses that "various forms of forward error correction (FEC)" are known techniques for addressing interference. Ex. 1005, 2:10-13. A POSITA would understand that using FEC includes specifying a latency requirement, specifically a maximum latency. This is also demonstrated by G.992.3, which specifies maximum latency and maximum overhead for transmissions on DSL lines. *See, e.g.*, Ex. 1007, pp. 257, 271, 279. Thus, it would be obvious to a POSITA that specifying a maximum latency requirement teaches sending instructions to implement coding/latency requirements.

4. Claim 4: The method of claim 1, wherein the output data from the primary line is collected over time on a periodic basis.

102. Rezvani teaches Claim 4 for at least the reasons discussed with respect to 1[b]. *See supra*, § X.A.2.1[b]. As discussed above with respect to limitation 1[b], Rezvani teaches collecting output data from the selected subscriber line during the interference determination phase. Ex. 1005, 14:31-51. Rezvani further teaches that the interference determination phase, among others, "may be carried out on initialization of the first and subsequent subscriber lines, as well as after all lines have been initialized and have entered showtime." *See* Ex. 1005, 21:28-31. In other words, Rezvani teaches that output data may be acquired on initialization and during showtime. Additionally, Rezvani teaches that subscriber lines may be re-initialized, also referred to as "spectral optimization," which "may be iterated until data rates on each of the subscriber lines have reached a maximum." Ex. 1005, 14:28-30.

Rezvani further explains that "each module in the receive path [of the DSP] can execute independently of the other at the appropriate time whatever actions are required of it." Ex. 1005, 12:25-29. Thus, Rezvani teaches that the training data can be injected into tones on crosstalking lines and detected and collected in output data periodically over time during initialization and showtime. A POSITA would also understand that iterating spectral optimization and/or performing it at the appropriate time means that output data may be collected periodically. Thus, Rezvani renders obvious that "the output data from the primary line is collected over time on a periodic basis."

5. Claim 5: The method of claim 1, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) that is a decibel-magnitude value representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.

103. Rezvani alone or Rezvani in view of Cendrillon I teaches Claim 5 for at least the reasons discussed with respect to 1[d]. *See supra*, § X.A.2.1[d].

104. Rezvani is directed to "dynamic spectrum management" or "DSM" of bundled subscriber lines. *See* Ex. 1005, 4:23-43; *see also id.* at 4:35-43 ("The multi-line dynamic spectral management methods and apparatus described and discussed in the following description can be used to optimize data flow to meet subscriber requirements on any of the subscriber line bundles . . . to extend the reach of the high

speed data path."). Specifically, the spectrum manager uses the spectral profile, interference profiles, and/or demand profiles to "dynamically allocate[] spectrum to each subscriber line in a bundle." Ex. 1005, 17:7-10. A POSITA would understand that Rezvani (mainly) teaches spectrum coordination or DSM Level 2. *See* Ex. 1005, 4:23-43. Moreover, Rezvani also teaches that the interference matrix, which represents "for each sub-channel on each subscriber line the relative interference in terms of noise injected from all other subscriber lines" is used for "cross channel interference techniques or less granular energy balancing techniques." Ex. 1005, 8:46-48. Thus, a POSITA would understand that the interference matrix is a DSM-data quantity that Rezvani indicates can be used for either DSM Level 2 techniques (energy balancing techniques) or DSM Level 3 techniques (cross channel interference techniques). In this regard, while the '458 patent states that Xlog is typically compliant with DSM Level 3, "Xlog is also useful is DSL systems with level 2 spectrum balancing, band preference, or OSM (Optimum Spectrum Management, also referred to as Optimum Spectrum Balancing—OSB)." Ex. 1001 at 8:28-36; *see also id.* at 8:42-43 ("Xlog may also be reported and of use in Level 2 DSM."); 2:63-54 ("Xlog(u,n) quantity can be used in jointly determining spectra, even when no crosstalk cancellation is used in a given system."). Accordingly, it would be obvious to a POSITA that the interference matrix is a DSM-data quantity.

105. Further, FIG. 6A of Rezvani teaches the data quantity Xlog(u,n), where *u* is the crosstalking line index and *n* is the subcarrier index. FIG. 6A of Rezvani depicts the calculated interference matrix "expressed in terms of signal strength vs. frequency which are injected into a subscriber line from each of the other subscriber lines in the bundle." Ex. 1005, 18:42-43, 14:47-49, 7:23-26, FIG. 6A. In other words, FIG. 6A shows the cumulative interference from all other crosstalking subscriber $Line_{1..N}$ ("u") at subcarriers or frequencies f_1-f_6 ("n") on a subject line. Ex. 1005, 18:42-43, 14:47-49, 7:23-26, FIG. 6A. Additionally, a POSITA would understand that signal coordination requires knowledge of Xlin values, whereas spectrum coordination only requires knowledge of the magnitude of the Xlin values, which is equivalent to knowing the Xlog values. *See* Ex. 1001, 2:63-54 ("Xlog(u,n) quantity can be used in jointly determining specra [spectrum coordination], even when no crosstalk cancellation [signal coordination] is used in a given system."); *see also* Ex. 1006, p. 3, Equation 4 (showing squared magnitudes of $h_k^{(n,m)}$); Ex. 1011, p. 6, Equation 6 (same). However, because Xlin values are complex values (*see* Ex. 1001, 10:37-41; Ex. 1001, 10:55-57), a POSITA would understand that representations of these values could be plotted graphically (e.g., as shown in Rezvani's FIG. 6A) by squaring the magnitude of these values to demonstrate a magnitude of power from crosstalk interference. *See* Ex. 1006, p. 3, Equation 4 (showing squared magnitudes of $h_k^{(n,m)}$); Ex. 1011, p. 6, Equation 6 (same). Thus, because FIG. 6A shows the

cumulative interference from all other subscriber lines on a subject line, a POSITA would understand that FIG. 6A teaches the Xlin data quantity. Moreover, a POSITA would be familiar with using logarithmic scales in DSL. *See e.g.*, Ex. 1006, pp. 4-5; Ex. 1007, pp. 92-93. Accordingly, because Xlog is the logarithmic equivalent of Xlin, it would be obvious to a POSITA to convert FIG. 6A into logarithmic form and thus generate Xlog(u,n).

106. Moreover, a POSITA would understand that the interference signal strength is likely expressed in a decibel level magnitude, specifically using units dBm/Hz or dBmW/Hz (decibel-milliwatts), which is an absolute unit of power level expressed using a logarithmic decibel (dB) scale respective to one milliwatt (mW). FIG. 11C further supports this understanding, which "indicat[es] power levels in each sub-channel 1134-1138 covered by the PSD mask," in terms of the power spectral density dBm/Hz. *See* Ex. 1005, 17:39-42, FIG. 11C. Thus, a POSITA would understand that the interference matrix of Rezvani teaches a quantity Xlog(u,n) that is a decibel-magnitude value representative of the extent of crosstalk coupling

associated with each of the crosstalking lines and the primary line within the channel.[5]

107. To the extent it is argued that Rezvani alone does not teach Claim 5, Rezvani in view of Cendrillon I does. As noted above, a POSITA would understand that signal coordination requires knowledge of Xlin values, whereas spectrum coordination only requires knowledge of the magnitude of the Xlin values, which is equivalent to knowing the Xlog values. *See* Ex. 1001, 2:63-54 ("Xlog(u,n) quantity can be used in jointly determining specra [spectrum coordination], even when no crosstalk cancellation [signal coordination] is used in a given system."); *see also* Ex. 1006, p. 3, Equation 4 (showing squared magnitudes of $h_k^{(n,m)}$); Ex. 1011, p. 6, Equation 6 (same). Cendrillon I teaches Equation 1 below, which is a condensed version of Equation 1 in Cendrillon II (Ex. 1008, p. 1521) is the basic model for all DSM techniques, i.e., for both spectrum coordination and signal coordination. *See*

[5] I note that the specification defines Xlog(u,n) as a power ratio reciting specific loading on a line u and is a description of the decibel-magnitude value representative of the extent of crosstalk coupling, likely under specific test conditions. Rezvani's interference matrix provides the same information, calculated under any conditions (including a system operating under the conditions reflected in the '458 patent at 8:65-9:5).

Ex. 1006, p. 1. As indicated below and as further explained in Cendrillon II (Ex. 1008, p. 1521), Equation 1 models crosstalk independently on each tone for N+1 users, where "x_k^n and y_k^n denote the symbols transmitted and received, respectively by user *n* on tone *k*," "$h_k^{(n,n)}$ is the direct channel of user *n* at tone *k*," "$h_k^{(n,m)}$ is the crosstalk channel from user *m* into user *n*," and "z_k^n represents the additive noise experienced by user *n* on tone *k*." Ex. 1006, p. 1; Ex. 1008, p. 1521.

Ex. 1006, p. 1, Equation 1.

$$\mathbf{y}_k = \mathbf{H}_k \mathbf{x}_k + \mathbf{z}_k$$

Ex. 1008, p. 1521, Equation 1.

$$\begin{bmatrix} y_k^1 \\ \vdots \\ y_k^{N+1} \end{bmatrix} = \begin{bmatrix} h_k^{(1,1)} & \cdots & h_k^{(1,N+1)} \\ \vdots & \ddots & \vdots \\ h_k^{(N+1,1)} & \cdots & h_k^{(N+1,N+1)} \end{bmatrix} \begin{bmatrix} x_k^1 \\ \vdots \\ x_k^{N+1} \end{bmatrix} + \begin{bmatrix} z_k^1 \\ \vdots \\ z_k^{N+1} \end{bmatrix},$$

$$\mathbf{y}_k = \mathbf{H}_k \mathbf{x}_k + \mathbf{z}_k. \qquad (1)$$

108. A POSITA would understand that Equation 1 of Cendrillon I (Ex. 1006) teaches the quantity Xlin(u,n). *See, e.g.*, Ex. 1001, 9:43-49 (stating that Xlin(u,n) is the linear crosstalk insertion-loss equivalent of Xlog(u,n) and "is analogous to the Hlin[n] specified in Section 6.3.1.1 of the referenced DSM Report and in ADSL2/2+(and likely VDSL2)"). For example, with respect to $h_k^{(n,m)}$ within channel matrix H_k, if Line 1 is the primary subject line, a POSITA would understand

that Xlin(u,n) (with tone index n and interferers u=1…U) corresponds to the $h_k^{(1,m)}$ values in the first row of channel matrix H_k (with tone index k, and reordered interferers m=2…N+1). *See* Ex. 1006, p. 1; Ex. 1008, p. 1521. In fact, the first row of channel matrix H_k here equivalent to the data in Rezvani's interference matrix, albeit for a single frequency (corresponding to tone k). *See* Ex. 1006, p. 1; Ex. 1008, p. 1521; Ex. 1005, FIG. 6A. Thus, a POSITA would understand that channel matrix H_k of Cendrillon I teaches Xlin(u,n), and like the interference matrix of Rezvani, is representative of the extent of the crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.

109. Further still, a POSITA would understand that for spectrum coordination, only the real-valued magnitudes of $h_k^{(n,m)}$ are needed, i.e., $|h_k^{(n,m)}|$. *See* Ex. 1001, 2:63-54 ("Xlog(u,n) quantity can be used in jointly determining spectra [spectrum coordination], even when no crosstalk cancellation [signal coordination] is used in a given system."); *see also* Ex. 1006, p. 3, Equation 4 (showing squared magnitudes of $h_k^{(n,m)}$); Ex. 1011, p. 6, Equation 6 (same). Moreover, it would be obvious to a POSITA that the real-valued magnitudes $|h_k^{(n,m)}|$ can be converted to logarithmic form to reduce the dynamic range of the real-valued magnitudes $|h_k^{(n,m)}|$, which allows for a more compact representation and reduces storage requirements (i.e. with fewer bits). *See* Ex. 1007, pp. 92-93; Ex. 1001, 2:63-

54 ("Xlog(u,n) quantity can be used in jointly determining spectra, even when no crosstalk cancellation is used in a given system."); *see also id.* at 9:44-55 (describing Xlin(u,n) as the linear equivalent of Xlog(u,n) and that the logarithmic magnitude Xlog (u, n) is "derived"). Thus, by converting the real-valued magnitudes $|h_k^{(n,m)}|$ into logarithmic form, a POSITA would understand that Cendrillon I, alone or in combination with Rezvani, teaches a quantity "Xlog(u,n) that is a decibel-magnitude value representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.

6. *Claim 7: The method of claim 5, wherein the DSM-data quantity Xlog(u,n) is specified during a diagnostics mode, an initialization mode, or during both the diagnostics and the initialization mode.*

110. Rezvani teaches Claim 7 for at least the reasons discussed with respect to Claim 5. *See supra*, § X.A.5.

111. Rezvani teaches that the interference matrix is calculated during the interference determination phase. *See* Ex. 1005, 18:9-11. As discussed above, training sequences are injected into each subscriber line, the resulting crosstalk is monitored, and the corresponding data is used to generate a DSM-data quantity, specifically the interference matrix. *See* Ex. 1005, 18:28-46. While Rezvani may contemplate that the training process of the interference determination phase occurs after initialization, a POSITA would understand that the initialization phase may include several processes including training and channel measurement. *See* Ex.

1005, 2:21-25 ("Aggregate subscriber line approaches involve vector cancellation applied to all the subscriber lines in a bundle ***with the training*** necessary to calculate vectors accomplished ***during the initialization of all lines***."); Ex. 1001, 9:38-40 ("Nominally, advanced modems using a capability like Xlog would be expected to know (for example, via a training procedure) the input level of the other line."). Indeed, Rezvani teaches that "[t]he processes [of FIG. 12] discussed above ***may be carried out on initialization*** of the first and subsequent subscriber lines, ***as well as after all lines have been initialized and have entered showtime***." Ex. 1005, 21:28-31 (emphasis added). Thus, to the extent that Rezvani does not teach that the interference determination phase occurs during initialization, it would be obvious to a POSITA to modify the process of Rezvani such that the interference matrix is calculated during initialization. Thus, Rezvani teaches specifying the DSM-data quantity Xlog(u,n) (the interference matrix) during an initialization mode.

112. Relatedly, Rezvani further teaches that "[t]he spectrum manager may determine the spectral profile from a number of parameters provided by the modems. The modems may provide the relative lengths of each of the subscriber lines based either on bit loading levels in each of the sub-channels or on an actual comparison of transmit and receive power levels and the attenuation of same across the entire spectrum." Ex. 1005, 17:57-63. Notably, "[e]ither of these parameters are already part of the existing X-DSL specifications and are exchanged between modem pairs

during initialization." Ex. 1005, 17:63-65 (emphasis added). Further, Rezvani teaches that additional parameters used to determine the spectral profile include interference levels and noise margins. Ex. 1005, 17:21-27, FIG. 11A. From these disclosures, a POSITA would understand that the initial bit-loading, power level ratios, interference levels, and/or noise margins are specified during initialization. Thus, it would be obvious to a POSITA that Rezvani teaches the DSM-data quantity Xlog(u,n) is specified during an initialization mode.

7. Claim 9

9[a]: The method of claim 1, wherein the output data further comprises far-end crosstalk (FEXT) and/or near-end crosstalk (NEXT) transfer functions between the primary line and each of the crosstalking lines; and

113. Rezvani alone or Rezvani in view of Cendrillon I teaches 9[a] for at least the reasons discussed with respect to 1[b] and Claim 5. *See supra*, §§ X.A.2.1[b], X.A.5.

114. As discussed above with respect to 1[b], Rezvani teaches that during the interference determination phase, training sequences are injected into each subscriber line at various tones, and the resulting crosstalk on the remaining subscriber lines is monitored and output data is detected on the receive paths of the remaining subscriber lines. Ex. 1005, 14:41-47; *see also id.* at 18:34-39. Using this data, an interference matrix is generated for each primary line that shows interference levels contributed by each interfering line at each of the plurality of

frequencies. Ex. 1005, 7:23-50. Rezvani further teaches that the resulting interference matrix (an example of which is depicted in FIG. 6A) shows the interference signal strength as a function of frequency. *See* Ex. 1005, 8:44-45 ("A complete interference matrix as a function of frequency can be constructed."); *see also id.* at FIG. 6A. A POSITA understands that in DMT transmissions, evaluating interference at a particular frequency or subcarrier corresponds to evaluating the interference transfer function at the particular frequency or subcarrier. *See* Ex. 1005, 1:52-64, 14:49-51, FIG. 6A. Thus, a POSITA would understand that the output data, as well as the resulting interference matrix, is representative of transfer functions that reflect crosstalk (including NEXT and FEXT that are a part of the interference between bundled lines) affecting subscriber lines in a bundle. *See* Ex. 1005, 6:33-60, 14:31-53. Ex. 1006, pp. 1, 2.

115. Cendrillon I similarly describes that FEXT is one type of crosstalk reflected in the output data and the resulting interference matrix Ex. 1006, p. 1. Figure 1 of Cendrillon I (shown below) is a plot of crosstalk transfer functions, and more particularly FEXT transfer functions $h(1,2)$, $h(1,3)$, and $h(1,4)$, indicating the decibel-magnitude value of the transfer function at varying frequencies. *See* Ex. 1006, pp. 2, 6, FIG. 1.

Ex. 1006, p. 6, FIG. 1.

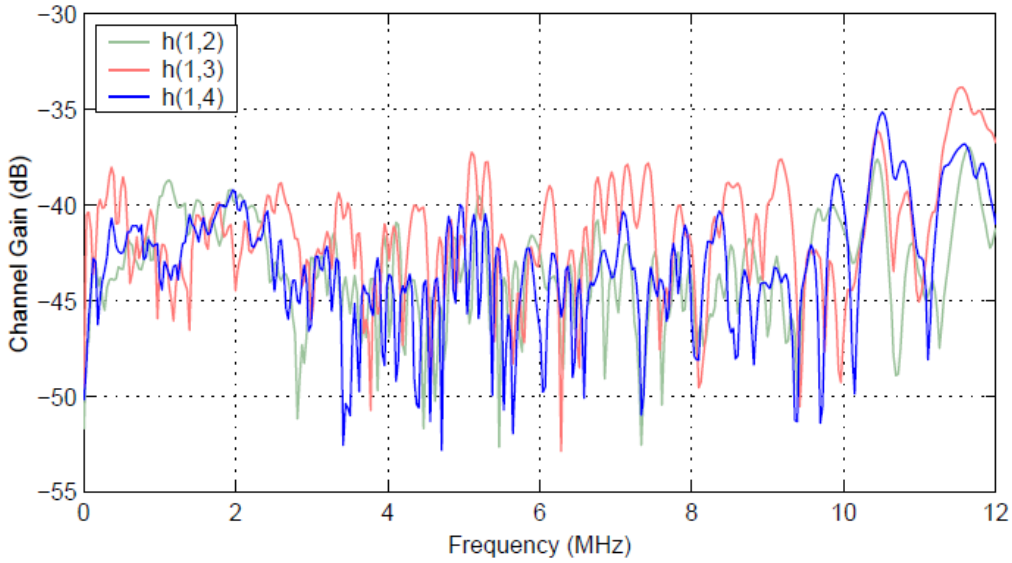


Fig. 1. FEXT Transfer Functions for 0.5 mm British Telecom Cable

116. Moreover, a POSITA would understand that the transfer functions allow a transmitter and/or a receiver to implement crosstalk cancellation or other mitigation techniques and so those transfer functions would be provided to the far-end management entity, for example, as a part of output data. *See* Ex. 1005, 2:9-25 (describing "current solutions to interference" to enable a receiver to separate data from the noise); Ex. 1006, p. 5 (explaining that "all DSL lines [may] be served from a single DSLAM which may centralize crosstalk cancellation into a single module"). Indeed, Rezvani teaches that by monitoring crosstalk (output data) during the interference determination phase, the spectrum manager is provided "detailed co-interference parameters between subscriber lines" and calculates an interference matrix representative of those interference parameters. Ex. 1005, 14:31-51.

9[b]: further wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) that is a decibel-magnitude value of the insertion loss equivalent of the FEXT and/or NEXT transfer functions.

117. Rezvani alone or Rezvani in view of Cendrillon I teaches 9[b] for at least the reasons discussed with respect to 1[d], Claim 5, and 9[a]. *See supra*, §§ X.A.2.1[d], X.A.5, X.A.7.9[a].

118. As discussed above with respect to Claim 5, "multi-line dynamic spectral management methods" may include determining an interference matrix representing for each tone on each subscriber line the interference level from each of the other subscriber lines. Rezvani discloses a DSM-data quantity Xlog(u,n), specifically, an interference matrix generated for each primary line that represents the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line. That interference matrix is a transfer function that can reflect both FEXT and NEXT interference that are a part of the total interference between DSL lines in a bundle. *See* Ex. 1005, 6:33-60, 14:31-53. Ex. 1006, pp. 1, 2.

119. Similarly, Cendrillon I teaches that FEXT is one type of crosstalk. Ex. 1006, p. 1. Figure 1 of Cendrillon I is a plot of crosstalk transfer functions, and more particularly FEXT transfer functions $h(1,2)$, $h(1,3)$, and $h(1,4)$, indicating the decibel-magnitude value of the channel gain at varying frequencies. *See* Ex. 1006, pp. 2, 6, FIG. 1.

Ex. 1006, p. 6, FIG. 1

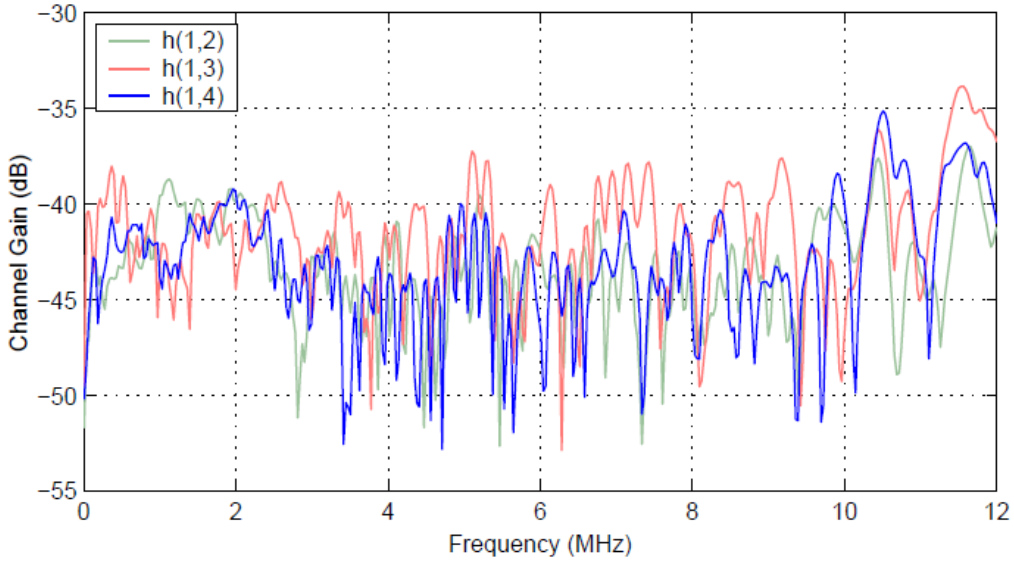


Fig. 1. FEXT Transfer Functions for 0.5 mm British Telecom Cable

8. ***Claim 10: The method of claim 1, wherein the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises a Dynamic Spectrum Management data (DSM-data) quantity Xlin(u,n) that is representative of the extent of crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel.***

120. Rezvani alone or Rezvani in view of Cendrillon I teaches Claim 10 for at least the reasons discussed with respect to 1[d] and Claim 5. *See supra*, §§ X.A.2.1[d], X.A.5.

9. *Claim 12: The method of claim 1, wherein transmit signals on the plurality of lines are co-generated with a common clock and processor at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system.*

121. Rezvani alone or Rezvani in view of Cendrillon I teaches Claim 12 for at least the reasons discussed with respect to Claim 1. *See supra*, § X.A.2.

122. Referring to FIGs. 8A and 8B, Rezvani teaches that a spectrum manager is included in or coupled to logical modem 800 and modem set 864, respectively, and couples the modems to communication network 164. Ex. 1005, FIGs. 8A, 8B. Rezvani further teaches that the modems may include "[a] digital signal processor (DSP) 802 [that] communicates via a packet based bus 818 with the AFEs 820, 824 to send and receive data across the corresponding subscriber lines." Ex. 1005, 10:31-34; *see also id.* at 10:26-29 ("Each logical modem includes ***a common digital signal processor*** driving multiple analog and hybrid front ends (AFEs) and (HFEs) respectively."). "The DSP includes in addition to transmit and receive path components 804, 810, 814, 816 a spectrum manager 812 which couples to the transmit and receive paths. The spectrum manager determines the spectral profile of each line, may also determine the interference profile and subscriber demand profile for each line and from one or more of these datum determines how best to optimize the spectrum accorded to each subscriber line in the bundle including: dropping or adding sub-channels, altering PSD masks, and or band plans." Ex. 1005, 10:34-43; *see also id.* at 13:46-50 ("The spectrum manager 812 . . . interfaces with and manages

the spectral profiles of all subscriber lines driven by the DSP 802 through associated AFE, HFE pairs 820-822 and 824-826."). In some embodiments, "the overall operation [is] controlled solely by spectrum manager 812 within modem 800 which might for example be located at a Central Office at which access to all the lines of a bundle is practicable." Ex. 1005, 10:49-54. "This device architecture allows the DSP transmit and receive paths to be fabricated as independent modules or sub modules which respond to packet header control information for processing of successive packets with different XDSL protocols, e.g. a packet with ADSL sample data followed by a packet with VDSL sampled data." Ex. 1005, 12:30-36; *see also id.* at 12:48-50 ("On the downstream side (Transmit path) the same architecture applies."). Thus, it would be obvious to a POSITA that the spectrum manager of a common DSP, located at the central office, co-generates transmit signals using a ***common processor*** "at a Digital Subscriber Line Access Multiplexer (DSLAM) end of the DSL system."

123. To the extent it is argued that Rezvani does not teach Claim 12, Rezvani in view of Cendrillon I does. Cendrillon I teaches that "crosstalk can be modeled independently on each tone" "[t]hrough synchronized transmission." Ex. 1006, p. 1. Moreover, "crosstalk cancellation of all lines in a binder [can be] integrated into a single processing module at the CO." Ex. 1006, p. 5. "Then all DSL lines will be served from a single DSLAM which may centralize crosstalk cancellation into a

single module." Ex. 1006, p. 5. Thus, in order to have synchronized transmissions from a single DSLAM, it would be obvious to a POSITA that the DSLAM would include a ***common clock*** and processor. Moreover, if all lines are served from a single DSLAM, then it would be obvious to a POSITA that the DSLAM co-generates transmit signals on the DSL lines.

10. *Claim 14: The method of claim 1, wherein the plurality of crosstalking lines are allocated to a single customer.*

124. Rezvani teaches Claim 14 for at least the reasons discussed with respect to Claim 1. *See supra*, § X.A.2. It is worth noting that the '458 patent does not define the phrase "a single customer." A POSITA would understand "a single customer" to mean either a single user or a single entity that contracts with a DSL service provider. Referring to FIG. 1, Rezvani teaches that a subscriber line bundle 158 bundling a plurality of subscriber lines connects Office 156 to Remote Terminal 160 and thus central office 124. Ex. 1005, 4:23-33, FIG. 1. Thus, it would be obvious to a POSITA that Rezvani teaches that the plurality of subscriber lines of subscriber line bundle 158 can be allocated to a single customer or entity, i.e., Office 156. *See* Ex. 1005, 4:23-33, FIG. 1. Further, a POSITA would be familiar with bonded-DSL systems, in which several DSL lines are multiplexed to form a single high-speed connection. *See* Ex. 1011, p. 3. Thus, to the extent Rezvani does not teach allocating the plurality of crosstalking lines to a single customer, it would have been obvious that the

plurality of crosstalking lines could be bonded into a single high-speed connection for a single customer. *See* Ex. 1005, 2:36-39; Ex. 1011, p. 3.

11. *Claim 15: The method of claim 14, wherein generating the data quantity representative of the crosstalk coupling between the primary line and each of the crosstalking lines comprises generating a Dynamic Spectrum Management data (DSM-data) quantity Xlog(u,n) representing line transfer functions between crosstalking line u and the primary line at a subcarrier index n.*

125. Rezvani alone or Rezvani in view of Cendrillon I teaches Claim 15 for at least the reasons discussed with respect to Claims 1, 5, and 14. *See supra*, §§ X.A.2, X.A.5, X.A.10. While Rezvani and Cendrillon I teach that the quantity Xlog(u,n) is representative of crosstalk coupling between crosstalking line *u* and the primary line at a subcarrier index *n*, I note that the language of Claim 15 is not identical to Claim 5. However, to the extent Claim 15 classifies Xlog(u,n) as a line transfer function, a POSITA understands that in DMT transmissions, evaluating interference at a particular frequency or subcarrier corresponds to evaluating the interference transfer function at the particular frequency or subcarrier. *See* Ex. 1005, 1:52-64, 14:49-51, FIG. 6A.

B. Ground 2: Claim 11 is rendered obvious over Rezvani in view of Cendrillon I and G.992.3.

126. Rezvani in view of Cendrillon I and G.992.3 teaches all of the limitations of Claim 11.

1. Motivation to combine.

127. A POSITA would have been motivated to modify Rezvani with the teachings of Cendrillon I as discussed above, specifically to apply partial crosstalk cancellation methods such as those discussed in Cendrillon I to Rezvani's DSL system to thereby improve signaling on DSL lines with improved efficiency over complete crosstalk cancellation. *See* Ex. 1005, 8:44-48; Ex. 1006, p. 6. A POSITA would have been motivated to further modify Rezvani to incorporate the teachings of G.992.3 to utilize known transfer function formatting for channel characterization. *See* Ex. 1005, 1:42-64, 2:10-25; Ex. 1006, p. 6, FIG. 1; Ex. 1007, pp. 92-94; Ex. 1016. Rezvani recognizes several XDSL standards, including ADSL and VDSL standards (among others) (Ex. 1005, 1:42-54), and teaches that the specific architecture of the DSP (digital signal processor) allows for "processing of successive packets with different XDSL protocols, e.g., a packet with ADSL sample data followed by a packet with VDSL sampled [sic] data." Ex. 1005, 12:30-46, FIG. 9. Therefore, a POSITA would have considered relevant portions of XDSL standards, including ADSL2 as reflected in G.992.3, when implementing the methodology disclosed by Rezvani. A POSITA would have reviewed the standardized transfer function formats (specifically Hlog(f) and Hlin(f)) for line characterization provided in G.992.3. *See* Ex. 1005, 1:42-64, 2:10-25; Ex. 1007, pp. 92-94. Moreover, a POSITA would have been motivated to use the known transfer

function formats of Hlin(f) and Hlog(f) for representing channel characteristics as discussed in G.992.3 to characterize crosstalk interference in the form of interference matrices. *See* Ex. 1005, 1:42-64, 2:10-25, 8:44-48, 14:49-51; Ex. 1006, pp. 5-6, FIG. 1; Ex. 1007, pp. 92-94. Specifically, G.992.3 has already demonstrated that this formatting is effective for conveying line characteristic data. *See* Ex. 1007, pp. 92-94. Thus, a POSITA would know to use the same format for characterizing crosstalk interference from multiple crosstalking lines, when applying known mitigation techniques (e.g., those taught by Rezvani in view of Cendrillon I) to address crosstalk interference. *See* Ex. 1005, 1:42-64, 2:10-25, 8:44-48, 14:49-51; Ex. 1006, pp. 5-6, FIG. 1; Ex. 1007, pp. 92-94; Ex. 1011; Ex. 1016.

128. Moreover, a POSITA would have been further motivated to modify Rezvani based on the teachings of G.992.3 because utilizing transfer functions that have a known and standardized format, such as those specified in G.992.3, offers efficient data storage. *See* Ex. 1005, 1:42-64, 2:10-25, 2:36-49; Ex. 1006, pp. 1-2, 6, FIG. 1; Ex. 1007, pp. 92-94; Ex. 1016.

129. A POSITA would have had a reasonable expectation of success of combining Rezvani's teachings (as modified in view of Cendrillon I) with G.992.3's discussion of channel characteristics, because each of Rezvani's and Cendrillon I's transfer functions are described in a manner analogous to those of Hlog and Hlin as discussed in G.992.3. *See* Ex. 1005, 6:33-60, 7:23-50, FIG. 6A; Ex. 1006, pp. 1, 5-

6, FIG. 1; Ex. 1008, p. 1521 (Equation 1); Ex. 1009, p. 2007. Moreover, Rezvani recognizes several XDSL standards, including ADSL and VDSL standards (among others) (Ex. 1005, 1:42-54), and those standards are presented to improve communications according to those standards. *See* Ex. 1005, 2:36-39; Ex. 1006, p. 1; Ex. 1007, pp. 1-2. Thus, a POSITA looking to those standards would have had a reasonable expectation of success of combining Rezvani's teachings (as modified in view of Cendrillon I) with G.992.3 because POSITAs are already familiar with the transfer function formats specified in G.992.3 to represent channel characteristics (or signal degradation generally on a primary line), and those formats accommodate data quantities reflecting crosstalk interference from multiple crosstalking lines at multiple frequencies. *See* Ex. 1005, 1:42-64, 2:10-25, 8:44-48, 14:49-51; Ex. 1006, pp. 5-6, FIG. 1; Ex. 1007, pp. 92-94. And because G.992.3 has already demonstrated that this formatting is effective for conveying line characteristic data, a POSITA would have a reasonable expectation of success in using those formats for characterizing crosstalk. *See* Ex. 1005, 1:42-64, 2:10-25, 2:36-49; Ex. 1006, pp. 1-2, 6, FIG. 1; Ex. 1007, pp. 92-94; Ex. 1016. Therefore, Rezvani's teachings (even as modified in light of Cendrillon I) are presented to optimize system performance while utilizing known transfer function formats specified in relevant xDSL standards, including ADSL2 reflected in G.992.3.

2. Claim 11

11[a]: The method of claim 10, wherein Xlin(u,n) is represented in a linear format by a scale factor scale(u) and a normalized complex number a(u,n)+j*b(u,n), where n is a subcarrier index n=0, . . . , NSC, wherein NSC is a number of carriers used, u is an index of a line transfer function between a one of the crosstalking lines and the primary line, and further wherein a(u,n) and b(u,n) are coded as 16-bit 2's complement signed integers, and

130. Rezvani in view of Cendrillon I and G.992.3 teaches 11[a] for at least the reasons discussed with respect to 1[c], 1[d], and Claims 5 and 10. *See supra*, §§ X.A.2.1[c], X.A.2.1[d], X.A.5, X.A.8.

131. As discussed above in reference to element 1[c], 1[d], and Claim 5, Rezvani discloses an interference matrix for a primary line as a function of u and n, wherein u is an index of a line transfer function between the primary line and one of the crosstalking lines and n is a subcarrier (or tone) index from n=0 to NSC, wherein NSC is a number of carriers used. *See* Ex. 1005, FIG. 6A. FIG. 6A of Rezvani, reproduced below, visualizes this interference matrix for a primary line 202, which shows the line transfer functions between the primary line 202 and crosstalking lines 206, 210, and 212 for all subcarriers (only subcarriers f_1-f_6 are specifically denoted in the figure for explanation).

Ex. 1005, FIG. 6A

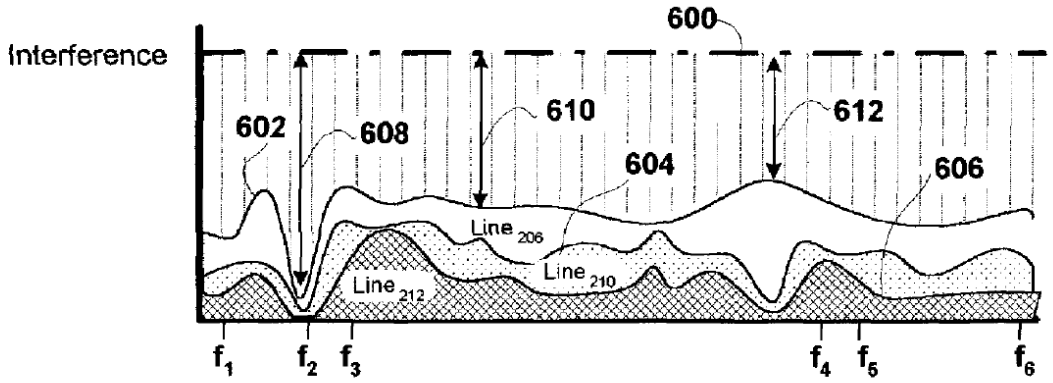


FIG. 6A **Interference Profile on a Line k=202 from Other Lines$_{1..N}$ in Bundle**

132. Moreover, as discussed in reference to Claim 5, Cendrillon I further discloses that the interference functions (such as those illustrated in Rezvani's FIG. 6A) can be provided in a matrix reflecting the interference between a primary line and different crosstalking lines for different frequencies (as discussed above, Cendrillon I provides this data in different matrices generated for different frequencies, instead of providing this data in different matrices generated for different primary lines as reflected in Rezvani's FIG. 6A). *See* Ex. 1006, p. 1; Ex. 1008, p. 1521 (Equation 1); Ex. 1009, p. 2007; Ex. 1011, p. 4.

133. Rezvani and Cendrillon do not disclose the use of a scale factor and a normalized complex number. However, the scaling and formatting recited in 11[a] are reflected in G.992.3's discussion of channel characteristics for a single channel,

specifically formatted as "Hlin(f): a format provided complex values in linear scale". Ex. 1007, pp. 93-94.

134. Specifically, G.992.3 states:

> The channel characteristics function Hlin(i × Δf), shall be represented in linear format by a scale factor and a normalized complex number a(i) + j × b(i), where i is the subcarrier index i = 0 to NSC – 1. The scale factor shall be coded as a 16-bit unsigned integer. Both a(i) and b(i) shall be coded as a 16-bit 2's complement signed integer. The value of Hlin(i × Δf) shall be defined as Hlin(i × Δf) = (scale/2^{15}) × (a(i) + j × b(i))/2^{15}. In order to maximize precision, the scale factor shall be chosen such that max(|a(i)|, |b(i)|) over all i is equal to 215 – 1.

Ex. 1007, pp. 93-94.

135. G.992.3 discusses that Hlin(f) may characterize attenuation of a single line, and therefore the scale factor can be a constant. *See* Ex. 1007, pp. 93-94. For a multi-variable transfer function describing interference from multiple crosstalking lines at different frequencies, such as Xlin(u,n) however, a POSITA would recognize that the scale factor can vary as a function of each interferer line, which would be denoted as *scale(u)* using the nomenclature of the '458 patent. *See* Ex. 1005, 8:44-48, FIG. 6A; Ex. 1006, pp. 3-5; Ex. 1009, p. 2014. Therefore, a POSITA would have been motivated to modify the crosstalk transfer function as taught by Rezvani and

Cendrillon I in view of G.992.3's formatting and scaling requirements discussed for Hlin, but instead select a scaling factor that is a function of the crosstalking line (u). A POSITA would have had a reasonable expectation of success because this formatting was already known from G.992.3 to effectively represent channel characteristics using that same formatting for characterizing crosstalk and then using the values reflected by the transfer functions in this same format. *See* Ex. 1005, 1:42-64, 2:10-25, 2:36-49; Ex. 1006, pp. 1-2, 6, FIG. 1; Ex. 1007, pp. 1-2, 92-94; Ex. 1016. Thus, implementing transfer functions already having a known format, such as described in G.992.3, along with a scaling factor that is a function of the crosstalking line (u) would achieve the benefits of Rezvani's and Cendrillon I's crosstalk mitigation or cancelling on a primary line. *See* Ex. 1005, 5:10-17, 6:33-60, 8:44-48, 12:30-47; Ex. 1006, pp. 1, 5-6; Ex. 1007, pp. 1-2, 92-94.

11[b]: further wherein the value of Xlin(u,n) is defined as Xlin(u,n)=scale(u)/2^{15})*(a(u,n)+j*b(u,n)/2^{15}.

136. Rezvani in view of Cendrillon I and G.992.3 teaches 11[b] for at least the reasons discussed with respect to 1[c], 1[d], and Claims 5, 10, and 11[a]. *See supra*, §§ X.A.2.1[c], X.A.2.1[d], X.A.5, X.A.8, X.B.2.11[a]. As discussed above in reference to 11[a], this definition of Xlin(u,n) is identical to G.992.3's definition of

Hlin(f),[6] be it that that Xlin is a function of two variables u and n. *See* Ex. 1001, 10:57; Ex. 1007, pp. 93-94. As discussed in reference to element 11[a], a POSITA would be motivated to adapt the Hlin format in G.992.3 to fit the multi-variable format of the crosstalk interference transfer functions of Rezvani and Cendrillon I, but instead implement a scale factor dependent on u, and make the recited normalized complex number a function of the two variables reflecting different crosstalk lines (u) and different frequencies (n). *See* Ex. 1005, 8:44-48, FIG. 6A; Ex. 1006, pp. 3-5; Ex. 1007, pp. 93-94; Ex. 1009, p. 2014. Moreover, a POSITA would have had a reasonable expectation of success because this formatting was already known from G.992.3 to effectively represent channel characteristics (Ex. 1007, pp. 1-2, 92-94), and the same formatting is usable for characterizing crosstalk interference. *See* Ex. 1005, 1:42-64, 2:10-25, 2:36-49; Ex. 1006, pp. 1-2, 6, FIG. 1; Ex. 1007, pp. 92-94; Ex. 1016. Thus, implementing transfer functions already having a known format (such as described in G.992.3) along with implementing a scale

[6] Element 11[b] mistakenly omits open- and close-parentheses in the written equation, thereby rendering the equation mathematically incorrect. However, I assume for the sake of argument that parentheses are appropriately present as shown in the ’458 patent’s Equation (1), at 10:57, which matches the equation for Hlin(i × Δf) at page 94 G.992.3. *See* Ex. 1001, 10:57; Ex. 1007, p. 94.

factor dependent on u and, making the recited normalized complex number a function of crosstalk lines (u) and frequencies (n), would achieve the benefits of Rezvani's and Cendrillon I's crosstalk mitigation or cancelling on a primary line. *See* Ex. 1005, 5:10-17, 6:33-60, 8:44-48, 12:30-47; Ex. 1006, pp. 1, 5-6; Ex. 1007, pp. 1-2, 92-94.

XI. CONCLUSION

The opinions and conclusions expressed in this Declaration represent my current opinions and conclusions, and the bases thereof. They may be revised and/or supplemented should additional information or insights become available to me.

As discussed above, it is my opinion that Claims 1, 2, 4-5, 7, 9-12, and 14-15 of the ’458 patent are obvious and should be canceled as unpatentable over the prior art.

I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 or Title 18 of the United States Code.

Executed this 22nd day of January, 2025.