UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

DISH NETWORK CORP.; DISH NETWORK LLC; AND
DISH NETWORK SERVICE LLC,

Petitioners

v.

ENTROPIC COMMUNICATIONS, LLC

Patent Owner.

PTAB Case No. IPR 2023-00391

Patent No. 7,130,576

DECLARATION OF DAN SCHONFELD, PH.D. IN SUPPORT OF PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,130,576

TABLE OF CONTENTS

I. INTRODUCTION AND QUALIFICATIONS 1
A. Qualifications 2
B. Materials Reviewed 6
II. GOVERNING LAW AND PERSPECTIVES APPLIED 10
A. Types of Claims 10
B. Anticipation and Obviousness 11
C. Claim Construction 14
III. PERSON OF ORDINARY SKILL IN THE ART 14
IV. STATE OF THE ART AND APPLICANT ADMITTED PRIOR ART (AAPA) 16
A. Direct Broadcast Satellite Systems and Key Terminology 17
B. ODU Processing of an RF Satellite Signal 24
C. Set-Top Boxes / Integrated Receiver Decoders 28
D. Signal Processing and Distribution 31
1. Signal Switching 33
2. Signal / Band Stacking 35
3. Transponder Signal Selection Stacking 37
E. Signal Digitization 40
F. Broadband Analog-to-Digital Conversion 46
G. Building and Maintaining a Translation Table 48
H. Summary of the State of the Art 50
V. THE '576 PATENT 52
A. The Alleged Invention of the Challenged Claims 52
B. Prosecution History of the '576 Patent 59

1. Original Prosecution 59
2. Reexamination of the ’576 Patent.....61
C. Assumed Priority Date of the ’576 Patent 64
VI. DESCRIPTION OF THE PRIOR ART 64
A. Williams-873.....64
B. Pugel.....68
VII. PETITIONERS’ GROUNDS FOR CHALLENGE.....69
A. Ground 1: Claims 14-23, 34-42 and 8-13 are Obvious over Williams-873 in view of Pugel.....70
1. Motivation to Combine.....70
2. Independent Claim 14.....76
3. Dependent Claim 15 94
4. Dependent Claim 16 97
5. Dependent Claim 17 99
6. Dependent Claim 18 101
7. Dependent Claim 19 103
8. Dependent Claim 20 105
9. Dependent Claim 21 106
10. Dependent Claim 22 106
11. Dependent Claim 23 106
12. Dependent Claim 34 106
13. Dependent Claims 35 and 36.....107
14. Dependent Claim 37 108
15. Dependent Claim 38 110
16. Dependent Claim 39 111
17. Dependent Claim 40 111

18. Dependent Claim 41 113
19. Dependent Claim 42 114
20. Independent Claim 8 115
21. Dependent Claim 9 122
22. Dependent Claim 10 123
23. Dependent Claim 11 125
24. Dependent Claim 12 125
25. Dependent Claim 13 126
VIII. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS....126
IX. CONCLUSION 126

EXHIBIT LIST

Ex.1001	U.S. Patent No. 7,130,576 ("'576 patent")
Ex.1002	Declaration of Dr. Dan Schonfeld ("Schonfeld") and Appendix A Thereto (CV)
Ex.1003	U.S. Patent No. 6,493,873 ("Williams-873")
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Ex.1014	Dan Logan, The Scoop on the Dish, Los Angeles Times (1996), https://www.latimes.com/archives/la-xpm-1996-09-07-hm-41715-story.html
Ex.1015	U.S. Patent No. 4,675,732 ("Oleson")
Ex.1016	European Patent No. EP0740434B1 ("Carnero") with Certified English Translation with Translator's Affidavit

Ex.1017	Alan V. Oppenheim *et al*., Discrete-Time Signal Processing, Prentice Hall (1999), excerpts ("Oppenheim")
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Ex.1020	Site Editor, RG6 vs RG59: Which Should You Buy?, Foshan New King Cable Industrial Co., Ltd. (2020), https://newkingcable.com/rg6-vs-rg59-which-one-to-choose.html
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Ex.1029	Reserved
Ex.1030	S.J. Crowley, "Capacity Trends in Direct Broadcast Satellite and Cable Television Services," National Association of Broadcasters, National Religious Broadcasters, and National Black Religious Broadcasters (2013) https://www.nab.org/documents/newsroom/pdfs/100813_capacity_trends_in_dbs_and_cable_tv_services.pdf

Ex.1031	DVB-S, Wikipedia (2022), https://en.wikipedia.org/wiki/DVB-S
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Ex.1033	Walt Kester (ed.), Ch. 1, Data Converter History, in ANALOG-DIGITAL CONVERSION, (2004)
Ex.1034	Rajendra Kumar et al., Signal Processing Techniques for Wideband Communication Systems, MILCOM 1999, IEEE MILITARY COMMS. CONF. PROCS. 452 (1999)
Ex.1035	*Entropic Communications v. DirectTV, LLC*, Case No. 2:22-cv-07775-JWH-JEM, C.D. Cal., Plaintiff's Claim Construction Statement, December 1, 2022

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

1. I have been retained as an expert consultant by DISH Network Corporation, DISH Network L.L.C., and Dish Network Service L.L.C. ("Petitioners") in this proceeding before the United States Patent and Trademark Office ("PTO") against Entropic Communications, LLC ("Patent Owner") regarding U.S. Patent No. 7,130,576 ("the '576 patent"). (Ex.1001.) I have been asked to consider whether certain references disclose or suggest the features recited in claims 8-23 and 34-42 ("the challenged claims") of the '576 patent. My opinions are set forth below.

2. I am being compensated at my standard consulting rate of $750/hour for my work in this proceeding. 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.

I. INTRODUCTION AND QUALIFICATIONS

3. 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 technology and multimedia information systems referenced in this Declaration.

4. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. I understand that a copy of my current curriculum vitae, which includes a more detailed summary of my education and professional and academic experience, is provided as Appendix A to this Declaration. The following provides an overview of some of my experience that is relevant to the matters set forth in this Declaration.

A. Qualifications

5. I am a Professor in the Department of Electrical and Computer Engineering at the University of Illinois at Chicago. 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 the University of Illinois.

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

7. In 1990, I joined the Department of Electrical Engineering and Computer Science at the University of Illinois, Chicago, Illinois, where I am a tenured Professor in the Departments of Electrical and Computer Engineering, Computer Science, and Bioengineering. I serve as Co-Director of the Multimedia

Communications Laboratory ("MCL") and member of the Signal and Image Research Laboratory ("SIRL"). I have also served as 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 the University of Illinois at Chicago, I served as an instructor in the Department of Electrical and Computer Engineering at The Johns Hopkins University.

8. 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, Australia, (b) the Department of Information Engineering and Computer Science ("DISI") at the University of Trento, Italy, (c) the School of Computer Engineering at the Nanyang Technological University, Singapore, and (d) the Department of Electrical Engineering—Systems at Tel-Aviv University, Israel.

9. I have previously served as 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 Area Editor for special issues of the IEEE Signal Processing Magazine. I have also served as 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, EURASIP Journal of Image

and Video Processing, Research Letters in Signal Processing, and Bentham Science Publishers, Ltd.'s "Recent Patents on Computer Science" and "Recent Patents on Electrical Engineering" publications. I have served as guest editor of numerous special issues in various journals in the area of multimedia systems.

10. I currently serve on the Conference Board of the IEEE Signal Processing Society. I have previously served as Technical Program Chair of the IEEE International Conference on Acoustics, Speech, and Signal Processing ("ICASSP") 2018 as well as Program Chair of the IEEE Conference on Visual Communications and Image Processing ("VCIP") 2015. I have previously served as General Co-Chair of the Workshop on Big Data in 3D Computer Vision 2013 and the IEEE International Conference on Multimedia and Expo ("ICME") 2012. I have also served as Chair of the IEEE Workshop on Video Mining 2008 and the SPIE Conference on Visual Communications and Image Processing 2007. I have also served on the organizing committees of various conferences including the IEEE International Conference on Image Processing 1998, 2012, and 2020.

11. I have authored and co-authored over 200 technical papers for various journals and conferences. I was author of a book chapter, entitled: "Image and video communication networks," and later editions entitled: "Video communication networks." I was also co-author (with Carlo Giulietti 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. I was also coauthor (with Junlan Yang) of a paper that won the Best Student Paper Award at the IEEE International Conference on Image Processing 2007. I was also co-author (with Wei Qu) of a paper that won the Best Student Paper Award at the IEEE International Conference on Image Processing 2006. I was also co-author (with Nidhal Bouaynaya) of a paper that won the Best Student Paper Award in Visual Communications and Image Processing 2006. In addition, many of my publications relate to the broad topic of multimedia systems, which includes audio, image, and video processing. My publications in the area of multimedia systems dates back to 1988.

12. I was invited as a Plenary Speaker and Keynote Speaker to the International Conference on Intelligent Control and Information Processing ("ICICIP") 2013 and International Conference on Brain Inspired Cognitive Systems ("BICS") 2013, IEEE/EIT International Conference on Audio, Language, and Image Processing 2010, the IEEE International Conference on Advanced Video and Signal-Based Surveillance 2009, and the ASME International Conference on Communications, Signals and Systems 1995 and 2001.

13. I have served as Representative of Regions 1-6 (North America) on the

Chapters Committee of the IEEE Signal Processing Society. I have also served as Chairman of the IEEE Signal Processing Chicago Chapter. I have also served on the IEEE Image, Video and Multidimensional Signal Processing Technical Committee as well as the IEEE Multimedia Communications Technical Committee. I also serve on the American National Standards Institute ("ANSI") / Underwriters Laboratory ("UL") Standards Technical Panel ("STP") on Multimedia Systems.

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

B. Materials Reviewed

15. 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 multimedia communications technology and/or multimedia information systems including, for example, television signal processing and satellite communications, or a related field.

16. 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. 7,130,576 ("'576 patent")
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Ex.1035	*Entropic Communications v. DirectTV, LLC*, Case No. 2:22-cv-07775-JWH-JEM, C.D. Cal., Plaintiff's Claim Construction

	Statement, December 1, 2022

17. My opinions contained in this Declaration are based on the documents I reviewed and considered, and my knowledge and professional judgment. My opinions have also been guided by my appreciation of how a person of ordinary skill in the art ("POSITA") would have understood the state of the art, the prior art, and the claims and the specification of the '576 patent at the time of the alleged invention.

18. I have been asked to initially consider that the time of the alleged invention of the '576 patent encompasses the time frames near and including November 7, 2001. I understand the application for the '576 patent claims priority to multiple applications, the earliest of which was filed on November 7, 2001. (Ex.1001-'576 patent, 1.) My opinions reflect how one of ordinary skill in the art (which I describe below) would have understood the '576 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.

19. Based on my experience and expertise, it is my opinion that the prior art discloses and/or suggests all the limitations recited in challenged claims 8-23 and 34-42 of the '576 patent, as I discuss in detail below.

II. GOVERNING LAW AND PERSPECTIVES APPLIED

20. 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.

21. 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 POSITA at the time the invention was made.

22. 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

23. 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 aspects stated in the independent claim. I further understand that dependent claims include the aspects stated in that dependent claim, and any other aspects stated in any claim from which that dependent claim depends.

B. Anticipation and Obviousness

24. 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.

25. I further understand that obviousness of a claim requires that the claim be obvious from the perspective of a person of ordinary skill in the relevant art, at the time the invention was made. I understand that the earliest patent application filing leading to the ’576 patent was a U.S. provisional patent application filed on November 7, 2001, and I have assumed this is the ’576 patent's alleged invention date.

26. I have therefore analyzed the unpatentability of the claims as of that day. I may refer to the relevant time period as the “2001 timeframe” in this Declaration, with the understanding that this does not include the time period on or after the filing date of the first application (*i.e.*, November 7, 2001).

27. 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.

28. 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.

29. 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 person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill. 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.

30. 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 '576 patent and reserve my right to review and respond to such evidence if presented.

C. Claim Construction

31. 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.

32. 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 November 7, 2001 for reasons explained above.

III. PERSON OF ORDINARY SKILL IN THE ART

33. 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 understandings as to 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 '576 patent, a person of ordinary skill in the art ("POSITA") at the time of the alleged invention of the '576 patent (*e.g.*, November 7, 2001) would have had at least: (i) a bachelor's degree in electrical engineering, computer engineering, or the equivalent, and three or more years of experience with television signal processing and satellite communications; (ii) a master's degree in electrical engineering, computer engineering, or a related field, and at least one year of experience in television signal processing and satellite communications; or (iii) a doctoral degree in electrical engineering, computer engineering, or a related field, and at least some experience in television signal processing and satellite communications. Additional education may substitute for professional experience, and significant work experience may substitute for formal education.

34. Based on my review of the '576 patent and my technical experience, it is my opinion that a person of ordinary skill in the art would have possessed knowledge of conventional satellite communications technologies and techniques, such as the structure and properties of signals transmitted by orbital satellites, including transponders, polarity, analog and digital data, etc.; satellite signal

receivers, such as satellite dishes, including components such as feedhorns; low-noise amplifiers and block-down converters (LNBs); satellite signal processing in the analog and digital domains including broadband analog-to-digital conversion, filtering, frequency shifting/translating, and combining; signal distribution technologies and techniques, including transmission media (coaxial cable, Ethernet cable, wireless, etc.) (*See generally* Ex.1001-'576 patent, 1:19-11:57.) As described in further detail below, many of these technologies and associated techniques fall generally within communications and networking concepts related to the satellite signal processing and distribution known at the relevant time.

IV. STATE OF THE ART AND APPLICANT ADMITTED PRIOR ART (AAPA)

35. The '576 patent describes and claims features relating to distributing received satellite television channels, and the use of known processes and technologies to facilitate the distribution of the television channels to a plurality of set-top boxes ("STBs")/integrated receiver decoders ("IRDs"). However, as I explain below, it is my opinion that such methods and related technologies were conventional and known to persons of ordinary skill in the art at and before November 2001.

36. Below, I present a brief overview of certain aspects of satellite signal processing and distribution, and use of known components and processes, like those

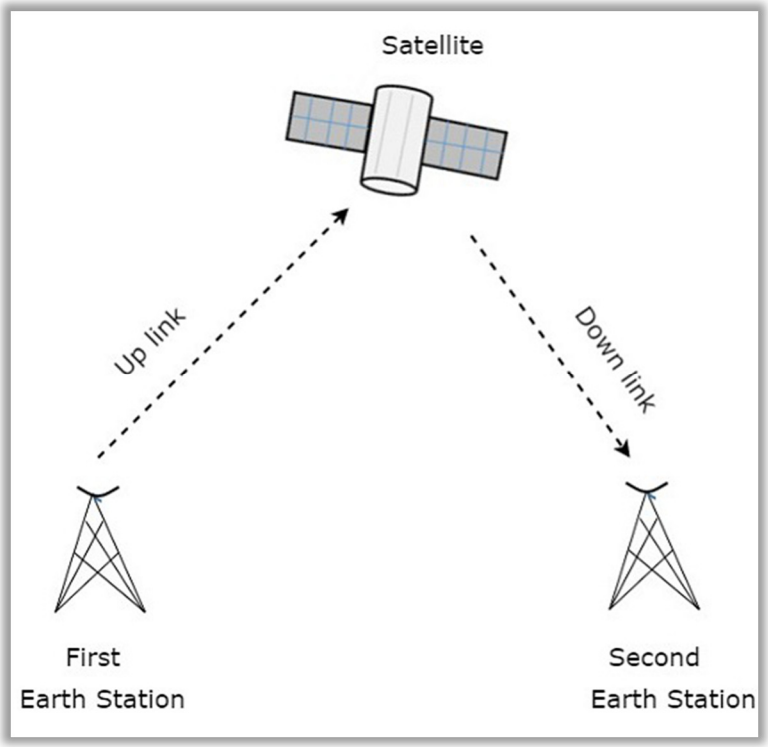
discussed and claimed in the '576 patent that were known to a person of ordinary skill in the art prior to and at the time of the alleged invention of the '576 patent. The features, functionalities, and concepts I describe below in this technical background section reflect the state-of-the-art knowledge that a person of ordinary skill in the art would have had prior to and at the time of the alleged invention of the '576 patent (*e.g.*, November 2001). 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 challenged claims of the '576 patent and how and why a person of ordinary skill in the art 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 person of ordinary skill in the art at the time when considering the prior art identified below, such as Applicant Admitted Prior Art ("AAPA") Petruzzelli and Williams-419, and other references discussed herein, including Oleson, Green, Hentschel, Lovinggood, Davis, and Pugel.

A. Direct Broadcast Satellite Systems and Key Terminology

37. By November 2001, orbital satellites had been used for nearly forty 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. (*See* Ex.1012, 3.) By the mid-1980's (in the United States, at least), individual consumers were permitted by law under the 1984 Cable Communications Policy Act of 1984 to decrypt satellite signals, ushering in the era of satellite television services. 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 direct broadcast satellite ("DBS") services. These satellite systems were designed to broadcast digital video data (*i.e.*, video data carried on high-frequency, analog RF signals) by using geostationary satellites. The digital video data is transmitted to the satellite via an uplink antenna on the ground over a band (or range) of frequencies referred to as the uplink frequencies and is retransmitted by the satellite to various antennas back on the ground (*e.g.*, a subscriber's satellite dish) at a different band of frequencies referred to as the downlink frequencies. A simple depiction of the system is shown in the figure below:[1]

[1] The image was obtained from https://www.tutorialspoint.com/satellite_communication/satellite_communication_quick_guide.htm on January 6, 2023.



38. "Transponder" and "channel" are two important terms POSITAs use to describe the distribution of television data by satellites, and because these terms are often used to refer to different aspects of the distribution, I will first discuss each term and explain how I am using them in this Declaration. I also discuss the term "program" in relation to the different kinds of "channels."

39. The original understanding of "transponder" referred to specialized hardware on a satellite that processes the signal transmitted over an uplink before responding by broadcasting the signal to subscribers. "Transponder" is a portmanteau of the words "transmit" and "respond." Satellites have a plurality of transponders that receive, process, and broadcast a portion of an uplink signal. Thus,

"transponder" is sometimes also used to refer either to the *signal* that is the portion of the uplink received, processed, and broadcast by the transponder, or alternatively to the frequency *channel* through which the signal is communicated (more on channel in the next paragraph). When referring to the signal received by the transponder, I will use the term "transponder signal" as it is more precise than "transponder."

40. "Channel" is also a term with multiple meanings in this art. The original understanding of "channel" referred to a defined frequency used by a particular transponder. To be clear, although a channel is often discussed with reference to a single frequency, it actually refers to a range of frequencies (*i.e.*, the frequency band) centered about the single frequency carrying the received uplink signal and the single frequency of the signal broadcasted by the transponder (*i.e.*, the "transponder channel"). However, most lay people instead think of "channel" in this context to refer to a television channel—ESPN™, HBO™, Disney™, etc.—and POSITAs will sometimes do the same. For example, when analog signals were transmitted by satellites, each transponder channel typically carried only a single analog television channel, so a given television channel (*e.g.,* channel number 38, ESPN) corresponded to a specific transponder channel (*e.g.*, the channel associated with transponder number five on a satellite having sixteen transponders). In the digital

broadcast systems that became common in the late 1990's, compressed digital signals associated with several television channels could be transmitted within a single transponder channel, creating potential confusion when the word "channel" is used, by itself. In this Declaration, I will use the terms "transponder channel" and "television channel" to distinguish these two kinds of channels.

41. I note that some of the prior art discussed herein uses the word "transponder," by itself, to refer to either the signal from a transponder or the transponder channel. (*E.g.*, Ex.1009-AAPA Williams-419, 1:52-54; Ex.1008-AAPA Petruzzelli, 5:1-15.) To the extent I use "transponder" in discussing or quoting that prior art, I am referring to a "transponder signal" or "transponder channel" and not the physical transponder, unless otherwise stated. This is consistent with the uses of these terms in the '576 patent. (*See, e.g.*, Ex.1001-'576 patent, 6:14-18 ("Each transponder channel may be frequency translated to the desired new carrier frequency, then filtered to produce a single transponder signal that can be combined with other similarly selected transponder channels.").)

42. Finally, "program" refers to the audio and video data associated with a single "television channel." In digital broadcast systems, "programs" are generally transmitted as MPEG-encoded video and audio. POSITAs will sometimes use the term "program multiplex" to refer to the data of a particular "transponder channel."

(*E.g.,* Ex.1009-AAPA Williams-419, 1:52-55.) This is because the programs associated with a plurality of "television channels" are multiplexed together for transmission over a single "transponder channel."

43. The '576 patent describes DBS satellite systems that were commonplace as of 2000, when satellites typically broadcast 16- or 32- transponder signals. (*See* Ex.1001-'576 patent, 1:19-2:50.) The total bandwidth of the RF signal broadcast by the satellite, the number of transponder signals within the broadcast signal, and the number of television channels per transponder signal were a function of both technical and regulatory concerns. Typically, within these systems, an uplink would be used to transmit to transponders on the satellite a high-frequency, analog RF signal carrying digital video data that represents multiple (*i.e.*, tens to hundreds) of streams of programming. Transponders at the satellite would then translate the programs included in the RF signal received from the uplink into one or more transponder channels for broadcast over the downlink to the requesting subscriber antennas. In 2001, a single transponder signal having a bandwidth of 36 MHz (typical, as the '576 patent admits) generally carried six or more programs in the program multiplex. (Ex.1001-'576 patent, 1:19-43; Ex.1008-AAPA Petruzzelli, 1:21-62, 2:11-21; Ex.1009-AAPA Williams-419, 2:11-40.)

44. As early as the 1980's, satellites were able to increase throughput by

simultaneously distributing two sets of transponder channels over the same frequency range by taking advantage of polarity multiplexing (also called polarization-division multiplexing). Polarity is a physical signal property, meaning that it differentiates two signals with otherwise identical properties. In satellite systems commonplace by the 1990's, a single satellite can emit two information signals—typically characterized as either left/right hand polarized, or vertical/horizontal polarized—over the same frequency range. (*See, e.g.*, Ex.1011-Green (1989), 1:42-68.) This enabled satellites to transmit, and satellite dish receivers to receive, twice as many transponder signals from a single satellite. The '576 patent admits that polarization-division multiplexing was known in the prior art. (*See* Ex.1001-'576 patent, 1:44-2:47.)

45. The excerpt from Figure 10 of EP 0 740 434 (Ex.1016-Carnero) visually depicts a typical satellite signal having twenty-four transponder channels (numbered 70-93), with twelve transponder channels per polarity (vertical and horizontal), all located in the X-band (between 7 and 12 GHz).

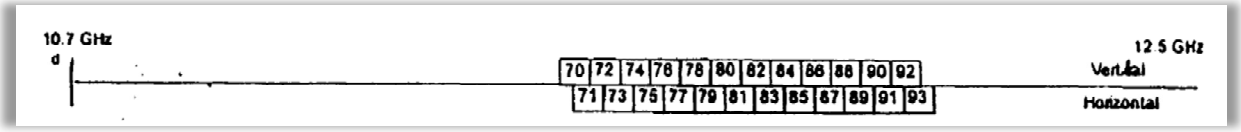


Figure 10 — Signal Received by a Left Parabolic Antenna from an Orbital Satellite.

46. Signal modulation schemes—changing the amplitude, frequency, or

phase of the signal—can allow for transmission of multiple television channels over a particular frequency range, but with quality and fidelity as trade-offs. Early analog satellite television services relied on frequency modulation (FM). (*See, e.g.*, Ex.1030, 5.) Quadrature phase-shift keying (QPSK), sometimes also referred to as 4-phase-shift keying (4-PSK), was already a standard satellite modulation technique in the early 1980's and remained a (if not the) prevailing modulation scheme for transmitting satellite television channels by November 2001. (Ex.1013-Baran, 1:31-39.) For example, the Digital Video Broadcasting–Satellite (DVB-S)—a digital video broadcasting standard for satellite communications released in 1995—used QPSK. (*See, e.g.*, Ex.1031, 1.) The main advantage of QPSK is its power efficiency, which comes at the expense of the bandwidth required. (Ex.1032, 171.) Other common modulation schemes (such as variations of quadrature amplitude modulation, QAM, used to distribute for terrestrial television signals) provide distinct advantages and disadvantages. For example, QAM typically requires less frequency bandwidth to transmit a television program relative to QPSK, but the signal will be of lower quality with a higher potential for error.

B. ODU Processing of an RF Satellite Signal

47. At the downlink, and consistent with AAPA and Background within the '576 patent, an antenna (*i.e.*, "satellite dish") at each subscriber location received the high-frequency (4GHz–18GHz+) RF satellite signals transmitted by the satellite

transponders. (Ex.1008-AAPA Petruzzelli, 1:21-62, 2:11-21; Ex.1009-AAPA Williams-419, 2:11-40.) Early dishes were very large—often three or more meters tall—but by the mid to late-1990's, the dishes used for consumer satellite television services were around a meter tall. While dish size dropped significantly from the 1970's through the year 2000, the core functionality remained the same.

48. A dish receiver has one or more "feedhorns"—one per transmitting satellite—that are capable of receiving satellite signals at very high frequencies: typically, in the C-band (3.7–4.2 GHz), X-band (7–12 GHz), and/or Ku-band (12-18+ GHz) ranges. (*E.g.*, Ex.1008-AAPA Petruzzelli, 1:21-37; Ex.1001-'576 patent, 1:33-39.) Figure 1 of the '576 patent depicts what the patentee admits is prior art. The figure shows a parabolic satellite receiver 150 ("dish antenna") having two satellite feedhorns 130.

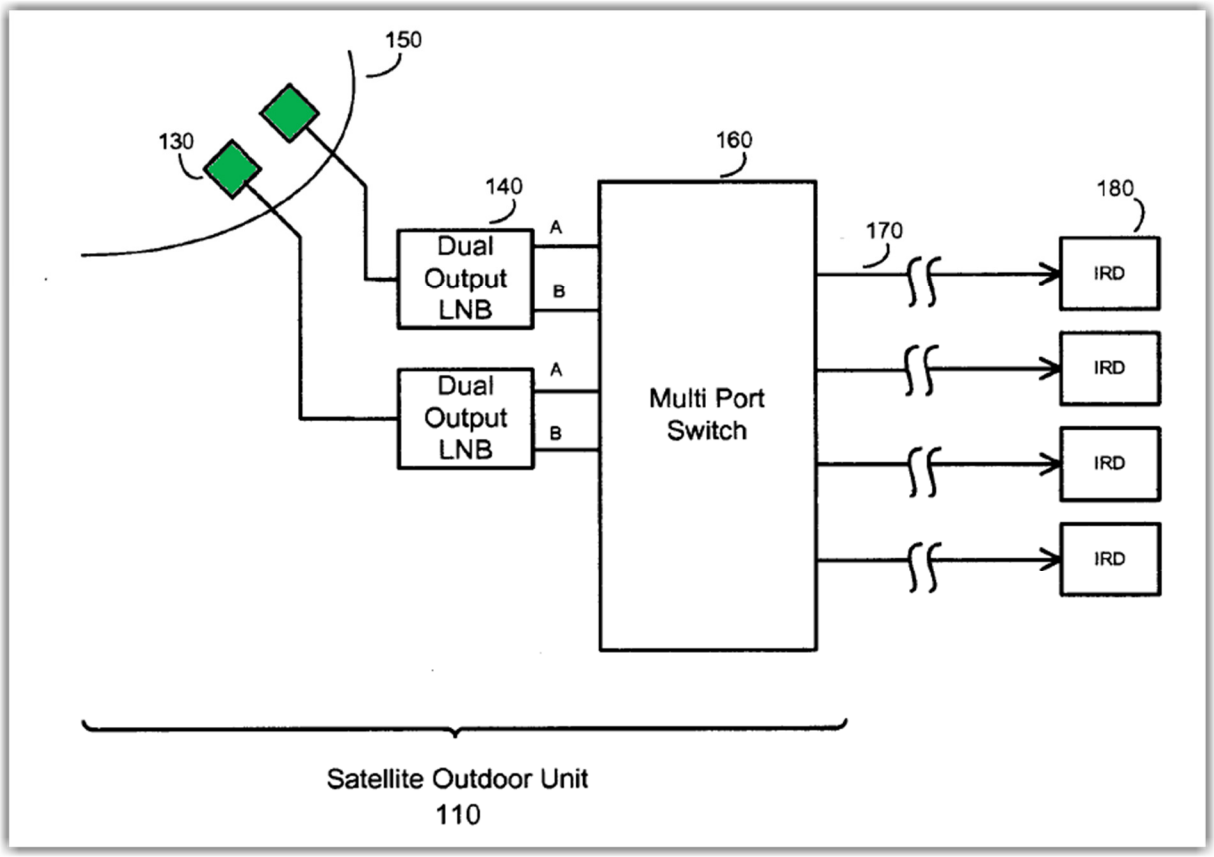


Figure 1 — Feedhorns 130, Part of Satellite Receiver 150 (AAPA).

49. While satellite signals are typically received in frequencies exceeding 10 GHz, the signals must be converted to lower frequencies, "down converted," for local distribution. For example, coaxial cables are best suited to transmit signals three orders of magnitude smaller—approximately 2 MHz or lower (within the "intermediate frequency" range of radio frequencies). Even wireless networks (*e.g.*, Wi-Fi) typically transmitted at 2.4 GHz in November 2001. (*See* Ex.1018, 2 (discussing 802.11b standard, released in 1997).) As such, satellite receivers have long been required to down-shift the frequencies of the received signals for distribution.

50. The well-known solution to preparing received satellite signals for terrestrial distribution is the use of low noise amplifier and block-down converters ("LNBs"). (*See, e.g.,* Ex.1011-Green, 2:26-35, 6:28-53, 9:45-50.) The low noise amplifiers boost (or "amplify") the received signals, and the block-down converters shift the frequencies of the received signals typically into the sub-2 MHz range. Figure 1 of the '576 patent describing the prior art shows two dual output LNBs 140, each of which receives a polarized signal from feedhorns 130, down-converts the signals into IF, and outputs a separate signal for each polarization received from the corresponding feedhorn (A and B).

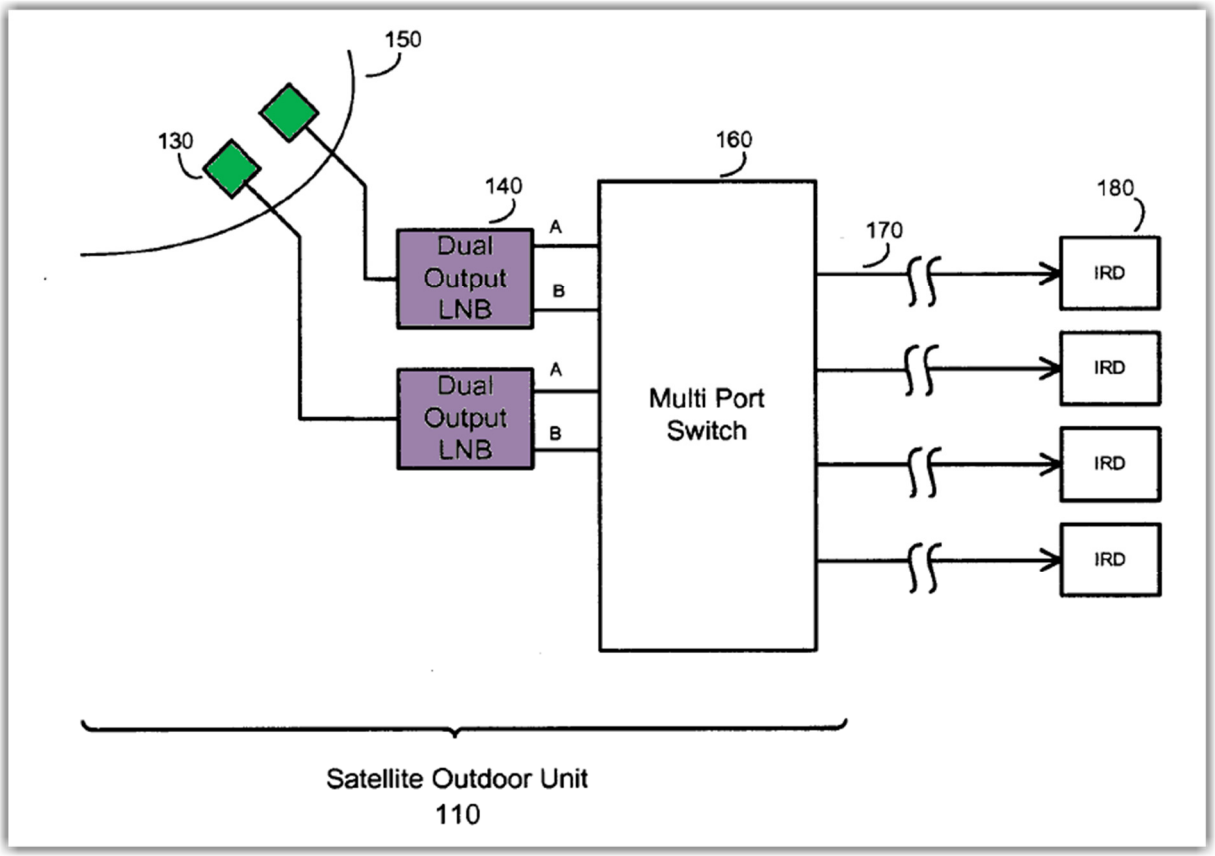


Figure 1 — Feedhorns 130 Output to Dual Output LNBs (One Per Input

Signal Polarity) (AAPA).

(*See also* Ex.1001-'576 patent, 1:19-29, 1:44-45.) Figure 10 of Carnero (Ex.1016) provides a visual depiction of the signal at the input of an LNB (line "d"), and the resulting outputs, which contain all transponder channels from a single polarity in the IF range of 950 MHz - 2,050 MHz (lines "g" and "h", corresponding to A and B in the '576 patent, Figure 1).

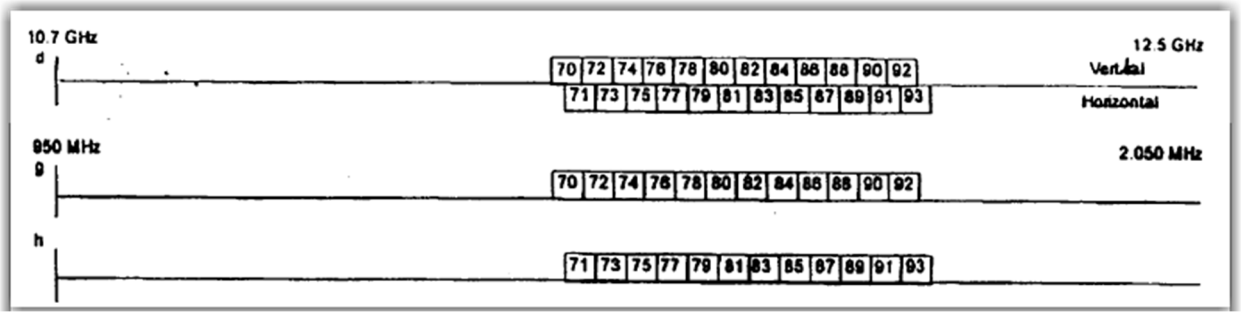


Figure 10 — Down Converters (LNBs) Select a Polarization and Down-Shift into IF.

51. The feed components are part of the outdoor unit ("ODU") located at or near the exterior of a building or home at as subscriber location. (Ex.1001-'576 patent, 1:19-27, 1:44-2:7.) The '576 patent discloses each of these components as part of the prior art ODUs. (Ex.1001-'576 patent, 1:19-54, Figure 1; *see also* Ex.1008-AAPA Petruzzelli, 1:21-37, 2:54-65, 4:23-45, 4:58-5:15, 5:1-15, 5:61-6:21; Ex.1009-AAPA Williams-419, 2:11-40.)

C. Set-Top Boxes / Integrated Receiver Decoders

52. After down-conversion, received transponder signals are suitable for distribution to integrated receiver/decoders ("IRDs"), also known as set-top boxes

("STBs"). Because the method of distribution is purportedly a source of novelty over the prior art, I discuss the STBs first.

53. The original purpose for an STB, which is still an important purpose, was to decode received television signals so the signal could be displayed on a television. For decades, televisions were designed to receive and display television signals transmitted "over-the-air" in an analog, standard-definition signal. In the United States, the prevailing standard modulation since the 1950's was called NTSC, an acronym for the National Televisions Standards committee. The television would include a "tuner" that could "tune" (*i.e.*, detect only) a channel at a center frequency in a received NTSC signal and display a television program in the channel. But as cable and satellite television services rose throughout the 1980's and 90's, alternative modulation schemes arose to meet the needs of particular distribution networks (including QAM and QPSK, discussed above). And analog signals were increasingly used to carry digital television signals that were encoded (*e.g.*, in accordance with the MPEG standard), which further reduced the bandwidth needed to transmit a given television program (which became especially important in the late 1990's with the introduction of high-definition television—HDTV) and provided other advantages such as reliability. In order to ensure compatibility with NTSC-compliant television, a receiver decoder was used to receive a cable or

satellite television signal and output an NTSC-compliant signal for display on the television.

54. When an STB receives a signal containing a program stream, the STB "tunes" to the transponder channel carrying a desired television program (*e.g.*, "ESPN2") for processing and display. (Ex.1001-'576 patent, 1:39-43.) The STB then performs other operations including demodulating the IF signal down to a baseband signal, decoding digital video data encoded within the RF satellite signal (including demultiplexing an MPEG stream comprising a plurality of television programs, which includes the desired program), and generating the RF output signal necessary to display content on a connected television. (Ex.1001-'576 patent, 1:39-43.)

55. Figure 1 of the '576 patent (and its related disclosure), which describe the admitted state of the art, depicts an ODU distributing down-converted IF satellite television signals to a plurality of IRDs simultaneously.

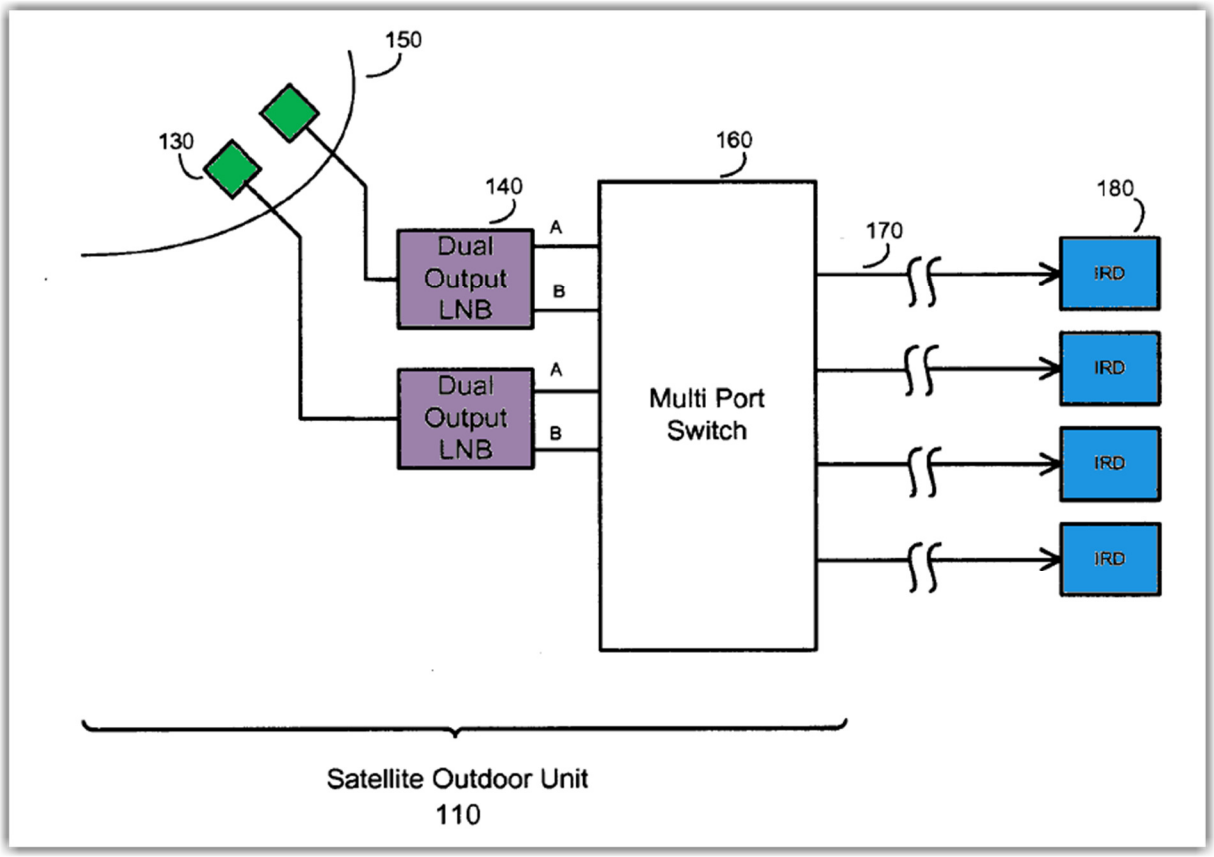


Figure 1 — Outputs of Dual-Output LNBs Distributed to a Plurality of IRDs (AAPA).

(*See* Ex.1001-'576 patent 1:19-2:7.) AAPA Williams-419 also teaches IRDs performing tuning, demodulation, and decoding, as the '576 patent recognizes. (Ex.1001-'576 patent at 2:8-25, *see generally* Ex.1009-AAPA Williams-419 at 14:4-18:29.)

D. Signal Processing and Distribution

56. In a system where a single transponder signal is received by the satellite dish (as in the Telstar I example form the 1960's), distribution would be simple: connect the output of the LNB to an STB. If the hypothetical system involves receipt

of a plurality of transponder signals in a single satellite signal (*e.g.*, the signal on either of the "A" or "B" cables in Figure 1 of the '576 patent, or lines "g" or "h" from Carnero's Figure 10), the distribution system still requires just one connection, for example, by coaxial cable, between the LNB output and an STB. But even by the 1970's, satellite systems were rarely so limited.

57. POSITAs have long been motivated to invent local satellite distribution systems that can distribute transponder signals from a plurality of received satellite signals, each comprised of dozens (if not 100+) of television channels, so that a plurality of STBs can each receive the programing desired by their operator (*i.e.*, a television viewer), in an economical, efficient, and practical manner, bearing in mind the well-known bandwidth limitations of distribution media (namely, coaxial cables). Among the motivations:

- Capability to distribute the ever-increasing number of available satellite television programs to viewers. The 1980's saw the advent of many new "cable" channels such as HBO, TBS, CNN and Showtime, which satellite television subscribers also wanted to watch. Case in point, by the mid-1990's, the leading satellite television service providers (including DISH) simultaneously offered well over 100 television programs (*see* Ex.1014, 3);

- Providing satellite television channels from a plurality of received satellite signals to a plurality of STBs within a single home or multi-dwelling unit (such as an apartment or hotel) wherein each STB is able to receive a desired television channel without interfering with the television channels other STBs are able to receive. At least by the mid-1980's, persons inventing in the field observed that a single satellite DISH could be used to serve "hundreds and even thousands" of hotel

rooms, or a multi-television home, as it was "fairly common" for homes at the time to have between four and six televisions. (Ex.1015-Oleson, 1:24-31.) POSITAs sought to invent to accommodate such use cases; and

- Optimally distributing satellite television channels in accordance with the above motivations in light of physical limitations of the distribution media and the distribution area (*i.e.*, a home or building). The typical distribution medium at the time of its invention was a coaxial cable, particularly what are known as the RG-6 or RG-59 cables, and these cables had limited available bandwidth. For example, the attenuation (signal loss) for an RG-6 and RG-59 is 4.3 and 7.0 dB per 100 ft, respectively, at 400 MHz; compared to an attenuation of 7.0 and 12.0 dB per 100 ft, respectively, at 1,000 MHz. (Ex.1019, 4-5; Ex.1020, 6-7.) As the '576 patent correctly recognizes, it would not have been possible to distribute more a few LNB output signals (*i.e.*, 24-36 transponder signals) simultaneously over a single coaxial cable. (Ex.1001-'576 patent at 2:34-47.) Thus, where a building contained multiple STBs, the cost and difficulty of running multiple coaxial cables to each STB necessitated solutions limiting the number of cables to carry video data ultimately destined for the multiple STBs.

58. Since at least the early 1980's, POSITAs have come up with signal distribution solutions bearing in mind the above considerations. This Declaration describes three in detail: signal switching, signal stacking, and transponder selecting and stacking.

1. Signal Switching

59. The '576 patent describes what it calls a "typical[]" or "conventional" satellite distribution system which I will refer to as "signal switching." (*See* Ex.1001-'576 patent, 1:19-62, Fig. 1.) Signal switching is among the least sophisticated of the distribution methods, and was long past being the "state of the art" in November

2001, as the following sections will make clear. Thus, while not representative of the state of the art at the time of the alleged invention, I briefly describe it here because it is discussed in the '576 patent.

60. In a signal switching system, a plurality of signals are input into a switch, such as the multiport cross point switch 160 discussed in the Background of the '576 patent. In the example of Figure 1, the switch receives four input signals, each containing a plurality of transponder signals from one polarity of a received satellite signal (these are "LNB output signals"). When a television viewer desires to watch a specific television program (*e.g.*, SportsCenter on ESPN2), the STB 180 associated with the television communicates a request to be switched to the LNB output signal having that program. The switch facilitates the selection, and the STB is supplied on its dedicated cable 170 the entire LNB output signal, which contains a plurality of transponder channels, and the STB tunes to the transponder channel bearing the desired program and performs its ordinary signal processing to output the desired program to a display (*e.g.*, television set).

61. The switch is able to provide any of the input signals to each of the STBs in the distribution system; in the example in Figure 1, to four STBs (shown as "IRD"s).

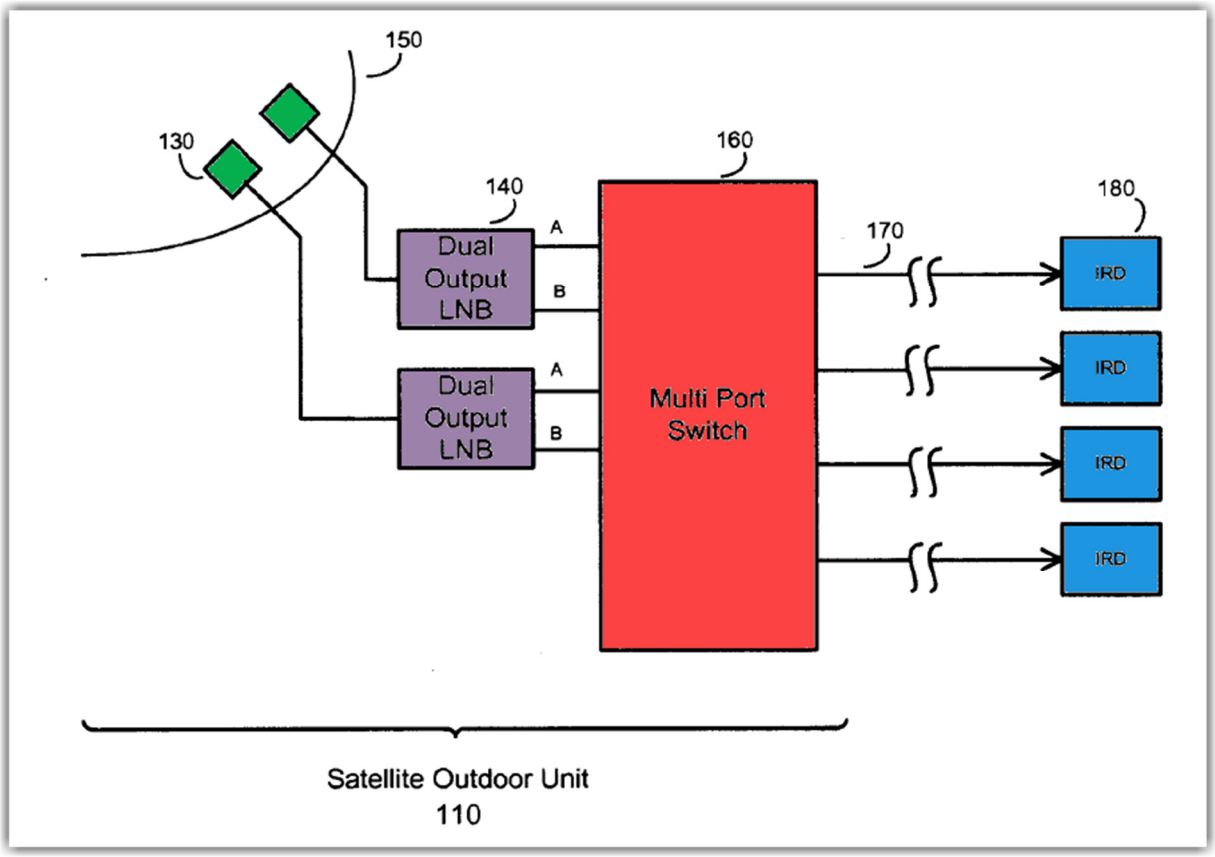


Figure 1 — Each IRD (STB) Receives One of Four LNB Output Signals (AAPA).

62. The advantage of signal switching is that each STB can be supplied with the television program desired by its user without interfering with any other STB's ability to obtain whatever program it desires. The downside, as the '576 patent recognizes, is that each STB requires a separate cable; otherwise, only television channels from a single input signal would be available for selection by all STBs, limiting user choice.

2. Signal / Band Stacking

63. One alternative to signal selection is what I will call "signal stacking"

or "band stacking," which takes multiple LNB outputs and combines them for distribution as a single signal (which the '576 patent calls a "composite signal"). One example signal stacking implementation is taught in AAPA Petruzzelli. I understand that the original assignee of the patent, Echostar Engineering Corporation, was a subsidiary of Echostar Corporation which operated the DISH Network satellite television service.

64. AAPA Petruzzelli teaches that two "bands" of transponder channels can be distributed together, where a "band" refers to one set of sixteen transponder channels received on one polarization of a dual-polarized satellite signal. (*See generally* Ex.1008-AAPA Petruzzelli, 5:46-6:50.) When the LNBs down-convert the received bands of transponder channels from each polarization, each band is still shifted into the IF range, but the ranges do not overlap. (*See* Ex.1008-AAPA Petruzzelli, 5:45-6:50.) For example, one set of sixteen transponder channels occupies a 500-MHz band between 950-1450 MHz, and another set occupies a band of the same width between 1550-2050 MHz, which leaves a 100-MHz "guard band." (Ex.1008-AAPA Petruzzelli, 7:64-8:39.) Hardware to combine signals, such as a diplexer, combines the two bands into a single signal so they can be "transmi[tted] by a single cable." (*See* Ex.1008-AAPA Petruzzelli, Abstract.)

65. Petruzzelli posits that frequencies below 950 MHz may be used to

transmit terrestrial television signals (*see id.* 6:22-36), but this frequency range is equally available to transmit at least two other bands of transponder signals.

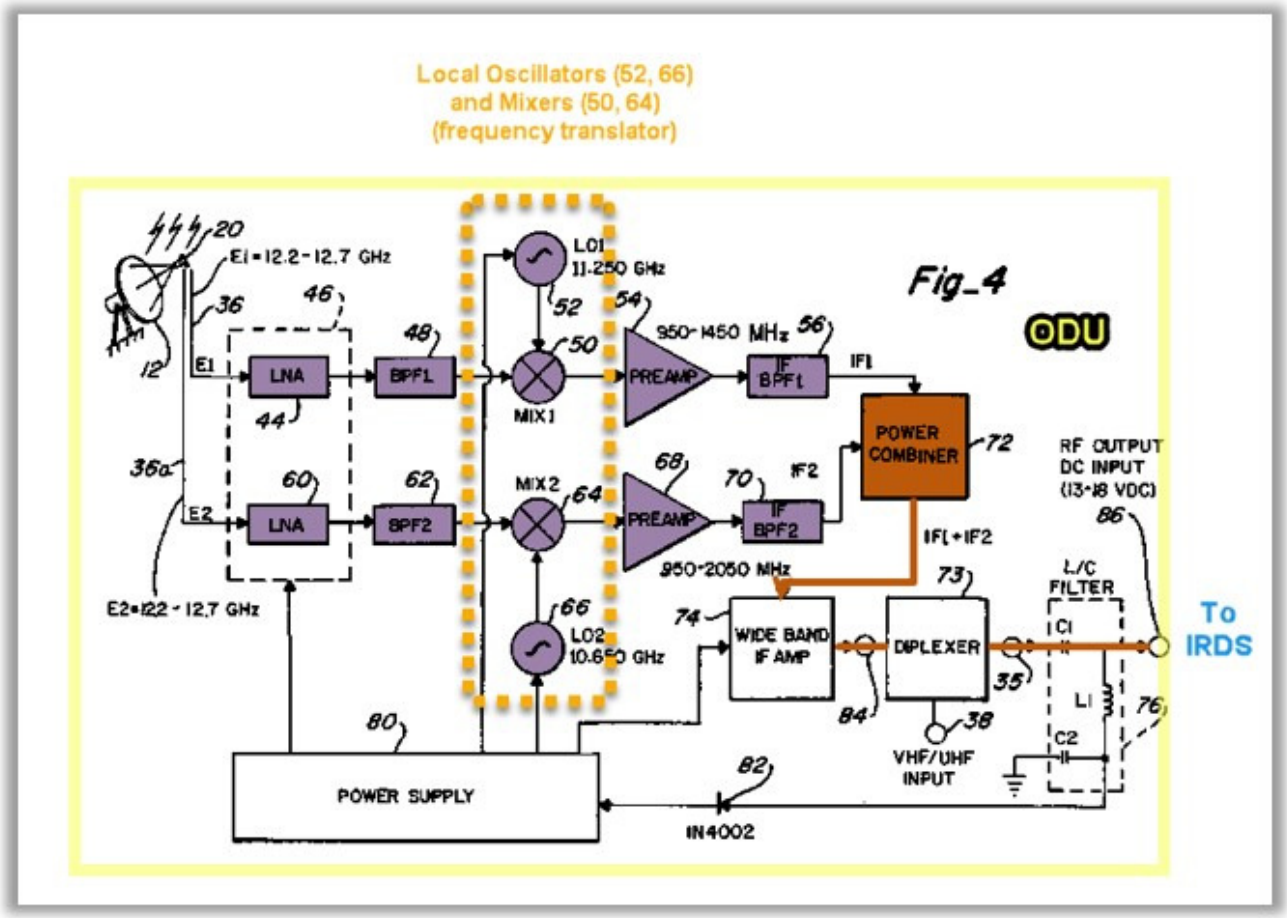


Figure 4 — AAPA Petruzzelli's Signal Distribution System.

3. Transponder Signal Selection Stacking

66. Rather than select and distribute entire blocks of transponder signals from the same received satellite signal, some persons inventing in the field instead proposed selecting individual transponder signals from various received satellite signals, and in some cases, stacking those transponder signals together to form a single signal for distribution. While the '576 patent suggests these are novel

concepts, they were actually proposed as much as sixteen years earlier.

67. U.S. Patent No. 4,675,732 to Oleson was filed in 1984 and is discussed in AAPA Petruzzelli. Oleson proposed using a small multipurpose computer programmed to manage a signal distribution matrix to distribute received satellite television channels to a plurality of TVs. Oleson uses a plurality of "channel strips" comprising variable tuner, filter and variable modulator, with each channel strip associated with a predefined output frequency. (*See* Ex.1015-Oleson, 1:14-58.) Under control of the computer, the channel strips each tune to a particular input frequency and supply it at a fixed and distinct output for distribution to a plurality of televisions. (*See* Ex.1015-Oleson, 1:14-58, 7:21-35.)

68. U.S. Patent No. 5,073,930 to Green, filed in 1989 and also discussed in AAPA Petruzzelli, similarly sought to more effectively distribute desired television programs in a multi-television environment. Green offered a two-tiered solution. First, Green proposed selecting transponder signals from various broadband LNB outputs, frequency shifting the selected transponder signals, and outputting a block of 12 transponder signals in the standard 950-1500 MHz range for distribution to receivers in the community, without demodulating the signal. (Ex.1011-Green, 9:65-10:63.) The resulting "mapped" output would appear as if the selected transponder signals originated on the same signal polarity after it was output by an LNB, as

shown in Figure 2 from Green:

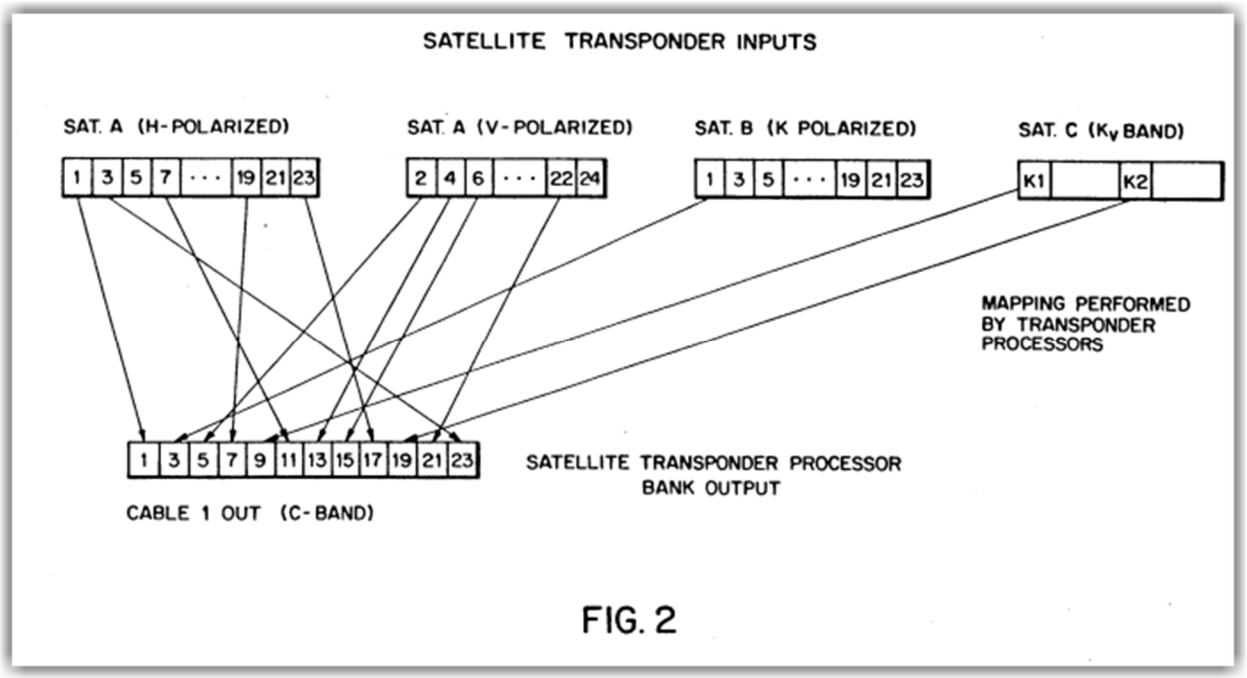


Figure 2 — Transponder Processors Perform Mapping of Transponder Signal Inputs to Bank Output.

Green surmised that this selection, extraction and combination process could be performed four separate times, resulting in four signals in the 950-1500 MHz range, each comprising 12 selected transponder signals, all provided to a central "multiplexor/selector" via a distinct distribution cable. (*See* Ex.1011-Green, 8:22-37, 9:65-10:63.) From here, the multiplexor/selector switches each STB to the cable containing the television channel desired by the STB. (*See* Ex.1011-Green, 8:22-37.)

69. Finally, AAPA Williams-419 describes a system for transmitting a combined satellite/cable signal over a single coaxial cable. (Ex.1009-AAPA Williams-419, Fig. 1 (below), 9:40-67.)

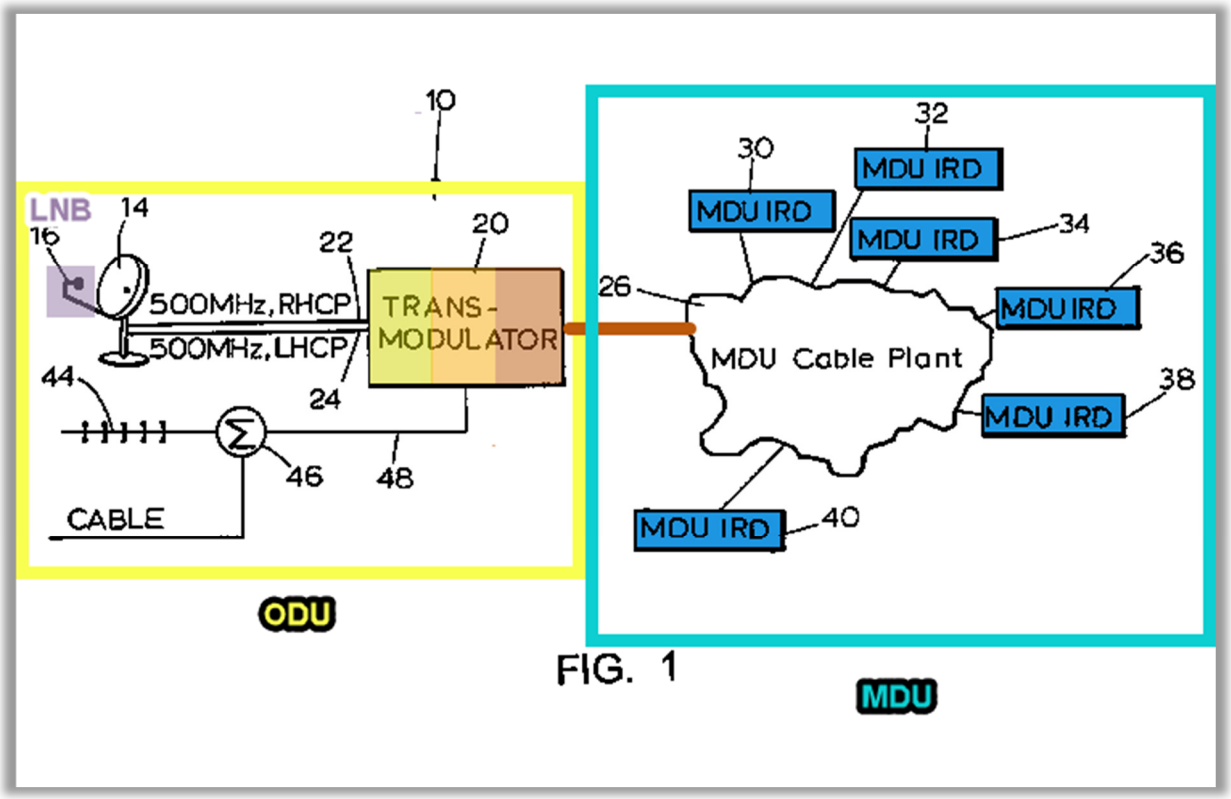


FIG. 1

Figure 1 — AAPA Williams's Signal Distribution System.

The Williams solution teaches reducing the bandwidth necessary to transmit a narrow bandwidth RF signal (*e.g.*, a QPSK-modulated signal typical of satellite systems) into a wide bandwidth RF signal (*e.g.*, a 128-QAM signal typical of cable systems) by adjusting modulation schemes. (Ex.1009-AAPA Williams-419, 6:52-67.)

E. Signal Digitization

70. Signal digitization was well known in electronic systems generally, and in radio-frequency ("RF") front-end systems in particular well before November 2001 and was specifically 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.1028, 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.").)

71. 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.

72. 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).

73. 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.1028, 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.1028, 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.1028, 6.)

74. 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, Hentshcel's ideal software radio receiver clearly discloses a system of receiving a analog RF signal and converting the signal into a digitized signal.

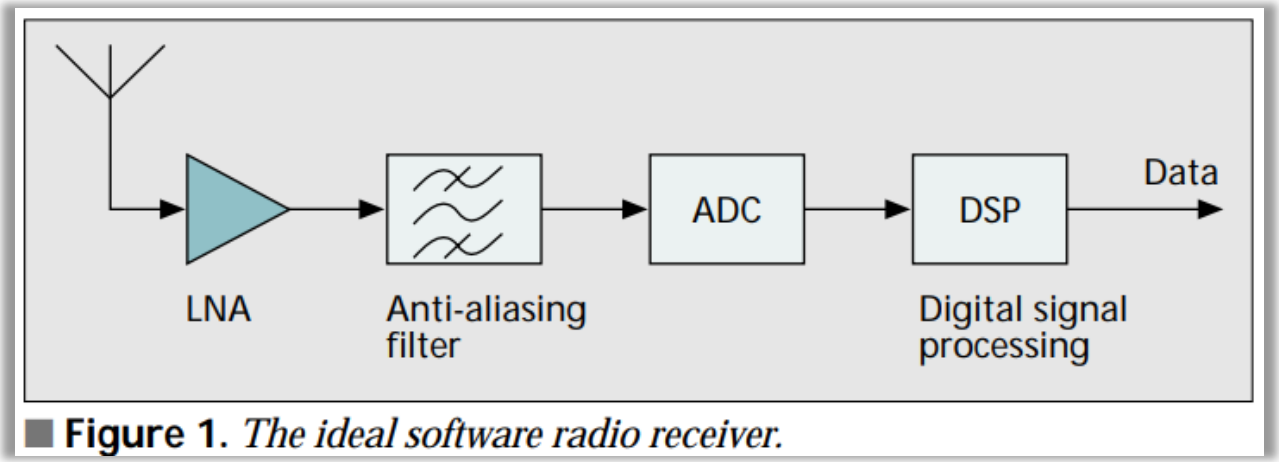


Figure 1. *The ideal software radio receiver.*

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

75. Similar digital channelizers, which converted incoming RF signals into digital signals through an ADC, were discussed and known in the art other documents. For example, U.S. Patent No. 6,697,603 ("Lovinggood," filed in 1999) discloses a digital repeater for receiving and retransmitting RF signals with applications in TV, radio, and cellular transmissions. (Ex.1023, Abstract, 1:42-2:11.) The digital down converter is shown in Figure 3 including an ADC at the front-end

digitizing received wideband RF signals. (Ex.1023, 5:3-25.)

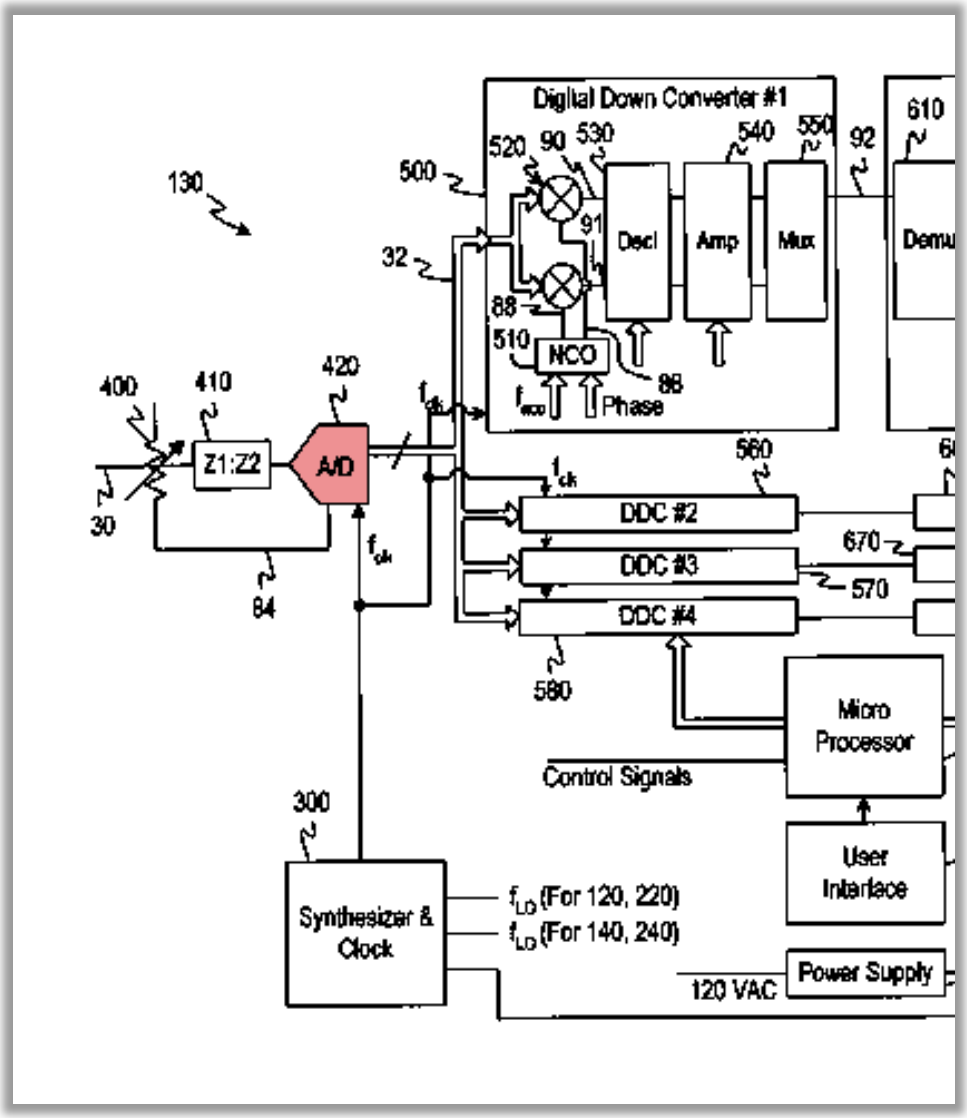


Figure 3 — Part of Lovinggood's Digital Signal Processing Module.

Numerically-controlled oscillators are used to select digital signals and frequency translate them to any desired frequency for eventual redistribution in RF (*e.g.*, to TV receivers). (Ex.1023, 7:57-8:41.) Using an NCO to select signals in the digital domain and translate them to a desired output frequency would have been within the

skill and knowledge of a POSITA at least by the November 2001 priority date of the '576 patent. The selected and translated signals are added by a multichannel digital adder 690, converted back into analog, and distributed (e.g., to TV receivers). (Ex.1023, 9:58-67.) Digital adders were likewise known in the art separate from their disclosure in Lovinggood.

76. The digitization of incoming RF signals was known in the field as of November 2001 in radio-receiver technology and a POSITA during the November 2001 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 included one or more ADCs to digitize a signal, or a component thereof.

77. An example of a television system incorporating an ADC to digitize a signal is described in a patent application to Davis *et al.*, filed April 15, 2002 and claiming priority to a provisional application filed in April 2001. (Ex.1021.) The provisional application discloses an interface device with "receivers inside for each LNB that convert the RF input into digital base band information," which can be filtered to discard unwanted information, can be compressed if it is not already, [] encrypted for privacy if desired," and then "multiplexed together and sent via [] LAN." (Ex.1022, 9.) The Davis application further 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.1021, ¶41.) Davis further explains that the "tuner/demodulator pair processes an RF input from each cable 22 and produces a ***corresponding digital output***." (Ex.1021, ¶41 (emphasis added.) Thus, Davis clearly describes a television system where incoming analog RF signals are digitized.

78. Another example of a television system incorporating an ADC to digitize a signal is described in Pugel, which I describe in later detail throughout this Declaration including as part of the Grounds for Invalidity.

79. In light of the above discussion, I find that methods and structures for digitizing incoming RF signals were well known before the November 2001 timeframe, both generally and for television systems, specifically.

F. Broadband Analog-to-Digital Conversion

80. The concept of wideband (or "broadband") analog-to-digital conversion, like the general concept of digitizing RF signals in a receiver system discussed above, was also well known before November 2001. I interpret the term "broadband" digitization, in the context of RF receivers, to mean the digitization of an incoming RF signal having a broad 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 broadband ADC to digitize

received RF signals in various applications before November 2001.

81. 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.1033, 1.49.) Kester explains that, in the 1980s, monolithic ADCs and monolithic flash ADCs were commonplace and were commonly available in audio applications. (Ex.1033, 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.1033, 1.53-1.54.) A POSITA would understand that these ADC architectures introduced in the 1980s are appropriately considered some of the earliest broadband ADC structures.

82. In the 1990s, interest in broadband 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.)

83. 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.1034, 452; Ex.1033.) Kumar discussed several techniques for performing wideband digitization as multiple methods for wideband digitization in communications systems were common at that time. 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.1034, 452; Ex.1033.)

84. Additionally, as discussed above, Lovinggood, in 1999, disclosed front-end architectures for wideband receivers in digital radio systems. Figures 2-3 and col. 5, lines 3-25, clearly disclose 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.1021.) Pugel likewise performs broadband digitization, as discussed in greater detail below. (Ex.1004-Pugel, ¶18.)

G. Building and Maintaining a Translation Table

85. Whenever a distribution system alters the frequency of a received transponder channel, such as in the systems of AAPA Petruzzelli, AAPA Williams-419, Oleson, and Green discussed above, it is necessary to maintain information that allows an STB to locate the channel at its new frequency so the STB is able to tune to the proper frequency associated with the transponder channel. Given that there were many solutions prior to November 2001 that shift the frequency of transponder

channels as a part of signal distribution, maintaining such a table was known in the art, and would not have been difficult to implement, store, and exchange.

86. For example, Green teaches that its transponder processors 112 "perform[] a selected frequency 'mapping' or conversion process." (Ex.1011-Green, 10:4-12.) Selector 208 of Green contains a mapping of the original channel locations at the input of Green's transponder processors 112 and the new channel locations on the transponder processor output. (*See* Ex.1011-Green, 12:57-16:2.) While not expressly disclosed in Green, the STBs receiving the distributed signals of Green would have needed this information to correctly select the cable on which a desired channel is located, and then to tune to the frequency where the channel is located. As another example, U.S. Patent No. 7,376,387 to Eck teaches utilizing the "QPSK carrier frequency" information that is included in a received digital satellite signal (which indicates the frequency at which the satellite signal is received by all customer receivers) and preparing a "frequency translation table" at the STB additionally containing the frequency at which the signal is distributed locally after frequency translation. (*See, e.g.,* Ex.1025-Eck, 1:21-35, 1:54-64, 2:10-25.) And more generally, *virtual channel* remapping could be used to associate program identifiers or transport stream IDs associated with a specific program with a new television channel to which it has been remapped, for example, out of a desire to

make a set of related television channels, like the ESPN family of television channels, appear to be located consecutively when they are not received in that fashion. (*See generally* Ex.1024.)

H. Summary of the State of the Art

87. I have prepared the below table to summarize how various concepts relevant to the challenged claims of the ’576 patent were found in the art, primarily using AAPA and the file history of a family member of the ’576 patent, before the priority date of the ’576 patent. The cited prior art references in the table, and the citations to specific passages and figures in each reference, are not meant to be exhaustive, but to merely provide examples.

Concepts Relevant to Challenged Claims	Disclosure of Concept in State of Art as Shown in AAPA and Prosecution History
Receiving and down-converting broadband satellite signals at an ODU.	Ex.1001-’576 patent, 1:19-555 (Background); Ex.1008-AAPA Petruzzelli, 1:21-62, 2:11-21, 2:54-65, 4:23-45, 4:58-5:15, 5:1-15, 5:61-6:21; Ex.1009-AAPA Williams-419, 2:11-40; Ex.1027-Shah, 1:64-3:6, Figs. 1, 4 (Ex.1006-’576 FH, 96); “Eutelsat Installers Guide,” Figs. 8, 11 (Ex.1007-’576 Reexam, 276-77); Ex.1015-Oleson, 4:35-50.
Digitization of broadband RF signals.	Ex.1034-Kumar, 452; Ex.1021-Lovinggood, Figs. 2-3, 5:3-25; Ex.1004-Pugel, ¶¶6, 18.
Selecting transponder signals from broadband satellite signals based on request information.	**Analog**: “Eutelsat Installers Guide,” 19, 26, Figs, 7, 11 (Ex.1007-’576 Reexam, 277-79). **Digital:**

Concepts Relevant to Challenged Claims	Disclosure of Concept in State of Art as Shown in AAPA and Prosecution History
	Ex.1023-Lovinggood, Figs. 2-3, 5:3-25; Ex.1004-Pugel, ¶¶6, 18.
Frequency translating selected transponder signals.	**Analog**: Ex.1008-AAPA Petruzzelli, Abstract, 5:45-6:50, 7:64-8:39; Ex.1027-Shah, 2:66-3:3, 4:61-67, Figs. 1, 4 (Ex.1006-'576 FH, 96); "Eutelsat Installers Guide," 15, 19, Figs. 7, 11 (Ex.1007-'576 Reexam, 281-82); Ex.1015-Oleson, 1:14-58, 7:21-35. **Digital:** Ex.1023-Lovinggood, Figs. 2-3, 5:3-25; Ex.1004-Pugel, ¶22.
Combining selected transponder signals for distribution.	**Analog**: Ex.1008-AAPA Petruzzelli, Abstract, 5:45-6:50, 7:64-8:39; Ex.1027-Shah, 3:55-4:38, Figs. 1, 4 (Ex.1006-'576 FH, 96-97); "Eutelsat Installers Guide," 15, 19, 27, Figs. 7, 11 (Ex.1007-'576 Reexam, 281-82, 284-85); Ex.1015-Oleson, 1:14-58, 7:21-35. **Digital:** Ex.1023-Lovinggood, 9:58-67; Ex.1004-Pugel, ¶26.
Distributing selected transponder signals in the same modulation as received in broadband satellite signals.	Ex.1008-AAPA Petruzzelli, Abstract, 5:45-6:50, 7:64-8:39; Ex.1015-Oleson, 1:14-58, 7:21-35; "Eutelsat Installers Guide," Fig. 7 (Ex.1007-'576 Reexam, 281-82).
Maintaining and distributing information about frequency locations for selected transponder signals.	Shah, 4:28-52 (Ex.1006-'576 FH, 98); "Eutelsat Installers Guide," 27 (Ex.1007-'576 Reexam, 287); Ex.1025-Eck, 1:21-35, 1:54-64, 2:10-25.

V. THE '576 PATENT

A. The Alleged Invention of the Challenged Claims

88. The '576 patent addresses an age-old problem within video distribution systems: how to efficiently deliver satellite video signals to more than one integrated receiver decoder ("IRD"), also known as a "set-top box" ("STB"), within a multiroom building such as a house or a hotel. A conventional satellite video distribution system including an ODU and multiple IRDs is depicted below in Figure 1 of the '576 patent.

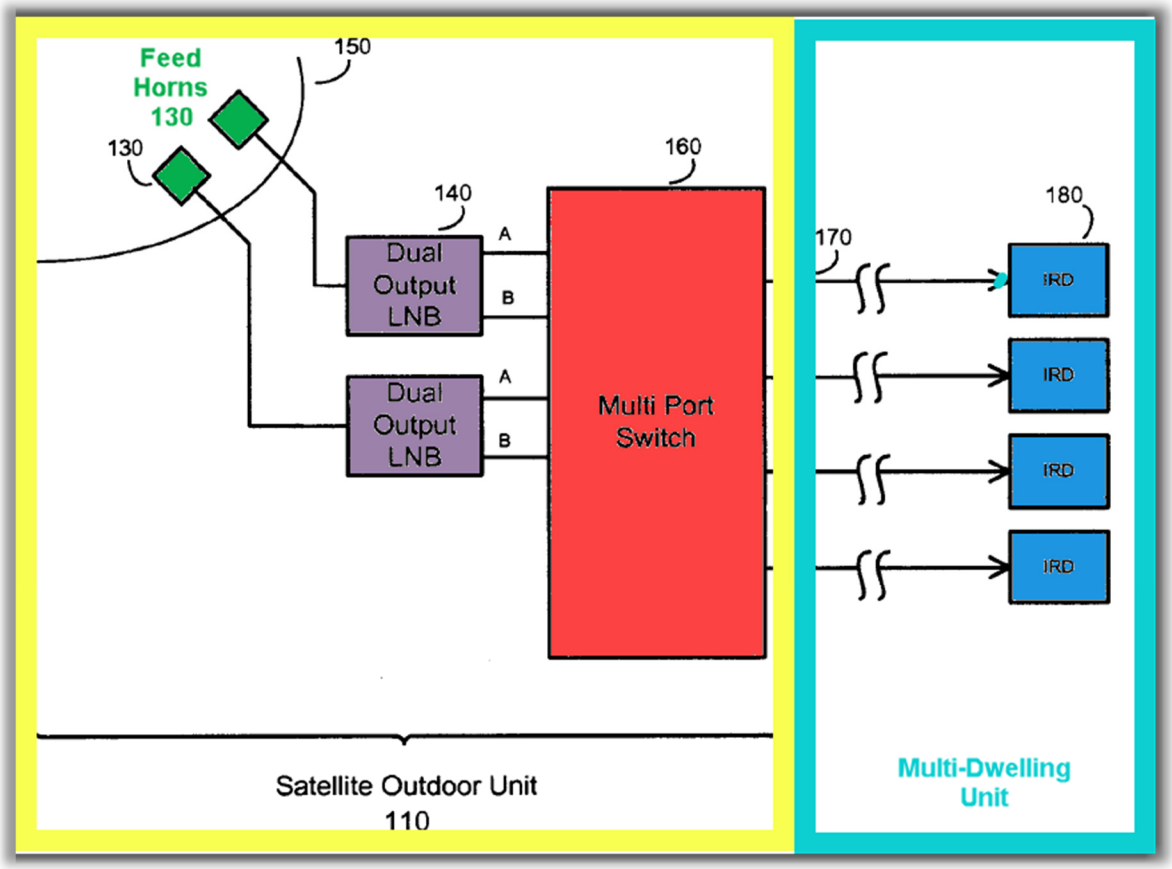


Figure 1 — Video Signal Distribution System (AAPA).

89. The ’576 patent explains that under “the conventional” approach, requiring separate cables between the ODU and each IRD was inconvenient when adding additional IRDs to new locations within a building. (Ex.1001-’576 patent, 1:44-54.) The ’576 patent’s purported solution draws on known techniques, including those summarized in the table above, to transmit desired channels as a combined signal that is outputted to all IRDs. (*See* §IV.H, *supra*.) Specifically, the ’576 patent teaches “selecting” requested satellite signals (*e.g.*, selecting transponder signals from a broadband LNB output signal), “translating” those transponder signals to various frequencies for transmission within an intermediate frequency (IF) signal, and “combining” the selected, translated transponder signals into a composite IF signal for output to all IRDs. (Ex.1001-’576 patent, 2:54-3:4.)

90. The ’576 patent’s process for creating a “composite signal” is illustrated in Figure 5 below.

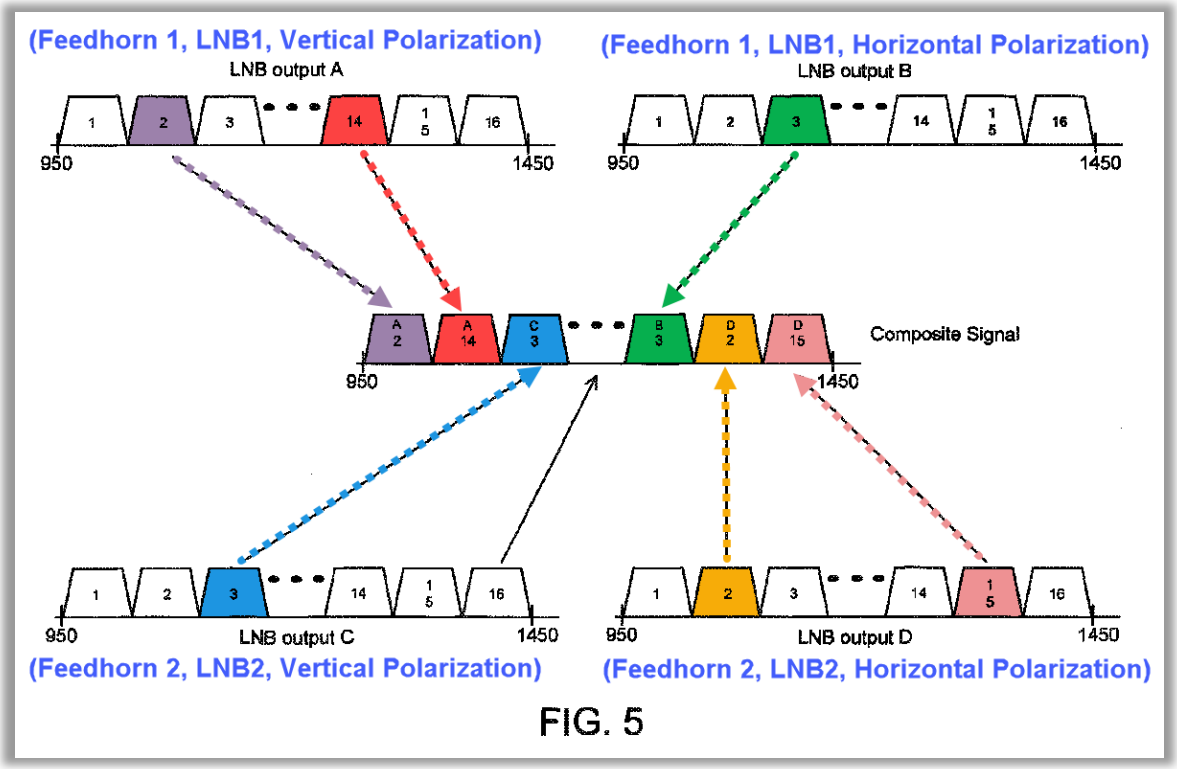


Figure 5 — The '576 patent's "Composite Signal" For Transmission Over a Single Cable.

91. Here, each numbered frequency block represents a transponder channel having a transponder signal comprising one or more television channels. The transponder channels are grouped together into four satellite signals (*i.e.*, broadband LNB outputs), labeled A-D, that correspond to the satellite hardware (*i.e.*, transponder) and signal polarization (*i.e.*, left- or right-polarity) of the satellite signals received by the feedhorns on the satellite antenna. (*See, e.g.*, Ex.1001-'576 patent, 1:44-54, 7:32-39.) Upon receiving these four satellite signals, selected transponder channels from the broadband LNB output signals are combined into a "composite" IF signal having a frequency range of 950 to 1450 MHz. (Ex.1001-'576

patent, 7:32-39.) Figure 9 depicts system components for selection, translation, and combination to create the composite IF signal. (Ex.1001-'576 patent, 3:55-58.)

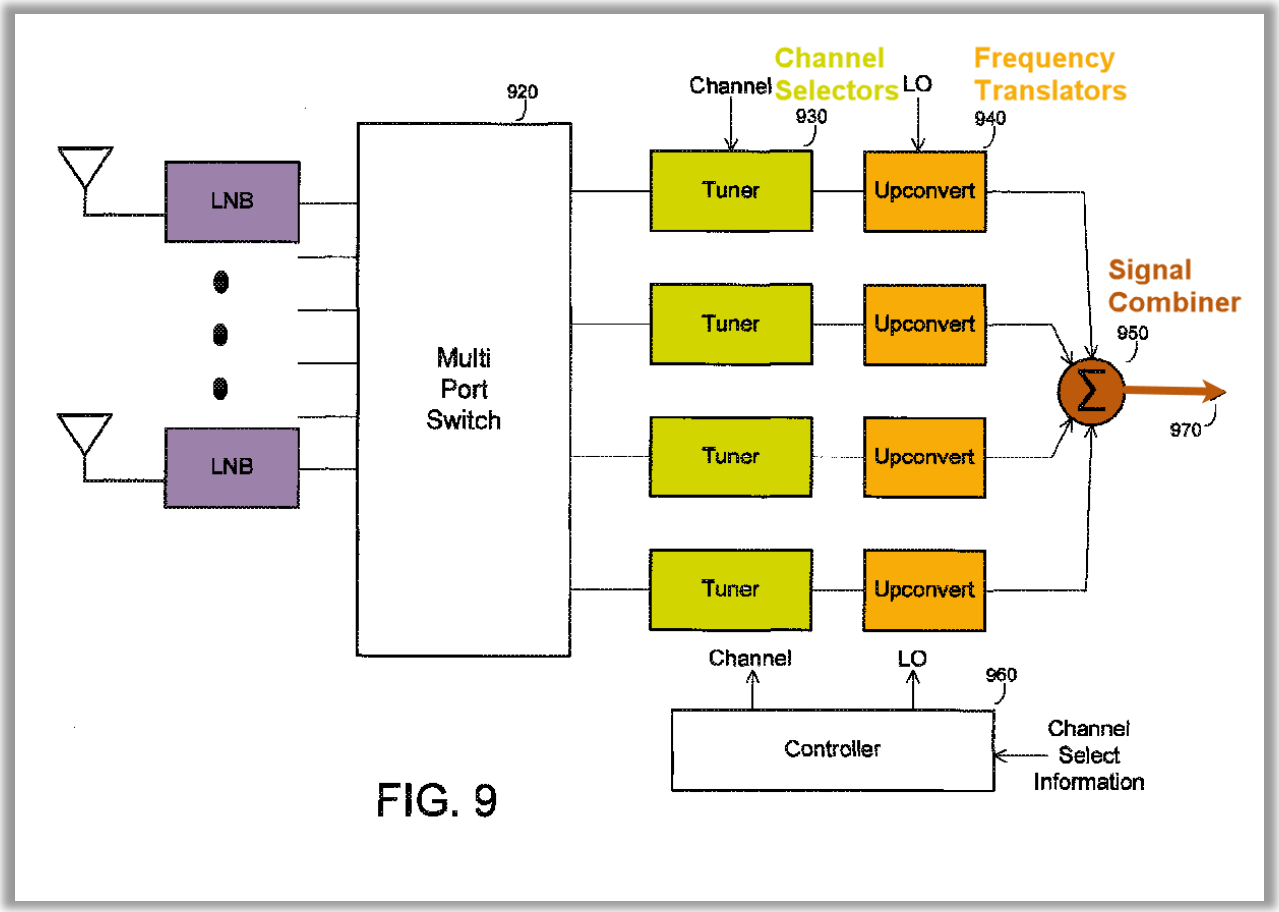


Figure 9 — Tuners and Upconverters Used to Select and Combine Channels.

92. Figure 9 illustrates that each LNB output signal carries frequencies corresponding to particular satellite transponder channels that communicate video and audio data. Desired transponder channels are selected by tuners 930. (Ex.1001-'576 patent, 8:65-9:25.) The frequency range for the selected satellite transponder channels is shifted by up converters 940. (Ex.1001-'576 patent, 8:65-9:25.) Finally, all frequency-translated channels selected for distribution are combined into a

composite signal for distribution over cable 970. (*Id.*, 8:65-9:25.)

93. The '576 patent teaches that the tuning, upconverting, and combining depicted in Figure 9 is performed in the "digital domain"—that is, by a digital signal processor performing functions that are the digital equivalent of long-used analog signal processing techniques. (Ex.1001-'576 patent, 10:60-63.) However, nearly a decade before the '576 patent's 2001 priority date, the book "Communication Services Via Satellite" (1992)—part of the AAPA (*see* §IV.H, *supra*)—touted the "considerable advantages gained by changing to the digital concept," including to increase bandwidth, minimize error, and optimize distribution. (Ex.1010, 104-05; *see also* §§IV.E-F, *supra*.) Moreover, the '576 patent expressly recognizes that conventional distribution system already operated in the digital domain. For example, QPSK—a digital signal modulation technique—was the "dominant modulation type in direct broadcast satellite systems" (Ex.1001-'576 patent, 1:54-57), and the received transponder channels carried multiplexed streams of video programs encoded using MPEG, a digital encoding method (*id.*, 9:26-33).

94. It is my opinion that the '576 patent uses what it expressly admits are known digital equivalents of analog signal processing, including digital filtering to select a signal instead of tuning (which the patent describes as "well known"), digital mixing to frequency shift a signal instead of analog mixing via an oscillator, and

digitally combining to create a composite signal in lieu of an analog signal combiner such as a summer. (Ex.1001-'576 patent, 5:12-6:18; *see also* §§IV.E-F, *supra*.) As I explain above in §IV.E-F, these digital counterparts were known in the art and within the skill of a POSITA to incorporate into digital signal processing.

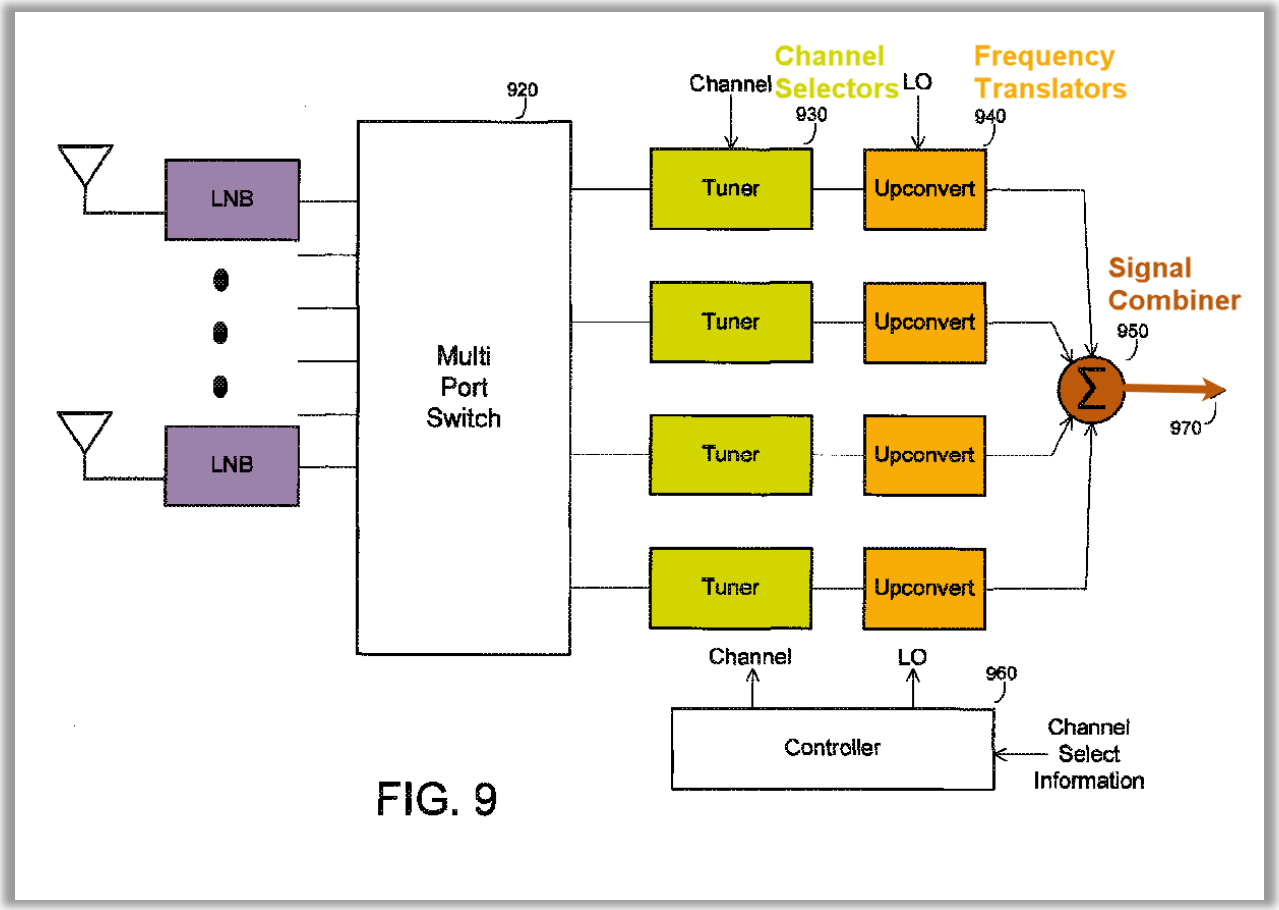


FIG. 9

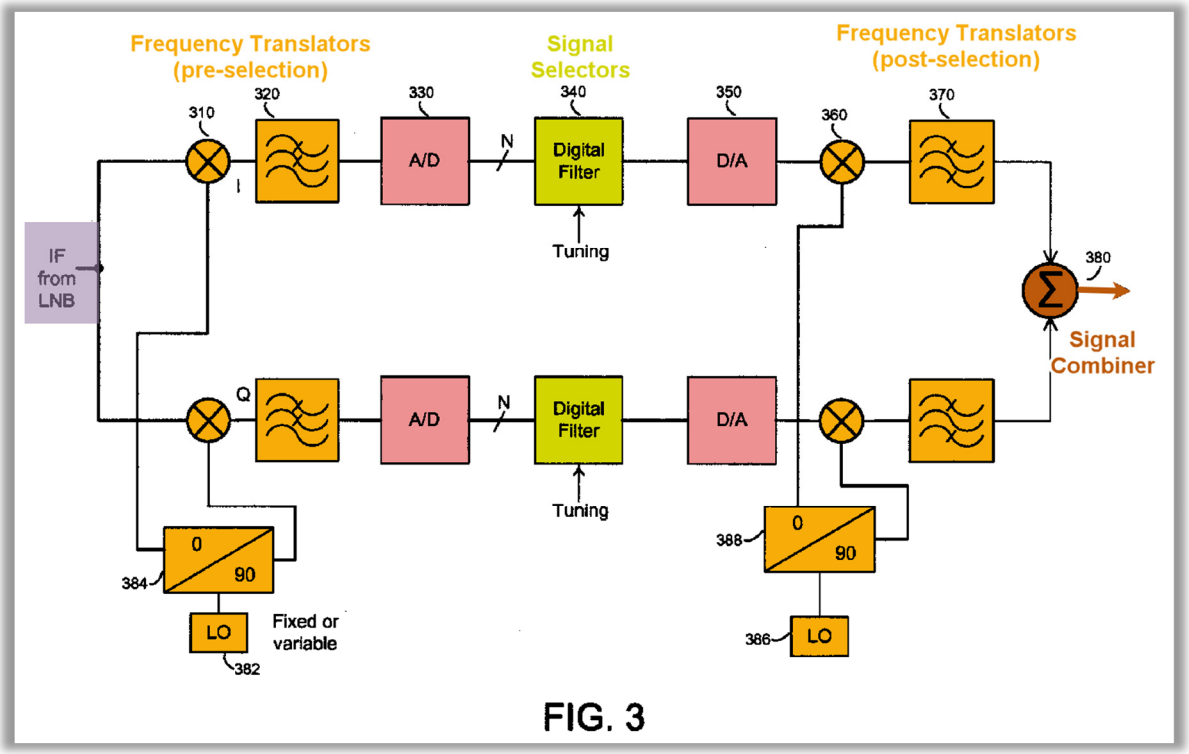


FIG. 3

Figures 9 and 3 — Signal Selection, Frequency Translation, and Signal Combination in the Analog (Fig. 9) and Digital (Fig. 3) Domains.

95. Because the transponder signals are received using an analog carrier, the digital signal processing embodiment requires the step of creating a digital representation of the analog signal. (Ex.1001-'576 patent, 4:51-64.) And because the existing IRDs were configured to receive transponder signals in the format output by the LNB (*i.e.*, as an analog carrier signal typically modulated using QPSK), the digital signal processing further required converting the digital signal back to analog. These steps are shown in Figure 3 by the "analog to digital" ("A/D") and "digital to analog" ("D/A") converters 330 and 350, respectively. (Ex.1001-'576 patent, Figure 3, 4:4:51-5:54.)

B. Prosecution History of the ’576 Patent

1. Original Prosecution

96. I understand that, during the prosecution of the ’576 patent, the original patent owner (Entropic Communications, Inc.) communicated with the USPTO. To further inform myself as to the content of the ’576 patent, I reviewed the written record between the Applicant and the UPSTO.

97. From reading this record, I understand the Examiner found that all of the originally filed claims were not allowable. Specifically, in an Office Action communication, the Examiner found all claims were anticipated by Williams-873, and/or rendered obvious by Williams-873 in combination with U.S. Patent No. 6,493,873 (“Seo”). (Ex.1006-’576 FH, 85.) Applicant responded by arguing that the claims distinguished over Williams-873 because “[a]n important distinction between applicant’s invention and the Williams reference is that Williams uses transmodulation where the applicant’s invention does not transmodulate.” (*Id.*, 85-86.) To apparently make the distinction between the claims and the Williams-873 patent clear, Applicant amended the claims to include the following limitation “*wherein the modulation of the transponder signal is not altered by the steps of selecting, combining, and transmitting*.” (Ex.1006-’576 FH, 83, 85.)

98. I assume that these arguments and amendments persuaded the Examiner because in his next Office Action he no longer relied primarily on

Williams-873 but instead found the claims as amended were not allowable because Shah (U.S. Patent No. 6,441,767) disclosed or rendered obvious all the limitations. (Ex.1006-'576 FH, 96-104.) Once again, Applicant amended its claims to distinguish over the Shah-based rejections. In pertinent part, the claim amendments now require that "*in the ODU, selecting a plurality of transponder signals extracted from the received satellite broadband signals, wherein the selecting is responsive to the transponder request signals*." (Ex.1006-'576 FH, 111.) Finally, I understand that the Applicant and Examiner conducted an interview in June 2006 and the Examiner ultimately allowed the claims without providing any reasons for his allowance. (Ex.1006-'576 FH, 141-47, 154 (notice of allowance).)

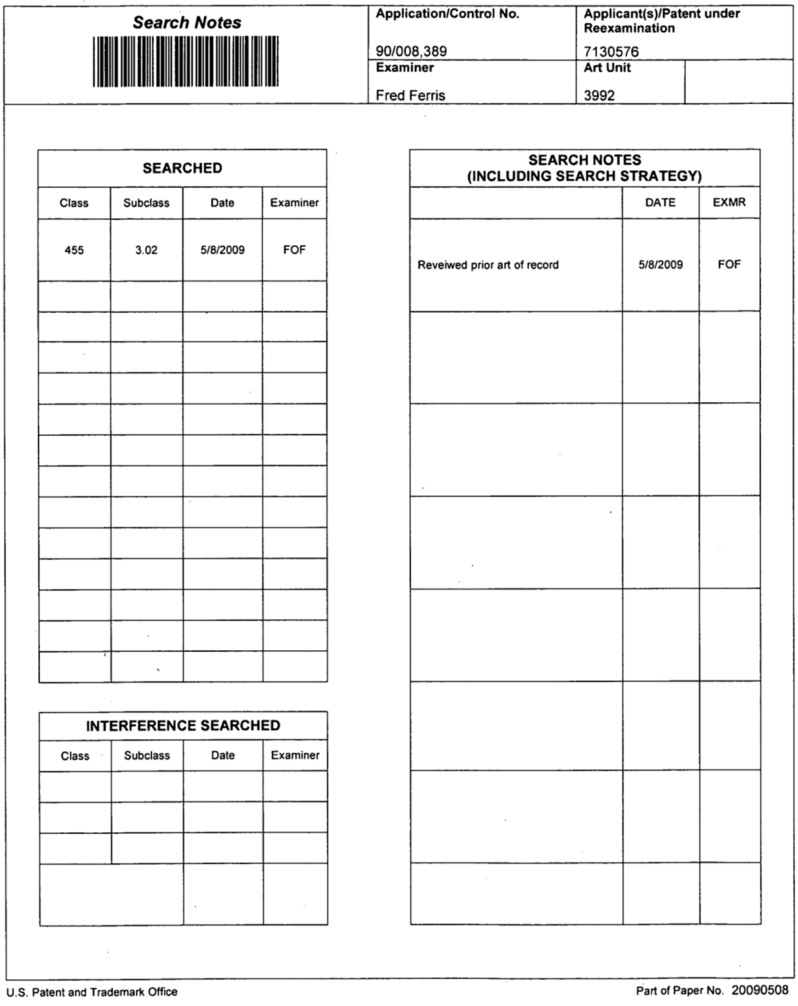
99. As I explain in detail below (§VII.A.3, limitation 14[d], *infra*), I believe the Examiner erred by overlooking express and key disclosure in the Willaims-'873 patent describing the exact feature that the Applicant argued distinguished its claims from Williams-'873 patent. It is my opinion the Williams-'873 patent clearly describes an entire embodiment that does not use transmodulation and thus does not alter the original modulation of the signal. When read in totality it is clear to me—and would be clear to a POSITA—that the Williams'873 patent described an embodiment where transmodulation is not used or needed. (§VII.A.3, limitation 14[d], *infra*.)

2. Reexamination of the ’576 Patent

100. I understand that in 2007, a third party filed an *ex parte* reexamination challenging the validity of the ’576 patent. I reviewed this record too and the cited prior art. I understand that upon reviewing the reexamination petition, the Patent Office agreed that the “Eutelsat Installer Guide” prior art anticipated the ’576 patent claims reciting selecting, extracting, and combining of transponder signals to produce to a composite signal for transmission over a single cable without altering the transponder signal’s modulation. (Ex.1007-’576 Reexam, 276, 289-92.) I assume because the original Patent Owner was unable to distinguish the claims over the Eutelsat prior art, the Patent Owner instead was forced to narrow its claims to avoid a finding of invalidity. (Ex.1007-’576 Reexam, 318 (admitting that “the Eutelsat references teach reception systems performing channel selection and combining” including via “reception architectures” that do not involve remodulation, such as “IF-IF conversion”); *see also id.*, 320-21.) This time, Patent Owner narrowed the independent claims to recite “*digitizing the plurality of satellite broadband signals*.” (Ex.1007-’576 Reexam, 311.) Patent Owner argued that Eutelsat did “not teach or suggest broadband digitization of the incoming signal combined with channel selection from that digitized signal in the digital domain,” including the step of “extracting selected channels from the digitized broadband signals in the digital

domain." (Ex.1007-'576 Reexam, 320-21.) After this amendment claims 1-23 were then found patentable as amended, and new claims 24-42 were added.

101. Here again, it is my opinion that the Patent Office erred and should have understood that by 2001 digitization and processing of broadband signals was well known. (§IV.E-F, *supra*.) In my review of the reexamination record, after the Patent Owner submitted its amendments, it appears that the Examiner did not go beyond the prior art of record with the exception of searching Class 455, subclass 3.02—which apparently did not turn up any results as indicated by the Examiner notes below. Based on my review, the Examiner did not record the search terms used when searching Class 455.



Search Notes

Application/Control No.	Applicant(s)/Patent under Reexamination
90/008,389	7130576
Examiner	**Art Unit**
Fred Ferris	3992

SEARCHED

Class	Subclass	Date	Examiner
455	3.02	5/8/2009	FOF

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
Reveiwed prior art of record	5/8/2009	FOF

U.S. Patent and Trademark Office — Part of Paper No. 20090508

Examiner Search Notes Dated May 8, 2009.

(Ex.1007-'576 Reexam, 366.)

102. As I explained above in detail, by November 2001, POSITAs would have understood how to use a DAC to digitize broadband signals and perform processing on the digitized broadband signal such as signal selection and frequency translation, and would have understood the benefits of so doing (discussed in further detail below regarding Pugel, which expressly teaches such benefits. And there were

multiple documents known in the patent and non-patent literature disclosing these techniques and the benefits therefrom.

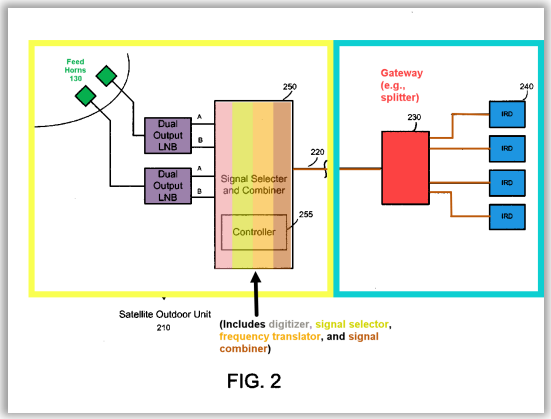
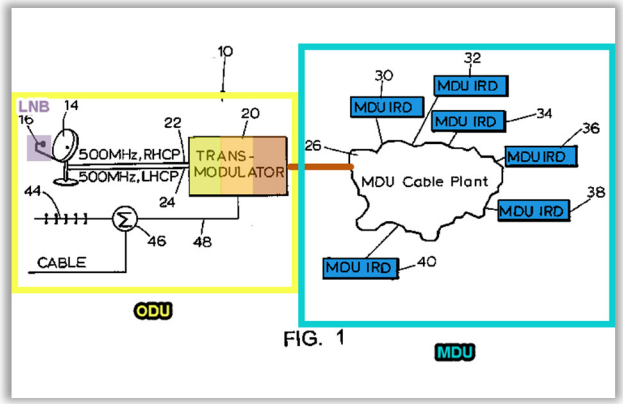
C. Assumed Priority Date of the '576 Patent

103. I have been asked to assume, for the purposes of this proceeding only, that the '576 patent's priority date is November 7, 2001.

VI. DESCRIPTION OF THE PRIOR ART

A. Williams-873

104. Williams-873 describes and solves the same problem as the '576 patent—how to deliver video signals to a plurality of IRDs using the same signal. (Ex.1003-Williams-873, Abstract, Fig. 1.) Williams-873 sought to improve conventional limits on the bandwidth available for video transmission over "typical cables" and noted the inability of the prior art to "broadcast a large number of transponder signals associated with one or more satellites over the same cable line." (Ex.1003-Williams-873, 2:36-3:32; *compare with* Ex.1001-'576 patent, 1:55-62.)

’576 Patent’s Video Distribution Sys.	Williams-873’s Video Distribution Sys.
 FIG. 2	 FIG. 1

105. Williams-873’s solution placed a transmodulator between two video sources—a satellite receiver and cable network receiver—that selected and combined signals into a composite signal for transmission over a single cable line for distribution via a cable network 26 within a multi-dwelling unit (“MDU”).

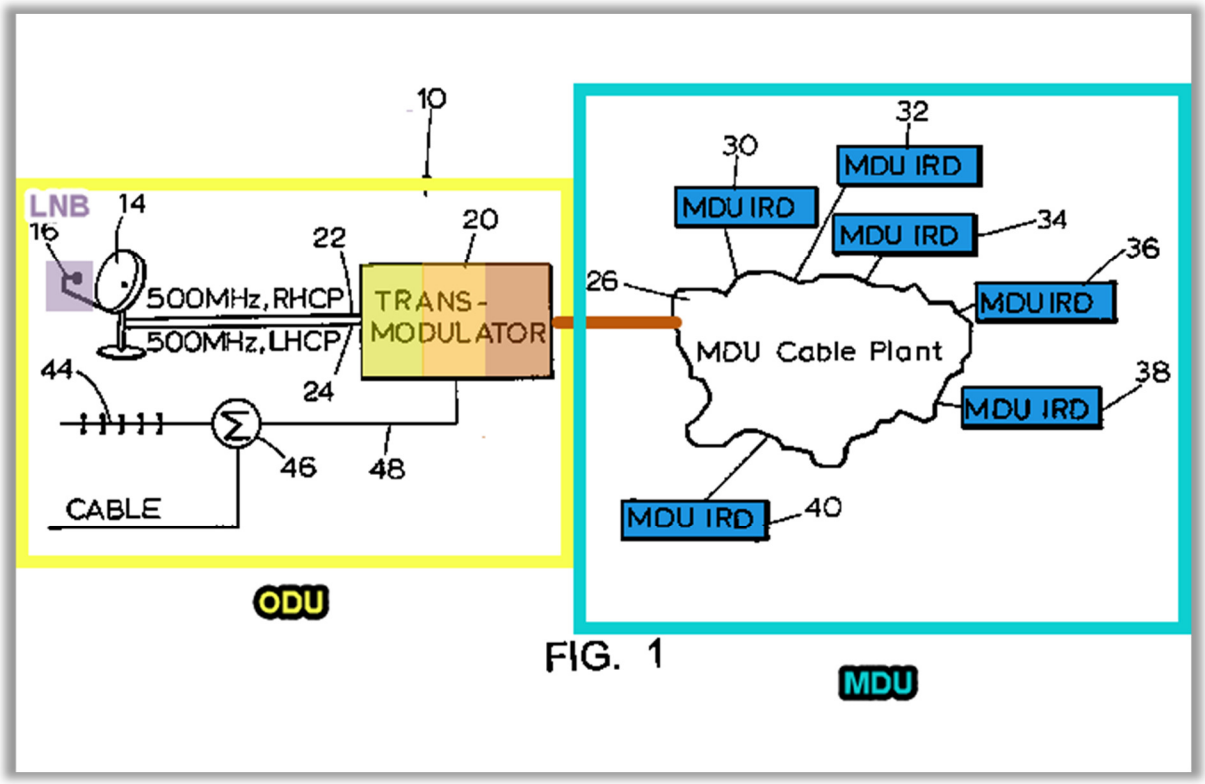


FIG. 1

Figure 1 — Signal Distribution System of Williams-873.

106. In Williams-873, the transmodulator 20 receives input audio and video signals from a plurality of sources, including broadband satellite television signals 22 and 24 received by antenna 14 and down-converted by LNBs 16. (Ex.1003-Williams-873, 5:59-6:11; *compare with* Ex.1001-'576 patent, 4:28-50.) The transmodulator also receives a plurality of transponder request signals from the IRDs located within the MDU. (Ex.1003-Williams-873, 16:5-11; *compare with* Ex.1001-'576 patent, 3:10-19.) Each requested transponder signal is selected and processed by a transmodulator channel of the transmodulator 20. (Ex.1003-Williams-873, 4:16-39; *compare with* Ex.1001-'576 patent, 8:61-63, Fig. 8.) An exemplary set of

transmodulator channels each having a tuner, decoder, packetizer, cable encoder, and upconverter are shown below in Figure 3.

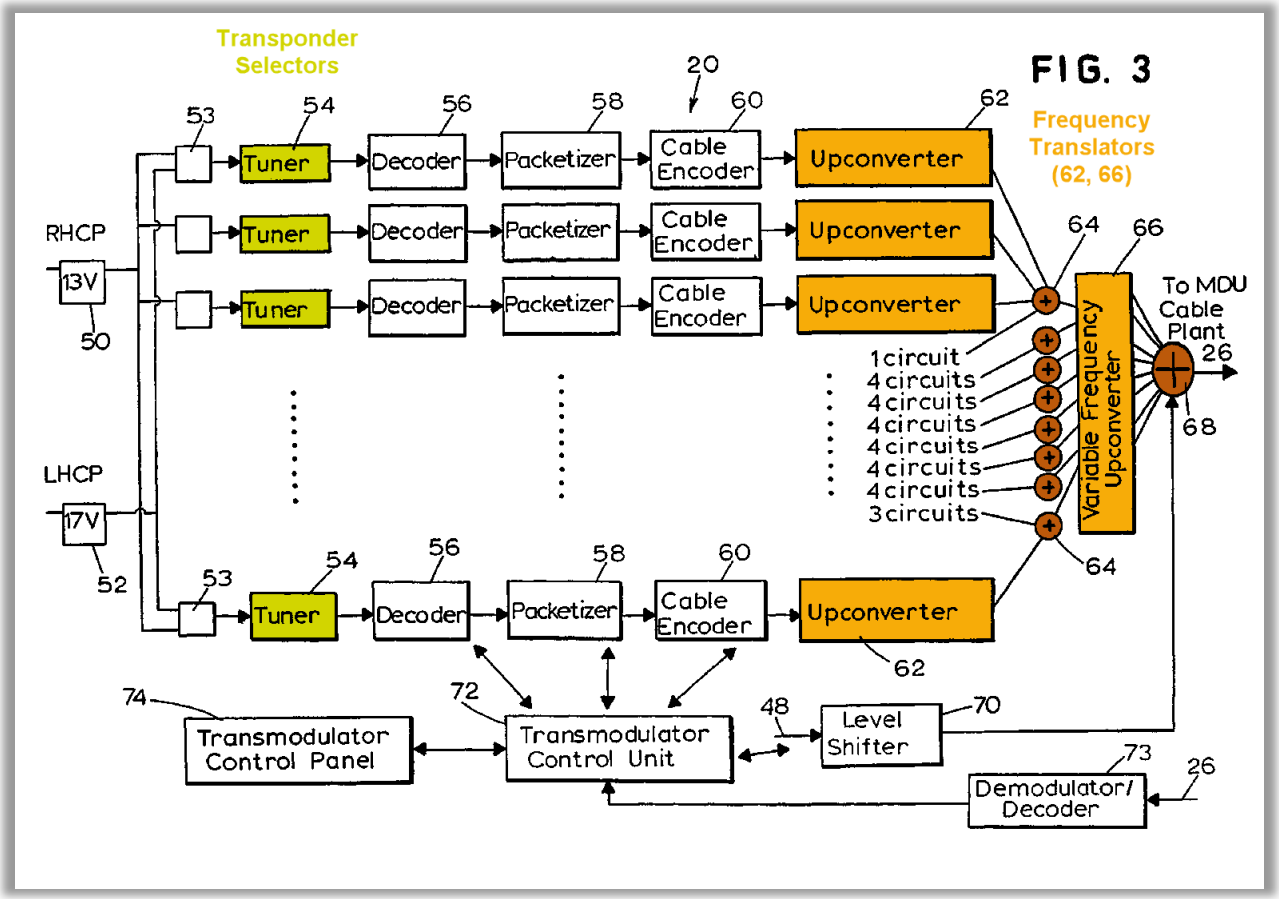


Figure 3 — Transmodulator 20 Contains a Plurality of Transmodulator Channels.

107. The output of each transmodulator channel is shifted to a distinct frequency by the upconverter 62, summers 64, and the variable frequency upconverter 66 before being summed by summer 68, and the resulting signal is distributed to the cable network of an MDU over a single cable 26. (Ex.1003-Williams-873, 10:34-39; *compare with* Ex.1001-'576 patent, 5:31-42 ,5:55-6:19,

Figs. 14-15.)

108. Importantly, although Williams-873 teaches exemplary transmodulator channels capable of changing the modulation of the selected signal, Williams-873's system does not require transmodulation. For example, Williams-873 explains that "in some cases in which only a few of the selected signals are being distributed, the transmodulator may not need to remodulate the selected signals but may, instead, send these signals over the cable network 26 at the received modulation scheme." (Ex.1003-Williams-873, 7:14-20.) The transmodulator 20 instead can "shift selected ones of the[] [received] signals to different frequencies for transmission over the cable network" without changing modulation. (Ex.1003-Williams-873, 15:15-27.)

B. Pugel

109. Pugel discloses simultaneously processing a plurality of extracted satellite signals in a digital domain for distribution as a combined signal. (Ex.1004-Pugel, Abstract, ¶6; *compare with* Ex.1001-'576 patent, 4:51-6:19.) Pugel's receiver 100 "comprises a direct broadcast satellite (DBS) receiver" including an analog processing section 110, for processing the received signal in the 950-1,450 MHz range. (Ex.1004-Pugel, ¶¶15-17.) The output is then fed to an A/D converter 12 that "receives all . . . 16 channels" of the received signal "simultaneously and produces at its output a digital bit stream S3 that is representative of the 16 channels in a digital format." (Ex.1004-Pugel, ¶18; *compare with* Ex.1001-'576 patent, 4:51-64, 7:23-

31.) Channel processors 130 receive the digital signal and extract data associated with a particular transponder channel (*i.e.*, extract a transponder signal). (Ex.1004-Pugel, ¶¶21-26; *compare with* Ex.1001-'576 patent, 5:12-30.) Pugel teaches that all received transponder channels are processed by the channel processors 130 and combined in a manner for more efficient distribution (*i.e.*, through a network). Alternatively, a subset of the received channels is processed by a smaller number of channel processors, the subset selected based on the needs of the system at the time. (Ex.1004-Pugel, ¶¶23, 37-39; *compare with* Ex.1001-'576 patent, 4:48-50, 5:31-42, 5:55-6:19, Figs. 14-15.)

110. Pugel teaches several advantages to its digital channel processing receiver 100. For example, it removes the "typical analog conversion stage found in a direct conversion receiver," and "[s]pecifically [avoids] analog mixers and oscillators." (Ex.1004-Pugel, ¶51.) It also advantageously avoids the "high-cost tuning and processing arrangement" associated with simultaneous channel processing in the analog domain. (Ex.1004-Pugel, ¶52.)

VII. PETITIONERS' GROUNDS FOR CHALLENGE

111. Independent claims 8 and 14 are directed to a system and method for distributing received satellite signals. Claims 9-13 depend from claim 8, and claims 15-23 and 34-42 depend from claim 14. Because I understand that claim 14 and most

of its dependent claims are asserted by Patent Owner in the District Court litigation, I address those claims first.

A. Ground 1: Claims 14-23, 34-42 and 8-13 are Obvious over Williams-873 in view of Pugel.

1. Motivation to Combine

112. It is my opinion that a POSITA would have been motivated to combine the teachings of Williams-873 and Pugel. Both Williams-873 and Pugel are directed to satellite television signal distribution systems and address the same problem—how to optimally process and distribute received signals in view of user needs at a given point in time. (Ex.1003-Williams-873, Abstract; Ex.1004-Pugel, ¶¶3-4.) Moreover, both Williams-873 and Pugel describe receiving, selecting, combining, and distributing satellite signals. Thus, a POSITA would look to these similar and related references to efficiently process and distribute received satellite television channels to multiple users for the reasons I describe in greater detail below.

113. First, a POSITA would understand the inherent design choice and trade-offs between digitizing an entire received broadband signal or only those signals which are selected for distribution. Portions of Williams-873's signal distribution system are performed in the digital domain, including decoding, packetizing, and cable encoding, performed on digital data in a "packet" form that is conventionally used to transmit digital data over a digital network. (Ex.1003-Williams-873, 9:39-

10:39.) However, the front portion of Williams-873's system, including the tuning (*i.e.*, channel selection), frequency translating, and signal combining, are not conducted in the digital domain.

114. Nevertheless, in view of Pugel, a POSITA would have been motivated to shift the point of digitization earlier in Williams-873's distribution system so the digitization would occur prior to signal selection and after an LNB has down-converted received satellite signals so that at least signal selection (and subsequent processing) is performed in the digital domain.

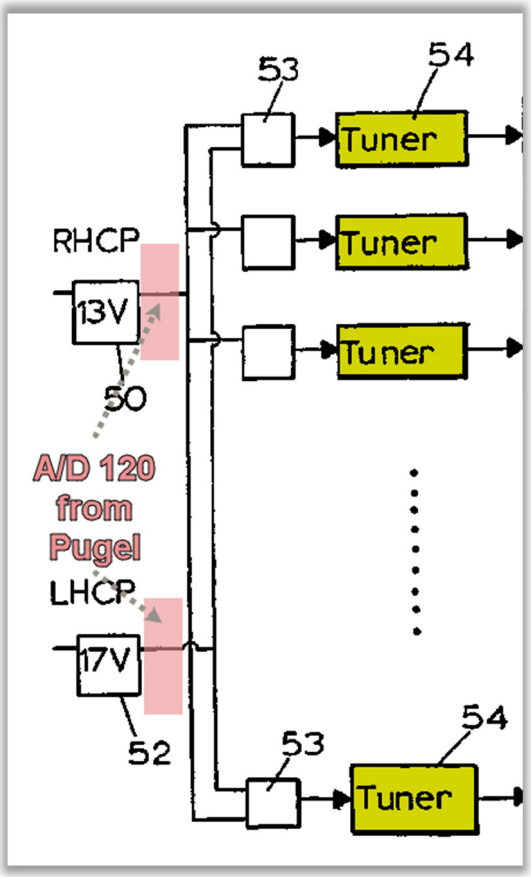


Figure 3 — Shifting the Point of Digitization in Williams-873 Transmodulator 20 in View of Pugel 120.

115. 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; (b) flexibility of digital design provided by hardware and software options that can be easily modified in the future; and (c) simplifying signal selection (as Pugel explains in detail). These benefits, however, are attained at the expense of the high-sampling rate needed when applied to a wideband or broadband signal because (according to the Nyquist rate) the sampling rate is proportional to its highest frequency component.

116. An alternative design option relies on digitization in later stages by first decomposing wideband or broadband signals to multiple narrowband signals in the analog domain, and only then proceeding to digitize any desired narrowband analog components of the broadband signal. 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 or broadband signal. (*See* Ex.1004-Pugel, ¶52 (discussing "high cost" for analog "tuning and processing arrangement[s].")

117. 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 November 2001, the improved digitization technology reached ultra-high sampling rates that could accommodate the digitization of wideband/broadband analog signals. (Ex.1033, 1.52 ("As previously mentioned, the rapidly growing digital video market, coupled with the introduction of the TRW TDC-1007J 8-but, 30Ms/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 500 Ms/s. The peak years for flash converters were approximately 1970 to 1990.").) (§§IV.E-F, *supra*.)

118. With this general knowledge in mind, it is my opinion that a POSITA would have known to use the A/D Converters 120 of Pugel—and apply them prior to Williams-873's switches 53 and certainly before tuners 54 (collectively, "signal selection") because the earlier digitization approach would result in a flexible and efficient digital selection and avoid the cost associated with multiple analog tuners.

119. Moreover, Pugel teaches that the only processing performed prior to the use of A/D Converter 120 is by "analog processor 110" that "produce[s] an output signal S2 suitable for processing by the A/D converter 120." (Pugel, ¶16.) Therefore, a POSITA would have been motivated to use the teachings of Pugel to insert an analog-to-digital converter (such as A/D Converter 120) as early as possible in Williams-873's signal distribution system, and to substitute known digital equivalents for the switches 53 and tuners 54 in Williams-873 to obtain the benefits Pugel teaches regarding processing in the digital domain. Modifying Williams-873 to include A/D converters after down-conversion (as shown above in Figure 3) would have been an obvious location to perform digitization because it would have required lower sampling rates and thus less expensive analog-to-digital converter hardware than digitization prior to down-conversion, while ensuring compatibility with commonly used satellite receiver/LNBs.

120. Second, a POSITA would have also known to use digital signal

processing equivalents for the analog signal selection and frequency translation functions taught by Williams-873, including those taught in Pugel. For example, a POSITA would have known that there are numerous digital filtering techniques that could be employed for signal selection in the digital domain including both techniques obtained by mapping conventional analog filters (*e.g.*, Butterworth filter) as well as intrinsically digital filter design methods (*e.g.*, Parks-McClellan algorithm). (*See*, *e.g.*, Ex.1017-Oppenheim, 439-511.)

121. Pugel would further motivate a POSITA to implement in the digital domain the functionality of Williams-873 analog switches 53, tuners 54, and variable frequency upconverter 66, because such a skilled artisan would have known that the digital equivalent of each were generally more efficient, reliable, flexible, and less expensive than their analog counterparts, as taught in Pugel. (*See generally* Ex.1017-Oppenheim, 439-511.) For example, the digital counterpart of analog switches 53, tuners 54, and variable frequency upconverter 66 can be implemented in digital hardware or in software using a general-purpose processor, thus offering an inexpensive implementation of these functionalities, while providing the flexibility to easily modify and enhance the system in the future.

122. Digitizing before signal selection and performing the signal selection and translation functions in the digital domain, were within the general knowledge

of a POSITA and would have been implemented with a reasonable expectation of success utilizing known components to make Williams-873's system more economical. Indeed, during the *ex parte* reexamination, the Office found that "using a[n] … analog to digital converter would have been part of the ordinary capabilities of a skilled artisan and there would have been a reasonable expectation of success based on similar uses of" analog-to-digital converters "in the same technological area." (Ex.1007-'576 Reexam, 297; *see also* Ex.1005-Kelley, 6:31-34, 7:34-40.)

2. Independent Claim 14

14[pre] "A method of communicating a plurality of transponder signals from a satellite outdoor unit (ODU) that receives a plurality of satellite broadband signals to an integrated receiver decoder (IRD) over a single cable connected to the ODU, the method comprising the steps of:"

123. To the extent the preamble is limiting, Williams-873 discloses it.

124. Williams-873 discloses a *method of communicating a plurality of transponder signals from a satellite ODU that receives a plurality of satellite broadband signals*. Williams-873 discloses that main signal receiver 14, LNB 16, and transmodulator device 20—collectively the *satellite ODU*—are responsible for receiving and processing a plurality of satellite signals 22/24, including at least the broadband signals RHCP 22 and LHCP 24, and then communicating a composite signal to an IRD in a multi-dwelling unit. (Ex.1003-Williams-873, Abstract (system includes "a main receiving antenna that receives a broadband video/audio/data signal

having a number of individual program multiplex signals therein."), 3:50-4:3 ("[A] receiving antenna receives a broadband signal from, for example, a satellite … [a] transmodulator … transmits this transmodulated signal … [over] a communication channel, such as a cable), 5:59-6:11 ("The signal distribution system 10 includes a main signal receiver 14 disposed on, for example, the roof of an MDU or any other location capable of receiving a signal transmitted by a satellite or other signal source."), Figs. 1, 3.)

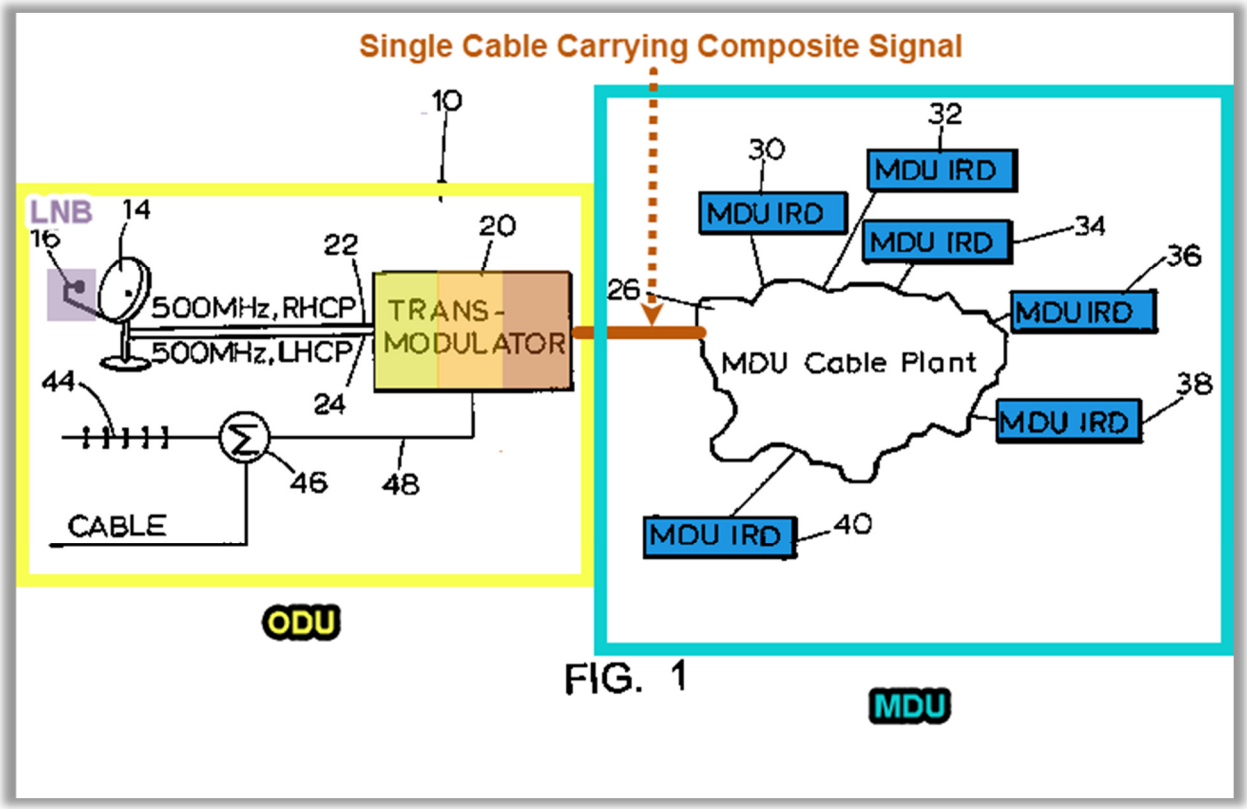


Figure 1 — Williams-873's Signal Distribution System.

125. Figure 1 of Williams-873 further illustrates that the *communicated transponder signals* are directed to *at least one IRD* (*i.e.*, MDU IRDs 30, 32, 34, 36,

38, or 40) *over a single cable connected to the ODU*.[2] "The transmodulator 20" places the "transponder signals on a cable plant or cable network 26 within an MDU for distribution to a number of IRDs." (Ex.1003-Williams-873, 6:12-34, 10:24-39 ("A summer 68 then combines these upconverted transmodulated signals with each other … for propagation over the cable network 26 of Fig. 1.), claim 14 ("The signal distribution system of claim 9, wherein the main transmitter transmits the combined signal to the individual receivers over a cable …").)

126. Accordingly, Williams-873 discloses this limitation.

14[a] "communicating a transponder request signal to the ODU from the IRD;"

127. Williams-873 discloses this limitation. Williams-873's *IRDs* "receive[]

[2] In its infringement contentions in co-pending District Court litigation, I understand that Patent Owner appears to interpret "over a single cable to the ODU" to mean that the composite signal is first transmitted from the ODU into a house/MDU over a single cable but is then "split" onto multiple other cables connecting each IRD to the ODU—meaning that in direct contrast to the express claim language—at least two cables are required. While I understand that DISH does not agree with this apparent construction, I have been asked to adopt this interpretation for the purposes of this Declaration.

satellite signal requests from a user and then send[] requests to the transmodulator 20" of the ODU "to have the requested transponder signals … transmitted to the IRD via cable network 26" (*i.e.*, *communicate transponder request signals*). (Ex.1003-Williams-873, Figure 1 elements 30, 32, 34, 36, 38 or 40, 16:5-11, Abstract ("receiver units send requests for user-selected ones of the individual program multiplex signals to the transmodulator device"), 4:33-38 ("The signal distribution system also includes a request receiver that receives a request signal from each of the individual receivers, ...").) Specifically, *the transponder request signals* are received by a transmodulator control unit 72 of *the ODU*, which may be a microprocessor that controls subsequent signal processing by the transmodulator 20. (Ex.1003-Williams-873, 10:53-11:21.)

"in the ODU …"

128. Each of limitations 14[b][1]-[3] is performed by Williams-873's transmodulator 20 as modified in view of Pugel. Williams-873's receiver 14, LNB 16, and transmodulator 20 are the claimed ODU, such that each of the elements recited in limitation14[b][1]-[3] are performed in the ODU. *See* element 14[pre], *supra*.

129. During original prosecution of the '576 patent, Applicant attempted to distinguish Williams-873 based on a narrow interpretation of the claimed *ODU*. (Ex.1006-'576 FH, 85-86.) To the extent Patent Owner repeats that argument here,

the combination of Williams-873 and Pugel would nonetheless render that interpretation obvious.

130. Specifically, Applicant stated that "[d]ue to the complexity, size, and power consumption of the Williams[-873] approach, it is not suitable for installation in the outdoor unit (ODU), where applicant's invention is installed in the outdoor unit"— apparently contending that the claimed ODU must be integrated in the signal receiver (*i.e.*, dish) to perform the claimed signal selection and combination. (Ex.1006-'576 FH, 85-86.) Under this interpretation, it would have been obvious in the modified system of Williams-873 in view of Pugel to include the transmodulator within a single integrated receiver. As Pugel recognizes, switching from analog tuners (taught in Williams) to digital tuners reduces complexity, prevents "high cost," and thus avoids issues related to power necessary to amplify and split a signal between multiple analog tuners. (Ex.1004-Pugel, ¶52.) Indeed, Pugel teaches that its entire signal processing system, including the analog-to-digital converter, digital tuner, and digital frequency translator, is part of a single satellite receiver 100. (Ex.1004-Pugel, ¶15.) A POSITA would have been motivated by Pugel to integrate the signal processing steps within a single receiver to reduce the number of components and potential fault points as well as cost and would have had a reasonable expectation of success in doing so. For example, a POSITA would have

been motivated by Pugel to implement Williams-873's switches 53, tuners 54, variable frequency upconverter 66, and summers 64, 68 in a single microprocessor. For example, a POSITA would have been motivated by Pugel to implement Williams-873's switches 53, tuners 54, variable frequency upconverter 66, and summers 64, 68 in a single microprocessor. Accordingly, to the extent Williams-873 alone does not meet the narrower interpretation of an ODU, it would have been obvious based on the combination of Williams-873 and Pugel.

14[b][1] "digitizing the plurality of satellite broadband signals"

131. This limitation would have been obvious to a POSITA based on Williams-873 in view of Pugel. As discussed, Williams-873 does not expressly disclose digitizing the plurality of satellite broadband signals, but Williams-873's system does operate in the digital domain when it decodes into digital data packets the signals selected by the analog tuner. (§VII.A.1, *supra*.) Nevertheless, in view of Pugel, it would have been obvious to modify Williams-873 to *digitize the plurality of satellite broadband signals* (*i.e.*, all of the signals including RHCP 22 and LHCP 24 received by a satellite dish) before any signal processing, including signal selecting for at least the reasons below.

132. First, Pugel teaches using analog-to-digital converters for "directly converting a plurality of carrier signals" (*i.e., satellite broadband signals*) "into a digital data stream." (Ex.1004-Pugel, ¶6.) As I explain above in detail, analog-to-

digital converters (A/Ds) allow for conversion of all received signals for subsequent digital processing, which, as Pugel explains, provides cost and complexity advantages by allowing filtering for select signals in the digital domain, relative to a system using filtering select signals in the analog domain like Williams-873. (Ex.1004-Pugel, ¶¶18, 52; §§IV.E-F and VII.A.1, *supra*.)

133. Second, it was well within the general state of the art and knowledge of a POSITA that performing signal processing in the digital domain would lead to well-known advantages, including but not limited to (1) removing complex analog electronics required to filter a plurality of narrowband components of the wideband signal, which Pugel recognizes were "costly"; and (b) loss in fidelity incurred by the use of analog filters in the initial processing of the wideband or broadband signal. (§IV.E-F and §VII.A.1, *supra*.) Indeed, the '576 patent admits that these digitization advantages were well within the knowledge of a POSITA and used in satellite distribution systems a decade before its priority date. (Ex.1010, AAPA-Communication Services Via Satellite, 104-05.) Even during reexamination of the '576 patent, the Patent Office recognized the benefits and predictable success of using analog-to-digital converters in the context of communications and signal processing. (Ex.1007-'576 Reexam, 297). It is therefore my opinion that a POSITA would have had more than a reasonable expectation of success of digitizing the

plurality of satellite broadband signals received by Williams-873's system before selecting, extracting, and combining the selected transponder signals ultimately transmitted. (§IV.E-F and §VII.A.1, *supra*.)

134. Accordingly, *digitizing the plurality of satellite broadband signals* would have been obvious to a POSITA based on the combination of Williams-873 and Pugel.

> *14[b][2] "selecting and extracting a plurality of transponder signals from the received satellite broadband signals, wherein the selecting is responsive to the transponder request signals;"*

135. Williams-873's transmodulator includes a plurality of tuners 54 that are each part of a "transmodulator channel" and responsible for *selecting and extracting* a *transponder signal from the received satellite broadband signals*. (Ex.1003-Williams-873, 4:16-39, 9:28:39.)

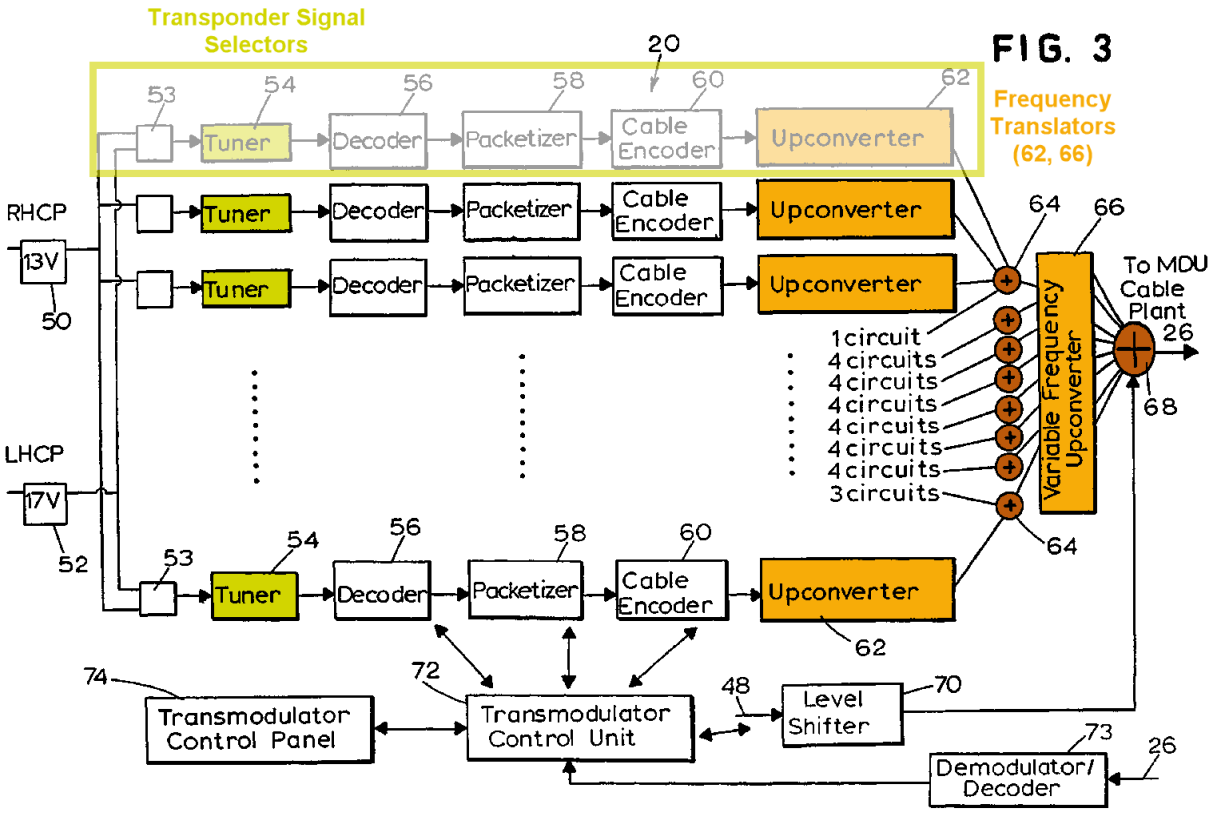


Figure 3 — Each Row of Processing is a Transmodulator Channel of Williams-873's Transmodulator 20.

136. In Williams-873's Figure 3, tuners 54 *select and extract* a transponder signal. Specifically, each tuner 54 "tunes to one of the transponder signals associated with" the received digital broadband satellite signals. (Ex.1003-Williams-873, 9:40-48.) Williams-873 described in detail that each tuner selects a transponder from either the RHCP 22 or LHCP 24 broadband signal, each a *received satellite broadband signal*. (Ex.1003-Williams-873, 9:40-48.) The tuner simultaneously "filter[s] out the other 15 transponder signals within that band, to produce a 24 MHz-wide, QPSK-modulated signal corresponding to a *selected* one" of the received

transponder signals. (Ex.1003-Williams-873, 9:40-48 (emphasis added).)

137. In the modified system of Williams-873 and Pugel, each of the *received satellite broadband signals* is digitized prior to tuning, and thus digital tuners (such as the mixer 132 and decimator/filter 134 taught in Pugel) are used in place of Williams-873's analog tuners 54. Both the digital mixer 132, which uses a numerically-controlled oscillator (NCO) signal, and the digital decimator/filter 134, were known in the art for performing the digital equivalent of tuning/filtering functions well before they were disclosed in Pugel. (*See* §§IV.E-F, *supra*.)

138. A POSITA would have been motivated to obtain the advantages of digital tuning and would have had a reasonable expectation of success incorporating digital tuners into Williams-873's distribution system at least based on the recommendation by Pugel. (*See* §VII.A.1 and limitation 14[b][1], *supra*.) Indeed, Pugel expressly teaches using digital tuners to "extract from the digital data stream data carried by" a carrier signal (*i.e.*, from the digitized *satellite broadband signals*). (Ex.1004-Pugel, ¶¶5-6.) This is the same purpose for *extracting* as described in the '576 patent: selecting digital signals associated with a subset of a broader signal for further processing and discarding the remainder of the broader signal. (*See* Ex.1001-'576 patent, 3:5-9 ("LNB outputs can be sampled by a broadband A/D converter and filtered with a digital filter to select a transponder channel. Alternatively, a tuner can

select a transponder channel. The selecting process extracts from the wide band LNB output a narrow band transponder channel.").) And use of a digital tuner to select and extract transponder signals would not alter the modulation of the selected transponder signals, as required in limitation 14[d].

139. Williams-873 further teaches that the transponder signal selection *is responsive to the transponder request signals*. Williams-873's transmodulator 20 and its control unit 72 "receive[] and decode[] requests for … satellite signals" (*i.e., transponder request signals*) "from each of the IRDs 30-40 that are active." (Ex.1003-Williams-873, 6:35-42.) Under the control of control unit 72, tuners 54 then "tune[] to … only those selected satellite or transponder signals." (Ex.1003-Williams-873, 6:35-42, 10:53-11:5 ("control unit 72 … preferably controls … the tuners 54."), 11:6-16 ("[T]he control unit 72 assimilates all of the satellite signal requests received from the IRDs 30-40, determines which of the satellite signals or transponder signals must be decoded to satisfy these requests and controls a different one of the transmodulator channels," which process the "so-determined transponder signals for transmission over the cable network 26.").) As part of modifying Williams-873 to include a digital tuner (as taught in Pugel), a POSITA would have been motivated to maintain that transponder signal selection *is responsive to the transponder request signals* to ensure that IRDs receive desired transponder signals

while avoiding further processing and communications of signals that were not requested (which would have been wasteful of the resources available such as bandwidth, power, memory, etc.).

140. Accordingly, it is my opinion that the combination of Williams-873 and Pugel renders obvious *selecting and extracting a plurality of digitized transponder signals from the received satellite broadband signals, wherein the selecting is responsive to the transponder request signals*.

14[b][3] "combining extracted selected transponder signals into a composite signal;"

141. Williams-873's "summer 68 [] *combines*" the *extracted selected* "*signals* with each other and with any desired frequency-shifted or non-frequency-shifted terrestrial signals (delivered by a level shifter 70) for propagation over the cable network 26 of FIG. 1." (Ex.1003-Williams-873, 10:24-39 (emphasis added); 4:29-33 ("A combiner combines the multiplicity of transmodulated signals at different carrier frequency bands to produce a combined signal and a transmitter transmits the combined signal over the communication channel to the individual receivers.").) As shown in Williams-873's Figure 3, summers 64, 68, and variable frequency upconverter 66 of transmodulator 20 combines all selected transponder signals into a composite signal.

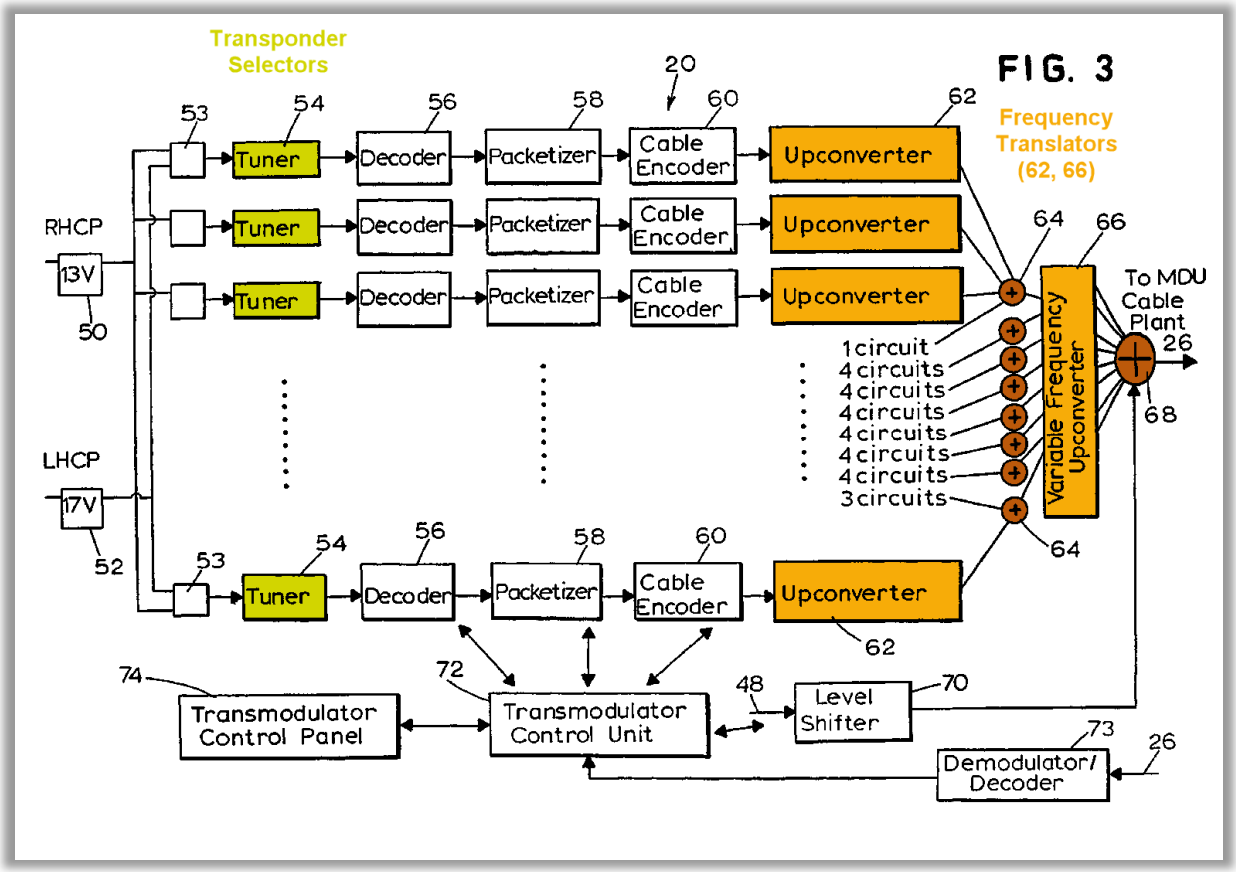


Figure 3 — Transmodulator 20 Includes Summer 68.

142. The output of summer 68 is the claimed *composite signal*.

143. Because Williams-873's IRDs are configured to receive analog RF, and not digital, signals, the composite signal transmitted to the IRDs must be an analog RF signal. A POSITA would have understood when combining Williams-873 and Pugel that there are two options to ensure that the digitized selected and extracted transponder signals were provided for distribution as analog RF signals. First, a POSITA could use Williams-873's analog summer 68, but would need to convert each selected and extracted transponder signal from digital to analog prior to

summing. Second, and preferably, a POSITA would have known to replace Williams-873's summer 68 with a digital combiner—as taught in Pugel—and convert the output of the digital combiner into an analog RF signal for distribution. (Ex.1004-Pugel, ¶45.) Each implementation would have been well within a POSITA's general knowledge and would provide tradeoffs and advantages. The first option permits use of Williams-873's analog summer 68, but requires a plurality of digital-to-analog converters prior to summation, while the second option requires replacing the summer 68 with a digital equivalent (as taught in Pugel), but beneficially requires only one digital-to-analog converter following signal summation. The second option is consistent with modern design techniques that aim to perform processing in the digital domain when possible by delaying digital-to-analog conversion until just prior to transmission over a communications network, and thus would have been the preferred method. In my opinion, either of these options would have been obvious implementation and design choices, and neither would result in altering the modulation of the selected transponder signals, as required in limitation 14[b].

144. Accordingly, it is my opinion that *combining extracted selected transponder signals into a composite signal* is obvious over Williams-873 and Pugel.

14[c] "transmitting the composite signal over the single cable from the ODU to the IRDs,"

145. Williams-873's transmodulator 20 transmits its output containing the combined selected transponder signals "over a communications channel, ***such as a cable***, … to a number of individual receiver units [IRDs] within [a multi-dwelling unit]." (Ex.1003-Williams-873-873, 3:40-4:3 (emphasis added).) The transmission originates at the summer 68 in transmodulator 20, which is part of the ODU or would have been obvious to include in the ODU. (*See* limitations 14[a]-b[b], *supra*; Ex.1004, 10:24-39, Fig. 3.) The transmission reaches the individual IRDs via a cable network 26 within a multi-dwelling unit, also called a cable plant. (Ex.1003-Williams-873, 10:24-39.) Figure 1 of Williams-873 shows the transmission by the transmodulator 20 to a plurality of MDU IRDs originating on a single cable. *See* Footnote. 3, *supra.*

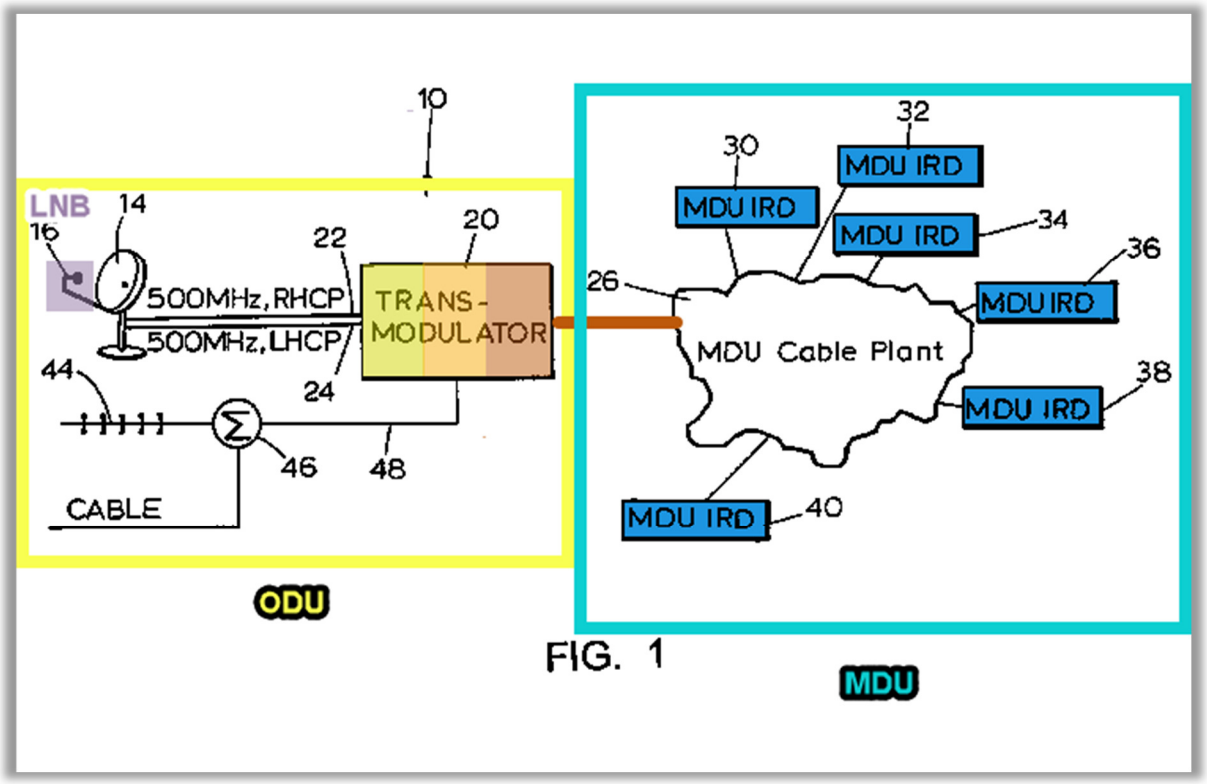


FIG. 1

Figure 1 — Signal Distribution System of Williams-873.

146. The transmission taught in Williams-873 would not result in altering the modulation of the selected transponder signals transmitted on the composite signal, as required in limitation 14[d].

147. Accordingly, it is my opinion that Williams-873 discloses *transmitting the composite signal over the single cable from the ODU to the IRDs.*

> *14[d] "wherein the modulation of the transponder signal is not altered by the steps of selecting, combining, and transmitting."*

148. In direct contrast to Applicant's characterization of Williams-873 during prosecution of the '576 patent, Williams-873 does in fact expressly disclose a broadband signal distribution system that **does not *alter*** *the modulation of the*

transponder signal. While Williams-873 teaches various embodiments where selected signals are transmodulated prior to combining in many instances, Williams-873 also expressly discloses an alternative embodiment where transmodulation is not required, and therefore will not be performed. For example, Williams-873 expressly states that "in some cases, [where] only a few of the selected channels are being distributed, the transmodulator may not need to remodulate the selected signals." (Ex.1003-Williams-873, 7:15-23 (emphasis added).) Williams-873 further explains that "transmodulator 20 need not remodulate the received transponder signals, but may, instead, shift selected ones of these signals to different frequencies for transmission over the cable network 26." (*Id.*, 4:57-60, 15:15-27 (emphasis added).)

149. Williams-873 goes on to articulate the tradeoffs associated with the alternative embodiment and explained:

> This configuration only reduces the bandwidth used by the signals transmitted over the cable network to the extent that it eliminates some of the received satellite transponder signals. Thus, the more received satellite transponder signals that are to be sent to the IRDs 30-40, i.e., the more transmodulator channels there are, the less viable this option becomes.

(Ex.1003-Williams-873, 15:20-27.) In other words, transmission of the selected signals by shifting the frequency bands, but without remodulation, benefits from bandwidth reduction by the selection of the received signals only and does not gain

any further bandwidth reduction due to the remodulation scheme employed. Therefore, Williams-873's alternative embodiment is only possible in circumstances when the available bandwidth is sufficient to accommodate a limited number of selected signals in their existing modulation format; however, the "limited number" of selected signals could easily encompass twenty-plus transponder signals, each containing a plurality of television programs.

150. Williams-873 also explains that, although this alternative approach may not realize the potential bandwidth reduction offered by remodulation, it benefits from having a simpler, lower-cost system because, "in this case, each transmodulator channel would [only] need to include a tuner and a frequency shifter" and would not require the complexity associated with remodulation. (Ex.1003-Williams-873, 15:18-20.) This is consistent with the goal of Williams-873, which states that "[t]he present invention relates to a low-cost system and method for distributing a set of programs multiplexed A-V signals ... to a multiplicity of receiver units within one or more MDUs using an MDU cable network or other transmission channel." (Ex.1003-Williams-873, 3:50-54.)

151. In the '576 prosecution history, the Applicant ignored that this alternative embodiment does not require remodulation when the number of users is relatively small. In fact, the rationale that the '576 patent provided for the advantages

of the alleged claimed invention compared to Williams-873 (simplicity of hardware and reduced cost with a small number of users) is precisely the reason a POSITA would have been motivated to use the alternative non-remodulating embodiment in Williams-873 in the same circumstances.

152. When read in full, and dismissing the '576 Applicant's characterizations, Williams-873 undeniably discloses a system *wherein the modulation of the transponder signal is not altered by the steps of selecting, combining, and transmitting*. And, as discussed above in limitations 14[b][2], 14[b][3], and 14[c], the modifications made in view of Pugel–the use of a digital tuner/filter to select and extract, and possibly a digital combiner to combine selected extracted transponder signals in the digital domain–likewise do not alter modulation.

153. In conclusion, is my opinion that independent claim 14 is rendered obvious based upon the combination of Williams-873 and Pugel.

3. Dependent Claim 15

The method of claim 14 wherein the step of selecting and extracting a transponder signal comprises the step of: filtering a transponder signal with a band pass filter having a bandwidth ranging from 5% to 100% wider than the bandwidth of the transponder signal.

154. Pugel teaches using decimator/filter 134 as part of channel selection to "remove" "non-desired channel energy" to "retain only the channel energy associated with a specific desired channel." (Ex.1004-Pugel, ¶23.) Because Pugel's

signal selection occurs in the digital domain, a POSITA would have understood decimator/filter 134 is a digital filter. A POSITA would also have understood Pugel's disclosure of decimator/filter 134 to be a band-pass filter (specifically, a "*low pass filter*"), as it allows the transponder signal located at baseband to pass through but filters out signals at a higher frequency.

155. As discussed above in limitation 14[b][1], a POSITA would have known to replace Williams-873's analog tuner 54 with Pugel's digital band-pass filter. Williams-873 already teaches that as part of selecting and extracting in the analog domain, transmodulator 20 "filter[s] out the other 15 transponder signals within that band" leaving a single signal "corresponding to a selected" one transponder signal. (Ex.1003-Williams-873, 9:40-48.) The filtering by Williams-873's analog tuner 54 is the equivalent in the analog domain to Pugel's mixer 132 decimator/filter 134 operating in the digital domain. After incorporating Pugel's teaching of digitizing the broadband satellite signal prior to selecting and extracting, it would have been obvious (if not necessary) to modify Williams-873's filter to operate as digital band-pass filter. A POSITA would have had a reasonable expectation of success in incorporating a digital band-pass filter as part of channel selection in view of the known digital filtering techniques known in the art. (*See* §§IV.E-F, *supra*.)

156. The ’576 patent concedes that “digital filtering,” including “applying a band pass filter transfer function to the broadband signal to isolate a single transponder channel,” used “known digital architectures” and was “well known in the digital signal processing field.” (Ex.1001-’576 patent, 5:12-29.) And during the *ex parte* reexamination, the Office also acknowledged that “using a digital filter … would have been part of the ordinary capabilities of a skilled artisan and there would have been a reasonable expectation of success based on similar uses of” digital filters in the “same technological area.” (Ex.1007-’576 Reexam, 297.)

157. It would have further been obvious to modify Williams-873 so that the *digital band-pass filter* adopted from Pugel has *a bandwidth ranging from 5% to 100% wider than the bandwidth of the transponder signal* being selected. A POSITA would have been motivated to leave a buffer to ensure that the entire transponder signal is selected as insurance against potential signal processing inconsistencies upstream (*e.g.*, down-converting inconsistencies by the LNB whereby it shifts a desired transponder signal to a slightly different center frequency than desired). Setting the filter at least 5% wider than the transponder signal bandwidth would accomplish this goal. Typically there is an empty frequency band on either side of a transponder (a “guard band”) to avoid interference, so filtering for a frequency range slightly broader than the transponder signal could be performed without selecting

any part of an adjacent transponder signal. Indeed, the '576 patent explains that "typically" a 500 MHz satellite signal contains 16 transponder signals of 24 MHz, leaving 118 MHz for guard bands, approximately 7.25 MHz per transponder (30% of transponder bandwidth). (Ex.1001-'576 patent, 1:44-54.)[3] Pugel teaches guard bands of 5.16 MHz, approximately 21% of transponder signal bandwidth. (Ex.1004-Pugel Figs. 2A-2B.)

158. Accordingly, claim 15 is obvious over Williams-873 in view of Pugel.

4. Dependent Claim 16

The method of claim 14 wherein the step of combining comprises frequency translating the selected and extracted transponder channels to a variable frequency before combining.

159. In Williams-873, the output of a plurality of transmodulator channels—

[3] In response to an office action rejecting claim 15 based on Williams-873, Applicant misrepresented to the Patent Office that "[t]he bandpass filtering of Williams-873 is 500 MHz wide and spans all transponders output from one polarization of the LNB." (Ex.1006-'576 FH, 88-89.) As noted above, Williams at 9:40-48 discloses that transmodulator 20 filters out all but a selected transponder signal, meaning that Williams teaches a filter of approximately the size of a transponder channel (on the order of 20-30 MHz), not 500 MHz.

each row of Figure 3 including selection and extraction of a transponder signal by a tuner 54—ultimately reaches a "*variable frequency* upconverter 66." (Ex.1003-Williams-873, 9:28-39, 10:24-39.)

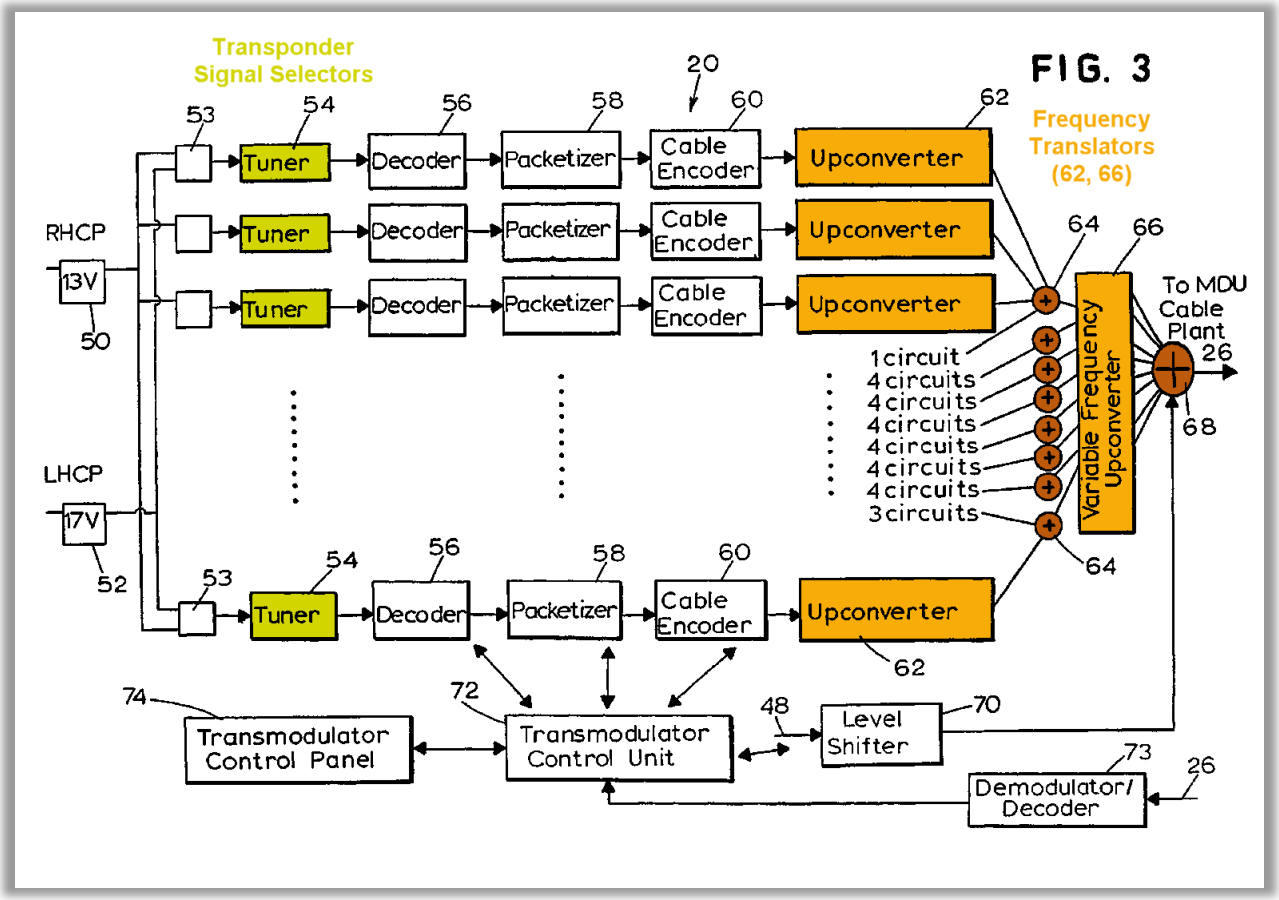


Figure 3 — Transmodulator 20 Includes Variable Frequency Upconverter 66.

160. Variable frequency upconverter 66 "upconverts each of up to eight groups of … signals to a different carrier frequency band." (Ex.1003-Williams-873, 10:24-39.) Williams-873 teaches that variable frequency upconverter 66 may be under the control of control unit 72, which "control[s] the frequencies at which the [] signals … are transmitted over the cable network 26," *i.e.*, on the composite signal.

(Ex.1003-Williams-873, 11:36-40.) The variable frequency converter 66 is part of the *step of combining*, as it sits between one set of summers 64 (*combiners*) and the final summer 68, which combines selected and extracted transponder signals to form the *composite signal*. Accordingly, it is my opinion that claim 16 is disclosed by the combination of Williams-873 and Pugel.

5. Dependent Claim 17

> *The method of claim 15 further comprising frequency translating the selected transponder channels to a predetermined frequency before combining.*

161. Williams discloses this limitation in two ways. First, Williams-873 teaches that as part of selecting and extracting (*i.e.*, before combining), each tuner 54 "may shift the tuned 24 MHz-wide, QPSK-modulated signal down to baseband." (Ex.1003-Williams-873, 9:47-48.) This approach has the advantage that once all selected and extracted transponder signals have been translated to baseband, Williams-873's upconverter 62 of each transmodulator channel and the variable frequency upconverter 66 can be fixed to a particular frequency and be assured that there is no overlap between the transponder signals on the combined signal at the output of summer 68. A POSITA would have understood translation of the 24 MHz-wide, QPSK-modulated transponder signal to baseband (*i.e.*, a frequency between zero and 24 MHz) is a *translation of the selected transponder signals to a predetermined frequency*.

162. Second, Williams-873 teaches that each *selected transponder signal* is frequency translated by an upconverter 62 *prior to being combined* by summers 64 and 68. Williams-873 explains that each upconverter 62 "shifts" the selected transponder signal "to an intermediate frequency (IF), preferably comprising one of four different carriers IFs used by the transmodulator 20." (Ex.1003-Williams-873, 10:16-23.) As shown in Figure 3, each summer 64 is fed by four transmodulator channels (*i.e.*, each row in Figure 3).

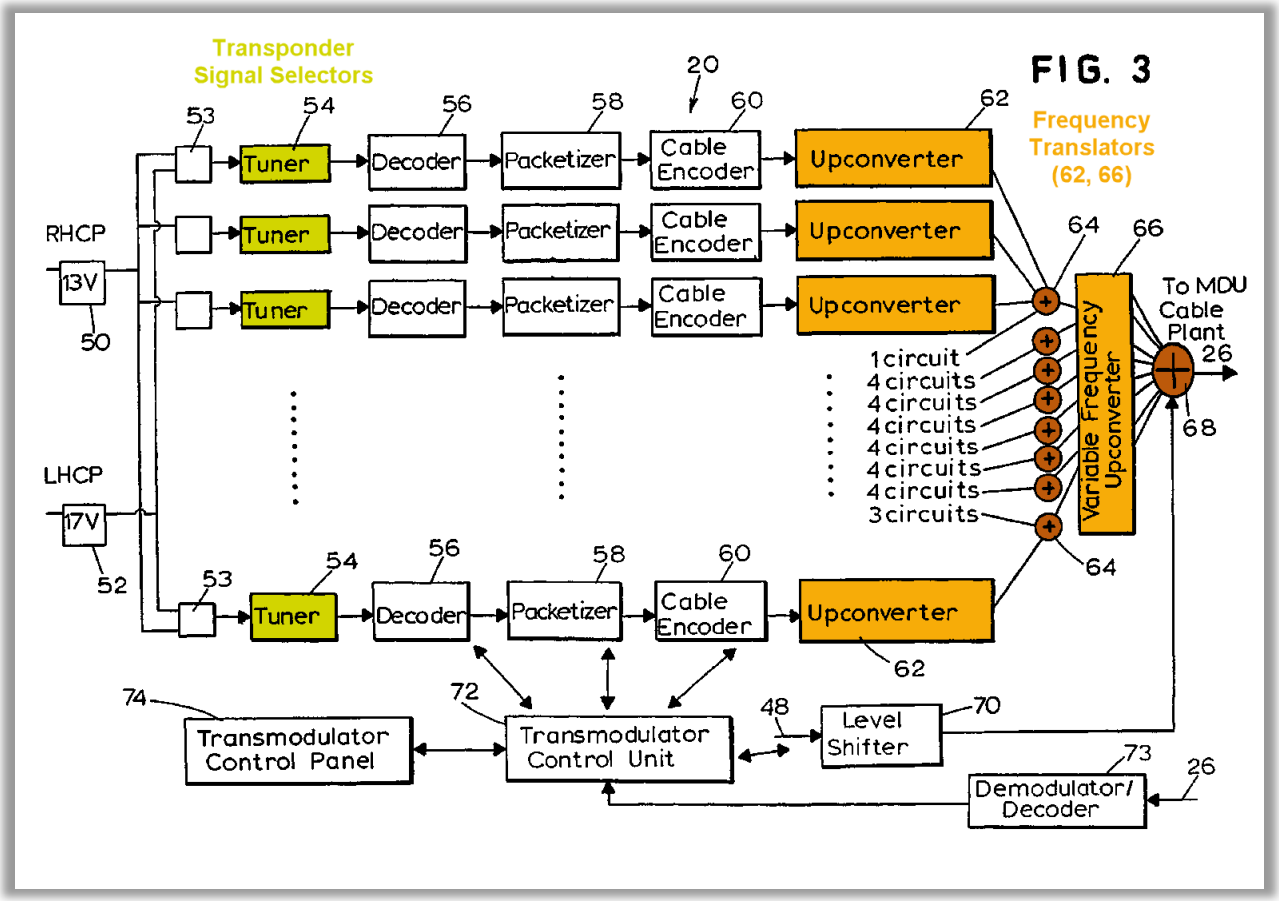


Figure 3 — Each Transmodulator Channel of Transmodulator 20 includes Upconverter 62.

163. In view of this disclosure, a POSITA would have understood that Williams-873 preferably teaches that each of the four transmodulator channels feeding a given summer 64 upconverts (*frequency translates*) to a fixed one of the four carrier IFs, and thus, to a *predetermined frequency before combining*. Accordingly, it is my opinion that claim 17 is disclosed by the combination of Williams-873 in view of Pugel.

6. Dependent Claim 18

The method of claim 14 further comprising the step of splitting the composite signal inside a home and distributing to a plurality of IRDs.

164. Williams-873 teaches that its "combined signal" (*composite signal*) is transmitted over a "communications channel" (*e.g.*, coaxial cable) to a plurality of "individual receivers" (*IRDs*) within a multi-dwelling unit, defined as "any [] type of building or structure in which multiple signal receivers may be located." (Ex.1003-Williams-873, 4:22-32, 4:50-5:5, 5:57-58.) As shown in Figure 1, the composite signal enters the MDU plant (the network of cables within the MDU, such as a home) on a single cable. (Ex.1003-Williams-873 3:50-54.)

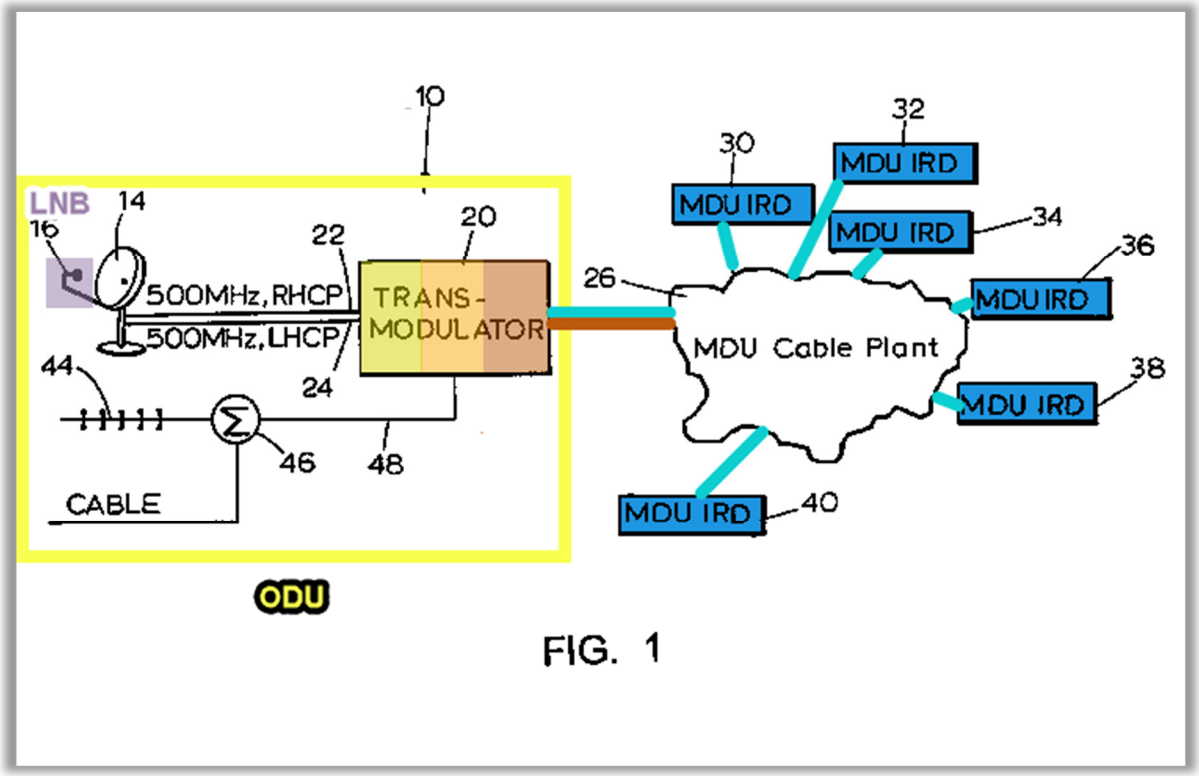


FIG. 1

Figure 1 — Williams-873's Video Distribution System.

165. A POSITA would have understood that for the signal originating on the single cable to be distributed to a plurality of IRDs within the home, the signal was usually transmitted over multiple cables inside the multi-dwelling unit—one terminating at each IRD. A POSITA would also have understood that to distribute a signal from a single cable to multiple cables, the signal must be duplicated and conveyed over the cables. Using a splitter to duplicate the signal for output to a plurality of *IRD*s was well known in the art. Accordingly, it is my opinion that claim 18 is obvious over Williams-873 in view of Pugel.

7. Dependent Claim 19

The method of claim 14 wherein the transponder request signal is transmitted over the cable from an IRD and all IRDs receive the same composite signal.

166. Consistent with Patent Owner's interpretation of single cable in its Infringement Contentions, Williams-873 also discloses that "satellite signal requests" (*transponder request signals*) are transmitted over the cable (*i.e.*, the cable connecting the transmodulator 20 and cable plant 26) from each IRD. (Ex.1003-Williams-873, 10:53-11:5.) Specifically, Williams-873 teaches that "satellite signal requests may be transmitted from the IRDs 30-40 over the cable network [*i.e.*, plant] 26 at, for example, a dedicated frequency." (Ex.1003-Williams-873,7:24-47 ("the IRD sends a request to the transmodulator 20 to tune to" and "transmit the requested signal over the cable network 26. This request may be sent via the cable network 26 … the request signal may be sent to the transmodulator using the well known Multi-Media Cable Network System (MCNS protocol), which provides communication over the same cable as the video signals.").) Because the "satellite signal requests" (transponder request signals) and the combined signal at the output of summer 68 (composite signal) are sent over the same cable network 26 connected via a single cable to the transmodulator 20, a POSITA would have understood that transponder request signals from the IRDs are transmitted over the cable network 26 and received via a single cable by the transmodulator 20. (*See, e.g.,* Ex.1003-Williams-873, Fig.

1 and Fig. 3.) For example, a POSITA would have understood that the MCNS protocol utilizes different frequency bands for bidirectional transmission of the combined signal and the satellite signal requests. (Ex.1003-Williams-873 at 7:44-47 ("The MCNS protocol typically utilizes the range from 5 to 42 MHz and enables multiple receivers to communicate to the same transmodulator."); 8:36-48 ("The right-most column of FIG. 2 illustrates a configuration in which the transmodulator 20 places groups of selected ones of the 32, 6 MHz-wide, 128-QAM-modulated signals at any number of different spaced-apart frequency bands within the available cable network spectra. In particular, the transmodulator 20 may provide any number. (less than, for example, 32) of the 6 MHz-wide transmodulated signals at any of the unused carrier frequency bands between 60-66 MHz, 82-88 MHz, 180-186 MHz, 192-198 MHz, 204-210 MHz, 470-554 MHz, and 560-704 MHz, as generally illustrated in FIG. 2, while sending terrestrial signals at bands between 54-60 MHz, 66-82 MHz, 88-180 MHz, 186-192 MHz, 198-204 MHz, and 210-470 MHz.").)

167. Williams-873 further discloses that all IRDs receive the same composite signal. As taught in Williams-873, the "combined signal" is sent by a "transmitter" "over the communication channel" (*i.e.*, cable) "to the individual receivers" (IRDs). (Ex.1003-Williams-873, 4:22-32, 4:60-5:5 ("a further aspect of the present invention" is "a method of distributing a subset of a plurality of

individual signals associated with a composite signal to multiple individual receivers.").) Because the composite signal is created based on the requests of the various IRDs (*see* claim 14, *supra*), a POSITA would have understood this disclosure means that the composite signal is provided to each IRD so that each IRD receives its requested signal. This is confirmed by Williams-873's disclosure of the transmission of the combined signal at the output of summer 68 from the transmodulator 20 over the single cable via cable network 26 to each of the IRDs. As stated above, POSITA would have understood that the MCNS protocol utilizes different frequency bands for bidirectional transmission of the combined signal and the satellite signal requests. (Ex.1003-Williams-873 at 7:44-47 and 8:36-48.) Accordingly, it is my opinion that claim 19 is disclosed by the combination of Williams-873 and Pugel.

8. Dependent Claim 20

The method of claim 14 wherein the transponder request signal is transmitted over a wireless link to the ODU.

168. Williams-873 discloses that the "request to the transmodulator 20 to tune to" a "requested signal" (*transponder request signal*) may be transmitted to the transmodulator 20 "via any desired wireless network." (*i.e., transmitted over a wireless link to the ODU*). (Ex.1003-Williams-873, 7:24-47, 10:53-11:5.) Accordingly, it is my opinion that claim 20 is disclosed by Williams-873 and Pugel.

9. Dependent Claim 21

The method of claim 14 further comprising the steps of: frequency translating the selected transponder channels to a variable frequency before combining; and splitting the composite signal inside a home and distributing to a plurality of IRDs.

169. *See* claims 16 and 19, *supra.*

10. Dependent Claim 22

The method of claim 21 wherein the transponder request signal is transmitted over the cable from an IRD.

170. *See* claims 14 and 19, *supra.*

11. Dependent Claim 23

The method of claim 21 wherein the transponder request signal is transmitted over a wireless link to the ODU.

171. *See* claims 20, *supra.*

12. Dependent Claim 34

The method of claim 14, wherein selecting and extracting comprises applying a pass band filter transfer function to the digitized broadband signal.

172. *See* claim 15, *supra*.

173. The term "pass band filter transfer function" is not a term of art in the field. To the extent "pass band filter transfer function" has meaning to a POSITA that can be understood in light of the specification, it refers to the application of a digital band-pass filter having a corresponding transfer function (*i.e.*, rejection of all signal components at frequencies other than the selected frequency band) to a

digitized broadband signal. (Ex.1001-'576 patent at 5:12-15 ("Digital filtering 340 is used to select one or more of the transponder output signals. The digital filter may operate by applicating a band pass filter transfer function to the broadband signal to isolate a single transponder channel.").) Pugel discloses using a digital band-pass filter on a digital signal as part of selecting and extracting a signal from a digitized broadband signal, and the '576 patent refers to this "filtering technique" as "well known in the digital signal processing field." (*See* claim 15, *supra*.) As discussed in claim 15, it would have been obvious to modify Williams-873's teaching of an analog filter and replace it with a digital band-pass filter to process the digitized broadband signal and gain the well-known advantages associated with digital processing of satellite television signals. Accordingly, it is my opinion that this claim is obvious over Williams-873 in view of Pugel.

13. Dependent Claims 35 and 36

35. The method of claim 14, further comprising converting the selected signal to an analog signal using a digital to analog converter prior to combining.

36. The method of claim 14, wherein the combining is performed in the digital domain.

174. *See* limitation 14[b], *supra*.

175. Whether to combine selected transponder signals in the analog domain as taught in Williams-873 (which first requires converting the selected signal to an

analog signal using a digital to analog converter prior to combining) or to modify Williams-873 to combine in the digital domain (as taught in Pugel) is an implementation decision within the skill and knowledge of a POSITA, with each option providing well-known advantages and disadvantages relative to the other option. (§VII.A.1, limitation 14[b], *supra*.) As such, these claims are obvious over Williams-873 in view of Pugel.

14. Dependent Claim 37

The method of claim 17, wherein frequency translating comprises using a digital mixer to apply a rotating phasor to the data samples to translate their frequency.

176. Pugel teaches the user of mixers 132 which "operate[] to perform a frequency rotation function," which is a digital operation allowing a desired part of a digital signal (*e.g.*, a selected transponder signal) to be translated to a desired frequency. (Ex.1004-Pugel, ¶22.) Specifically, Pugel's *digital mixers* 132 operate on the digital signal from the A//D converter, which are *data samples*. (Ex.1004-Pugel, ¶¶18-19 ("The A/D converter 120 comprises a high-speed analog-to-digital converter operating at a sampling rate of FS."), 25 ("In an exemplary embodiment, the A/D converter 120 operates using an 8-bit sample.").) The mixers "mix[] the digital signal S3 with a respective numerically controlled oscillator (NCO) signal to produce respective in-phase I and quadrature Q signal components," allowing the mixer to "*rotat[e]*" a "selected channel to baseband from the under-sampled digital

signal S3." (Ex.1004-Pugel, ¶22 ("This may be accomplished by using a numerical table to extract (or rotate) the desired channel frequency from the digital signal comprising all available frequencies processed by the A/D converter 120.").) Based on the above, a POSITA would have understood this disclosure to teach the application of a *rotating phasor to the data samples to translate their frequencies*.

177. Furthermore, a POSITA would have been motivated to further modify Williams-873 to employ the digital mixers of Pugel. As discussed above in claims 16 and 17, Williams-873 teaches frequency translating selected, extracted transponder signals before combination via a variable frequency upconverter 66. (Ex.1003-Williams-873, 10:24-39.) Williams-873 does not disclose what circuitry or components make up the variable frequency upconverter 66, although it teaches the use of "standard … mixer circuitry" for other frequency translation operations. (Ex.1003-Williams-873, 10:40-52.) In view of Pugel, it would have been obvious to further modify Williams-873 so that the variable frequency upconverter 66 is a digital mixer. To obtain further advantages from processing in the digital domain, a POSITA would have been motivated to additionally perform frequency translation in the digital domain, especially where the signals have already been digitized prior to transponder selection. (§§IV.E-F, *supra*.) Pugel expressly recognizes the benefits of its digital frequency translating: "avoid[ing]" the need for "analog mixers."

(Ex.1004-Pugel, ¶51.) And a POSITA would have had a reasonable expectation of success modifying Williams-873 to use digital mixers using a numerically-controlled oscillator, which were well known in digital signal processing before the '576 patent's priority date. (§§IV.E-F, VII.A.1, *supra*.)

15. Dependent Claim 38

> *The method of claim 14, further comprising frequency translating the digitized broadband signal prior to selecting and extracting transponder signal.*

178. Pugel teaches that each mixer 132 "mixes the digital signal S3" (*digitized broadband signal*) "with a respective numerically controlled oscillator (NCO)" wherein "[t]he respective NCO frequency is selected to derotate a desired signal or channel" to "baseband." (Ex.1004-Pugel, ¶22.) That is, the entire *digitized broadband signal* is *frequency translated* in such a way (derotated) that a desired transponder signal is translated to a near-zero frequency *prior to selection and extraction*. A POSITA would have understood that rotating a signal to baseband prior to selection and extraction simplifies the filtering operations necessary to select and extract a transponder signal. With the selected transponder signal rotated to baseband, only a "high-pass filter" is needed to filter out frequencies above the selected transponder signal; otherwise, a "low-pass filter" would also be necessary to tune out lower frequencies.

179. Moreover, it would have been obvious to additionally incorporate this

aspect of Pugel into Williams-873. Williams-873 teaches that its analog tuner 54 "may shift the tuned 24 MHz-wide, PSK-modulated signal down to baseband," but only after selection occurs (Ex.1003-Williams-873, 9:47-48.) A POSITA would have been motivated to further modify Williams-873 such to shift the entire broadband signal (which is digitized, *see* claim 14) so that the desired transponder signals are located at baseband prior to selection and extraction, as in Pugel, to obtain the advantages discussed in the preceding paragraph. Accordingly, it is my opinion that this claim is disclosed by the combination of Williams-873 and Pugel.

16. Dependent Claim 39

> *The method of claim 38, wherein frequency translating comprises translating the original digitized broadband signal to locate a selected transponder channel at baseband.*

180. A POSITA would have been motivated to modify Williams-873 to include Pugel's teaching of frequency translating comprises translating the original digitized broadband signal to locate a selected transponder channel at baseband. (*See* claim 38, *supra*.) It is my opinion that this claim is disclosed by the combination of Williams-873 and Pugel.

17. Dependent Claim 40

> *The method of claim 14, further comprising maintaining a channel translation table at the outdoor unit, the channel translation table*

specifying assigned frequency slots for transponder channels in the composite signal.

181. Williams-873 teaches "generat[ing] an information signal, known as side data, which may include … frequency index set-up information," "frequency assignments," and "information … indicating the carrier frequencies, etc., of the … signals that are on the cable network 26." (Ex.1003-Williams-873, 4:40-45, 15:53-16:21.) As I discuss above in §IV.G, it was known that where the frequency at which a television signal is received is modified (*e.g.,* translated) before distribution to receivers, it was beneficial (if not necessary) to provide information to the receiver that would allow the receiver to identify the updated frequency for the signal based on the information it already possesses (which may be the original frequency location of a desired signal). In view of this background knowledge, a POSITA would have understood that Williams-873's side data includes a *channel translation table* that *specifies assigned frequency slots for transponder channels in the composite signal* so that Williams-873's IRDs can identify and locate signals on the cable network 26.

182. The side data (*channel translation table*) is maintained by the transmodulator 20, which is part of the *outdoor unit* (or would have been obvious to include in the ODU). (*Id.*, 15:53-16:4 ("[T]he transmodulator 20 may actively signal the channel locations, ordering, frequency assignments, etc. of the transmodulated

satellite signals … using side data.").) Accordingly, it is my opinion that claim 40 is disclosed by the combination of Williams and Pugel.

18. Dependent Claim 41

The method of claim 38, further comprising providing the channel translation table to the IRD to allow the IRD to tune to a desired selected translated transponder channels.

183. The transmodulator 20 of Williams-873 (part of the ODU) maintains side data, which is a *channel translation table* specifying assigned frequency slots for transponder channels in the combined signal. (*See* claim 40, *supra*.) The transmodulator 20 communicates the side data to IRDs. (Ex.1003-Williams-873, 16:5-21 (IRDs receive "information from the transmodulator 20 indicating the carrier frequencies, etc. of the … signals that are on the cable network 26.")) A POSITA would have understood that the side data *allows the IRDs to tune to a desired selected translated transponder* signal located at a particular frequency *channel*, because the side data contains information relating to the channel frequencies on the combined signal and without access to this side data, the IRD would be unable to select the desired channel from the combined signal received by the IRD. (Ex.1003-Williams-873 at 4:40-45 ("the signal distribution system generates an information signal, known as side data, which may include channel set-up information, frequency index set-up information, etc. This information signal is used by the receiver to select a requested signal from the plurality of individual

program multiplex signals."); 6:42-44 ("The transmodulator sends the updated frequency index to the receiver via side data."); 11:22-27 ("If desired, the control unit 72 may provide a signal via side data to each of the IRDs 30-40 specifying which transponder signals are being transmodulated and transmitted over the cable network 26 and the frequencies at which the transmodulated transponder signals are located on the cable network 26."); ("the transmodulator 20 may actively signal the channel locations, ordering, frequency assignments, etc. of the transmodulated satellite signals and/or terrestrial signals [to the IRD 30] via a communication channel (using side data) established over, for example, the cable network 26.").) Accordingly, it is my opinion that claim 41 is disclosed by the combination of Williams-873 and Pugel.

19. Dependent Claim 42

The method of claim 14, wherein selecting and extracting comprises low-pass filtering the translated digitized broadband signal thereby substantially removing signal information from non-selected transponder channel.

184. *See* claims 15 and 38-39, *supra*.

185. Pugel discloses *translating digitized broadband signal* so that a selected transponder channel is located at baseband. (*See* Ex.1004-Pugel, ¶22.) Pugel further discloses using a filter/decimator 134 on the translated digitized broadband signal "to retain only the channel energy associated with [the] specific desired

channel" located at baseband (*i.e.*, *substantially removing signal information from non-selected transponder channels*). (*See* claim 15, *supra.*) Pugel's filter is a *low pass filter* because it allows to pass the selected transponder signal (located effectively around 0 MHz), while removing signal information from the non-selected transponder signals at higher frequencies.

186. A POSITA would have been motivated to incorporate the baseband translation and low-pass filter aspects of Pugel in the place of Williams-873's analog filter and would have had a reasonable expectation of success to achieve known benefits from filtering digitally in so doing. (*See* claims 15, 38-39, *supra*.) Accordingly, it is my opinion that claim 42 is obvious over Williams-873 in view of Pugel.

20. Independent Claim 8

a. Construction of Means-Plus-Function Terms

187. Independent claim 8 and its dependent claims 9-13 are not asserted in the co-pending District Court litigation and I understand that Patent Owner has not advanced any construction for these claims. Because the claim limitations either recite the term "means . . . for" and/or other well-known "nonce" words (*i.e.*, "unit"), I further understand that these terms require construction pursuant to 35. U.S.C. 112, ¶ 6. *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1349 (Fed. Cir. 2015) (*en banc*) (internal citations omitted), *Diebold Nixdorf, Inc. v. Int'l Trade Comm'n*, 899

F.3d 1291, 1301 (Fed. Cir. 2018). Additionally, the phrase "means in the first unit for" appears in four different limitations in claim 8 and is associated with different functions. The phase "*means in the second unit for*" appears twice in claim 8 and is likewise associated with different functions. Therefore, I understand that Petitioners consolidate their proposed claim construction and detailed description of how Willaims-873 discloses each limitation, which I address on a limitation-by-limitation basis.

> *8[pre] A signal distribution system for distributing signals comprising a plurality of satellite transponder channels of a broadband signal from a plurality of sources between a first unit and a second unit over a communication medium comprising:*

188. *See* element 14[pre], *supra*. To the extent the preamble is limiting, it is disclosed in Williams-873. Williams-873's Figure 1 discloses *a satellite distribution system*. Williams-873 *distributes signals* comprising a plurality of "transponder signals" (*plurality of transponder channels*) selected and extracted from a received "broadband K-u-band satellite signal (comprising up to 32, QPSK-modulated transponder signals transmitted from one or more satellites)." (Ex.1003-Williams-873, Abstract, 3:50-4:3, 5:59-6:1, 15:15-27.) Williams-873 further discloses a broadband signal from a plurality of sources including RHCP 22 and LHCP 24 received by a satellite dish. (Ex.1003-Williams-873, 5:59-6:11, 7:48-8:8.) The signals are distributed from Williams-873's ODU (*first unit*) to one or more IRDs

disposed within a multi-dwelling unit (*second unit(s)*) over a single cable and an MDU cable plant (*communication medium*). (Ex.1003-Williams-873, Abstract, 3:50-4:30, 6:12-34.) The recited "first unit" and "second unit" are addressed below and incorporated herein. Williams-873 discloses claim 8's preamble.

8[a] means in the first unit for digitizing the broadband signal from each of the plurality of sources;

"Means in the first unit for"

- **Function:** digitizing the broadband signal from each of a plurality of sources.
- **Corresponding Structure:** an ODU is the "first unit" including analog-to-digital converters. (Ex.1001-'576 patent, 3:5-9, 4:56-5:3, 7:5-31, 8:45-47, 11:3-12, Figs. 6-9; Ex.1002.)

189. *See* limitation 14[b][1], *supra.* It would have been obvious to incorporate the analog-to-digital converters of Pugel into the transmodulator 20 of Williams-873 to digitize each of the signals RHCP 22 and LHCP 24. (*See* §§IV.E-F and VII.A.1, *supra*.) The analog-to-digital converters of Pugel function to "directly convert[] a plurality of carrier signals," *i.e.*, *broadband signals from each of the plurality of sources*, "into a digital data stream." (Pugel, ¶6.) Accordingly, it is my opinion that this limitation is obvious over Williams-873 in view of Pugel.

8[b] means in the first unit responsive to information transmitted by the second unit for extracting selected channels from the digitized broadband signals in the digital domain, and

"Means in the first unit for"

- **Function:** extracting selected channels from the digitized broadband signals in the digital domain in response to information transmitted for extracting selected channels.
- **Corresponding Structure:** an ODU including a controller and digital filters, the filters "tuned by programming a set of filter coefficients to select a specific pass band." (Ex.1001-'576 patent, 3:5-9, 4:29-34, 5:12-42, 8:49-51, 8:52-60.)

190. *See* limitation 14[b][2] and claims 15, 34, *supra.* It would have been obvious to substitute the digital filters of Pugel into Williams-873's transmodulator 20 in place of the analog tuners, which are part of the ODU of Williams-873 (*first unit*). Pugel's digital tuners are used to "extract from the digital data stream data carried by" a carrier signal (*i.e.*, to *extract selected* transponder *channels from the digitized broadband signals in the digital domain*). (Ex.1004-Pugel, ¶¶5-6; *see supra* limitation 14[b][2].) A POSITA would have known that the digital tuners of Pugel are digital filters tuned to a particular frequency range (*i.e.*, a specific pass band) by selecting filter coefficients (*i.e.*, programming a set of filter coefficients) using conventional filter design methods. (*See, e.g.*, Ex.1017-Oppenheim, 439-511.) The

tuners of Williams-873 perform selections under direction of control unit 72 (a controller, as in the '576 patent), which receives the "requests for … satellite signals" transmitted "from each of the IRDs" (*second unit(s)*), and a POSITA would have been motivated to retain the request-based selection after incorporating Pugel's digital tuners (Ex.1003-Williams-873, 6:35-42.) Accordingly, this limitation is obvious over Williams-873 in view of Pugel.

8[c] means in the first unit for combining the selected channels into a composite signal without demodulating channels and without changing the modulation of the channels and transmitting the composite signal over the medium; and

"Means in the first unit for"

- **Function 1:** combining the selected channels into a composite signal without demodulating channels and without changing the modulation of the channels.
- **Function 2:** transmitting the composite signal over a medium.
- **Corresponding Structure:** an ODU including a signal summer (such as 380, 670, 950, or 1740) output to a cable. (Ex.1001-'576 patent, 4:29-34, 5:31-42, 6:32-46, 8:49-51, 8:65-9:13, 11:50-57, Figs. 8-9, 17.)

191. *See* limitations 14[b][3], 14[c]-[d], *supra*. The output of each transmodulator channel of Williams-873 is shifted to a distinct frequency by the

upconverter 62, summers 64, and the variable frequency upconverter 66 before being summed by summer 68 (also called "combiner"), which are part of the ODU of Williams-873 (*first unit*) and "combine" *selected channels* "with each other … for propagation over the cable network 26" as a *composite signal*. (Ex.1003-Williams-873 10:24-39, 4:29-33, Fig. 3.) The process of combining selected channels in Williams-873 wou*ld not involve demodulating channels or changing the modulation of the channels*. Like the '576 patent's signal summer, the summer/combiner in Williams-873 outputs the *composite signal*, and connecting a cable (*medium*) to the output of the summer, *transmits the composite signal* over that *medium*. Williams-873 discloses this limitation.

8[d] means in the second unit for receiving the composite signal and demodulating and decoding at least one channel, and

"Means in the second unit for"

- **Function 1:** receiving the composite signal and demodulating and decoding at least one channel.
- **Corresponding Structure:** IRD including a tuner and cable decoder. (Ex.1001-'576 patent, 6:62-66, 9:20-25, 9:34-10:18, 10:48-51; Ex.1009-AAPA Williams-419, 14:4-67 (incorporated into the '576 patent).)

192. The '576 patent disclosure is sparse as to the corresponding structure

performing these claimed functions beyond the fact that they are performed by an IRD/STB. (Ex.1001-'576 patent, 6:64-66.) However, AAPA Williams-419 provides a detailed description of typical IRD components responsible for *demodulating and decoding at least one channel*: a tuner (for tuning "to the frequency associated with a selected" channel), and a cable decoder, such as a "standard DVB cable decoder" which "includes a … demodulator that demodulates" the tuned channel, and an "R-S decoder" to perform decoding. (Ex.1009-AAPA Williams-419, 14:27-54, 16:28-32.) Williams-873's disclosure of the IRDs disposed within a multi-dwelling unit (*i.e.*, MDU IRDs 30, 32, 34, 36, 38, or 40) (second unit(s)) contains the identical disclosure of AAPA Williams-419 as to the cable decoder, and similar disclosure regarding the tuner, and thus discloses this limitation. (*Compare* Ex.1003-Williams-873, 16:6-56 *with* Ex.1009-AAPA-Williams-419, 14:11-43.)

> *8[e] means in the first unit and second units for bi-directionally communicating control information between the second unit and the first unit.*
>
> **"Means in the first and second units:"**
>
> - **Function 1:** bi-directionally communicating control information between the second unit and first unit.
> - **Corresponding Structure:** communications interfaces of an ODU (*first unit*) and IRD(s) (*second unit(s)*) for communication

via cable, wireless RF, and/or wireless IR. (Ex.1001-'576 patent, 3:10-19, 4:28-41, 9:5-13.)

193. *See* limitations 14[a], 8[b], claims 40-41, *supra*. The transmodulator 20 of Williams-873, which is part of the ODU (*first unit*), communicates to the IRDs (*second unit(s)*) *control information* called "side data," specifying "frequency index set-up information," "frequency assignments," and "which transponder signals are being … transmitted over the cable network 26 and the frequencies at which the … transponder signals are located on the cable network." (Ex.1003-Williams-873, 4:40-45, 11:22-35, 15:53-16:35 (IRDs receive "information from the transmodulator 20 indicating the carrier frequencies, etc. of the … signals that are on the cable network 26.").) The IRDs (*second unit(s)*) communicate *control information* constituting "requests for … satellite signals" to the ODU (*first unit*) that the control unit of the ODU uses for channel selection. (Ex.1003-Williams-873, 6:35-42, 11:22-35; limitation 8[b], *supra*.) The *bi-directional communication* of *control information* is performed via "the cable network 26" or using "any other wire or wireless network." (Ex.1003-Williams-873, 7:24-47, 11:22-35.) Thus, Williams-873 discloses this limitation, and claim 8 is obvious over Williiams-873 in view of Pugel.

21. Dependent Claim 9

The signal distribution system of claim 8 wherein the control information comprises channel selection requests originating from the

second unit and the control information comprises channel mapping information originating from the first unit.

194. *See* limitation 8[e]. The IRD (*second unit*) transmits *control information* that is a "requests for … satellite signals" from the ODU (*channel selection requests*), and the ODU (*first unit*) transmits *control information* that "specifi[es] which transponder signals are being … transmitted over the cable network 26 and the frequencies at which the … transponder signals are located on the cable network" (*channel mapping information*). (*Id.*) Accordingly, claim 9 is obvious over Williams-873 in view of Pugel.

22. Dependent Claim 10

The signal distribution system of claim 8, further comprising a means in the first unit for carrier offset correction.

"Means in the first unit for"

- **Function:** carrier offset correction
- **Corresponding Structure:** an ODU is the "first unit" including a controller, one or more filters, power measurement circuitry, and a digital rotating phasor (Ex.1001-'576 patent, 7:38-8:4.)

195. In a received broadband satellite signal, "carrier offset" refers to the deviation of the analog RF carrier frequency band from the range at which it was communicated. For example, a signal transmitted in the range of 800-900 MHz that is received in the range of 804-904MHz has an offset of 4MHz. The '576

specification recognizes that there are "several know [sic] techniques for estimating the carrier offset," and describes two techniques that involve one and two filters, respectively, to help identify the offset, and a digital rotating phasor for correcting any offset. (Ex.1001-'576 patent, 7:38-8:4.)

196. It would have been obvious to a POSITA to modify the ODU of Williams-873 to include means for carrier offset correction in view of Pugel. Carrier offset correction is a standard and routine procedure in most communications systems. Without some means to account for potential variations in the frequency band of a received RF signal, satellite distribution systems such as Williams-873 and Pugel would be susceptible to selecting and distributing only portions of received television signals. And because offset impacts the entire received broadband signal, *see* Ex.1001-'576 patent, 7:38-8:4, failure to account for it could render ineffectual distribution of any desired transponder signals. Claim 15 teaches a mechanism to account for (but not correct) carrier offset when selecting a transponder signal (selecting with a band-pass filter 5%-100% of the bandwidth of the selected signal), but as an alternative, a POSITA would have known to perform a correction on the entire broadband signal prior to performing transponder signal selection and found it desirable to do so in order to, for example, simplify signal selection.

197. Pugel discloses structures that can be used for carrier offset on a

digitized broadband signal: programmable digital filters and numerically controlled oscillators (to apply a rotating phasor). (Ex.1004-Pugel, ¶¶21-23.) A POSITA would have had a reasonable expectation of success using these structures to perform carrier offset correction using any of the "several know[n] techniques" following digitization in the modified system of Williams-873. (Ex.1001-'576 patent, 7:38-8:4.) Accordingly, claim 10 is obvious over Williams-873 in view of Pugel.

23. Dependent Claim 11

The signal distribution system of claim 8 wherein the first unit is a satellite outdoor unit and the second unit is a satellite integrated receiver decoder unit.

198. *See* claim 8, *supra*. The '576 patent teaches and Williams-873 discloses that the structure of the *first unit is a satellite outdoor unit* and the structure of the *second unit is a satellite integrated receiver decoder unit* (IRD). For the reasons set forth in claim 8, this claim is obvious over Williams-873 in view of Pugel.

24. Dependent Claim 12

The signal distribution system of claim 11 wherein the communication medium consists of a single coaxial cable connected to the satellite outdoor unit.

199. *See* claims 8, 11, *supra.* The '576 patent specification teaches and the Williams-873 reference discloses that the structure of the *communication medium consists of a single coaxial cable connected to the satellite outdoor unit* and the cable network 26. (*See* element 8[pre], *supra*.) For the reasons set forth in claims 8 and

11, this claim is obvious over Williams-873 in view of Pugel.

25. Dependent Claim 13

The signal distribution system of claim 12 wherein the means for communicating uses the same communication medium as the composite signal.

200. *See* claim 8, *supra*. Williams discloses that among the *communications medium* that its ODU (*first unit*) and STBs (*second unit(s)*) use to communicate *control information* (*see* limitation 8[e]) is cable network 26 over which the ODU transmits the composite signal (*see* limitation 8[c], *supra*). A POSITA would have understood that the communication medium also includes the cable connecting the ODU and the cable network 26. Accordingly, claim 13 is obvious in view over Williams-873 in view of Pugel.

VIII. SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS

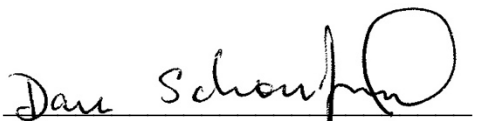
201. I am not presently aware of any secondary considerations of non-obviousness relevant to my analysis in this Declaration. To the extent Patent Owner identifies purported secondary considerations, I reserve the right to respond and supplement my analysis, if necessary.

IX. CONCLUSION

202. For the reasons set forth above, it is my opinion that all challenged claims 8-23 and 34-42 of the ’576 patent are obvious in view of the prior art because

all limitations were disclosed and/or suggested 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 21, 2023 By: 
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APPENDIX A

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A. TABLE OF CONTENTS

A. TABLE OF CONTENTS 1
B. PROFESSIONAL BIOGRAPHY 3
C. RESEARCH INTERESTS 4
D. HONORS AND AWARDS 4
E. IN THE NEWS 7
F. EDUCATION 8
G. WORK EXPERIENCE 8
H. CONSULTING EXPERIENCE 10
I. VISITING POSITIONS 11
J. INTERDISCIPLINARY PROGRAMS 12
K. PROFESSIONAL ACTIVITIES 12
K.1. EDITORSHIPS 12
K.2. COMMITTEES 15
K.3. REVIEW PANELS 18
K.4. CONFERENCE CHAIR 20
K.5. ORGANIZING COMMITTEES 22
K.6. TECHNICAL PROGRAM COMMITTEES 24
K.7. SESSION ORGANIZER 30
K.8. SESSION CHAIR 31
K.9. PANELIST AND PARTICIPANT 34
K.10. OUTREACH ACTIVITIES 35
L. PUBLICATIONS 35
L.1. THESIS 36
L.2. BOOKS 36
L.3. BOOK CHAPTERS 36
L.4. JOURNAL EDITORIALS 37
L.5. REFEREED JOURNAL PAPERS 38
L.6. REFEREED CONFERENCE PAPERS 44
L.7. PRESENTATIONS 59
L.8. PATENTS 60
M. KEYNOTE AND PLENARY TALKS 60

DISH 1002

N. INVITED SEMINARS 61

O. GRADUATE STUDENTS AND VISTING SCHOLARS 68

O.1. VISITING SCHOLARS 68
O.2. POSTDOCTORAL FELLOWS 69
O.3. VISITING STUDENTS 69
O.4. DOCTORAL STUDENTS 70
O.5. MASTERS THESIS STUDENTS 76
O.6. MASTERS PROJECT STUDENTS 79

P. RESEARCH GRANTS 81

Q. ADMINISTRATIVE ACTIVITIES 85

Q.1. ADMINISTRATIVE POSITIONS 85
Q.2. UNIVERSITY COMMITTEES 85
Q.3. COLLEGE COMMITTEES 87
Q.4. DEPARTMENTAL COMMITTEES 87
Q.5. CURRICULUM COMMITTEES 90
Q.6. QUALIFIER COMMITTEES 93
Q.7. RESEARCH LABORATORIES AND CENTERS 94

R. TEACHING ACTIVITIES 94

R.1. THE JOHNS HOPKINS UNIVERSITY 94
R.2. UNIVERSITY OF ILLINOIS AT CHICAGO 94
R.3. UNIVERSITY OF TRENTO 103

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 Giulietti 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
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Graduate Mentoring Award
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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
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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
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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
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2013

Outstanding Associate Editor Award – IEEE Circuits and Systems Society
IEEE Circuits and Systems Society
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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
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Certificate of Appreciation – IEEE Circuits and Systems Society
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2010

Certificate of Appreciation – IEEE Circuits and Systems Society
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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
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Certificate of Appreciation – IEEE Signal Processing Chicago Chapter Chair
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Top Reviewer Recognition Certificate
IEEE International Conference on Image Processing (ICIP)
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2018 Albert Nelson Marquis Lifetime Achievement Award
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Who's Who in the World
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Who's Who in the World
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2018 Edition

Worldwide Who's Who
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Who's Who in America (WWA)
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Who's Who in America (WWA)
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E. IN THE NEWS

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November 4, 2011
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Customs Litigation
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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
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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

DISH 1002

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

DISH 1002

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

DISH 1002

Editorial Board
Research Letters in Signal Processing
Hindawi Publishing Corporation
2007—2009

Editorial Board
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

DISH 1002

CSVT Best Paper Award
IEEE Circuits and Systems Society
2020—2021

Best Paper Award Selection Committee
CSVT Best Paper Award
IEEE Circuits and Systems Society
2019—2020

Best Paper Award Selection Committee
CSVT 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

DISH 1002

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

DISH 1002

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 6268: 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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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)

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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-Chefchaouni 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, Massachussets, 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, Massachussets, 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.

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L.7. Presentations

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L.8. Patents

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M. KEYNOTE AND PLENARY TALKS

Stochastic noise process enhancement of nonlinear filtering
INPT/ASME International Conference on Communications, Signals and Systems
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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
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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)
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Morphological image processing and analysis: Theory and applications
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Morphological image representation: Theory and applications
DOD Tri-Service Workshop on Stochastic Methods in Image Analysis
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Morphological representation of nonlinear filters: Theory and applications
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Morphological image representation: Theory and applications
ONR Workshop on Vision and Optical Information Processing
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Nonlinear Signal and Image Processing
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Nonlinear Operators: Theory and Application to Image Processing and Communications
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Stochastic Noise Process Enhancement of Nonlinear Filtering
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Morphological Signal and Image Processing: Theory and Applications
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VORTEX: Video Retrieval and Tracking from Compressed Multimedia Databases
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Mathematical Morphology and Computer Vision
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VORTEX: Video Retrieval and Tracking from Compressed Multimedia Databases
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Time-Series Analysis Based on Statistical Signal Processing:
Segmentation, Prediction, and Tracking
Global Electronic Trading Company (Getco)
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Particle Filtering for Head Tracking in Wireless Communications
Motorola Research Labs

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Schaumburg, Illinois
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Real-Time Video Communications: Compression, Tracking, Retrieval, and Networking
University of Illinois
Chicago, Illinois
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Real-Time Video Tracking and Retrieval from Multimedia Databases
Motorola Research Labs
Schaumburg, Illinois
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Real-Time Multiple Object Tracking and Motion Trajectory-Based Video Databases: Indexing, Retrieval, and Activity Recognition
Hewlett-Packard Research Labs
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Real-Time Video Tracking Based on Particle Filtering
University of Illinois
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Real-Time Collaborative Distributed Tracking and Trajectory Analysis from Multiple Camera and Sensor Networks
School of Electrical and Computer Engineering
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A New Method for Multidimensional Optimization and Its Application in Image and Video Processing
Department of Electrical Engineering and Computer Science
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Protein Communication System: Evolution and Genomic Structure
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IneractiveVision: Distributed Image and Video Processing
Intellectual Property Technical Lecture Series
McAndrews, Held & Malloy, Ltd.
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Distributed Image and Video Processing:
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MotionSearch: Content-Based Video Retrieval and Classification
Joint Chapters of the IEEE
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Evolution and Genomic Structure: A Signal Processing Perspective
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Evolution and Genomic Structure: A Signal Processing Perspective
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MotionSearch: Content-Based Video Retrieval and Classification
Distinguished Speaker in the Joint College Colloquium Series
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Evolution and Genomic Structure: A Signal Processing Perspective
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MotionSearch: Content-Based Video Retrieval and Classification
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Distributed Multi-Camera Networks: Graphical Models, Tensor Representation, and Plenoptic Functions
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Personalized Visual Interaction: Robust Video-Conferencing and Human-Computer Interaction Using a Two-Camera Computer System
Qualcomm Corp.
San Diego, California
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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
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A Novel Cache Optimization Algorithm and Video Streaming Protocol for Pure Peer-to-Peer Networks
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Distributed Multi-Camera Networks: Graphical Models, Tensor Representation, and Plenoptic Functions
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Compiler Optimization for Translating Software Binaries onto FPGAs
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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.

DISH 1002

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;

DISH 1002

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

DISH 1002

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.

DISH 1002

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

DISH 1002

(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
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

DISH 1002

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, Politechnico 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

DISH 1002

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

DISH 1002

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

DISH 1002

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)

DISH 1002

"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

DISH 1002

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

DISH 1002

2022-2023

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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

DISH 1002

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
Patten Recognition
Spring 2016

ECE 530
Random Signal Analysis
Spring 2016

ECE 434
Multimedia Systems
Fall 2016

ECE 517
Image Processing
Fall 2016

ECE 407
Patten 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

DISH 1002

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

Department of Information Engineering and Computer Science
University of Trento
May 2010