

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

DISH NETWORK CORPORATION, DISH NETWORK L.L.C., AND
DISH NETWORK SERVICE L.L.C.,

Petitioners

v.

ENTROPIC COMMUNICATIONS, LLC

Patent Owner.

PTAB Case No. IPR 2023-00393

Patent No. 8,792,008

**DECLARATION OF DAN SCHONFELD, PH.D.
IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S.
PATENT NO. 8,792,008**

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EXHIBIT LIST

Ex. 1001	U.S. Patent No. 8,792,008 (“’008 patent”)
Ex. 1002	Declaration and Curriculum Vitae of Dr. Daniel Schonfeld (“Schonfeld”)
Ex. 1003	File History of U.S. Patent 8,792,008
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Ex. 1016	NASA Content Administrator, <i>July 12, 1962: The Day Information Went Global</i> , NASA (Jan. 30, 2018).
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Ex. 1018	Stephen P. Dulac & John P. Godwin, <i>Satellite Direct-to-Home</i> , 94 PROCS. OF THE IEEE 158, (Jan. 2006).
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Ex. 1029	U.S. Patent No. 6,791,995 ("Azenkot")
Ex. 1030	U.S. Patent No. 6,061,393 ("Tsui")
Ex. 1031	Rajendra Kumar et al., <i>Signal Processing Techniques for Wideband Communication Systems</i> , MILCOM 1999, IEEE MILITARY COMMS. CONF. PROCS. 452 (1999).

I, Dan Schonfeld, Ph.D., declare as follows:

1. I have been retained by Perkins Coie LLP on behalf of DISH Network Corporation, DISH Network L.L.C., and Dish Network Service L.L.C. (“Petitioners” or “Petitioner”), to provide this Declaration concerning technical subject matter relevant to the petition for *inter partes* review of U.S. Patent No. 8,792,008 (“the ’008 patent”) (Ex. 1001). I have been asked to consider whether certain references disclose or suggest the features recited in claims 1-18 of the ’008 patent (“the ’008 patent claims”). My opinions are set forth below.

2. I am an independent consultant. All my opinions stated in this Declaration are based on my own personal knowledge and professional judgment. In forming my opinions, I have relied on my knowledge and experience in designing, developing, researching, and teaching regarding multimedia communications, signal monitoring technology, and information referenced in this Declaration.

3. I am over 18 years of age. I have personal knowledge of the facts and opinions stated in this Declaration and could competently testify to them if asked to do so. I have been warned that willful false statements and the like are punishable by fine, imprisonment, or both.

4. I am being compensated at my standard consulting rate of \$750/hour for my work in this proceeding. I am also being reimbursed for expenses that I may

incur during the course of this work. I am not receiving any other form of compensation. My compensation is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other interest in this proceeding.

5. I have reviewed and am familiar with the specification and claims of the '008 patent. In general, I will cite to the specification of an issued United States patent using the following format: Patent No., Column:Line number(s). For example, the citation "'008 patent, 1:1-11" points to the '008 patent specification at column 1, lines 1 through 11. For convenience, I will use *italics* to denote limitations from the challenged claims.

I. QUALIFICATIONS

6. A copy of my current curriculum vitae ("CV"), which includes a more detailed summary of my education and professional and academic experience, is provided as an Appendix to this Declaration. The following provides an overview of some of my experience that is relevant to the matters set forth in this Declaration.

7. I am a Professor in the Department of Electrical and Computer Engineering at the University of Illinois Chicago ("UIC"). I have been elected Fellow of the Institute of Electrical and Electronics Engineers ("IEEE") as well as Fellow of the International Society for Optics and Photonics ("SPIE"). I have also been elected University Scholar of UIC.

8. I received my Bachelor of Science degree in Electrical Engineering and Computer Science from the University of California, Berkeley in 1986 and both my Master of Science and Doctor of Philosophy (“Ph.D.”) degrees in Electrical and Computer Engineering from Johns Hopkins University in 1988 and 1990, respectively.

9. In 1990, I joined the Department of Electrical Engineering and Computer Science at UIC, where I currently work as a tenured Professor in the Departments of Electrical and Computer Engineering, Computer Science, and Bioengineering. I serve as a co-director of the Multimedia Communications Laboratory (“MCL”) and as a member of the Signal and Image Research Laboratory (“SIRL”). I have also served as a director of the University Industry Engineering Research Center (“UIERC”), also known as the Manufacturing Research Center (“MRC”), in the College of Engineering. Before I joined UIC, I served as an instructor in the Department of Electrical and Computer Engineering at Johns Hopkins University.

10. Over the past two decades, I have also served as a visiting professor in (a) the Advanced Analytics Institute (“AAI”) at the University of Technology Sydney in Australia, (b) the Department of Information Engineering and Computer Science (“DISI”) at the University of Trento in Italy, (c) the School of Computer

Science and Engineering (“SCSE”) at the Nanyang Technological University in Singapore, and (d) the Department of Electrical Engineering - Systems at Tel Aviv University in Israel.

11. I have previously served as the editor-in-chief and deputy editor-in-chief of the IEEE Transactions on Circuits and Systems for Video Technology. I have also previously served as an area editor for special issues of the IEEE Signal Processing Magazine. I have also served as an associate editor of the IEEE Transactions on Circuits and Systems for Video Technology, IEEE Transactions on Image Processing, and IEEE Transactions on Signal Processing. I have also served on the editorial board of the IEEE Signal Processing Magazine, European Association for Signal Processing (“EURASIP”) Journal of Image and Video Processing, Research Letters in Signal Processing, and two patent-focused publications titled “Recent Patents on Computer Science” and “Recent Patents on Electrical Engineering.” I have served as a guest editor of numerous special issues in various journals in the area of multimedia systems.

12. I currently serve on the Conference Board of the IEEE Signal Processing Society. I have previously served as a technical program chair of the IEEE International Conference on Acoustics, Speech, and Signal Processing (“ICASSP”) in 2018 as well as a program chair of the IEEE Conference on Visual

Communications and Image Processing (“VCIP”) in 2015. I have previously served as a general co-chair of the Workshop on Big Data in 3D Computer Vision in 2013 and the IEEE International Conference on Multimedia and Expo (“ICME”) in 2012. I have also served as a chair of the IEEE Workshop on Video Mining in 2008 and the SPIE Conference on Visual Communications and Image Processing in 2007. Additionally, I have served on the organizing committees of various conferences including the IEEE International Conference on Image Processing in 1998, 2012, and 2020.

13. I have authored and co-authored over 200 technical papers for various journals and conferences. For example, I was the author of a book chapter, entitled “Image and Video Communication Networks” in the “Handbook of Image and Video Processing,” edited by Alan Bovik. I was also a co-author (with Carlo Giuletta and Rashid Ansari) of a paper that won the Best Paper Award at the Association for Computing Machinery’s (“ACM’s”) Multimedia Workshop on Advanced Video Streaming Techniques for Peer-to-Peer Networks and Social Networking in 2010. I was also a co-author of various papers that won the Best Student Paper Award, including a paper, with Junlan Yang, at the IEEE International Conference on Image Processing in 2007, a paper, with Wei Qu, at the IEEE International Conference on Image Processing in 2006, and a paper, with Nidhal

Bouaynaya, in Visual Communications and Image Processing in 2006. In addition, many of my publications relate to the broad topic of multimedia systems, which includes audio, image, and video processing and signal analysis. My publications in the area of multimedia systems dates back to 1988.

14. I was invited as a plenary and keynote speaker to the International Conference on Intelligent Control and Information Processing (“ICICIP”) in 2013, International Conference on Brain Inspired Cognitive Systems (“BICS”) in 2013, IEEE/Electro/Information Technology (“EIT”) International Conference on Audio, Language, and Image Processing in 2010, the IEEE International Conference on Advanced Video and Signal- Based Surveillance in 2009, and the American Society of Mechanical Engineers (“ASME”) International Conference on Communications, Signals and Systems in 1995 and 2001.

15. I have served as a representative of regions 1-6 (North America) on the Chapters Committee of the IEEE Signal Processing Society. I have also served as a chairman of the IEEE Signal Processing Chicago Chapter, and have served on the IEEE Image, Video and Multidimensional Signal Processing Technical Committee and the IEEE Multimedia Communications Technical Committee. I currently serve on the American National Standards Institute (“ANSI”) / Underwriters Laboratory (“UL”) Standards Technical Panel (“STP”) on Multimedia Systems.

16. I have taught various courses that relate to multimedia systems. For example, since the late 1990s, I have introduced and taught an advanced undergraduate-level/first-year graduate-level course on multimedia systems (originally called multimedia communication networks).

II. MATERIALS REVIEWED

17. The opinions contained in this Declaration are based on the documents I reviewed, my professional judgment, as well as my education, experience, and knowledge regarding the multimedia communications technology and/or signal monitoring technology including, for example, monitoring satellite and/or cable signal quality, television signal processing, and satellite communications, or a related field.

18. In forming my opinions expressed in this Declaration, I reviewed the following materials and information (and any other materials and information I reference in this Declaration):

Ex. 1001	U.S. Patent No. 8,792,008 (“’008 patent”)
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Ex. 1003	File History of U.S. Patent 8,792,008
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Ex. 1031	Rajendra Kumar et al., <i>Signal Processing Techniques for Wideband Communication Systems</i> , MILCOM 1999, IEEE MILITARY COMMS. CONF. PROCS. 452 (1999).

19. I have been asked to initially consider that the time of the alleged invention of the '008 patent encompasses the time frames near and including September 8, 2011. I understand the application for the '008 patent claims priority to multiple applications, the earliest of which was filed on September 8, 2011. (Exs. 1001 and 1004.) I have also been told that, in the related litigation, Patent Owner contends that the '008 patent was conceived as of February 25, 2011. For the purposes of my analysis, my opinions reflect how one of ordinary skill in the art (which I describe below) would have understood the '008 patent, the prior art to the patent, and the state of the art at the time of the alleged invention as I was asked to consider noted above.

20. Based on my experience and expertise, it is my opinion that the prior art discloses and/or suggests all the limitations recited in challenged 1-18 of the '008 patent, as I discuss in detail below.

III. GOVERNING LAW AND PERSPECTIVES APPLIED

21. I am not a lawyer, and I will not provide any legal opinions. Although I am not a lawyer, I have been advised that certain legal standards are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims.

22. I understand that a patent claim is invalid if it is anticipated or obvious in view of the prior art and that a claim can be unpatentable even if all of the requirements of the claim cannot be found in a single prior-art reference. I further understand that invalidating a claim requires that the claim be anticipated or obvious from the perspective of a person having ordinary skill in the art (“POSITA”) at the time the invention was made.

23. In forming my analysis, opinions, and conclusions expressed in this Declaration, I have applied the legal principles set forth below which were provided to me by counsel for Petitioners.

A. Types of Claims

24. I understand that there are two types of U.S. patent claims: 1) independent claims; and 2) dependent claims. I understand that independent

claims only include the language of the independent claim itself. I further understand that dependent claims includes both the language of a particular dependent claim and the language of any claim from which that particular dependent claim depends.

B. Anticipation and Obviousness

25. I understand that a claim is not patentable if it is anticipated or obvious. I understand that anticipation of a claim requires that every element of a claim is disclosed expressly or inherently in a single prior art reference.

26. I further understand that obviousness of a claim requires that the claim be obvious from the perspective of a POSITA at the time the invention was made. I understand that the earliest patent application filing leading to the '008 patent was a U.S. provisional patent application filed on September 8, 2011. As stated above, I have further been told that Patent Owner contends that the '008 patent was conceived as of February 25, 2011. I have assumed that February 25, 2011 is the '008 patent's alleged invention date, but I offer no opinion of whether the claims of the '008 patent are entitled to this date.

27. I have therefore analyzed the unpatentability of the claims as of that day. I may refer to the relevant time period as the "2011 timeframe" in this Declaration, with the understanding that this does not include the time period on or after the alleged date of invention (*i.e.*, February 25, 2011).

28. I understand that to prove that prior art or a combination of prior art renders a patent obvious, it is necessary to:

- a) identify the particular references that, singly or in combination, make the patent obvious;
- b) specifically identify which elements of the patent claim appear in each of the asserted references; and
- c) explain why a POSITA would have combined the references, and how they would have done so, to create the inventions claimed in the patent.

29. I further understand that exemplary rationales that may support a conclusion of obviousness include:

- a) combining prior art elements according to known methods to yield predictable results;
- b) simple substitution of one known element for another to obtain predictable results;
- c) use of known technique(s) to improve similar devices (methods or products) in the same way;
- d) applying a known technique to a known device (method or product) ready for improvement to yield predictable results;

- e) “obvious to try” - choosing from a finite number of identified, predictable solutions with a reasonable expectation of success;
- f) known work in one field of endeavor may prompt variations of the work for use in either the same field or a different field based on design incentives or other market forces if the variations are predictable to a POSITA; and
- g) some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

30. In analyzing obviousness, I understand that it is important to understand the scope of the claims, the level of skill in the relevant art, the scope and content of the prior art, the differences between the prior art and the claims, and any “secondary considerations” (described below). I also understand that if a technique has been used to improve one device, and a POSITA would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. Although I understand that it is not required, there may also be a specific “teaching, suggestion or motivation” to combine any first prior art reference with a second prior art reference. Such a “teaching, suggestion, or motivation” to combine the first prior art reference with the second

prior art reference can be explicit or implicit, and may provide further evidence of obviousness.

31. I understand that secondary (or objective) considerations are relevant to the determination of whether a claim is obvious. Such secondary (or objective) considerations can include evidence of commercial success caused by an invention, evidence of a long-felt need that was solved by an invention, evidence that others copied an invention, or evidence that an invention achieved a surprising or unexpected result. I understand that such evidence must have a nexus, or causal relationship to the elements of a claim, to be relevant to the obviousness or non-obviousness of the claim. I am not currently aware of any such evidence for the claims of the '008 patent and reserve my right to review and respond to such evidence if presented.

C. Claim Construction

32. I understand that, for purposes of my analysis, the terms appearing in the patent claims should be interpreted according to their “ordinary and customary meaning.” In determining the ordinary and customary meaning, the words of a claim are first given their plain meaning that those words would have had to a POSITA. I understand that the structure of the claims, the specification, and the file history also may be used to better construe a claim term. Additionally, treatises and dictionaries may be used, in limited circumstances, to determine the meaning attributed by a

person of ordinary skill in the art to a claim term at the time of filing. I have followed this approach in my analysis, and for all of the claim terms considered in this Declaration, I have applied the ordinary and customary meaning of those terms.

33. I also understand that the words of the claims should be interpreted as they would have been interpreted by a POSITA at the time the alleged invention was made and not as of today. I have used the date of February 25, 2011, for reasons explained above.

IV. BASIS FOR MY OPINIONS

34. In forming my opinions, I have relied on the '008 patent, specification, figures and claims along with the '008 patent's prosecution history, which I understand is the written record with the U.S. Patent Office, the exhibits to the Petition for *inter partes* review of the '008 patent, the additional materials identified in this Declaration, and my own experience and expertise as a skilled artisan in the relevant art in the 2011 timeframe as set forth above.

V. SUMMARY OF MY OPINIONS

35. I have been asked to consider whether claims 1-18 of the '008 patent are anticipated or rendered obvious by certain prior art references. Based on the analysis set forth herein, including my experience and knowledge in the field, my understanding of the claims, the prior art, the applicable law, and the level of skill in

art in the 2011 timeframe, my opinion is that the '008 patent claims are invalid as obvious for the reasons set forth herein.

VI. PERSON OF ORDINARY SKILL IN THE ART

36. Based on my review of the '008 patent and my technical experience, it is my opinion that a POSITA would have possessed knowledge of conventional signal processing technologies for various kinds of television signals, such as satellite and/or cable television signals. Conventional signal processing technologies include the structure and properties of signals to undergo analysis, components of television systems, including low-noise amplifiers and block-down converters (LNBs), set-top boxes (STBs), television headends, signal receptors, analog-to-digital and/or digital-to-analog converters, components to analyze signals, such as video analyzers, audio analyzers, and/or computers, and so on. (*See generally* '008 patent, 1:28-61.) As described in further detail below, many of these technologies and associated techniques fall generally within communications and networking concepts related to the signal monitoring and processing known at the relevant time.

VII. STATE OF THE ART IN 2011

37. The '008 patent describes and claims features relating to set-top boxes ("STBs") and methods performed on STBs. STBs, as extraordinarily well known in the art well before February 2011, refer to equipment located at a customer's premise that are usable to receive signals containing television channels and to provide

television content to a customer. STBs may also be called receiver devices, integrated receiver decoders (“IRDs”), converter boxes, and other similar terms. More specifically, the ’008 patent specification and claims recite known methods of operations digitizing a received television signal comprising television channels, analyzing at least a first portion of the television signal to determine signal characteristics of the television signal, and concurrently outputting at least a second portion of the television signal to recover content carried on at least one television channel. However, as I explain below, it is my opinion that such methods and related technologies were conventional and known to POSITAs prior to February 2011.

38. Below, I present a brief overview of certain aspects of television systems, including cable and satellite television systems, narrowband signal and wideband signal digitization, and signal monitoring/spectrum analysis operations, both generally and, more particularly, for television systems, like those discussed and claimed in the ’008 patent. These television systems and signal monitoring operations were known to a POSITA prior to and at the time of the alleged invention of the ’008 patent.

39. The features, functionalities, and concepts I describe below in this technical background section reflect the state-of-the-art knowledge that a POSITA would have had prior to and at the time of the alleged invention of the ’008 patent. I

rely on and incorporate the following disclosures and opinions to support my opinions in this Declaration, including those opinions relating to how the prior art discloses and/or suggests the claims of the '008 patent and how and why a POSITA would have been motivated to consider and combine the disclosures and suggestions from one or more prior art references as I explain throughout this Declaration. The concepts below would have been within the knowledge and mindset of a POSITA at the time of the alleged invention when considering the prior art identified below.

A. History of Cable and Satellite Television Systems

40. By February 2011, both cable and satellite systems were extraordinarily well known, with both systems receiving television signals at a set-top box, which is the instrument that the '008 patent calls a “receiver circuit.” (*See* '008 patent, 3:7-10.) Set-top boxes were well known to include many types of functionality, including recording and play back functionality, cable and/or satellite signal interpretation, Internet-access functionality allowing two-way communication, and so on. (Ex. 1010, 6.)

41. In the United States, cable television was available to the public in the late 1940s in order to provide high-quality television signals to remote locations, as such locations had poor reception of over-the-air television signals. (Ex. 1011, 79-80.)

42. A typical cable television distribution system as of the 2011 timeframe included a television headend, which was operated by a television service provider. A headend (also written as “head end” or “head-end”) was, and still is, a centralized facility that received television programming from various sources (*e.g.*, from individual channel providers) via satellite, off-the-air, and/or terrestrial sources. (Ex. 1012, 141.) Once collected at a headend, television programming was processed and distributed to subscribers. The Figure provided below depicts an example cable television system, as known in the 2011 timeframe, where a network of cables distributed television signals to various customers, illustrated as a “customer drop.”

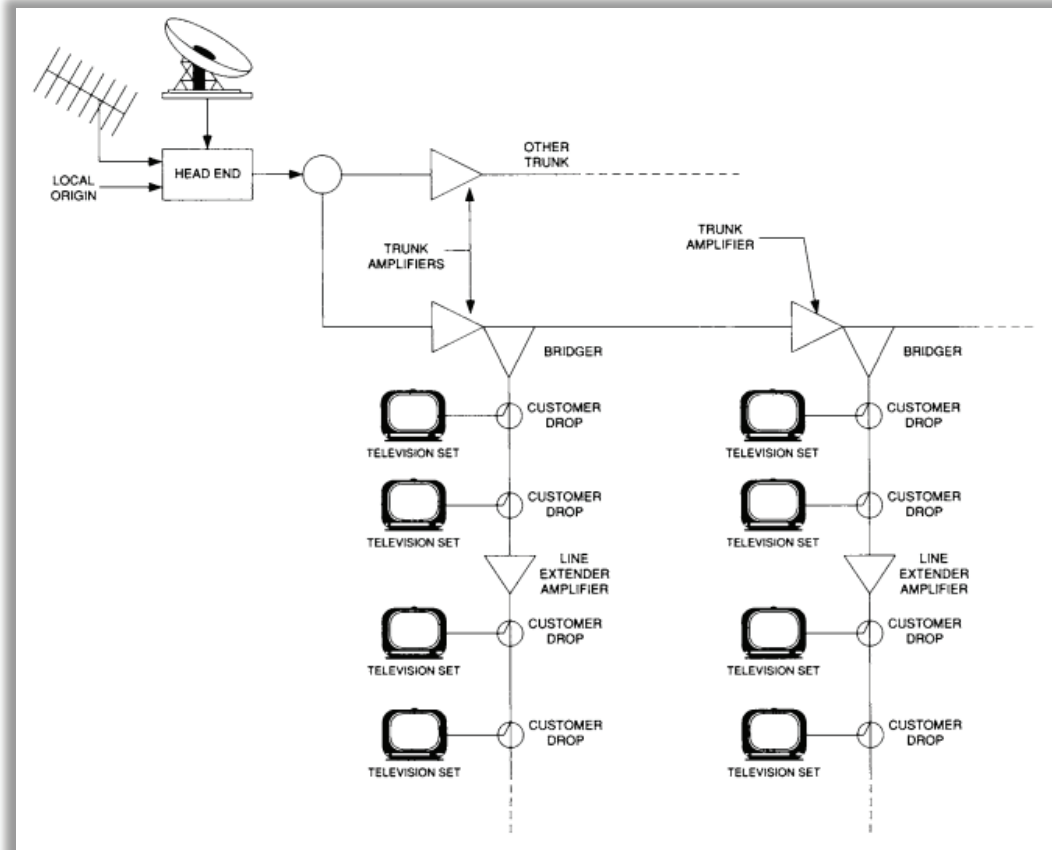


Figure 12.8 — A Typical Cable Television System. (Ex. 1012)

43. Satellite television developed soon after cable television and, by February 2011, orbital satellites had been used for nearly fifty years to communicate video, audio, and data signals. The Telstar I, launched in 1962 by Bell Labs and NASA, was the first direct-relay communications satellite, and could communicate a single television program across the Atlantic Ocean. (Ex. 1016.) The use of satellites to distribute a plurality of signals bearing televisions programs proliferated in the early to mid-1990's with the introduction of EchoStar's DISH Network and Hughes Network System's DirecTV, among other services. (Ex. 1017.)

44. Like cable television systems, satellite television systems known before the 2011 timeframe also included a headend; though instead of distributing television signals through cable, the satellite television headend transmitted television signals to satellites for distribution to satellite dishes at a customer's home. (Ex. 1013, 370-74.) As seen in the figure below, a television headend operated as an "Earth transmitting station," where television signals were transmitted as a signal uplink to a satellite. (Ex. 1013, 370-71; Ex. 1014, 416-35.) Once received at the satellite, the satellite transmitted the television signals to a customer's satellite dish operating as an "Earth receiving station," where television signals were received as a signal downlink. (Ex. 1013, 370-71.)

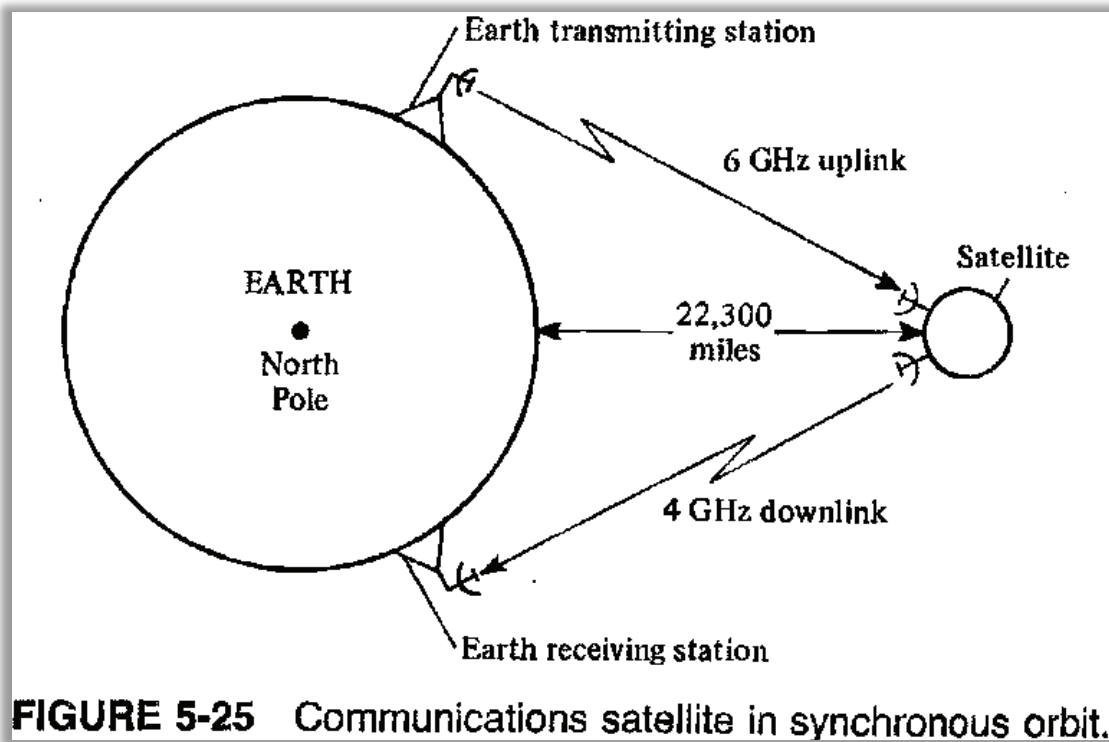


Figure 5-25 — A Typical Satellite System. (Ex. 1013)

45. Dulac and Godwin discuss a typical implementation of direct-to-home (“DTH”) digital satellite television systems, as known at least as early as 2006. As Dulac and Godwin discuss, DTH digital satellite television systems were broadly organized into three interconnected systems: 1) the broadcasting facility (otherwise called an uplink facility and/or a headend); 2) one or more satellites in geosynchronous orbit; and 3) customer-premises equipment. Dulac and Godwin illustrate each of these systems in Figure 1, reproduced below. I discuss each of these systems in the following paragraphs. (Ex. 1018.)

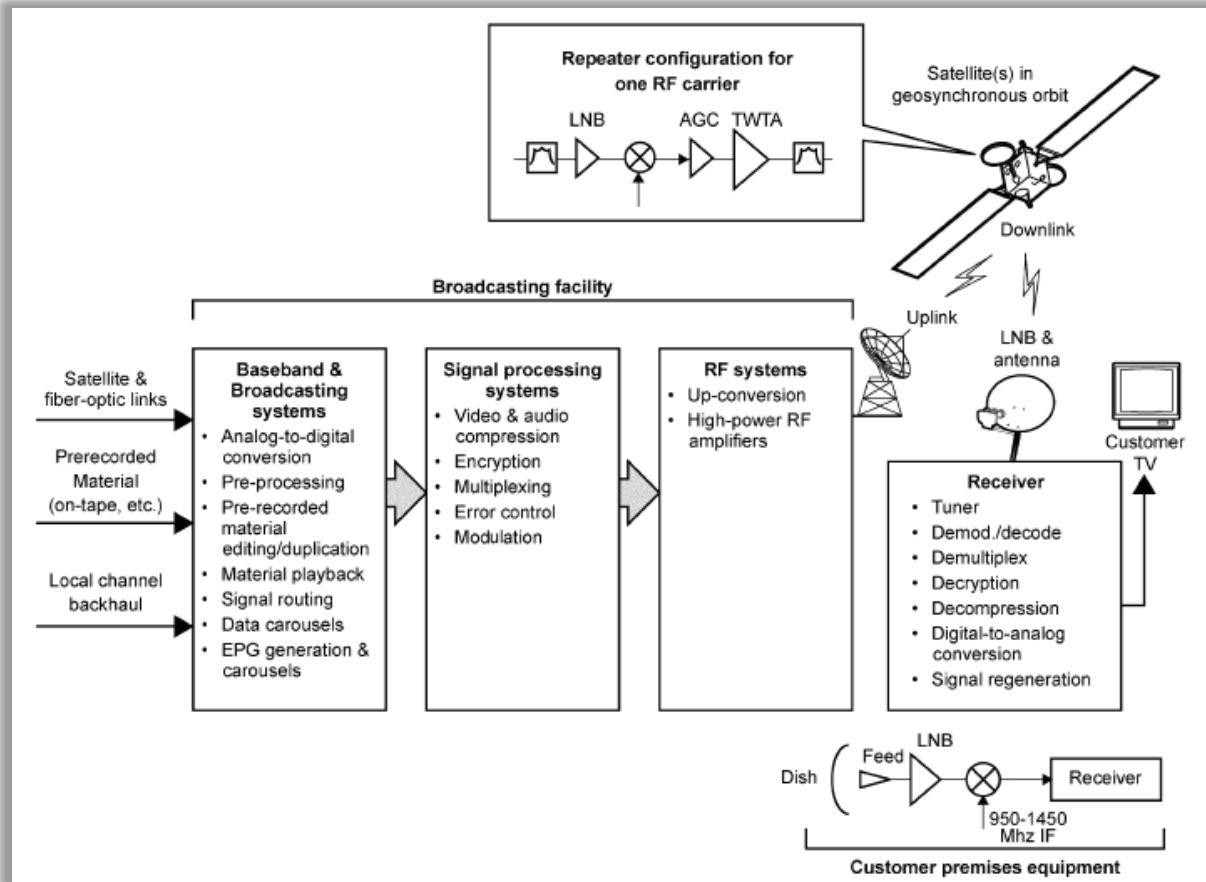


Figure 1 — Multichannel Satellite System. (Ex. 1018)

46. The broadcasting facility, as illustrated above, acted as a collection and distribution center and, therefore, collected and distributed television programming to satellites for ultimate distribution to customer-premises equipment. Broadcasting facilities collected television from a variety of sources, including fiber-optic cables for satellite distribution facilities, prerecorded material (*e.g.*, hard drives or tapes), and local channel backhauls. (Ex. 1018, 162-63.) Broadcasting facilities performed several additional processes to prepare television signals for distribution, including signal processing, encryption, video and audio compression, signal routing, and RF

processing. Broadcasting facilities additionally performed signal monitoring operations, which included analyzing incoming signals for quality control purposes. (Ex. 1018, 162.) Once the broadcasting facility sufficiently prepared the television signals for distribution, the signals were transmitted to a satellite for ultimate distribution to customer-premises equipment.

47. Broadcasting satellites are satellites that orbit the Earth at a given orbital location, receive television signals transmitted from a broadcasting facility, and transmit the received television signals downstream to customers of the satellite television service. (Ex. 1018, 163-64; Ex. 1021.) As Dulac and Godwin explain, multiple communications satellites, at adjacent orbital locations, were utilized to distribute television signals across overlapping portions of the electromagnetic spectrum, resulting in customers receiving high-quality signals. (Ex. 1018, 163-64, Figs. 3 and 4.) These signals, as transmitted from the communications satellites, were ultimately received by customer-premises equipment at a customer's home.

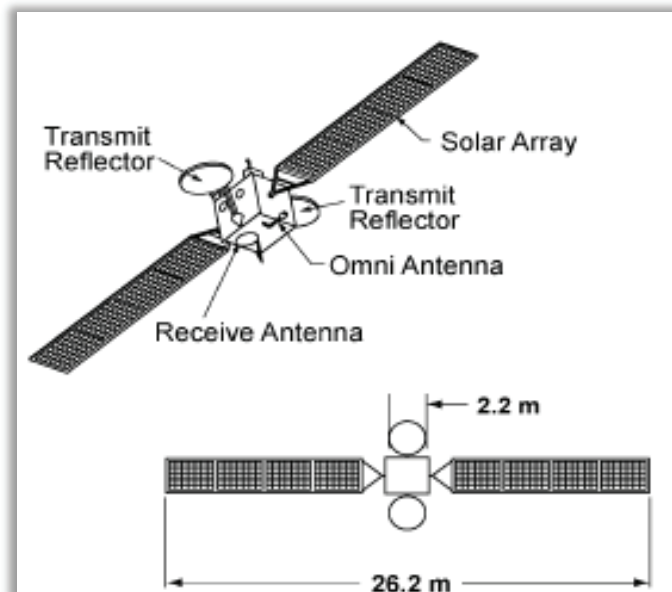


Figure 3 — Example Broadcasting Satellite. (Ex. 1018)

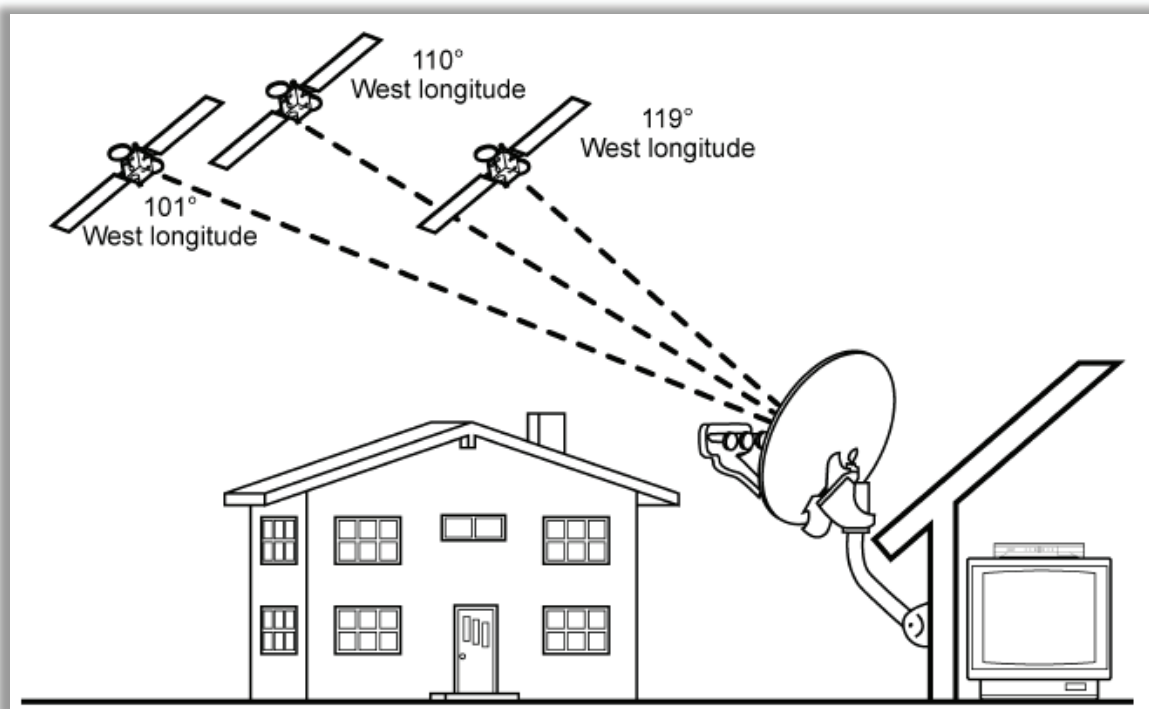


Figure 4 — Example Reception of Satellite Signals. (Ex. 1018)

48. Before the 2011 timeframe, both cable and satellite television services typically used equipment provided at a customer's premise, such as set-top boxes.

Dulac and Godwin discuss example set-top boxes (“receivers”) in conventional satellite systems as of 2006, such as depicted in Figure 5, below. Dulac and Godwin discuss many common features of satellite receivers, including tuning, demodulation, decoding, demultiplexing, and decryption functionality. (Ex. 1018, 162.)

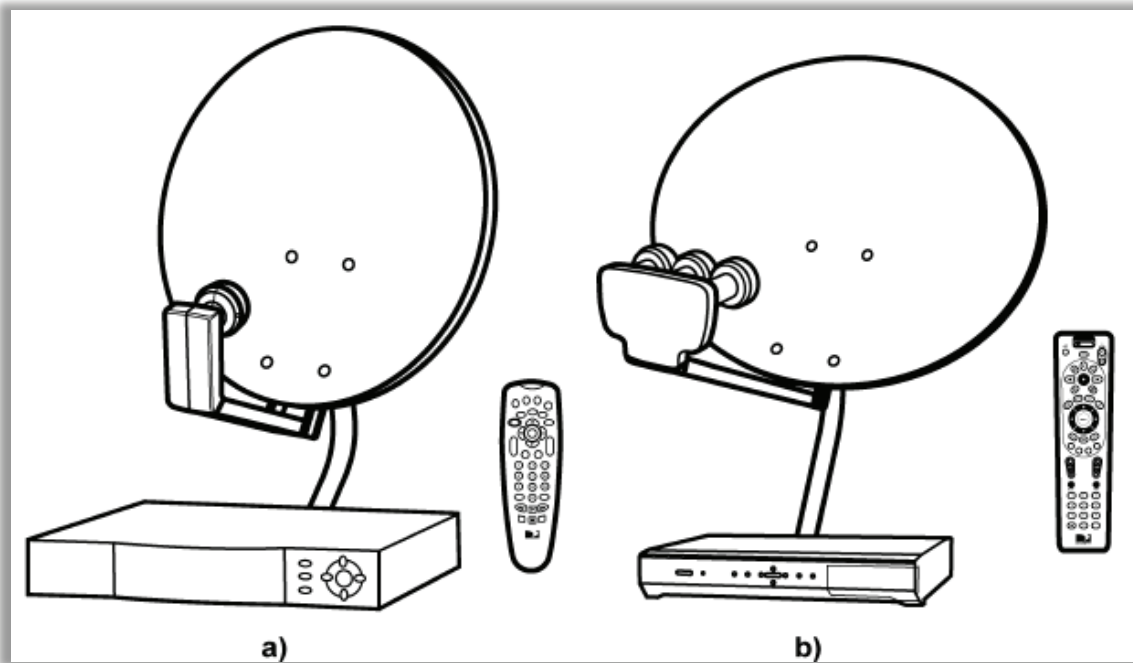


Figure 5 — Example Satellite Receivers. (Ex. 1018)

49. During the 2011 timeframe, in both satellite and cable television systems, these set-top boxes (“receivers”) operated as the most user-visible piece of equipment. Set-top boxes, for example, received remote control signals and performed operations such as channel changes, volume control, and so on. Set-top boxes also performed the more transparent functionality involved with tuning, demodulation, decoding, demultiplexing, etc. as I discuss above. Set-top boxes are

radio terminals specifically designed for television systems. I discuss example radio terminals in the following section particularly with respect to Hentschel *et al.* (Ex. 1019.)

50. While set-top boxes for cable and satellite systems are largely similar, they did have some unique functionality. One of the major distinctions between cable and satellite television systems was where a signal transmitted by a television headend is received at the customer's premise. In cable television, television signals were transmitted through a network, typically a hybrid fiber-coaxial cable ("HFC") network, from the cable television headend and were first received, by a customer, at a set-top box located at the customer's premise. In satellite television, on the other hand, signals were transmitted wirelessly via satellite, and so a customer's premise additionally required a satellite dish and associated electronics, collectively called an "outdoor unit," or "ODU," to receive the satellite signal before transmitting the signal to a set-top box within the customer's home. An example ODU, including a satellite dish (antenna) and a low-noise block downconverter ("LNB"), as was

typical during the 2011 timeframe, is discussed in Dulac and Godwin as shown in the annotated Figure below.

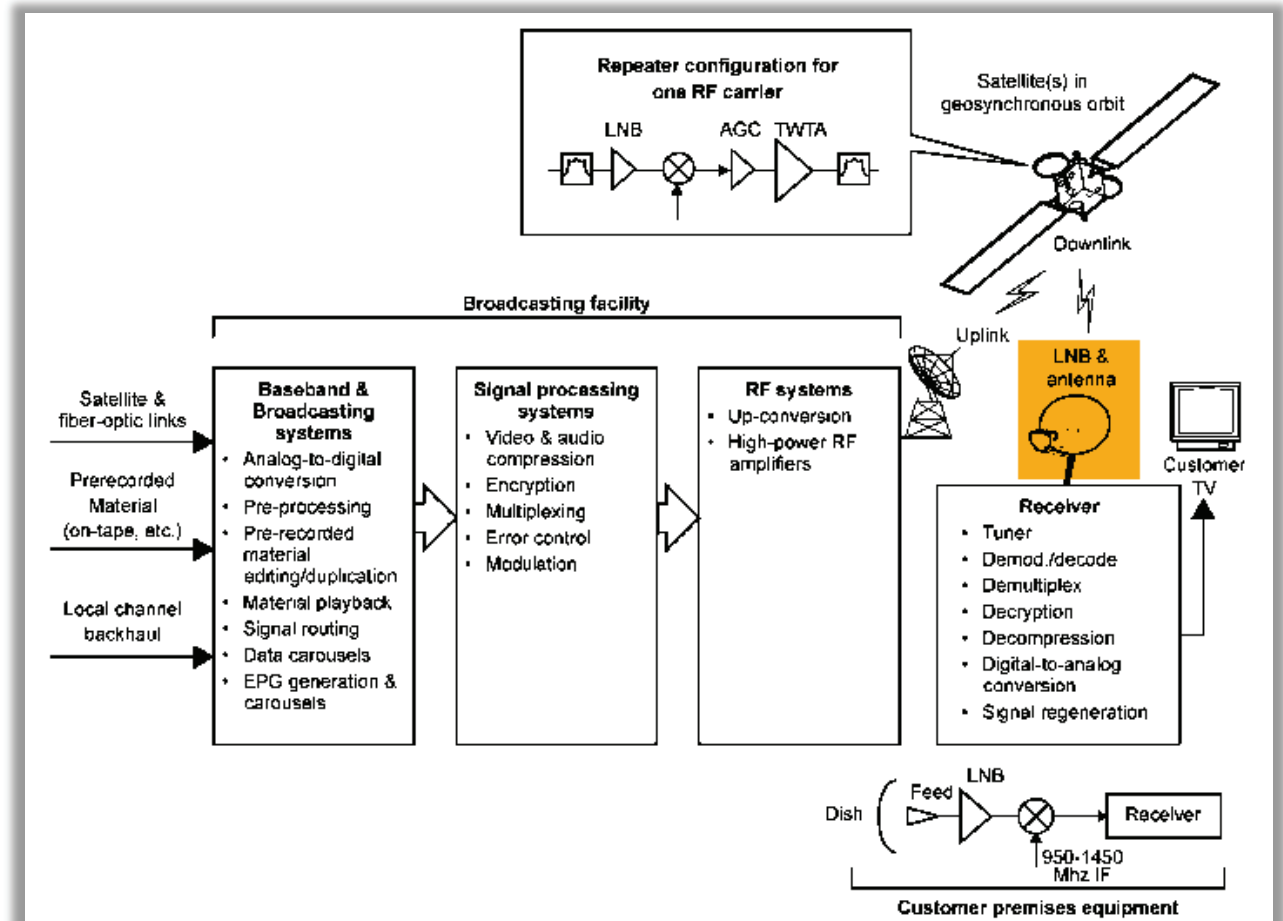


Figure 1 — Multichannel Satellite System. (Ex. 1018)

51. In my review of the '008 patent, I find that the specification considers both cable and satellite systems that incorporate an “RF receive front-end,” as known during the 2011 timeframe. With reference to Figure 1B of the '008 patent, a receiver circuit 100 is discussed, as incorporated in a cable television system. The receiver circuit 100 includes an RF receive front-end 158, which first receives television

signals from an HFC network. The RF receive front-end 158 was a well-known component of cable set-top boxes before the 2011 timeframe.

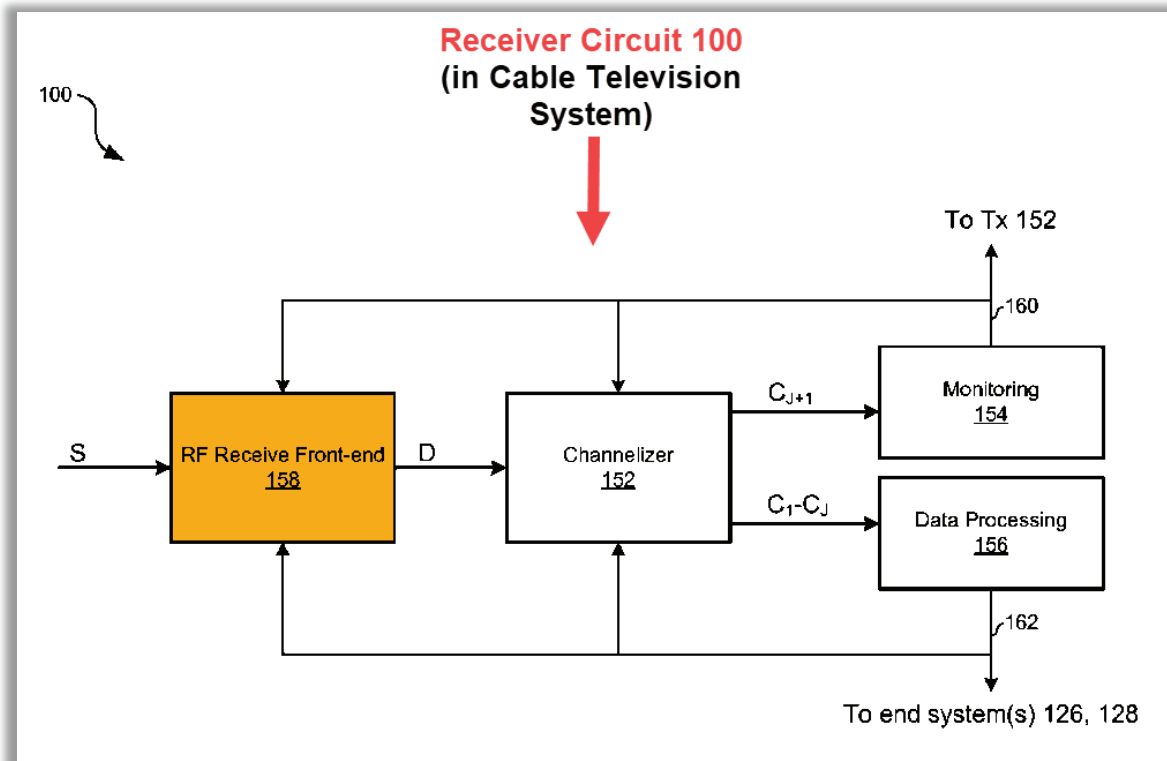


Figure 1B — '008 Patent's Receiver Circuit 100, Including a Conventional RF Receive Front-End 158.

52. With reference to Figure 1C, a subassembly 174 is discussed, as incorporated in a satellite television system. As depicted in Figure 1 of Dulac and Godwin, which I discuss above, components of the subassembly 174, such as front-end 158, were well known and conventional before the 2011 timeframe. The subassembly 174 is an example ODU. In satellite systems, the front-end 158 is the component that first receives a signal S, as output from an LNB 194.

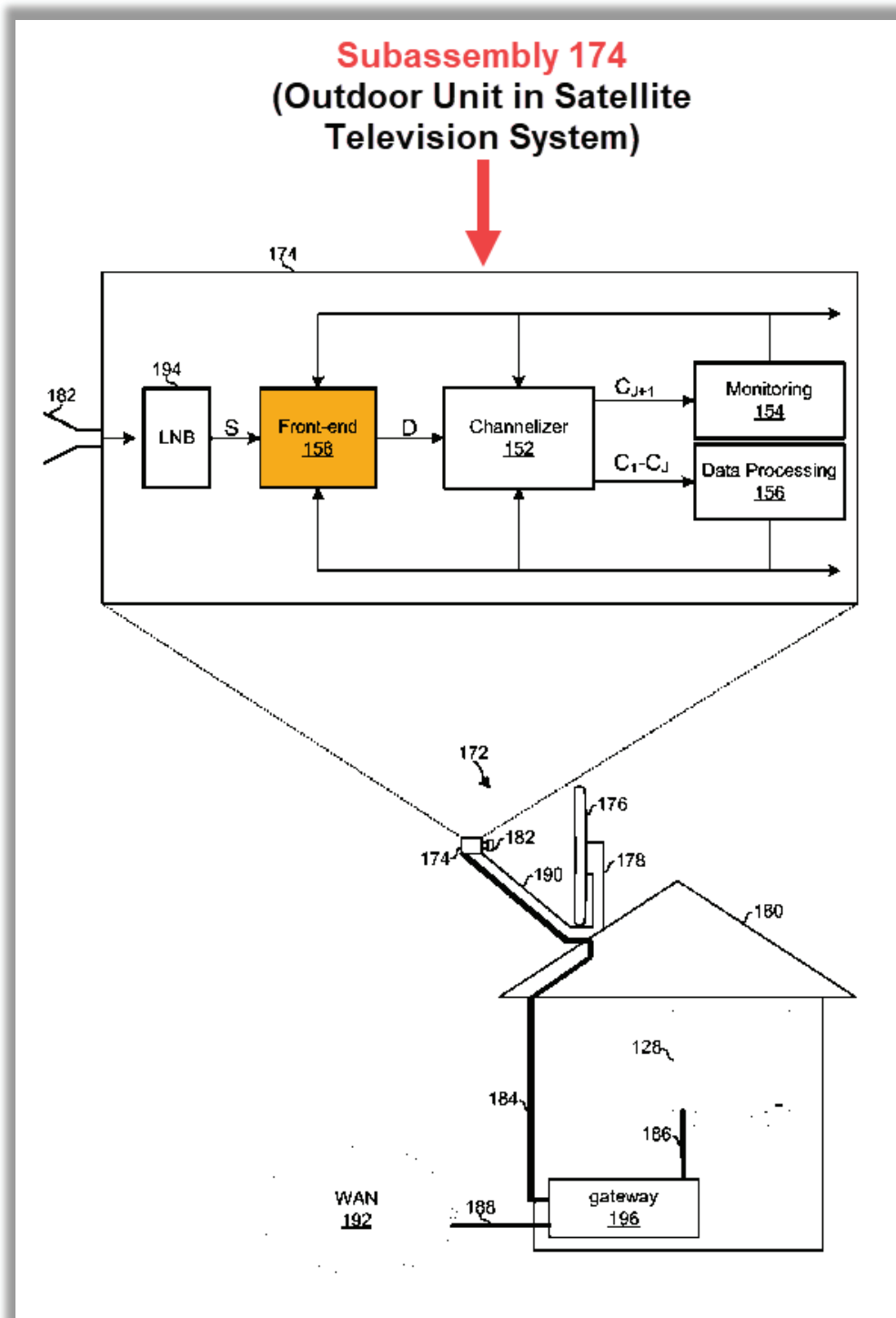


Figure 1C — '008 Patent's Subassembly 174 (ODU), Including a Conventional Front-End 158.

B. Signal Digitization

53. Signal digitization was well known in electronic systems generally, and in radio-frequency (“RF”) front-end systems in particular well before 2011 and was commonly applied to satellite communications systems. As discussed in the technical literature of the late 1990s, replacing analog signal processing with digital signal processing at the front-end was a common approach of digital channelized receivers. (Ex. 1018, 6 (“Apparently a standard design of mainly digital filters, the digital front-end turns out to be one of the most power- and time-critical functionalities of the software radio terminal.”).)

54. The migration of electronic systems from analog to digital technology began at least by the late-1970’s. At its core, digitization represents analog signals that are continuous in time and amplitude by discrete samples in time that are quantized in amplitude. It has been shown by the Nyquist Theorem that a continuous signal can be represented exactly by its discrete-time samples provided that those samples are taken at a rate that is at least the Nyquist rate (*i.e.*, rate corresponding to twice the highest frequency component of the analog signal). Failure to sample at a sufficiently high rate will produce aliasing (degradation of the high-frequency component of the signal). The quantization of the amplitude results in a discrete representation of the samples that can be stored on a digital device such as a

computer. The quantized samples, however, cannot be used to recover the original continuous amplitude samples.

55. Despite its limitations in terms of aliasing due to sampling and the loss of information attributed to quantization, the electronic community has been steadfast in its attempt to convert all electronic systems from analog to digital systems. The reason for the transition from analog to digital technology is that the initial loss in signal quality is a small price to pay for high-fidelity (essentially loss-less) reproductions. Simply put, analog signals may be infinitely precise upon initial recording but continuously degrade when transmitted over distances or stored over time; whereas digital signals may be imperfect when initially digitized but can be reproduced with exact precision even when sent over wide distances or stored for long periods. Moreover, the initial degradation incurred by digitization can be made negligible by sampling at a sufficiently high rate and representing the quantized samples with a sufficient number of binary coefficients (bits).

56. In 1999, Hentschel *et al.* (“Hentschel”) discussed a software radio receiver (*i.e.*, an RF front-end) that included circuitry to digitize an incoming analog RF signal. (Ex. 1018, 6.) As Hentschel discussed, such a digital front-end has the utility of providing a high degree of flexibility and allowed system parameters to be easily changed with software. (Ex. 1018, 6.) This stands in contrast to prior analog-

based systems where parameters such as channel spacing and carrier frequency could not be changed by software. (Ex. 1018, 6.)

57. In Figure 1 below, Hentschel depicts an ideal software radio receiver. The components of Hentschel's disclosed digital front-end include a Low-Noise Amplifier ("LNA") for amplifying a low-power signal without significantly degrading the signal-to-noise ratio ("SNR"), an Anti-Aliasing Filter ("AAF") for restricting a signal bandwidth to reduce high-frequency aliasing, an Analog-to-Digital Converter ("ADC") for digitizing an incoming RF signal, and a Digital Signal Processing ("DSP") circuit for processing the digitized signal. Put simply, Hentschel's ideal software radio receiver clearly discloses a system of receiving an analog RF signal and converting the signal into a digitized signal.

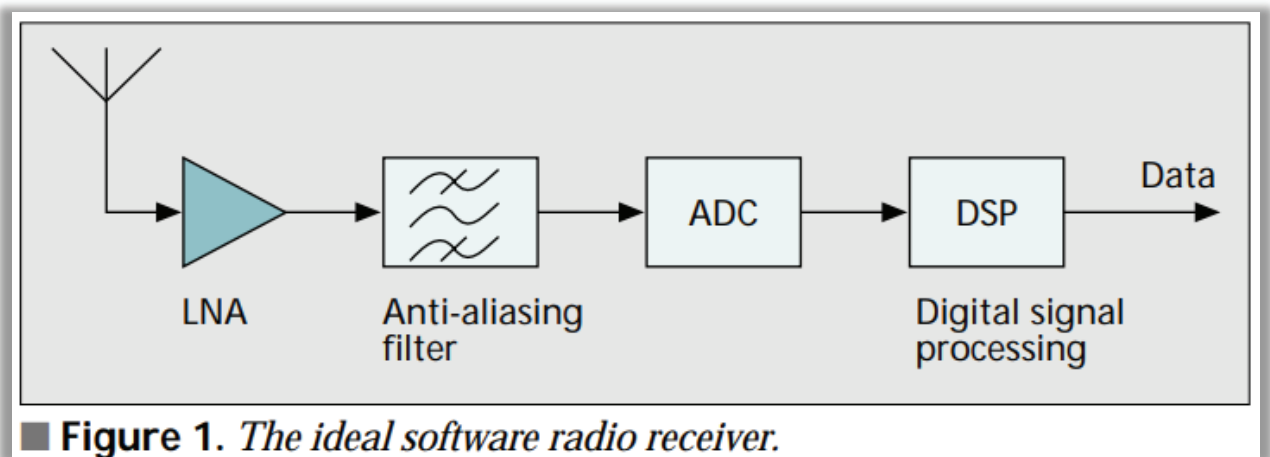


Figure 1 — Hentschel's Ideal Digital Front-End.

58. Similar digital channelizers, which converted incoming RF signals into digital signals through an ADC, were discussed in many other documents. Pucker,

for example, discussed front-end architecture for digital receivers, including both narrowband and wideband receivers. As illustrated in Pucker's Figure 3, reproduced below, example digital receivers were known to include one or more ADC circuits for digitizing received signals. (Ex. 1020.) I understand Pucker, and a POSITA would have also understood Pucker, to disclose a receiver circuit which digitizes an incoming signal.

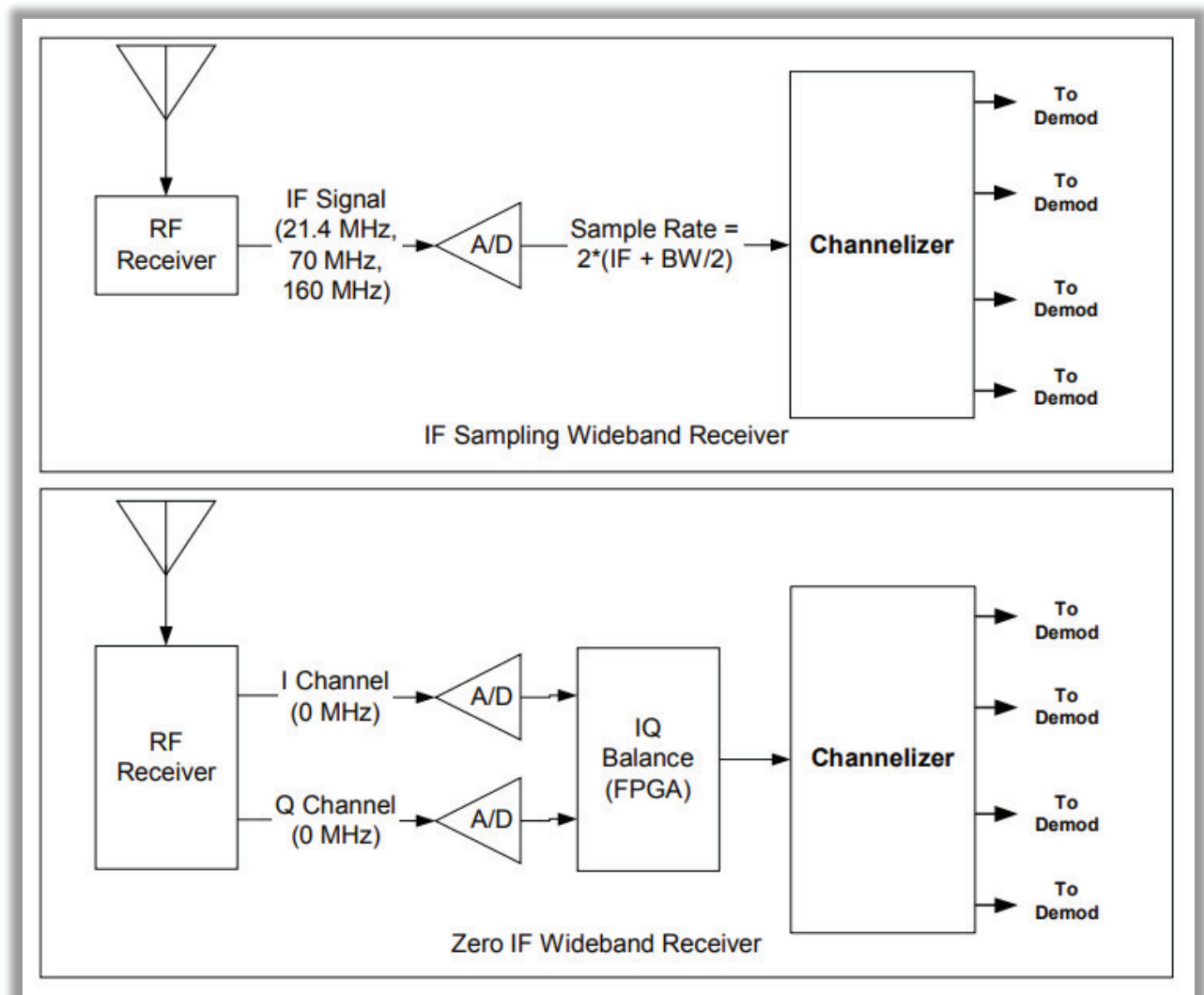


Figure 3 — Pucker's Example Front-End Architectures. (Ex. 1020)

59. The digitization of incoming RF signals was known in the field as of 2011 in radio-receiver technology and a POSITA during the 2011 timeframe would have been well aware of this technology. Television receivers, as an example product incorporating digital radio receivers, in both cable and satellite systems commonly included one or more ADCs to digitize a signal, or a component thereof.

60. An example a television system incorporating an ADC to digitize a signal is described in a patent application to Davis *et al.*, as filed April 15, 2002. (Ex. 1020.) Davis explains, with respect to Figure 5, that an LNB interface may include “conventional elements, such as a tuner/demodulator pair for processing an input from each [incoming] cable.” (Ex. 1020, [0041].) Davis further explains that the “tuner/demodulator pair processes an RF input from each cable 22 and produces a corresponding digital output.” (Ex. 1020, [0041]; emphasis added.) Thus, nearly 10 years before the earliest priority date of the ’008 patent, Davis clearly describes a television system where incoming analog RF signals are digitized.

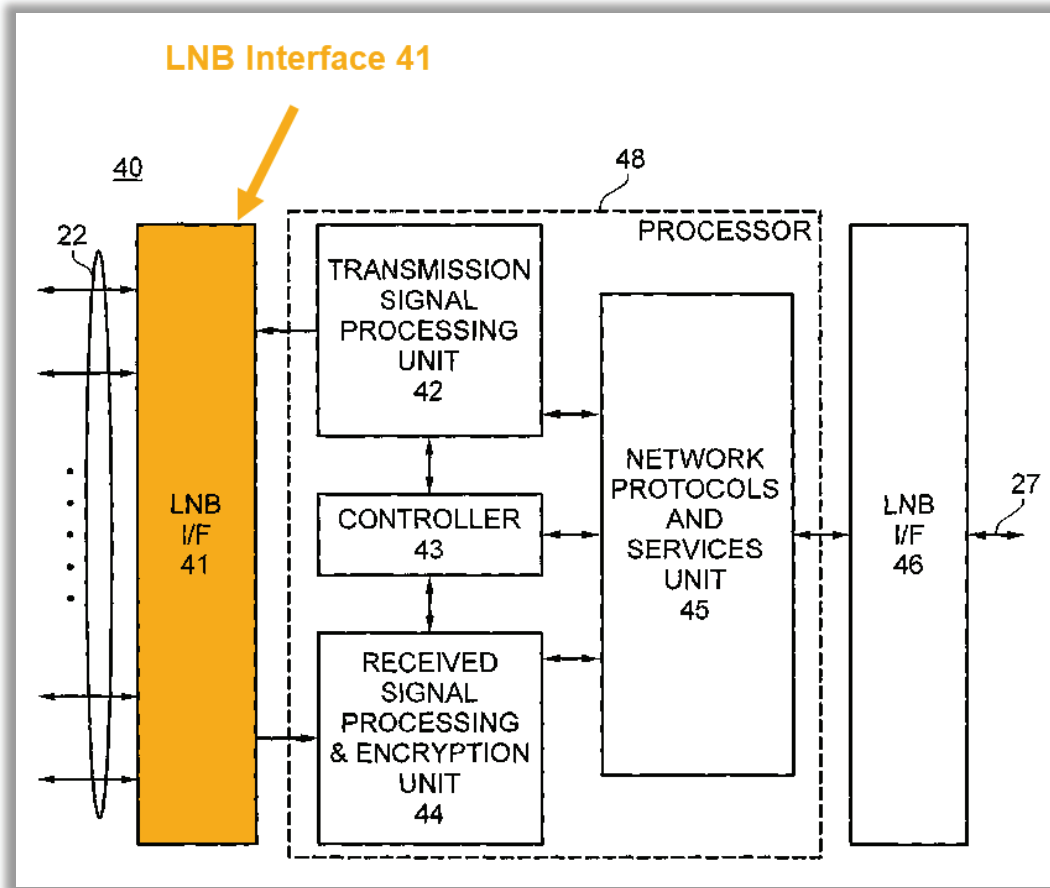


Figure 5 — Davis's Digitizing Interface Device 40 in a Typical Satellite System.

61. As another example, Zhang *et al.* ("Zhang") discloses the use of a prior art system that included A/D converters operable to digitize incoming RF signals from an RF tuner. (Ex. 1006, 1:41-65, Figure 1.) Figure 1 of Zhang is reproduced below, with highlighting added to emphasize the multiple A/D converters that digitized an incoming signal in a cable television system.

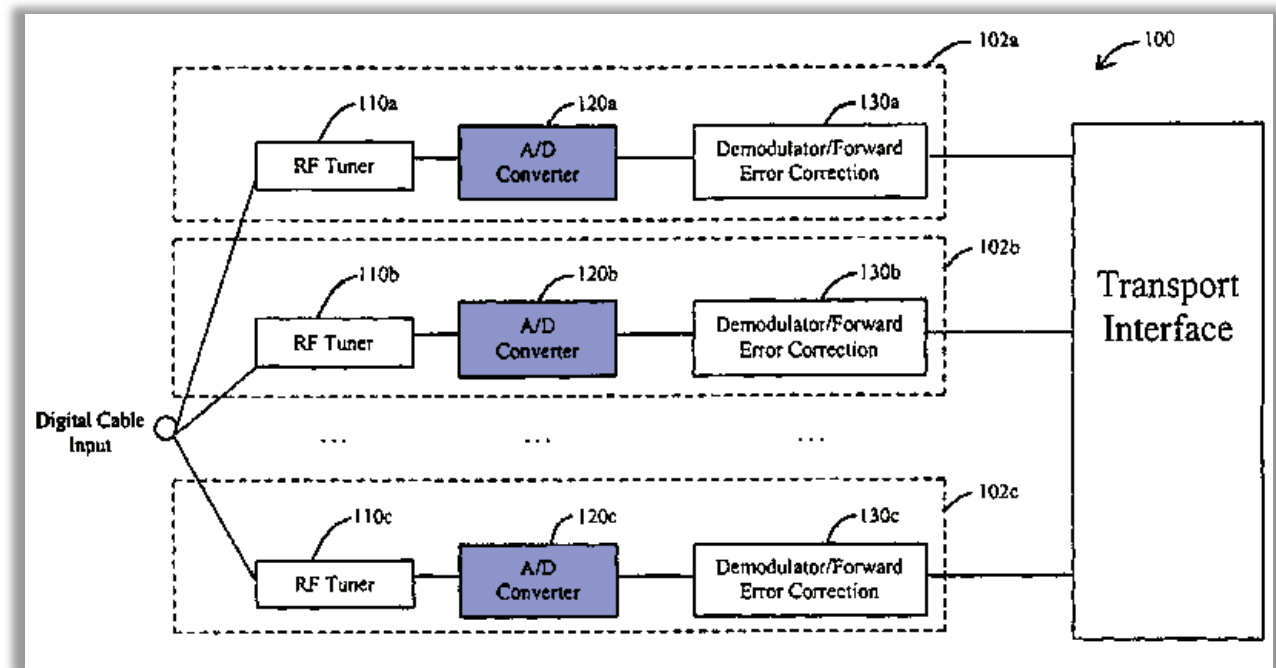


Figure 1 — Zhang’s Disclosure of Prior Art System with One A/D Converter Per RF Tuner.

62. Zhang additionally disclosed a multi-channel demodulator, where a high-speed A/D converter could digitize multiple channels at once. For example, Zhang disclosed “[a]n ADC 220 [that] converts the down-converted multi-channel analog RF signal to a multi-channel digital RF signal.” (Ex. 1006, 3:60-64.)

63. In light of the above discussion, I find that methods and structures for digitizing incoming RF signals were well known well before the 2011 timeframe, both generally and for television systems, specifically.

C. Wideband Analog-to-Digital Conversion

64. The concept of wideband analog-to-digital conversion, like the general concept of digitizing RF signals in a receiver system discussed above, was

also well known before 2011. I interpret the term “wideband” digitization, in the context of RF receivers, to mean the digitization of an incoming RF signal having a wide bandwidth and multiple channels, consistently with how the term is typically used by a POSITA. I discuss below just a few of the many patents and other references that describe using wideband ADC to digitize received RF signals in various applications long before 2011.

65. The 1980s was a period of high growth for data converters in general and there was a proliferation of many kinds of digital systems, many of which involved the conversion of analog signals into a digital format. (Ex. 1028, 1.49.) Kester explains that, in the 1980s, monolithic ADCs and monolithic flash ADCs were commonplace and were commonly available in audio applications. (Ex. 1028, 1.49-1.53.) The 1980s also saw the introduction of hybrid and modular ADCs, which could digitize a wider range of an incoming spectrum and could perform at a high speed. (Ex. 1028, 1.53-1.54.) A POSITA would understand that these ADC architectures introduced in the 1980s are appropriately considered some of the earliest wideband ADC structures.

66. In the 1990s, interest in wideband digitization techniques increased and various breakthroughs occurred where increasingly wider portions of an analog spectrum could be digitized. One example of such a breakthrough occurred

in 1995, where a wide dynamic range ADC was developed by Analog Devices.

(Ex. 1028, 1.61.)

67. By 1999, wideband digitization techniques were extremely well known in military RF digital receivers. In 1999, Kumar *et al.* discussed the conceptual designs of various circuitry that could be used to digitize a wide portion of an incoming analog signal received from communications satellites. (Ex. 1031, 452; Ex. 1015.) Kumar discussed several techniques for performing wideband digitization as, even during the 1999 timeframe, multiple methods for wideband digitization in communications systems were common. Kumar explains various benefits of digital-based systems when compared to analog-based systems, including “inherent advantages in terms of power efficiency, flexibility, error correction and detection coding and encryption.” (Ex. 1031, 452; Ex. 1015.)

68. Additionally, as discussed above, Pucker, in 2003, discussed various front-end architectures for wideband receivers in digital radio systems. Figure 3 of Pucker, for example, clearly illustrates various embodiments of receiving an RF signal at an RF receiver and digitizing the signal using one or more A/D converters in a system explicitly characterized as “wideband.” (Ex. 1020, Figure 3.)

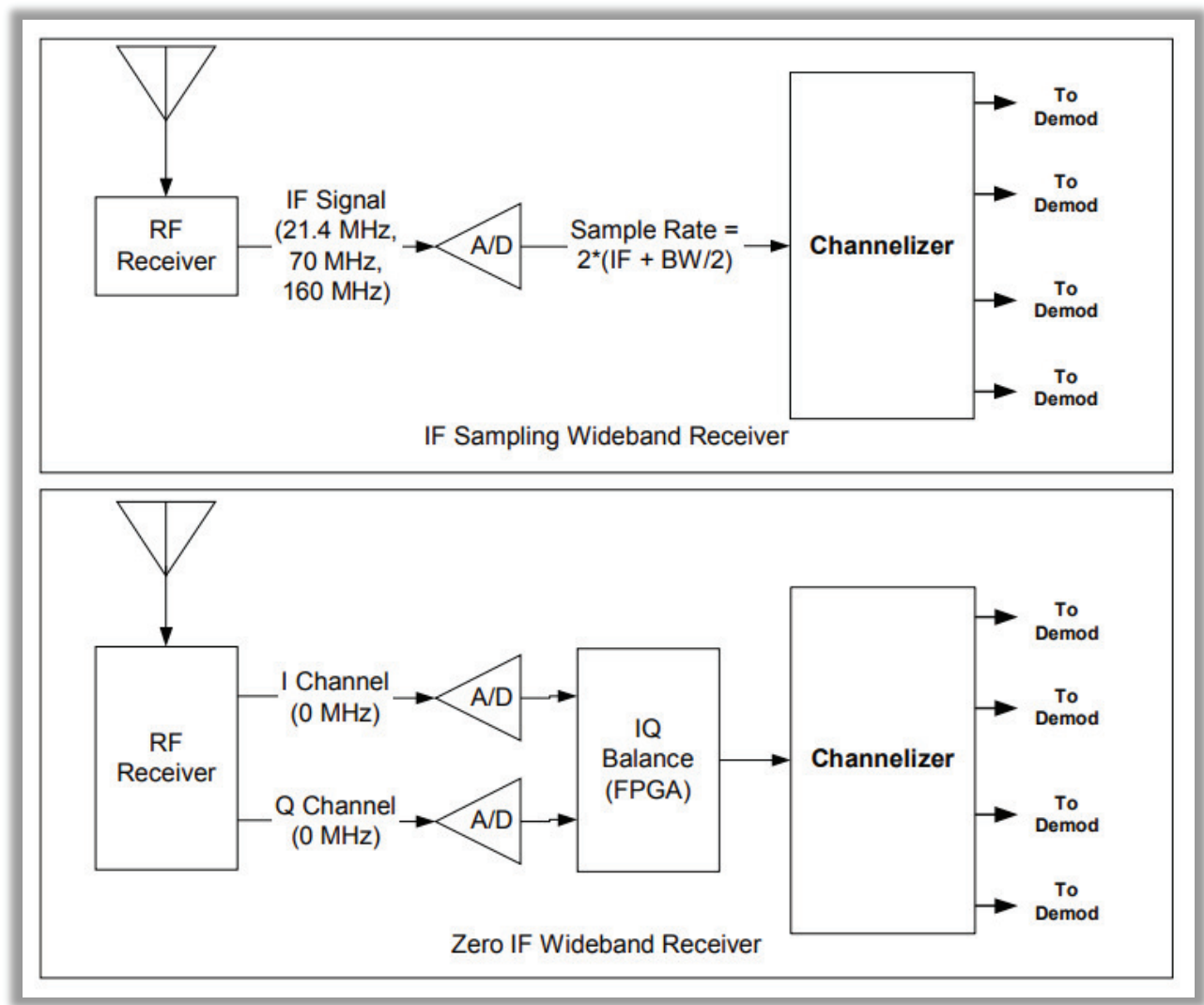


Figure 3 — Pucker’s Example Front-End Architectures. (Ex. 1020)

69. U.S. Patent Application Publication US2008/0207136 (“Tang”), titled “High Dynamic Range Transceiver for Cognitive Radio,” was published in August 2008 and disclosed a wideband receiver with wideband ADC that **“can operate on an entire band of interest, such as an entire TV band of 336 MHz bandwidth”** as shown by the excerpts below. (Ex. 1026.)

- [0090] From the above discussion, it can be appreciated that as long as the channel selection starts from a particular RF stage, in some embodiments the RF chain from that stage onward can be replicated for each additional channel. **In some embodiments it can be advantageous to defer channel selection all the way until the digital baseband. Such an embodiment can comprise a receiver that is capable of simultaneously decoding all of the channels in one or more specified bands, such as all of the TV channels in depicted in the graph 200.** Two issues can be addressed in such a system. (Ex. 1026, [0090] (emphasis added).)
- [0091] First, there can be a need to have fast and high-resolution sampling, because an ADC in such an embodiment sees an entire band of interest, such as a TV band (Channels 14-69) with 336 MHz of bandwidth. . . . (Ex. 1026, [0091].)
- [0093] **Current technology trends of digital scaling along with advances in high-speed ADCs can favor such an approach.** An RF system design for embodiments of such a wideband direct-conversion receiver is herein described; diagram 800 depicts an embodiment. **Such an architecture may be considered wideband because the RF**

receiver can operate on an entire band of interest, such as an entire TV band of 336 MHz bandwidth. In some embodiments, a system comprises a direct-conversion architecture wherein an RF signal can be directly down-converted to a baseband. (Ex. 1026, [0093].)

- Figure 8 below illustrates Tang’s “wideband direct-conversion receiver.” (Ex. 1026, [0025].)

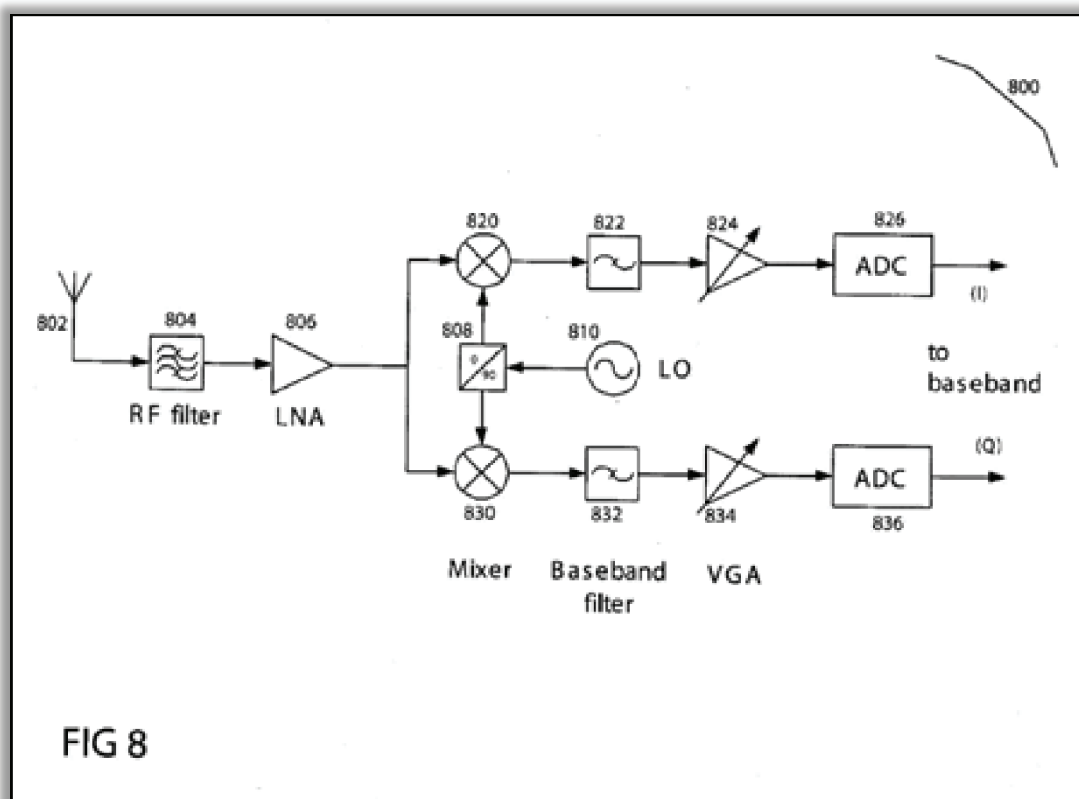


Figure 8 — A Wideband Direct-Conversion Receiver. (Ex. 1026)

70. In November 2006, US Patent Application Publication 2006/0256884 (“Tomioka”), titled “Radio Receiver and Radio Receiving Method,” also disclosed a multiple-band ADC. (Ex. 1027.) Tomioka depicts and describes that “[t]he

bandwidth Δf at the time when the signal is input to the A/D converter is greater than the difference between RF center frequencies of receiving systems having adjacent reception bands, for example, $f_2 - f_1$. As shown in FIG. 1A, reception bands apparently overlap. In this way, the signal that has F_{IF} (corresponding to the RF center frequency f_1) in center frequency and Δf in bandwidth is input to the A/D converter 5-1, sampled, and converted to a digital signal.” (Ex. 1027, [0036], Figure 1A reproduced below.)

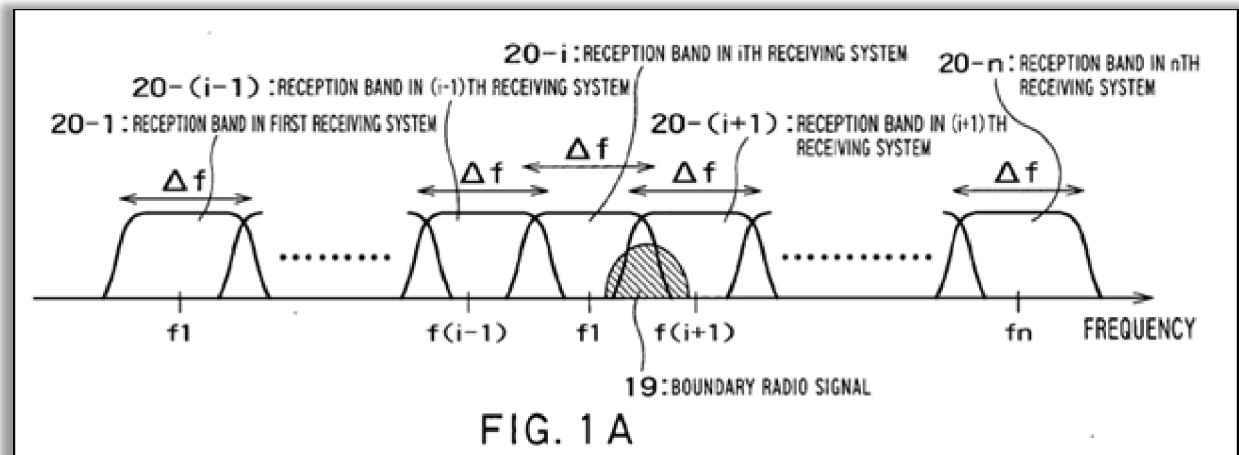


Figure 1A — Diagram Showing Reception Bands of a Receiving System in a Radio Receiver. (Ex. 1027, [0013])

71. In 2010, U.S. Patent Application Publication 2010/0253557 (“Kidambi”) explained that “[c]ertain popular communication system receivers such as that used in cable modem and set-top-box systems are trending toward processing more channels to provide faster broadband access and more video services to the home.” (Ex. 1007, [0082].) Kidambi further explained that “[o]ne alternative to having a tuner for each channel is to digitize the entire bandwidth of the cable

system” and disclosed a system capable of digitizing the entire bandwidth. (Ex. 1007, [0082].) Kidambi’s Figure 32 is provided below, with the wideband ADC 3206 highlighted for emphasis.

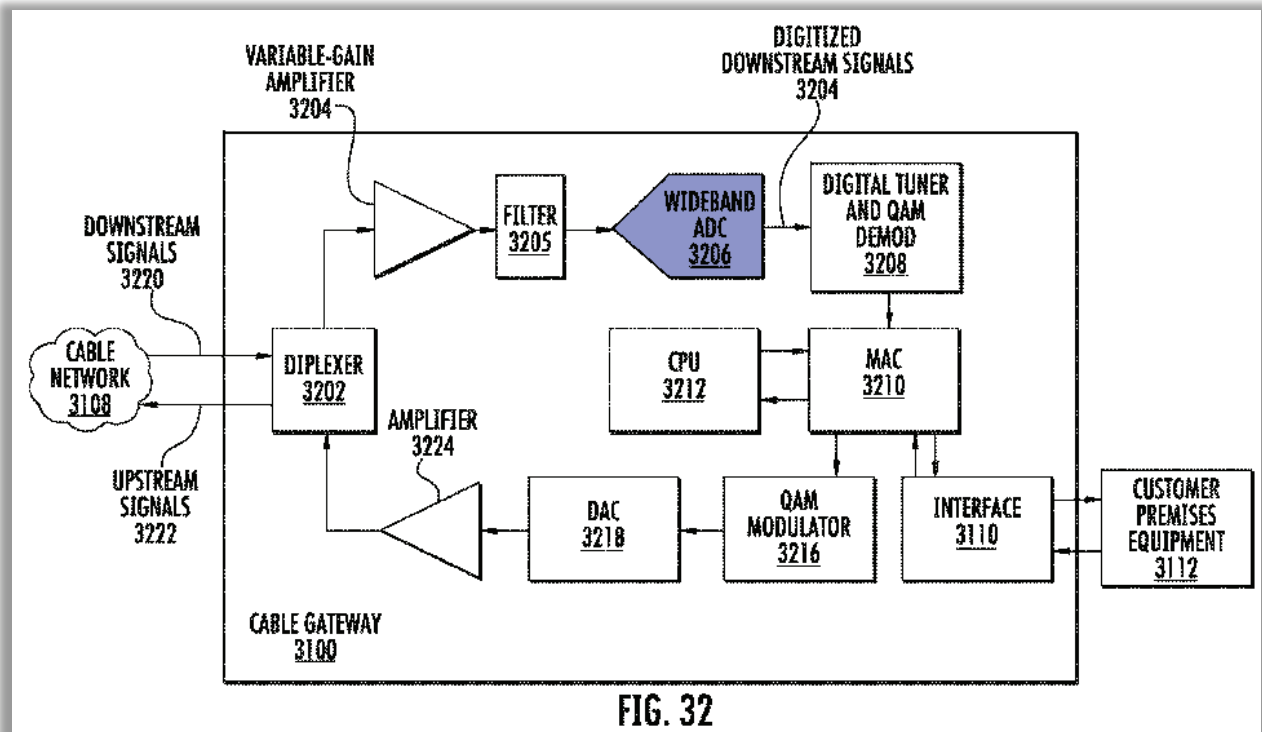


**Figure 32 — Kidambi’s Wideband Digitization in a Cable Television System.
(Ex. 1007)**

72. Kidambi continued to explain that the benefits of wideband digitization, particularly in the context of television systems. Kidambi noted that, in conventional systems where there was one tuner/ADC for each channel, the incremental costs associated with adding new channels could be high. (Ex. 1007, [0082].) However, systems incorporating wideband ADC components could add new channels relatively cheaply, and there would no longer be a need for additional, individual

ADC circuits. (Ex. 1007, [0082].) Kidambi noted the particular benefit of wideband systems in “cable and other communication systems” and considered such systems “an excellent application of this invention.” (Ex. 1007, [0082].)

73. In 2003, U.S. Patent No. 7,394,871 (“Zhang”) discussed wideband digitization in the context of television systems more than seven years before the ’008 patent. Figure 2 of Zhang depicts and discloses the use of a high-speed ADC 220 which, Zhang describes, “converts [a] down-converted multi-channel analog RF signal to a multi-channel digital RF signal.” (Ex. 1006, 3:60-61.) Zhang explained that ADC 220 “is a high-speed ADC so that an entire band with n channels can be converted.” (Ex. 1006, 3:62-63.) A POSITA in the 2011 timeframe would additionally have understood, that Zhang’s high-speed ADC is an ADC that digitizes a wideband spectrum.

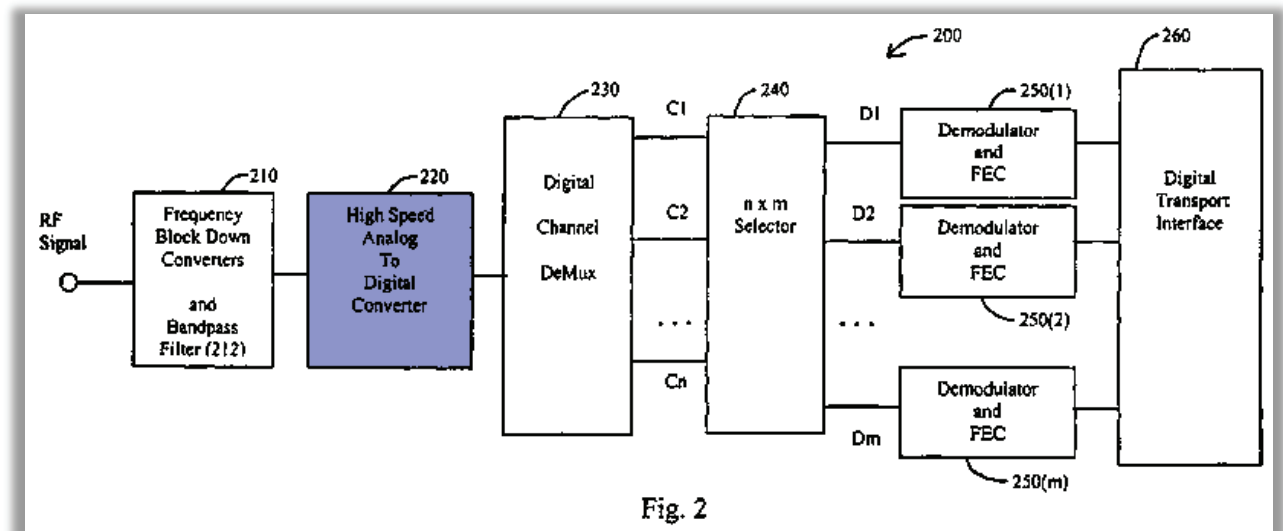


Figure 2 — Zhang’s Wideband Digitization in Television Systems. (Ex. 1006)

74. Like Kidambi, Zhang explained that wideband systems are preferred as traditional narrowband systems require one tuner per channel, which leads to increased cost, power consumption, and system complexity for multi-channel systems. (Ex. 1006, 1:66-2:2.) Zhang also applied his wideband ADC to both cable and satellite television systems.

D. Signal Monitoring Systems

75. As both cable and television service providers took significant effort in providing high-quality television services to consumers, they had a need in ensuring that their customers received high-quality signals. There are a number of factors that can degrade signal quality once the signal is transmitted by a television headend, including, for example, transmission power, signal modulation, distance travelled, operation and installation errors, and signal interference. (*See, e.g.*, Ex. 1023 at [0004].) That is, even if the signal transmitted by a television headend is of high quality, it is not guaranteed that the signal remains of high quality when it is received at a customer's premise.

76. To combat issues with signal degradation, commercial television operators used a variety of techniques to monitor signal quality and to, if necessary, take corrective action to combat low-quality signal reception. Corrective action included, for example, enhanced signal power and modulation, improved conduit

shielding and bundling, intermediate repeaters, and receiver filtering and amplification.

77. Azenkot, U.S. Patent No. 6,791,995 as filed in 2002, describes an example system where a spectrum analyzer is included in the circuitry of a digital front-end receiver so as to analyze portions of the incoming spectrum in a non-destructive manner. (Ex. 1029.)

78. As discussed throughout U.S. Patent No. 6,791,995, Azenkot describes a digital data receiver for use in television distribution systems, including cable distribution systems. (Ex. 1029, 1:6-14, 4:38-48.) Azenkot further explains that the cable front-end engages in wideband digitization of incoming analog signals so as to generate a wideband digital signal. (Ex. 1029, 4:49-53.)

79. As would be understood by a POSITA, Azenkot understood that signal quality is a pressing concern in television front-end technology. In order to monitor signal quality issues, including those related to narrowband interference, Azenkot discloses the use of a separate spectrum analyzer that monitors an incoming signal and determines whether narrowband interference is present. (Ex. 1029, 23:7-56, Figure 14.) If poor signal characteristics are detected, Azenkot discloses taking corrective action such as filtering undesired portions of an incoming signal. (Ex. 1029, 23:48-50.)

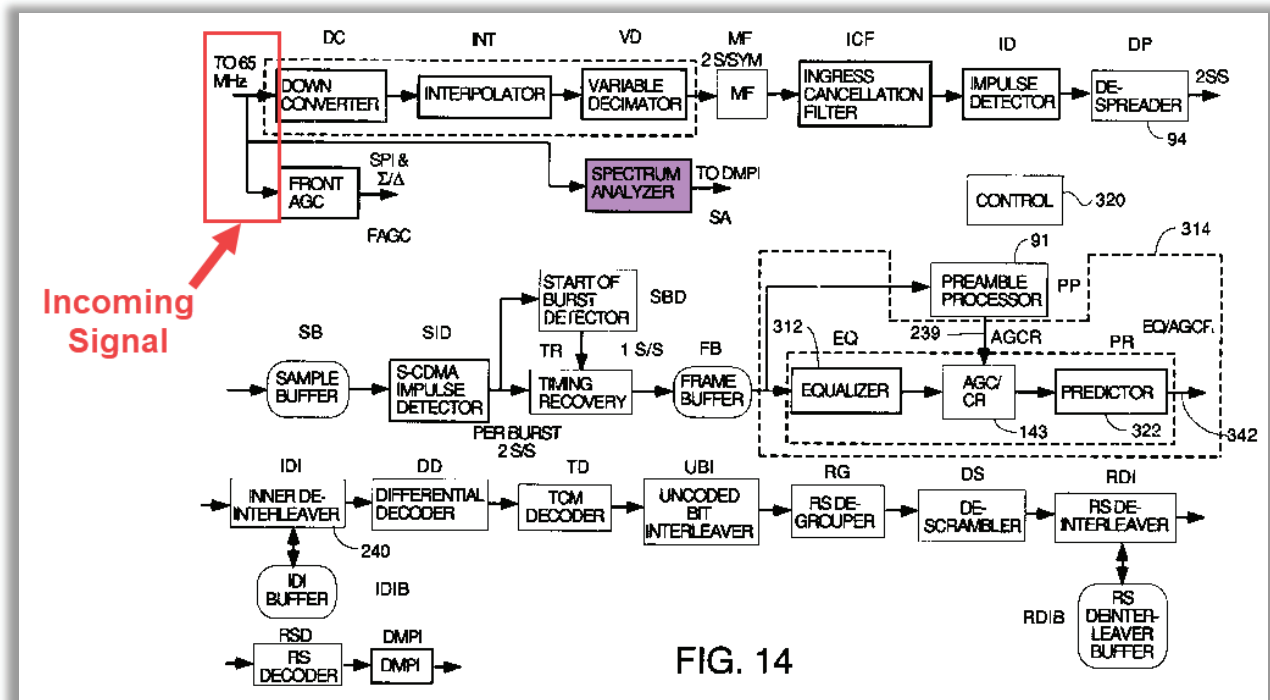


Figure 14 — Azenkot’s Signal Receiver Including Spectrum Analyzer. (Ex. 1029)

80. Tsui *et al.*, U.S. Patent No. 6,061,393 as filed in 1997, is another example of a system for testing signal quality of digital television communications systems in a non-invasive manner. (Ex. 1030.)

81. Tsui explains that, while digital communications technologies offer “numerous advantages over their analog predecessors,” there is a need for systems that monitor signal characteristics to ensure that digital communications systems retain high signal-quality characteristics. (Ex. 1030, 1:15-35.)

82. Tsui explicitly considers “non-invasive” testing, in order not to interrupt a user’s usage of a television receiver. (Ex. 1030, 1:55-63, 5:43-49.) As Tsui explains with respect to Figures 2A and 3, an AGC control circuit 204 may

have multiple outputs, including one output to a bandpass filter 206 and another output to a diagnostic processor/monitor 300 as illustrated in Tsui's Figure 3. (Ex. 1030, 5:50-54, Figures 2A and 3.) As this occurs in a non-invasive manner, the normal operation of Tsui's front-end is uninterrupted.

83. The diagnostic processor/monitor 300 operated along with analysis software in order to identify certain signal characteristics of an incoming wideband signal. (Ex. 1030, 6:25-30, 6:49-54.) As Tsui explains, the analysis process determines values for a number of different signal characteristics, including transmission channel response, carrier-to-noise ratio, interference signal spectrum, and so on. (Ex. 1030, 6:66-7:6.) By monitoring the incoming signals in this way, Tsui can perform corrective action to ensure high-quality signals.

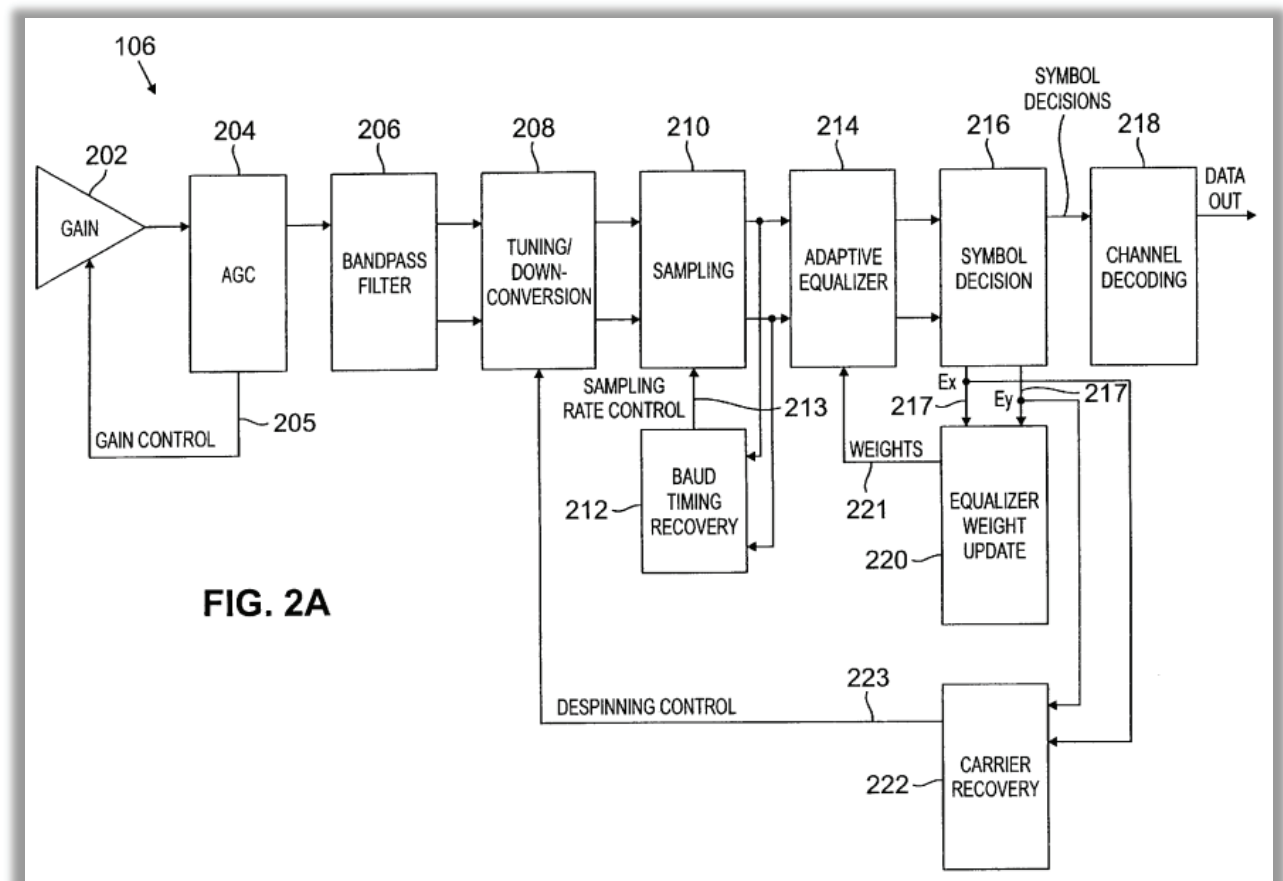


FIG. 2A

Figure 2A — Tsui's Digital Front-End. (Ex. 1030)

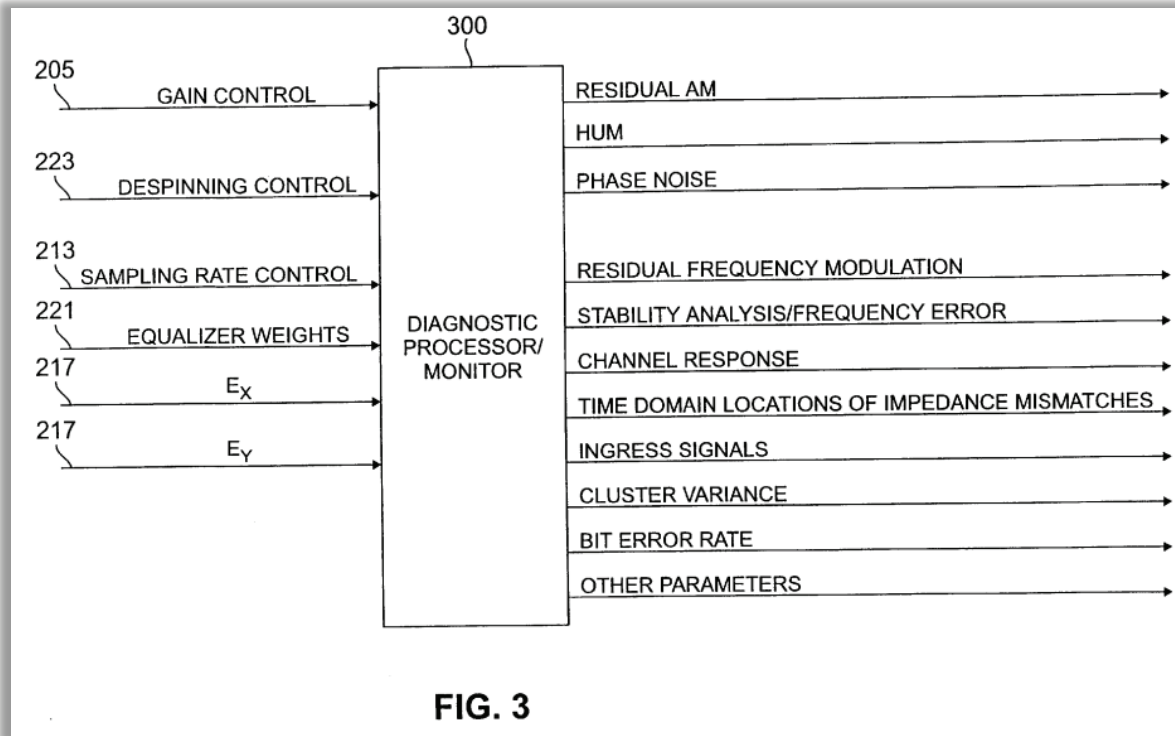


Figure 3 — Tsui’s Diagnostic Processor/Monitor 300. (Ex. 1030)

84. Another example of signal monitoring using a spectrum analyzer is disclosed in Harris, a patent that was originally filed as a provisional application on June 1, 2010. (*See* Ex. 1022.) Harris disclosed multiple television systems including a spectrum analyzer. The first disclosed system, illustrated in Figure 1, is described as a “prior art” system and included a high-resolution spectrum analyzer 110, which analyzed a digitized signal (*i.e.*, an output of ADC 30) before it reached a channelizer 40.

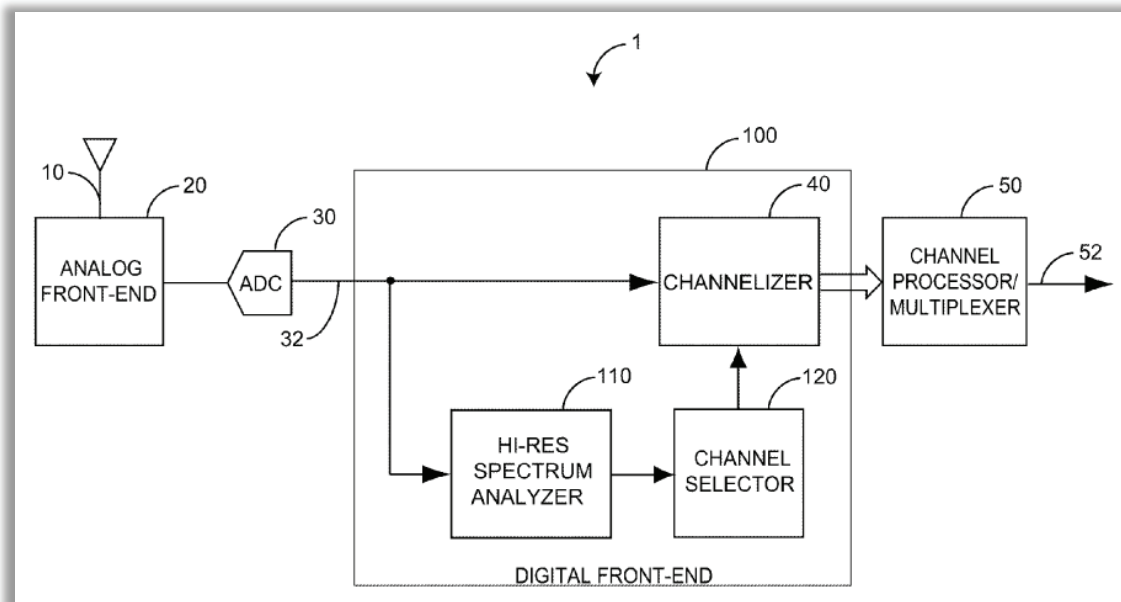


Figure 1 — Harris's Prior Art Hi-Res Spectrum Analyzer.

85. As discussed by Harris, the hi-res spectrum analyzer 110 identified signal characteristics, by identifying channels of interest, and produced spectral outputs characteristic of signal details. (Ex. 1022, 1:22-30, 1:66-2:20.)

VIII. OVERVIEW OF THE '008 PATENT

A. The Conventional Television Systems and Monitoring System Described in the '008 Patent

86. The claims of the '008 patent are directed to systems that analyze and recover content from portions of a digitized signal. Specifically, the '008 patent describes a system that digitizes a received signal, selects a first portion and a second portion of the digitized signal, analyzes the first portion of the digitized signal to determine a signal characteristic, and recovers content from the second portion of the digitized signal. The '008 patent further discloses cable and satellite television

systems that monitor portions of a received signal to assess whether the signal quality falls within acceptable parameters. ('008 patent, Abstract, 1:34-50, 3:33-60.)

87. In the '008 patent's Background of the Invention section, it explains that network-based services (*i.e.*, television services) may become unacceptable if “network parameters fall outside of those for which receivers in the network were designed.” ('008 patent, 1:34-36.) The '008 patent explains that “[c]onventional methods and apparatuses for monitoring network parameters” were “too costly and impractical for use in customer-premises equipment (CPE).” ('008 patent, 1:42-45.) To satisfy the apparent deficiency in conventional systems, the '008 patent proposes using known mechanisms, including wide-band analog-to-digital conversion, to enable a low-cost signal monitoring solution. As I discuss below, I find that this type of signal digitization and signal analysis was both conventional and well known as of 2011.

88. In the Detailed Description of the Invention section, the '008 patent begins by illustrating and discussing a cable communication system including conventional components. Figure 1A, for example, illustrates a communication system for providing cable television signals to a customer's premise.

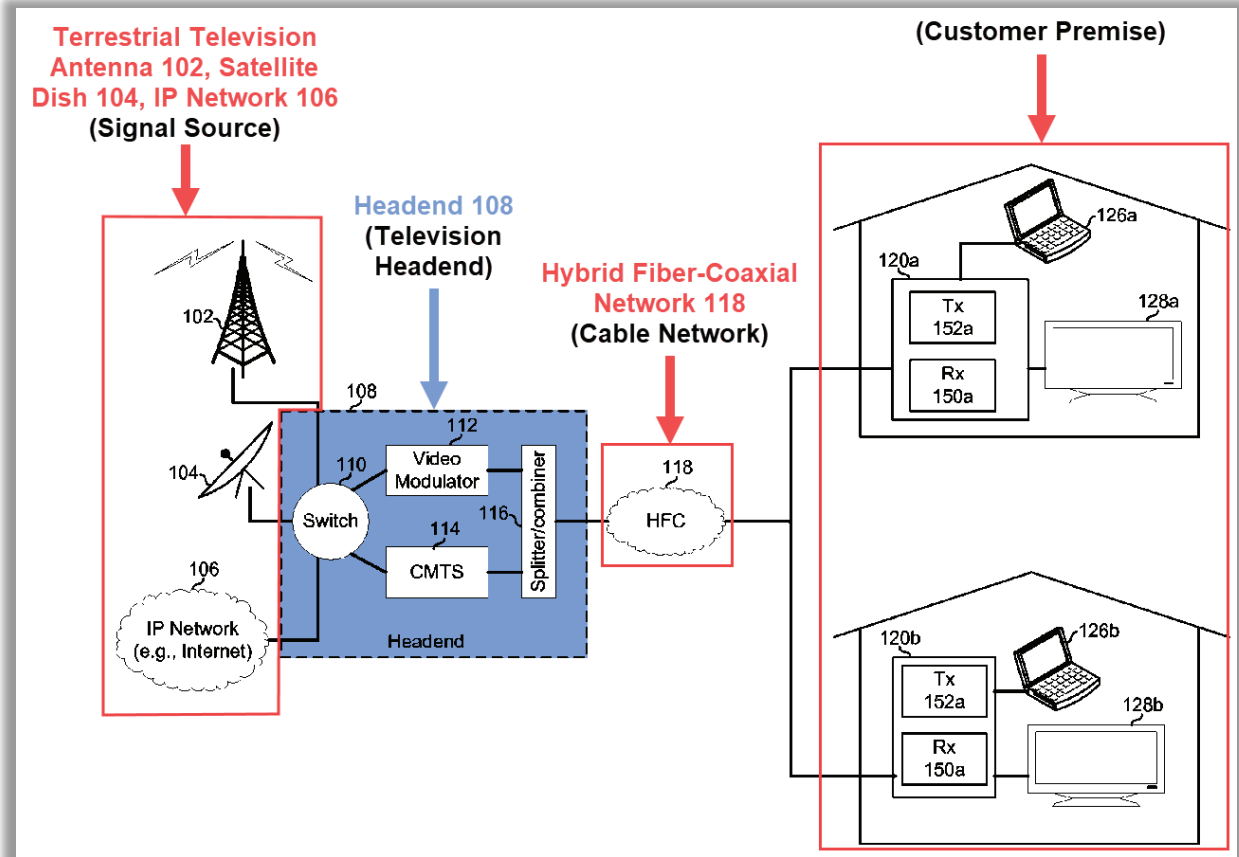


Figure 1A — '008 Patent's Example Cable System.

89. As illustrated in Figure 1A, and as discussed in the '008 patent, a “headend 108 may receive television signals via the [terrestrial television] antenna 102 and the satellite dish 104, and may receive data via the IP network 106.” ('008 patent, 2:44-46.) Though not explicit in the '008 patent, the headend 108 refers to a conventional headend operated by a television provider (a cable television provider, in the case of Figure 1A) where television signals are collected from a variety of sources (typically satellite sources) and distributed to downstream consumer devices. (See Ex. 1011, 141, Figure 12.8.)

90. Continuing the '008 patent's discussion on cable television systems, Figure 1B depicts the components of an example receiver in such a system. The disclosed components of Figure 1B's receiver include an RF receive front-end 158, a channelizer 152, a monitoring unit 154, and a data processing unit 156. ('008 patent, Figure 1B, 3:5-4:10.) I will discuss each of these components in turn, with reference to Figure 1B of the '008 patent specification.

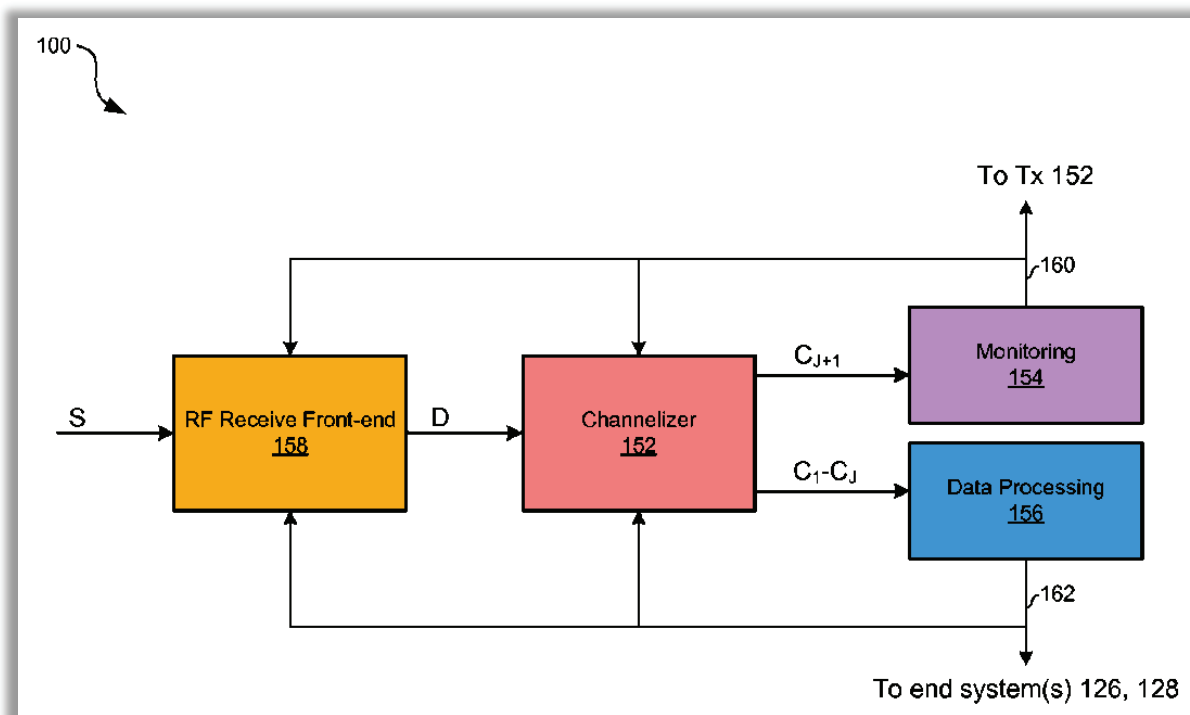


Figure 1B — '008 Patent's Receiver Circuit.

91. The RF receive front-end 158 receives a signal (*e.g.*, a television signal) and includes an analog-to-digital converter to digitize the received signal. ('008 patent, 3:11-16, Figure 2B.) After the received signal is digitized, the signal is transmitted to a channelizer 152, which can select portions of the signal

corresponding to one or more television channels. ('008 patent, 3:20-28, Figure 2B, element 256.) Channelizer 152 selects portions of the channelized signal— C_{J+1} and C_1 - C_J —where the first selected portion (C_{J+1}) is transmitted to a monitoring module 154 where it is analyzed to determine signal characteristics, such as signal-to-noise ratio (“SNR”). ('008 patent, 3:20-23, 3:57-60, 4:26-50, 6:27-31.) The second selected portion (C_1 - C_J) is concurrently transmitted to the data processing module 156 and processed to recover the data. ('008 patent, 4:45-47, 6:28-30.) Figure 4 of the '008 patent illustrates this process.

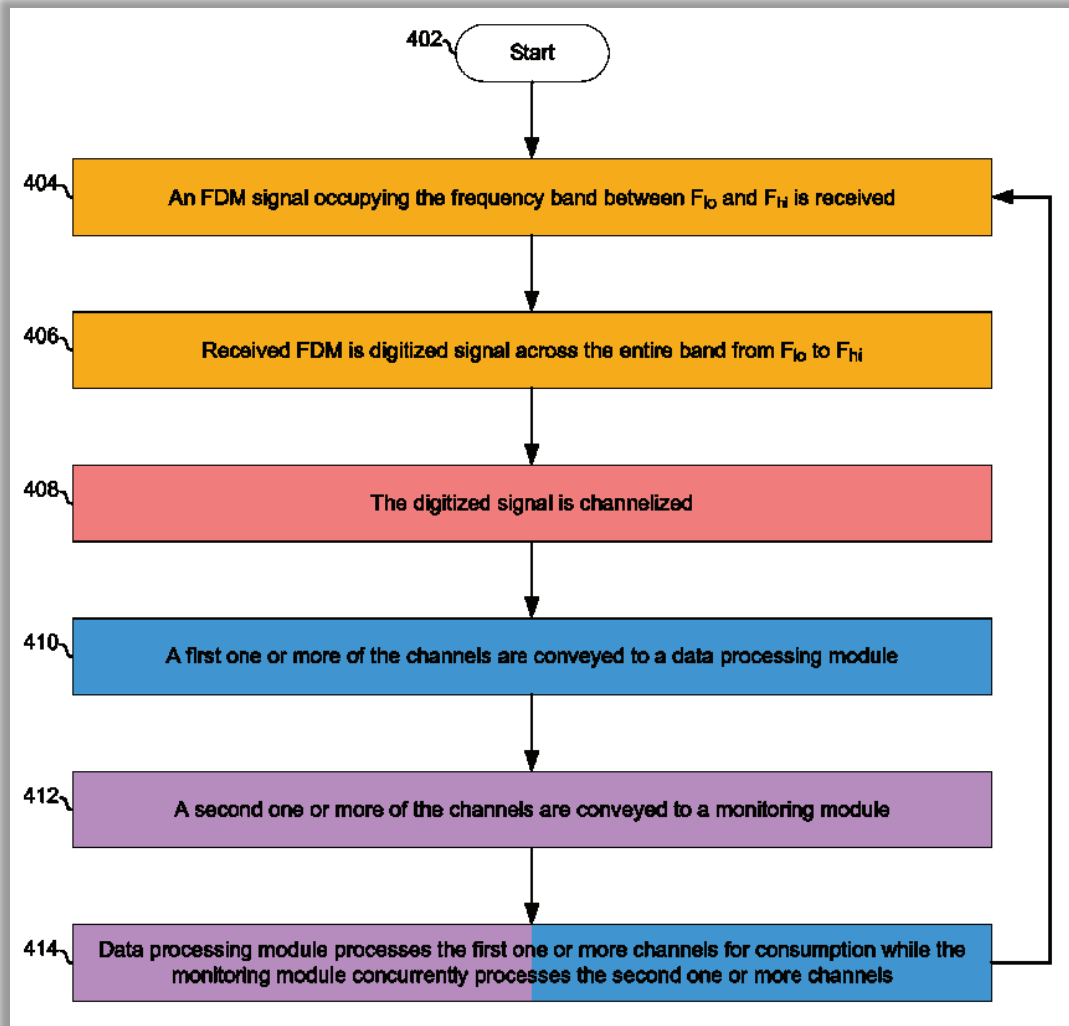


Figure 4 — '008 Patent's Spectrum Analysis Process.

92. In addition to cable systems, the '008 patent also considers satellite television systems. As depicted in Figure 1C of the '008 patent, below, a subassembly 174 containing a front-end 158, a channelizer 152, a monitoring module 154, and a data processing module 156 is located outside a customer's premise—specifically within a satellite dish assembly 172. In the disclosed satellite system, a signal received via the satellite dish undergoes the process described above

in the cable system (*see* Figure 4). ('008 patent, 4:51-5:11.) Because the subassembly 174 is outside the customer's premise, however, an additional gateway 196 is provided to receive data from the subassembly 174 via cables 184. ('008 patent, 5:6-11.)

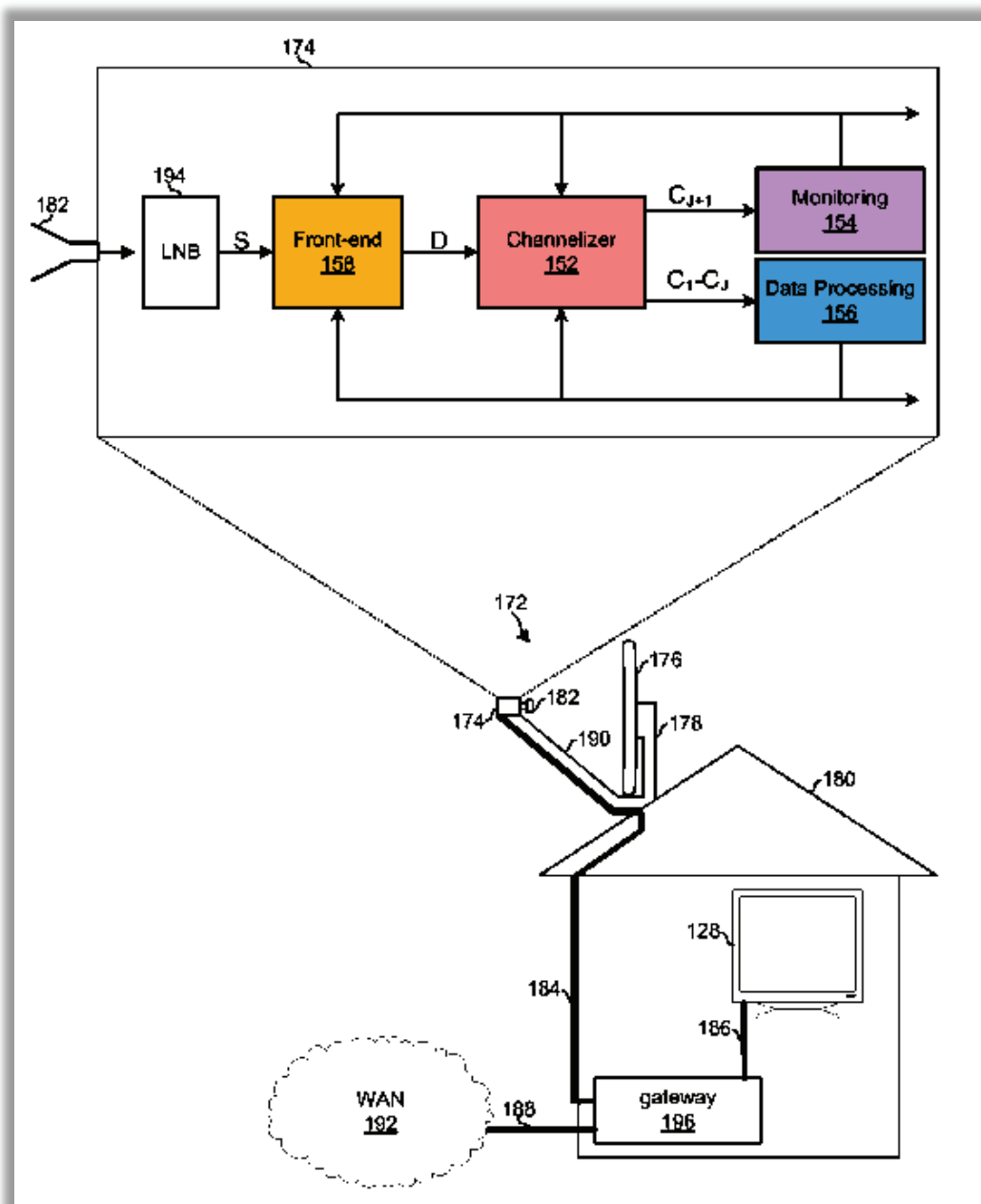


Figure 1C — '008 Patent's Satellite Receiver Circuit.

B. Applications Incorporated By Reference Into the '008 Patent

93. The '008 patent specification incorporates by reference multiple other U.S. Patent applications into its specification. I have reviewed and considered these applications including:

- The '483 application, titled “Multi-layer Time Interleaved Analog-to-Digital Converter (ADC),” was issued as U.S. Patent No. 8,611,483 and characterized by the '008 patent as an exemplary embodiment of an “ADC.” ('008 patent, 5:50-57, 1:14-25.) The '483 application was filed by MaxLinear, Inc. on May 31, 2012.
- The '451 application, titled “Method and Apparatus for Broadband Data Conversion,” issued as U.S. Patent No. 9,991,847 and is characterized as describing the “operation of the RF front end 158 and/or processing of signals generated by the RF front-end 158.” ('008 patent, 5:25-34, 1:14-25.) The '451 application was filed on December 23, 2011 and assigned to MaxLinear Inc.
- The '769 application, titled “Multi-Standard Coverage Map Generation,” issued as U.S. Patent No. 9,026,118 to MaxLinear and is incorporated by reference into the '008 patent. ('008 patent, 1:14-25.)

C. The Prosecution History

94. I understand that, during the prosecution of the '008 patent, the original patent owner communicated with the USPTO. I further understand that in 2021, the

original patent owner MaxLinear, Inc. assigned the patent to non-practicing entity Entropic Communications, LLC. To further inform myself as to the content of the '008 patent, I reviewed the written record between the Applicant and the USPTO in the '008 patent.

95. From reading the written record of the '008 patent, I understand the patent Examiner found that the originally filed claims were not allowable. Particularly, in a non-final office action, the Examiner found the claims not allowable, but did find that the claims would be allowable if amended to include the signal analysis and reporting limitations: “*analyzing said first portion to determine a characteristic of said received signal*” and “*reporting said determined characteristic to a source of said received signal.*” (Exs. ___, at (FH, NFJ 1/16/14, 8) and (FH Claims of Sept. 10, 2012, 2).) The patent Applicant accepted the Examiner’s proposal and that the patent proceeded to issuance.

D. Priority Date of the '008 Patent

96. The '008 patent issued from U.S. Patent Application No. 13/607,916, which was filed on September 10, 2012. It further claims priority to provisional application 61/532,098, filed on September 8, 2011. I offer no opinion regarding whether the '008 patent is entitled to the September 8, 2011 provisional date, but all

of the prior art discussed below predates September 8, 2011.¹ I understand that Patent Owner contends that the inventors conceived of the invention claimed in the '008 patent as of February 25, 2011. Even if Patent Owner establishes a February 25, 2011 conception date, the prior art analyzed below still applies because all of the references pre-date February 25, 2011.

IX. CLAIM CONSTRUCTION

97. Petitioner interprets the claim terms according to their plain and ordinary meaning as understood by a POSITA at the time of the invention in view of the specification and the prosecution history. (37 C.F.R. 42.100 (b); *Phillips v. AWH Corp.*, 415 F.3d 1302, 1312-12 (Fed. Cir. 2005).) I understand that in the co-pending litigation, Patent Owner also contends that each claim term should be accorded its plain and ordinary meaning. I reserve the right to propose a construction of certain claim terms in the litigation and/or to respond to any proposed constructions that Patent Owner may present in this proceeding.

98. I note, however, that the '008 patent claims recite two terms where clarification is beneficial to avoid possible confusion. While the terms do not require

¹ I understand Petitioner does not concede that the provisional application includes written description necessary to support the challenged claims.

a construction because they can be understood by a POSITA and their meanings are not likely to be disputed, explanation nevertheless may be helpful.

A. “a received signal spanning an entire television spectrum” (Claim 1) / “receiving a signal having a bandwidth that spans from a first frequency, F_{lo} , to a second frequency, F_{hi} ” (Claims 3 and 11)

99. Independent claim 1 recites digitizing “a received signal spanning an entire television spectrum” while independent claims 3 and 11 require digitizing “a received signal having a bandwidth that spans from a first frequency, F_{lo} , to a second frequency, F_{hi} .” In light of the ’008 specification, a POSITA would have understood that these received signals differ and have different meanings.

100. In the context of receiving a signal “spanning an entire television spectrum,” the ’008 patent discloses an RF receive front-end that is capable of “full-spectrum” capture, *e.g.*, of **all** received television signal(s), and that an “RF front-end of a receiver [is] operable to perform spectrum monitoring.” (’008 patent, 5:41-47.) The ’008 patent further explains that the received television signal(s) are ultimately provided to an analog-to-digital converter (*e.g.*, ADC 256) and may comprise the “entire cable downstream” for cable television, or “the received signal at the input of the LNB, and/or the downconverted signal ... at the output by an LNB” for satellite television. (’008 patent, 5:60-65.) A POSITA would thus understand that the phrase “a received signal spanning an entire television spectrum”

refers to **all** received television signals. This interpretation is consistent with the plain and ordinary meaning of the phrase.

101. In contrast, claims 3 and 11 recite “a received signal having a bandwidth that spans from a first frequency F_{lo} , to a second frequency, F_{hi} .” Unlike claim 1, here the claim language requires—and a POSITA would have understood—that a signal “[spanning a bandwidth] from a first frequency F_{lo} , to a second frequency, F_{hi} ” is simply a received signal consisting of any continuous frequencies between a low frequency F_{lo} and a high frequency F_{hi} ,” and not necessarily all received television signals. For example, the '008 patent states that “[i]n an example embodiment, signal S may be a cable television signal with $F_{lo}=55\text{MHz}$, $F_{hi}=1002\text{MHz}$. In another embodiment, signal S may be a MoCA signal with with [sic] $F_{lo}=1150\text{Mhz}$ and $F_{hi} = 2100\text{MHZ}$.” ('008 patent, 4:11-15.) The '008 specification further explains that the front-end may receive one or more television signals, as well as other signals, including DOCSIS or MoCA signals. ('008 patent, 3:12-15, 4:11-15.) As such, the “signal S may be the result of a plurality of television and/or DOCSIS channels being frequency division multiplexed into a signal and that signal S may occupy a frequency range from F_{lo} to F_{hi} .” ('008 patent, 3:12-15.) Thus, unlike “entire television spectrum,” this signal would not necessarily be all received

television signals, but rather a received signal having a continuous range of frequencies from a low to a high, which may include television and/or data signals.

X. LEVEL OF ORDINARY SKILL

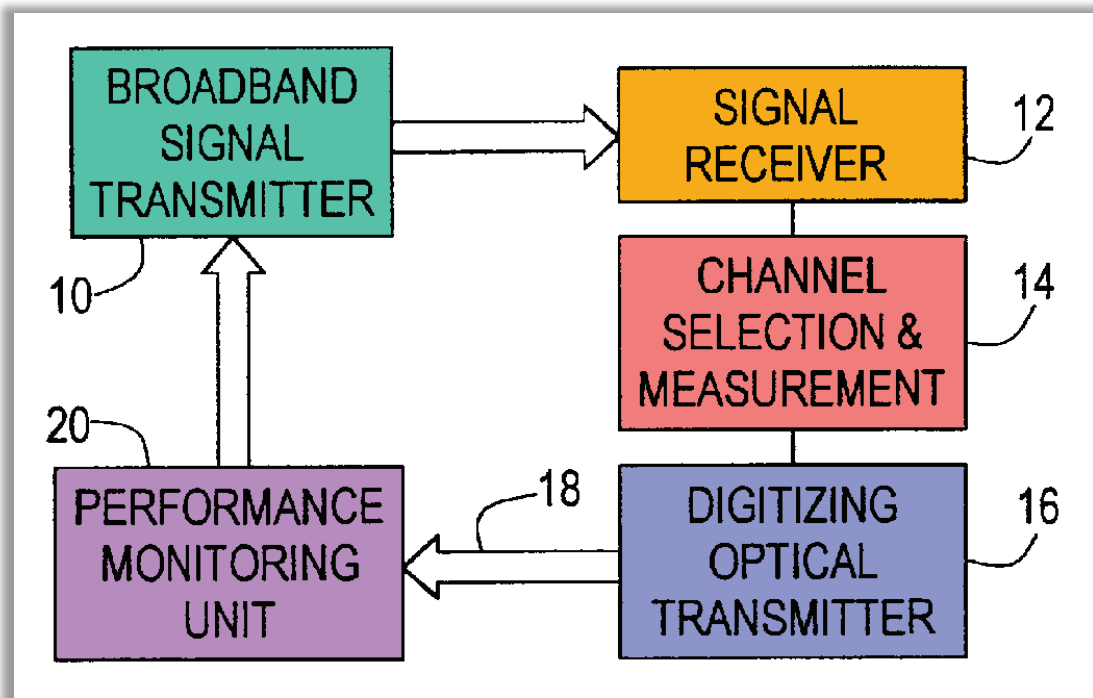
102. Based on my knowledge and experience, I understand what a person of ordinary skill in the art would have known at the time of the alleged invention. My opinions herein are, where appropriate, based on my understanding as a person of ordinary skill in the art at that time. In my opinion, based on the materials and information I have reviewed, and based on my experience in the technical areas relevant to the '008 patent, a person of ordinary skill in the art ("POSITA") at the time of the alleged invention of the '008 patent (*e.g.*, September 8, 2011) would have had at least: i) a bachelor's degree in electrical engineering or the equivalent, and three or more years of experience in cable and/or satellite television signal processing and communication systems; ii) a master's degree in electrical engineering or a related field, and one or more years of experience in of cable and/or satellite television signal processing and communication systems; or iii) a doctoral degree in electrical engineering or a related field, and at least some experience in cable and/or satellite television signal processing and communication systems. Additional education may substitute for professional experience, and significant work experience may substitute for formal education.

XI. DESCRIPTION OF THE PRIOR ART

A. Maycock (Ex. 1005)

103. Maycock is in the same field as the '008 patent—audio and video systems—and addresses the same problem as the '008 patent—how to remotely monitor video signals. (Maycock, Title, Abstract, 1:6-9, 2:20-23.)

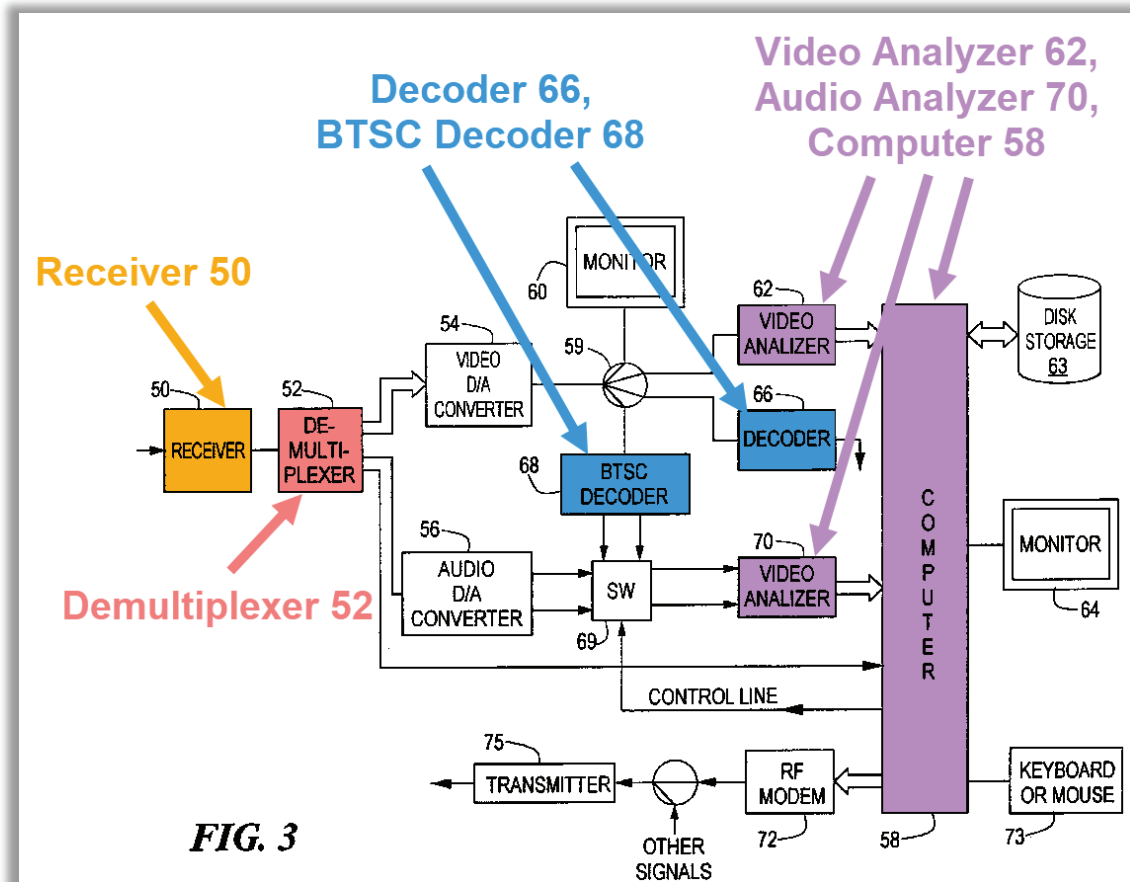
104. Figure 1 of Maycock is a block diagram of a high-level video system including a transmitter and components on the receiver-side. This comprises two-way communication between the transmitter and the receiver-side components:



Maycock — Figure 1.

105. In Maycock's system, received broadband video signals are processed by channel selector 14, which measures parameters of the signals and then selects a

channel for further analysis. (Maycock, 3:9-16, 3:30-50.) A more detailed system is set forth in Figure 3 of Maycock, below:



Maycock — Figure 3.

106. Maycock explains that a digitized signal is received at receiver 50. (Maycock, 5:65-6:7.) Receiver 50 outputs the digitized signal to demultiplexer 52 where it separates the digitized signal into three outputs and sends those outputs to both computer 58 for analysis and to the video and audio analyzer/processing systems. (Maycock, 6:2-7.) The video portion of the demultiplexer 52 output is analyzed—to measure signal-quality parameters—at video analyzer 62 and is then

decoded to demodulate information contained in the video signal. (Maycock, 6:24-29, 6:38-43.) Similarly, the audio portion of the output from demultiplexer 52 is analyzed at an audio analyzer 70 and decoded at BTSC decoder 68 to process the audio for stereo output. (Maycock, 6:45-60.) Computer 58 operates both to store measured information and to monitor information output from demultiplexer 52. (Maycock, 6:2-7, 6:62-67, 7:21-35.)

B. Zhang (Ex. 1006)

107. Zhang teaches a high-speed analog-to-digital converter for performing wideband ADC conversion by converting an “entire signal band” from the analog domain to the digital domain. (Zhang, 3:60-63.)

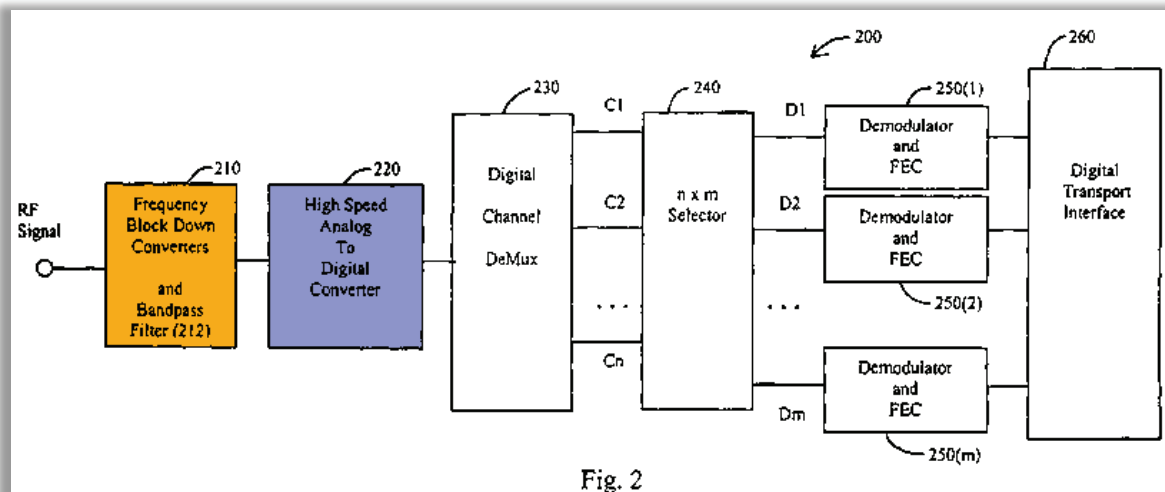


Figure 2 — Zhang’s Circuitry for Digitizing an Entire Spectrum.

108. Zhang’s Figure 2 depicts a frequency-block down-converter 210 that receives one or more analog television channels and outputs these channels to a high-speed ADC 220, where digitization of multiple channels occurs. (Zhang, 3:13-63.)

C. Kidambi (Ex.1007)

109. Like the '008 patent, Kidambi teaches digitizing an entire bandwidth of a television system at a set-top box prior to performing error correction. (Kidambi, [0082]-[0084].) To do so, Kidambi teaches using a wide bandwidth M-channel time-interleaved analog-to-digital converter (MCTIADC) and then correcting offset, gain, and timing errors in the digital signal. (Kidambi, Title, Abstract, [0005].)

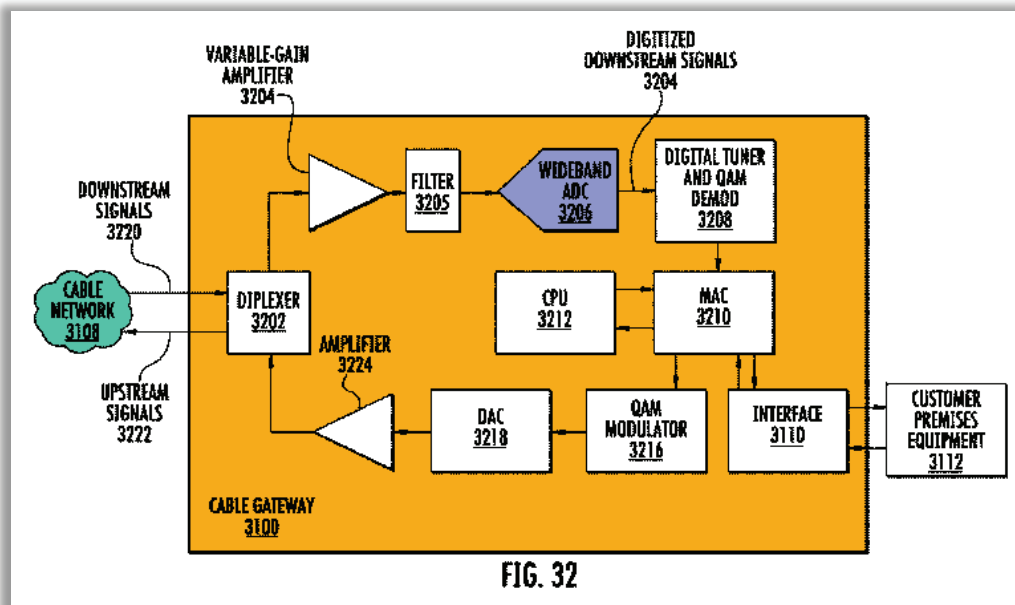


Figure 32 — Kidambi’s Circuitry for Digitizing an Entire TV Spectrum.

110. Kidambi’s Figure 32 depicts cable gateway 3100 using a wideband, multi-channel, time-interleaved, analog-to-digital converter 3206 to digitize signals (e.g., all of the signals) received from cable network 3108. (Kidambi, [0084].) Kidambi emphasizes that the entire received bandwidth is digitized, so that the system can tune to multiple digital channels rather than analog channels. (Kidambi, [0082], [0084].)

D. Coyne (Ex. 1008)

111. Coyne relates to a channelized receiver in a communications system. (Coyne, Title, Abstract, [0006].) Coyne explains that the detection/collection of a wide range of electromagnetic signals has several uses in military and commercial applications. (Coyne, [0003].) To detect signals across multiple RF channels 210A-210n, Coyne discusses combining these signals at a receiver/adaptor 201 using a combiner 220. (Coyne, [0020]-[0022], Figure 2.) Once combined, the output of the combiner 220 is routed to wide-band ADC 230, which creates a digital representation of the combined signal. (Coyne, [0022], [0029]-[0030], Figure 2.) This digital representation is fed into channelizer 240, where the combined digital signal is separated into different channel outputs. (Coyne, [0030]-[0031].) Figure 2 of Coyne, below, is an embodiment of this system.

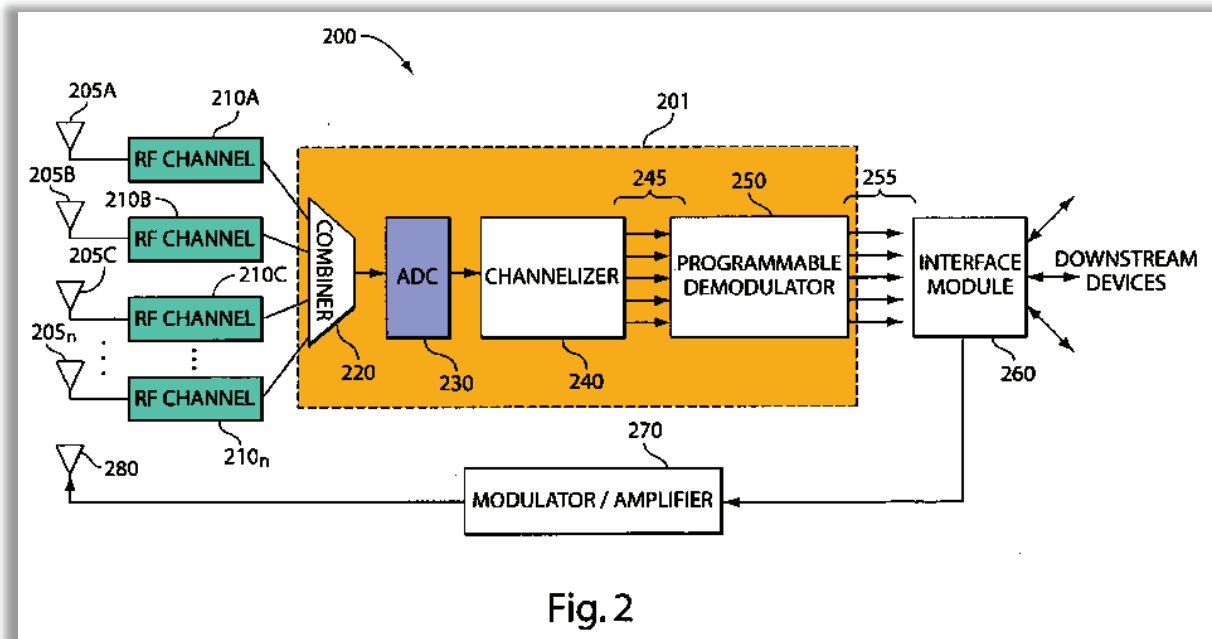


Figure 2 — Coyne.

112. Coyne further explains that portions of channelizer 240 output are outputted to at least two different locations including (1) signal detection decision logic 430 and (2) demodulation processing logic 440. (Coyne, [0044], Figure 4.) Signal detection decision logic 430 identifies whether certain channels of the digitized incoming combined signal contain a signal that should be selected for further processing. (Coyne, [0005], [0044].) Demodulation processing logic 440 extracts communications data from the digitized incoming combined signal. (Coyne, [0044].) Coyne additionally teaches switch 410 that rapidly establishes connections between channelizer 240, signal detection decision logic 430, and demodulation processing logic 440. (Coyne, [0044]-[0045].) In some configurations, switch 410 is

controlled such that signal detection decision logic 430 and demodulation processing logic 440 receive signals simultaneously. (Coyne, [0045].)

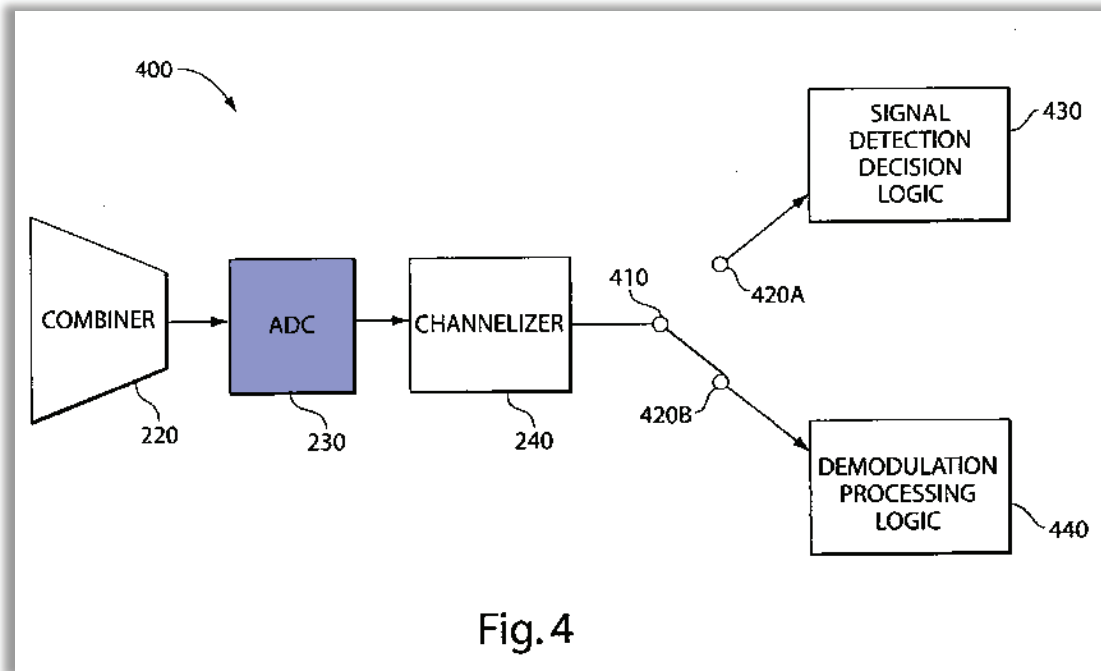


Fig. 4
Coyne — Figure 4.

E. Petrovic (Ex. 1009)

113. Petrovic discloses a system for monitoring transmissions of television content across a spectrum to obtain and report data regarding the use of the content. (Petrovic, Abstract, [0002].) Petrovic teaches obtaining different types of transmission data including data regarding “quality” of the television content or data regarding various channel characteristics, *e.g.*, signal-to-noise ratio. (Petrovic, [0003], [0011].) Petrovic discloses that “transmissions” can be satellite, cable television, radio, and the like. (Petrovic, [0011, 0038].)

114. Petrovic's system monitors transmissions at the national, regional, and/or local levels of distribution and can detect any signal ultimately received by the public. (Petrovic, [0015], [0038], [0040].) The monitoring sites, also referred to as EARs (event airplay receivers) are preferably situated on premises of independent contractors remote from the broadcaster. (Petrovic, [0015], [0038], [0040].) Petrovic further discloses that each EAR or monitoring site can monitor multiple channels, typically between 8 to 80 channels. (Petrovic, [0043].) Specifically, the monitoring sites can monitor the SNR for all incoming signals, such as audio signals, at the signal reception sites. (Petrovic, [0058]-[0059].)

115. Figures 1 and 2 of Petrovic, below, depict the entire system, including the monitoring site.

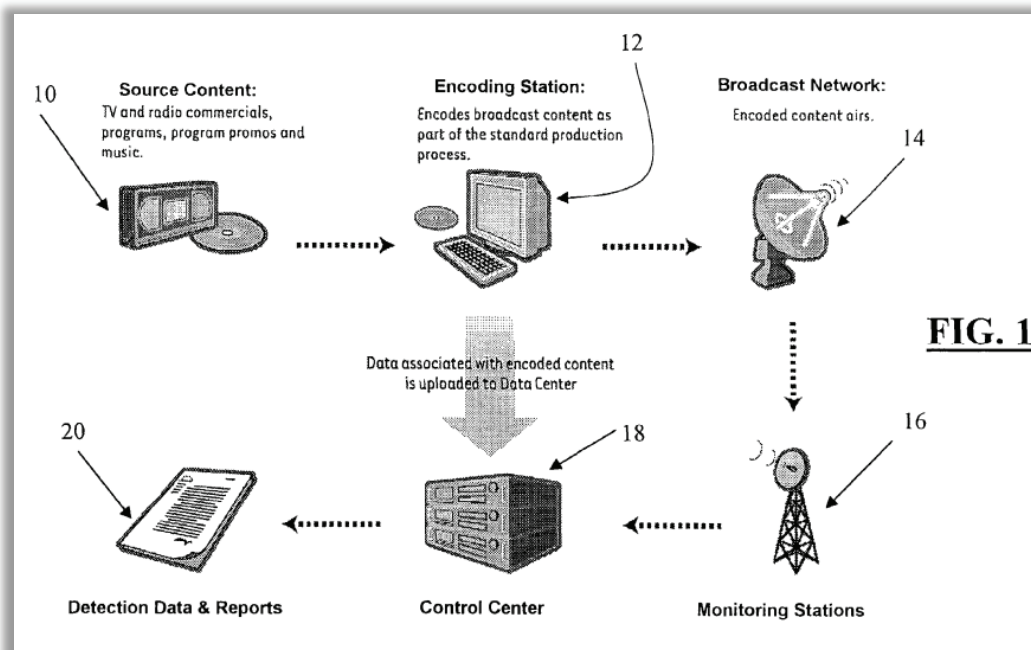


Figure 1 — General Monitoring Network Connectivity Framework.

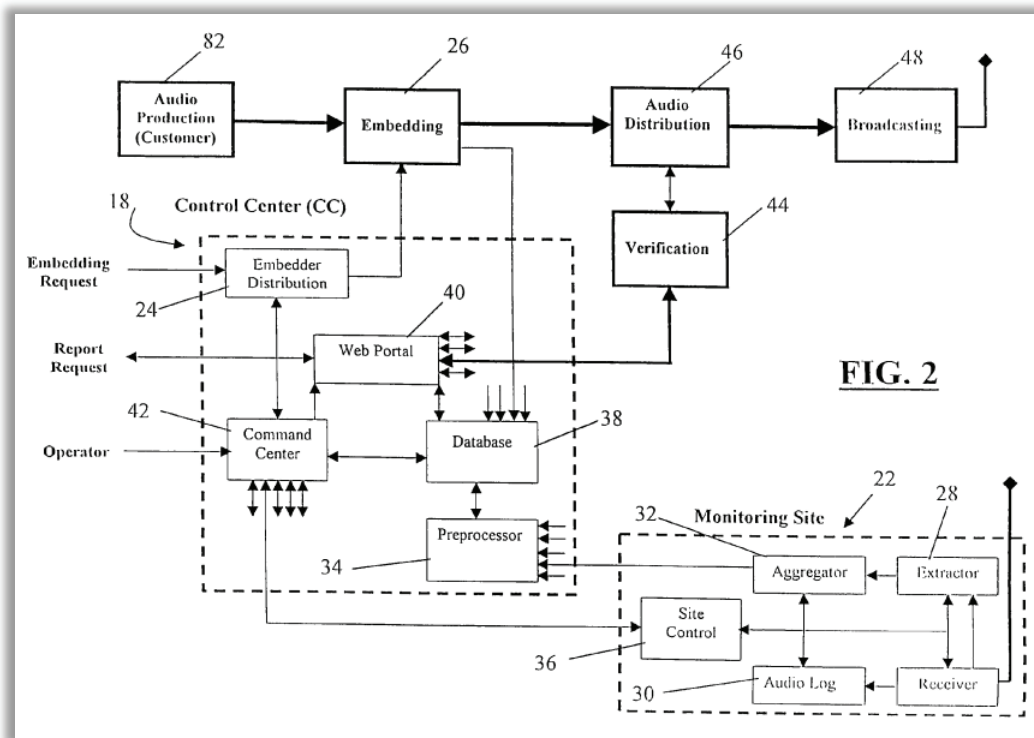


Figure 2 — Petrovic's Preferred Monitoring System.

116. Each of the monitoring sites has a site control module (36) that generates alarms communicated to the control center, such as alarms based on the power or quality of the incoming signal determined by monitoring SNR. (Petrovic, [0056]-[0057], [0060].) Petrovic also teaches sending transmitted content to both the consumers and the monitoring sites in parallel. (Petrovic, [0037]-[0038].)

XII. GROUNDS FOR CHALLENGE

A. Ground 1: Claims 1-18 are Obvious over Maycock and Zhang, and in further view of the General Knowledge of a POSITA

1. Motivation to Combine Maycock and Zhang

117. A POSITA would have been motivated to combine Maycock and Zhang to incorporate Zhang's wideband capture and digitization into Maycock's signal monitoring system. Maycock and Zhang both disclose systems for transmitting and receiving television signals and therefore are in the same technical field. (Maycock, 4:1-6; Zhang, 3:15-18.) Like the '008 patent, Maycock's system monitors television signals to provide high-quality television services to their customers by collecting channel-quality data from the signal, monitoring that data, and warning the television provider when the signal quality is poor. (Maycock, 2:20-29, 3:2-16, 7:21-25, 7:41-53.) While Maycock teaches monitoring one channel at a time, it also clearly suggests performing multiple, successive signal monitoring processes to collect data for multiple television channels (Maycock, 7:27-29, 8:1-25 ("All Channels")) and discloses using an ADC 38 to convert a selected channel for digitization before monitoring the signal "so as not to degrade the performance of the received signal." (Maycock, 4:28-30.)

118. Zhang, on the other hand, expressly touts the benefits of wideband digitization, explaining that conventional systems having one analog tuner per RF

channel—like Maycock—resulted in “the cost, power consumption, and complexity go[ing] up as the required number of RF channels goes up.” (Zhang, 1:66-2:2.) Therefore, Zhang taught a wideband ADC converter for digitizing multiple channels at once. (Zhang, 6:38-61.)

119. A POSITA would have known and understood that Maycock’s signal monitoring system could be modified by replacing Maycock’s ADC with Zhang’s wideband ADC to digitize multiple signals at once in an efficient and less computationally intensive manner. By incorporating Zhang’s disclosure of wideband capture and digitization, a POSITA would have known that digitizing the entire wideband spectrum would provide the benefit of having a more efficient digital signal processing system with reduced complexity by avoiding multiple digital conversions for specific RF channels, with only a slight expense of a relatively small initial computational cost required for digitization of a wideband analog signal at a high sampling rate. Digitizing multiple RF channels at a time is especially advantageous as the required number of RF channels increases. Digitizing multiple (or all) channels also allows for faster channel switching because the system already has a digital representation to provide to a display without delays or additional processing costs caused by changing the frequency of a tuner.

120. A POSITA would also have understood how to incorporate Zhang's high-speed ADC 220 (or, equivalently, ADCs 620a and 620b) to the wideband analog input signal of Maycock, while removing the A/D converter(s) 38 from the system of Maycock with a reasonable expectation of success and predictable results. Such a shift in the position (and sampling rate) of the ADC is a standard and routine design choice in digital signal processing systems that receive analog input signals.

121. The exact stage of the electronic system that is digitized is determined by a design choice intended to balance the inherent tradeoffs between two approaches: early- versus later-digitization. The advantages of early digitization of electronic systems are clear: (a) precise reproducibility of digital signals is achieved throughout the system; and (b) flexibility of digital design provided by hardware and software options that can be easily modified in the future. These benefits, however, are attained at the expense of the high-sampling rate needed when applied to a wideband signal because (according to the Nyquist rate) the sampling rate is proportional to its highest frequency component.

122. An alternative design option relies on digitization in later stages by first decomposing wideband signals to multiple narrowband signals in the analog domain, and only then proceeding to digitize the narrowband analog components. This approach still has the benefits of digital systems (*i.e.*, precise reproducibility

and flexible hardware/software design) but only requires a modest sampling rate applied to each of the narrowband components. To achieve these benefits, the later-stage digitization approach sacrifices: (a) complex analog electronics required to filter a plurality of narrowband components of the wideband signal; and (b) loss in fidelity incurred by the use of analog filters in the initial processing of the wideband signal.

123. At its infancy, the tradeoff between early- and later-digitization of wideband signals in electronic systems was resolved in favor of the later-digitization design approach by using conventional analog filters to decompose wideband analog signals into multiple narrowband digital signals. However, as the sampling technology improved and ultra-high sampling rates were achieved by commercially-available analog-to-digital converters (ADCs), digital system designers naturally transitioned the digitization process into the earliest possible stage of electronic systems. The increased sampling rate of ADCs was a result of the steady improvement in digitization technology since its infancy. By the early 2000s and certainly by 2011, the improved digitization technology reached ultra-high sampling rates that could accommodate the digitization of wideband analog signals. (Ex. 1032 (“As previously mentioned, the rapidly growing digital video market, coupled with the introduction of the TRW TDC-1007J 8-bit, 30-Ms/s flash ADC in 1979, spurred

many IC manufacturers to develop similar, but lower powered flash ADCs with resolutions ranging from 4 to 10 bits, and sampling rates as high as high as 500 Ms/s. The peak years for flash converters were approximately 1979 to 1990.”.)

2. Independent Claim 1

124. In my opinion, the combination of Maycock’s signal monitoring system and Zhang’s wideband ADC renders claim 1 obvious under the plain and ordinary meaning of “entire television spectrum” understood as “all received television signals.” In the event the Patent Owner argues that “entire television spectrum” is understood as all received signals (television, data, etc.), Zhang—when combined with Maycock—still renders the claims obvious.

I[pre] “A system comprising:”

125. To the extent that the preamble is limiting, Maycock discloses a “video signal transmission monitoring system.” (Maycock, 2:52-54, claim 13.) Maycock’s Figure 1 depicts its exemplary video signal transmission monitoring system.

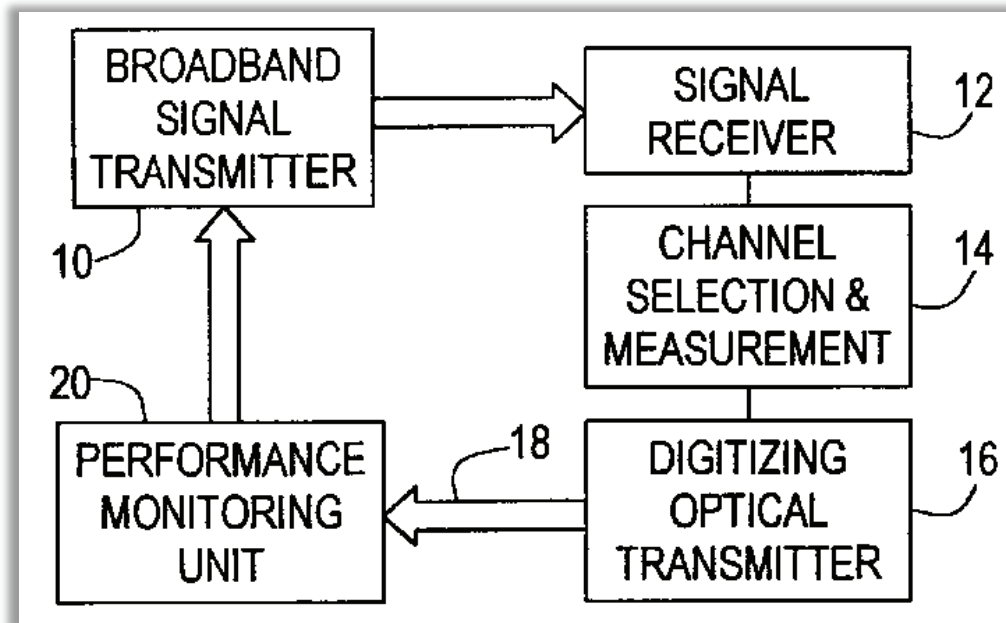


**Figure 1 — Maycock’s “Video Signal Transmission Monitoring System.”
(2:52-54)**

1[a] “an analog-to-digital converter operable to digitize a received signal spanning an entire television spectrum comprising a plurality of television channels, said digitization resulting in a digitized signal;”

126. Zhang discloses wideband analog-to-digital converter(s) that digitize a received signal spanning an entire television spectrum comprising a plurality of television channels to generate a digitized version. (Zhang, 3:60-63, 6:3-35.) A POSITA would have understood how—and would have been motivated—to incorporate Zhang’s wideband ADC(s) into Maycock’s signal monitoring system to digitize the received signal spanning the entire television spectrum as required by limitation 1[a]. See §XI.A.1, *supra*.

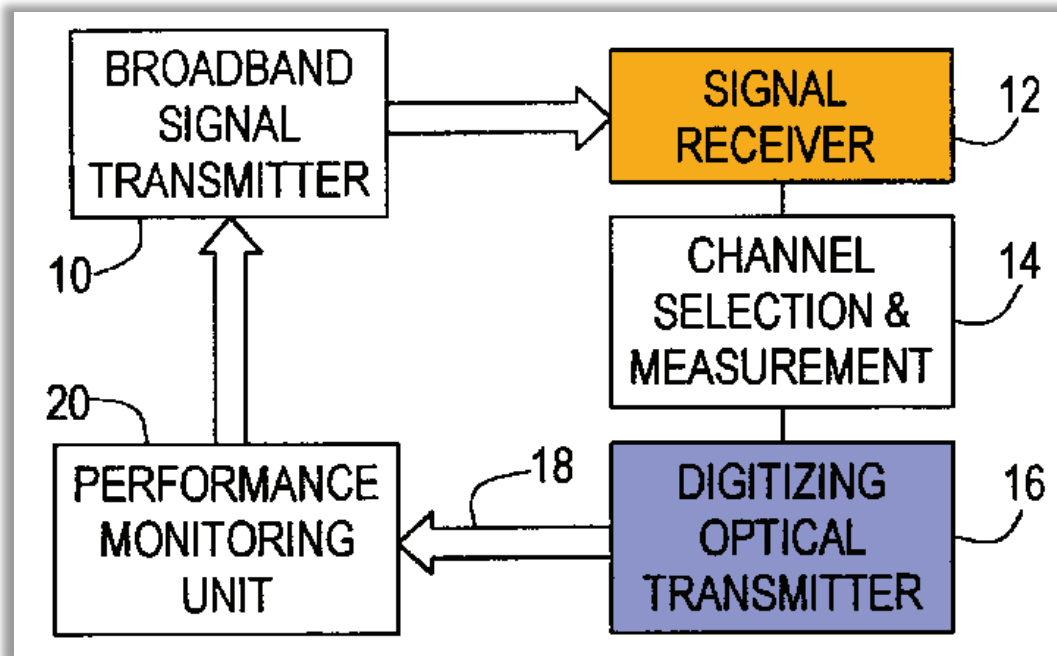


Figure 1 — Block Diagram of Maycock’s “Video Signal Transmission Monitoring System.” (2:52-54)

127. Turning first to Maycock’s system, Figure 1 depicts signal receiver 12 that receives broadband analog video and audio signals from a broadband signal transmitter (*e.g.*, cable headend, etc.). (Maycock, 3:2-16.) Signal receiver 12 is “an optical receiver, an antenna, or any other device which enables the capture of a broadband signal.” (Maycock, 3:5-9.) Maycock further teaches that the “channel selection & measurement” element 14, depicted in Maycock’s Figure 2 as the channel selector 14a, contains analog-to-digital converter 38 (video), which digitizes video components of an incoming analog television signal, and analog-to-digital converters 37a/37b (audio), which digitize audio components of the incoming analog television signal. (Maycock, 3:60-61, 4:25-58, Figure 2.) A digitized signal is

thereby created, combined into one signal at multiplexer 43, and transmitted to performance monitoring unit 20 for analysis (*see* Figure 4) by digitizing optical transmitter 16. (Maycock, 5:23-35, 5:38-47.) Maycock, therefore, teaches the claimed analog-to-digital converter operable to digitize a signal comprising a television channel.

128. Limitation *1[a]* further requires digitizing the “received signal spanning an entire television spectrum comprising a plurality of television channels.” As explained above, based on the ’008 patent and my knowledge of the art as a POSITA, the phrase “entire television spectrum” refers to all television signals received at the receiver front-end. Zhang discloses and/or suggests this limitation because Zhang teaches using a “high-speed ADC” to digitize “an entire signal band with n channels” as depicted in Figure 2. (Zhang, 3:62-63.)

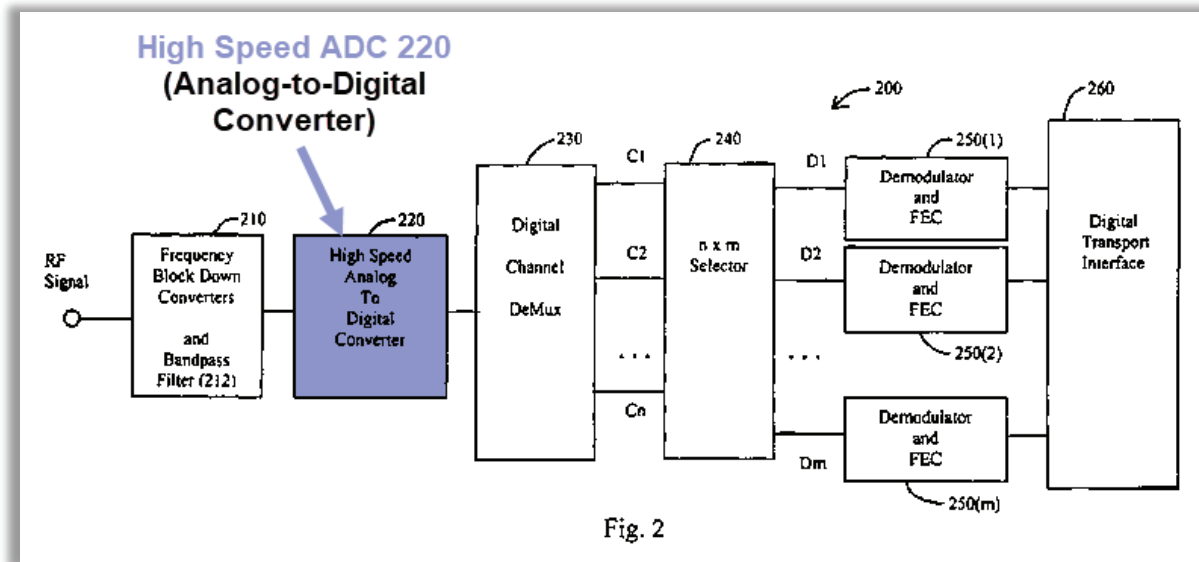


Figure 2 — Zhang’s “Multi-Channel Demodulator.” (2:56-58)

129. Zhang explains that a single ADC can be used to digitize incoming television signals. (Zhang, 3:49-53.) Zhang’s single ADC “receives the multi-channel analog RF signal ... and converts the multi-channel analog RF signal to a multi-channel digital RF signal.” (Zhang, 2:14-17.) Put another way, Zhang’s multi-channel ADC is operable to digitize a multi-channel incoming signal.

130. Zhang further explains that, in systems that receive a multi-channel RF signal that “carries multiple RF channels,” each RF channel “can carry one or more content channels.” (Zhang, 3:15-35.)

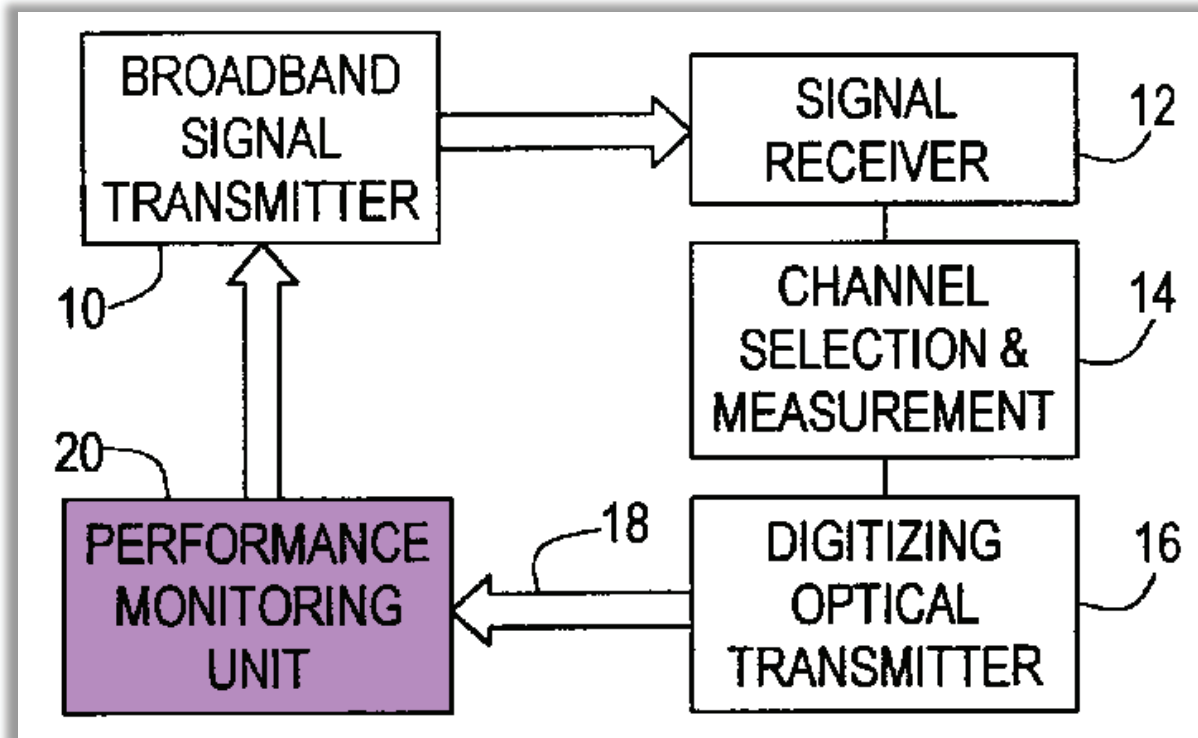
131. A POSITA would have understood that Zhang’s “High Speed Analog to Digital Converter 220” is an ADC operable to digitize all received television signals because Zhang discloses that multiple ADCs are used to digitize all of the received television channels, but only when the received spectrum exceeds the

bandwidth a single ADC can digitize. (Zhang, 6:3-35, 6:52-61.) If the bandwidth of the received signal does not exceed the bandwidth of a single ADC, then Zhang discloses that a single ADC can be used. Further, according to Zhang, RF signals may include television (*e.g.*, audio and video) components and non-television components, such as DOCSIS information. (Zhang, 3:31-34, 7:6-7.) Zhang thus teaches the advantage of using a single ADC where possible to digitize the bandwidth of the received signal, *e.g.*, of a television spectrum. It is my opinion that the combination of Maycock and Zhang discloses limitation 1[a].

132. I understand that the Patent Owner in the District Court contends that “entire television spectrum” should be given its plain and ordinary meaning. Should the Patent Owner argue that the plain and ordinary meaning requires all received signals to be digitized and not just the received television signals, it is my opinion that the combination of Maycock and Zhang renders the claim obvious under this construction, too. Zhang makes clear that the only reason more than one ADC would be used is because a single ADC does not have sufficient bandwidth to digitize the received signal, so it would be obvious to use a single ADC that had sufficient bandwidth although a POSITA might or might not choose to use a single ADC depending on cost considerations.

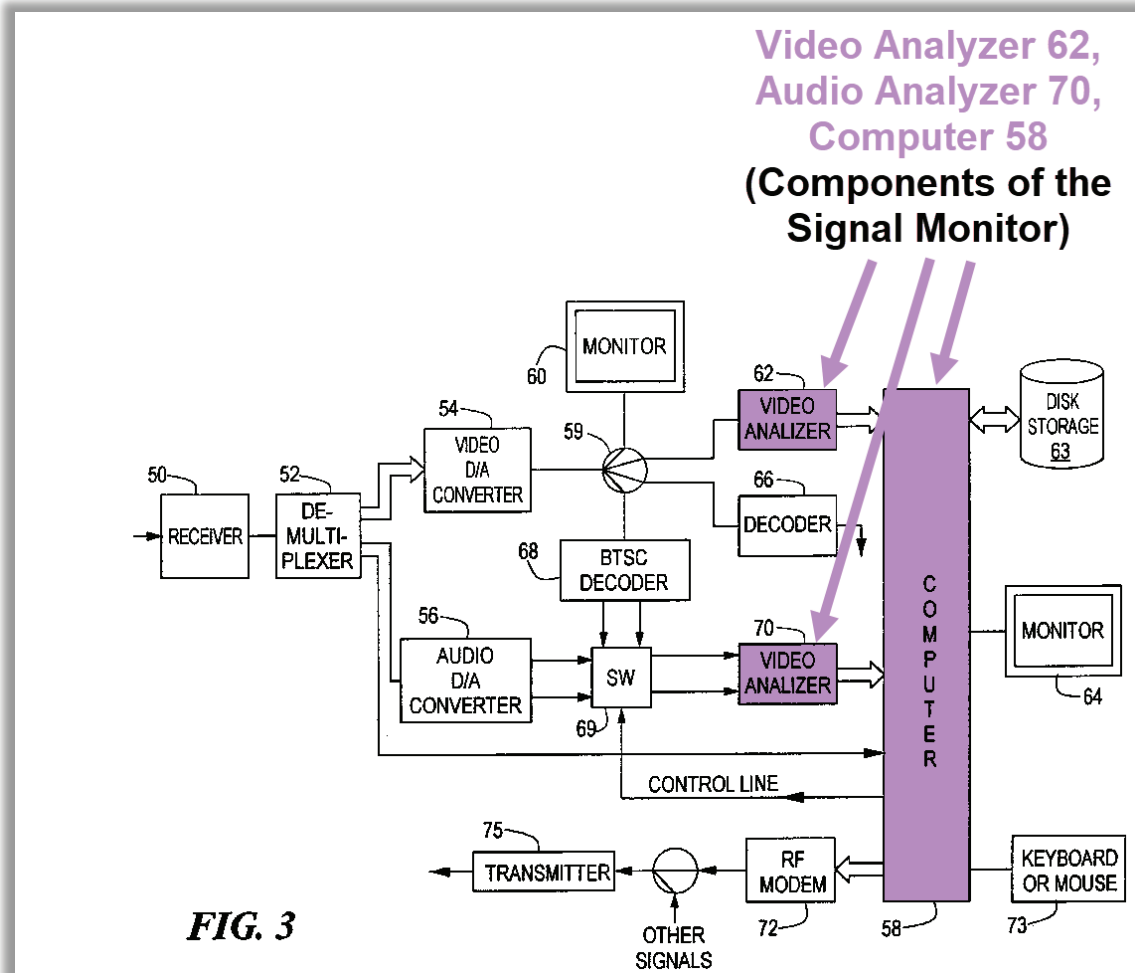
1[b] “a signal monitor operable to:”

133. Maycock discloses a signal monitor. For example, Maycock’s Figure 1 broadly depicts “performance monitoring unit 20” for analyzing “both for audio and video content and [comparing] the measurement data ... with reference data stored.” (Maycock, 3:18-20.)



Block Diagram of Maycock’s “Video Signal Transmission Monitoring System.” (2:52-54)

134. Maycock’s Figure 3 depicts in more detail the components and functionality of the claimed “signal monitor.” (Maycock, 5:65-7:20.) Video analyzer 62, audio analyzer 70, and computer 58 analyze the signal, determine the signal characteristics and provide the reporting as required by limitation *1[b]* and therefore together are the claimed “system monitor.”



Maycock — Figure 3.²

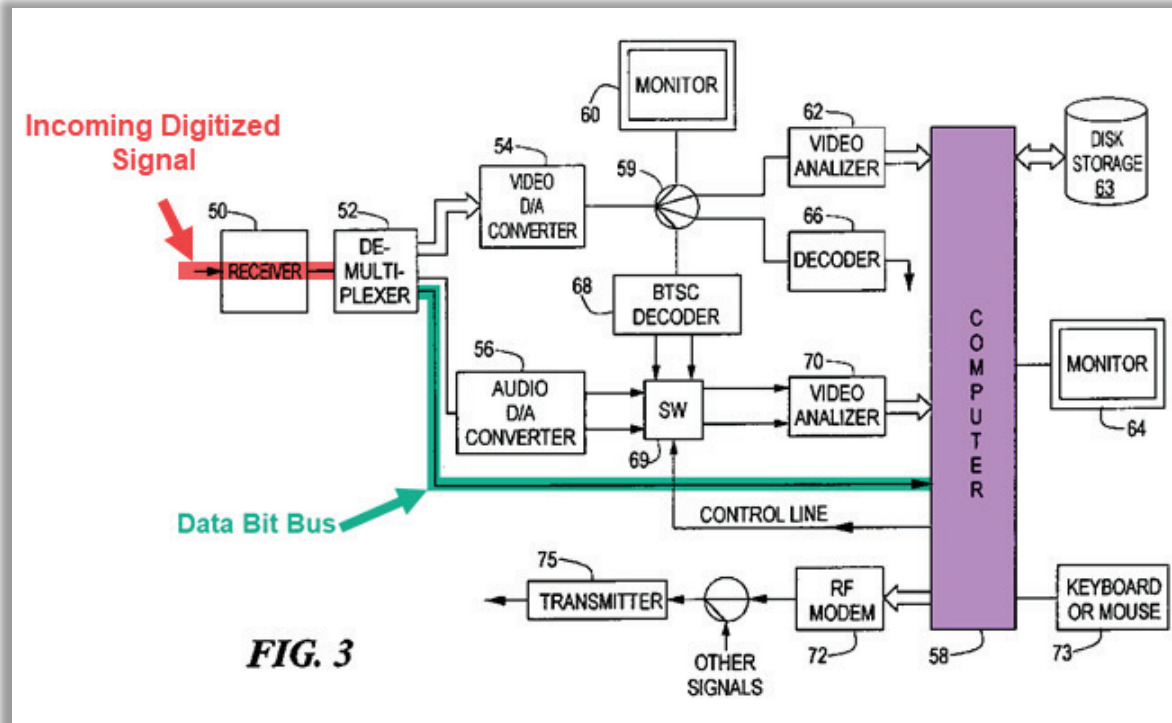
135. Maycock’s “video analyzer 62 measures signal-quality parameters such as signal-to-noise ratio, differential gain, differential phase and other video

² I note that element 70 in Figure 3 appears to have been mislabeled as a “video analyzer.” I understand element 70 to be an “audio analyzer.” This is consistent with the description in Maycock and makes logical sense given the two paths depicted for audio and video signals. (Maycock, 6:55.)

parameters” while “audio analyzer 70 performs measurements of parameters such as signal-to-noise ratio and harmonic distortion.” (Maycock, 6:55-57, 6:23-26.) Finally, computer 58 acts to analyze the outputs of the video analyzer 62 and the audio analyzer 70 and also monitors a portion of a digital signal output from the demultiplexer 52 (“a third data bit bus”) “for analysis of the digitized performance information.” (Maycock, 6:4-7.) It is my opinion that the combination of Maycock and Zhang discloses limitation 1[b].

1[b][1] “analyze said digitized signal to determine a characteristic of said digitized signal; and”

136. It is my opinion that Maycock’s monitoring system “*analyze[s] said digital signal to determine a characteristic of said digital signal*” as required by limitation 1[b][1]. Figure 3 illustrates the “components of [Maycock’s] monitoring unit 20” and shows receiver 50 receiving a digitized signal and transmitting that signal to demultiplexer 52. (Maycock, 5:39-42, 5:65-6:2.)



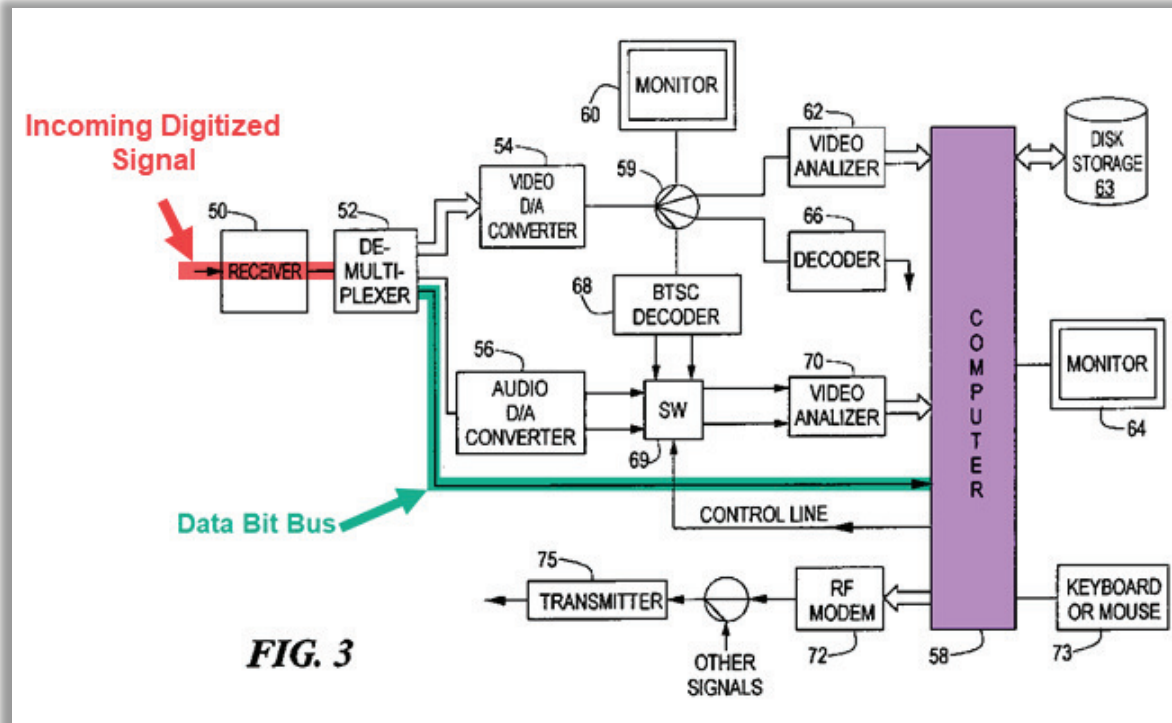
Maycock — Figure 3.

137. Demultiplexer 52 separates the 10-bit digitized signal into three different signal parts: 8 video bits are transmitted to video digital-to-analog converter 54, a single audio bit is transmitted to audio digital-to-analog converter 56, and a bit is transmitted directly to control computer 58 “for analysis of the digitized performance information.” (Maycock, 6:2-7.)

138. The 8 video bits are converted back to an analog format by video D/A converter 54 and then analyzed by video analyzer 62, which measures various signal-quality parameters including but not limited to “[s]ignal-to-noise ratio, differential gain, differential phase and other video parameters” (Maycock, 6:23-26.) Similarly, the audio bit is converted back to an analog format by audio D/A

converter 56 and then analyzed by audio analyzer 70, which measures “parameters such as signal-to-noise ratio and harmonic distortion,” as well as “digitized performance information.” (Maycock, 6:55-57.) Maycock’s signal-quality parameters (*e.g.*, signal-to-noise ratio, differential gain, and harmonic distortion) are the exact same examples of “a characteristic” as the characteristics described in the ’008 patent. (*Compare with* ’008 patent, 3:33-45 (identifying “characteristics” such as signal-to-noise ratio and various frequency functions).)

139. Limitation 1[b][1] simply requires “*analyz[ing] said digitized signal to determine a characteristic of said digitized signal.*” In my opinion, however, nothing in the claim requires that the analysis be performed exclusively in the digital domain. Instead, the claim only requires that the signal monitor receive a digitized signal and perform signal analysis on that digitized signal to determine a signal characteristic. Thus, it does not matter whether the signal varies between analog and digital form at other points as long the signal received by the signal monitor is in the digital domain.



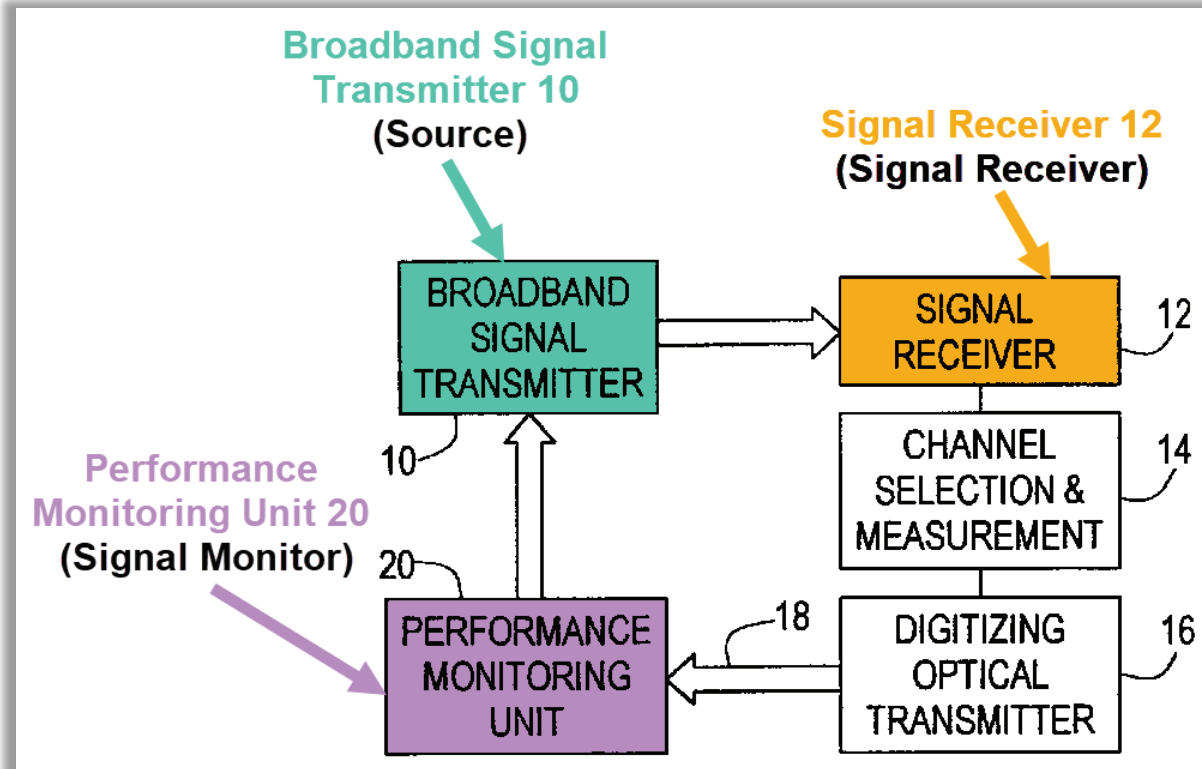
Maycock — Figure 3.

140. As shown by the RED line annotation in Figure 3, Maycock's performance monitoring unit 20 receives a 10-bit digitized signal, performs various processing techniques, and analyzes this digital signal. Hypothetically, if performance monitoring unit 20 was a black box, a POSITA would have understood that a digitized signal is the input and that the unit outputs signal characteristics to computer 58. (Maycock, 5:65-6:2, 7:4-13, 7:21-35.) In my opinion, Maycock's performance monitoring unit 20 analyzes and determines characteristics of the incoming digitized signal, as determined by the video analyzer 62, the audio analyzer 70, and/or the computer 58.

141. Nevertheless, if the Patent Owner contends that the monitoring and analysis must be performed exclusively on a digital signal in the digital domain, Maycock's performance monitoring unit 20 teaches this too. Maycock explains that demultiplexer 52 creates a "third data bit bus" from an incoming digitized signal and transmits a third data bit bus "directly to a control computer 58 for analysis of the digitized performance information." (Maycock, 6:4-7.) Maycock describes that this digitized performance information includes "digital carriers derived from the microprocessor" (*i.e.*, microprocessor 30, *see* Maycock, 5:13-16) that "contain information such as video level, video carrier frequency, audio carrier level, audio carrier frequency plus other digitally encoded information" and thus are the claimed characteristics. (Maycock, 6:62-67.) It is my opinion that the combination of Maycock and Zhang discloses limitation 1[b][1].

1[b][2] "report said determined characteristic to a source of said received signal;"

142. Maycock, alone or in view of the general knowledge of a POSITA, discloses reporting a determined characteristic to a source of a received signal. As shown in Maycock's Figure 1, a video signal transmission head-end 10 operates as the source of the received signal at the monitoring unit. (Maycock, 3:2-5.)



Maycock — Block Diagram of Maycock’s “Video Signal Transmission Monitoring System.” (2:52-54)

143. The goal of Maycock’s system was to provide performance and signal-quality monitoring as the signal passed through a single point in the system, as opposed to monitoring the status of equipment at numerous points along the signal’s transmission path, as was done by conventional systems. (Maycock, 1:31-44.) This “performance monitoring,” as opposed to “status monitoring,” enabled a signal operator (*e.g.*, a controller of a source broadband signal like a cable television provider) to identify whether the signal itself was of poor quality. (Maycock, 1:14-23.) Maycock’s Figure 1 expressly shows a signal transmission from the performance monitoring unit (20) to the video head-end (10). A POSITA would have

understood that providing feedback about the signal's quality to the signal's source (e.g., the cable operator) is invaluable because it allows the operator to modify outgoing signal metrics and/or take other corrective action to preemptively fix an issue and keep its television customers happy. *See* §VI.D, *supra*.

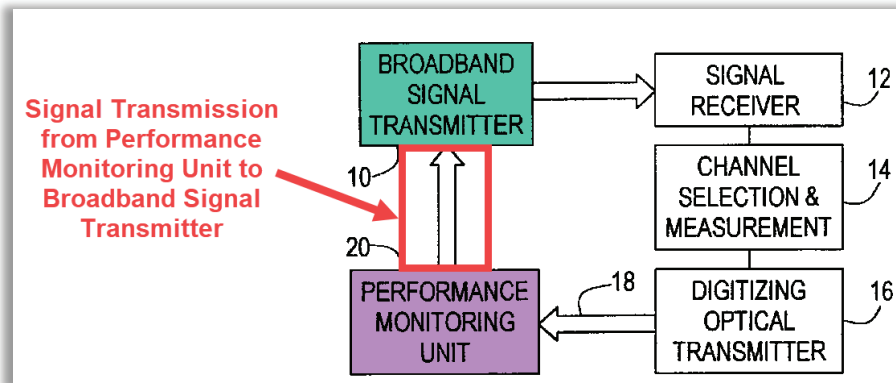


Figure 1 — Maycock's System - Annotated to Show Communication from the Performance Monitoring Unit to the Signal Source.

144. While Maycock's specification does not explicitly state that its reporting is sent to "the signal's source," Maycock's own figures show that this is the case. Maycock's Figure 1 shows an arrow clearly indicating that performance monitoring unit 20 (the signal monitor) transmits information back to broadband signal transmitter 10 (the source). It is my opinion that the transmitted information relates to signal quality and is the claimed "measured characteristics."

145. Maycock also discloses using its collected data in a "sequence for initializing the measurements and collecting the results in the computer 58." (Maycock, 7:21-25, Figure 5 ("History File" & "Disk Storage").) A POSITA would have understood that this constitutes the collection/storage of data including

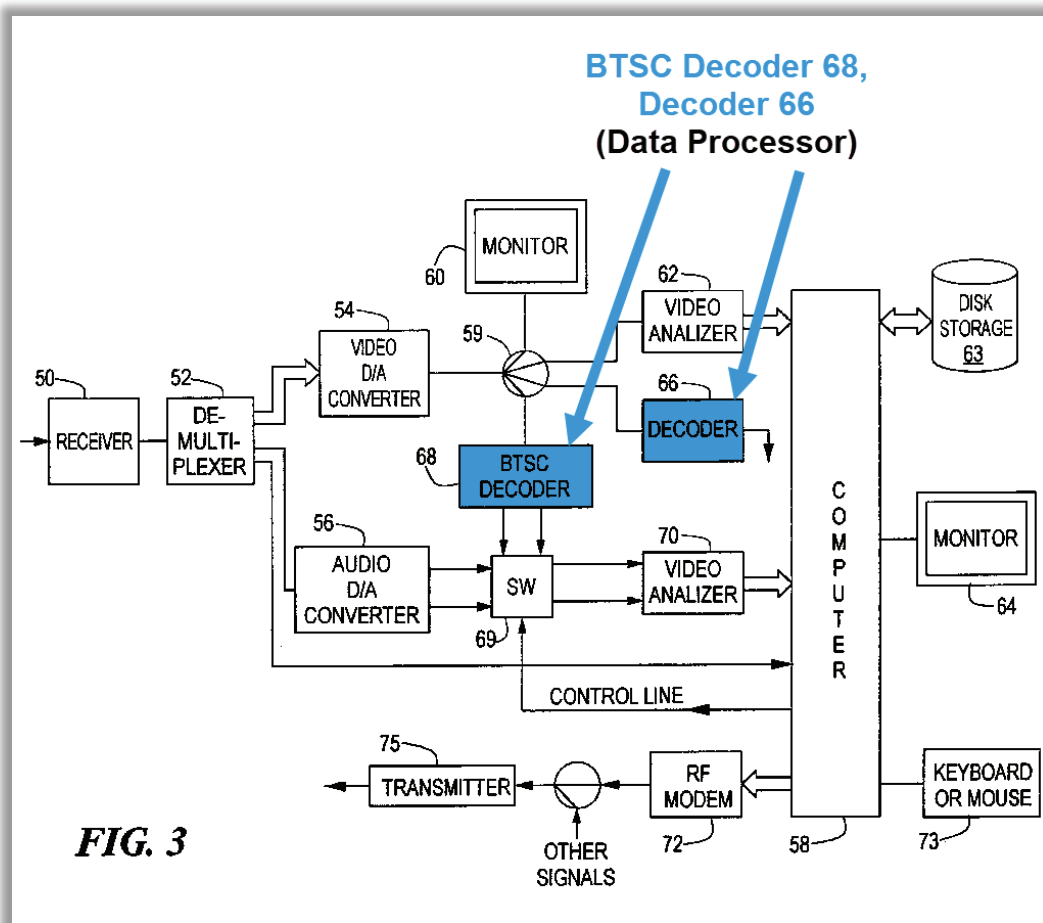
measured characteristics data, where the collected/stored data is then used to prepare a report for the source's use to maintain/correct signal quality. Furthermore, a POSITA would have known that a system developed to monitor signal quality cannot reach its full potential unless results are shared with the source of the signal being monitored so any errors or issues can be corrected. A POSITA would have understood this benefit. It is my opinion that Maycock in view of the general knowledge of a POSITA discloses limitation 1[b][2].

1[c] “a data processor operable to process a television channel to recover content carried on the television channel; and”

146. Maycock explains that certain components, such as a BTSC decoder 68 and a decoder 66, process a television channel to recover content. For example, regarding BTSC decoder 68, Maycock teaches that “a baseband signal output which contains both video and audio information ... is split by a splitter 59 into four paths” and that one of those paths “is fed to a BTSC stereo audio decoder 68 which recreates the left and right audio channel from the BTSC standard signal.” (Maycock, 6:9-14, 6:45-47.) From this description, a POSITA would have understood that the BTSC decoder 68 processes the television channel to recover content (*i.e.*, right and left audio channel content) from the television channel.

147. As explained above, a POSITA would have understood that the phrase “to recover content carried on the television channel” means “to extract the

information carried on the television channel.” At least Maycock’s decoder 66 extracts information carried by the signal when it “demodulate[s] information encoded in the video signal, for example channel insertion (used for advert deletion and substitution), scrambler and set top information.” (Maycock, 6:38-41, *see also* Reddy, 4:4-12, 4:44-49 (patent incorporated by reference in ’008 specification).) A POSITA would have read this description and understood that decoder 66 processes a television channel to recover content.



Maycock — Figure 3.

148. Maycock therefore discloses limitation *I[c]*.

I[d] “a channelizer operable to:”

149. Maycock discloses a channelizer. Maycock explains that certain components, such as a demultiplexer 52 and a splitter 59, operate to separate portions of incoming signals into channels. Specifically, Maycock explains that demultiplexer 52 operates to output 10 bits, with “[e]ight bits ... go[ing] to a video digital-to-analog converter 54 to reconstitute the video signal and its sub-carriers,” “[a]n audio bit bus go[ing] to an audio digital-to-analog converter 56,” and “a third data bit bus go[ing] directly to a control computer 58” (Maycock, 6:2-7.) Maycock additionally explains that splitter 59 outputs four legs (“four paths”) going to the various locations as illustrated in Figure 3. (Maycock, 6:12-14, Figure 3.) A POSITA would have understood both the demultiplexer 52 and the splitter 59 operate as channelizers, as they create multiple channel outputs from a single incident signal. It is my opinion that Maycock discloses limitation *I[d]*.

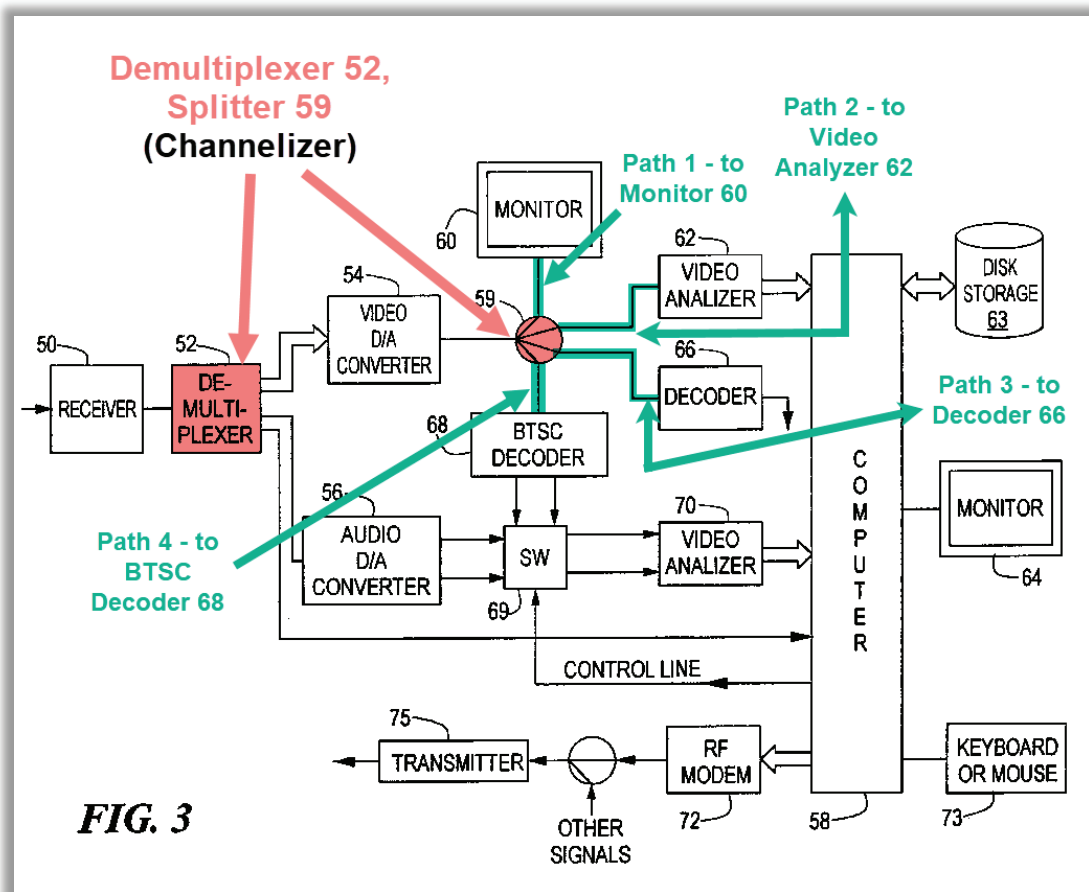


Figure 3 — Maycock's Channelizer.

1[d][1] “select a first portion of said digitized signal;”

150. Maycock discloses selecting a first portion of a digitized signal wherein demultiplexer 52 outputs one digital performance information bit of a 10-bit bus directly to a control computer 58 for analysis. (Maycock, 6:6-7.) It is my opinion that Maycock discloses limitation *1[d][1]*.

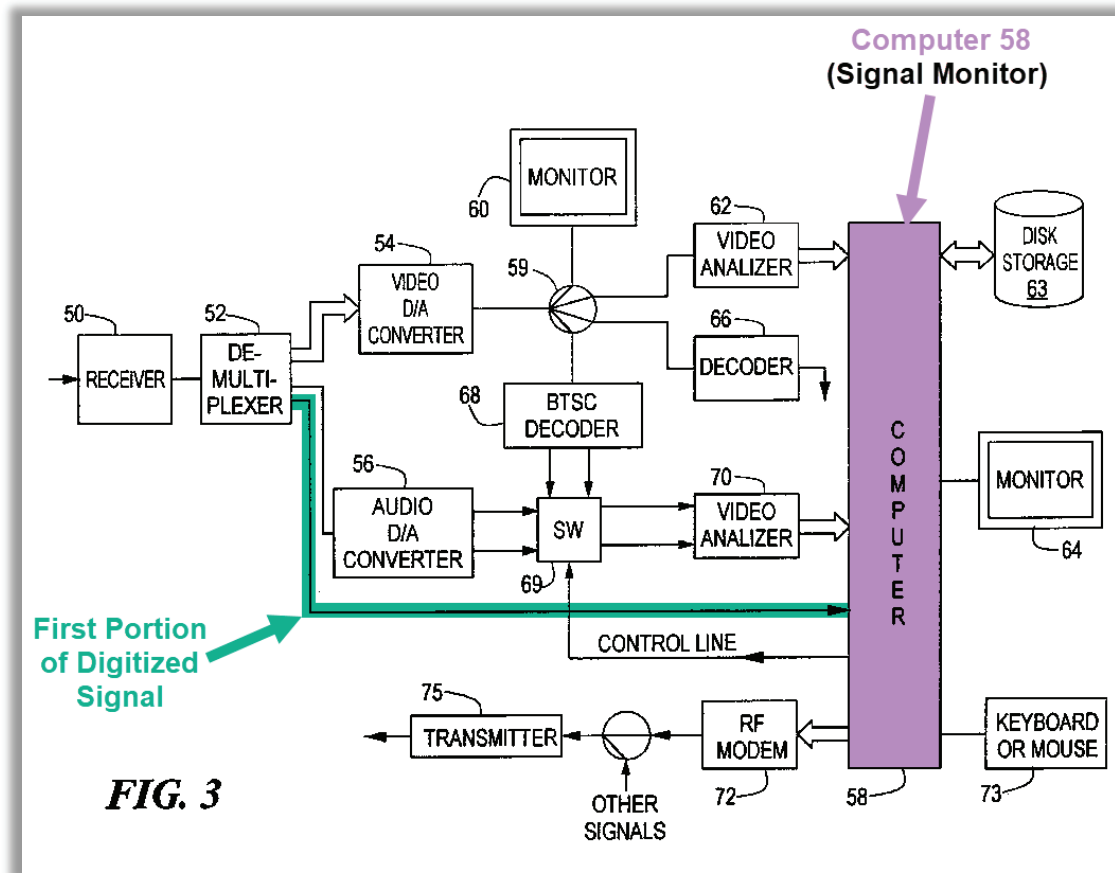
1[d][2] “select a second portion of said digitized signal; and”

151. Maycock discloses selecting a second portion of a digitized signal wherein Maycock's demultiplexer 52 outputs nine bits of a 10-bit bus, with eight

bits to a video D/A converter 54 and one bit to an audio D/A converter 56. (Maycock, 6:2-4.) These nine bits, specifically the eight bits to video D/A converter 54 and the one bit to audio D/A converter 56, are the selected second portion of the digitized signal. It is my opinion that Maycock discloses limitation 1[d][2].

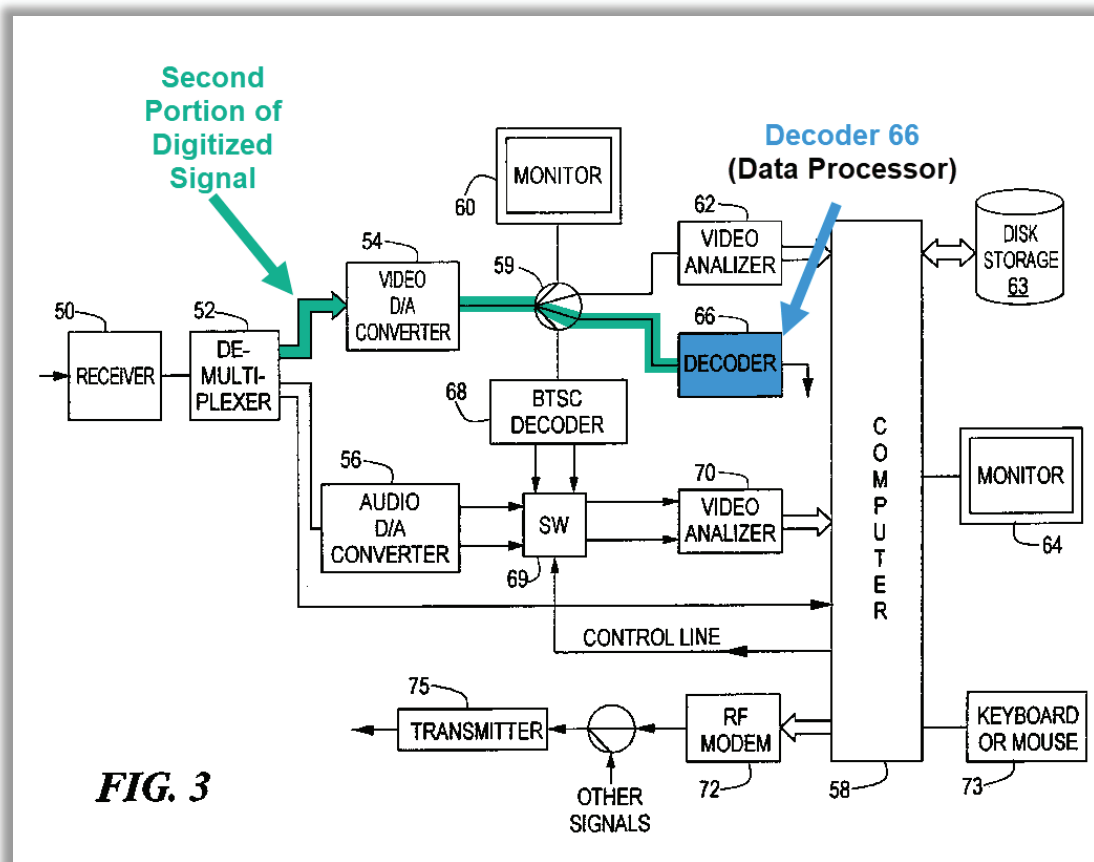
1[d][3] “concurrently output said first portion of said digitized signal to said signal monitor and said second portion of said digitized signal to said data processor.”

152. Maycock’s demultiplexer 52 outputs one bit of a 10-bit bus to a control computer 58 for analysis, as discussed above. Additionally, as also explained above, control computer 58 acts as a signal monitor, or a component thereof, because it analyses digitized performance information. (Maycock, 6:6-7, Figure 3.)



Maycock — Figure 3.

153. As further described above, Maycock’s demultiplexer 52 outputs eight bits of a 10-bit bus to a video D/A converter 54, then to decoder 66 after being split at a splitter 59. (Maycock, 6:2-4, 6:38-41.) Decoder 66 is an exemplary data processor, at least because it “demodulate[s] information encoded in the video signal, for example channel insertion (used for advert deletion and substitution), scrambler and set top information.” (Maycock, 6:38-41.)



Maycock — Figure 3.

154. As for “concurrently,” demultiplexer 52 separates an incoming signal into multiple portions, and these multiple portions are outputted concurrently or simultaneously. A POSITA would have understood that the output of the demultiplexer 52 (*i.e.*, the first portion of the digitized signal and the second portion of the digitized signal) are outputted concurrently (10 bits at a time). It is my opinion that the combination of Maycock and Zhang in further view of the general knowledge of a POSITA discloses limitation 1[d][3].

3. Dependent Claim 2

The system of claim 1, wherein said first portion of said digitized signal spans said entire television spectrum.

155. As disclosed in Maycock, the so-called “first portion” of the digitized signal is transmitted from demultiplexer 52 to computer 58. (*See* limitation 1[d][3], *supra*.) Maycock explains that the final bit (corresponding to the “first portion”) contains “digital data information ... [comprising] digitally encoded information comprising signal quality data indicative of the quality of the selected channel.” (Maycock, 4:59-63.) From the description of Maycock, it is clear that this portion comprises (“spans”) information for the entire received signal (*e.g.*, entire television spectrum). (Maycock, 6:4-7.)

156. By using Zhang’s wideband ADC in Maycock’s television monitoring system, a POSITA would have understood that this enables all received signals to be digitized at once. Moreover, given Maycock’s description of analyzing *all signals* at once (via a first portion of a digitized signal) would have been obvious to a POSITA to use wideband digitization of all signals to increase analysis efficiency. (Maycock, 8:1-25.) It is my opinion that the combination of Maycock and Zhang in further view of the general knowledge of a POSITA discloses claim 2.

4. Independent Claim 3

3[pre] “A method comprising:”

157. To the extent that the preamble is limiting, Maycock describes a “method of monitoring the transmission of an analog video signal through a video signal transmission channel.” (Maycock, Abstract (emphasis added), claim 18.) Maycock discloses element 3[pre].

3[a] “performing by one or more circuits: receiving a signal having a bandwidth that spans from a first frequency, F_{lo} , to a second frequency, F_{hi} , wherein said signal carries a plurality of channels;”

158. Maycock, in view of Zhang, discloses limitation 3[a]. Maycock discloses receiving a signal with a bandwidth from F_{lo} , to F_{hi} , carrying multiple channels. (Maycock, Figures 1, 1A, 2, 3, 1:12-15, 1:47-50, 7:28-30, 8:1-25.) Zhang also describes circuitry for receiving a multi-channel RF signal by frequency block down converters 210. (Zhang, 3:15-19 (“A frequency-block down-converter 210 receives one or more multi-channel analog RF signals”), 3:20-22 (“For the purposes of this description, a multi-channel RF signal is an RF signal in a given frequency band that carries multiple RF channels.”).)

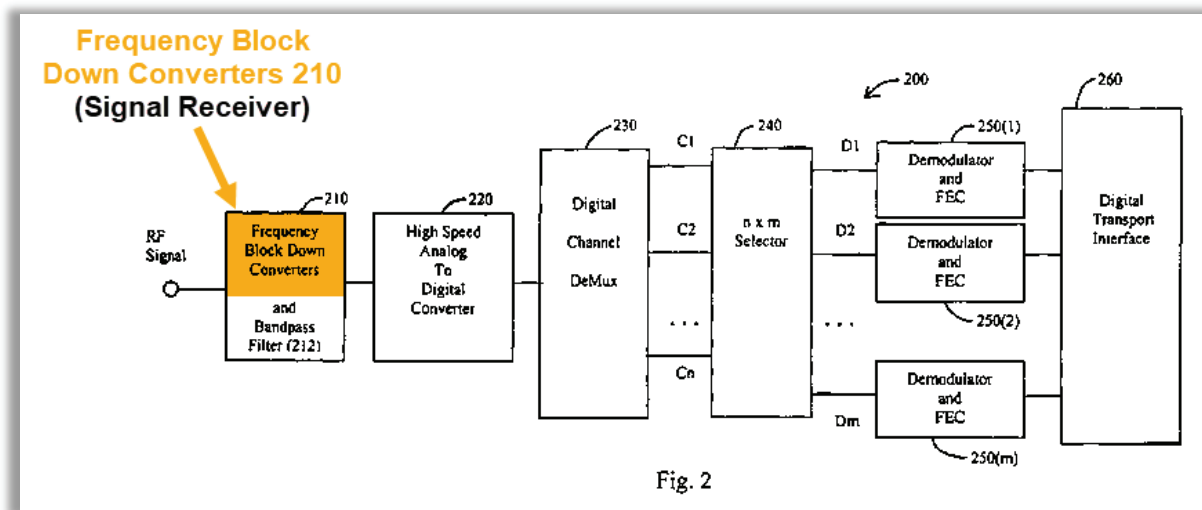


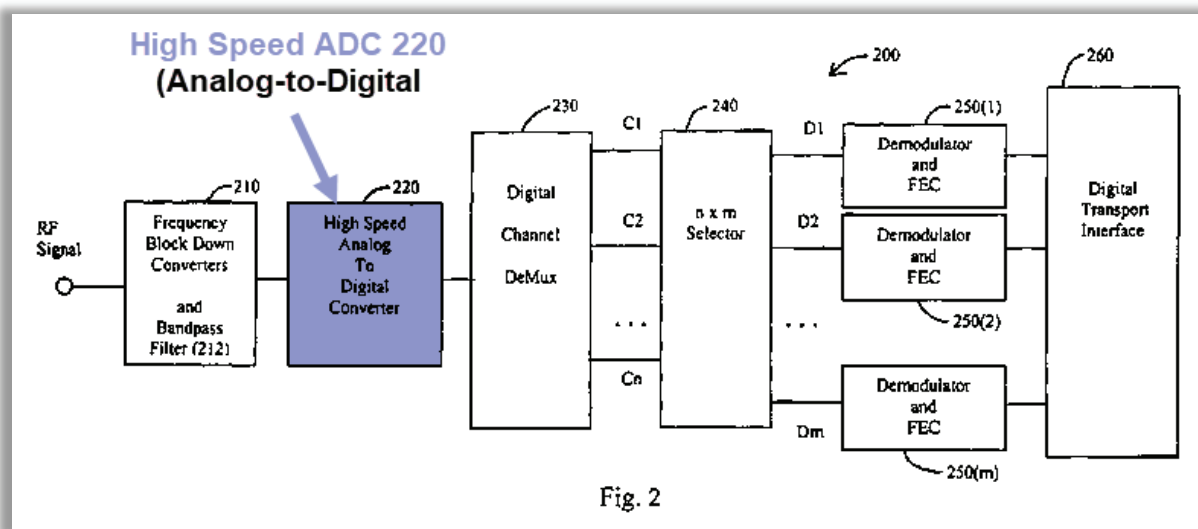
Figure 2 — Zhang’s Multi-Channel Demodulator.

159. Zhang explicitly discloses digitizing a received signal that carries multiple television channels and is in a given frequency band. (Zhang, 2:10-14, 3:20-22.) As discussed above, when reading the '008 patent, a POSITA would have understood “signal having a bandwidth that spans from a first frequency F_{lo} to a second frequency, F_{hi} ” as referring to a continuous range of frequencies from a high to a low. (See §VIII, *supra*.) Zhang’s “multi-channel analog RF signal” spans from a first frequency, F_{lo} , to a second frequency, F_{hi} , at both ends of the frequency band, as is inherent in such a signal and thus is a continuous range of frequencies from a low to high. (Zhang, 3:20-22.) It is my opinion that Zhang discloses limitation 3[a].

3[b] “digitizing said received signal from F_{lo} to F_{hi} to generate a digitized signal;”

160. Zhang discloses the use of a “high-speed ADC” that digitizes “an entire signal band with n channels” (*i.e.*, a band of channels from a low frequency to a high

frequency). (Zhang, 3:62-63.) Zhang further emphasizes that at least the system illustrated in Figure 2, receives a multi-channel RF signal that “carries multiple RF channels,” where each RF channel “can carry one or more content channels.” (Zhang, 3:15-35.) A POSITA would have understood that Zhang’s “High Speed Analog to Digital Converter 220,” is an ADC in that digitizes a signal spanning from F_{lo} to F_{hi} and that the ADC’s output is a digitized signal. (Zhang, 3:60-63 (“An ADC 220 then converts the down-converted multi-channel analog RF signal to a multi-channel digital RF signal.”).) To the extent that a signal exceeds the bandwidth of a single ADC, Zhang discloses using multiple ADCs to digitize the entire signal. (Zhang, Figures 2, 6, 6:3-35.) It would have been obvious to a POSITA that a single ADC or multiple ADCs could be used, depending upon cost and other performance factors.



Zhang — Figure 2.

161. Maycock also discloses digitizing a received signal and, as I explained, a POSITA would have known to replace Maycock's ADC with Zhang's high-speed ADC to digitize a signal spanning from F_{lo} to F_h more efficiently. (See §VI.B-C; XI.A.1, *supra*; see also limitation 1[a].) It is my opinion that the combination of Maycock and Zhang discloses limitation 3[b].

3[c] "selecting a first portion of said digitized signal;"

162. See VIII.A.2, limitation 1[d][1], *supra*.

3[d] "selecting a second portion of said digitized signal; and"

163. See VIII.A.2, limitation 1[d][2], *supra*.

3[e] "concurrently outputting said selected first portion and said selected second portion, wherein:"

164. See VIII.A.2, limitation 1[d][3], *supra*.

3[f][1] "said selected first portion is output to a signal analyzer which analyzes said selected first portion to determine one or more characteristics of the received signal,"

165. See VIII.A.2, limitations 1[b][1] and 1[d], *supra*. A POSITA would have understood that a signal analyzer and a signal monitor perform the same functions. See §VI.D, *supra*.

3[f][2] "and which reports said determined one or more characteristics to a source of said received signal; and"

166. See VIII.A.2, limitation 1[b][2], *supra*.

3[g] “said selected second portion is output to a data processor for recovery of data carried on one or more of said plurality of channels.”

167. See VIII.A.2, limitations 1[b][2], 1[c], and 1[d], *supra*.

5. Dependent Claim 4

The method of claim 3, wherein said first portion comprises all of said received signal from F_{lo} to F_{hi} .

168. See VIII.A.2, claim 2, *supra*. As discussed above, the first portion as disclosed in Maycock contains information that spans the entire incoming signal from F_{lo} to F_{hi} .

6. Dependent Claim 5

The method of claim 3, wherein said one or more characteristics is one of: signal power vs. frequency, phase vs. frequency, signal-to-noise ratio, peak-to-average ratio, noise levels, bit error rate, and symbol error rate.

169. This limitation would have been suggested in view of Maycock. Maycock discloses that one measured characteristic, as detected by the computer 58, video analyzer 62, and/or audio analyzer 70 (signal analyzer), is signal-to-noise ratio. (Maycock, 6:24-29, 6:55-57.) Maycock further discloses that the digital data information on the third bit line comprises information such as “signal quality information indicative of the quality of the selected channel” and that this comprises power level, frequency, temperature, and other local status information. (Maycock, 4:59-5:16.) Although the signal-quality information does not expressly include SNR

or measuring power vs. frequency, it would have been obvious in view of Maycock's disclosure of measuring SNR to include SNR data as part of the quality information in the "digital data information." It is my opinion that Maycock discloses claim 5.

7. Dependent Claim 6

The method of claim 3, wherein: said received signal is a cable television signal; and said plurality of channels comprises a plurality of television channels.

170. Maycock discloses that its system relates to cable or satellite systems. (Maycock at 1:5-9.) Zhang also discloses that the received signal is a cable television signal output by a low noise block downconverter. Zhang discloses a "frequency-block down-converter 210" (low noise block downconverter) that receives a multi-channel RF signal and that outputs the processed signal to an ADC 220. (Zhang, 3:15-19, 3:54-61.) Zhang describes the signal as a cable signal (Zhang, 3:49) and that the signal comprises a plurality of television channels (Zhang, 3:26-35). It is my opinion that the combination of Maycock and Zhang discloses claim 6.

8. Dependent Claim 7

The method of claim 3, wherein: said received signal is a satellite television signal output by a low noise block downconverter; and said plurality of channels comprises a plurality of television channels.

171. Maycock discloses that its apparatus relates to cable or satellite systems. (Maycock at 1:5-9.) A POSITA knew that, for example, satellite systems

used low-noise block downconverters (LNBs) at a receiver/antenna. Zhang's system is also described as a as a cable system or a satellite system and therefore comprises a plurality of television channels. (Zhang, 3:15-19, 3:45-53.) Zhang additionally describes a low-noise block downconverter. (Zhang, 3:15-19.) Accordingly, it would have been obvious in view of Zhang and/or Maycock that the received signal that is digitized would be a satellite signal from an LNB comprising a plurality of television channels. It is my opinion that the combination of Maycock and Zhang discloses claim 7.

9. Dependent Claim 8

The method of claim 3, wherein said one or more circuits reside in a customer premises satellite reception assembly.

172. Zhang discloses that the one or more circuits could reside in a number of different applications, such as “digital set-top boxes, PVRs, home gateways and home media centers.” (Zhang, 6:52-54.) Zhang further discloses that the system may be a “home media server.” (Zhang, 6:57.) A POSITA would have understood that Zhang describes the one or more circuits residing in a customer-premises satellite reception assembly such as a set-top box. It is my opinion that the combination of Maycock and Zhang discloses claim 8.

10. Dependent Claim 9

The method of claim 3, wherein said one or more circuits reside in a customer premises gateway.

173. Zhang discloses that the one or more circuits could reside in several applications, such as “digital set-top boxes, PVRs, home gateways and home media centers.” (Zhang, 6:52-54 (emphasis added).) A POSITA would have understood that a “home gateway” is another name for a customer-premises gateway. It is my opinion that the combination of Maycock and Zhang discloses claim 9.

11. Dependent Claim 10

The method of claim 3, wherein a bandwidth and/or center frequency of said selected first portion is configurable during operation of said one or more circuits.

174. Zhang discloses digital selector 240 which receives a digital RF signal and “then selects one or more of the RF channels ... that are selected or used by a subscriber.” (Zhang, 4:3-8.) As understood by a POSITA, this refers to changing a bandwidth and/or center frequency of a selected portion of a digital signal. That is, the digital selector 240 selects signals by configuring a bandwidth and/or center frequency, as well understood in channel selection processes. It is my opinion that the combination of Maycock and Zhang discloses claim 10.

12. Independent Claim 11

11[pre] “A system comprising: one or more circuits that are operable to:”

175. *See element 3[pre], supra.*

11[a] “receive a signal having a bandwidth that spans from a first frequency, F_{lo} , to a second frequency, F_{hi} , wherein said signal carries a plurality of channels;”

176. *See XI.A.1 and XI.A4, limitation 3[a], supra.*

11[b] “digitize said received signal from F_{lo} to F_{hi} to generate a digitized signal;”

177. *See XI.A.4, limitation 3[b], supra.*

11[c] “select a first portion of said digitized signal;”

178. *See XI.A.4, limitation 3[c], supra.*

11[d] “select a second portion of said digitized signal; and”

179. *See XI.A.4, limitation 3[d], supra.*

11[e] “concurrently output said selected first portion and said selected second portion, wherein:”

180. *See XI.A.4, limitation 3[e], supra.*

11[f.1] “said selected first portion is output to a signal analyzer that is operable to analyze said first portion to determine one or more characteristics of said first portion,”

181. *See XI.A.4, limitation 3[f][1], supra.*

11[f.2] “and that is operable to report said determined one or more characteristics to a source of said received signal; and”

182. *See XI.A.4, limitation 3[f][2], supra.*

11[g] “said selected second portion is output to a data processor for recovery of data carried on one or more of said plurality of channels.”

183. *See XI.A.4, limitation 3[g], supra.*

13. Dependent Claim 12

The system of claim 11, wherein said first portion comprises all of said received signal from F_{lo} to F_{hi} .

184. *See XI.A.5, claim 4, supra.*

14. Dependent Claim 13

The system of claim 11, wherein said one or more characteristics is one of: signal power vs. frequency, phase vs. frequency, signal-to-noise ratio, peak-to-average ratio, noise levels, bit error rate, and symbol error rate.

185. *See XI.A.6, claim 5, supra.*

15. Dependent Claim 14

The system of claim 11, wherein: said received signal is a cable television signal; and said plurality of channels comprises a plurality of television channels.

186. *See XI.A.7, claim 6, supra.*

16. Dependent Claim 15

The system of claim 11, wherein: said received signal is a satellite television signal output by a low noise block downconverter; and said plurality of channels comprises a plurality of television channels.

187. See XI.A.8, claim 7, *supra*.

17. Dependent Claim 16

The system of claim 15, wherein said one or more circuits reside in a customer premises satellite reception assembly.

188. See XI.A.9, claim 8, *supra*.

18. Dependent Claim 17

The system of claim 11, wherein said one or more circuits reside in a customer premises gateway.

189. See XI.A.10, claim 9, *supra*.

19. Dependent Claim 18

The system of claim 11, wherein a bandwidth and/or center frequency of said selected first portion is configurable during operation of said one or more circuits.

190. See XI.A.11, claim 10, *supra*.

B. Ground 2: Claims 1 and 2 are Obvious over Maycock and Kidambi, and in Further View of the General Knowledge of a POSITA

191. If Patent Owner argues that the plain and ordinary meaning of “a received signal spanning an entire television spectrum” requires digitizing all received signals and/or if Patent Owner (wrongly) contends that Zhang’s disclosure falls short of meeting this broad interpretation, it is my opinion that the combination

of Maycock and Kidambi renders claim 1 obvious because Kidambi expressly teaches digitizing all received signals, for example using a single ADC. (Kidambi, [0082]-[0083].)

1. Motivation to Combine Maycock and Kidambi

192. A POSITA would have been motivated to combine Maycock and Kidambi for at least the following reasons. Both Maycock and Kidambi relate to the same technology area. Both disclose systems for transmitting and receiving television signals, specifically both disclose systems related to cable television. (Maycock, 4:1-6; Kidambi, [0081]-[0082].) Maycock explains that television providers monitor audio and video signal quality to provide high-quality television to their end-users. (Maycock, 1:31-44.) To this end, Maycock teaches monitoring television signals on a channel-by-channel basis. (Maycock, 2:20-29, 3:2-16.) Upon collecting channel quality data from the television signal, Maycock teaches 1) storing the data; and 2) warning the television provider if the stored data indicates poor signal quality. (Maycock, 7:21-25, 7:41-53.) This is the same type of signal monitoring discussed in the '008 patent.

193. While Maycock explicitly discusses monitoring one channel at a time, Maycock recommends performing multiple, successive signal monitoring processes to collect data for multiple television channels. (Maycock, 7:27-29, 8:1-25 (“All Channels”).) Maycock also teaches using an analog-to-digital converter 38 to

convert a selected channel for digitization (before signal monitoring), with a carefully chosen resolution “so as not to degrade the performance of the received signal.” (Maycock, 4:28-30.) Kidambi emphasizes the need for wideband digitization (*e.g.*, digitizing many channels simultaneously) even though it requires a “very high sampling rate” because of the advantages wideband digitization offers, including faster access and more available channels. (Kidambi, [0082]-[0084].) Kidambi goes on to describe digitization of an entire received spectrum using a wideband ADC 3206. (Kidambi, [0084].)

194. A POSITA would have been motivated to incorporate wideband ADCs into television systems, such as the one described in Maycock, particularly where multiple channels are monitored and/or provided to a customer for viewing. In fact, Kidambi expressly discloses the benefits of simultaneously digitizing multiple channels as a replacement for previous types of single-channel digitization, including speed and additional available channels. (Kidambi, [0082].) Kidambi describes an “increasing need for a wideband spectrum incorporating frequency multiplexed signals” in cable systems. A POSITA would have known how to incorporate Kidambi’s wideband ADC shown in Figure 32 into Maycock’s signal monitoring system to replace the digitization described in Maycock, with a reasonable expectation of success. By incorporating Kidambi’s disclosure of

wideband digitization, a POSITA would have understood that, at the expense of a relatively small initial computational cost required for digitizing the entire wideband spectrum at a high sampling rate, one gains to benefit by having a more efficient digital processing system and reduced complexity by avoiding the need for single-channel digitization, which is especially advantageous when digitizing multiple channels.

195. The combination of Maycock and Kidambi would allow a POSITA to capture the entire received television spectrum at once, and, to analyze/monitor the entire television spectrum at once (via a first portion of a digitized signal), rather than monitoring each channel through successive monitoring. This would have been obvious because of increased efficiency, performance, and accuracy of signal analysis and monitoring, while avoiding additional processing costs required for processing a plurality of single channels. Of course, it would come at the cost of including a high-performance ADC but doing so would have been a simple design choice.

196. Moreover, a POSITA would have been motivated to incorporate Kidambi's wideband ADC on the wideband analog input signal of Maycock, while removing the A/D converter(s) 38 from the system of Maycock. Such a shift in the position (and a large increase in the sampling rate) of the ADC is a standard and

routine design choice in digital signal processing systems that receive analog input signals. Finally, my opinions detailed above regarding expectations of success and predictable results achieved by incorporating a wideband ADC in Maycock's system apply here as well. *See* §XI.A.1, *supra*.

2. Independent Claim 1

1[pre] "A system comprising:"

197. To the extent that the preamble is limiting, it is taught by Maycock.

Maycock is clearly directed to a "system." (*See* §XI.A.2, limitation *1[pre]*.)

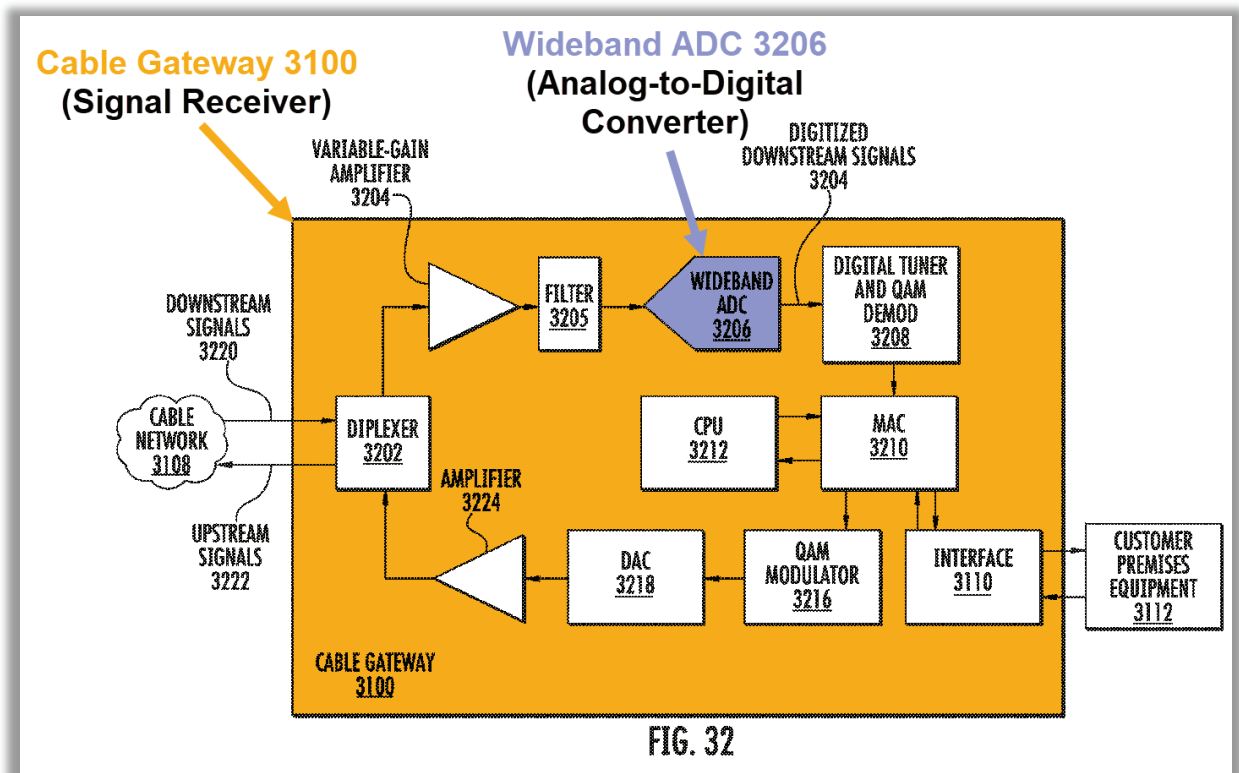
1[a] "an analog-to-digital converter operable to digitize a received signal spanning an entire television spectrum comprising a plurality of television channels, said digitization resulting in a digitized signal;"

198. *See* XI.A.2, limitation *1[a]*.

199. Kidambi discloses a wideband capture technique where an "entire bandwidth of [a] cable system" is digitized at once using a wideband ADC. (Kidambi, [0082].) If digitizing "*a received signal spanning an entire television spectrum*" is broadly understood to mean digitizing all received signals, Kidambi expressly discloses this. Kidambi explains that conventional cable and/or set-top-box systems had a tuner for each individual channel, where low-speed analog-to-digital converters could digitize a single channel at a time. (Kidambi, [0081].) As high-speed analog-to-digital converters became feasible, Kidambi teaches that it

became possible to digitize many channels at once, thus providing the benefit of reducing the incremental cost of adding additional channels. (Kidambi, [0082].)

200. Referring to Figure 32, Kidambi discusses a cable gateway 3100 that receives television signals from a cable network 3108. (Kidambi, [0083].) The received signals are sent to a wideband analog-to-digital converter 3206 which “digitizes the received signal” and transmits the digitized signal downstream to customer-premises equipment 3112. (Kidambi, [0085], Figure 32.) Wideband ADC 3206 digitizes the “entire bandwidth of the cable system,” which is useful to tune multiple channels at the same time. (Kidambi, [0082]-[0083].)



Kidambi — Figure 32.

201. Both Maycock and Kidambi disclose digitizing a received analog television signal to generate a digitized signal. Kidambi expressly discloses digitizing/converting an entire bandwidth of a television (e.g., cable) system, which corresponds to digitizing an “entire television spectrum comprising a plurality of television signals” even under a claim construction, where “entire television spectrum” means all received signals. It is my opinion that the combination of Maycock and Kidambi discloses limitation 1[a].

1[b] “a signal monitor operable to:”

202. Maycock discloses and/or suggests this limitation. See XI.A.2, limitation 1[b], *supra*.

1[b][1] “analyze said digitized signal to determine a characteristic of said digitized signal; and”

203. See XI.A.2, limitation 1[b][1], *supra*.

1[b][2] “report said determined characteristic to a source of said received signal;”

204. Maycock discloses and/or suggests this limitation. See XI.A.2, limitation 1[b][2], *supra*.

1[c] “a data processor operable to process a television channel to recover content carried on the television channel; and”

205. Maycock discloses and/or suggests this limitation. See XI.A.2, limitation 1[c], *supra*.

1[d] “a channelizer operable to:”

206. Maycock discloses and/or suggests this limitation. See XI.A.2, limitation 1[d], *supra*.

1[d][1] “select a first portion of said digitized signal;”

207. Maycock discloses and/or suggests this limitation. See XI.A.2, limitation 1[d][1], *supra*.

1[d][2] “select a second portion of said digitized signal; and”

208. Maycock discloses and/or suggests this limitation. See XI.A.2, limitation 1[d][2], *supra*.

1[d][3] “concurrently output said first portion of said digitized signal to said signal monitor and said second portion of said digitized signal to said data processor.”

209. Maycock discloses and/or suggests this limitation. See XI.A.2, limitation 1[d][3], *supra*.

3. Dependent Claim 2

The system of claim 1, wherein said first portion of said digitized signal spans said entire television spectrum.

210. Maycock discloses and/or suggests this limitation. See XI.A.2 limitations 1[d][1] and 1[d][3], 2, *supra*.

C. Ground 3: Claims 3-5, 10-13, and 18 are Obvious over Coyne and Petrovic and in further view of the General Knowledge of a POSITA

1. Motivation to Combine Coyne and Petrovic

211. A POSITA would have been motivated to combine Coyne and Petrovic to incorporate signal monitoring and reporting of an entire spectrum, as disclosed in Petrovic into the channelized receiver disclosed in Coyne. Coyne and Petrovic both relate to the same or similar communications technologies. Both Coyne and Petrovic explicitly disclose systems for transmitting and receiving satellite signals. (Coyne, [0023]; Petrovic, 7:3-8.) Moreover, Coyne and Petrovic both expressly relate to processing digitizing received video signals. (Coyne, [0030]; Petrovic, 17:46-61.)

212. Coyne discusses a multichannel receiver and channelizer system used for electronic surveillance monitoring in the military communications area. Figure 2 of Coyne shows the use of a modulator/amplifier 270 and an antenna 280 that transmits signals after those signals are digitized at ADC 230. (Coyne, [0040].)

213. Similarly, Petrovic discusses a monitoring system for monitoring media content. (Petrovic, Abstract.) Petrovic considers a monitoring station 16, which monitors airwaves in search of encoded content. (Petrovic, 7:13-14.) Petrovic additionally discloses generating a report from received signals for the purpose of measuring signal quality. (Petrovic, 4:19-35.)

214. It would have been obvious in view of Coyne's and Petrovic's teachings to apply Coyne's receiver with Petrovic's monitoring and reporting in satellite communications systems. Coyne expressly teaches that its "invention relate[s] generally to communication systems, and particularly to digital signal processing" (Coyne, [0002]) and cable and satellite television systems indeed are communications systems involving signal processing. It also would have been obvious to add the monitoring and reporting functions disclosed by Petrovic, to, for example, provide the source of the signals received by Coyne with signal-quality data to allow to correct for insufficient signal strength or low signal-to-noise ratio, for example, by increasing transmission strength, changing the direction of transmission, and/or retransmitting the data.

2. Independent Claim 3

3[pre] "A method comprising: performing by one or more circuits:"

215. To the extent that the preamble is limiting, Coyne depicts and describes a method, with respect to the structure illustrated in Coyne's various Figures. (Coyne, Abstract, Figures 1-4, claim 1.) Coyne additionally discloses the use of "one or more circuits," as claimed. (Coyne, Figures 2 and 4.)

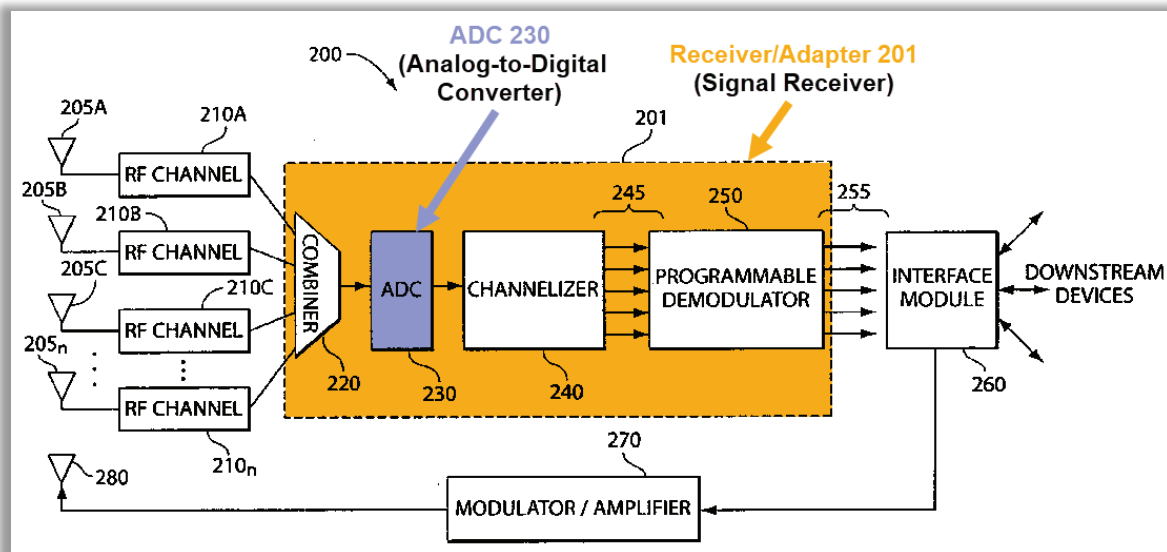
3[a] “receiving a signal having a bandwidth that spans from a first frequency, F_{lo} , to a second frequency, F_{hi} , wherein said signal carries a plurality of channels;”

216. Coyne discloses an analog-to-digital converter that digitizes a received signal comprising a plurality of channels to generate a digitized signal of the combined signals/channels using an ADC (element 230 in Figures 2 and 4). (Coyne, [0022].)

217. As Coyne discusses with respect to Figure 2, a receiver/adaptor 201 receives incoming radio frequency (RF) signals 210A-210n from multiple antennas. (Coyne, [0020]-[0021].) These RF signals are then combined into a wideband or ultra-wideband spectral space at combiner 220. (Coyne, [0022].) A POSITA would have understood that the incoming RF signals span from a first frequency to a second frequency, as is inherent in the incoming RF signals spanning multiple channels, and therefore digitizes a continuous range of frequencies from a high to a low, as explained above. *See §VIII, supra.* A POSITA would have further understood that the combiner 220 combines the incoming RF signals into a wideband signal that spans from a first frequency to a second frequency and carries a plurality of channels, and therefore also meets the proposed claim construction set forth above. It is my opinion that Coyne discloses limitation 3[a].

3[b] “digitizing said received signal from F_{lo} to F_{hi} to generate a digitized signal;”

218. Coyne discloses digitizing the received signal, spanning from a high to a low frequency. After multiple RF signals (channels) are combined at a combiner 220, the combiner 220 outputs the combined, multi-channel signal that is received by an analog-to-digital converter (ADC 230), which digitizes (“provides a digital representation of”) the combined signal. (Coyne, [0022].)



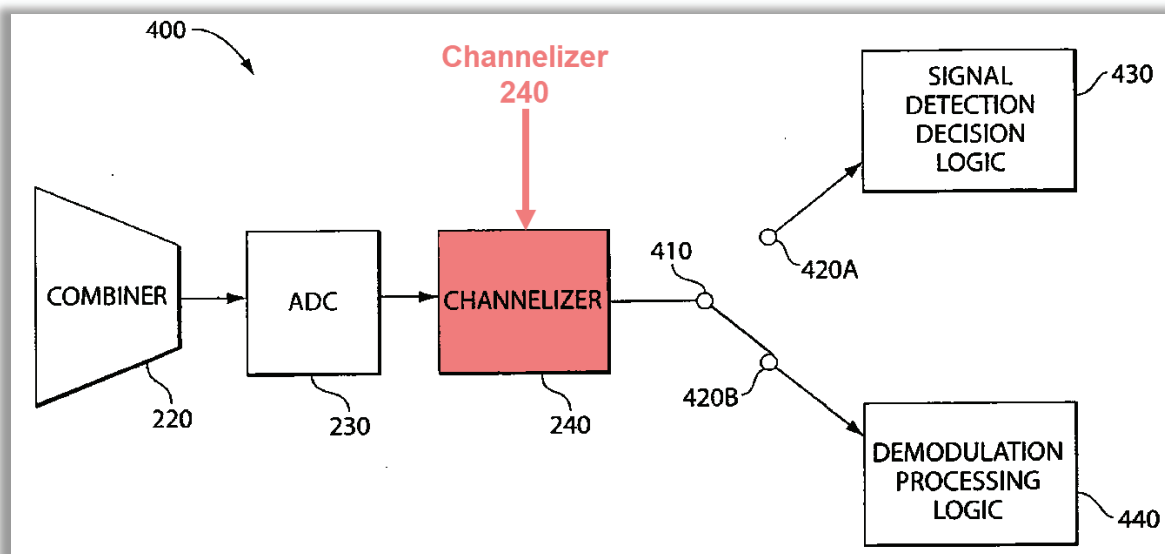
Coyne — Figure 2.

219. Because the digitized signal spans multiple channels combined by combiner 220 from RF channels 210A-210n, a POSITA would have understood that the combined signal from a low to a high frequency is digitized. Furthermore, because the combined signal output by combiner 220 comprises the incoming RF signals 210A-210n received by the multiple antennas, a POSITA would have understood that the incoming RF signals 210A-210n are also digitized as part of the

digitization of the combined signal. It is my opinion that Coyne discloses limitation 3[b].

3[c] “selecting a first portion of said digitized signal;”

220. Coyne discloses selecting a first portion of a digitized signal. For example, Coyne discloses a channelizer 240 that channelizes the digitized signal into different channel outputs and has at least two possible output paths: one through path 420A to signal detection decision logic 430 and the other through path 420B to demodulation processing logic 440. Coyne’s channelizer 240 sends a first portion of the digitized output of the ADC 230 to the signal detection decision logic 430 when the switch 410 makes the connection across path 420A. (Coyne, [0044], Figure 4.) It is my opinion that Coyne discloses limitation 3[c].



Coyne — Figure 4.

*3[d] “selecting a second portion of said digitized signal;
and”*

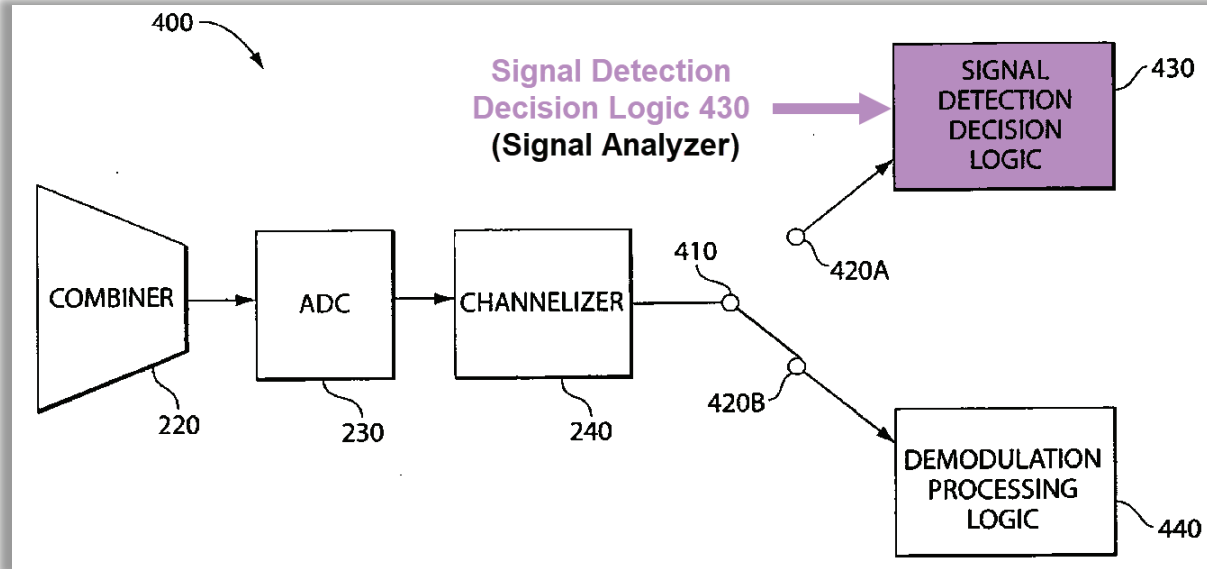
221. Coyne discloses selecting a second portion of a digitized signal. Coyne’s channelizer 240 sends a second portion of the digitized output of the ADC 230 to the demodulation processing logic 440 when the switch 410 makes the connection across path 420B. (Coyne, [0044].) It is my opinion that Coyne discloses limitation 3[d].

*3[e] “concurrently outputting said selected first portion and said
selected second portion, wherein:”*

222. Coyne discloses concurrently outputting a first portion of the digitized signal and a second portion of the digitized signal. Coyne discloses a switch 410 that can be used to send a portion of a signal to demodulation processing logic 440 or signal detection logic 430. Coyne additionally discusses configurations where both signals are sent simultaneously through the use of a rapidly toggling switch. For example, Coyne explains that “some configurations may enable the system to perform as both a receiver [e.g., path 420A] and a communications adaptor [e.g., path 420B] *simultaneously*.” (Coyne, [0045] (emphasis added).) A POSITA would have understood that a rapidly toggling switch, as depicted in Figure 4, for providing parallel output paths would allow the channelizer to concurrently output a first portion of a signal and a second portion of the signal provided that the toggling frequency is sufficiently high. It is my opinion that Coyne discloses limitation 3[e].

3[f][1] “said selected first portion is output to a signal analyzer which analyzes said selected first portion to determine one or more characteristics of the received signal,”

223. Coyne discloses that the selected first portion is output to a signal analyzer that analyzes the first portion to determine one or more characteristics of the signal. Specifically, Coyne discloses “decision logic 140” which “processes the outputs to identify whether certain of the channels contains [sic] a signal that should be selected for further processing.” (Coyne, [0005].) As would have been understood by a POSITA, Coyne’s processing of the outputs is an example signal monitoring process. Coyne further discloses “signal detection decision logic 430,” as illustrated in Figure 4, which Coyne analogizes to decision logic 140 (*e.g.*, signal detection decision logic 430 can perform the same function as decision logic 140). (Coyne, [0044], Figure 4.)



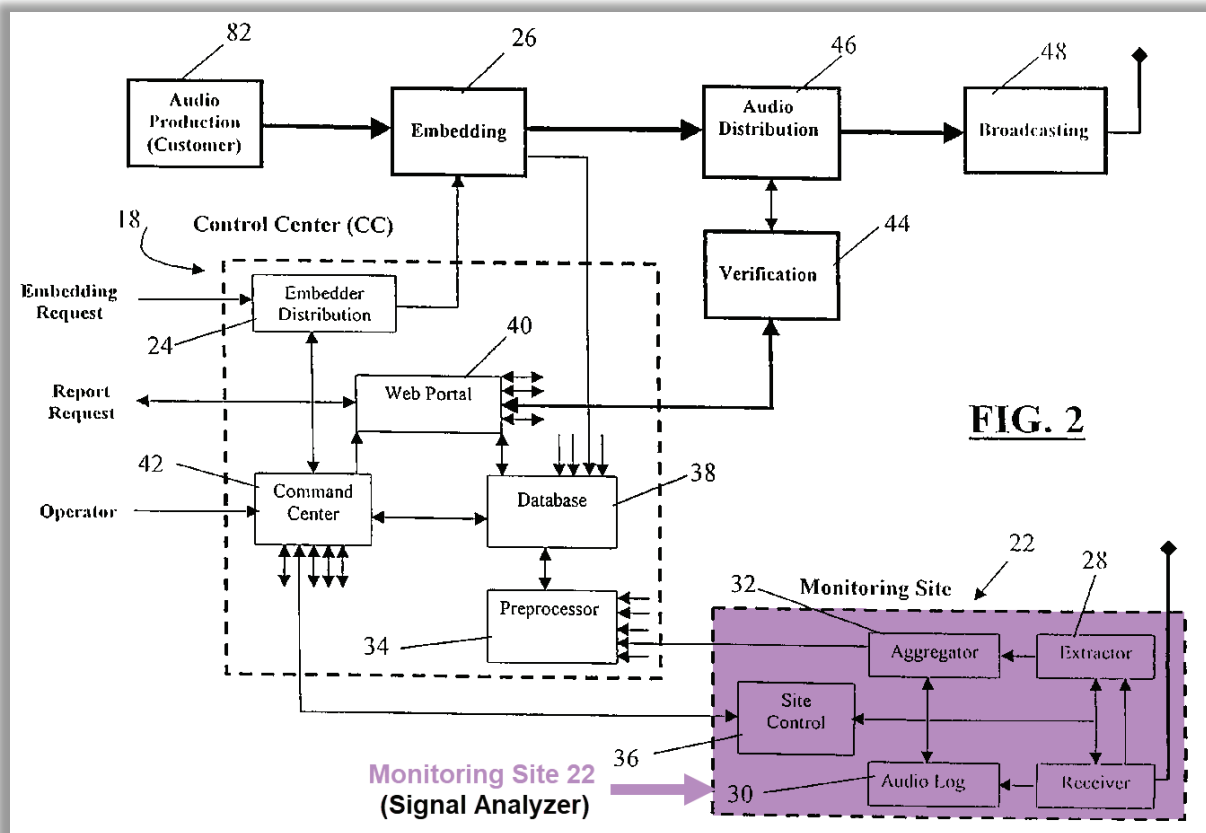
Coyne — Figure 4.

224. Coyne further discloses analyzing a digitized signal to determine a characteristic of the digitalized signal. (Coyne, [0047].)

225. With respect to signal detection decision logic 430 and decision logic 140, Coyne discloses processing an input (*i.e.*, a digitized signal selected by channelizer 240 from the output of the ADC 230) to see if the signal strength is such that it can “identify whether certain of the channels contains [sic] a signal.” (Coyne, [0005].) A POSITA would have understood that identifying a signal within a channel is an example “characteristic,” as the term is used in limitation 1/[b]/[1].

226. Additionally, or alternatively, in a similar field of endeavor, Petrovic discloses a monitoring site 22 that measures characteristics of incoming signals, including signal strength metrics, such as SNR. Petrovic explains that “[m]onitoring sites 22 are capable of measuring the SNR for all incoming audio signals at the signal

reception sites.” (Petrovic, 13:23-33.) A POSITA would have understood that SNR is an example “characteristic” as the term is used in this limitation. A POSITA would have been motivated to implement the monitoring site 22 of Petrovic as part of the signal detection decision logic 430 and signal detection decision logic 140 of Coyne. A POSITA would have recognized that the measurement of SNR taught by Petrovic would have improved Coyne’s signal detection decision logic 430 and signal detection decision logic 140 ability to “identify whether certain of the channels contains [sic] a signal.” (Coyne, [0005].) It is my opinion that Coyne discloses limitation 3[f][1].



Petrovic — Figure 2.

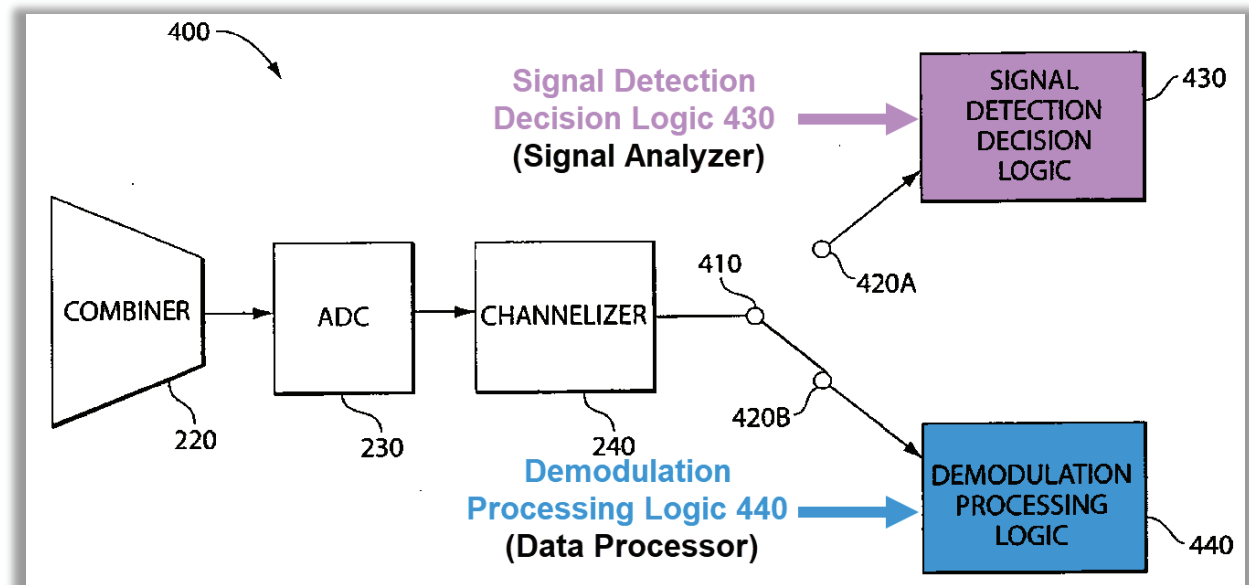
3[f][2] “and which reports said determined one or more characteristics to a source of said received signal; and”

227. Petrovic discloses reporting a determined characteristic to a source of a received signal. As discussed above with respect to limitation 3[f][1], Coyne discloses a monitoring site 22 which measures SNR values from an incoming signal. Petrovic further explains that, at the monitoring side, “the RF power of the incoming broadcast signal is continually measured to ensure that it is within acceptable bounds.” (Petrovic, 13:14-17.) Petrovic explains that such measurements provide “valuable information regarding the quality of [an] audio signal.” (Petrovic, 13:18-21.) Petrovic further discusses the generation of a report that, includes the collected data. For example, Petrovic states that “it is possible to continually monitor and log the quality of different audio stations” and that “the channel quality information for each geographical location may be shared with the customers and broadcasters.” (Petrovic, 13:51-67.) From the disclosure of Petrovic, a POSITA would have understood that Petrovic discloses sharing collected information (*characteristics*) with broadcasters (*source of a signal*) for the purpose of improving broadcast quality. It would have been obvious to a POSITA to incorporate the signal monitoring and reporting functionality disclosed by Petrovic into the channelized receiver of Coyne to provide feedback to the signal source to correct for insufficient received signal strength for those channels that have been identified as channels that

do not contain a signal. (§XI.A.1 and §XI.C.1, *supra*; see, e.g., Coyne, [0005].) It is my opinion that the combination of Coyne and Petrovic discloses limitation 3[f]/[2].

3[g] “said selected second portion is output to a data processor for recovery of data carried on one or more of said plurality of channels.”

228. Coyne discloses a data processor operable to process a channel to recover data carried on the channel. Coyne discloses a system where a digitized signal selected by channelizer 240 from the output of the ADC 230 can be transmitted to signal detection decision logic 430 (e.g., decision logic 140) and/or to demodulation processing logic 440 (e.g., programmable demodulator 250). (Coyne, [0044], [0047], Figure 4.)



Coyne — Figure 4.

229. Coyne explains that the demodulation processing logic 440 (which can be equivalent to programmable demodulator 250) operates to “process[] each channel output to extract any communications data provided therein, as is well-known to those skilled in the art.” (Coyne, [0032].) From the clear disclosure of Coyne, a POSITA would have understood that Coyne’s demodulation processing logic 440 operates as a data processor to recover data and therefore meets the proper claim construction set forth above. It is my opinion that Coyne discloses limitation 3[g].

3. Dependent Claim 4

The method of claim 3, wherein said first portion comprises all of said received signal from F_{lo} to F_{hi} .

230. Coyne explains that the first portion (*i.e.*, the portion sent to the signal analyzer) comprises all of the received signal from a low to a high frequency. Coyne explains that, in some embodiments, the disclosed system may operate simultaneously as both a receiver and a communications adaptor. (Coyne, [0045].) A POSITA would have understood this to mean that all of the received signal, from a low to a high frequency, is transmitted to both the signal detection decision logic 430 (*signal analyzer*) and the demodulation processing logic 440 (*data processor*).

231. Alternatively, Coyne explains that both the signal detection decision logic 430 and the demodulation processing logic 440 “may be provided by a single

component.” (Coyne, [0047].) A POSITA would have understood that this single component may receive the entire digitized signal. It is my opinion that Coyne discloses claim 4.

4. Dependent Claim 5

The method of claim 3, wherein said one or more characteristics is one of: signal power vs. frequency, phase vs. frequency, signal-to-noise ratio, peak-to-average ratio, noise levels, bit error rate, and symbol error rate.

232. As discussed above, Petrovic discloses that one of the characteristics is a signal-to-noise ratio. (Petrovic, 13:23-33 (“Monitoring sites 22 are capable of measuring the SNR for all incoming audio signals at the signal reception sites.”).) Coyne further describes monitoring the signal, *e.g.*, the signal strength, to determine if a signal is present on the particular channel. (Coyne, Figures 2 and 4, [0003]-[0005], [0016] [0044]-[0047].) It is my opinion that Coyne or, alternatively, Coyne in view of Petrovic’s explicit disclosure of SNR monitoring, discloses claim 5.

5. Dependent Claim 10

The method of claim 3, wherein a bandwidth and/or center frequency of said selected first portion is configurable during operation of said one or more circuits.

233. Coyne discloses that a bandwidth and/or center frequency of a multi-channel signal is configurable during operation. Coyne discloses the use of switch 410 to transmit information to either terminal 420A or terminal 420B. (Coyne,

[0044].) A POSITA would have understood that a practitioner could control an operation of the switch 410, thereby allowing a bandwidth and/or a center frequency of the selected first portion to be configurable.

6. Independent Claim 11

11[pre] “A system comprising: one or more circuits that are operable to:”

234. *See XI.C.2, element 1[pre], XI.C.4, element 3[pre].*

11[a] “receive a signal having a bandwidth that spans from a first frequency, F_{lo} , to a second frequency, F_{hi} , wherein said signal carries a plurality of channels;”

235. *See XI.C.2, limitation 3[a], supra.*

11[b] “digitize said received signal from F_{lo} to F_{hi} to generate a digitized signal;”

236. *See XI.C.2, limitation 3[b], supra.*

11[c] “select a first portion of said digitized signal;”

237. *See XI.C.2, limitation 3[c], supra.*

11[d] “select a second portion of said digitized signal; and”

238. *See XI.C.2, limitation 3[d], supra.*

11[e] “concurrently output said selected first portion and said selected second portion, wherein:”

239. *See XI.C.2, limitation 3[e], supra.*

11[f.1] “said selected first portion is output to a signal analyzer that is operable to analyze said first portion to determine one or more characteristics of said first portion,”

240. *See XI.C.2, limitation 3[f][1].*

11[f.2] “and that is operable to report said determined one or more characteristics to a source of said received signal; and”

241. *See XI.C.2, limitation 3[f][2], supra.*

11[g] “said selected second portion is output to a data processor for recovery of data carried on one or more of said plurality of channels.”

242. *See XI.C.2, limitation 3[g], supra.*

7. Dependent Claim 12

The system of claim 11, wherein said first portion comprises all of said received signal from F_{lo} to F_{hi} .

See XI.C.3, claim 4, supra.

8. Dependent Claim 13

The system of claim 11, wherein said one or more characteristics is one of: signal power vs. frequency, phase vs. frequency, signal-to-noise ratio, peak-to-average ratio, noise levels, bit error rate, and symbol error rate.

243. *See XI.C.4, claim 5, supra.*

9. Dependent Claim 18

The system of claim 11, wherein a bandwidth and/or center frequency of said selected first portion is configurable during operation of said one or more circuits.

244. *See XI.C.5, claim 10, supra.*

D. Ground 4: Claims 1, 2, 6-9, and 14-17 Are Obvious over Coyne, Petrovic, and Zhang, and in further view of the General Knowledge of a POSITA

1. Motivation to Combine Coyne, Petrovic, and Zhang

245. A POSITA would have been motivated to combine Coyne and Petrovic at least for the reasons discussed in Section XI.C.1, above. *See also* §XI.A.1, *supra*.

246. A POSITA additionally would have been motivated to add Zhang to the combination of Coyne and Petrovic. From Coyne, a POSITA would have known that many applications of Coyne's technology are possible, including to television because Coyne teaches that its invention relates generally to communication systems and specifically references satellite data. One such application is discussed in Zhang, which uses a similar multichannel ADC system in the context of cable and satellite television to users. (Zhang, 3:13-35.) Petrovic also explicitly discloses that it is used in satellite and cable television systems. (Petrovic, [0037].)

247. A POSITA would have been motivated to modify Coyne in view of Petrovic further in view of Zhang to use the combination of Coyne, Petrovic and/or Zhang for the purpose of generating reports and sending those reports to a television signal operator. In this way, Coyne's channelized receiver could be used to improve the signal quality of detected signals, by informing signal operators of potential issues with outgoing signals. Further, as discussed above, a POSITA would have

been motivated to apply the multichannel receiver device of Coyne in a television context, as considered in Zhang.

2. Independent Claim 1

1[pre] “A system comprising:”

248. *See XI.C.2 and XI.C.6 element 3[pre] and element 11[pre], supra.*

1[a] “an analog-to-digital converter operable to digitize a received signal spanning an entire television spectrum comprising a plurality of television channels, said digitization resulting in a digitized signal;”

249. Coyne discloses an analog-to-digital converter that digitizes the received signals comprising a plurality of channels, combines them, and digitizes them to generate a digitized signal, as discussed in §XI.C.2, *supra*. Zhang additionally discloses an analog-to-digital converter that digitizes a received signal spanning an entire television spectrum and comprising a plurality of television channels.

250. Coyne explains that the disclosed system “may be employed in any setting in which a system adapted to perform both signal detection and communications functions is useful, such as for commercial and/or civilian uses.” (Coyne, [0016].) Coyne does not explicitly discuss television systems, though it does disclose satellite systems and transmitting video and images. (Coyne, [0014], [0016], [0023], [0030].) A POSITA would have known that satellite communications are

commonly used for various applications, including both television and military communications, especially in view of Petrovic's and Zhang's explicit disclosure of satellite and cable television systems.

251. As discussed above, Zhang discusses a channelized receiver used in a television context, such that an ADC digitizes a received signal comprising one or more television signals received by a receiver circuit (*e.g.*, spanning an entire television spectrum). (Zhang, 2:10-20, 3:45-53.) A POSITA, therefore, would have understood that the combination of Coyne and Zhang discloses limitation 1[a].

1[b] “a signal monitor operable to:”

252. *See XI.C.2, limitation 3[c], supra.*

1[b][1] “analyze said digitized signal to determine a characteristic of said digitized signal; and”

253. *See XI.C.2, limitation 3[f], supra.*

1[b][2] “report said determined characteristic to a source of said received signal;”

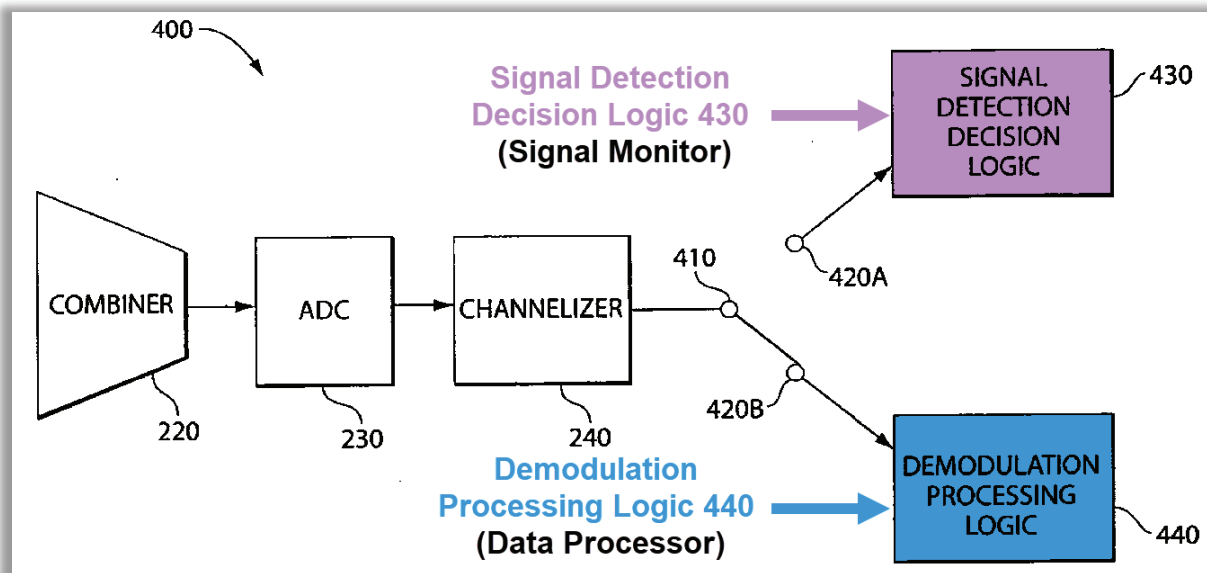
See XI.C.2, limitation 3[f], supra.

1[c] “a data processor operable to process a television channel to recover content carried on the television channel; and”

254. Coyne discloses a data processor operable to process a channel to recover content carried on the channel. Zhang discloses a similar data processor

operator to perform the same functionality as the data processor in Coyne, but specifically to recover content carried on a television channel.

255. Coyne discloses a system where an output from an ADC can be transmitted to signal detection decision logic 430 (e.g., decision logic 140) and/or to demodulation processing logic 440 (e.g., programmable demodulator 250). (Coyne, [0044], [0047], Figure 4.)



Coyne — Figure 4.

256. Coyne explains that the demodulation processing logic 440 (which can be equivalent to programmable demodulator 250) operates to “process[] each channel output to extract any communications data provided therein, as is well-known to those skilled in the art.” (Coyne, [0032].)

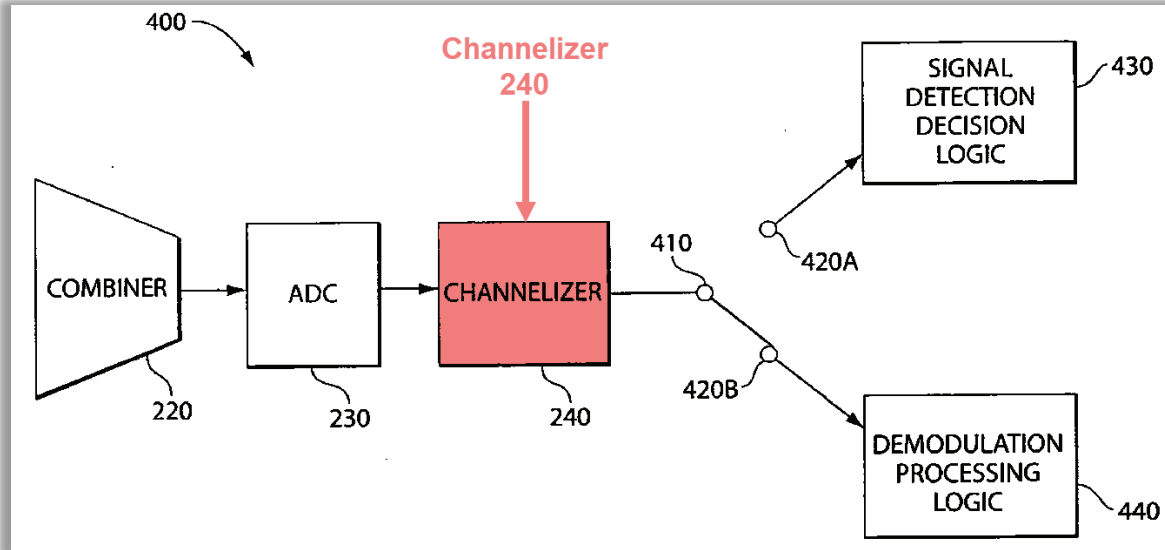
257. While Coyne considers several different applications for the disclosed channelized receiver, including satellite communications ([0002], [0014], [0016],

[0023]), Coyne does not explicitly identify a television system. But Zhang discloses a demodulator 250, which processes television channels. (Zhang, 4:16-36.) As discussed in depth, above, Zhang's system is a television system that digitizes many television channels at once. The demodulator 250 disclosed in Zhang is an example of a conventional data processor in a television system. Petrovic also discloses monitoring signals in both satellite and cable television systems. (Petrovic, [0037].)

258. A POSITA would have understood that at least the combination of Coyne in view of Zhang and/or Petrovic discloses limitation *I[c]* because it would have been obvious in view of Coyne and Petrovic further in view of Zhang to apply the channelized receiver with reporting/monitoring of Coyne in view of Petrovic in televisions systems to recover television content on a television channel. It is my opinion that the combination of Coyne and Petrovic discloses limitation *I[c]*.

I[d] “a channelizer operable to:”

259. Coyne discloses a channelizer 240 that “is used to generate multiple channel outputs, each [of which] may span [] any desired portion of the entire frequency spectrum of interest.” (Coyne, [0031].)



Coyne — Figure 4.

1[d][1] “select a first portion of said digitized signal;”

260. *See XI.C.2, limitation 3[c], supra.*

1[d][2] “select a second portion of said digitized signal; and”

261. *See XI.C.2, limitation 3[d], supra.*

1[d][3] “concurrently output said first portion of said digitized signal to said signal monitor and said second portion of said digitized signal to said data processor.”

262. *See XI.C.2, limitation 3[e], supra.*

3. Dependent Claim 2

The system of claim 1, wherein said first portion of said digitized signal spans said entire television spectrum.

263. The combination of Coyne and Zhang discloses the limitations of claim 2, where the first portion of the digitized signal spans the entire television spectrum.

264. As discussed with respect to limitations *1[d][1]* and *1[d][3]*, above, Coyne discloses an ADC that digitizes many channels of information simultaneously. (Coyne, [0022].) Coyne discusses many military and civilian applications, including video applications, but does not explicitly mention television. (Coyne, [0016].)

265. But, with respect to limitation *1[a]* above, Zhang discloses methods and apparatuses for performing wideband analog-to-digital conversion so that “an entire signal band with n channels can be converted.” (Zhang, 3:60-63.)

266. In light of the disclosure of Coyne and Zhang, a POSITA would have been motivated to apply the teachings of Coyne to a television system, such as Zhang. A combination of Coyne and Zhang would allow a POSITA to capture an entire television spectrum at once. Additionally, a POSITA would have been motivated to make this combination in order to allow a customer to receive more channels without adding additional ADC elements.

4. Dependent Claim 6

The method of claim 3, wherein: said received signal is a cable television signal; and said plurality of channels comprises a plurality of television channels.

267. Coyne in view of Petrovic renders obvious claim 3. *See* Section X.I.2. Petrovic discloses monitoring in cable television systems. (Petrovic, [0037].) Zhang also discloses that the received signal is a cable television signal output by a low

noise block downconverter. Zhang discloses a “frequency-block down-converter 210” (low noise block downconverter) that receives a multi-channel RF signal and that outputs the processed signal to an ADC 220. (Zhang, 3:15-19, 3:54-61.) Zhang additionally explains that the signal is a cable signal (Zhang, 3:49) and that the signal comprises a plurality of television channels (Zhang, 3:26-35). It would have been obvious to apply Coyne’s system in view of Zhang and/or Petrovic to cable and satellite television systems, as discussed for claim 1. Thus, it is my opinion that claim 6 is obvious in view of Coyne and Petrovic and/or Zhang.

5. Dependent Claim 7

The method of claim 3, wherein: said received signal is a satellite television signal output by a low noise block downconverter; and said plurality of channels comprises a plurality of television channels.

268. Coyne in view of Petrovic renders obvious claim 3, as discussed in Section XI.C.2, *supra*. Petrovic discloses monitoring in satellite television systems. (Petrovic, [0037].) Zhang further discloses that the received signal is a satellite television signal output by a low noise block downconverter. Zhang states that the disclosed system may be a cable system or a satellite system. (Zhang, 3:15-19, 3:45-53.) It would have been obvious to apply Coyne’s system in view of Zhang and/or Petrovic to cable and satellite television systems, as discussed above for claim 1.

Thus, it is my opinion that claim 7 is obvious in view of Coyne and Petrovic and/or Zhang.

6. Dependent Claim 8

The method of claim 3, wherein said one or more circuits reside in a customer premises satellite reception assembly.

269. Coyne in view of Petrovic renders obvious claim 3, as above in Section XI.C.2. Zhang additionally discloses that the one or more circuits could reside in a number of different applications, such as “digital set-top boxes, PVRs, home gateways and home media centers.” (Zhang, 6:52-54.) Zhang further discloses that the system may be a “home media server.” (Zhang, 6:57.) A POSITA would have understood that this language of Zhang refers to the one or more circuits residing in a customer-premises satellite reception assembly. It would have been obvious to apply Coyne’s system in view of Zhang and/or Petrovic to cable and satellite television systems, including in a customer-premises satellite reception assembly (e.g., a receiver) as discussed above for claim 1. Thus, it is my opinion that claim 8 is obvious in view of Coyne and Petrovic and/or Zhang.

7. Dependent Claim 9

The method of claim 3, wherein said one or more circuits reside in a customer premises gateway.

270. Coyne in view of Petrovic renders obvious claim 3, as discussed in Section VIII.C.2. Petrovic discloses monitoring in satellite television systems.

(Petrovic, [0037].) Zhang discloses that the one or more circuits could reside in a number of different applications, such as “digital set-top boxes, PVRs, home gateways and home media centers.” (Zhang, 6:52-54 (emphasis added).) A POSITA would have understood that a “home gateway” is another name for a customer-premises gateway. It would have been obvious to apply Coyne’s system in view of Zhang and/or Petrovic to cable and satellite television systems, including in a customer-premises gateway (*e.g.*, a receiver) as discussed above for claim 1. Thus, claim 9 is obvious in view of Coyne and Petrovic and/or Zhang.

8. Dependent Claim 14

The system of claim 11, wherein: said received signal is a cable television signal; and said plurality of channels comprises a plurality of television channels.

271. See XI.D.4, claim 6, *supra*.

9. Dependent Claim 15

The system of claim 11, wherein: said received signal is a satellite television signal output by a low noise block downconverter; and said plurality of channels comprises a plurality of television channels.

272. See XI.D.5, claim 7, *supra*.

10. Dependent Claim 16

The system of claim 15, wherein said one or more circuits reside in a customer premises satellite reception assembly.

273. See XI.D.6, claim 8, *supra*.

11. Dependent Claim 17

The system of claim 11, wherein said one or more circuits reside in a customer premises gateway.

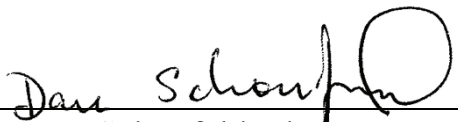
274. See XI.D.7, claim 9, *supra*.

XIII. CONCLUSION

For the reasons set forth above, it is my opinion that all elements of claims 1-18 of the '008 patent are disclosed in the prior art as discussed above.

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

Dated: February 6, 2023

By: 
Dan Schonfeld, Ph.D.

APPENDIX A

DAN SCHONFELD

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B. PROFESSIONAL BIOGRAPHY

Dr. Schonfeld received the B.S. degree in Electrical Engineering and Computer Science from the University of California, Berkeley, California, and the M.S. and Ph.D. degrees in Electrical and Computer Engineering from The Johns Hopkins University, Baltimore, Maryland, in 1986, 1988, and 1990, respectively.

In August 1990, he joined the Department of Electrical Engineering and Computer Science at the University of Illinois, Chicago, Illinois, where he is currently a Professor in the Departments of Electrical and Computer Engineering, Computer Science, and Biomedical Engineering. He has also served as Director of the University-Industry Engineering Research Center (UIERC), also known as the Manufacturing Research Center (MRC). He is also Co-Director of the Multimedia Communications Laboratory (MCL) and member of the Signal and Image Research Laboratory (SIRL).

Dr. Schonfeld has been elevated to the rank of Fellow of the IEEE “for contributions to image and video analysis.” He was also elevated to the rank of Fellow of the SPIE “for specific achievements in morphological image processing and video analysis.” Dr. Schonfeld has been elected University Scholar of the University of Illinois and received the Graduate Mentoring Award of the University of Illinois at Chicago.

Dr. Schonfeld has authored over 250 technical papers in various journals and conferences. He was co-author (with Carlo Giuliatti and Rashid Ansari) of a paper that won the Best Paper Award at the ACM Multimedia Workshop on Advanced Video Streaming Techniques for Peer-to-Peer Networks and Social Networking 2010. He was also co-author (with Junlan Yang) of a paper that won the Best Student Paper Award in the IEEE International Conference on Image Processing 2007. He was also co-author (with Wei Qu) of a paper that won the Best Student Paper Award in the IEEE International Conference on Image Processing 2006. He was also co-author (with Nidhal Bouaynaya) of a paper that won the Best Student Paper Award in Visual Communication and Image Processing 2006.

Dr. Schonfeld has served as Editor-in-Chief of the IEEE Transactions on Circuits and Systems for Video Technology. He has also served as Deputy Editor-in-Chief of the IEEE Transactions on Circuits and Systems for Video Technology as well as Area Editor for Special Issues of the IEEE Signal Processing Magazine. He has also served as Associate Editor of the IEEE Transactions on Image Processing (on image and video storage, retrieval and analysis), Associate Editor of the IEEE Transactions on Circuits and Systems for Video Technology (on video analysis), Associate Editor of the IEEE Transactions on Signal Processing (on multidimensional signal processing and multimedia signal processing), and Associate Editor of the IEEE Transactions on Image Processing (on nonlinear filtering). He has also served on the editorial board of various journal publications. He has also served as guest editor for numerous special issues in various journal publications.

Dr. Schonfeld is currently serving on the Conference Board of the IEEE Signal Processing Society. He has also served as Technical Program Chair of the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) 2018. He was also organizer of the Thematic Symposium on Multimedia Search and Retrieval at the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) 2009. He has also served as General Chair of the International Conference on Internet Multimedia Computing and Service (ICIMCS) 2018, the IEEE Conference on Visual Communication and Image Processing (VCIP) 2016, the Workshop on Big Data in 3D Computer Vision 2013, and the IEEE International Conference on Multimedia and Expo (ICME) 2012. He has also served as Program Chair of the IEEE Conference on Visual Communication and Image Processing (VCIP) 2015. He has also served as Technical Program Chair of the IEEE Workshop on Genomic Signal Processing and Statistics (GENSIPS) 2009 as well as Chair of the Workshop on Video Mining 2008. He has also served as Chair of the SPIE Conference on Visual Communication and Image Processing (VCIP) 2007. He was a member of the organizing committees of the IEEE International Conference on Image Processing (ICIP) 1998, 2012, 2018, and 2020, IEEE/SPIE

International Conference on Visual Communications and Image Processing (VCIP) 2007, 2010, 2015, 2016, and 2017, and IEEE Workshop on Nonlinear Signal and Image Processing (NSIP) 1997.

Dr. Schonfeld was keynote speaker at the N-Brain Alliance Launch & Product Release Conference 2018 as well as Think for Education Conference (TEC) AI+Education 2018. He was also keynote speaker at the International Conference on Wireless Communications and Signal Processing (WCSP) 2016. He was also keynote speaker at the International Conference on Intelligent Control and Information Processing (ICICIP) 2013 and International Conference on Brain Inspired Cognitive Systems (BICS) 2013. He was also plenary speaker at the IEEE/IET International Conference on Audio, Language and Image Processing (ICALIP), Shanghai, China, in 2010. He was also plenary speaker at the IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS), Genoa, Italy, in 2009. He was also plenary speaker at the INPT/ASME International Conference on Communications, Signals, and Systems (ICCSS), Rabat Morocco, in 1995 and 2001.

Dr. Schonfeld has served as Representative of Regions 1-6 (North America) in the Chapters Committee of the IEEE Signal Processing Society. He has also served as Chairman of the Chicago Chapter of the IEEE Signal Processing Society. He is currently serving on the IEEE Multimedia Communications Technical Committee and IEEE Visual Signal Processing and Communications (VSPC) Technical Committee. He has also served on the IEEE Image, Video, and Multidimensional Signal Processing (IVMSP) Technical Committee, formerly the IEEE Image and Multidimensional Signal Processing (IMDSP) Technical Committee. He also served on the American National Standards Institute (ANSI) / Underwriters Laboratory (UL) Standards Technical Panel ("STP") on Multimedia Systems.

His current research interests are in signal processing, image and video analysis, video retrieval and communications, multimedia systems, computer vision, medical imaging, and genomic signal processing.

C. RESEARCH INTERESTS

Signal Processing, Image and Video Analysis, Video Retrieval and Communications, Multimedia Systems, Computer Vision, Machine Learning, Medical Imaging, and Genomic Signal Processing.

D. HONORS AND AWARDS

IAM Patent 1000 2015: The World's Leading Patent Practitioners

The Worlds Leading Patent Litigation Expert Witnesses

Fourth Edition

2015

Graduate Mentoring Award

University of Illinois at Chicago

2014

University Scholar

University of Illinois

2010

Fellow

Asia-Pacific Artificial Intelligence Association (AAIA)

2021

Fellow

International Society for Optics and Photonics (SPIE)

“For Specific Achievements in Morphological Image Processing and Video Analysis”

2011

Fellow

Institute of Electrical and Electronics Engineers (IEEE)

“For Contributions to Image and Video Analysis”

2010

Senior Member

Institute of Electrical and Electronics Engineers (IEEE)

2005

Best Paper Award

C. Giulietti, D. Schonfeld, and R. Ansari

“A Novel Cache Optimization Algorithm and Protocol
for Video Streaming in Pure Peer-to-Peer Networks”

ACM Multimedia Workshop on Advanced Video Streaming Techniques
for Peer-to-Peer Networks and Social Networking

2010

Best Student Paper Award

J. Yang, D. Schonfeld and M. Mohamed

“Robust Focused Image Estimation from Multiple Images in Video Sequences”

IEEE International Conference on Image Processing

2007

Best Student Paper Award

W. Qu and D. Schonfeld

“Robust Kernel-Based Tracking Using Optimal Control”

IEEE International Conference on Image Processing

2006

Best Student Paper Award

N. Bouaynaya and D. Schonfeld

“Spatially-variant morphological image processing: Theory and applications”

SPIE Conference on Visual Communications and Image Processing

2006

Advising Award

College of Engineering

University of Illinois at Chicago

2013

Outstanding Associate Editor Award – IEEE Circuits and Systems Society

IEEE Circuits and Systems Society

IEEE Transactions on Circuits and Systems for Video Technology

2009

Most Active Chapter Award – IEEE Signal Processing Chicago Chapter Chair
IEEE – Region 4
2008

Service Award – IEEE Signal Processing Chicago Chapter Chair
IEEE – Chicago Section
2007

Certificate of Appreciation – IEEE Signal Processing Society
Chair, IEEE Signal Processing Chapter
Chicago Section
2006-2012

Certificate of Appreciation – IEEE Circuits and Systems Society
IEEE Circuits and Systems Society
Prize Paper Award Subcommittee
2010

Certificate of Appreciation – IEEE Circuits and Systems Society
IEEE Circuits and Systems Society
Deputy Editor-in-Chief of the IEEE Transactions on Circuits and Systems for Video Technology
2008 – 2010

Certificate of Appreciation – IEEE Circuits and Systems Society
IEEE Circuits and Systems Society
Associate Editor of the IEEE Transactions on Circuits and Systems for Video Technology
2008 – 2010

Certificate of Appreciation – IEEE Signal Processing Chicago Chapter Chair
IEEE – Chicago Section
2006

Top Reviewer Recognition Certificate
IEEE International Conference on Image Processing (ICIP)
Abu Dhabi, United Arab Emirates
2020

2018 Albert Nelson Marquis Lifetime Achievement Award
Marquis Who's Who

Who's Who in the World
2021 Edition

Who's Who in the World
2020 Edition

Who's Who in the World
2019 Edition

Who's Who in the World

2018 Edition

Worldwide Who's Who

2014 Edition

Who's Who in America (WWA)

2019 Edition

Who's Who in America (WWA)

2012 Edition

Who's Who in America (WWA)

2011 Edition

Who's Who in America (WWA)

2010 Edition

Who's Who in Engineering Education (WWE)

2002 Edition

University Fellowship

The Johns Hopkins University

1986—1990

E. IN THE NEWS

IEEE Fellow Dan Schonfeld: Helping Catch Thieves & Read Fuzzy Faxes

e-Scanfax: IEEE Chicago Section Newsletter

January 2010

<http://www.ieeechicago.org/LinkClick.aspx?fileticket=Py81tdr4GTM%3D&tabid=390&mid=884>

IEEE-Chicago Fellows Provide Words of Wisdom to New IEEE Members

e-Scanfax: IEEE Chicago Section Newsletter

May 2010

http://www.ieeechicago.org/LinkClick.aspx?fileticket=2GIDPZnZQ_M%3D&tabid=390&mid=884

What You See, What You Get

University Scholar Dan Schonfeld

Paul Francuch

UIC News

November 10, 2010

<http://www.uic.edu/htbin/cgiwrap/bin/uicnews/articledetail.cgi?id=14769>

Genomic Signal Processing May Yield Clues to Cancer Treatment

Paul Francuch

UIC News Release

November 17, 2010

[http://tiger.uic.edu/htbin/cgiwrap/bin/newsbureau/cgi-bin/index.cgi?
from=Releases&to=Release&id=3073&start=1232172000&end=1329285600&topic=2&dept=64](http://tiger.uic.edu/htbin/cgiwrap/bin/newsbureau/cgi-bin/index.cgi?from=Releases&to=Release&id=3073&start=1232172000&end=1329285600&topic=2&dept=64)

New Camera Focuses Photos After They Are Taken

Morgen Peck

InnovationNewsDaily Contributor

November 4, 2011

<http://www.innovationnewsdaily.com/camera-focuses-photos-after-2358/>

F. EDUCATION

Ph.D. July 1990

The Johns Hopkins University

Department of Electrical & Computer Engineering

Concentration: Nonlinear Signal Processing / Image Analysis

Thesis Title: "Optimal Morphological Representation and Restoration of Binary Images: Theory and Applications"

First Reader: Prof. John Goutsias; Second Reader: Prof. Victor Solo

M.S. May 1988

The Johns Hopkins University

Department of Electrical & Computer Engineering

Concentration: Speech Processing / Biomedical Signal Processing

Advisor: Prof. Moise H. Goldstein

B.S. May 1986

University of California at Berkeley

Department of Electrical Engineering & Computer Science

Concentration: Computer Engineering / Systems Engineering

Advisor: Prof. Michael J. Sabin

G. WORK EXPERIENCE

Director

Manufacturing Research Center (MRC)

University-Industry Engineering Research Center (UIERC)

College of Engineering

University of Illinois at Chicago

Chicago, Illinois

2008—2011

Professor with Tenure

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2007—Present

Professor (Courtesy Appointment)

Department of Computer Science

University of Illinois at Chicago

Chicago, Illinois
2007— 2025

Professor

Department of Biomedical Engineering
University of Illinois at Chicago
Chicago, Illinois
2021— Present

Professor

Department of Bioengineering
University of Illinois at Chicago
Chicago, Illinois
2007— 2021

Associate Professor with Tenure

Department of Electrical & Computer Engineering
University of Illinois at Chicago
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2001—2007

Associate Professor (Courtesy Appointment)

Department of Computer Science
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2001—2007

Associate Professor

Department of Bioengineering
University of Illinois at Chicago
Chicago, Illinois
1998—2007

Associate Professor with Tenure

Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
Chicago, Illinois
1996—2001

Co-Director

Multimedia Communications Laboratory (MCL)
Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
1997—Present

Assistant Professor

Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
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1990—1996

Member

Signal and Image Research Laboratory (SIRL)
Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
1990—2002

Instructor

Department of Electrical and Computer Engineering
The Johns Hopkins University
Baltimore, Maryland
1987—1990

Teaching Assistant

Department of Electrical and Computer Engineering
The Johns Hopkins University
Baltimore, Maryland
1986—1990

Software Engineer

Computer Aided Design
Teledyne Systems
Northridge, California
Summer 1984—85—86

H. CONSULTING EXPERIENCE

Consultant & Expert Witness

2001—Present

Consulting Activities:

Deposition and Trial Testimony
Patent Litigation
Copyright Litigation
Trade Secret Litigation
International Trade Litigation
Customs Litigation
Contract Litigation

Areas of Expertise:

Multimedia Systems
Multimedia Retrieval, Storage, and Communication Systems
Image and Video Processing
Signal Processing and Communications

Examples of Previous Litigation Experience:

Cable Systems
Camera Systems
Graphics Processors

Image Compression Systems
Image Processing Systems
Internet Advertising
Internet Streaming
Jukebox Systems
Medical Imaging
Signal Processing
Smartphones and Tablets
Television Systems
Video-on Demand (VoD) Systems
Video Compression Systems
Video Storage Systems
Video Streaming Systems
Wireless Systems

Companies:

Served as a consultant and expert witness for various companies including ARRIS, Blackberry, Broadcom, Cablevision, Cisco, Dell, Google, Hewlett-Packard, Huawei, Motorola, NVIDIA, Panasonic, Qualcomm, Samsung, Time Warner, Zeiss.

Consultant & President

Schonfeld Consulting Corporation
Multimedia Systems
Northbrook, Illinois
2017—Present

Consultant & President

Multimedia Systems Corporation
Multimedia Systems
Glenview, Illinois
2002—2005

Consultant

Chicago Merchantile Exchange
Multimedia Communication Networks
Chicago, Illinois
1998

Consultant

PrairieComm Corp.
Multimedia Wireless Networks
Arlington Heights, Illinois
1997

I. VISITING POSITIONS

Distinguished Visiting Scholar

Advanced Analytics Institute (AAI)
University of Technology

Sydney, Australia
2012

Visiting Professor

Department of Information Engineering and Computer Science - DISI
University of Trento
Trento, Italy
May 2010

Visiting Professor

School of Computer Engineering
Nanyang Technological University
Singapore
July 2009

Visiting Associate Professor

Department of Electrical Engineering—Systems
Tel-Aviv University
Tel-Aviv, Israel
December 1996—January 1997

J. INTERDISCIPLINARY PROGRAMS

Collaborative Neuroimaging Environment for Connectomics (CoNECT)

University of Illinois at Chicago
2013—Present

Clinical and Translational Science (CCTS)

Biomedical Informatics Core Consult Group
University of Illinois at Chicago
2009—Present

Graduate Program in Neuroscience

University of Illinois at Chicago
2001—Present

Bioinformatics Program

Department of Bioengineering
University of Illinois at Chicago
2000—Present

K. PROFESSIONAL ACTIVITIES

K.1. Editorships

Editor-in-Chief (EIC)

IEEE Transactions on Circuits and Systems for Video Technology
2014—2017

Deputy Editor-in-Chief (DEIC)

IEEE Transactions on Circuits and Systems for Video Technology
2010—2013

Area Editor, Special Sections

Special Issues
IEEE Signal Processing Magazine
2009—2011

Editor

Video Search and Mining
Studies in Computational Intelligence Series
Springer-Verlag
2009

Associate Editor

IEEE Transactions on Image Processing
Image and Video Storage, Retrieval and Analysis
2007—2009

Associate Editor

IEEE Transactions on Circuits and Systems for Video Technology
Video Analysis
2006—2009

Associate Editor

IEEE Transactions on Signal Processing
Multidimensional Signal Processing &
Multimedia Signal Processing
1999—2000

Associate Editor

IEEE Transactions on Image Processing
Filtering and Enhancement
1994—1996

Guest Editor

IEEE Journal of Special Topics in Signal Processing
Special Issue on Mathematical Morphology
and Its Applications to Image and Signal Processing
2011—2012

Guest Editor

IEEE Transactions on Image Processing
Special Issue on Distributed Camera Networks:
Sensing, Processing, Communication and Computing
2010—2011

Guest Editor

EURASIP Journal on Image and Video Processing

Special Issue on Advanced Video-Based Surveillance
2010—2011

Lead Guest Editor

IEEE Journal of Special Topics in Signal Processing
Special Issue on Recent Advances in Video Processing for Consumer Displays
2009—2011

Guest Editor

IEEE Transactions on Circuits and Systems for Video Technology
Special Issue on Event Analysis in Videos
2008

Lead Guest Editor

IEEE Journal of Special Topics in Signal Processing
Special Issue on Genomic and Proteomic Signal Processing
2007—2008

Guest Editor

Journal of Advances in Multimedia
Special Issue on Plenoptic Signal and Image Processing
2007—2008

Advisory Board

Bentham Books
Bentham Science
2021—Present

Editorial Board

Sensors
MDPI
2021—Present

Editorial Board

Recent Advances in Computer Science and Communications
Bentham Science Publishers, Ltd.
2012—Present

Editorial Board

Journal of Electrical and Computer Engineering
Hindawi Publishing Corporation
2009—2019

Editorial Board

EURASIP Journal of Image and Video Processing
2009—2013

Editorial Board

IEEE Signal Processing Magazine
2008—2011

Editorial Board

Research Letters in Signal Processing
Hindawi Publishing Corporation
2007—2009

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Recent Patents on Computer Science
Bentham Science Publishers, Ltd.
2007—2019

Editorial Board

Recent Patents on Electrical Engineering
Bentham Science Publishers, Ltd.
2007—2012

Contributor

Science and Technology: SPIE Newsroom
Electronic Imaging and Signal Processing
2005—2008

K.2. Committees

Moving Picture, Audio and Data Coding by Artificial Intelligence (MPAI)

2020

MPEG Future

2020–Present

Ad-Hoc Committee of the Conferences Board on Flagship Conferences Future Strategy

IEEE Signal Processing Society
2020-2021

Ad-Hoc Committee on Multi-Scale Models at SPS Flagship Conferences

IEEE Signal Processing Society
2019-2020

IEEE Signal Processing (SPS) Liaison

IEEE Signal Processing Society
2019-2021

Conference Board

IEEE Signal Processing Society
2019-2020

Award Committee

Association for Computing Machinery (ACM)
ACM Multimedia
2020

Best Paper Award Selection Committee

CSV T Best Paper Award
IEEE Circuits and Systems Society
2020—2021

Best Paper Award Selection Committee

CSV T Best Paper Award
IEEE Circuits and Systems Society
2019—2020

Best Paper Award Selection Committee

CSV T Best Paper Award
IEEE Circuits and Systems Society
2013

Steering Committee

International Association for Pattern Recognition (IAPR)
Discrete Geometry and Mathematical Morphology (DGMM)
2022—Present

Travel Grant Selection Committee

IEEE Signal Processing Society
IEEE International Conference on Image Processing
2011

Steering Committee

International Society of Mathematical Morphology (ISMM)
International Symposium on Mathematical Morphology (ISMM)
2011—Present

Advisory Committee

IEEE Circuits and Systems Society
Visual Signal Processing and Communication (VSPC) Technical Committee
IEEE Conference on Visual Communications and Image Processing (VCIP)
2010—Present

Steering Committee

SPIE and IEEE Circuits and Systems Society
Conference on Visual Communications and Image Processing
2008—2010

Scientific Advisory Board

World Congress of NeuroTalk
From Nervous Functions to Treatment
Singapore Expo, Singapore
2010

Chair

Nominations and Elections Subcommittee
Image, Video, and Multidimensional Signal Processing (IVMSP) Technical Committee
IEEE Signal Processing Society
2010—2011

Honorable Member

Visual Signal Processing and Communications (VSPC) Technical Committee
IEEE Circuits and Systems Society
2018— Present

Member

Visual Signal Processing and Communications (VSPC) Technical Committee
IEEE Circuits and Systems Society
2015— 2019

Associate Member

Image, Video, and Multidimensional Signal Processing (IVMSP) Technical Committee
IEEE Signal Processing Society
2014— Present

Member

IEEE Multimedia Communications Technical Committee (MMTC) Technical Committee
IEEE Communications Society
2009— Present

Member

Image, Video, and Multidimensional Signal Processing (IVMSP) Technical Committee
IEEE Signal Processing Society
2009— 2012

Member

Image and Multidimensional Signal Processing (IMDSP) Technical Committee
IEEE Signal Processing Society
2007—2008

Member

Signal and Image Processing in Medicine Technical Committee
IEEE Circuits and Systems Society
1990—1996

Member

P2P Communication and Networking Technical Subcommittee
Multimedia Communications Technical Committee
IEEE Communications Society
2006—Present

Representative

Regions 1-6 (North America)
Chapters Committee
IEEE Signal Processing Society
2006—2012

Chairman

Chicago IEEE Signal Processing Chapter
2006—2012

Member

American National Standards Institute/Underwriters Laboratory (ANSI/UL)
Standards Technical Panels (STP)

STP 1863: Communications-Circuit Accessories

UL 1863: Standard for Communications-Circuit Accessories

STP 6065: Audio, Video And Similar Electronic Apparatus - Safety Requirements

UL 150: Standard for Antenna Rotators

UL 452: Standard for Antenna – Discharge Units

UL 469: Standard for Musical Instruments and Accessories

UL 813: Standard for Commercial Audio Equipment

UL 1412: Standard for Fusing Resistors and Temperature-Limited Resistors for Radio- and Television-Type Appliances

UL 1413: Standard for High-Voltage Components for Television-Type Appliances

UL 1416: Standard for Overcurrent and Overtemperature Protectors for Radio- and Television-Type Appliances

UL 1417: Standard for Special Fuses for Radio- and Television-Type Appliances

UL 1492: Audio/Video Products and Accessories

UL 1676: Standard for Conductive-Path and Discharge-Path Resistors for Use in Radio-, Video-, or Television-Type Appliances

UL 6500: Standard for Audio/Video and Musical Instrument Apparatus for Household, Commercial, and Similar General Use

UL 60065: Standard for Audio, Video and Similar Electronic Apparatus – Safety Requirements

STP 62368: Audio/Video, Information Technology, And Communication Technology Equipment

UL 62368: Audio/video, Information and Communication Technology Equipment

STP 9990: Information and Communication Technology (ICT) Cables

UL 9990: Standard for Safety for Information and Communication Technology (ICT) Power Cables

2002—Present

K.3. Review Panels**Member**

Expert Panel
Faculty of Computing and Electrical Engineering
Tampere University of Technology (TUT)
Tampere, Finland
2011

Member

Paper Award Committee
IEEE International Conference on Advanced Video and Signal-Based Surveillance (AVSS)
Genoa, Italy
2009

Member

Technical Jury
NTT DoCoMo USA Labs Most Innovative Paper Awards

IEEE International Conference on Image Processing
San Diego, California
2008

Member

Technical Jury
NTT DoCoMo USA Labs Most Innovative Paper Awards
IEEE International Conference on Image Processing
San Antonio, Texas
2007

Member

Technical Jury
NTT DoCoMo USA Labs Most Innovative Paper Awards
IEEE International Conference on Image Processing
Atlanta, Georgia
2006

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Computing and Communication Foundations (CCF)
Image and Multi-Dimensional Signal Processing (IMDSP)
2015

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Computing and Communication Foundations (CCF)
Communications and Information Foundations (CIF)
2012

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Computing and Communication Foundations (CCF)
Communications and Information Foundations (CIF)
2011

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Information & Intelligent Systems (IIS)
Databases and Data Mining (DB/DM)
2007

Member

NSF Review Panel
Small Business Innovation Research (SBIR) Program
Robotics II
Phase II

2007

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Information & Intelligent Systems (IIS)
Information Management (IM)
2006

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Information & Intelligent Systems (IIS)
Information & Knowledge Management (IKM)
2005

Member

NSF Review Panel
Small Business Innovation Research (SBIR) Program
Robotics II
Phase I
2005

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Advanced Networking Infrastructure and Research (ANIR)
Information Technology Research (ITR)
Networking Research
Small Grants
2002

Member

NSF Review Panel
Small Business Innovation Research (SBIR) Program
Diagnostic Systems and Signal Processing
Phase I
2002

Member

NSF Review Panel
Computer & Information Science & Engineering (CISE)
Information Technology Research (ITR)
Biology & Information Technology
Computational Biology / Biocomputation
Medium Grants
2003

K.4. Conference Chair

General Chair

International Conference on Internet Multimedia Computing and Service (ICIMCS)
Nanjing, China
2018

Technical Program Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)
Calgary, Canada
2018

General Co-Chair

IEEE Conference on Visual Communications and Image Processing (VCIP)
Chengdu, China
2016

Program Co-Chair

IEEE Conference on Visual Communications and Image Processing (VCIP)
Singapore
2015

General Co-Chair

Workshop on Big Data in 3D Computer Vision
Held in conjunction with the IEEE International Conference on Computer Vision (ICCV)
Melbourne, Australia
2013

General Co-Chair

IEEE International Conference on Multimedia and Expo (ICME)
Melbourne, Australia
2012

Technical Program Chair

IEEE International Workshop on Genomic Signal Processing and Statistics (GENSIPS)
Minneapolis, Minnesota
2009

Chair

Workshop on Video Mining
IEEE International Conference on Data Mining
Held in conjunction with the IEEE International Conference on Data Mining (ICDM)
Pisa, Italy
2008

Chair

SPIE International Conference on Visual Communications and Image Processing (VCIP)
San Jose, California
2007

Multimedia Content Analysis Track Chair

IEEE International Conference on Multimedia and Expo
New York, New York

2009

Technical Program Committee / Area Chair

IEEE International Conference on Image Processing
San Diego, California
2008

Technical Program Committee / Area Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Las Vegas, Nevada
2008

Technical Program Committee / Area Chair

IEEE International Conference on Image Processing
San Antonio, Texas
2007

Associate Program Chair

ACM Multimedia
Juan Les Pins, France
2002

K.5. Organizing Committees

TBD

IEEE International Conference on Image Processing (ICIP)
Abu Dhabi, United Arab Emirates
2024

Special Sessions Co-Chair

IEEE International Conference on Image Processing (ICIP)
Abu Dhabi, United Arab Emirates
2020

Technical Program Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)
Calgary, Canada
2018

Plenary Co-Chair

IEEE Conference on Visual Communications and Image Processing (VCIP)
St. Petersburg, Florida
2017

General Co-Chair

IEEE Conference on Visual Communications and Image Processing (VCIP)
Chengdu, China
2016

Program Co-Chair

IEEE Conference on Visual Communications and Image Processing (VCIP)
Singapore
2015

General Co-Chair

Workshop on Big Data in 3D Computer Vision
Held in conjunction with the IEEE International Conference on Computer Vision (ICCV)
Melbourne, Australia
2013

General Co-Chair

IEEE International Conference on Multimedia and Expo (ICME)
Melbourne, Australia
2012

Plenary Chair

IEEE International Conference on Image Processing (ICIP)
Orlando, Florida
2012

Publications Chair

IEEE Conference on Advanced Video and Signal-based Surveillance (AVSS)
Beijing, China
2012

USA Liaison Chair

IEEE Conference on Advanced Video and Signal-based Surveillance (AVSS)
Klagenfurt, Austria
2011

Publicity Co-Chair

IEEE/SPIE International Conference on Visual Communications and Image Processing (VCIP)
Huang Shan, An Hui, China
2010

Technical Program Chair

IEEE International Workshop on Genomic Signal Processing and Statistics (GENSIPS)
Minneapolis, Minnesota
2009

Organizer

IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)
Thematic Symposium on Multimedia Search and Retrieval
Taipei, Taiwan
2009

Chair

Workshop on Video Mining
Held in conjunction with the IEEE International Conference on Data Mining (ICDM)
Pisa, Italy
2008

Chair

SPIE International Conference on Visual Communications and Image Processing (VCIP)
San Jose, California
2007

Technical Organizing Committee

IS&T/SPIE Annual Symposium on Electronic Imaging: Science and Technology
San Jose, California
2007

Publications Chair

IEEE International Conference on Image Processing
Chicago, Illinois
1998

Plenary Talks and Special Session Chair

IEEE/EURASIP Workshop on Nonlinear Signal and Image Processing
Mackinac Island, Michigan
1997

K.6. Technical Program Committees

Technical Program Committee

SPIE Conference on Video Surveillance and Transportation Imaging
San Francisco, California
2015

Technical Program Committee

SPIE Conference on Video Surveillance and Transportation Imaging
San Francisco, California
2014

Program Committee

IEEE International Conference on Automatic Face and Gesture Recognition (FG 2013)
Shanghai, China
2013

Technical Program Committee

SPIE Conference on Video Surveillance and Transportation Imaging
San Francisco, California
2013

Technical Program Committee

SPIE Conference on Visual Information Processing and Communication
San Francisco, California
2013

Technical Program Committee

ICST International Conference on

Wireless Mobile Communication and Healthcare (MobiHealth)
Paris, France
2012

Technical Program Committee

SPIE Conference on Visual Information Processing and Communication
San Francisco, California
2012

Program Committee

International Workshop on Video Event Categorization, Tagging and Retrieval (VECTaR)
Held in conjunction with the International Conference on Computer Vision
Barcelona, Spain
2011

Technical Program Committee

ICST International Conference on
Wireless Mobile Communication and Healthcare (MobiHealth)
Kos Island, Greece
2011

Technical Program Committee

SPIE Conference on Visual Information Processing and Communication
San Francisco, California
2011

Technical Program Committee

IEEE International Workshop on Genomic Signal Processing and Statistics
Cold Spring Harbor Laboratory, New York
2010

Technical Program Committee

IEEE International Conference on Multimedia and Expo (ICME)
Singapore
2010

Technical Program Committee

International Conference on Pattern Recognition (ICPR)
Track I: Computer Vision
Istanbul, Turkey
2010

Technical Program Committee

ACM/IEEE International Conference on Distributed Smart Cameras (ICDSC)
Atlanta, Georgia
2010

Technical Program Committee

IEEE Workshop on Multimedia Computing and Communications (MCC)
Held in conjunction with the International Conference on Computer Communications and Networks (ICCCN)

Zurich, Switzerland
2010

Program Committee

ACM International Conference on Bioinformatics and Computational Biology (ACM-BCB)
Niagara Falls, New York
2010

Technical Program Committee

IEEE/SPIE International Conference on Visual Communications and Image Processing
Huang Shan, An Hui, China
2010

Technical Program Committee

ICST International Conference on
Wireless Mobile Communication and Healthcare (MobiHealth)
Ayia Napa, Cyprus
2010

Technical Program Committee

SPIE International Conference on Visual Information Processing and Communications
San Jose, California
2010

Program Committee

International Workshop on Video Event Categorization, Tagging and Retrieval (VECTaR)
Held in conjunction with the Asian Conference on Computer Vision
Xi'an, China
2009

Program Committee

IEEE International Workshop on Video-Oriented Object and Event Classification (VOEC)
Held in conjunction with the International Conference on Computer Vision (ICCV)
Kyoto, Japan
2009

Program Committee / Reviewer

IEEE International Conference on Computer Vision
Kyoto, Japan
2009

Technical Program Committee

IEEE International Conference on Advanced Video and Signal-Based Surveillance (AVSS)
Genoa, Italy
2009

Technical Program Committee

IEEE Workshop on Multimedia Computing and Communications (MCC)
Held in conjunction with the International Conference on Computer Communications and Networks (ICCCN)
San Francisco, California

2009

Technical Program Committee

International Conference on Image and Graphics
Xi'an, China
2009

Program Committee

International Conference on Advances in Multimedia (MMEDIA)
Colmar, France
2009

Technical Program Committee

IEEE International Workshop on Computational Advances
in Multi-Sensor Adaptive Processing (CAMSAP)
Dominican Republic
2009

Technical Program Committee

SPIE International Conference on Visual Communications and Image Processing
San Jose, California
2009

Technical Program Committee / Reviewer

IEEE International Conference on Image Processing
San Diego, California
2008

Program Committee

IEEE Conference on Computer Vision and Pattern Recognition
Anchorage, Alaska
2008

Technical Program Committee / Reviewer

IEEE International Conference on Acoustics, Speech, and Signal Processing
Las Vegas, Nevada
2008

Technical Program Committee

IEEE International Workshop on Genomic Signal Processing and Statistics
Phoenix, Arizona
2008

Technical Program Committee

International Workshop on Multimedia Analysis & Processing (IMAP)
U.S. Virgin Islands
2008

Technical Program Committee

SPIE International Conference on Visual Communications and Image Processing
San Jose, California

2008

Program Committee

IEEE International Conference on Computer Vision
Rio de Janeiro, Brazil
2007

Technical Program Committee / Reviewer

IEEE International Conference on Image Processing
San Antonio, Texas
2007

Technical Program Committee

IEEE International Workshop on Genomic Signal Processing and Statistics
Tuusula, Finland
2007

Technical Program Committee

SPIE International Conference on Visual Communications and Image Processing
San Jose, California
2007

Technical Program Committee

IEEE International Conference on Image Processing
Atlanta, Georgia
2006

Technical Program Committee

IEEE International Workshop on Genomic Signal Processing and Statistics
College Station, Texas
2006

Technical Program Committee

SPIE International Conference on Visual Communications and Image Processing
San Jose, California
2006

Technical Program Committee / Reviewer

IEEE International Conference on Acoustics, Speech, and Signal Processing
Toulouse, France
2006

Technical Program Committee

IEEE International Conference on Image Processing
Genova, Italy
2005

Technical Program Committee / Reviewer

IEEE International Conference on Acoustics, Speech, and Signal Processing
Philadelphia, Pennsylvania
2005

Technical Program Committee
IEEE International Conference on Image Processing
Singapore
2004

Technical Program Committee
IEEE International Conference on Image Processing
Barcelona, Spain
2003

Technical Program Committee
IEEE International Conference on Image Processing
Rochester, New York
2002

Technical Program Committee
IEEE International Conference on Image Processing
Thessaloniki, Greece
2001

Technical Program Committee
IEEE International Conference on Image Processing
Vancouver, Canada
2000

Technical Program Committee
IEEE International Conference on Image Processing
Kobe, Japan
1999

Technical Program Committee
IEEE International Conference on Image Processing
Chicago, Illinois
1998

Technical Program Committee
International Symposium on Mathematical Morphology
Amsterdam, The Netherlands
1998

Technical Program Committee
SPIE International Conference on Visual Communications and Image Processing
San Jose, California
1998

Technical Program Committee
SPIE International Conference on Visual Communications and Image Processing
San Jose, California
1997

Technical Program Committee

SPIE International Conference on Visual Communications and Image Processing
Orlando, Florida
1996

Technical Program Committee

IEEE International Conference on Image Processing
Austin, Texas
1994

Technical Program Committee

IEEE International Symposium on Circuits and Systems
Chicago, Illinois
1993

K.7. Session Organizer

Chair

IEEE International Conference on Image Processing
Special Session on Face Recognition II
Orlando, Florida
2012

Organizer and Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Special Session on Video Search and Event Analysis
Taipei, Taiwan
2009

Organizer

Workshop on Global Multimedia Mobile Communications
University of Illinois at Chicago
Chicago, Illinois
2005

Organizer and Chair

IEEE International Conference on Image Processing
Special Session on Nonlinear Filtering
Austin, Texas
1994

Organizer and Chair

IEEE International Symposium on Circuits and Systems
Special Session on Medical Image and Signal Processing
Singapore
1991

Organizer and Chair

Conference on Information Sciences and Systems
Session on Nonlinear Image and Signal Processing I

Baltimore, Maryland
1991

K.8. Session Chair

Chair

IEEE International Conference on Image Processing
Session on Defect Removal
Taipei, Taiwan
2019

Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Session on Stereoscopic and 3D Processing
Brighton, United Kingdom
2019

Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Session on Image and Video Indexing and Retrieval
Prague, Czech Republic
2011

Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Session on Image/Video Semantic Understanding
Dallas, Texas
2010

Chair

IEEE International Conference on Advanced Video and Signal-Based Surveillance (AVSS)
Session on Trajectory Analysis and Learning
Genoa, Italy
2009

Chair

IEEE International Conference on Multimedia and Expo
Session on Multimedia Content Analysis and Synthesis IV
New York, New York
2009

Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Session on Stereoscopic and 3-D Processing
Taipei, Taiwan
2009

Chair

IEEE International Conference on Image Processing
Session on Enhancement and Denoising II

San Diego, California
2008

Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Session on Restoration and Enhancement
Las Vegas, Nevada
2008

Chair

SPIE Electronic Imaging Conference on Visual Communications and Image Processing
Session on Image Processing
San Jose, California
2008

Chair

IEEE International Conference on Image Processing
Session on Image and Video Restoration and Enhancement I
San Antonio, Texas
2007

Chair

IEEE International Conference on Image Processing
Session on Image and Video Filtering
Atlanta, Georgia
2006

Chair

IEEE International Conference on Multimedia and Expo
Session on Media Signal Processing
Toronto, Canada
2006

Chair

IEEE International Conference on Multimedia and Expo
Session on Multimedia Database Applications
Toronto, Canada
2006

Chair

IEEE International Conference on Multimedia and Expo
Session on Peer-to-Peer Multimedia Streaming
Toronto, Canada
2006

Chair

SPIE Electronic Imaging Conference on Visual Communications and Image Processing
Session on Computer Vision
San Jose, California
2006

Chair

IEEE International Conference on Acoustics, Speech, and Signal Processing
Session on Video Segmentation and Tracking
Philadelphia, Pennsylvania
2005

Chair

SPIE Electronic Imaging Conference on Image and Video Communications and Processing
Session on Selective Encryption for Image/Video
San Jose, California
2005

Chair

SPIE Electronic Imaging Conference on Image and Video Communications and Processing
Session on Object Tracking
San Jose, California
2005

Chair

INPT/ASME International Conference on Communications, Signals and Systems
Session on Signals and Data
Rabat, Morocco
2001

Chair

SPIE Conference on Multimedia Storage and Archiving Systems III
Session on Video Segmentation
Boston, Massachusetts
1998

Chair

IEEE International Conference on Image Processing
Session on Image Sequence Segmentation
Chicago, Illinois
1998

Chair

International Symposium on Mathematical Morphology
Session on Theory
Atlanta, Georgia
1996

Chair

INPT/ASME International Conference on Communications, Signals and Systems
Session on Signals and Data
Rabat, Morocco
1995

Chair

IEEE Workshop on Nonlinear Signal and Image Processing
Session on Mathematical Morphology and Fuzzy DSP

Neos Marmaras, Halkidiki, Greece
1995

Chair

IEEE International Conference on Image Processing
Session on Shape Representation and Image Modeling
Austin, Texas
1994

Chair

SPIE Conference on Visual Communications and Image Processing
Session on Mathematical Morphology
Boston, Massachusetts
1992

Chair

Conference on Information Sciences and Systems
Session on Signal Representation, Modeling, and Analysis
Baltimore, Maryland
1991

K.9. Panelist and Participant

Panelist

DOD Tri-Service Workshop on Stochastic Methods in Image Analysis
Session on Mathematical Morphology
U.S. Army Harry Diamond Laboratories
Adelphi, Maryland
1992

Participant

Institute for Mathematics and its Applications (IMA)
Workshop on Large Data Sets in Medical Informatics
Minneapolis, Minnesota
2011

Participant

NSF Workshop on Improving Domestic Student Participation
in Electrical and Computer Engineering Graduate Programs
University of Tennessee
Knoxville, Tennessee
2009

Participant

Workshop on Global Multimedia Mobile Communications
University of Illinois at Chicago
Chicago, Illinois
2005

Participant

Workshop on Extraction of Visual Information by Biological and Non-Biological Systems
University of Illinois at Chicago
Chicago, Illinois
2002

Participant

Workshop on Multimedia Information Systems
Capri, Italy
2001

Participant

NSF Advanced Networking Infrastructure Support
National Workshop on Developing Guidance
Research Competitiveness Program
Washington, D.C.
1999

Participant

Institute for Mathematics and its Applications (IMA)
Workshop on Applications and Theory of Random Sets
Minneapolis, Minnesota
1996

Panelist

VCIP 2015 Panel Discussion: What's Next in Visual Communications and Image Processing?
IEEE Conference on Visual Communications and Image Processing (VCIP)
Singapore
2015

K.10. Outreach Activities

Judge

Region 6 Science Fair Paper Session
Illinois Junior Academy of Science
Stevenson High School
Lincolnshire, Illinois
2022

Judge

State Science Fair Poster Session
Illinois Junior Academy of Science
Peoria Civic Center
Peoria, Illinois
2022

L. PUBLICATIONS

L.1. Thesis

- [1] D. Schonfeld, *Optimal Morphological Representation and Restoration of Binary Images: Theory and Applications*. Department of Electrical and Computer Engineering, The Johns Hopkins University, Baltimore, Maryland, 1990.

L.2. Books

- [1] C.-W. Chen, D. Schonfeld, and J. Liu, (Eds.), *Proceedings of the SPIE/IS&T International Conference on Visual Communications and Image Processing*. SPIE Press, 2007.
- [2] D. Schonfeld, C. Shan, D. Tao, and L. Wang, (Eds.), *Video Search and Mining*. Studies in Computational Intelligence Series, Springer-Verlag, 2010.

L.3. Book Chapters

- [1] M. Charif-Chefchaoui and D. Schonfeld, "Spatially-Variant Mathematical Morphology: Minimal Basis Representation," *Mathematical Morphology and Its Applications to Image and Signal Processing*. P. Maragos, R.W. Schafer, and M.K. Butt, (ed.), pp. 49-56, Kluwer Academic Publishers: Boston, Massachusetts, 1996.
- [2] D. Schonfeld, "Weighted Composite Order-Statistics Filters: Optimal Morphological Pattern Recognition," *Mathematical Morphology and Its Applications to Image and Signal Processing*. P. Maragos, R.W. Schafer, and M.K. Butt, (ed.), pp. 163-170, Kluwer Academic Publishers: Boston, Massachusetts, 1996.
- [3] D. Schonfeld, "Image and Video Communication Networks," (**Invited Chapter**). *Handbook of Image and Video Processing*. A. Bovik (ed.), Academic Press: San Diego, California, Chapter 9.3, pp. 717-732, 2000.
- [4] D. Lelescu and D. Schonfeld, "Video skimming and summarization based on principal component analysis," *Management of Multimedia on the Internet*, Lecture Notes in Computer Science, E.S. Al-Shaer and G. Pacifici (Eds.), Springer-Verlag, pp. 128-141, 2001.
- [5] F. Bashir, S. Khanvilkar, A. Khokhar, and D. Schonfeld, "Multimedia systems: Content based indexing and retrieval," (**Invited Chapter**). *Electrical Engineering Handbook*. W-K. Chen (ed.), Academic Press: San Diego, California, pp. 379-400, 2004.
- [6] S. Khanvilkar, F. Bashir, D. Schonfeld, and A. Khokhar, "Multimedia networks and communication," (**Invited Chapter**). *Electrical Engineering Handbook*. W-K. Chen (ed.), Academic Press: San Diego, California, pp. 401-425, 2004.
- [7] D. Schonfeld, "Video Communication Networks," (**Invited Chapter**). *Handbook of Image and Video Processing. Second Edition*. A. Bovik (ed.), Academic Press: San Diego, California, Chapter 9.3, pp. 1031-1064, 2005.
- [8] D. Schonfeld, "Video Communication Networks," (**Invited Chapter**). *The Essential Guide to Video Processing*. A. Bovik (ed.), Elsevier: Chennai, India, Chapter 16, pp. 473-526, 2009.

- [9] X. Ma, X. Chen, A. Khokhar, and D. Schonfeld, "Motion trajectory-based video retrieval, classification, and summarization," *Video Search and Mining*. Studies in Computational Intelligence Series, Springer-Verlag, pp. 53-82, 2010.
- [10] J. J. GadElkarim, D. Schonfeld, O. Ajilore, L. Zhan, A. Zhang, J.D. Feusner, P. M. Thompson, T. J. Simon, A. Kumar, and A. D. Leow, "A framework for quantifying node-level community structure group differences in brain connectivity networks," *Medical Image Computing and Computer-Assisted Intervention – MICCAI, Lecture Notes in Computer Science*. Vol. 7511, pp. 196-203, 2012.
- [11] N. Bouaynaya, R. Shterenberg, D. Schonfeld, and H. M. Fathallah-Shaykh, "Intervention and Control of Gene Regulatory Networks: Theoretical Framework and Application to Human Melanoma Gene Regulation," F. Emmert-Streib, and M. Dehmer, Matthias (eds.), *Statistical Diagnostics for Cancer: Analyzing High-Dimensional Data*. Wiley-VCH, Quantitative and Network Biology, 2013.
- [12] S. Friedland, Q. Li, D. Schonfeld, and E. A. Bernal, "Two algorithms for compressed sensing of sparse tensors," Boche H., Calderbank R., Kutyniok G., Vybíral J. (eds.), *Compressed Sensing and its Applications*. Springer-Verlag, pp. 259-281, 2015.
- [13] I. Fortel, M. Butler, L. E. Korthauer, L. Zhan, O. Ajilore, I. Driscoll, A. Sidiropoulos, Y. Zhang, L. Guo, H. Huang, D. Schonfeld, and A. Leow, "Brain dynamics through the lens of statistical mechanics by unifying structure and function," *Medical Image Computing and Computer-Assisted Intervention – MICCAI, Lecture Notes in Computer Science 11768*. (D. Shen et al., Eds.). Springer Nature Switzerland AG, pp. 503-511, 2019.

L.4. Journal Editorials

- [1] D. Schonfeld, J. Goutsias, I. Shmulevich, I. Tabus, and A.H. Tewfik, "Introduction to the issue on genomic and proteomic signal processing," *IEEE Journal of Selected Topics in Signal Processing*, Special Issue on Genomic and Proteomic Signal Processing, vol. 2, pp. 257-260, 2008.
- [2] S.-F. Chang, J. Luo, S. Maybank, D. Schonfeld, and D. Xu, "An Introduction to the special issue on event analysis in videos," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 18, pp. 1469-1472, 2008.
- [3] D. Schonfeld, "Perspectives on special issues," *IEEE Signal Processing Magazine*, vol. 26, issue 5, 2009.
- [4] D. Schonfeld, "The evolution of signal processing," *IEEE Signal Processing Magazine*, vol. 27, issue 5, 2010.
- [5] R. Chellappa, W. Heinzelman, J. Konrad, D. Schonfeld, and M. Wolf, "Introduction to Special Section on Distributed Camera Networks: Sensing, Processing, Communication, and Implementation," Special Section on Distributed Camera Networks: Sensing, Processing, Communication, and Implementation, *IEEE Transactions on Image Processing*, vol. 19, pp. 2513-2515, 2010.
- [6] D. Schonfeld, J. Biemond, G. de Haan, and A. Kaup, "Introduction to the issue on recent advances in video processing for consumer displays," *IEEE Journal of Selected Topics in Signal Processing*,

Special Issue on Recent Advances in Video Processing for Consumer Displays, vol. 5, pp. 213-216, 2011.

- [7] L. Di Stefano, C. Regazzoni, and D. Schonfeld, "Advanced Video-Based Surveillance," *EURASIP Journal on Image and Video Processing*, Special Issue on Advanced Video-Based Surveillance, Volume 2011, Article ID 857084, 2 pages, 2011.
- [8] D. Schonfeld and D. Li, "Signal Processing Trends in Media, Mobility, and Search," *IEEE Signal Processing Magazine*, vol. 28, issue 4, 2011.
- [9] L. Najman, J. Barrera, B. S. D. Sagar, P. Maragos, and D. Schonfeld, "Introduction to the issue on filtering and segmentation with mathematical morphology," *IEEE Journal of Selected Topics in Signal Processing*, vol. 6, pp. 737-738, 2012.
- [10] D. Schonfeld, "Editor-in-chief message," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 24, pp. 181-182, 2014.
- [11] D. Schonfeld, "Editor-in-chief message," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 25, p. 181, 2015.

L.5. Refereed Journal Papers

- [1] D. Schonfeld and J. Goutsias, "Optimal morphological pattern restoration from noisy binary images," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 13, pp. 14-29, 1991.
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- [179] D. Aggarwal, M. Zafar, D. Schonfeld, K. Avanaki, "Deep learning-boosted photoacoustic microscopy with an extremely low energy laser," *Proceedings of the SPIE BiOS Symposium Conference on Photons Plus Ultrasound: Imaging and Sensing*, San Francisco, California, 2022.
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- [182] M.M. Karaman, S. Maraka, T. Valyi-Nagy, S. Khalid, K. Slavin, G. Atwal, A. Daher, G. Dan, A. Scotti, Schonfeld, and X.J. Zhou, “Establishing a correlation between diffusion heterogeneity and tissue structural heterogeneity using stereotactic biopsies on brain tumors,” *Proceedings of the Annual Meeting of the International Society of Magnetic Resonance Imaging in Medicine (ISMRM)*, Toronto, Ontario, Canada, 2023.

L.7. Presentations

- [1] N. Bouaynaya and D. Schonfeld, “Protein communication channel: Analysis of proteomics and genomics based on signal processing and communication,” *The Fourth Annual Chicago Biomedical Consortium Symposium*, Chicago, Illinois, 2006.
- [2] N. Bouaynaya and D. Schonfeld, “Protein communication channel: Analysis of proteomics and genomics based on signal processing and communication,” *Biomedical Informatics Workshop*, Chicago, Illinois, 2006.
- [3] M. Dutta, D. Schonfeld, S. Liao, and M. Strosio, “Quantum Dot Blinking: Physical Limit for Nanoscale Optoelectronic Device,” *International Workshop of Computational Electronics*, Amherst, Massachusetts, 2007.
- [4] C. Chen and D. Schonfeld, “Spectral analysis of unstructured plenoptic sampling,” *Illinois Computer Vision Workshop*, Toyota Technological Institute at Chicago, Chicago, Illinois, 2009.
- [5] S. Zhao, D. Tuninetti, R. Ansari, and D. Schonfeld, “On the distortion exponent of block-fading Gaussian channels,” *Proceedings of the Information Theory and Applications Workshop*, San Diego, California, 2010.
- [6] N. Bouaynaya and D. Schonfeld, “Inverse perturbation for optimal intervention in genetic regulatory networks,” *Institute for Mathematics and its Applications (IMA) Workshop on Large Data Sets in Medical Informatics*, Minneapolis, Minnesota, 2011.
- [7] N. Bouaynaya and D. Schonfeld, “Intervention and control of large-scale gene regulatory networks,” *Institute for Mathematics and its Applications (IMA) Workshop on Large Data Sets in Medical Informatics*, Minneapolis, Minnesota, 2011.
- [8] J. J. GadElkarim, D. Schonfeld, O. Adjilore, A. Kumar, P. M. Thompson, and A. D. Leow, “Partition the human brain with binary trees using simulated annealing,” *Annual Meeting of the Organization for Human Brain Mapping (OHBM)*, Beijing, China, 2012.
- [9] Q. Li, D. Schonfeld, and S. Friedland, “Generalized tensor compressive sensing,” *Matheon-Workshop Compressed sensing and its Applications*, (Invited Lecture), Berlin, Germany, 2013.
- [10] C. Agarwal, E. Schonfeld, D. Schonfeld, B. Mokhlesi, and B. Prasad, “Predicting blood pressure response to sleep apnea treatment,” *IEEE International Conference on Biomedical and Health Informatics (BHI)*, Chicago, Illinois, 2019.

- [11] C. Agarwal, I. Imayama, E. Schonfeld, D. Schonfeld, B. Mokhlesi, and B. Prasad, "Prediction of acute blood pressure response to obstructive apneas and hypopneas using routine polysomnography data," *International Conference on Sleep & Breathing*, Tampere, Finland, 2019.

L.8. Patents

- [1] D. Schonfeld, K. Hariharakrishnan, P. Raffy, and F. Yassa, "Object tracking using adaptive block-size matching along object-boundary and frame skipping when object motion is low," U.S. Patent No. 7095786, Patent Issued August 28, 2006.
- [2] D. Schonfeld, K. Hariharakrishnan, P. Raffy, and F. Yassa, "Occlusion/disocclusion detection using K-means clustering near object boundary with comparison of average motion of clusters to object and background motions," U.S. Patent No. 7142600, Patent Issued November 28, 2006.
- [3] W. Qu, D. Schonfeld, and M. Mohamed, "Method and Apparatus to Disambiguate State Information for Multiple Items Tracking," Patent Application, Filed October 13, 2006.
- [4] W. Qu, D. Schonfeld, and M. Mohamed, "Method and Apparatus to facilitate use of conditional probabilistic analysis of multi-point-of-reference samples of an item to disambiguate state information as pertains to the item," Patent Application, Filed December 15, 2006.
- [5] D. Schonfeld and N. Bouaynaya, "Dynamic tree programming – Extension of the Viterbi algorithm to multidimensional systems," Provisional Patent, Filed February 19, 2006.
- [6] D. Schonfeld, K. Hariharakrishnan, P. Raffy, and F. Yassa, "Object tracking using adaptive block-size matching along object-boundary and frame skipping when object motion is low," Patent Application 12/324,481, Filed November 26, 2008.
- [7] D. Schonfeld, K. Hariharakrishnan, P. Raffy, and F. Yassa, "Occlusion/disocclusion detection using K-means clustering near object boundary with comparison of average motion of clusters to object and background motions," U.S. Patent No. RE42790 E, Patent Issued October 4, 2011.

M. KEYNOTE AND PLENARY TALKS

Stochastic noise process enhancement of nonlinear filtering

INPT/ASME International Conference on Communications, Signals and Systems
Rabat, Morocco
1995

VORTEX: Video Retrieval and Tracking from Compressed Multimedia Databases

INPT/ASME International Conference on Communications, Signals and Systems
Rabat, Morocco
2001

MotionSearch: Content-Based Video Retrieval and Activity Recognition in Video Surveillance

IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS)
Genoa, Italy
2009

Distributed Multi-Camera Networks: Graphical Models, Tensor Representation, and Plenoptic Functions

IEEE International Conference on Networking, Sensing, and Control (ICNSC)
Chicago, Illinois
2010

Signal Processing for Distributed Multi-Camera Networks: Theory and Applications

IEEE/IET International Conference on Audio, Language and Image Processing (ICALIP)
Shanghai, China
2010

The Visual Brain: Biologically-Inspired Imaging and Vision

International Conference on Intelligent Control and Information Processing (ICICIP)
International Conference on Brain Inspired Cognitive Systems (BICS)
Beijing, China
2013

Distributed Multi-Camera Networks: Graphs, Grammars, and Tensors

International Conference on Wireless Communications and Signal Processing (WCSP)
Yangzhou, China
2016

University of Illinois – New Oriental Artificial Intelligence Research Laboratory

N-Brain Alliance Launch & Product Release Conference
New Oriental AI Research Academy
Beijing, China
2018

AI Technology in Education and Academic Thinking

Think for Education Conference (TEC) AI+Education
Beijing, China
2018

Advances in Deep Learning: Theory and Applications

IEEE International Conference on Computer, Electrical and Communication Engineering (ICCECE)
Kolkata, India
2023

N. INVITED SEMINARS

Optimal morphological representation and detection of binary images

Department of Electrical Engineering and Computer Science
Northeastern University
Boston, Massachusetts
1990

Optimal morphological representation and detection of binary images

The Johns Hopkins University
Applied Physics Laboratory

Laural, Maryland
1990

Optimal morphological representation and detection of binary images

Center for Automation Research
University of Maryland
College Park, Maryland
1990

Optimal morphological representation and restoration of binary images: Theory and applications

Department of Electrical and Computer Engineering
Illinois Institute of Technology
Chicago, Illinois
1990

Optimal morphological representation and restoration of binary images: Theory and applications

Department of Electrical and Computer Engineering
University of California
Santa Barbara, California
1990

Optimal morphological representation and restoration of binary images: Theory and applications

Department of Electrical Engineering and Computer Science
Northwestern University
Evanston, Illinois
1991

Morphological image processing and analysis: Theory and applications

Department of Electrical and Computer Engineering
University of Illinois
Urbana-Champaign, Illinois
1992

Morphological image representation: Theory and applications

DOD Tri-Service Workshop on Stochastic Methods in Image Analysis
U.S. Army Harry Diamond Laboratories
Adelphi, Maryland
1992

Morphological representation of nonlinear filters: Theory and applications

Department of Electrical and Computer Engineering
Illinois Institute of Technology
Chicago, Illinois
1993

Morphological image representation: Theory and applications

ONR Workshop on Vision and Optical Information Processing
Arlington, Virginia

1994

Nonlinear Signal and Image Processing

Department of Electrical Engineering and Computer Science

University of Illinois

Chicago, Illinois

1996

Nonlinear Operators: Theory and Application to Image Processing and Communications

School of Electrical and Computer Engineering

Technion – Israel Institute of Technology

Haifa, Israel

1996

Stochastic Noise Process Enhancement of Nonlinear Filtering

Department of Electrical Engineering

Northern Illinois University

DeKalb, Illinois

1996

Morphological Signal and Image Processing: Theory and Applications

Department of Electrical Engineering—Systems

University of Tel-Aviv

Tel-Aviv, Israel

1997

VORTEX: Video Retrieval and Tracking from Compressed Multimedia Databases

Department of Electrical and Computer Engineering

Illinois Institute of Technology

Chicago, Illinois

2001

Mathematical Morphology and Computer Vision

University of Illinois at Chicago

Chicago, Illinois

2002

VORTEX: Video Retrieval and Tracking from Compressed Multimedia Databases

Department of Electrical and Computer Engineering

Drexel University

Philadelphia, Pennsylvania

2002

Time-Series Analysis Based on Statistical Signal Processing:

Segmentation, Prediction, and Tracking

Global Electronic Trading Company (Getco)

Chicago, Illinois

2004

Particle Filtering for Head Tracking in Wireless Communications

Motorola Research Labs

Schaumburg, Illinois
2004

Real-Time Video Communications: Compression, Tracking, Retrieval, and Networking

University of Illinois
Chicago, Illinois
2005

Real-Time Video Tracking and Retrieval from Multimedia Databases

Motorola Research Labs
Schaumburg, Illinois
2005

**Real-Time Multiple Object Tracking and Motion Trajectory-Based Video Databases:
Indexing, Retrieval, and Activity Recognition**

Hewlett-Packard Research Labs
Haifa, Israel
2005

Real-Time Video Tracking Based on Particle Filtering

University of Illinois
Chicago, Illinois
2005

**Real-Time Collaborative Distributed Tracking and Trajectory Analysis from Multiple
Camera and Sensor Networks**

School of Electrical and Computer Engineering
Purdue University
West Lafayette, Indiana
2005

**A New Method for Multidimensional Optimization and Its Application in Image and Video
Processing**

Department of Electrical Engineering and Computer Science
Northwestern University
Evanston, Illinois
2006

Protein Communication System: Evolution and Genomic Structure

Department of Electrical and Computer Engineering
University of Illinois at Urbana-Champaign
Urbana-Champaign, Illinois
2006

Protein Communication System: Evolution and Genomic Structure

Bioinformatics Group
Mathematics and Computer Science Division
Argonne National Laboratory
Argonne, Illinois
2006

**Distributed Image and Video Processing:
Directed Graphs, Bayesian Estimation, and Hidden Markov Models**
College of Information Science and Engineering
Graduate School
Chinese Academy of Science
Beijing, P.R. China
2007

**Distributed Image and Video Processing:
Directed Graphs, Bayesian Estimation, and Hidden Markov Models**
Visual Computing Group
Microsoft Research Asia
Beijing, P.R. China
2007

**Distributed Image and Video Processing:
Directed Graphs, Bayesian Estimation, and Hidden Markov Models**
School of Electronic and Information Institute
Tongji University
Shanghai, P.R. China
2007

**Distributed Image and Video Processing:
Directed Graphs, Bayesian Estimation, and Hidden Markov Models**
School of Automation
Institute of Automation
Hangzhou Dianzi University
Hangzhou, P.R. China
2007

**Distributed Image and Video Processing:
Directed Graphs, Bayesian Estimation, and Hidden Markov Models**
Department of Information Science and Electronic Engineering
Institute of Information and Communication Systems
Zhejiang University
Hangzhou, P.R. China
2007

InteractiveVision: Distributed Image and Video Processing
Intellectual Property Technical Lecture Series
McAndrews, Held & Malloy, Ltd.
Chicago, Illinois
2007

**Distributed Image and Video Processing:
Directed Graphs, Bayesian Estimation, and Hidden Markov Models**
Departments of Computer Science and Electrical & Computer Engineering
Technion, Israel Institute of Technology
Haifa, Israel
2007

MotionSearch: Content-Based Video Retrieval and Classification

Joint Chapters of the IEEE
Rochester, New York
2008

Evolution and Genomic Structure: A Signal Processing Perspective

Bioinformatics Cluster
University of Rochester
Rochester, New York
2008

Evolution and Genomic Structure: A Signal Processing Perspective

Department of Electrical Engineering
Columbia University
New York, New York
2008

Evolution and Genomic Structure: A Signal Processing Perspective

Department of Electrical Engineering and Computer Science
Northwestern University
Evanston, Illinois
2008

MotionSearch: Content-Based Video Retrieval and Classification

Distinguished Speaker in the Joint College Colloquium Series
College of Engineering and Information Technology and College of Science and Mathematics
Department of Applied Science
University of Arkansas at Little Rock
Little Rock, Arkansas
2008

Evolution and Genomic Structure: A Signal Processing Perspective

Department of Electrical and Computer Engineering
University of Wisconsin – Madison
Madison, Wisconsin
2008

MotionSearch: Content-Based Video Retrieval and Classification

Department of Electrical & Computer Engineering
Tufts University
Medford, Massachusetts
2009

MotionSearch: Content-Based Video Retrieval and Classification

Department of Electrical & Microelectronics Engineering
Rochester Institute of Technology
Rochester, New York
2009

MotionSearch: Content-Based Video Retrieval and Classification

School of Computer Engineering

Nanyang Technological University
Singapore
2009

Distributed Multi-Camera Networks: Graphical Models, Tensor Representation, and Plenoptic Functions

Department of Electrical and Computer Engineering
Illinois Institute of Technology
Chicago, Illinois
2010

Personalized Visual Interaction: Robust Video-Conferencing and Human-Computer Interaction Using a Two-Camera Computer System

Qualcomm Corp.
San Diego, California
2010

Evolution and Genomic Structure: A Signal Processing Perspective

Department of Information Engineering and Computer Science - DISI
Microsoft Research-University of Trento Centre for Computational and Systems Biology
University of Trento
Trento, Italy
2010

A Novel Cache Optimization Algorithm and Video Streaming Protocol for Pure Peer-to-Peer Networks

Motorola Research Labs
Schaumburg, Illinois
2010

Distributed Multi-Camera Networks: Graphical Models, Tensor Representation, and Plenoptic Functions

Research Center of Automation
Northeastern University
Shenyang, P.R. China
2010

Distributed Multi-Camera Networks: Graphical Models, Tensor Representation, and Plenoptic Functions

School of Automation and Electric Engineering
Zhejiang University of Science and Technology
Hangzhou, P.R. China
2010

Distributed Multi-Camera Networks: Graphical Models, Tensor Representation, and Plenoptic Functions

Center for OPTical IMagery Analysis and Learning (OPTIMAL)
State Key Laboratory of Transient Optics and Photonics
Xi'an Institute of Optics and Precision Mechanics
Chinese Academy of Sciences
Xi'an, P.R. China

2010

Distributed Multi-Camera Networks: Graphs, Grammars, and Tensors

Dean's Leadership in Innovation Seminar Series

Advanced Analytics Institute (AAI)

University of Technology

Sydney, Australia

2012

Genomic Signal Processing: Evolution, Structure, and Regulation

Dean's Leadership in Innovation Seminar Series

Advanced Analytics Institute (AAI)

University of Technology

Sydney, Australia

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Distributed Multi-Camera Networks: Theory and Applications

Harbin Engineering University (HEU)

Harbin, China

2014

Distributed Multi-Camera Networks: Theory and Applications

Electrical and Computer Engineering Graduate Program

Ryerson University

Toronto, Canada

2014

Genomic Signal Processing: Evolution, Structure, and Regulation

Distinguished Lecturer Seminar Series

Electrical Engineering Department

The Pennsylvania State University

University Park, Pennsylvania

2015

Genomic Signal Processing: Evolution, Structure, and Regulation

School of Electrical & Electronic Engineering

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2015

O. GRADUATE STUDENTS AND VISTING SCHOLARS

O.1. Visiting Scholars

Mohammed Charif-Chefchaoui

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago

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1995

Position: Director and Professor, National Institute of Postes and Telecommunications, Morocco.

Yuesong Lin

Department of Electrical and Computer Engineering
University of Illinois at Chicago
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2007

Position: Professor, Institute of Information and Control, Hangzhou Dianzi University, Hangzhou, P.R. China.

Haihong Chi

Department of Electrical and Computer Engineering
University of Illinois at Chicago
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2010

Position: Associate Professor, College of Automation, Harbin Engineering University (HEU), Harbin, P.R. China.

Claudio Piciarelli

Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
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2010

Position: Postdoctoral Fellow, Department of Mathematics and Computer Science, University of Udine, Udine, Italy.

O.2. Postdoctoral Fellows

Mohammed Charif-Chefchaoui

Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1994

Position: Director and Professor, National Institute of Postes and Telecommunications, Morocco.

O.3. Visiting Students

Alessio Dore

Department of Electrical and Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2008

Former Position: Doctoral Candidate, DIBE - Department of Biophysical and Electronic Engineering, University of Genova, Genoa, Italy.

Current Position: Postdoctoral Fellow, Imaging Sciences Centre, Institute of Biomedical Engineering, Imperial College, London, United Kingdom.

Yunmei Gong

Department of Electrical and Computer Engineering

University of Illinois at Chicago
Chicago, Illinois
2008-09

Current Position: Doctoral Candidate, Information and Communication Engineering, College of Electronics and Information Engineering, Tongji University, Shanghai, P.R. China.

Nicola Piotto

Department of Electrical and Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2010

Current Position: Doctoral Candidate, Department of Engineering and Computer Science – DISI, Multimedia Signal Processing and Understanding Lab – MMLab, University of Trento, Trento, Italy.

O.4. Doctoral Students

Mohammed Charif-Chefchaoui

“Morphological Representation of Nonlinear Filters: Theory and Applications”

Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1993

Former Position: Professor, National Institute of Postes and Telecommunications, Rabat, Morocco.

Current Position: Director, National Institute of Postes and Telecommunications, Rabat, Morocco.

Dan Lelescu

“VORTEX: Video Retrieval and Tracking from Compressed Multimedia Databases”

Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
2000

Former Position(s): Senior Research Scientist, Lead of Algorithms Group, Compression Sciences, Campbell, California, USA; Senior Researcher, NTT DoCoMo Communications Laboratories USA, San Jose, California, USA; Principal Scientist, Advanced Imaging Research & Development Laboratory, Micron Technology, California, USA; Chief Scientist, Pelican Imaging Corporation, Mountain View, California, USA; Chief Scientist, Emergent VR, Campbell, California, USA.

Current Position: Engineer, Apple, Cupertino, California, USA.

Bulent Cavusoglu

“Real-Time Content-Based Video Communications over Heterogeneous Networks”

(Jointly Supervised with Prof. Rashid Ansari)

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2005

Current Position: Professor, Ataturk University, Erzurum, Turkey.

Faisal Bashir

“MotionSearch: Object Motion Trajectory-Based Video Search and Classification System”

(Jointly Supervised with Prof. Ashfaq Khokhar)

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2006

Internship: Mitsubishi Electric Research Laboratory (MERL), USA.

Former Position(s): Intern, Mitsubishi Electric Research Laboratory (MERL), Cambridge, Massachusetts, USA; Senior Imaging Scientist, Retica Systems, Inc., Waltham, Massachusetts, USA; Senior Vision Engineer, Heartland Robotics, Cambridge, Massachusetts, USA.

Current Position: Senior Principal Engineer – Advanced Development Group, Security and Detection Systems, L-3 Communications, Woburn, Massachusetts, USA.

Wei Qu

“Real-Time Distributed Video Tracking of Multiple Objects from Single and Multiple Cameras”

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2006

Internship: Mitsubishi Electric Research Laboratory (MERL), USA; Siemens Medical Systems, USA.

Former Position(s): Senior Research Scientist, Motorola Research Labs, Schaumburg, Illinois, USA; Senior Scientist, Siemens Medical Solutions USA, Hoffman Estates, Illinois, USA; Associate Professor, Graduate University of Chinese Academy of Sciences, Beijing, China; CEO Special Assistant, Director of Technology, President of CSST Research, Hong Kong; Vice President, R&D, Special Assistant to CEO, President of Beijing Research Institute, Beijing, China; Co-Founder, SmartVision Technology, Beijing, China.

Current Position: President, Artificial Intelligence Research Institute, New Oriental Education & Technology Group Inc., Beijing, China.

Nidhal Bouaynaya

“Analysis of Proteomics and Genomics Based on Signal Processing and Communication Theory”

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2007

Former Position: Assistant Professor, Department of Systems Engineering, University of Arkansas at Little Rock, Little Rock, Arkansas, USA.

Current Position: Associate Dean for Research & Graduate Studies, Rowan University, Glassboro, New Jersey, USA.

Hunsop Hong

Constrained and Hierarchical Density Estimation for Image Reconstruction and Sensor Networks

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2008

Current Position: Senior Research Engineer, Samsung Information Systems America, Irvine, California, USA.

Pan Pan

Video Tracking Based on Particle Filters: Particle Allocation, Graphical Models, and Performance Evaluation

Department of Electrical & Computer Engineering

University of Illinois at Chicago
Chicago, Illinois
2009

Internship: NTT Research Laboratory, Japan; Mitsubishi Electric Research Laboratory (MERL), USA.
Former Position: Senior Researcher, Project Manager, Fujitsu Research and Development, Beijing, China.

Current Position: Technical Director, Alibaba Group, Beijing, China.

Xiang Ma

Motion Trajectory-Based Video Retrieval and Recognition: Tensor Analysis and Multi-Dimensional Hidden Markov Models

(Jointly Supervised with Prof. Ashfaq Khokhar)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2009

Internship: Knowledge Media Institute, Open University, United Kingdom; Siemens Medical Solutions USA, Hoffman Estates, Illinois, USA; Computer Vision Research Engineer, IntuVision, Inc., Woburn, Massachusetts, USA.

Former Position: Senior Research Scientist and Engineer, IntuVision, Inc., Woburn, Massachusetts, USA; Lead Engineer – 3D Maps & Reality Capture Processing, Nokia, Chicago, Illinois, USA; Research Manager, Manager of Engineering – Computer Vision, Artificial Intelligence R&D, HERE Technologies, Chicago, Illinois, USA.

Current Position: Applied Science Manager – Computer Vision and Artificial Intelligence, Amazon, Boston, Massachusetts, USA.

Junlan Yang

Virtual Video Enhancement for Handheld Mobile Cameras: Stabilization, Auto-Focus, and Super-Resolution

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2009

Internship: Ricoh Research Laboratory, Menlo Park, California, USA; Sharp Laboratories of America, USA.

Former Position: Senior Software Engineer, iKoa Corporation, Menlo Park, California, USA; Research Scientist, Marseille Networks, Santa Clara, California, USA.

Current Position: Software Engineer, Google LLC, Mountain View, California, USA.

Chong Chen

Multi-Camera Vision Systems: Distributed Pose Estimation and Plenoptic Imaging

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2009

Internship: Siemens Research Laboratory, USA; FX Palo Alto Laboratory (FXPAL), USA; Abbott Laboratories, USA.

Former Position: Senior Research Engineer, Samsung Information Systems America, Irvine, California, USA.

Current Position: Video Engineer, Apple, Cupertino, California, USA.

Xu Chen

Localization and Trajectory Estimation of Mobile Objects from a Single Sensor

(Jointly Supervised with Prof. Ashfaq Khokhar)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2010

Internship: Institute of Electrical Engineering, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland; Kodak Research Laboratories, USA.

Former Position(s): Postdoctoral Fellow, Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan, USA; Postdoctoral Fellow, Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina, USA; Senior Researcher, Sharp Laboratories of America, Camas, Washington, USA.

Current Position: Senior Machine Learning Developer, SAS, Cary, North Carolina, USA.

Lei Gao

Compiler Optimization for Translating Software Binaries onto FPGAs

(Jointly Supervised with Prof. Prith Banerjee)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2010

Internship: Binachip, Inc., Chicago, Illinois, USA.

Former Position: Senior Engineer, Binachip, Inc., Chicago, Illinois, USA.

Current Position: Staff R&D Engineer, Synposis, Inc., Marlborough, Massachusetts, USA.

Liuling Gong

Machine Learning for Signal Processing:

Geometry, Kernels, and Symbolic Sequences

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2010

Internship: eBay Research Labs, USA.

Former Position: Postdoctoral Fellow, Center for the Study of Complex Systems, University of Michigan, Ann Arbor, Michigan, USA; Seismic Imager, CGGVeritas, Houston, Texas, USA; Data Scientist, GE Oil & Gas, Houston, Texas, USA.

Current Position: Data Scientist, Equinor, Houston, Texas, USA.

Songqing Zhao

Multiple Description Coding for Correlated Multi-Path Networks

(Jointly Supervised by Profs. Rashid Ansari and Daniela Tuninetti)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2010

Internship: Mitsubishi Electric Research Laboratory (MERL), USA.

Former Position: Voice and Data Quality Engineer, Voice & Data Quality and Performance Analysis Group, Alcatel-Lucent, Murray Hill, New Jersey, USA.

Current Position: Senior Wireless Engineer, Apple, Cupertino, California, USA.

Xiangqiong Shi

Bayesian Networks: Performance Analysis of Loopy Belief Propagation

(Jointly Supervised with Prof. Daniela Tuninetti)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2011

Internship: Motorola Research Labs, Schaumburg, Illinois, USA; Technicolor, Research & Innovation, Princeton, New Jersey, USA; Nokia Research Center, Palo Alto, California, USA.

Former Positions: Software Engineer, Volkswagen of America, Electronics Research Lab, Herndon, Virginia, USA; Software Engineer, Apple, Cupertino, California, USA.

Current Position: Software Engineer, Ouster, San Francisco, California, USA.

Liming Wang

Genomic Signal Processing and Regulatory Networks: Representation, Dynamics and Control

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2011

Former Position: Postdoctoral Fellow, Department of Electrical Engineering, Columbia University, New York, New York, USA; Postdoctoral Associate, Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina, USA; Postdoctoral Associate, Department of Electrical and Computer Engineering, Ohio State University, Columbus, Ohio, USA.

Current Position: Lead Data Scientist, HERE Technologies, Chicago, Illinois, USA.

Jing Huang

Distributed Signal and Image Processing:

Particle Filters, Context Grammars, and Dynamic Games

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2013

Internship: Fuji Xerox Palo Alto Laboratory (FXPAL), Palo Alto, California, USA; Motorola Mobility, Applied Research Center, Libertyville, Illinois, USA; Nokia Research Center, Berkeley, California, USA.

Former Positions: Software Development Engineer, TeraRecon, Inc., Foster City, California, USA; Senior Deep Learning Software Engineer, Intel Artificial Intelligence, Intel Corporation, Santa Clara, California.

Current Position: Software Engineer, Microsoft Artificial Intelligence & Research, Bellevue, Washington, USA.

Qun Li

Multilinear Algebra in High-Order Data Analysis: Retrieval, Classification and Representation

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2013

Internship: Xerox Research Center, Xerox Innovations Group, Webster, New York, USA.

Former Positions: Research Scientist, Xerox Research Center, Xerox Innovations Group, Webster, New York, USA; Research Scientist, PARC, A Xerox Company, Palo Alto, California, USA.

Current Position: Senior Data Scientist, Microsoft, Bellevue, Washington, USA;

Johnson Jonaris GadElkarim Keiriz

From Micro to Macro: A Study of Human Brain Structure Based on Diffusion MRI and Neuronal Networks

(Jointly Supervised by Profs. Alex Leow and Richard Magin)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2013

Former Position: Postdoctoral Fellow, Department of Psychiatry, University of Illinois, Chicago, Illinois, USA; Lead Developer, nView medical Inc., Salt Lake City, Utah, USA; Research Scientist, Tamaggo, Montreal, Quebec, Canada; Research Scientist – Senior Software Engineer, Object Research Systems (ORS) Inc., Montreal, Quebec, Canada; Research Associate, Electronic Visualization Laboratory (EVL), University of Illinois at Chicago (UIC), Chicago, Illinois; USA.

Current Position: Principal CT Software Engineer, Canon Medical Research USA, Inc. Vernon Hills, Illinois, USA.

Lingdao Sha

When Sparsity Meets Graphs, Images, Structured and High-Dimensional Data

(Jointly Supervised with Prof. Jing Wang)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2018

Current Position: Senior Machine Learning Scientist, Tempus Labs, Inc., Chicago, Illinois, USA.

Haoyu Wang

Depth-constrained Feature-based Stitching System for Stereoscopic Panoramic Video Generation

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2019

Current Position: Computer Vision Engineer, Blackmagic Design, Colorado Springs, Colorado, USA.

Mehdi Sharifzadeh

Steganography and Steganalysis of Raw and Compressed Image Data

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2019

Internships: Software Engineering Intern, Google Brain, Mountain View, California, USA; Data Scientist Intern, Western Digital, Milpitas, California, USA; Data Scientist Intern, SanDisk, Milpitas, California, USA.

Previous Position: Research Engineer, Snap, Inc., Santa Monica, California, USA.

Current Position: Software Engineer, Google, Inc., Los Angeles, California, USA.

Chirag Agarwal

Robustness and Explainability of Deep Neural Networks: Architectures and Applications

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2020

Internships: Research Intern, Geisinger Health Systems, Danville, Pennsylvania, USA; Research and Development Intern, Kitware Inc., Clifton Park, New York, USA; Imaging Science Intern, Tempus Labs Inc., Chicago, Illinois, USA; Computer Vision / Augmented Reality Intern, Robert Bosch LLC, Farmington Hills, Michigan, USA.

Previous Position: Postdoctoral Research Fellow, Department of Computer Science, Department of Biomedical Informatics, and Business School, Harvard University, Cambridge, Massachusetts, USA.

Current Position: Research Scientist, Media and Data Science Research Laboratory, Adobe Research, Bangalore, India.

Mohammed Aloraini

Digital Media Forgery Detection

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2020

Current Position: Assistant Professor, Qassim University, Buraydah, Qassim, Saudi Arabia.

Igor Fortel

Excitation-Inhibition Balance: A Study of Brain Network Dynamics Using Statistical Mechanics

(Jointly Supervised by Prof. Alex Leow)

Video Steganography

Department of Biomedical Engineering

University of Illinois at Chicago

Chicago, Illinois

2021

Current Position: Systems Design Engineer, T-Mobile, Chicago, Illinois; Research Specialist, University of Illinois at Chicago, Chicago, Illinois.

O.5. Masters Thesis Students

Vladimir Pavlovic

“Stochastic Noise Process Enhancement of Hopfield Neural Networks”

(Jointly Supervised with Prof. Gary Friedman)

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago

Chicago, Illinois

1993

Position: Associate Professor, Department of Computer Science, Rutgers University, New Jersey, USA.

Deepak K. Bal

“Transmission of Real-Time MPEG-2 Video Over Differentiated Services Networks”

(Jointly Supervised with Prof. Rashid Ansari)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2003

Position: Takata, Inc., Michigan, USA.

Karthik Hariharakrishnan

“Visual Tracking: New Methods Using Adaptive Block Matching and Particle Filters”

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2003

Internship: NeoMagic Corp., USA.

Previous Position(s): National Instruments, India; Motorola, India; Senior Design Engineer, ARM, Ltd., United Kingdom.

Current Position: Staff Software Engineer, ARM, Ltd., United Kingdom.

Subhash Balam

“Associative Processors for Video Coding”

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2004

Position: Senior Staff Engineer/Manager, Qualcomm Corp., California, USA.

Emir Mulabegovic

“Lightweight Streaming Protocol for Real-Time Video Communications”

(Jointly Supervised with Prof. Rashid Ansari)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2005

Former Position: PCTEL, Illinois, USA.

Current Position: Systems Architect, Personal, Inc., Sarajevo, Bosnia and Herzegovina.

Andrea De Mauro

“A Peer-to-Peer Network for Real-Time Multiple-Description Video Communications Using Multiple Paths”

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2006

Former Position: Financial Solutions Systems Analyst, Procter & Gamble, Newcastle, United Kingdom.

Current Position: Business Intelligence Manager, Procter & Gamble, Newcastle, Rome, Italy.

Claudio Rossi

“A Partially-Reliable Multihomed Transport Protocol for Real-Time Multiple-Description Multimedia Traffic”

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2006

Position: Area Manager, IBM, Milan, Italy.

Amita Talati

Design and Evaluation of Data Compression and Decompression Applications on Field Programmable Gate Arrays

(Jointly Supervised with Prof. Prith Banerjee)
Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2008

Former Position: Customer Applications Engineer, Newark Corporation, Cleveland, Ohio, USA.
Current Position: Senior Engineer, Newark Corporation, Cleveland, Ohio, USA.

Carlo Giulietti

A Novel Cache Optimization Algorithm and Protocol for Video Streaming in Pure Peer-to-Peer Networks

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2010

Position: Software Engineer, Astek, Sophia Antipolis, France.

Edmond Gjondrekaj

Clustering and Similarity Analyses of miRNA Assay by Means of Reprogrammable Devices

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2010

Alberto Mannari

Enhanced Frame Buffer Management for HEVC Encoders and Decoders

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2015

Position: Specialist Electronics Engineer, Teoresi Inc., Burr Ridge, Illinois.

Vasundhara Goyal^[1]

Generation of Stereoscopic Video From Monocular Image Sequences Based on Epipolar Geometry

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2017

Akreem Talal Mohammed Saeed

Location Based Assistant on Android Platform

Department of Electrical & Computer Engineering
University of Illinois at Chicago
Chicago, Illinois
2017

Lorenzo Norcini

Attention-Guided Mask Propagation for Video Object Segmentation

Department of Computer Science
University of Illinois at Chicago
Chicago, Illinois

2019

Position: Software Engineer, Amazon, Seattle, Washington.

Francesca Pistilli

GraphPointNet: Graph Convolutional Neural Network for Point Cloud Denoising

Department of Electrical & Computer Engineering

University of Illinois at Chicago

Chicago, Illinois

2019

Position: Doctoral Student, Politecnico di Torino, Turin, Italy.

O.6. Masters Project Students

Neil Zalut

“Linear Restoration of Medical Images: An Overview”

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago

Chicago, Illinois

1993

Branislav Kisacanin

“A Fast Thresholded Linear Convolution Representation of Morphological Operations”

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago

Chicago, Illinois

1993

Alan Baumgartner

“Morphological Segmentation of Computed Tomography Images”

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago

Chicago, Illinois

1994

Alvin Ng

“Spatially-Variant Morphological Skeleton Representation”

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago

Chicago, Illinois

1994

Smriti Anand

“Efficient Fast Reconstruction Algorithms in Computerized Tomography”

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago

Chicago, Illinois, May 1995

Stephan W. Wegerich

“Subband Image Restoration and Blur Identification Using the EM Algorithm and Cross-Filtering”

Department of Electrical Engineering and Computer Science

University of Illinois at Chicago
Chicago, Illinois
1995

Robert Werckmeister

“Performance Analysis of Video Communications in Multimedia Networks”
(Jointly Supervised with Prof. Ouri Wolfson)
Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1996

Margaret Kelton

“A Fast Method for Transform Conversion for Use in Image Processing”
Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1998

Kailash Ravishankar

“Frequency Prediction of High-Order Autoregressive Moving Average Sequences”
Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1998

Amir Yafe

“Transmission of MPEG-2 Streams Over Packet-Switched Networks”
Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1998

Steven J. Doering

“Digital Modulation: Applications to CDMA Communication Systems (IS-95)”
Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1999

Abhijit Bhattacharya

“MPEG-1 and H.263 Video Decoding on Motorola GSM Cellular Phone”
Department of Electrical Engineering and Computer Science
University of Illinois at Chicago
Chicago, Illinois
1999

Qin Cai

“Differentiated Transmission of MPEG-2 Video Bitstream Over Communication Networks”
(Jointly Supervised with Prof. Rashid Ansari)
Department of Electrical Engineering and Computer Science

University of Illinois at Chicago
Chicago, Illinois
2000

P. RESEARCH GRANTS

D. Schonfeld (PI)
“Morphological image representation: Theory and applications”
Office of Naval Research (ONR)
\$150,000
1991-1995

S. Corson (PI) and D. Schonfeld (Co-PI)
“Parallel processing research”
University of Illinois
Campus Research Board (CRB)
\$14,995
1994-1995

R. Ansari (PI), P. Hesketh (Co-PI), and D. Schonfeld (Co-PI)
“One-step process for instant ticket validation”
GTECH Corporation
\$5,000
1997

D. Schonfeld (PI)
“National Communications Forum”
International Engineering Consortium (IEC)
\$500
2000

D. Schonfeld (PI)
“Real-Time Very-Low Bit-Rate MPEG-4 Video Compression for Wireless Communication Application”
Neomagic Corporation
\$69,553
2001-2003

A. Khokhar (PI), R. Ansari (Co-PI), R. Grossman (Co-PI), D. Schonfeld (Co-PI), and C. Yu (Co-PI)
“High-Speed Terabyte Storage Server Based on Intelligent Disk Technology”
Army Research Office (ARO)
DURIP Program
\$422,626
2002-2004

D. Schonfeld (PI)
“Computer Architectures for Real-Time Video Communications”
Neomagic Corporation
\$76,075

2002-2004

M. Dutta (PI) et al.
“Design of a Super-Biological Eye Sensor System”
Defense Advanced Research Projects Agency (DARPA)
Army Research Office (ARO)
\$200,000 (Seed Project)
2002-2003

D. Schonfeld (PI)
“OMAP Code Composure Studio Software for Real-Time Video Communications”
Texas Instruments, Inc.
DSP University Program
\$4,500
2003

D. Schonfeld (PI)
“Real-Time Object Tracking of Video Sequences on Associative Processor Arrays”
Neomagic Corporation
\$68,750
2003-2005

D. Schonfeld (PI)
“Real-Time Low-Power High-Quality Interactive Video Telephony
for Wireless Communication Applications”
Motorola, Inc.
\$19,331
2004-2005

D. Schonfeld (PI)
“Real-Time Low-Power High-Quality Interactive Video Communications
for Video Animation and Stereography”
Motorola, Inc.
\$22,000
2005-2006

D. Schonfeld (PI)
“Real-Time High-Quality Video Communications from Handheld Cameras
Using Video Stabilization and Auto-Focus”
Motorola, Inc.
\$75,000
2005-2008

D. Schonfeld (PI)
“Interactive Video Communications Based on Stereographic Imaging
From a Single Camera”
Motorola, Inc.
\$22,000
2006-2007

A. Khokhar (PI) and D. Schonfeld (Co-PI)

“MotionSearch: Motion Trajectory-Based Object Activity Retrieval and Recognition from Video and Sensor Databases”

National Science Foundation (NSF)

\$410,000

2006-2009

D. Schonfeld (PI)

“Real-Time Financial Forecasting Based on Statistical Signal Processing:
Correlation Analysis and Fast Algorithms”

Gelber Group

\$66,522

2006-2007

D. Schonfeld (PI)

“Signal Communication and Processing in a RFID Sensor Network System”

Your Life Essentials

\$4,000

2006-2008

D. Schonfeld (PI)

“MobilePlenoptics: Panoramic Video Communications in Mobile Devices”

Motorola, Inc.

\$22,000

2007-2008

D. Schonfeld (PI)

“Machine Learning and Event Detection in Biological Systems”

VG Bioinformatics, Inc.

\$40,000

2007-2008

A. Khokhar (PI) and D. Schonfeld (Co-PI)

“International Supplement to MotionSearch: Motion Trajectory-Based Object Activity Retrieval and Recognition from Video and Sensor Databases”

National Science Foundation (NSF)

\$37,468

2007-2008

D. Schonfeld (PI)

“InteractiveVision: Collaborative Multiple-Input-Multiple-Output Inverse Problems
with Application in Image and Video Processing”

National Science Foundation (NSF)

\$232,496

2007-2010

A. Khokhar (PI) and D. Schonfeld (Co-PI)

“Research Experiences for Undergraduates (REU) Supplement to MotionSearch: Motion Trajectory-Based Object Activity Retrieval and Recognition from Video and Sensor Databases”

National Science Foundation (NSF)

\$12,000

2008-2009

D. Schonfeld (PI)
“Real-time Superresolution for Enhanced Video Streaming”
iKoa Corporation
\$25,000
2008-2009

D. Schonfeld (PI)
“Tracking Performance Evaluation based on a Reflective Model and Perturbation Analysis”
Mitsubishi Electric Research Laboratories (MERL)
\$1,228
2009

R. Magin (PI), M. Ragozzino (Co-PI), K. Rockne (Co-PI), T. Royston (Co-PI), and D. Schonfeld (Co-PI)
“Acquisition of a High Field Magnetic Resonance Imaging System for Science and Engineering Research”
National Science Foundation (NSF)
\$1,995,000
2009

D. Schonfeld (PI), N. Bouaynaya (Key/Senior Personnel), and H.M. Fathallah-Shaykh (Key/Senior Personnel)
“Minimal-Perturbation Dynamic Control of the Melanoma Gene Regulatory Network” (R01)
National Institutes of Health (NIH)
\$1,200,000
2010-2015

X. Joe Zhou (PI), D. Schonfeld (Co-PI), H. Engelhard (Co-PI), R. Magin (Co-PI), and T. Valyi Nagy (Co-PI)
“Probing Intra-voxel Tissue Heterogeneity Using MRI” (R01)
National Institutes of Health (NIH)
NIH R01EB026716-01
\$2,173,399
2018-2023

D. Schonfeld (PI)*
“University of Illinois - New Oriental Artificial Intelligence Research Laboratory (UINO-AIRL)”
New Oriental Education & Technology Group Inc.
\$1,600,425
2019-2024

* Funding was approved by the research sponsor but declined by the university because of potential conflict with export controls.

B. Prasad (PI), D. Schonfeld (Co-Investigator), S. Basu (Collaborator), M. Maienschein-Cline (Collaborator)
“Machine Learning and Exosome Derived Biomarkers of Obstructive Sleep Apnea Induced Hypertension”
National Institutes of Health (NIH)
NIH R01EB026716-01
\$676,935

Q. ADMINISTRATIVE ACTIVITIES

Q.1. Administrative Positions

Director

University-Industry Engineering Research Center (UIERC)

College of Engineering

University of Illinois at Chicago

2008—2011

Supervisor

Web Development

Department of Electrical & Computer Engineering

University of Illinois at Chicago

2001—2002

Director

Timetable Schedule

Department of Electrical Engineering & Computer Science

University of Illinois at Chicago

1999—2000

Q.2. University Committees

Co-Chair

University All-Campus Promotion and Tenure Committee

University of Illinois at Chicago

2010—2011

Member

Graduate College Executive Committee

University of Illinois at Chicago

2020—2022

Member

COVID-19 Relief Fund Application Review Committee

University of Illinois at Chicago

2022

Member

Dean Review Committee

University of Illinois at Chicago

2017—2018

Member

Graduate Mentor Award Committee

University of Illinois at Chicago
2014—2016

Member
Chancellor's Graduate Research Fellowship Program
University of Illinois at Chicago
2014—2016

Member
University Vision and Strategy
University of Illinois at Chicago
2012—Present

Member
University Ad-Hoc Advisory Committee for the Office of Faculty Affairs
University of Illinois at Chicago
2012—2013

Member
University Task Force to Review Non-Tenure Promotion Guidelines
University of Illinois at Chicago
2011—2012

Member
University Promotion and Tenure Norms and Criteria Committee
University of Illinois at Chicago
2011—2012

Member
University Honorary Degree Nominating Committee
University of Illinois at Chicago
2010—2011

Member
University Promotion and Tenure Seminar Panel
Natural Science, Health Science, and Engineering
University of Illinois at Chicago
2010—2011

Member
University All-Campus Promotion and Tenure Committee
University of Illinois at Chicago
2008—2011

Member
University Campus Research Board Committee
University of Illinois at Chicago
2001—2004

Member
University Awards Committee

University of Illinois at Chicago
1998—2001

Member

Student Appeals Board

University of Illinois at Chicago
2004—2005

Q.3. College Committees

Member

College Executive Committee

College of Engineering
University of Illinois at Chicago
2009-2012, 2015-2017; 2019-2020; 2022-2023

Member

Dean of the College of Engineering Search Committee

College of Engineering
University of Illinois at Chicago
2007-2008

Member

Wexler Chair in Information Technology Search Committee

College of Engineering
University of Illinois at Chicago
2006

Member

Advisory Committee for Bioinformatics Program in Bioengineering

University of Illinois at Chicago
2000—2010

Chair

Networking Curriculum Subcommittee

College of Engineering
University of Illinois at Chicago
2005

Member

Departmental Reorganization and Formation Committee

College of Engineering
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1999—2000

Q.4. Departmental Committees

Mentoring Coordinator

Department of Electrical & Computer Engineering

University of Illinois at Chicago
2021—Present

Chair

Departmental Faculty Search Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2006-2008; 2010-2011; 2016-2017

Chair

Departmental Grievance Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2013—2019

Chair

Departmental Research & Colloquium Committee

Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1996—1998; 2003—2004

Chair

Departmental Seminar Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2008—2010

Chair

Departmental Web Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2001—2003

Chair

Departmental Web & Computer Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2020-2021

Member

Department of Mathematics, Statistics, and Computer Science

Personnel Review Committee for Jing Wang
2020—2021

Member

Departmental Advisory Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
1995—1996; 1998—1999; 2000—2002; 2004—2005; 2007—2010; 2015—2016; 2022—Present

Member

Departmental Computer Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
1990—1992; 2001—2004

Member

Departmental Computer & Web Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2013—2016

Member

Departmental Diversity & Inclusion Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2020—2021

Member

Departmental Electronics Instructional Laboratory Committee

Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1997—1998

Member

Departmental Faculty Search Committee

Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1994—1995; 1998—2001; 2006—2008; 2010-2011; 2016—2017; 2021—Present

Member

Departmental Graduate Admission and Recruitment

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2022—Present

Member

Departmental Graduate Committee

Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1995—2000; 2011—2015

Member

Departmental Grievance Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2012—2021

Member

Departmental Promotion & Tenure Committee

Department of Electrical & Computer Engineering
University of Illinois at Chicago

1996—Present

Member

Departmental Research & Colloquium Committee

Department of Electrical Engineering & Computer Science

University of Illinois at Chicago

1992—1998; 2001—2004

Member

Departmental Scholarship Committee

Department of Electrical Engineering & Computer Science

University of Illinois at Chicago

1990—1996

Member

Departmental Scholarship & Awards Committee

Department of Electrical & Computer Engineering

University of Illinois at Chicago

2019—Present

Member

Departmental Seminar Committee

Department of Electrical & Computer Engineering

University of Illinois at Chicago

2008—2013

Member

Departmental Undergraduate Committee

Department of Electrical & Computer Engineering

University of Illinois at Chicago

1998—2003; 2005—2011; 2015—2019

Member

Departmental Web Committee

Department of Electrical & Computer Engineering

University of Illinois at Chicago

2000—2011

Member

Departmental Web & Computer Committee

Department of Electrical & Computer Engineering

University of Illinois at Chicago

2019-2021

Q.5. Curriculum Committees

Chair

Departmental Communications and Networks Curriculum Subcommittee

of the Undergraduate and Graduate Committees

Department of Electrical & Computer Engineering
University of Illinois at Chicago
2001—2002; 2004

Chair

Departmental Signal Processing Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2011

Member

Departmental Communications Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2011

Member

Departmental Communications and Networking Curriculum Subcommittee
of the Undergraduate and Graduate Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2001—2002; 2004

Member

Departmental Computer Engineering Curriculum Subcommittee
of the Undergraduate and Graduate Committee
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1998—2002

Member

Departmental Electrical Engineering Curriculum Subcommittee
of the Undergraduate and Graduate Committee
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1996—2000

Member

Departmental Imaging Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1993

Member

Departmental Information and Computer Systems Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical & Computer Engineering
University of Illinois at Chicago

2011

Member

Departmental Masters of Engineering Program Subcommittee
of the Graduate Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2005

Member

Departmental Multimedia Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
2005

Member

Departmental Networking Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1999—2000; 2005

Member

Departmental Signals and Systems Curriculum Subcommittee
of the Graduate Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2004

Member

Departmental Signal Processing Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2011

Member

Departmental Signal Processing and Communications Curriculum Subcommittee
of the Undergraduate and Graduate Committees
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1991

Member

Departmental Student Cheating Policy Subcommittee
of the Undergraduate Committee
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1999

Member

Departmental Teaching Assistant Assignment Subcommittee
of the Undergraduate Committee
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1996—1997

Member

Departmental Teaching Assistant Award Subcommittee
of the Scholarship Committee
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago
1994

Q.6. Qualifier Committees

Chair

Departmental Communications Qualifier Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2003—2004; 2012

Chair

Departmental Computer Communication Network Qualifier Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2002—2003; 2005

Chair

Departmental Signal Processing Qualifier Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
1991—1995; 2001; 2002; 2008—2014, 2015—Present

Member

Departmental Communications Qualifier Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
1997—2004; 2009—2014

Member

Departmental Computer Communications Networks Qualifier Committee
Department of Electrical & Computer Engineering
University of Illinois at Chicago
2002—2005

Member

Departmental Computer Vision Qualifier Committee
Department of Electrical Engineering & Computer Science
University of Illinois at Chicago

1993—2001

Member

Departmental Signal Processing Qualifier Committee

Department of Electrical & Computer Engineering

University of Illinois at Chicago

1991—2001; 2004—Present

Q.7. Research Laboratories and Centers

Director

University-Industry Engineering Research Center (UIERC)

College of Engineering

University of Illinois at Chicago

2008—2011

Co-Director

Multimedia Communications Laboratory (MCL)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

1997—Present

Member

Departmental Signal and Image Research Laboratory (SIRL)

Department of Electrical & Computer Engineering

University of Illinois at Chicago

1991—2002

R. TEACHING ACTIVITIES

R.1. The Johns Hopkins University

ECE 137

Digital Signals and Systems

Fall 1987

ECE 137

Digital Signals and Systems

Fall 1988

ECE 137

Digital Signals and Systems

Fall 1989

R.2. University of Illinois at Chicago

EECS 212

Signal Processing

Fall 1990

EECS 212

Signal Processing

Winter 1991

EECS 416

Advanced Topics in Digital Signal Processing

Spring 1991

EECS 417

Digital Signal Processing

Fall 1991

EECS 554

Estimation Theory

Fall 1991

EECS 311

Communication Engineering

Spring 1992

EECS 554

Estimation Theory

Fall 1992

EECS / BioE 479

Real-Time Data Processing

Spring 1993

EECS / BioE 479

Real-Time Data Processing

Fall 1993

EECS 516

Optimal and Adaptive Digital Filters

Fall 1993

EECS 517

Image Processing

Spring 1994

EECS / BioE 479

Real-Time Data Processing

Fall 1994

EECS 517

Image Processing

Spring 1995

EECS 531

Detection and Estimation Theory
Spring 1995

EECS / BioE 479
Real-Time Data Processing
Fall 1995

EECS 517
Image Processing
Spring 1996

EECS 531
Detection and Estimation Theory
Spring 1996

EECS 530
Statistical Communication Theory
Fall 1996

EECS 517
Image Processing
Spring 1997

EECS / BioE 407
Pattern Recognition
Fall 1997

EECS 530
Statistical Communication Theory
Fall 1997

EECS / BioE 407
Pattern Recognition
Spring 1998

EECS 517
Image Processing
Spring 1998

EECS 517
Image Processing
Motorola Campus
Spring 1998

EECS 171
Introduction to Programming
Summer 1998

EECS 516
Optimal and Adaptive Digital Filters
Fall 1998

EECS 530

Statistical Communication Theory
Motorola Campus
Fall 1998

EECS 418

Digital Signal Processing II
Spring 1999

EECS 517

Image Processing
Spring 1999

EECS 531

Detection and Estimation Theory
Motorola Campus
Spring 1999

EECS 171

Introduction to Programming
Summer 1999

EECS 417

Digital Signal Processing I
Fall 1999

EECS 491

Multimedia Communication Networks
Spring 2000

EECS 311

Communication Engineering
Summer 2000

EECS 491

Multimedia Communication Networks
Internet Course (Preparation)
Fall 2000

EECS 516

Optimal and Adaptive Digital Filters
Fall 2000

EECS 531

Detection and Estimation Theory
Fall 2000

EECS 491

Multimedia Communication Networks
Internet Course

Spring 2001

EECS 517

Image Processing
Spring 2001

EECS 171

Introduction to Programming
Summer 2001

ECE 516

Optimal and Adaptive Digital Filters
Fall 2001

ECE 531

Detection and Estimation Theory
Fall 2001

ECE 434

Multimedia Communication Networks
Internet Course
Spring 2002

ECE 517

Image Processing
Spring 2002

CS 102

Introduction to Programming
Summer 2002

ECE 433

Computer Communication Networks
Fall 2002

ECE 434

Multimedia Communication Networks
Fall 2002

ECE 333

Computer Communication Networks
Laboratory (Preparation)
Spring 2003

ECE 311

Communication Engineering
Fall 2003

ECE 434

Multimedia Communication Networks
Fall 2003

ECE 517

Image Processing
Spring 2004

ECE 434

Multimedia Communication Networks
Fall 2004

ECE 516

Optimal and Adaptive Digital Filters
Fall 2004

ECE 517

Image Processing
Spring 2005

ECE 311

Communication Engineering
Summer 2005

ECE 434

Multimedia Systems
Fall 2005

ECE 516

Optimal and Adaptive Digital Filters
Fall 2005

ECE 517

Image Processing
Spring 2006

ECE 311

Communication Engineering
Summer 2006

ECE 434

Multimedia Systems
Fall 2006

ECE 516

Optimal and Adaptive Digital Filters
Fall 2006

ECE 531

Detection and Estimation Theory
Spring 2007

ECE 311

Communication Engineering

Summer 2007

ECE 434

Multimedia Systems

Fall 2007

ECE 516

Optimal and Adaptive Digital Filters

Fall 2007

ECE 531

Detection and Estimation Theory

Spring 2008

ECE 434

Multimedia Systems

Fall 2008

ECE 516

Optimal and Adaptive Digital Filters

Fall 2008

ECE 530

Random Signal Analysis

Spring 2009

ECE 517

Image Processing

Fall 2009

ECE/BIOE 407

Pattern Recognition

Spring 2010

ECE 434

Multimedia Systems

Fall 2010

ECE 530

Random Signal Analysis

Spring 2011

ECE 434

Multimedia Systems

Fall 2011

ECE 530

Random Signal Analysis

Spring 2012

ECE 594

Machine Learning
Spring 2012

ECE 434
Multimedia Systems
Fall 2012

ECE 517
Image Processing
Fall 2012

ECE 530
Random Signal Analysis
Spring 2013

ECE 434
Multimedia Systems
Fall 2013

ECE 517
Image Processing
Fall 2013

ECE 434
Multimedia Systems
Fall 2014

ECE 517
Image Processing
Fall 2014

ECE 434
Multimedia Systems
Fall 2015

ECE 517
Image Processing
Fall 2015

ECE 434
Multimedia Systems
Fall 2015

ECE 517
Image Processing
Fall 2015

ECE 407
Pattern Recognition
Spring 2016

ECE 530
Random Signal Analysis
Spring 2016

ECE 434
Multimedia Systems
Fall 2016

ECE 517
Image Processing
Fall 2016

ECE 407
Pattern Recognition
Spring 2017

ECE 434
Multimedia Systems
Fall 2017

ECE 517
Image Processing
Fall 2017

ECE 517
Image Processing
Spring 2018

ECE 530
Random Signal Analysis
Spring 2018

ECE 434
Multimedia Systems
Fall 2018

ECE 517
Image Processing
Fall 2018

ECE 530
Random Signal Analysis
Spring 2019

ECE 434
Multimedia Systems
Fall 2019

ECE 517
Image Processing
Spring 2020

ECE 530

Random Signal Analysis
Spring 2020

ECE 434

Multimedia Systems
Fall 2020

ECE 530

Random Signal Analysis
Spring 2021

ECE 531

Detection and Estimation Theory
Spring 2021

ECE 434

Multimedia Systems
Fall 2021

ECE 517

Image Processing
Fall 2021

ECE 530

Random Signal Analysis
Spring 2022

ECE 531

Detection and Estimation Theory
Spring 2022

ECE 434

Multimedia Systems
Fall 2022

ECE 517

Image Processing
Fall 2022

ECE 530

Random Signal Analysis
Spring 2023

R.3. University of Trento**Content-Based Video Analysis: Tracking, Retrieval, and Classification**

Information and Communication Technology (ICT) – International Doctoral School

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University of Trento
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