UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NOKIA OF AMERICA CORP.;

Petitioner

v.

ADAPTIVE SPECTRUM AND SIGNAL ALIGNMENT, INC.,

Patent Owner.

IPR2025-00492

U.S. PATENT NO. 7,593,458

PETITION FOR *INTER PARTES* REVIEW
UNDER 35 U.S.C. §312 AND 37 C.F.R. §42.104

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Nokia of America Corp. ("Nokia") ("Petitioner") petitions for IPR under 35 U.S.C. §§ 311–319 and 37 C.F.R. § 42 of Claims 1, 2, 4-5, 7, 9-12, and 14-15 ("the Challenged Claims") of U.S. Patent No. 7,593,458 ("the '458 patent"). Petitioner requests cancellation of the Challenged Claims.

I. STANDING UNDER 37 C.F.R. § 42.104(a)

Petitioner certifies the '458 patent is available for IPR, and Petitioner is not barred or estopped from requesting IPR.

II. PAYMENT OF FEES

Petitioner authorizes Account No. 16-0605 to be charged.

III. OVERVIEW OF CHALLENGES AND RELIEF REQUESTED

Pursuant to 37 C.F.R. §§ 42.22(a)(1) and 42.104(b)(1)–(2), Petitioner requests cancellation of the Challenged Claims pursuant to the grounds below. Additional support is provided in the Declaration of Dr. Marc Moonen (Ex. 1002). Ex. 1002, ¶¶1-136.

- **Ground 1**: Claims 1, 2, 4-5, 7, 9-10, 12, and 14-15 are unpatentable under 35 U.S.C. § 103 over U.S. Patent No. 7,356,049 ("Rezvani") in view of *Partial Crosstalk Cancellation Exploiting Line and Tone Selection in VDSL* ("Cendrillon I").

- **<u>Ground 2</u>**: Claim 11 is unpatentable under 35 U.S.C. § 103 over Rezvani, Cendrillon I, and ITU-T Recommendation G.992.3 ("G.992.3").

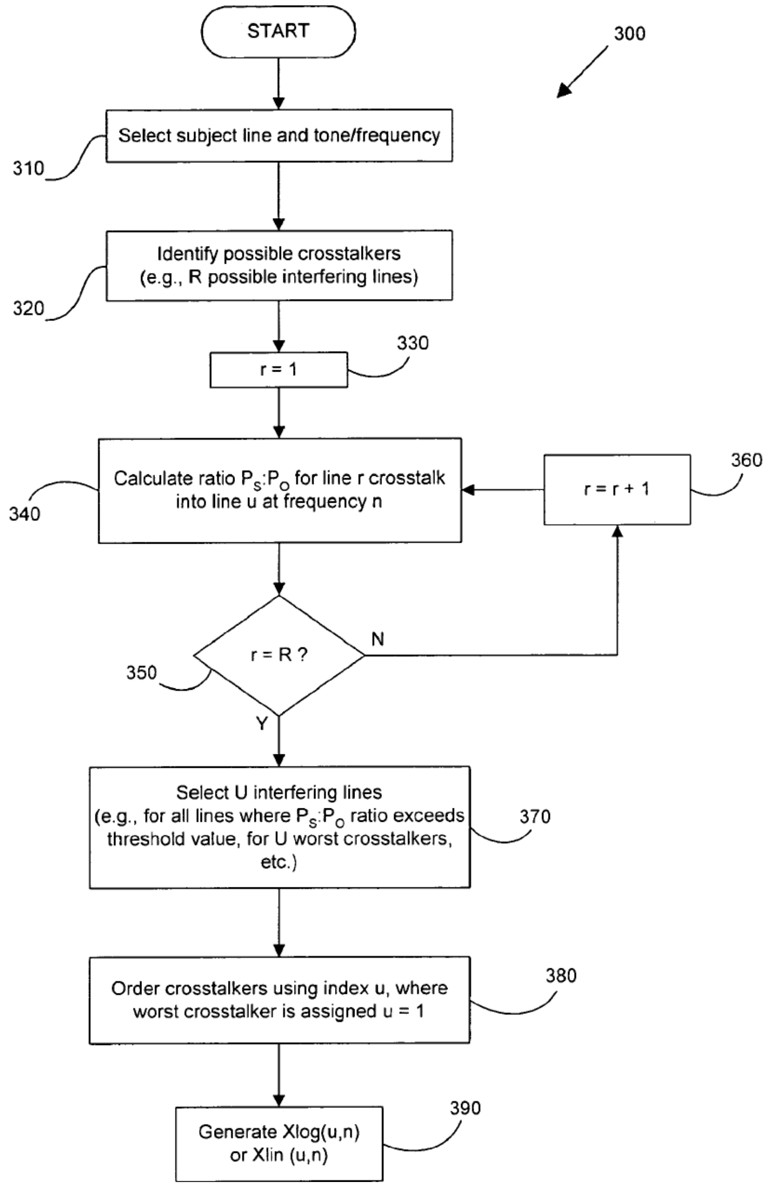
IV. BACKGROUND

A. Technical Background

The '458 patent describes a method of collecting operational data from DSL modems in conventional ADSL or VDSL systems and determining FEXT (far-end crosstalk) interference based on the collected operational data. Ex. 1001, 1:28-33, 4:66-5:12, 8:13-17, FIG. 1; Ex. 1002, ¶49. To do so, the '458 Patent describes two functions used to determine crosstalk interference on a given DSL line that are structured similar to insertion-loss quantities Hlog(n) and Hlin(n) described in existing ADSL2 standards. *See* Ex. 1001, 8:54-60, 9:43-46, Ex. 1007, pp. 92-94. Specifically, the '458 patent states that "[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 defined as the ratio of (1) a line u's source power into matched load of 100 Ohms when no binder is present to (2) the power at the output of the subject line when line u is excited with the same source and the binder is present." Ex. 1001, 2:53-60. Xlin(u,n), on the other hand, is simply "the linear equivalent of Xlog(u,n)." Ex. 1001, 2:60. 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 lines (for u=1,2,3,…U) on each of N tones (for n=1,2,3,…N). 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.

The ’458 patent describes one method for generating this Xlog(u,n) and Xlin(u,n) in FIG. 3 (shown below). Ex. 1001, 11:17-19, FIG. 3.

Ex. 1001, FIG. 3.



First, at step 310, "a subject communication line (for example, a DSL line) and tone/frequency are selected." Ex. 1001, 11:17-20. At step 320, for the given primary line, "[p]ossible crosstalking lines are identified," which may include lines in the same or different binders. Ex. 1001, 11:20-22. At step 330, the first potential crosstalking line (denoted as "R") is selected. Ex. 1001, 11:26-27. From there (at steps 340 through 360), the level of crosstalk interference is characterized for each crosstalking line at multiple frequencies n. Ex. 1001, 11:27-33. The '458 patent states that the crosstalk interference can be characterized as Xlog(u,n), which can be defined as 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. This process continues until all crosstalking lines have been evaluated. Ex. 1001, 11:27-33.

"Once all R of the potential crosstalkers have been evaluated and their ratios P_s:P_o calculated" for each tone, a subset of those crosstalkers (denoted as U) are selected at 370. Ex. 1001, 11:33-35. "At 380, the U crosstalkers are ordered according to the degree of crosstalk they induce in the subject line. The worst (most severe) crosstalker is assigned index u=1" with the progressively less severe crosstalkers being assigned progressively higher indexes u=2, 3,…,U. Ex. 11:38-42. The '458 patent describes one method for ranking the crosstalkers using a max function to assign a u value for each crosstalk line:

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

Ex. 1001, 9:15.

At step 390, after ordering the U crosstalkers, the ’458 patent explains that matrices Xlog(u,n) and/or Xlin(u,n) can be generated and used in the DSL system by something called a “DSL optimizer” to assist users and operators in improving system performance. Ex. 1001, 11:42-46.

This alleged crosstalk cancellation technique taught by the ’458 patent—which merely relied on well-known training algorithms as part of a DSL optimizer—was already known before the priority date of the ’458 patent. *See* Ex. 1002, ¶¶46-136.

B. Prosecution History

U.S. Patent Application No. 11/122,365 (“the ’365 Application”) was filed May 5, 2005. Ex. 1004, pp. 181-245; Ex. 1002, ¶39. During prosecution, the Applicant made two elections in response to two restriction requirements and made minor amendments to address § 112 concerns and clarify that “crosstalking lines” are excited with the known sequence of input symbols. Ex. 1004, pp. 106-107, 115-116, 124-135, 141-142; Ex. 1002, ¶¶40-44. The latter amendment was made to distinguish the claims from U.S. Patent Publ. No. 2002/0041565 (“Valenti”), which was cited as anticipating independent claim 1 and certain dependent claims. Ex. 1004, pp. 107-108, 118-122, Ex. 1002, ¶¶42-43.

C. Priority Date

In this Petition, Petitioner assumes that the earliest priority date for the '458 patent is May 18, 2004, based on Provisional Application No. 60/572,051. Ex. 1001; Ex. 1002, ¶46. If Patent Owner disputes the prior art status of any cited references, Petitioner reserves the right to challenge the priority date.

D. Claim Construction

Generally, the terms should receive their respective plain and ordinary meaning as understood by a person of ordinary skill in the art under *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005); Ex. 1002, ¶31. All of the claim terms in the '458 patent should be provided with their plain and ordinary meaning.

V. PRIOR ART REFERENCES

A. Rezvani (Ex. 1005)

U.S. Patent No. 7,356,049 to Rezvani, titled "Method and apparatus for optimization of channel capacity in multi-line communication systems using spectrum management techniques" was filed December 30, 2002, and issued on April 8, 2008. Rezvani is prior art under at least pre-AIA 35 U.S.C. § 102(e), based on its application date. *See* 35 U.S.C. §102(e); Ex. 1002, ¶53.

B. Cendrillon I (Ex. 1006)

"Partial Crosstalk Cancellation Exploiting Line and Tone Selection in VDSL" (Cendrillon I) is a conference paper published in the *Proceedings of the 6th Baiona Workshop on Signal Processing in Communications* found in the University of

Illinois Libraries (Urbana, Illinois). *See* Ex. 1022, ¶49. As explained in detail by Dr. Sylvia Hall-Ellis, the 6th Baiona Workshop on Signal Processing in Communications was held on September 8-10, 2003, in Baiona, Spain. Ex. 1022, ¶49. Cendrillon I, attached as Ex. 1006, is a true and correct copy of this conference paper and was publicly available as of October 1, 2003. Ex. 1022, ¶¶49-55. As a result, Cendrillon I became a "printed publication" on October 1, 2003. Ex. 1022, ¶¶49-55. Cendrillon I qualifies as prior art under 35 U.S.C. § 102(a) based on its public availability date.

C. G.992.3 (Ex. 1007)

ITU-T Recommendation G.992.3: Asymmetric Digital Subscriber Line Transceivers 2 (ADSL2) – Series G: Transmission Systems and Media, Digital Systems and Networks – Digital Sections and digital Line System – Access Networks (G.992.3) is a standards document issued by the International Telecommunication Union/ITU Telecommunication Sector. *See* Ex. 1007; Ex. 1022, ¶56. As explained by Dr. Sylvia Hall-Ellis, the ITU made the G.992.3 document available to the public on its website when it was adopted, at least as early as November 11, 2003. Ex. 1022, ¶¶56-62. As a result, G.992.3 was a "printed publication" under 35 U.S.C. §102 by November 11, 2003. Ex. 1022, ¶¶56-62. G.992.3 qualifies as prior art under 35 U.S.C. § 102(a) based on its public availability date.

VI. LEVEL OF ORDINARY SKILL IN THE ART

A person of ordinary skill in the art pertinent to the ’458 patent would have been a person with 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. Ex. 1002, ¶35. A person with a different degree but with additional relevant experience could still qualify if the additional experience compensates for the different educational background. Ex. 1002, ¶35.

VII. THE CHALLENGED CLAIMS ARE UNPATENTABLE

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

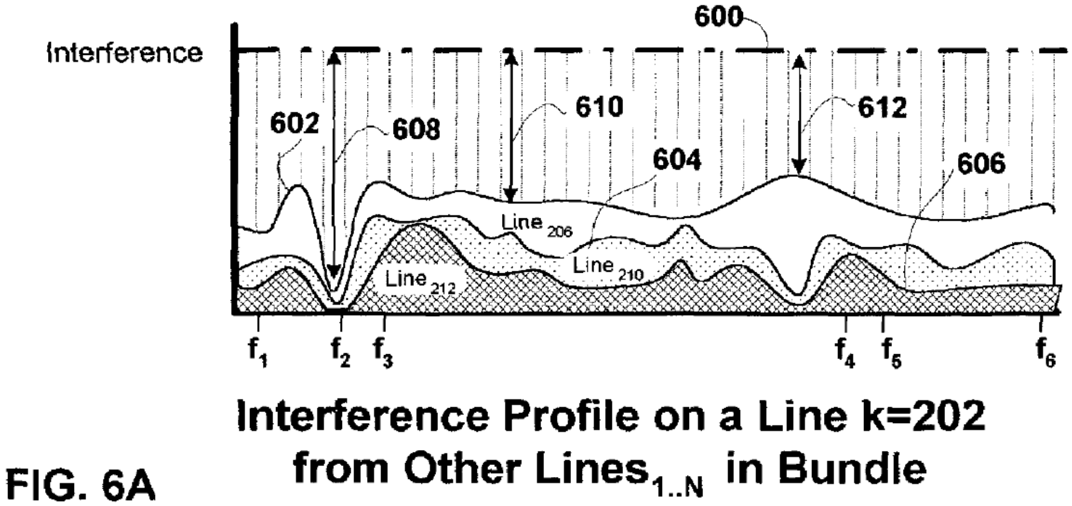
1. *Overview of Ground 1*

a. Rezvani

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.

Specifically, Rezvani explains that channel capacity can be optimized by a spectrum manager using an interference matrix describing the amount of crosstalk on a particular subscriber line from a plurality of other lines in a bundle of lines that is generated using a spectral profile determined for each subscriber line. 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," and which may be used for "cross channel interference cancellation techniques or less granular energy balancing techniques [] to optimize channel capacity." Ex. 1005, 8:42-48, 14:47-51; *see also id.* at 18:42-46. FIG. 6A depicts an interference profile of a single subject line from the calculated interference matrix. Particularly, FIG. 6A shows the cumulative amount of interference on line 202 caused by crosstalking Lines 206, 210, and 212, expressed in terms of signal strength vs. frequency. Ex. 1005, 7:23-37, FIG. 6A.

Ex. 1005, FIG. 6A.



b. Cendrillon I

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 far-end crosstalk (FEXT) is "*the* dominant source of performance degradation in VDSL." Ex. 1006, p. 1.

Accordingly, Cendrillon I teaches "a crosstalk cancellation scheme with scalable complexity." Ex. 1006, p. 1. Cendrillon I teaches partial crosstalk cancellation that "exploit[s] the space and frequency-selective nature of crosstalk channels." Ex. 1006, p. 1. 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.

c. Motivation to Combine

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 improve signaling on DSL lines with improved efficiency over complete crosstalk cancellation. Ex. 1002, ¶72. Rezvani and Cendrillon I are both directed towards optimizing channel performance by mitigating or cancelling interference among bundled DSL subscriber lines. Ex. 1002, ¶72; Ex. 1005, 2:4-49; Ex. 1006, p. 1. Rezvani discloses a typical DSL deployment in which "opposing sets of modems [are] coupled to one another by corresponding subscriber lines within a bundle." Ex. 1002, ¶72; Ex. 1005, 4:44-50, FIG. 2A; *see also id.* at 1:64-67. 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 X-DSL [lines (encompassing ADSL, VDSL, and other standards)] which are bundled with one another." Ex. 1002, ¶72; 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. 1002, ¶72; 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 … bit-loading, PSD mask and band plans for each subscriber line." Ex. 1002, ¶72; Ex. 1005, 7:52-57. The spectrum manager determines these interference profiles by injecting training sequences into tones of each subscriber line and monitoring the output to characterize the level of crosstalk between the bundled lines, and to calculate an interference matrix that may be used for "either cross channel interference cancellation techniques or less granular energy balancing techniques." Ex. 1002, ¶72; 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. *See* Ex. 1002, ¶72; Ex. 1006, pp. 1-2. Cendrillon I teaches that partial crosstalk cancellation techniques can achieve similar channel performance improvements to full crosstalk cancellation with less complexity. Ex. 1002, ¶72; Ex. 1006, p. 1.

More specifically, both Rezvani and Cendrillon I recognize efficiencies in mitigating or canceling crosstalk on the 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. 1002, ¶73; 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. 1002, ¶73; Ex. 1005, 7:46-50 (referring to

FIG. 6A and explaining that "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. Ex. 1002, ¶73; Ex. 1005, 8:42-48, FIG. 6A.

Cendrillon I teaches partial crosstalk cancellation techniques that take advantage of the differences in importance of contributing crosstalking lines by "exploit[ing] both space and frequency-selectivity" of the crosstalking channel. Ex. 1002, ¶74; Ex. 1006, p. 4. Cendrillon I also discusses FEXT interference and that the amount of crosstalk may vary between each tone of each subscriber line. Ex. 1006, p. 1. 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 [most important] tones and lines where it gives the most benefit." Ex. 1006, p. 6.

Given Cendrillon I's discussion of efficiency gains by performing partial crosstalk cancellation while achieving similar improvements in performance 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 crosstalking lines for a subject line. *See* Ex. 1002, ¶75; Ex. 1005, 8:46-48; Ex. 1006, p. 6 (describing the "combinations of partial crosstalk cancellation with dynamic spectrum management"). A POSITA would have understood that Rezvani's training phase for generating an interference matrix would enable Cendrillon I's partial crosstalk cancellation method to selectively cancel crosstalk from the crosstalking lines contributing the most interference. *See* Ex. 1002, ¶75; Ex. 1005, 8:46-48; Ex. 1006, p. 6.

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 crosstalking lines. *See* Ex. 1002, ¶76; Ex. 1005, 2:4-25, 8:46-48; Ex. 1006, p. 6. A POSITA would have been familiar with DSM techniques for mitigating or cancelling crosstalk and that DSM techniques are distinguished by "levels." *See e.g.*, Ex. 1002, ¶76; 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. 1002, ¶76; 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. Ex. 1002, ¶76. Specifically, Rezvani’s interference matrix could be used to determine the highest contributors of crosstalk interference, and then Cendrillon I’s partial crosstalk cancellation method could be used to cancel crosstalk interference from only the highest contributors of crosstalk interference. *See* Ex. 1002, ¶76; Ex. 1005, 2:4-25, 8:46-48; Ex. 1006, 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 via Cendrillon I’s signal coordination process. *See* Ex. 1002, ¶76; Ex. 1005, 2:4-25, 8:46-48; Ex. 1006, 6.

2. Claim 1

a. 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:

Rezvani renders obvious the preamble of Claim 1, to the extent it is determined to be limiting. Ex. 1002, ¶77.

While the ’458 patent does not define the term “operational characteristics,” which appears only in the preamble of Claim 1, the ’458 patent explains that "operational data" is 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 relate to "measurements and/or values obtained from a DSLAM . . . or any other suitable component in the DSL system." Ex. 1001, 13:19-22, 8:10-12. Such measurements and/or values may be "normally available from a DSL or other communication systems during normal operation" or "specifically requested, prompted and/or ordered." Ex. 1001, 4:28-33. Thus, a POSITA would have understood that "operational characteristics" describes information relating to two or more DSL lines that is used to enhance system performance. Ex. 1002, ¶78.

A POSITA would have understood that Rezvani teaches "***evaluating operational characteristics***." Ex. 1002, ¶79. Rezvani teaches that "[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. More particularly, Rezvani teaches that the initial spectral characteristics of a DSL line, interference co-parameters between DSL lines, and demand profiles may be evaluated to efficiently allocate transmission characteristics and implement revised spectral target parameters, such as bit-loading, PSD masks, and band plans. *See* Ex. 1005, 7:52-57, 14:35-39; *see also id.* at 10:37-53. Moreover, the initial spectral characteristics, for example, 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. Thus, a POSITA would have understood that the initial spectral characteristics, interference parameters, and/or demand profiles are information relating to two or more DSL lines that is evaluated to optimize system performance. *See* Ex. 1002, ¶79; Ex. 1005, 2:35-49. A POSITA would have understood that the spectral profiles, interference profiles, and/or subscriber demand profiles are evaluated to optimize system performance. Ex. 1002, ¶79; Ex. 1005, 2:35-49.

Further, 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)***." Ex. 1002, ¶¶77, 80. Rezvani teaches "a method and apparatus for optimizing channel capacity of multi-line multi-tone communications such as X-DSL among [a plurality of] subscriber lines which are bundled together" in "a common bundle." Ex. 1005, 2:36-40, 3:1-4, Abstract. Moreover, a POSITA would have understood that vectored DSL systems were known in the art by the time of the priority date of the '458 patent. *See* Ex. 1002, ¶80; Ex. 1005, 2:21-25 (explaining that known "[a]ggregate subscriber line approaches involve vector cancellation"). Thus, it would have been obvious to a POSITA 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).” Ex. 1002, ¶¶77-80.

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

Rezvani renders obvious Limitation 1[a]. Ex. 1002, ¶81.

Rezvani teaches that training is performed during the interference determination phase to measure or estimate channel characteristics, and more particularly, the amount of interference between DSL lines. *See* Ex. 1002, ¶81; Ex. 1001, 1:43-48; Ex. 1005, 2:21-25; Ex. 1007, p. 98; Ex. 1019, 10:13-22. Rezvani teaches that training sequences are injected into selected sub-channels of successively selected subscriber lines and “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, 18:19-25. A POSITA would have understood that the injected training sequences excite the other subscriber lines in the bundle so that crosstalk between the selected subscriber line and the remaining subscriber lines of a channel can be monitored and measured. *See, e.g.*, Ex. 1002, ¶81; Ex. 1001, 12:53-67; Ex. 1010, 5-6. In this same regard, a POSITA would have understood that the training sequences include “known input symbols” so that the injected training sequence can be compared to the output data on a select subscriber line to determine the interference between the selected subscriber line and the remaining subscriber lines. Ex. 1002, ¶81.

This is consistent with the description of the ’458 patent. Ex. 1002, ¶82. For example, the ’458 patent explains that crosstalk is measured so that the necessary amount of interference cancellation is applied to each DSL line. Ex. 1002, ¶82; Ex. 1001, 2:12-14; *see also id.* at 1:43-48. The ’458 patent further explains that NEXT and Xlin values, which the ’458 patent uses for crosstalk cancellation, “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 (emphasis added). Thus, a POSITA would have understood that a training sequence, like TRAIN(n,k), is “a known input sequence of symbol” used to excite the plurality of crosstalking lines. Ex. 1002, ¶82.

c. 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;

Rezvani renders obvious Limitation 1[b]. Ex. 1002, ¶83.

As described above with respect to Limitation 1[a], Rezvani teaches that the training sequences are injected on selected sub-channels of a selected subscriber line. Ex. 1002, ¶81. As training sequences are injected on the selected sub-channels, "interference on the same sub-channels is monitored on the receive path of all of the other lines in the bundle." 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. A POSITA would have understood that the corresponding data acquired is output data indicating the amount of interference on the selected subscriber line from the remaining subscriber lines. Ex. 1002, ¶83. In other words, the output data is the training sequences of know input symbols after having been affected by crosstalk coupling between the selected subscriber line and the remaining subscriber lines in the channel. *See, e.g.*, Ex. 1002, ¶83; Ex. 1001, 12:53-67; Ex. 1010, 5-6; *see also* Ex. 1001, 12:53-67.

This is also consistent with the '458 patent. Ex. 1002, ¶84. NEXT and Xlin 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 (emphasis added). Thus, the '458 patent discloses that the "outputs OUT(n,k)" or "output data" is acquired in the same way that Rezvani teaches acquiring data from monitoring the output on subscriber lines as a result of injecting the training sequences into other subscriber lines. Ex. 1002, ¶84.

d. 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;

Rezvani alone or in view of Cendrillon I renders obvious Limitation 1[c]. Ex. 1002, ¶85.

As discussed above with respect to Limitations 1[b] and 1[c], Rezvani teaches that the injected training sequences of known input symbols excite the crosstalking lines, and crosstalk between the selected subscriber line and the remaining subscriber lines is identified by detecting the same known training sequence of input symbols in the output of a selected subscriber line after having been affected by crosstalk from the remaining subscriber lines. Ex. 1002, ¶85; Ex. 1005, 14:30-56, 18:32-42, FIG. 6A. This is depicted in FIG. 6A of Rezvani, which shows the cumulative interference levels from each crosstalking line expressed in terms of the signal strength of the training sequence detected in the output of a primary line at each of the various frequencies. Ex. 1002, ¶¶85-86; Ex. 1005, 7:23-30.

Ex. 1005, FIG. 6A.

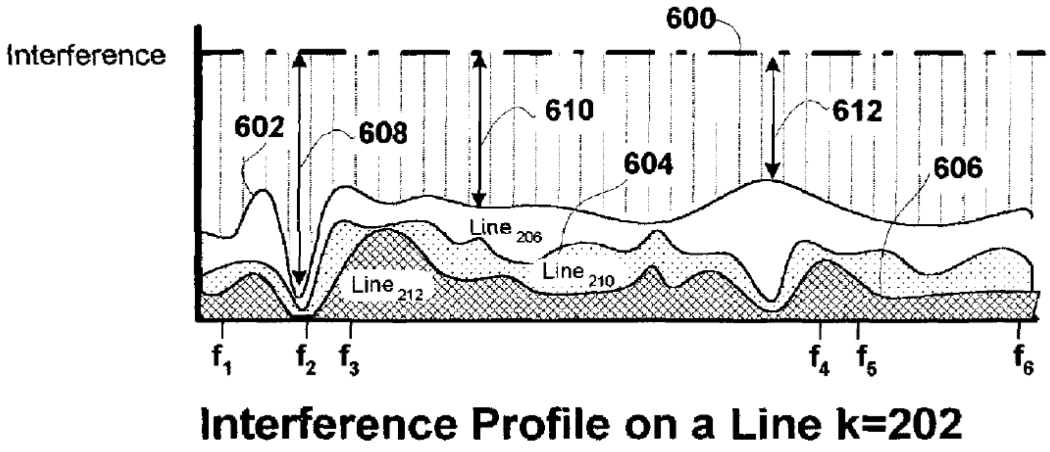


FIG. 6A

As reflected in FIG. 6A, "[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. 1002, ¶¶86-87; Ex. 1005, 7:23-34. Accordingly, Rezvani explains that as the output data is accumulated for the selected subscriber line, "***the interferer channels can be ranked in order of importance*** within each sub-channel." Ex. 1005, 8:42-45 (emphasis added), 18:32-43, FIG. 12 (step 1210); Ex. 1002, ¶87. A POSITA would have understood that Rezvani's ranking in "order of importance" for a selected subscriber line may be based on the amount of crosstalk injected into the selected subscriber line from the remaining subscriber lines, as lines that cause more crosstalk would have been more important to cancel crosstalk on. *See* Ex. 1002, ¶87; Ex. 1005, 7:23-57, 8:42-44, FIG. 6A. And because the amount of crosstalk interference is expressed in terms of signal strength, a POSITA would have recognized that the "order of importance" could be determined based on the signal strength of the training sequence detected in subscriber line output compared to the known training sequence of input symbols injected into the selected subscriber lines at each of the various frequencies.[1] *See* Ex. 1002, ¶87; Ex. 1005, 7:23-57, 8:42-44, FIG. 6A; *see also* Ex. 1006, p. 3; Ex. 1008, p. 1526; Ex. 1009, p. 2011.

To the extent it is argued that Rezvani alone does not render obvious Limitation 1[c], Rezvani in view of Cendrillon I does. Ex. 1002, ¶88. Cendrillon I teaches that by identifying the largest crosstalking lines and applying crosstalk cancellation only on those specific sub-carriers (tones) or subscriber lines, the DSL system can optimize system performance without having to perform complete

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[1] This claim limitation does not specify a criterion for "ordering" the crosstalking lines, such as discussed in the '458 patent specification. *See* Ex. 1002, ¶87, n. 4; Ex. 1001, 9:6-35. However, 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 have been a reasonable criterion to use. Ex. 1002, ¶87, n. 4.

crosstalk cancellation on all crosstalking lines. Ex. 1006, pp. 3, 6; Ex. 1002, ¶88. This is referred to as "partial crosstalk cancellation." Ex. 1006, pp. 3, 6; Ex. 1002, ¶88. Cendrillon teaches that Algorithm 1 (shown below) is one example of partial crosstalk crosstalk cancellation which employs line selection only. Ex. 1006, p. 4; Ex. 1002, ¶88.

Ex. 1006, p. 4.

Algorithm 1 Line Selection Only

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

When implementing Algorithm 1, Cendrillon I explains that "[m]aximizing $SINR_k^n$ and thus rate c_k^n corresponds to minimizing the amount interference in the set M_k^n. Ex. 1006, pp. 3-4; Ex. 1002, ¶88. "So 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); Ex. 1002, ¶88.

e. 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

Rezvani alone or in view of Cendrillon I renders obvious Limitation 1[d]. Ex. 1002, ¶89.

As discussed above, Rezvani teaches that the training sequences of known input symbols are injected to excite the crosstalking lines, and crosstalk between the selected subscriber line and the remaining subscriber lines is identified by comparing the output data (the training sequence of input symbols after having been affected by crosstalk from the remaining subscriber lines) against the known training sequence of input symbols. Ex. 1005, 14:30-56, 18:32-42, FIG. 6A; Ex. 1002, ¶85. Based on this information, Rezvani teaches generating a data quantity in the form of 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; Ex. 1002, ¶89. Data from this interference matrix is reflected in FIG. 6A, which 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 at each sub-carrier or frequency of a selected subscriber line 202. Ex. 1005, 7:23-37, 14:31-49, FIG. 6A. A POSITA would have understood 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 selected subscriber line k=202 and each of the crosstalking lines 206, 210, and 212. *See* Ex. 1005 7:23-57, FIG. 6A; Ex. 1002, ¶89.

Ex. 1005, FIG. 6A.

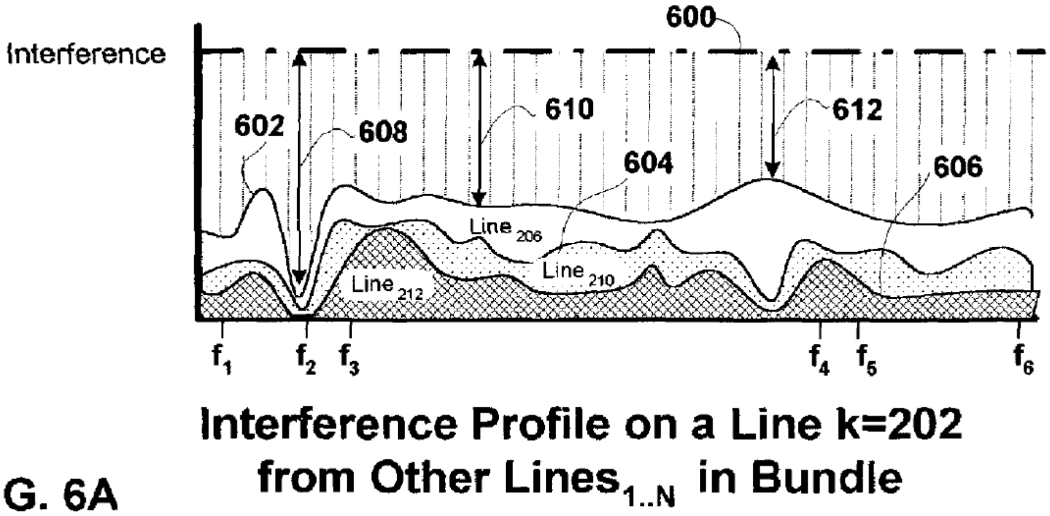


FIG. 6A

And as explained above, "the interferer channels can be ranked in order of importance within each sub-channel." Ex. 1005, 8:42-45; Ex. 1002, ¶90. A POSITA would have recognized that the "order of importance" characterizes which subscriber lines cause the greatest amount of crosstalk interference into the selected subject line. *See* Ex. 1002, ¶90; Ex. 1005, 7:23-57, 8:42-44, FIG. 6A. Thus, it would have been obvious to a POSITA that once the "ordering of importance" is determined, this would be reflected in the generated interference matrix. Ex. 1002, ¶90. Accordingly, the interference matrix would be representative of the crosstalk interference experienced on a selected subscriber line and could then be used for mitigating crosstalk interference from the most important crosstalk lines (e.g., highest sources of interference). Ex. 1002, ¶90.

To the extent it is argued that Rezvani alone does not render obvious Limitation 1[c], Rezvani in view of Cendrillon I does. Ex. 1002, ¶91. Cendrillon I explains that Equation 1 below is the basic model for DSM techniques implementing either spectrum or signal coordination. Ex. 1006, p. 1; *see also* Ex. 1008, p. 1521 (showing the same equation, but in matrix format); Ex. 1002, ¶91. 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; *see also* Ex. 1008, p. 1521. The channel transfer matrix H_k is a data quantity comprising $h_k^{(n,m)}$ values which represent the crosstalk effect from user *m* into user *n*. Ex. 1006, p. 1; *see also* Ex. 1008, p. 1521; Ex. 1002, ¶91.

Ex. 1006, p. 1, Equation 1.

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

And as described above with respect to Limitation 1[c], Cendrillon I explains that partial crosstalk cancellation is achieved by applying crosstalk cancellation only on "***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); Ex. 1002, ¶91. To identify and apply crosstalk cancellation only on the "largest crosstalkers," a POSITA would have understood that the crosstalking lines are ordered, and this ordering would have been reflected in the resulting data quantity (the channel transfer matrix H_k) that is used for partial crosstalk cancellation. Ex. 1002, ¶91.

f. 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.

Rezvani renders obvious Limitation 1[e]. Ex. 1002, ¶92.

Rezvani teaches that a spectral profiling phase, an interference determination phase, a demand determination phase, and a spectral allocation phase may be performed to send instructions to each modem for implementing revised spectral profile targets. *See* Ex. 1005, 5:39-46, 10:37-43; Ex. 1002, ¶¶92-93. In other words, Rezvani teaches that the revised spectral profile targets may be based on the interference matrix. *See* Ex. 1005, 5:39-46; Ex. 1002, ¶93.

Rezvani teaches that the first phase performed by the spectrum manager is the spectral profiling phase. During the spectral profiling phase, the spectrum manager determines the initial spectral characteristics or spectral profile of each subscriber line. Ex. 1005, 10:37-43; Ex. 1002, ¶93. These initial spectral characteristics may then be used in the subsequent phases to determine the instructions for implementing the revised spectral profile targets. *See* Ex. 1005, 10:37-43; Ex. 1002, ¶93. For example, the subsequent interference determination "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. This is also the phase during which the interference matrix is generated. Ex. 1005, 14:33-39; Ex. 1002, ¶¶89, 94. Thus, a POSITA would have understood that the interference matrix is used to further refine the revised spectral profile targets. Ex. 1005, 14:33-39; Ex. 1002, ¶¶89, 94. Likewise, the allocation phase also relies on the interference matrix (and the initial spectral characteristics) to allocate revised spectral profile targets. Ex. 1005, 14:67-15:3, 15:38-47; Ex. 1002, ¶95. Indeed, Rezvani explains that how the revised spectral profile targets are allocated "results directly from the interference parameters determined during the interference determination phase." Ex. 1005, 14:67-15:3; Ex. 1002, ¶95.

After each phase is complete, "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. A POSITA would have understood that determining the revised spectral profile target parameters is based on the generated interference matrix, and that Rezvani teaches sending instructions to one or more modems communicatively interfaced with the plurality of crosstalking lines in the channel for implementing the revised spectral profile target parameters by "download[ing] the corresponding target parameters to the associated modems." *See* Ex. 1002, ¶95; Ex. 1005, 19:24-27, 19:61-64, 20:23-27, 21:6-9.

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.*

Rezvani renders obvious dependent Claim 2 for at least the same reasons discussed with respect to Limitation 1[e] and as discussed below. *See supra*, § VII. A.2.f; Ex. 1002, ¶96.

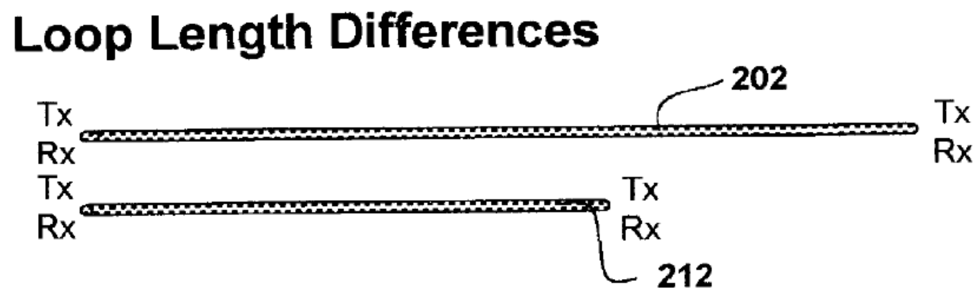
While the '458 patent does not define the term "***operational condition values***," which appears only once in the '458 patent specification other than the claims, the '458 patent describes "operational data" as explained above with respect to the preamble of Claim 1. *See supra*, § VII.A.2.a; *see also* Ex. 1001, 3:61-64, 4:24-39, 8:10-12, 13:19-22. Thus, a POSITA would have understood that "operational condition values" would include measurements or values indicative of channel conditions of two or more DSL lines during operation. Ex. 1002, ¶96.

As discussed above with respect to Limitation 1[e], Rezvani teaches sending instructions for implementing revised spectral profile target parameters to each modem. Rezvani further teaches that the revised spectral profile target parameters may include revised gain tables. *See, e.g.*, Ex. 1005, 5:39-46, 15:8-11, 15:53-55, 17:25-27; Ex. 1002, ¶97. "When 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 have understood that instructions for implementing revised gain tables to be instructions for implementing "***operational condition values***." Ex. 1002, ¶97.

Further, Rezvani teaches sending instructions for implementing "***a maximum data rate limit***." Ex. 1002, ¶98. Rezvani teaches that the initial spectral characteristics of each subscriber line are determined to send instructions for implementing revised spectral target parameters, such as revised band plans for a subscriber line. Ex. 1005, 5:39-46, 7:52-57; Ex. 1002, ¶98. Rezvani further teaches that the initial spectral characteristics may include the length of each subscriber line. Ex. 1005, 13:53-59; Ex. 1002, ¶98. As discussed with respect to FIG. 3A, a POSITA would have understood 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; Ex. 1002, ¶98. Thus, it would have been obvious to a POSITA that sending instructions for implementing a revised band plan having a maximum data rate limit on the shorter line 121 would mitigate the interference caused by the shorter line 121 into the longer line 202. *See* Ex. 1005, 5:47-6:7; Ex. 1002, ¶98.

Ex. 1005, FIG. 3A.

FIG. 3A



Further still, Rezvani teaches that the instructions for implementing revised band plans may include revised band plans dedicating high frequency sub-channels to upstream communications. *See* Ex. 1005, 9:41-54; Ex. 1002, ¶99. Thus, a POSITA would have understood that these revised band plans teach "***upstream transmission frequency band limits***." Ex. 1002, ¶99.

Further still, Rezvani teaches that the revised spectral profile target parameters may include revised PSD (power spectral density) masks for each sub-channel on each subscriber line. Ex. 1005, 5:39-46, 7:52-57; Ex. 1002, ¶100. Notably, the "PSD mask for each subscriber line" "sets the maximum transmit power for each of the sub-channels." Ex. 1005, 5:8-10. Thus, a POSITA would have understood that Rezvani teaches sending instructions to implement "***transmit power levels***." *See* Ex. 1002, ¶100; Ex. 1005, 9:37-48.

Further still, Rezvani teaches sending instructions for implementing "***coding/latency requirements***." Ex. 1002, ¶101. The '458 patent does not explain the term "coding/latency requirements," which is not defined in and appears only once in the ’458 patent other than the claims. Ex. 1001, 14:15-22; Ex. 1002, ¶101. Nevertheless, Rezvani teaches that “various forms of forward error correction (FEC)” are known techniques for addressing interference. Ex. 1005, 2:10-13; Ex. 1002, ¶101. A POSITA would have understood that FEC techniques include specifying a latency requirement, such as a maximum latency. Ex. 1002, ¶101. Indeed, this understanding is confirmed by the ADSL2 standard G.992.3, which specifies maximum latency and maximum overhead for transmissions on DSL lines. *See, e.g.*, Ex. 1007, pp. 257, 271, 279; Ex. 1002, ¶101. Thus, a POSITA would have understood that specifying a maximum latency requirement teaches sending instructions to implement “coding/latency requirements.” Ex. 1002, ¶101.

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

Rezvani renders obvious dependent Claim 4 for the same reasons discussed with respect to Limitation 1[b] and as discussed below. *See supra*, § VII. A.2.c; Ex. 1002, ¶102.

Rezvani teaches that during the interference determination phase, output data is acquired to characterize the amount of crosstalk interference from the remaining subscriber lines affecting the selected subscriber line. Ex. 1005, 14:31-51; Ex. 1002, ¶102. Rezvani further teaches that the interference determination phase “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; Ex. 1002, ¶102. 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; Ex. 1002, ¶102. 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 sequences can be injected into tones on crosstalking lines and detected and collected in output data from the primary line periodically over time during initialization and showtime. Ex. 1002, ¶102. A POSITA would have understood that iterating the above-described phases and/or performing them at the appropriate time means that output data may be monitored and collected over time on a periodic basis. Ex. 1002, ¶102.

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.*

Rezvani alone or in view of Cendrillon I renders obvious dependent Claim 5 for the same reasons discussed with respect to Limitation 1[d] and as discussed below. *See supra*, § VII. A.2.e; Ex. 1002, ¶103.

Rezvani is directed to "dynamic spectrum management" or "DSM" of bundled subscriber lines. *See* Ex. 1005, 4:23-43; *see also id.* at 17:7-10. Rezvani teaches spectrum coordination or DSM Level 2 to dynamically allocate power or transmit spectra to mitigate crosstalk interference. *See* Ex. 1005, 4:23-43; Ex. 1002, ¶104. Rezvani teaches that the interference matrix may be used for either "cross channel interference techniques or less granular energy balancing techniques." Ex. 1005, 8:46-48; Ex. 1002, ¶104. Accordingly, a POSITA would have understood that the interference matrix is a DSM-data quantity that Rezvani indicates can be used for either DSM Level 2 techniques or DSM Level 3 techniques. Ex. 1002, ¶104.

This is consistent with the discussion of the '458 patent, which describes Xlog as typically being associated with DSM Level 3, but that "Xlog is also useful is DSL systems with level 2 spectrum balancing, band preference, or [Optimum Spectrum Management or Balancing]." Ex. 1001 at 8:28-36; *see also id.* at 2:63-54, 8:42-43; Ex. 1002, ¶104.

FIG. 6A of Rezvani also teaches the data quantity Xlog(u,n), where "u" is the crosstalking line index and "n" is the subcarrier index. Ex. 1002, ¶105. FIG. 6A depicts the cumulative interference from all other crosstalking $\text{Lines}_{1..N}$ ("u") at subcarriers or frequencies, including f_1-f_6 ("n") on a selected subscriber line "expressed in terms of signal strength vs. frequency." Ex. 1005, 18:42-43, 14:47-49, 7:23-26, FIG. 6A. Additionally, a POSITA would have understood that DSM Level

3 signal coordination requires knowledge of the Xlin values, whereas DSM Level 2 spectrum coordination only requires knowledge of the magnitudes of the Xlin values, which is equivalent to knowing the Xlog values. *See* Ex. 1002, ¶105; Ex. 1001, 2:63-54; *see also* Ex. 1006, p. 3, Equation 4; Ex. 1011, p. 6, Equation 6. This is shown in Equation 4 of Cendrillon I below. *See* Ex. 1002, ¶105; Ex. 1006, p. 3, Equation 4.

Ex. 1006, p. 3, Equation 4.

$$\mathrm{SINR}_k^n \simeq \frac{\left|h_k^{(n,n)}\right|^2 s_k^n}{\sum_{m \notin \{n, \mathbb{M}_k^n\}} \left|h_k^{(n,m)}\right|^2 s_k^m + \sigma_k^2} \qquad (4)$$

A POSITA would have understood that Xlin values are complex values and cannot be represented graphically without modification. *See* Ex. 1002, ¶105; Ex. 1001, 10:37-41; Ex. 1001, 10:55-57. However, a POSITA would have understood that representations of these complex values could be plotted graphically (like in FIG. 6A) by squaring the magnitude of these values to demonstrate a magnitude of power of the crosstalk interference. *See* Ex. 1002, ¶105; Ex. 1006, p. 3, Equation 4; *see also* Ex. 1011, p. 6, Equation 6. Thus, because FIG. 6A shows the cumulative interference from all other subscriber lines on a selected subject line in terms of signal strength, a POSITA would have understood that FIG. 6A teaches the Xlin data quantity. Ex. 1002, ¶105. Moreover, the ’458 patent explains that Xlog is the logarithmic equivalent of Xlin, and a POSITA would have been familiar with using logarithmic scales in DSL. *See e.g.*, Ex. 1002, ¶105; Ex. 107, pp. 92-93. Thus, it would have been obvious to a POSITA to convert the values represented in FIG. 6A into logarithmic form and thus generate Xlog(u,n). Ex. 1002, ¶105.

Further still, it was well understood by the priority date of the ’458 patent that interference signal strength may be expressed in 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) per Hz. *See, e.g.*, Ex. 1002, ¶106; Ex. 1005, 17:39-42, FIG. 11C (“indicating power levels in each sub-channel” in terms of dBm/Hz). Thus, it would have been obvious to a POSITA that the interference matrix of Rezvani teaches a 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. Ex. 1002, ¶106.

To the extent it is argued that Rezvani alone does not render obvious Claim 5, Rezvani in view of Cendrillon I does. Ex. 1002, ¶107. As noted above, a POSITA would have understood that signal coordination requires knowledge of Xlin values, whereas spectrum coordination only requires knowledge of the magnitudes of the Xlin values, which is equivalent to knowing the Xlog values. *See* Ex. 1002, ¶107; Ex. 1001, 2:63-54; *see also* Ex. 1006, p. 3, Equation 4; Ex. 1011, p. 6, Equation 6.

And as explained above with respect to Limitation 1[d], Cendrillon I teaches that Equation 1 models crosstalk independently on each tone k for N+1 users, where "$h_k^{(n,m)}$ is the crosstalk channel from user *m* into user *n*." Ex. 1006, 1; Ex. 1008, p. 1521; Ex. 1002, ¶107.

Ex. 1006, p. 1, Equation 1.

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

In view of Equation 1 of Cendrillon I above, if Line 1 is the selected subject line, a POSITA would have understood 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. 1002, ¶108; Ex. 1006, p. 1; Ex. 1008, p. 1521. Indeed, the first row of channel matrix H_k with the $h_k^{(1,m)}$ values is equivalent to the data in Rezvani's interference matrix, but at a single frequency or tone *k*. *See* Ex. 1002, ¶108; Ex. 1006, p. 1; Ex. 1008, p. 1521; Ex. 1005, FIG. 6A. Thus, a POSITA would have understood that the channel matrix H_k in Equation 1 of Cendrillon I (Ex. 1006) teaches the quantity Xlin(u,n) that is representative of the extent of the crosstalk coupling associated with each of the crosstalking lines and the primary line within the channel. *See, e.g.*, Ex. 1002, ¶108; Ex. 1001, 9:43-49. Further still, a POSITA would have understood that, only the real-valued magnitudes of $h_k^{(n,m)}$ are needed for spectrum coordination, i.e., which is equivalent to knowing the Xlog values, *see* Ex. 1002, ¶109; Ex. 1001, 2:63-54; *see also* Ex. 1006, p. 3, Equation 4; Ex. 1011, p. 6, Equation 6, and that the real-valued magnitudes | $h_k^{(n,m)}$ | can be converted to logarithmic form. *See* Ex. 1002, ¶100; Ex. 1007, pp. 92-93; Ex. 1001, 2:63-54; *see also id.* at 9:44-55. Thus, by converting the real-valued magnitudes | $h_k^{(n,m)}$ | into logarithmic form, a POSITA would have understood that Rezvani in view of Cendrillon I teaches a 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." Ex. 1002, ¶109.

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.*

Rezvani renders obvious dependent Claim 7 for the same reasons discussed with respect to dependent Claim 5 and as discussed below. *See supra*, § VII. A.5; Ex. 1002, ¶110.

As discussed above with respect to Limitations 1[a] and 1[e], Rezvani teaches that training is conducted during the interference determination phase to generate an interference matrix (a DSM-data quantity Xlog(u,n)). *See* Ex. 1005, 18:9-46; Ex. 1002, ¶111. While Rezvani's discussion of FIG. 12 may indicate that the interference determination phase occurs after initialization, *see* Ex. 1005, 17:46-57, Rezvani teaches that "[t]he processes discussed above [such as the interference determination phase] ***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); *see also id.* at 2:21-25, 17:21-65; Ex. 1001, 9:38-40; Ex. 1002, ¶111. To the extent that Rezvani does not teach that the interference determination phase occurs during initialization, it would have been obvious to a POSITA to modify the process of Rezvani such that the interference matrix is calculated and/or specified during an initialization mode. Ex. 1002, ¶111. Relatedly, Rezvani further teaches that "[t]he spectrum manager may determine the spectral profile from a number of parameters provided by the modems. Ex. 1005, 17:57-63; Ex. 1002, ¶112. 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; Ex. 1002, ¶112. 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; Ex. 1002, ¶112. From these disclosures, a POSITA would have understood that the initial bit-loading, power level ratios, interference levels, and/or noise margins are specified during initialization. Ex. 1002, ¶112. Thus, it would have been obvious to a POSITA that Rezvani teaches that the DSM-data quantity Xlog(u,n) is specified during an initialization mode. Ex. 1002, ¶112.

7. Claim 9

a. 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

Rezvani alone or in view of Cendrillon I renders obvious dependent Limitation 9[a] for the same reasons discussed with respect to Claims 1[d] and 5 and as discussed below. *See supra*, §§ VII. A.2.e, VII. A.5; Ex. 1002, ¶113.

As discussed above with respect to Limitation 1[b], Rezvani teaches that after injecting training sequences into each subscriber line, 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; Ex. 1002, ¶114. By comparing the output data to the known training sequence of input symbols, an interference matrix is generated for each primary line that shows for each selected primary line the interference injected by each crosstalking line into the selected primary line at each frequency or subcarrier. Ex. 1005, 7:23-50, 8:44-45, FIG. 6A; Ex. 1002, ¶114. A POSITA have understood that in DMT transmission, evaluating interference at a particular frequency or subcarrier corresponds to evaluating the interference transfer function at the particular frequency or subcarrier.

See Ex. 1002, ¶114; Ex. 1005, 1:52-64, 14:49-51, FIG. 6A. Thus, the output data (and the resulting interference matrix) comprises transfer functions that reflect crosstalk including NEXT and FEXT interference between subscriber lines in a bundle. *See* Ex. 1002, ¶114; Ex. 1005, 6:33-60, 14:31-53. Ex. 1006, pp. 1, 2.

Similarly, Cendrillon I teaches that FEXT is one type of crosstalk reflected in the resulting channel matrix and that FIG. 1 is a plot of transfer functions, and more particularly FEXT transfer functions *h*(1,2), *h*(1,3), and *h*(1,4), indicating the decibel-magnitude value of each FEXT transfer function at varying frequencies. *See* Ex. 1006, pp. 1, 2, 6, FIG. 1; Ex. 1002, ¶115.

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

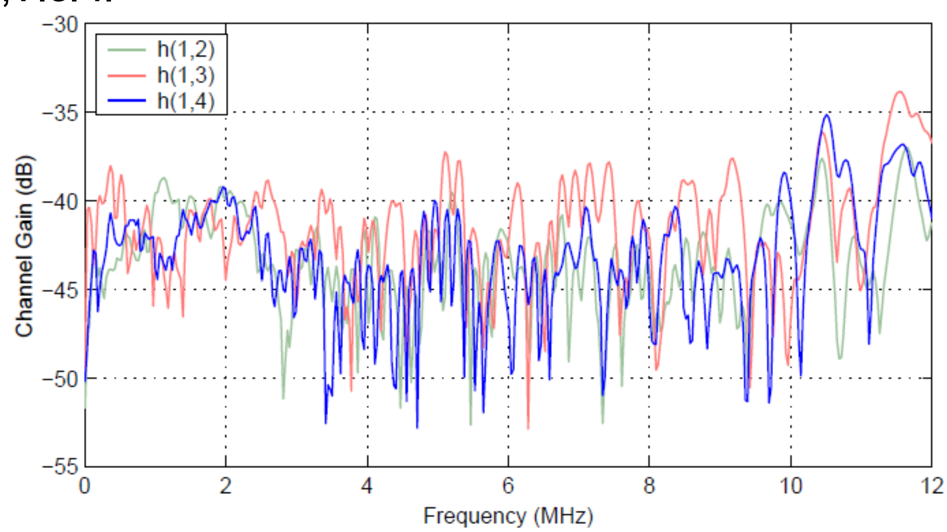


Fig. 1. FEXT Transfer Functions for 0.5 mm British Telecom Cable

Moreover, Rezvani teaches that the spectrum manager monitors crosstalk to provide "detailed co-interference parameters between subscriber lines," such as transfer functions, and calculate an interference matrix representative of those interference parameters. Ex. 1005, 14:31-51; Ex. 1002, ¶116. A POSITA would have understood that transfer functions are provided to a far-end management entity (like Rezvani's spectrum manager) in the form of output data to allow a transmitter and/or receiver to implement crosstalk mitigation/cancellation. *See* Ex. 1002, ¶116; Ex. 1005, 2:9-25 (describing "current solutions to interference" to enable a receiver to separate data from noise); Ex. 1006, p. 5 (describing "centraliz[ing] crosstalk cancellation into a single module").

b. 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

Rezvani alone or in view of Cendrillon I renders obvious dependent Limitation 9[b] for the same reasons discussed with respect to Claims 1[d], 5, and 9[a] and as discussed below. *See supra*, §§ VII. A.2.e, VII. A.5, VII. A.7.a; Ex. 1002, ¶117.

As discussed above with respect to Claim 5, a POSITA would have understood that Rezvani's interference matrix is a DSM-data quantity Xlog(u,n) representing for each subcarrier or frequency on each selected subscriber line the amount of interference injected into the selected subscriber line from each of the other subscriber lines, i.e., the extent of crosstalk coupling between each selected subscriber line and each of the remaining crosstalking lines. Ex. 1002, ¶118. That interference matrix is a transfer function that can reflect both FEXT and NEXT interference between DSL lines in a bundle. *See* Ex. 1005, 6:33-60, 14:31-53. Ex. 1006, pp. 1, 2; Ex. 1002, ¶118.

Similarly, Cendrillon I also teaches that FEXT is a type of crosstalk interference affecting bundled subscriber lines and that FIG. 1 below is a plot of 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 or subcarriers. *See* Ex. 1006, pp. 2, 6, FIG. 1; Ex. 1002, ¶119.

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

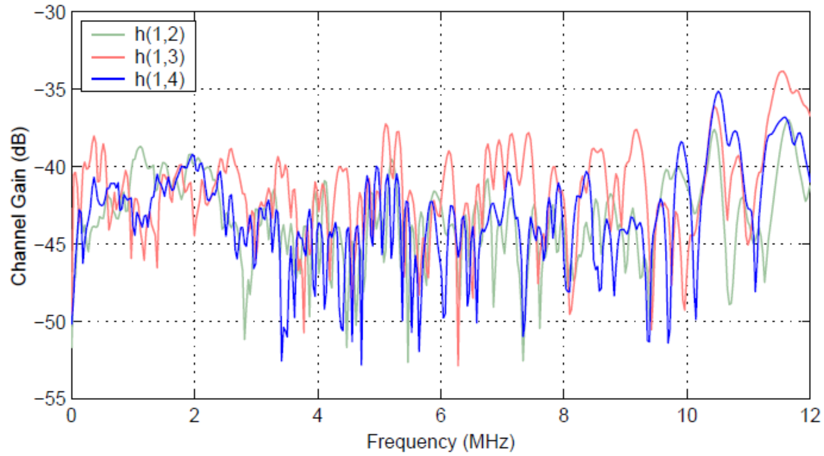


Fig. 1. FEXT Transfer Functions for 0.5 mm British Telecom Cable

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.*

Rezvani alone or in view of Cendrillon I renders obvious Claim 10 for the same reasons discussed with respect to Claims 1[d] and 5. *See supra*, §§ VII. A.2.e, VII. A.5; Ex. 1002, ¶120.

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.*

Rezvani alone or in view of Cendrillon I renders obvious dependent Claim 12 for the same reasons discussed with respect to Claim 1 and as discussed below. *See supra*, § VII. A.2; Ex. 1002, ¶121.

Rezvani teaches that the spectrum manager may be included within a digital signal processor. *See* Ex. 1005, 10:19-67, FIGs. 8A, 8B; Ex. 1002, ¶122. More specifically, the spectrum manager may be a part of ***a common digital signal processor*** such as "[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" as a result of the spectrum manager being coupled to transmit and receive path components 804, 810, 814, 816. Ex. 1005, 10:26-43; *see also id.* at 13:46-50; Ex. 1002, ¶122. 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; *see also id.* at 12:48-50 ("On the downstream side (Transmit path) the same architecture applies."); Ex. 1002, ¶122. Thus, it would have been 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." Ex. 1002, ¶122. To the extent FIGs. 8A and 8B refer to different embodiment, it would have been obvious to a POSITA to modify a set of physical modems to include features from the set of logical modems as this is expressly contemplated by Rezvani. *See* Ex. 1005, 10:64-67; Ex. 1002, ¶122.

To the extent it is argued that Rezvani does not render obvious Claim 12, Rezvani in view of Cendrillon I does. Ex. 1002, ¶123. In describing the basic channel model reflected in Equation I, Cendrillon I teaches that "[t]hrough synchronized transmission and the cyclic structure of DMT blocks crosstalk can be modeled independently on each tone." Ex. 1006, p. 1; Ex. 1002, ¶123. 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, 5. It would have been obvious to a POSITA that a single DSLAM serving all subscriber lines would include a ***common clock and processor*** in order to co-generate transmit signals and have synchronized transmissions from a single DSLAM. Ex. 1002, ¶123.

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

Rezvani renders obvious dependent Claim 14 for the same reasons discussed with respect to Claim 1 and as discussed below. *See supra*, § VII. A.2; Ex. 1002, ¶124.

FIG. 1 of Rezvani depicts, in part, a subscriber line bundle 158 bundling a plurality of subscriber lines connecting Office 156 to Remote Terminal 160 and thus central office 124. Ex. 1005, 4:23-33, FIG. 1. A POSITA would have understood "a single customer" to mean either a single user or a single entity that contracts with a

DSL service provider. Ex. 1002, ¶124. Thus, a POSITA would have recognized that FIG. 1 of Rezvani teaches that the plurality of subscriber lines in subscriber line bundle 158 can be allocated to a single customer or entity, such as Office 156. *See* Ex. 1005, 4:23-33, FIG. 1; Ex. 1002, ¶124. Further, a POSITA would have been familiar with bonded-DSL systems, in which several DSL lines are multiplexed to form a single high-speed connection. *See* Ex. 1002, ¶124; Ex. 1011, p. 3. Thus, to the extent that FIG. 1 of Rezvani does not teach the plurality of crosstalking lines are allocated to a single customer, it would have been obvious to a POSITA that the plurality of crosstalking lines could be bonded into a single connection for a single customer. *See* Ex. 1002, ¶124; 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.*

Rezvani alone or Rezvani in view of Cendrillon I renders obvious dependent Claim 15 for the same reasons discussed with respect to Claims 1, 5, and 14 and as discussed below. *See supra*, §§ VII. A.2, VII. A.5, VII. A.10; Ex. 1002, ¶125.

As explained above with respect to Claims 1[d], 5, 9[a], and 9[b], Rezvani alone or in view of Cendrillon I teach that the calculated interference matrix is a DSM-data quantity Xlog(u,n) that is representative of the crosstalk coupling between each crosstalking line u and the selected subscriber line at a frequency or subcarrier index n. Ex. 1002, ¶125. While the language of Claim 15 differs from that of Claim 5, a POSITA would have understood that evaluating interference at a particular frequency or subcarrier in DMT transmission corresponds to evaluating the interference transfer function at the particular frequency or subcarrier. *See* Ex. 1002, ¶125; Ex. 1005, 1:52-64, 14:49-51, FIG. 6A. Thus, to the extent Claim 15 classifies Xlog(u,n) as a line transfer function, it would have been obvious to a POSITA that Rezvani alone or Rezvani in view of Cendrillon I teaches that the interference matrix is a DSM-data "quantity Xlog(u,n) representing line transfer functions between crosstalking line u and the primary line at a subcarrier index n." Ex. 1002, ¶125.

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

1. *Overview of Ground 2*

a. G.992.3

G.992.3 describes procedures for transporting a bitstream over twisted pairs of copper wires. Ex. 1007, p. 52; Ex. 1002, ¶66. Those procedures include processes for determining channel characteristics as a function of subcarrier, which include the results of the following: the transmitter filter characteristics function, the channel characteristics function, and the receiver filter characteristics function. Ex. 1007, p. 93; Ex. 1002, ¶66. 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; Ex. 1002, ¶66.

The channel characteristics function Hlin ($i \times \Delta f$) is represented in linear format by a *scale* factor and a normalized complex number $a(i) + j \times b(i)$, where i is the subcarrier index. 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, pp. 93-94; Ex. 1002, ¶67.

The value of Hlin ($i \times \Delta f$) is defined as Hlin ($i \times \Delta f$)$=(scale/2^{15}) \times (a(i) + j \times b(i))/2^{15}$. 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; Ex. 1002, ¶68.

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 ($i \times \Delta f$)$=6-(m(i)/10)$. Ex. 1007, p. 94; Ex. 1002, ¶69.

b. Motivation to combine.

A POSITA would have been motivated to modify Rezvani with the teachings of Cendrillon I as discussed above, and would use Cendrillon I's partial crosstalk cancellation methods to mitigate the effects of crosstalk interference between lines in a bundle provided as a part of Rezvani's DSL system to improve signaling on

DSL lines, while taking advantage of efficiencies from canceling crosstalk on only the worst crosstalking lines. *See* Ex. 1002, ¶127; Ex. 1005, 8:44-48; Ex. 1006, p. 6. A POSITA would have been motivated to further modify Rezvani based on the teachings of G.992.3 to utilize known transfer function formatting for channel characterization. *See* Ex. 1002, ¶127; 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, 12:30-46, FIG. 9; Ex. 1002, ¶127. Therefore, Rezvani itself guided POSITAs to review and consider relevant portions of XDSL standards, including those reflected in G.992.3. Ex. 1002, ¶127. Moreover, Rezvani discusses certain line characteristics, including crosstalk interference as reflected in FIG. 6A, and therefore a POSITA would have reviewed the transfer function formats for line characterization provided in G.992.3 when reviewing the XDSL standards mentioned in Rezvani. *See* Ex. 1005, 1:42-64, 2:10-25; FIG. 6A Ex. 1007, pp. 92-94; Ex. 1002, ¶127. Moreover, a POSITA would have been motivated to use the known transfer function formats of Hlin(f) and Hlog(f) to characterize crosstalk interference in the form of interference matrices, because these transfer function formats were known and implemented by existing DSL equipment, and using the transfer functions to characterize other line characteristics (e.g., crosstalk interference) would not require changes to the formatting of those transfer functions. *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. 1002, ¶127. Specifically, G.992.3 demonstrated that this formatting is effective for conveying line characteristic data that can be used when enhancing the integrity of signals distorted by noise, line attenuation, or other sources of signal degradation. *See* Ex. 1007, pp. 92-94; Ex. 1002, ¶127. Thus, a POSITA would have known to use the same format for characterizing crosstalk interference from multiple crosstalking lines, so that known mitigation techniques (e.g., those taught by Rezvani in view of Cendrillon I) can be used to address crosstalk interference without significantly modifying those mitigation techniques to accommodate a different data format. *See* Ex. 1002, ¶127; 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.

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, reduces data storage requirements while still achieving the performance benefits of Rezvani and Cendrillon I. *See* Ex. 1002, ¶128; 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.

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 channel characteristics were represented in a manner analogous to those of Hlog and Hlin as discussed in G.992.3. *See* Ex. 1002, ¶129; Ex. 1005, 6:33-60, 7:23-50, FIG. 6A; Ex. 1006, pp. 1, 5-6, FIG. 1; Ex. 1008, p. 1521; 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; Ex. 1002, ¶129. 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 were already familiar with the transfer function formats specified in G.992.3 to estimate channel characteristics, and those formats accommodate matrix data quantities, such as the crosstalk interference data quantities reflected in Rezvani's FIG. 6A and the FEXT transfer functions discussed in Cendrillon I. *See* Ex. 1002, ¶129; 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 demonstrated that this formatting is effective for conveying line characteristic data, a POSITA would have had a reasonable expectation of success in using this formatting for characterizing crosstalk. *See* Ex. 1002, ¶129; 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) were presented to optimize system performance while utilizing known transfer function formats specified in relevant XDSL standards, including ADSL2 reflected in G.992.3. Ex. 1002, ¶129.

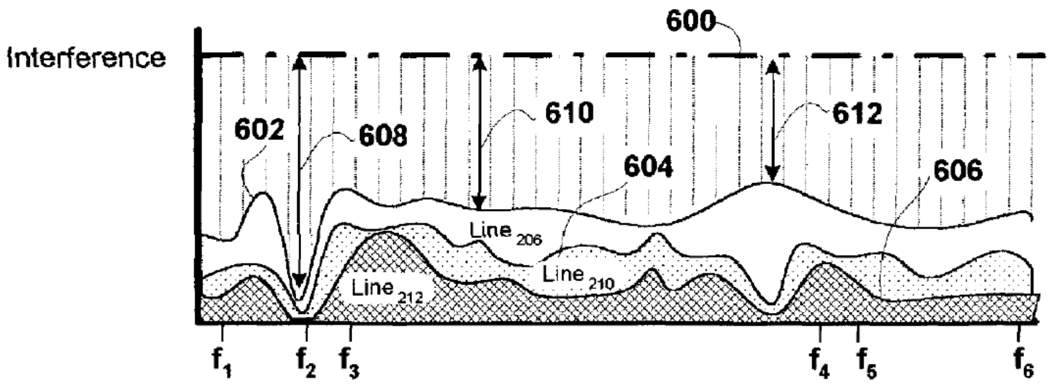
2. Claim 11

*a. 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*

Rezvani in view of Cendrillon I and G.992.3 teaches Limitation 11[a] for the same reasons discussed with respect to Claim limitations 1[c], 1[d], 5, and 10 and as discussed below. *See supra*, §§ VII. A.2.d, VII. A.2.e, VII. A.5, VII. A.8; Ex. 1002, ¶130.

As discussed above with respect to Limitations 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; Ex. 1002, ¶131. FIG. 6A of Rezvani 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 shown). Ex. 1005, FIG. 6A; Ex. 1002, ¶131.

Ex. 1005, FIG. 6A.



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

FIG. 6A

Moreover, as discussed with respect to Claim 5, Cendrillon I further discloses that crosstalk interference functions (such as those reflected in Rezvani's FIG. 6A) could be provided in a matrix reflecting the interference between a primary line and different crosstalking lines (indexed as "u") for different frequencies (n=0-NSC, wherein NSC is the number of carriers/frequencies used) (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; Ex. 1002, ¶132.

Rezvani and Cendrillon do not disclose the use of a scale factor and a normalized complex number. Ex. 1002, ¶133. However, G.992.3 discusses the same scaling and formatting of Element 11[a] for a single channel, specifically formatted as "Hlin(f): a format provided complex values in linear scale". Ex. 1007, pp. 93-94; Ex. 1002, ¶133.

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.

G.992.3 discusses that Hlin(f) characterizes attenuation of a single line, and therefore the scale factor is a constant. *See* Ex. 1007, pp. 93-94; Ex. 1002, ¶135. For a multi-variable transfer function describing interference from multiple crosstalking lines at different frequencies, such as Xlin(u,n) however, a POSITA would have recognized that the scale factor varies as a function of each interferer line, which would be denoted as *scale(u)* using the nomenclature of the '458 patent. *See* Ex. 1002, ¶135; 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. Ex. 1002, ¶135. A POSITA would have further selected a scaling factor that is a function of the crosstalking line (u). Ex. 1002, ¶135. A POSITA would have had a reasonable expectation of success using that same formatting for characterizing crosstalk because this formatting was already known from G.992.3 to represent channel characteristics. *See* Ex. 1002, ¶135; 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. Consistent with both Rezvani and Cendrillon I, the determined channel characteristics (e.g., provided in a format analogous to that discussed in G.992.3) would have been used to cancel or mitigate crosstalk interference. Ex. 1002, ¶135. 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 have achieved the benefits of Rezvani's and Cendrillon I's crosstalk mitigation or cancelling on a primary line. *See* Ex. 1002, ¶135; 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.

b. 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}

Rezvani in view of Cendrillon I and G.992.3 teaches dependent Limitation 11[b] for the same reasons discussed with respect to Claims 1[c], 1[d], 5, 10, and 11[a] and as discussed below. *See supra*, §§ VII. A.2.d, VII. A.2.e, VII. A.5, VII. A.8, VII. B.2.a; Ex. 1002, ¶136.

As discussed above with respect to Limitation 11[a], this definition of Xlin(u,n) is identical to G.992.3's definition of Hlin(f), but for Xlin being a function of two variables u and n. *See* Ex. 1001, 10:57; Ex. 1007, pp. 93-94; Ex. 1002, ¶136. A POSITA would have been motivated to adapt the Hlin format in G.992.3 to fit the multi-variable format of the crosstalk transfer functions of Rezvani and Cendrillon I with 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. 1002, ¶136; 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 represent channel characteristics (Ex. 1007, pp. 1-2, 92-94; Ex. 1002, ¶136), and both Rezvani and Cendrillon I discuss mitigation or cancelation of crosstalk interference that could be characterized using known equations *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; Ex. 1002, ¶136. Thus, implementing transfer functions having a known format (such as described in G.992.3) to reflect normalized complex numbers for crosstalk interference and using a scale factor dependent on u would achieve the benefits of Rezvani's and Cendrillon I's crosstalk mitigation or cancelling on a primary line. *See* Ex. 1002, ¶136; 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.

VIII. DISCRETIONARY ISSUES

A. The Petition Does Not Present the Same References Addressed in Prosecution.

Under *Advanced Bionics*, the Board should not deny institution under 35 U.S.C. § 325(d). *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH*, No. IPR2019-01469, Paper 6 at 7-8 (P.T.A.B. Feb. 13, 2020) (precedential).

The Board has held that the first prong of *Advanced Bionics* is not met where "neither [the combination references] nor similar prior art was before the examiner … the prosecution history does not include any overlapping arguments directed to this prior art." *Godsbern-Smith Constr. Co. v. Guntert & Zimmerman Const. Div., Inc.*, No. IPR2021-00050, Paper 24 at 19-21 (PTAB May 7, 2021). No combination of Rezvani, Cendrillon I, and G.992.3 was before the Examiner, and the prosecution history does not include any overlapping arguments to this Petition. Prosecution was short, and the claims were substantively amended to recite that a plurality of "crosstalking lines" are excited by the known sequence of input signals. Ex. 1004, pp. 106-107, 115-116, 124-135, 141-142; Ex. 1002, ¶¶40-44. Rezvani alone or in combination addresses this limitation, disclosing that 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." Ex. 1005, 14:41-45. *See*

Amphenol Corporation v. PPC Broadband, Inc., IPR2023-01363, Paper 9 at 30-31 (PTAB Mar. 20, 2024).

Accordingly, the combination of references used in this Petition cannot be cumulative of the art and/or arguments raised during prosecution as there are material differences between the grounds herein and what was previously presented. *Tianma Microelectronics Co., v. Japan Display Inc.*, IPR2021-01058, Paper 16 at 31 (PTAB Jan. 5, 2022). Because the first prong is not met, the Board need not consider the second prong. *See id*. at 21; *Oticon Med. AB v. Cochlear Ltd*., IPR2019-00975, Paper 15 at 20 (PTAB Oct. 16, 2019).

Therefore, the Board should not deny institution under § 325(d).

B. The Board Should Not Deny Institution Under *Fintiv*.

The ’458 patent has never been tested in view of the most relevant prior art. In view of these strong and compelling challenges, the on-going district court litigation against AT&T, and the ongoing cloud over all of Nokia’s customers, institution should not be discretionarily denied under §314(a). *See NHK Spring Co. v. Intri-Plex Techs., Inc.*, IPR2018-00752, Paper 8 at 19-20 (PTAB Sept. 12, 2018) (precedential); *Apple v. Fintiv, Inc.*, IPR2020-00019, Paper 11 at 13-14 (PTAB Mar. 20, 2020) (precedential).

As an initial matter, because Nokia is not currently a party to the underlying litigation and is the only petitioner here, the Board should not discretionally deny

Nokia's petition. For purposes of this petition, the litigation between ASSIA and AT&T is considered below.

Factor 1—a potential stay of the district court litigation—is at least neutral because no party has requested a stay in the action against AT&T. *VMWare, Inc. v. Intellectual Ventures I LLC*, IPR2020-00470, Paper 13 at 17 (PTAB Aug. 18, 2020) (finding in the absence of a stay motion that this factor "does not weigh for or against discretionary denial").

Factor 2—the district court trial date and the Board's statutory deadline—weighs against discretionary denial because of the high likelihood of transfer to another forum or a stay pending arbitration, either of which will significantly push back any potential trial date. This is a complex case with a complicated relationship between the Plaintiff and Defendant AT&T. Specifically, Defendant AT&T has a license to patents owned by the Plaintiff (including a claim that it jointly owns the '458 patent) where the licenses include a choice of forum clause requiring litigation to be brought in the Northern District of California rather than the Eastern District of Texas (any disagreement about this clause must be decided through arbitration). AT&T thus filed a motion to transfer the case to the Northern District of California or, in the alternative, arbitrate where the case should be brought. Given the strength of AT&T's motion, it is highly likely that trial will be pushed back (either because it is transferred or because arbitration is ordered) until well after the deadline for a final written decision. Ex. 1019. Moreover, even if the motion is denied, because jury selection is far in the future and is not set to begin until at least September 22, 2025, with trial set to begin thereafter, discretionary denial is still not warranted. *See Dish Network v. Broadband iTV*, IPR2020-01280, Paper 17 at 16 (PTAB Feb. 4, 2021) ("We cannot ignore the fact that the currently scheduled trial date is more than nine months away and much can change during this time").

Altogether, this factor weighs against discretionary denial.

Factor 3—investment in the district court proceedings—weighs against discretionary denial. The district court case is in its early stages and the district court has not issued any substantive rulings in with respect to the '458 patent. Specifically, invalidity contentions were served on October 7, 2024, the claim construction hearing is not scheduled until March 19, 2025, and opening expert reports are not due until April 29, 2025 with expert discovery extending into June. Ex. 1023.

Altogether, there is much work to be done in the district court and most of the work will be well in the future. Accordingly, the district court will not invest significant resources related to the challenged patent prior to the issuance of an institution decision. See *Fintiv*, IPR2020-00019, Paper 11 at 9-12; *DISH Network*, IPR2020-01280, Paper 17 at 18-21.

Factor 4—overlap between this proceeding and the district court proceedings—favors institution. As the district court case progresses, there will not be complete overlap between this IPR and the district court case. Although the same 11 claims challenged in this IPR are asserted in the district court case, the court has ordered the Patent Owner reduce the number of asserted claims to no more than 6 claims from each patent before trial. Ex. 1018. In light of this order, the district court case will not reach a conclusion as to the validity of all 11 claims challenged in this IPR. This factor thus weighs against discretionary denial.

Factor 5—overlapping parties—strongly favors institution. Here, the Petitioners include only Nokia, who is not currently a party in the underlying litigation. *Fintiv*, IPR2020-00019, Paper 11 at 13-14. As an initial matter, that means that if institution is denied and only the subset of claims raised at trial are rendered invalid at the district court, ASSIA may resort to gamesmanship and assert infringement of those claims not raised at trial (but challenged in this petition) against Nokia in a separate litigation. Additionally, in that underlying litigation, ASSIA has only accused AT&T of infringement (largely accusing Nokia products), but AT&T is just one of Nokia's many U.S. customers using Nokia's DSL products. Given ASSIA's history of suing Nokia's customers (including KPM in the Netherlands, Orange in France, and Fastweb in Italy), Nokia believes that ASSIA is likely to sue additional U.S.-based customers in the future, none of which are named in the underlying litigation.

The final *Fintiv* factor—other considerations—weighs strongly against discretionary denial. As detailed herein, the merits of the Petition are strong. More specifically, Rezvani and Cendrillon I teach the same concept of the ’458 patent (developing an interference matrix ranking crosstalk sources by their amount of crosstalk noise on a primary line to apply crosstalk mitigation or cancellation). To the extent the ’458 patent relies on partial crosstalk cancellation methodologies, Cendrillon I teaches those as well. Moreover, none of the grounds asserted herein were previously considered by either the Office or the district courts. *Cf. Comcast Cable Commn’s, LLC v. Rovi Guides, Inc.*, IPR2019-00231, Paper 14 at 11 (PTAB May 20, 2019).

C. The Board Should Not Deny Institution Under *General Plastic*.

The *General Plastic* factors do not apply for several reasons. First, this is the first and only *inter partes* review (“IPR”) petition filed by Petitioner with respect to the ’458 patent. As noted in Section IV.E, there are no other proceedings involving the ’458 patent, and therefore, there is no concern of serial petitions. Given the merits raised in this Petition have not been addressed to date, denial of institution under *General Plastic* is unwarranted. *Code200, UAB v. Bright Data, Ltd.*, IPR2022-00861, Paper 18 at 5-6 (P.T.A.B. Aug. 23, 2022) (precedential).

IX. CONCLUSION

Petitioner requests cancellation of the Challenged Claims.

X. MANDATORY NOTICES UNDER 37 C.F.R. §42.8

A. Real Party in Interest Under 37 C.F.R. §42.8(b)(1)

The real parties in interest are AT&T Services Inc., AT&T Enterprises, LLC, AT&T Mobility LLC, AT&T Mobility II LLC, and Nokia of America Corp.

Out of an abundance of caution, Petitioner has identified all current defendants in the below cases, as well as additional involved parties, as potential real parties in interest only for the purpose of this proceeding and only to the extent that Patent Owner contends that these separate legal entities should be named real parties in interest in this IPR. Petitioner does so to avoid the potential expenditure of resources to resolve such a challenge. Petitioner also acknowledges that each petitioner has a number of affiliates. No unnamed entity is funding, controlling, or otherwise has an opportunity to control or direct this Petition or Petitioner's participation in any resulting IPR. Petitioner is also not aware of any affiliate that would be barred from filing this Petition under 35 U.S.C. § 315(e).

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

The '458 patent is the subject of the following litigation:

- *Adaptive Spectrum and Signal Alignment, Inc. v. AT&T Enterprises, LLC, AT&T Mobility LLC, AT&T Mobility II LLC, and AT&T Services, Inc.*, No. 2:24-cv-00029-JRG-RSP

Petitioner is not aware of any other judicial or administrative matter that would affect or be affected by a decision in this IPR.

C. Designation of Counsel Under 37 C.F.R. §42.8(b)(3)

Petitioner provides the following designation of counsel.

Lead Counsel	Backup Counsel
M. Scott Stevens Reg. No. 54,762 **ALSTON & BIRD LLP** Vantage South End 1120 S. Tryon Street, Suite 300 Charlotte, NC 28203 Phone: 704.444.1000 Fax: 704.444.1111 Email: scott.stevens@alston.com	Christopher TL Douglas Reg. No. 56,950 Nicholas C. Marais Reg. No. 77,181 Matthew Turk Reg. No. 79,618 **ALSTON & BIRD LLP** Vantage South End 1120 S. Tryon Street, Suite 300 Charlotte, NC 28203 Phone: 704.444.1000 Fax: 704.444.1111 Email: christopher.douglas@alston.com Email: nic.marais@alston.com Email: matthew.turk@alston.com Daniel J. O’Connor Reg. No. 69,023 **ALSTON & BIRD LLP** 755 Page Mill Road Building C – Suite 200 Palo Alto, CA 94304 Phone: 650.838.2000 Fax: 650.838.2001 Email: dan.oconnor@alston.com

Pursuant to 37 C.F.R. § 42.8(b)(4), counsel agrees to service by mail as detailed above, and to electronic service by email as detailed above. Pursuant to 37

C.F.R §42.10(b), a Power of Attorney executed by Petitioner accompanies this Petition.

D. Service Information

Please address all correspondence and service to the addresses listed above. Petitioner consents to electronic service at the addresses above.

Date: January 22, 2025 By: /*M. Scott Stevens*/

M. Scott Stevens
Reg. No. 54,762
ALSTON & BIRD LLP
Vantage South End
1120 S. Tryon Street, Suite 300
Charlotte, NC 28203
Phone: 704.444.1000
Fax: 704.444.1111
Email: scott.stevens@alston.com

CLAIMS APPENDIX

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.

CERTIFICATION UNDER 37 C.F.R. §42.24

Petitioner certifies that the word count in this Petition is 13,987 words, as counted by the word-processing program (Microsoft Word for Office 365) used to generate this Petition, where such word count excludes the table of contents, table of authorities, mandatory notices, certificate of service, appendix of exhibits, and this certificate of word count. This Petition is in compliance with the 14,000-word limit set in 37 C.F.R. § 42.24(a)(1)(i).

Date: January 22, 2025 By: */ M. Scott Stevens/*

M. Scott Stevens
Reg. No. 54,762
ALSTON & BIRD LLP
Vantage South End
1120 S. Tryon Street, Suite 300
Charlotte, NC 28203
Phone: 704.444.1000
Fax: 704.444.1111
Email: scott.stevens@alston.com

CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. §§42.6(e), 42.105 and in view of the agreement between the Parties under 37 C.F.R. § 42.105(b), the undersigned hereby certifies that true and correct copies of the above-captioned PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 7,593,458, all associated exhibits, and Petitioner's Power of Attorney were served in their entireties on January 22, 2025, upon the Patent Owner at the following email addresses of Patent Owner's litigation counsel:

ASSIA-ATT@caldwellcc.com

bcaldwell@caldwellcc.com

jnemunaitis@caldwellcc.com

Date: January 22, 2025 By: */M. Scott Stevens/*

M. Scott Stevens
Reg. No. 54,762
ALSTON & BIRD LLP
Vantage South End
1120 S. Tryon Street, Suite 300
Charlotte, NC 28203
Phone: 704.444.1000
Fax: 704.444.1111
Email: scott.stevens@alston.com