

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MEDIATEK INC.,

Petitioner,

v.

PARKERVISION, INC.,

Patent Owner.

PTAB Case No. IPR2024-00150

Patent No. 7,292,835

DECLARATION OF DR. LAWRENCE E. LARSON

TABLE OF CONTENTS

I.	Introduction.....	1
II.	Qualifications.....	2
III.	Summary of Opinions and Materials Considered	7
IV.	Level of Skill in the Art.....	9
V.	Background Technology.....	11
	A. Wireless Communications Signals.....	11
	B. Modulating Signals for Wireless Communications	12
	1. Amplitude Modulation.....	13
	2. Phase Modulation.....	14
	3. Quadrature Amplitude Modulation.....	15
VI.	Overview of U.S. Patent No. 7,292,835	19
	A. Description of the Specification.....	19
	B. Prosecution History	23
VII.	The Challenged Claims of the '835 Patent.....	24
VIII.	Claim Construction.....	26
	A. Cable modem (claim 1, preamble)	27
	B. Storage module (claim 1)	29
IX.	Legal Principles	31
	A. Burden of Proof.....	31
	B. Priority	31
	C. Prior Art.....	32
	D. Obviousness.....	33
X.	Overview of Cited Prior Art References	36
	A. U.S. Patent No. 4,682,117 to Gibson (Ex. 1004).....	36
	B. U.S. Patent No. 5,339,459 to Schiltz (Ex. 1005)	38
	C. J. Crols & M. Steyaert, <i>A Single-Chip 900 MHz CMOS Receiver</i> <i>Front-End with a High Performance Low-IF Topology</i> , 30 IEEE JOURNAL OF SOLID-STATE CIRCUITS 1483 (Dec. 1995) (Ex. 1006)	41

D.	L. Goldberg, <i>MCNS/DOCSIS MAC Clears a Path for the Cable-Modem Invasion</i> (Ex. 1007)	46
E.	U.S. Patent No. 6,011,548 to Thacker (Ex. 1008)	48
F.	ITU-T J.83 Recommendation (April 1997) (Ex. 1009)	48
G.	Applicant Admitted Prior Art (“AAPA”)	49
XI.	Comparison of the Cited Prior Art References to the Challenged Claims of the ’835 Patent	50
A.	Gibson In View Of Schiltz Renders Obvious Claims 1-5	50
1.	Motivation to Combine	52
2.	Independent Claim 1	58
3.	Claim 2	79
4.	Claim 3	81
5.	Claim 4	91
6.	Claim 5	93
B.	Crols Renders Obvious Claim 1-5	95
1.	Motivation to Combine – Cable Modem References	95
2.	Independent Claim 1	100
3.	Claim 2	124
4.	Claim 3	126
5.	Claim 4	136
6.	Claim 5	137
XII.	Conclusion	139

EXHIBITS REFERENCED IN DECLARATION

No.	Description
EX-1001	U.S. Patent No. 7,292,835 (“’835 patent”)
EX-1002	Excerpts of prosecution file history for U.S. Patent No. 7,292,835
EX-1004	U.S. Patent No. 4,682,117 (“Gibson”)
EX-1005	U.S. Patent No. 5,339,459 (“Schiltz”)
EX-1006	J. Crols, <i>A Single-Chip 900 MHz CMOS Receiver Front-End with a High Performance Low-IF Topology</i> , 30 IEEE JOURNAL OF SOLID-STATE CIRCUITS 1483 (Dec. 1995) (“Crols”)
EX-1007	L. Goldberg, “MCNS/DOCSIS MAC Clears a Path for the Cable-Modem Invasion,” <i>Electronic Design</i> ; Dec. 1, 1997; 45, 27; Materials Science & Engineering Collection pg. 69 (“Goldberg”)
EX-1008	U.S. Patent No. 6,011,548 (“Thacker”)
EX-1009	ITU-T J.83 Recommendation (April 1997) (“ITU-T J.83”)
EX-1010	Declaration of Brenda Ray
EX-1011	Declaration of June Munford
EX-1016	Claim Construction Order, ParkerVision, Inc. v. Intel Corp., No. 6:20-cv-00108 (W.D. Tex. Jan. 26, 2021) (ECF 75)
EX-1021	J. Crols, A 1.5 GHz Highly Linear CMOS Downconversion Mixer, 30 IEEE JOURNAL OF SOLID-STATE CIRCUITS 736 (July 1995)

I, **Dr. Lawrence E. Larson**, declare as follows:

I. INTRODUCTION

1. I have been retained by Petitioner MediaTek Inc. (“MediaTek”) to serve as an independent expert consultant in *Inter Partes* review proceedings regarding U.S. Patent No. 7,292,835 (“the ’835 patent”) (EX-1001). I have been asked to consider the validity of claims 1-5 of the ’835 patent (the “Challenged Claims”). My opinions are set forth below.

2. I am being compensated at my normal rate of \$600/hour for all services rendered. My compensation is not dependent, in any way, on the nature of my findings, the content of my testimony, or the outcome of this proceeding or any other proceeding.

3. I have no other interest in this proceeding.

4. My analysis of the materials provided in this proceeding is ongoing and I will continue to review any new materials that are provided. This declaration is indicative of only those opinions that I have formed to date. I reserve the right to amend, revise, and/or supplement my opinions stated herein based on any new information that may become available to me or my continuing analysis of the materials already provided.

II. QUALIFICATIONS

5. My qualifications for forming the opinions in this report are summarized here and explained in more detail in my Curriculum Vitae (“CV”), which is attached as Appendix A to this declaration.

6. I hold a Ph.D. in Electrical Engineering from the University of California, Los Angeles (“UCLA”) (1986), as well as a M.B.A. degree from UCLA (1996), and Master of Engineering and Bachelor of Science degrees in Electrical Engineering from Cornell University (1980 and 1979, respectively).

7. I am currently Professor of Engineering at the School of Engineering, Brown University. I have also held the positions of Interim Provost of Brown University, as well as Sorensen Family Dean and Founding Dean of the School of Engineering. I held the position of Dean beginning in 2011, during which time I oversaw a large expansion in the number of tenure-track engineering faculty, substantial increases in external research funding, the creation of new graduate programs, and the construction of a state-of-the-art research and teaching facility.

8. I have over 40 years of experience in the design of high-performance circuits for RF communications and other applications, both in industry and academia. Those include but are not limited to the following work experience.

9. From 1980 to 1988, I was a Member of Technical Staff at Hughes Aircraft and Hughes Research Laboratories, where I was responsible for the

development of CMOS and III-V analog and digital integrated circuits, modeling and characterization of MESFETs and HEMTs and the development of improved III-V process techniques. During my tenure, among other things, I helped developed the first high-performance GaAs switched-capacitor circuits with clock rates in excess of 100 MHz, demonstrated the first use of low-temperature buffer GaAs MESFET technology with digital integrated circuits, setting a record for digital divider performance (22 GHz), and developed GaAs MESFET operational amplifier with record GBW (10 GHz).

10. From 1988 to 1992, I was an Adjunct Associate Professor at UCLA, where I was responsible for senior level digital and analog integrated circuit design courses and a graduate analog MOS integrated circuit design course.

11. From 1992 to 1994, I was an Assistant Manager for the DARPA / Hughes MIMIC Program, where I was responsible for Program Management of the Advanced Technology Portion of DARPA/Hughes MIMIC Program, with a budget of approximately \$8M/yr. In that capacity, I was responsible for the technical and program direction of GaAs HBT and PHEMT efforts. I also directed insertion of advanced GaAs-based technology into next generation communication and radar systems.

12. From 1988 to 1996, I was also a Manager in the HEMT Technology Department, Microwave Devices and Circuits Laboratory, at Hughes Research

Laboratories, where I directed research in high-speed III-V materials, devices, and circuits, and was responsible for approximately \$4M/yr. in Corporate IR&D and Government Research Contracts. In that capacity, I helped develop the first space-qualified InP low-noise millimeter wave HEMT. This effort was awarded the 1996 Lawrence Hyland Award – the highest technical achievement award at Hughes Electronics. I also helped develop the first micromachining (MEMS) switch and tuner applications for RF and microwave applications (1991). This technology has now become an extremely active area of worldwide research and development. I also helped demonstrate the first InP-based HEMT low-noise and high- power MMICs from 2– 60 GHz, with world record noise figures and power-added efficiencies. I further helped establish a state-of-the-art InP HEMT MMIC foundry at HRL, developed the first low-power/high-speed InP HEMT digital IC technology with ring oscillator delays of 4.2 pS, and directed the research program that demonstrated HEMTs with record f_T 's and f_{MAX} 's above 300 GHz (1993), which produced the highest frequency room temperature integrated circuit ever reported – a 210 GHz VCO (IEDM 1994).–

13. From 1994 to 1996, I was a Manager in the Telecommunications Technology Department, Microwave Devices and Circuits Laboratory, at Hughes Research Laboratories, where I directed the research and development of

integrated circuits for commercial RF and microwave communications applications, including DBS, cellular telephone, VSAT, and PCS.

14. From 1996 to 2011, I held the CWC Industry Chair Professor in Wireless Communications, in the Department of Electrical and Computer Engineering at the University of California, San Diego (UCSD). Among other things, I helped develop improved integrated circuit techniques and novel device structures for wireless communications applications. This required development of high-frequency integrated circuits, devices, and packaging techniques for ultra-wide bandwidth telecommunications applications, and development of novel data converter and analog-signal processing architectures that are matched to communications applications.

15. From 2000 to 2001, while on academic leave from UCSD, I was a Director at IBM's West Coast Design Center of Excellence in IBM Research Division, where I directed development of Radio Frequency Integrated Circuits for SiGe RFICs for 3rd Generation wireless cellular applications. I was also responsible for leading the team that developed a complete Wideband CDMA chip set for several "first tier" cellular telephone providers.

16. From 2001 to 2006, I was the Director of the UCSD Center for Wireless Communications (<http://cwc.ucsd.edu>), which is one of the largest industry-funded University Research Centers in the world. Involving over 20

professors, and supporting roughly 50 PhD graduate students during my tenure, with an annual budget in excess of \$3M, the CWC conducted research in all areas of wireless communications, from fundamental devices and materials to software applications. I was responsible for all aspects of the Center, from new member development to financial management and establishing the research direction.

17. From 2007 to 2011, I was the Chair of the Department of Electrical and Computer Engineering at the University of California, San Diego. The ECE Department at UCSD is the largest graduate program on the UCSD campus. As Chair, I oversaw the faculty development (hiring, promotion, and tenure process), educational policy and teaching, successful accreditation review, department resource allocation, and external relations. I also led the development (with CS) of the Executive Masters of Advanced Study in Embedded Wireless Systems program.

18. I have authored more than 125 refereed journal publications and more than 250 peer reviewed conference publications. I have also authored and/or edited 12 books or chapters, and am a named inventor on at least 43 issued patents. The works that I have authored include the following.

- L. E. Larson, RF AND MICROWAVE CIRCUIT DESIGN FOR WIRELESS COMMUNICATIONS (Artech House, Inc., 1996).
- J. Groe, and L. E. Larson, CDMA MOBILE RADIO DESIGN: SYSTEMS, ALGORITHMS, AND CIRCUITS (Artech House, Inc., 2000).

- CIRCUITS AND SYSTEMS FOR FUTURE GENERATIONS OF WIRELESS COMMUNICATIONS, A. Tasic, W. Serdijn, L. Larson, G. Setti, G. (Eds.), 2009, VIII, Springer.

19. I have been elected a Fellow of the IEEE. The Fellow is the highest grade of membership of the IEEE, a world professional body consisting of over 300,000 electrical and electronics engineers, with only one-tenth of one percent (0.1%) of the IEEE membership being elected to the Fellow grade each year. Election to Fellow is based upon votes cast by existing Fellows in IEEE. I have also served on a number of IEEE Committees and as a Paper Reviewer.

III. SUMMARY OF OPINIONS AND MATERIALS CONSIDERED

20. All of the opinions contained in this declaration are based on the documents I have reviewed and my professional judgment, as well as my education, experience, and professional knowledge. I am not an attorney and I am not offering any legal opinions in this declaration.

21. In forming my opinions expressed in this declaration, I have relied on the '835 patent (Ex. 1001), the prosecution history of the '835 patent, excerpts of which have been filed as Exhibit 1002, the prior art references cited herein, and other exhibits I have cited in this declaration. Each of these documents is a type of document that an expert in my field would have reasonably relied upon when forming their opinion.

22. My opinions are additionally guided by my appreciation and understanding of how a person of ordinary skill in the art would have understood the Challenged Claims of the '835 patent at the time of the alleged invention. I understand that while MediaTek does not concede that the Challenged Claims have an earlier priority than the filing date of the '835 patent, MediaTek contends that the earliest possible priority date for the Challenged Claims is January 28, 2000. For purposes of this declaration only, I have assumed that January 28, 2000 is the priority date for the Challenged Claims ("Priority Date"). Outside of whether certain references qualify as prior art depending on the priority date that applies, I am not aware that my opinions herein are impacted in any other way by the issue of which priority date applies.

23. Based on my experience and expertise, and for the reasons set forth herein, it is my opinion that:

- Claims 1–5 of the '835 patent are unpatentable in view of U.S. Patent No. 4,682,117 ("Gibson") (Ex. 1004) and U.S. Patent No. 5,339,459 ("Schiltz") (Ex. 1005);
- Claims 1–5 of the '835 patent are unpatentable in view of J. Crols, *A Single-Chip 900 MHz CMOS Receiver Front-End with a High Performance Low-IF Topology*, 30 IEEE JOURNAL OF SOLID-STATE CIRCUITS 1483 (Dec. 1995) ("Crols") (Ex. 1006); and

- To the extent that the Board determines that “cable modem” as recited in claim 1 of the ’835 patent is limiting, then claims 1–5 of the ’835 patent are unpatentable in view of Gibson and Schlitz in further view of one or more of L. Goldberg, “MCNS/DOCSIS MAC Clears a Path for the Cable- Modem Invasion,” Electronic Design; Dec. 1, 1997; 45, 27; Materials Science & Engineering Collection pg. 69 (“Goldberg”) (Ex. 1007), U.S. Patent No. 6,011,548 (“Thacker”) (Ex. 1008), ITU-T J.83 Recommendation (April 1997) (“ITU-T J.83”) (Ex. 1009), and Applicant admitted prior art (“AAPA”) set forth in the ’835 Patent (Ex. 1001) at column 40, lines 17-35.

IV. LEVEL OF SKILL IN THE ART

24. I understand that patent claims are interpreted from the perspective of a hypothetical person of ordinary skill in the art (“POSITA”) at the time of the alleged invention. As noted above, I have assumed for purposes of this declaration that the Priority Date of the Challenged Claims is January 28, 2000 (“Priority Date”). As of this date, I was at least a person of ordinary skill in the art of the technology relating to the ’835 Patent, and I had personal knowledge of the technologies involved in the ’835 Patent.

25. I understand that various factors are considered in determining the level of ordinary skill in the art. I understand that the factors include the types of

problems encountered in the art, prior solutions to those problems, rapidity with which innovations are made, sophistication of technology at the time of the invention, and educational levels and experience of persons working in the field and capable of understanding the applicable scientific and engineering principles. I understand that in determining the level of ordinary skill in the art, not all factors may be present or one or more factors may predominate.

26. Taking these factors into account, a POSITA relating to the technology of the '835 patent on or before the date of the alleged invention would have had at least a bachelor's degree in electrical engineering or a related subject and two or more years of experience in the field of RF circuit design, or would have had at least five years of work experience and training in the design and development of RF circuits and/or systems. Less work experience could be compensated by a higher level of education, such as a master's degree.

27. At least as of the date of the Priority Date of the alleged invention, my education, experience, and professional knowledge qualify me to be a POSITA for the '835 patent. I am qualified to provide opinions on what a POSITA would have known and understood at the time of the alleged invention (e.g., at least as of the Priority Date).

V. BACKGROUND TECHNOLOGY

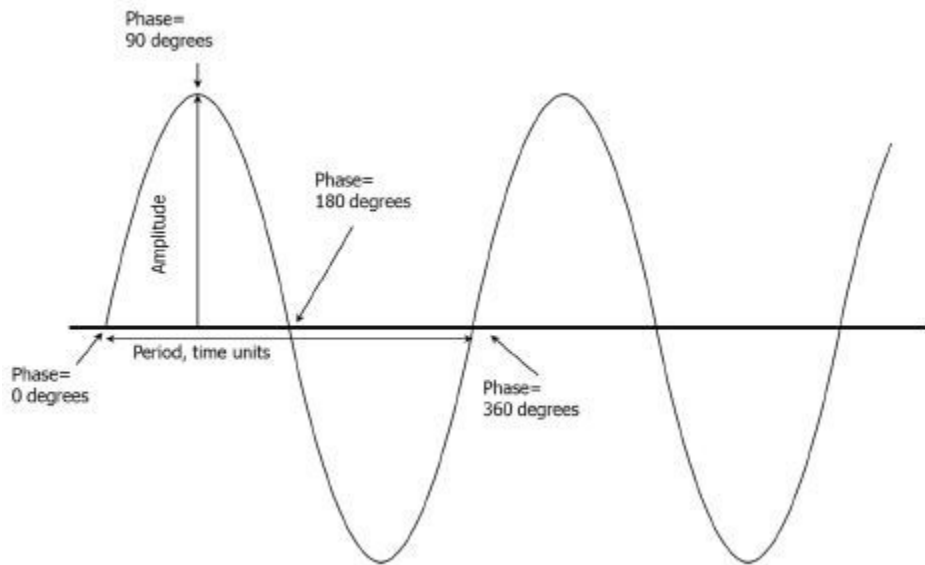
A. Wireless Communications Signals

28. Wireless devices (e.g., cellular phones) exchange information by transmitting and receiving electromagnetic signals. These signals are communicated from one device's transmitter to another device's receiver. The Challenged Claims focus on devices for receiving signals transmitted from another device.

29. As of the Priority Date (and well before it), a communication device such as a cellular telephone would generate a signal for transmission (e.g., the voice information of a telephone call). Prior to the process of transmitting the signal, the signal would have low-frequency content (like voice) capable of being manipulated by the circuitry of the communication device. Such a signal was called a "baseband signal" because it was the signal prior to modulation for transmission and because the range of frequencies prior to modulation were relatively low compared to the frequencies used in transmission (hence, the "base" band).

30. The baseband signal could have been digital or analog, and to transmit a digital baseband signal wirelessly, the digital signal sometimes required being converted into an analog signal. As shown below, an analog signal is a continuously changing signal. For electrical signals (other than direct current

signaling), an analog signal usually takes the form of varying voltage states over time. Those voltage states can be understood as a series of waveforms that oscillates at a particular frequency between maximum and minimum values, as shown below:



B. Modulating Signals for Wireless Communications

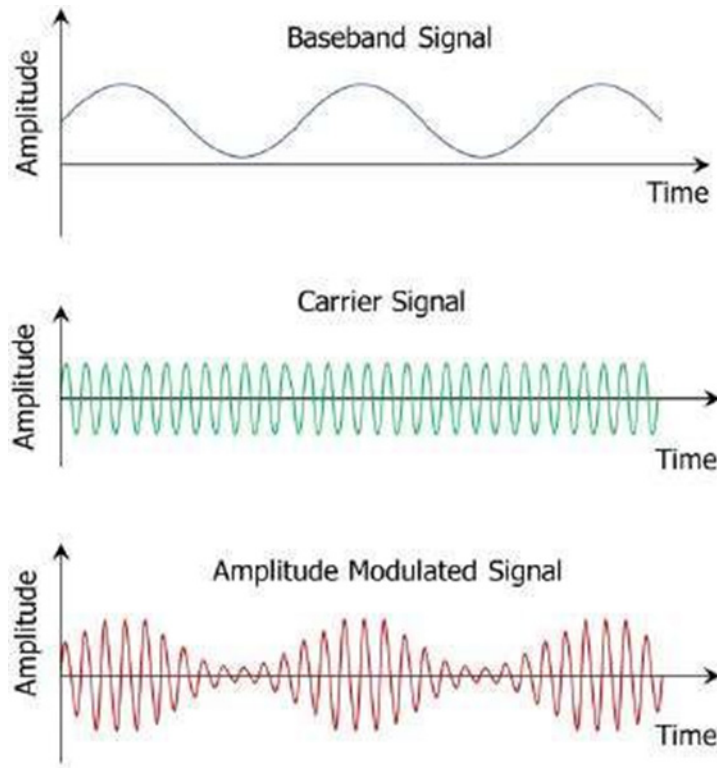
31. A wireless communications device ordinarily transmits a signal by propagating an electromagnetic wave using the frequency, phase, and magnitude of the underlying signal. Although all propagated electromagnetic signals travel at approximately the speed of light, “baseband” signals have relatively low frequencies and so cannot be effectively transmitted through the air between wireless devices. This is due to several reasons, including the size of the equipment needed to propagate and receive low-frequency signals, power requirements for such equipment, and signal interference at low frequencies.

32. As a result, to effectively transmit the information content of a baseband signal through the air, the baseband signal must be “imprinted” on or “upconverted” to a higher frequency signal—called a “carrier” signal—that can be transmitted more effectively through the air, including due to reduced equipment size and power requirements, as well as less signal interference.

33. This “imprinting” process is called “modulation,” and modulation is usually achieved by altering one or more of the frequency, the phase, or the amplitude of the carrier signal. The following sections describe amplitude modulation and phase modulation, pertinent here, in more detail.

1. Amplitude Modulation

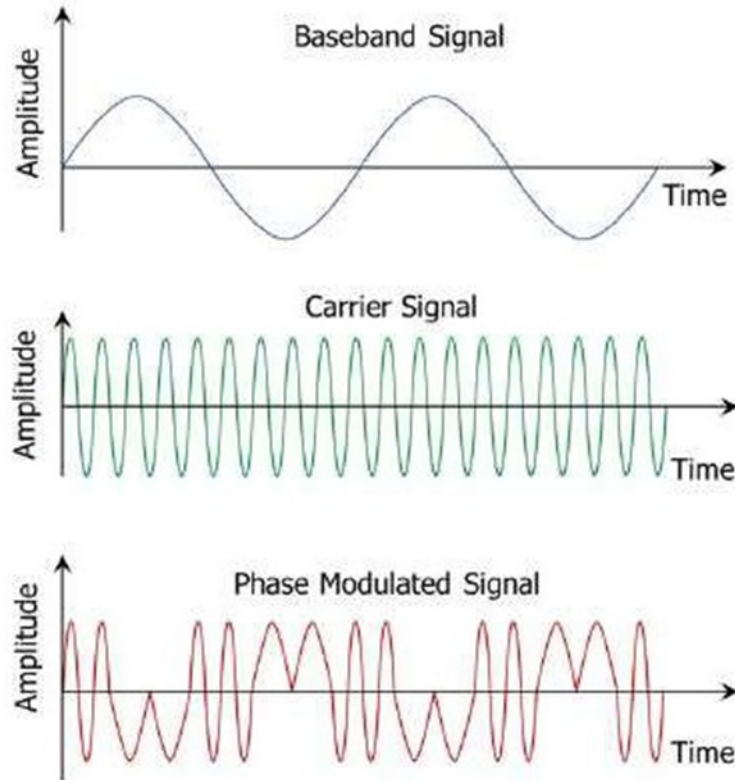
34. As shown below, modifying the carrier signal’s amplitude based on the amplitude of the baseband signal is known as “amplitude modulation.” The modified carrier signal is called an “amplitude modulated signal.”



35. Where such systems are (and were) used, the receiving device uses the frequency of the unmodulated carrier signal to recover the original baseband signal. In this way, the receiver extracts the amplitude modulations (or envelope of the carrier signal) and then uses that information to reconstruct the original baseband signal.

2. *Phase Modulation*

36. A baseband signal can also be transmitted wirelessly to another device by altering the “phase” of a carrier signal. This is called “phase” modulation, and an example of this is shown below.



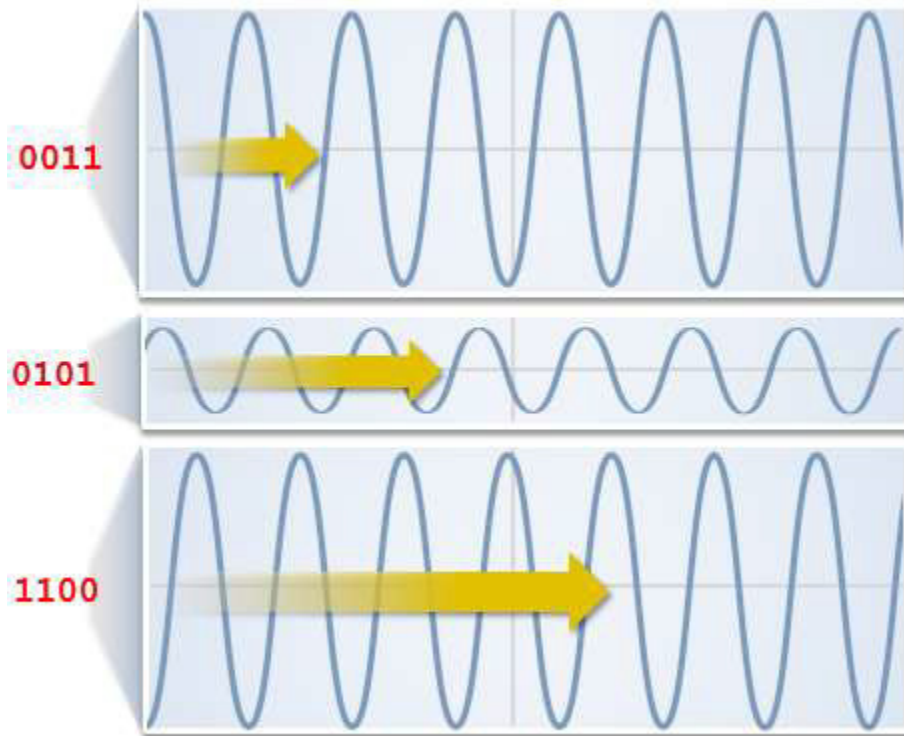
37. The modified carrier signal is called a “phase modulated signal,” where the phase shifting represents the information content of the underlying baseband signal. In a system using “phase modulation” to transmit signals wirelessly, as in a system using amplitude modulation, the receiving device uses the frequency of the unmodulated carrier signal to recover the original baseband signal. In this way, the receiver extracts the phase shifts and then uses that information to reconstruct the original baseband signal.

3. *Quadrature Amplitude Modulation*

38. Quadrature amplitude modulation (QAM) was and is a well-known technique for modulating a carrier signal, using both amplitude and phase variations. QAM involves two carrier waves of the same frequency that are out of

phase with each other by 90 degrees, a condition known as “quadrature.” The amplitude of each of the two carrier waves are independently modified in amplitude to convey information. Often one signal is called the in-phase or “I” signal, and the other is called the quadrature-phase or “Q” signal. After modulation of these two carriers waves, the signals are combined and transmitted. *See* ’835 patent (Ex. 1001) at 40:35-51. The combined, transmitted wave thus has variations in amplitude and phase, depending on the information that it conveys.

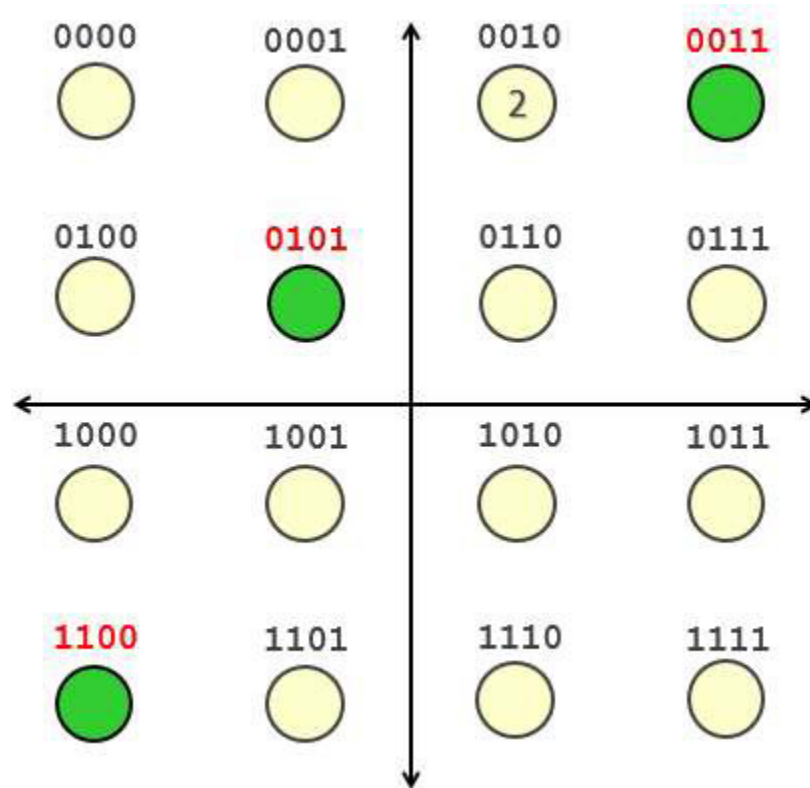
39. For example, information in a baseband signal may be represented by different combinations of amplitude and phase modulations, as shown below. In the example below, if the baseband signal contains the bit string or symbol “0011,” the QAM modulated wave may have a first amplitude and a first phase as shown on the top of the figure below. When the baseband signal contains the bit string or symbol “0101,” the QAM-modulated wave may have a second amplitude and a second phase as shown in the middle of the figure below. And when the baseband signal contains the bit string or symbol “1100,” the QAM-modulated wave may have a third amplitude and a third phase, as shown in the bottom of the figure below.



40. As with amplitude modulation and phase modulation schemes, the receiver in a QAM system uses the frequency and phase of the unmodulated carrier signal to recover the original baseband signal from the combined, modulated I and Q carrier signals. In this process, the QAM receiver separates the in-phase modulated signal from the quadrature-phase modulated signal and then recovers the underlying information content using the “known” modulation scheme (e.g., by using the separate, recovered I and Q signals to determine the “combined” amplitude and phase for both signals, which corresponds to a particular symbol).

41. Recovery of the transmitted data is further illustrated below using what is known as a “constellation” diagram, on which data symbols are represented

as coordinates of the recovered I signal (x-axis) and the recovered Q signal (y-axis).



42. The example above is known as “16-QAM” because the combined modulated wave can represent one of 16 symbols (with 4 bits per symbol). For, example, when a receiver detects a wave having the “combined” amplitude and phase corresponding to the green circle on the top right of the diagram, it interprets this as the bit string or symbol “0011.” When the receiver detects a wave having the “combined” amplitude and phase corresponding to the green symbol in the upper left quadrant, it interprets it as the bit string or symbol “0101.” When the receiver detects a wave having a “combined” amplitude and phase corresponding to the green symbol in the lower left quadrant, it interprets this as the bit string or

symbol “1100.” And so on. In this way, the receiver can demodulate the QAM-modulated signal and recover the transmitted information (e.g., a transmitted bit string).

VI. OVERVIEW OF U.S. PATENT NO. 7,292,835

A. Description of the Specification

43. The '835 patent is titled “Wireless and Wired Cable Modem Applications of Universal Frequency Translation Technology.” '835 patent (Ex. 1001) at (54). The patent provides that it relates to “frequency translation and applications of same” and specifically “cable modem applications.” *Id.* at Abstract, 1:50–54 (“The present invention is generally related to frequency translation, and applications of same, and more particularly to wireless and wired applications of cable modems using universal frequency translation technology.”).

44. As part of the patent’s disclosures, the patent discusses a “QAM modulation mode receiver” that is used to down-convert and demodulate an input signal that is modulated according to QAM. *Id.* at 42:43–43:57, Fig. 54B. While the patent discusses that the receivers of the invention “may be implemented in cable modems,” *id.* at 40:52–61, the patent also states that QAM “is a well known technique for modulating digital signals using both amplitude and phase coding,” *id.* at 40:37–51, and that “cable modem receivers . . . of the present invention may be implemented using a variety of well known devices,” *id.* at 40:17–35 (listing

multiple “Broadcom Corporation” chips, modems, and digital cable tuners). In other words, the described QAM receiver is implemented according to well known modulation conventions in conventional equipment.

45. Additionally, the specification and the Challenged Claims do not describe more than a basic, known structure for performing QAM down-conversion, and have nothing specific related to “cable modems” Particularly. Figure 54B (annotated below) depicts a modem (5402) receiving a signal (5416). The signal (5416) comprises “two information signals modulated with an RF carrier according to” the QAM modulation technique. ’835 patent at 42:43–43:57.

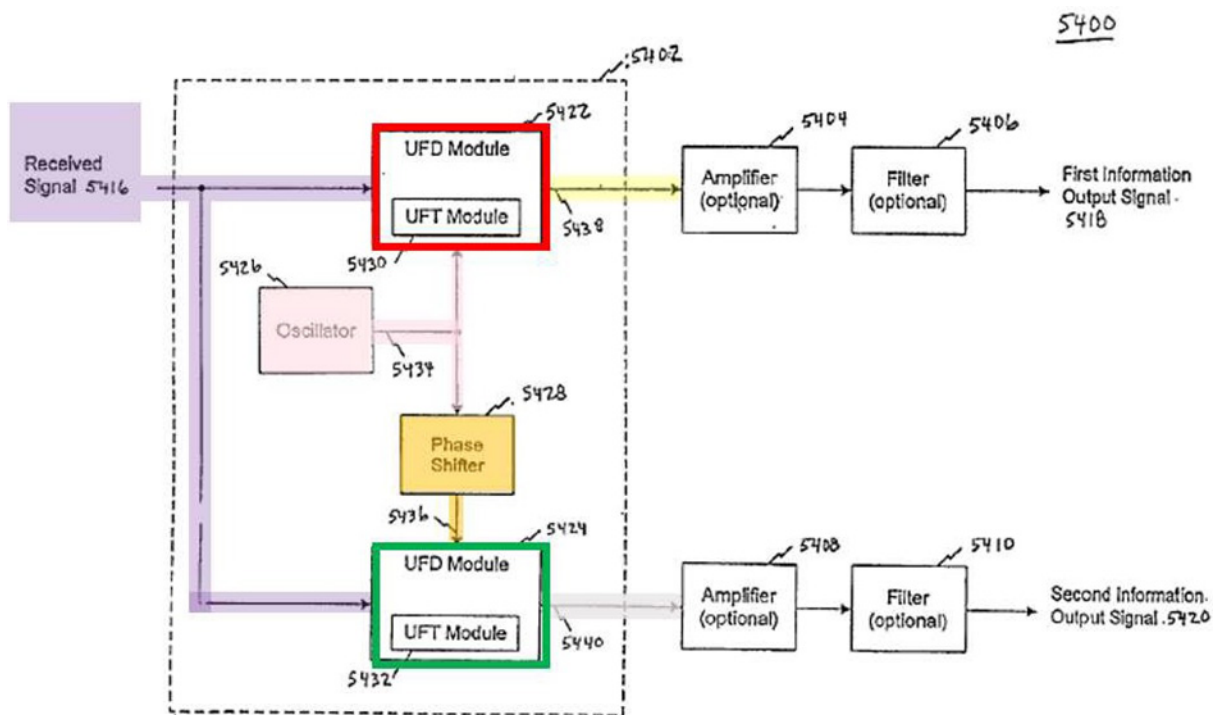


FIG. 54B

46. The received RF signal (annotated purple) is processed by two modules: a first “UFD [or frequency down-conversion] Module” (5422) (annotated red) and a second “UFD Module” (5424) (annotated green). An oscillator (5426) (annotated pink) generates an in-phase oscillating signal (5434) (also annotated pink), and a phase shifter (5428) (annotated orange) receives the in-phase oscillating signal and outputs a quadrature-phase oscillating signal (5436) (also annotated orange).

47. Figures 20A and 20A-1 (annotated below) depict exemplary frequency down-conversion modules having “UFT [or universal frequency translation] Module[s].” In each, the frequency down-conversion module is shown to comprise a “frequency translation module” (e.g., a switch (2008) (annotated blue)) and a storage module (e.g., a capacitor (2010) (annotated brown)).

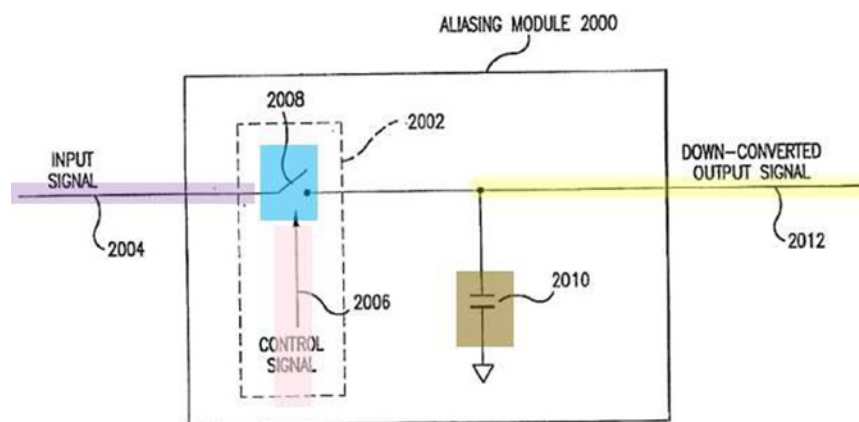


FIG. 20A

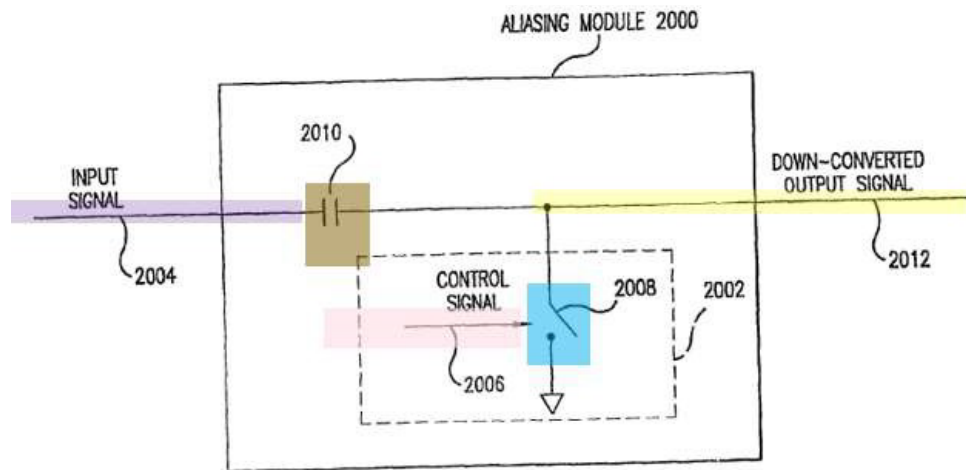


FIG. 20A-1

48. In Figure 54B of the patent, frequency translation module (5422) “samples” the RF signal (5416) at a rate that is a function of the in-phase oscillating signal (5434), creating a down-converted in-phase signal (5438) (annotated yellow). Frequency translation module (5424) samples RF signal (5416) at a rate that is a function of the quadrature-phase oscillating signal (5436), creating a down-converted quadrature-phase signal (5440) (annotated gray). The downconverted “I” and “Q” signals may be “information” signals with “more than two possible states or voltage levels” according to the QAM modulation technique. ’835 patent at 43:17–20, 43:32–34.

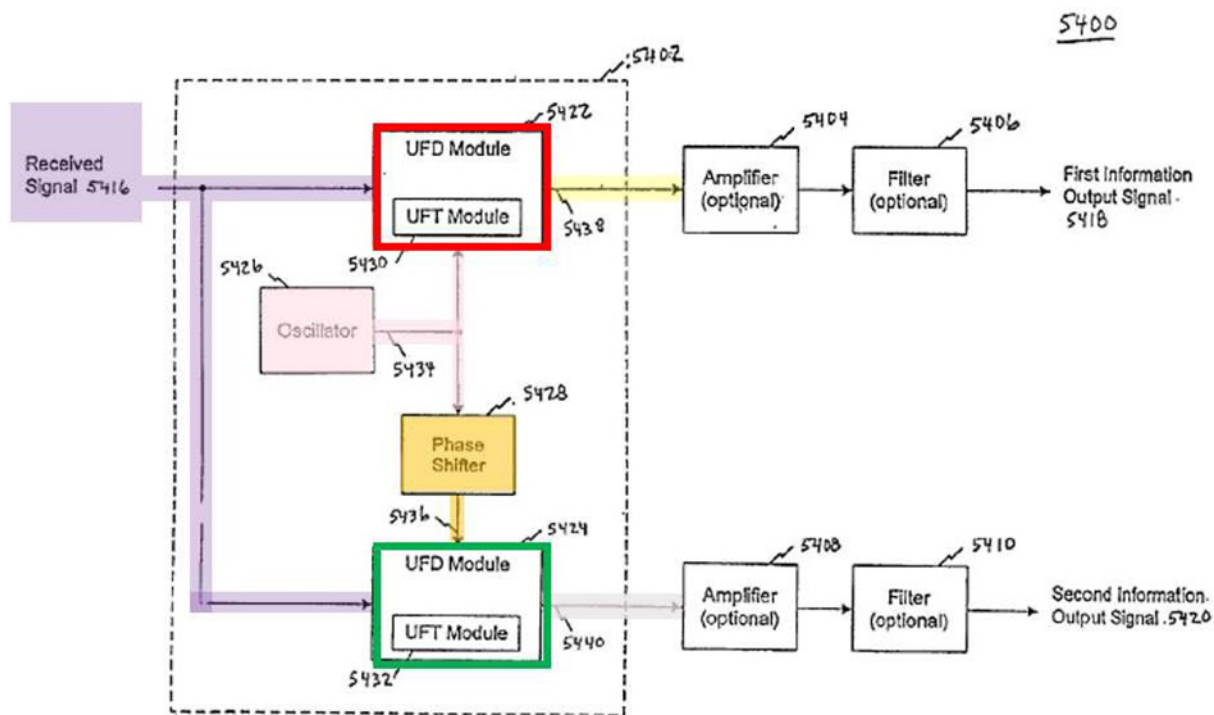


FIG. 54B

B. Prosecution History

49. The application that resulted in the '835 patent (Application No. 09/770,665) was filed on January 29, 2001. '835 patent (Ex. 1001) at (22). The patent issued six years later on November 6, 2007. *Id.* at (45) Outside of a November 30, 2004 restriction and/or election requirement, '835 Prosecution History (Ex. 1002) at 31–36, the Patent Office never issued an office action rejecting the pending claims. Instead, the Patent Office issued a notice of allowability on February 10, 2005, *id.* at 50–53, and then issued supplemental notices of allowability on December 5, 2005, April 27, 2007, and August 17, 2007, *id.* at 65–68, 82–83, 84–85, after the applicant requested continued prosecution and

submitted a further amendment and three additional supplemental information disclosure forms. In the February 10, 2005 and December 5, 2005 notices of allowability, the Examiner stated, as his reasons for allowance, that the prior art of record did not read on the pending claims. *Id.* at 52, 67 (“After considering the IDS, submitted on 07/01/05 and 03/01/05, the examiner found no references that read on the claimed subject matters of the invention.”). The Examiner stated no express reasons for allowance in the April 27 and August 17, 2007 supplemental notices of allowability.

50. The Examiner, however, did not consider any of Gibson, Crols, Goldberg, Thacker, and ITU-T J.83. '835 patent at (56). And although Schiltz is listed as a Cited Reference on the face of the '835 patent, the Examiner never discussed or cited Schiltz for any purpose.

VII. THE CHALLENGED CLAIMS OF THE '835 PATENT

51. I understand that MediaTek is challenging the patentability of claims 1–5 of the '835 patent. The Challenged Claims read:

1. A cable modem for down-converting an electromagnetic signal having complex modulations, comprising:
 - an oscillator to generate an in-phase oscillating signal;
 - a phase shifter to receive said in-phase oscillating signal and to create a quadrature-phase oscillating signal;
 - a first frequency down-conversion module to receive the electromagnetic signal and said in-phase oscillating signal;

a second frequency down-conversion module to receive the electromagnetic signal and said quadrature-phase oscillating signal; wherein

said first frequency down-conversion module further comprises a first frequency translation module and a first storage module, wherein said first frequency translation module samples the electromagnetic signal at a rate that is a function of said in-phase oscillating signal, thereby creating a first sampled signal; and

said second frequency down-conversion module further comprises a second frequency translation module and a second storage module, wherein said second frequency translation module samples the electromagnetic signal at a rate that is a function of said quadrature-phase oscillating signal, thereby creating a second sampled signal.

2. The cable modem of claim 1, wherein said quadrature-phase oscillating signal is out of phase with said in-phase oscillating signal by substantially 90 degrees.
3. The cable modem of claim 1, wherein said first storage device has a first storage first port and a first storage second port, said first storage first port being connected to said first sampled signal, and said first storage second port is connected to a first reference potential, and said second storage device has a second storage first port and a second storage second port, said second storage first port being connected to said second sampled signal, and said second storage second port is connected to a second reference potential.
4. The cable modem of claim 3, wherein said first storage device is a first capacitor, and said second storage device is a second capacitor.
5. The system of claim 3, wherein said first reference potential is substantially equal to ground, and said second reference potential is substantially equal to ground.

VIII. CLAIM CONSTRUCTION

52. I understand that when considering the meaning of claims subject to *inter partes* review, one must consider the claim language. I understand that claim terms are generally given their ordinary and customary meaning, as would be understood by one of ordinary skill in the art (a “POSITA”) at the time of invention in the context of the specification, the prosecution history, and other claims. I also understand that “extrinsic” evidence such as expert or inventor testimony, dictionaries, and learned treatises can be helpful in determining the meaning of claim terms, but that extrinsic evidence is of less significance than the claims, specification, and prosecution history.

53. For my opinions in this declaration, I believe it is helpful to address how a POSITA would have understood the claim terms “cable modem”, “frequency translation module”, and “storage module”, which are recited in independent claim 1 and dependent claim 18.

54. I have been asked to consider the remaining terms of the Challenged Claims under their ordinary and customary meanings as understood by a POSITA at the time of the alleged invention.

55. I have applied the above principles in forming my opinions provided in this declaration.

56. I reserve the right to offer opinions about other claim terms depending on the issues Patent Owner raises in this proceeding or in co-pending litigation (e.g., *ParkerVision Inc. v. MediaTek Inc.*, No. 6:22-cv-01163-ADA (W.D. Tex.)).

A. Cable modem (claim 1, preamble)

57. The preamble of claim 1 recites: “A cable modem for down-converting an electromagnetic signal having complex modulations” I understand that MediaTek contends that “cable modem” as recited in the preamble of claim 1 is not limiting. I further understand that a preamble is generally not limiting unless it gives life, meaning, and vitality to the claims. I also understand that the Board has determined that “cable modem” is not limiting in IPR2021-00985, Paper No. 44 at 21–25.

58. Should the Board reconsider its previous view and determine that “cable modem” is limiting, then in my opinion, a POSITA would have understood “cable modem” to mean any modem that could have been used to down-convert modulated signals from a TV network, whether wired or wireless, and regardless of whether it would have complied with any cable data standard.

59. The ’835 patent provides that its alleged invention is “directed to all types of cable modems.” Ex. 1001 at 36:24–25. It goes on to describe that cable modems “refer to modems that communicate across ordinary cable TV network cables” and that a “cable modem allows a computer system to interface with

networks, such as the Internet, at a greater speed than currently available with conventional data modems, which transmit across phone lines, for example.” *Id.* at 36:19–24.

60. The ’835 patent discloses that its cable modems can be both “wired” and “wireless.” *Id.* at 36:19–20 (“cables”); 36:50–56 (“FIG. 45A illustrates an exemplary wired cable modem environment 4500.”); 36:61–63 (“Cable 4502 is coupled to splitter 4504 via cable 4514.”); 37:24–30 (“FIG. 45B illustrates a wireless cable modem environment 4520.”); 37:31–50 (describing “wireless communication” between cable modem and antenna).

61. The ’835 patent further discloses that its “cable modem” need not operate on a specific data encoding and decoding protocol or standard. For example, “a variety of modulation schemes [] may be employed by cable modem embodiments of the present invention, including QPSK, QAM, OQPSK, I/Q, and others.” *Id.* at 36:26–41. Likewise, the patent provides: “DOCSIS is a Cable Modem Standard that stands for Data Over Cable Service Interface Specification (DOCSIS), and defines the interface requirements for cable modems involved in high-speed data transmission over cable television networks. The present invention is not limited to this standard, but to additional standards, and non-standard configurations.” *Id.* at 38:28–34.

62. Additionally, I note for purposes of completeness that, during the prosecution of the '835 patent, Patent Owner submitted a preliminary amendment on August 30, 2001, which amended the preamble of claim 1 from “A system for down-converting ...” to “A cable modem for down-converting ...” The Patent Owner, however, gave no reasons for this amendment. '835 Prosecution History (Ex. 1002) at 15–20.

63. For the reasons set forth in paragraphs 57-62 above, if “cable modem” were determined to be limiting, a POSITA would have understood “cable modem” to mean any modem that could have been used to down-convert modulated signals from a TV network, whether wired or wireless, and regardless of whether it would have complied with any cable data standard.

B. Storage module (claim 1)

64. Claim 1 recites “a first storage module” and “a second storage module.” A POSITA would have understood that “storage module” as recited in claim 1 would include a “capacitor.” For example, the patent describes that in an embodiment, a “capacitor 2010” is used to “store” charge from an input signal. *E.g.*, '835 patent (Ex. 1001) at 7:32–41. Likewise, the patent describes a “capacitor” as a “storage device”: “In another embodiment, the capacitor is replaced by another storage device, such as, and without limitation, an inductor.” *Id.* at 11:23–25. More importantly, claim 4 recites that “said first storage device is

a first capacitor, and said second storage device is a second capacitor.” *Id.* at 51:42–44.

65. To the extent that Patent Owner contends “storage module” as recited by claim 1 of the ’835 patent is means plus function term, subject to construction under 35 U.S.C. § 112(6), a POSITA would have understood the function to be “storage” of an electromagnetic charge, and that, for the reasons explained in paragraph 64 above, the corresponding structure would have included a “capacitor.”

66. Finally, I understand that in IPR2021-00985, the Board construed the term “storage module” as “a module of a system that stores non-negligible amounts of energy from an input EM signal.” IPR2021-00985, Paper No. 44 at 21. In doing so, the Board rejected Patent Owner’s attempt to require that the “storage module” be “of an energy transfer system.” I further understand that in other litigations, Patent Owner has attempted to read in related functional language, *i.e.*, “for driving a low impedance load,” but that such attempts have been rejected. Ex. 1016 (Claim Constr. Order in *ParkerVision v. Intel I*) at 4–5 (“Court’s Final Construction” did not include “for driving a low impedance load”).

67. I agree with the Board’s rejection of “of an energy transfer system”. Challenged Claim 1 recites “storage module” in an unqualified manner and do not ascribe any particular function to the storage module other than “storage” of an

electromagnetic charge. Likewise, Challenged Claim 4 recites that “storage module” is a “capacitor” without any qualifications regarding “energy transfer systems” or “low impedance loads.”

IX. LEGAL PRINCIPLES

68. I am not an attorney and I have not been asked to express any legal opinions. Rather, in connection with the analysis presented in this declaration, I have considered the following legal standards that counsel for Petitioner provided to me.

A. Burden of Proof

69. I understand that the Petitioner has the burden of proving the unpatentability by a preponderance of the evidence, which I understand as meaning more than 50% likely.

B. Priority

70. I have been informed that a claim of a continuation patent is not entitled to the priority date of an earlier application if the earlier application does not disclose all of the limitations of the claim in question. As noted in paragraph 24 above, I have assumed that the Priority Date for Challenged Claims 1–5 of the '835 patent is January 28, 2000, although I have been informed MediaTek does not concede that this is the correct priority date for those claims.

71. I further been informed that because the Priority Date for the Challenged Claims is before March 16, 2013, the claims are subject to review under pre-America Invents Act 35 U.S.C. §§ 102 and 103.

C. Prior Art

72. I have been informed that, because the Challenged Claims of the '835 patent are subject to review under pre-America Invents Act 35 U.S.C. §§ 102 and 103, a U.S. patent will be prior art to the Challenged Claims if, for example, the patent issued before the Priority Date for the Challenged Claims (January 28, 2000), and that the same is also true for non-patent publications. *See* 35 U.S.C. § 102(a) (“A person shall be entitled to a patent unless – (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent[.]”) I understand that the date of “invention” for purposes of the preceding sentence requires both (i) corroborated evidence of conception by the named inventor(s) and (ii) a reduction to practice.

73. I also understand that if a U.S. patent, for example, issues (or a non-patent publication is published) more than one-year before the filing date of the application leading to the Challenged Claims, then the U.S. patent (or publication) will be considered “incontestable” prior art. *See* 35 U.S.C. § 102(b) (“A person shall be entitled to a patent unless – ... (b) the invention was patented or described

in a printed publication in this or a foreign country ... more than one year prior to the date of the application for patent in the United States[.]”).

74. I further understand that an issued U.S. patent will be prior art to the Challenged Claims if it results from a U.S. patent application filed by someone other than the named inventor(s) before the date of the invention for the Challenged Claims. *See* 35 U.S.C. § 102(e)(2) (“A person shall be entitled to a patent unless – ... (e) the invention was described in – ... (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent”). I am informed that the date of “invention” for purposes of the preceding sentence requires both (i) corroborated evidence of conception by the named inventor(s) and (ii) a reduction to practice.

75. Additionally, I understand that if a reference (such as a U.S. patent) qualifies as prior art, then that reference can be used for purposes of both anticipation and obviousness.

D. Obviousness

76. I understand that a claim is obvious, and therefore not patentable, if at the time of the invention, the subject matter of the claim as a whole would have been obvious to a person of ordinary skill in the art. I understand that a proper obviousness analysis must consider the following four factors: (1) the scope and content of the prior art; (2) the level of ordinary skill in the art; (3) the differences

between the claimed subject matter and the prior art; and (4) any objective indicia of non-obviousness.

77. I understand that a reason to combine that merely describes the resulting combination without explaining the particular reason why one of ordinary skill would combine the elements of the prior art to form Patent Owner's claimed invention is merely conclusory and based on impermissible hindsight reasoning. It is not enough to simply show that the references disclose each limitation of a claim; it is also necessary to identify a reason that would have prompted a POSITA to combine the limitations in the manner set forth in the claim. I understand that a *prima facie* case of obviousness requires more than describing the results of the proposed combination. Rather, the Petitioner must articulate a reason for making the proposed combination in the first instance. I further understand that it is not enough to conclude that, once the proposed combination is made, the result is predictable; an obviousness finding requires that the Petitioner provide a reason, supported by a rational foundation, which explains why one of ordinary skill would have chosen to make the particular combination in the first place.

78. I have been informed that claimed subject matter can be rendered obvious by a combination of prior art if, for example, it results from the combination of known elements according to known methods to yield predictable results; the simple substitution of one known element for another to yield

predictable results; use of a known technique to improve similar devices in the same way; applying a known technique to a known device ready for improvement to yield predictable results; or applying known work in a field to create a variation, in light of design incentives or market forces, if the variation would yield predictable results. I have also been informed that the analysis of obviousness may include recourse to logic, judgment, and common sense available to a POSITA that does not necessarily require explicit disclosure in any reference.

79. I understand that, in analyzing the four obviousness considerations (listed in paragraph 76 above), a party challenging a patent must show that: (1) each and every limitation of the claimed subject matter was disclosed in the combination of prior art references; (2) a person of ordinary skill in the art would have had a reason to combine the teachings of the prior art references to achieve the claimed subject matter; and (3) a reasonable expectation would have existed that the combination of such teachings would achieve the claimed subject matter.

80. I understand that, in addition to its analysis of the teachings of the prior art, the fact finder must consider the Patent Owner's proffer, if any, of objective indicia of non-obviousness, including: (1) commercial success; (2) professional approval and praise by others; (3) expressions of disbelief and skepticism of those skilled in the art upon learning of the invention; (4) licenses showing industry respect and commercial acquiescence to the invention;

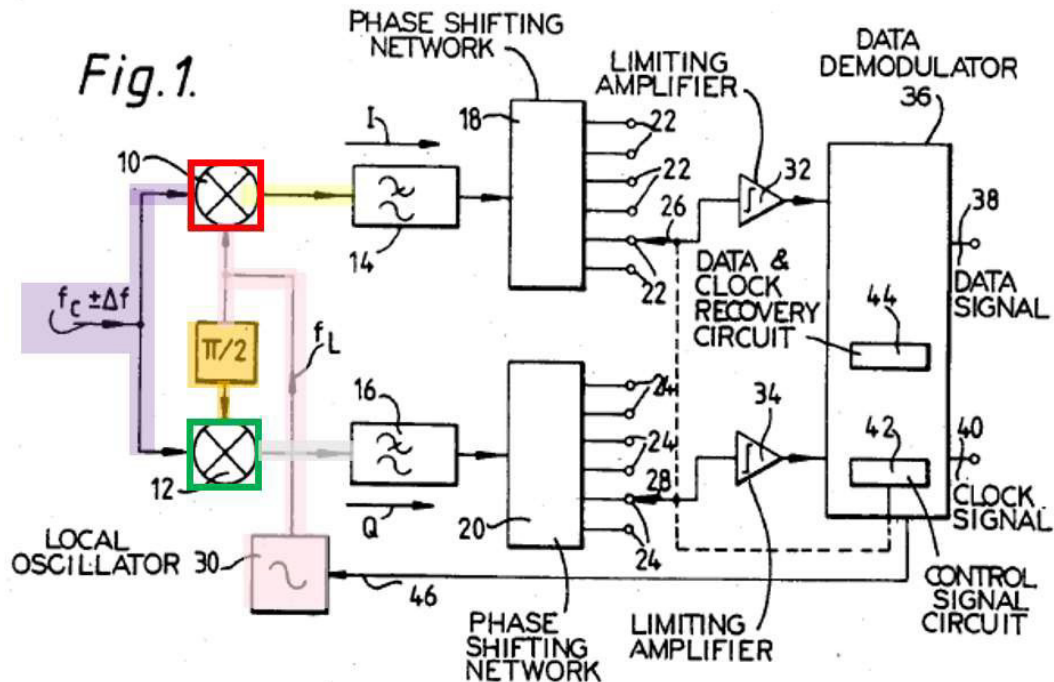
(5) copying; (6) long felt but unresolved need, and failure of others to solve the problem, including the passage of time between publication of the prior art and the invention; and (7) unexpected results. In reviewing the file history of the '835 patent and the other information discussed in this declaration, I am not currently aware of any evidence supporting any of the above factors.

X. OVERVIEW OF CITED PRIOR ART REFERENCES

A. U.S. Patent No. 4,682,117 to Gibson (Ex. 1004)

81. Gibson (Ex. 1004) is titled “Quadrature Demodulation Data Receiver with Phase Error Correction.” Gibson was filed on April 30, 1986 and issued on July 21, 1987. Gibson at (22), (45). I understand that Gibson is prior art to the Challenged Claims under 35 U.S.C. § 102(b).

82. Gibson discloses a data receiver that is used to down-convert a modulated radio-frequency or RF signal into an in-phase sampled signal (“I”) and a quadrature-phase sampled signal (“Q”). Gibson at 1:35–40, 2:56–3:17. Figure 1 discloses an example of Gibson’s data receiver:



83. The receiver receives an input electromagnetic signal (annotated purple). Gibson at 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30.”). The signal is then applied to two quadrature mixers (mixer 10, annotated red; mixer 12, annotated green). *Id.*

84. The receiver has a “local oscillator 30” that generates a signal “substantially equal to [the] carrier frequency f_c ” (annotated pink), which is then applied to quadrature mixer 10. This signal is also applied to quadrature mixer 12 after being phase shifted (annotated orange) to create a quadrature channel Q. *Id.* at 2:65–67 (“Thus in the in-phase channel I the signal is $+\Delta f$ or $-\Delta f$ and in the quadrature channel Q the signal is $+\Delta f - \pi/2$ or $-\Delta f - \pi/2$.”). In this way, Gibson

discloses that its system samples an input RF signal to create a down-converted in-phase signal on the I channel (annotated yellow) and a down-converted quadrature-phase signal on the Q channel (annotated gray).

85. Gibson further discloses that “[t]he outputs of the mixers 10, 12 are filtered in low pass filters 14, 16 which will pass the modulation frequency Δf ,” or that in “an alternative arrangement, now shown, the low pass filters 14, 16 may be omitted and the low pass filtering [] done in the mixers 10, 12.” *Id.* at 2:60–65.

B. U.S. Patent No. 5,339,459 to Schiltz (Ex. 1005)

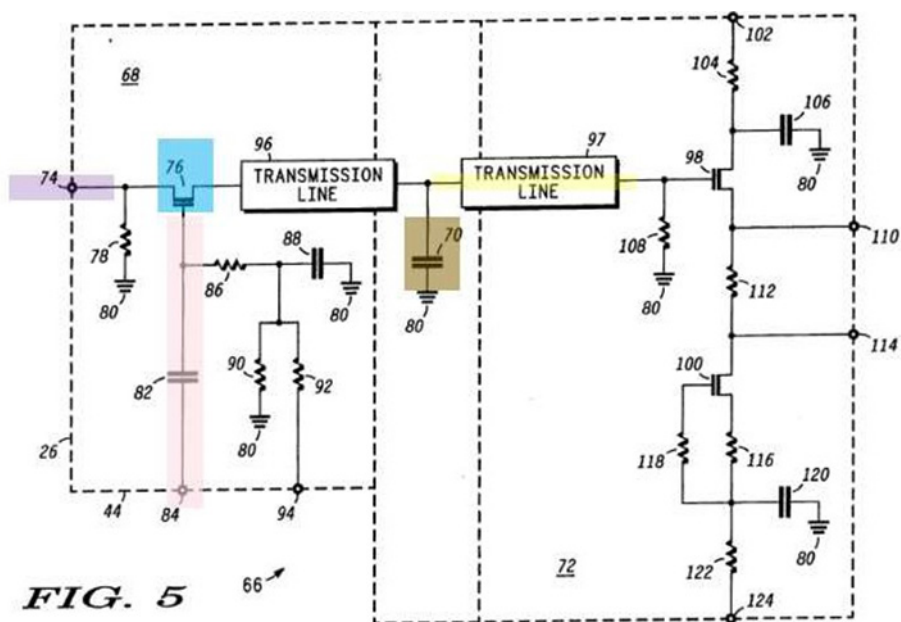
86. Schiltz (Ex. 1005) is titled “High Speed Sample and Hold Circuit and Radio Construction Therewith.” Schiltz was filed on December 3, 1992 and issued on August 16, 1994. Schiltz at (22), (45). I understand that Schiltz is prior art to the Challenged Claims under 35 U.S.C. § 102(b).

87. Schiltz discloses a “high speed sample and hold circuit” that serves “as a mixer,” comprising a switch and a capacitor. Schiltz at 1:5–10, 3:45–65 (“Details related to sample and hold circuit 26 are discussed below in connection with FIG. 5.”), 4:29–32 (“Sample and hold circuit 26 operates as a downconverter in radio 10. Sample and hold circuit 26 converts a high frequency RF signal into an IF signal in a single operation.”), 6:3–10 (“Sample and hold circuit 26 (see FIG. 1) samples the RF signal while the pulses supplied by pulse generator 30 (see FIG. 1) are active and holds the samples while the pulses are inactive. In other words,

sample and hold circuit 26 successively samples the RF signal for a duration of τ (the pulse width) and holds the sample for the remainder of the duration T_S (the sampling period).”), 7:58–65 (“IC 66 includes a sampling switch 68, a hold capacitor, and a buffer amplifier 72. ... FET 76 performs the above-discussed sampling of the RF signal.”), 8:21–29 (“A drain of FET 76 serves as the output of sample switch 68. The schematic diagram of FIG. 5 shows a transmission line 96, which couples sample switch 68 to a first node of hold capacitor 70. The schematic diagram of FIG. 5 also shows a transmission line 97, which couples the first node of hold capacitor 70 and sample switch 68 to an input of buffer amplifier 72. A second node of hold capacitor 70 couples to ground terminal 80.”), 10:15–18 (“In summary, the present invention provides an improved radio which uses a sample and hold circuit in various mixing applications, such as down conversion and oscillation signal generation circuits.”), 10:29–31 (“Due to the accurate high frequency operation, a high bandwidth results when the sample and hold circuit is used as a mixer.”), 10:40–45 (“[T]hose skilled in the art will appreciate that radio and other architectures other than those described herein may utilize a sample and hold circuit as a mixer.”).

88. Figure 5 depicts Schiltz’s sample and hold circuit and is shown, as annotated, below. Schiltz discloses that the circuit contains a switch 68, comprised

of a field effect transistor 76 (annotated blue), a control input for the FET 76 (annotated pink), and a “hold capacitor 70” (annotated brown).



89. As Schiltz discloses, “an RF signal [annotated purple] is applied to sample and hold circuit 26 at contact 74.” Schiltz at 7:61–62. Contact 74 is then coupled to a source input of FET 76. *Id.* at 7:62–64. “Contact 84 serves as the control input for sample and hold circuit 26. In other words, the stream of sampling pulses is applied to sample and hold circuit 26 at contact 84.” *Id.* at 8:5–7; *see also id.*, FIG. 1 (depicting pulse generator 30), 3:67–4:18. As noted above, FET 76 operates as a switch and samples the incoming signal according to the control input applied at control 84 (annotated pink). *Id.* at 7:64–65, 8:3–8. The “drain of FET 76 serves as the output of sample switch 68,” is coupled to a first node of “hold capacitor 70” (annotated brown), and outputs a sampled signal

(annotated yellow). *Id.* at 8:20–24. “A second node of hold capacitor 70 couples to ground terminal 80.” *Id.* at 8:27–29.

C. J. Crols & M. Steyaert, *A Single-Chip 900 MHz CMOS Receiver Front-End with a High Performance Low-IF Topology*, 30 IEEE JOURNAL OF SOLID-STATE CIRCUITS 1483 (Dec. 1995) (Ex. 1006)

90. Crols (Ex. 1006) was published in the IEEE Journal of Solid State Circuits in December 1995. I understand that Crols is prior art to the Challenged Claims under 35 U.S.C. § 102(b).

91. Crols discloses a receiver used in a wireless RF transceiver (a modem). Crols at Abstract (“An analog receiver front-end chip realized in a 0.7 μm CMOS technology is presented.”), 1483 (“One aspect of this evolution is the ever increasing level of integration of the transceivers ...”). Crols discloses that common RF downconversion topologies utilized quadrature mixers: “Fig. 12(a) shows the conventional quadrature down converter. The LO signal is put into quadrature and the down conversion is done twice. Signals situated at a frequency higher than the LO will be down converted to positive low frequencies. Signals lower than the LO will be down converted to negative frequencies. ...” Crols at 1489.

92. Crols further discloses that Figure 12(b) is “an alternative for the conventional quadrature down converter” with the only disclosed structural difference being that the RF, rather than the LO, is put into quadrature. *Id.* A

POSITA would have understood that the downconverter of Figure 12(a) and the downconverter of Figure 12(b) are IF or “zero-IF” downconverters. *See Crols at 1483* (“In the last few years, the world of wireless communications has been changed very rapidly [1]. One aspect of this evolution is the ever increasing level of integration of the transceivers, driven by the need for both a better portability and a lower cost prize. The consequence of this evolution is that the zero-IF downconversion topology is used more and more in receivers for mobile wireless telecommunications applications [2], [3]. The zero-IF receiver can be implemented with a much higher degree of integration than the conventional IF (heterodyne) receiver. This has made the zero-IF downconverter the preferred topology in the research towards the fully integrated single-chip transceiver.”).

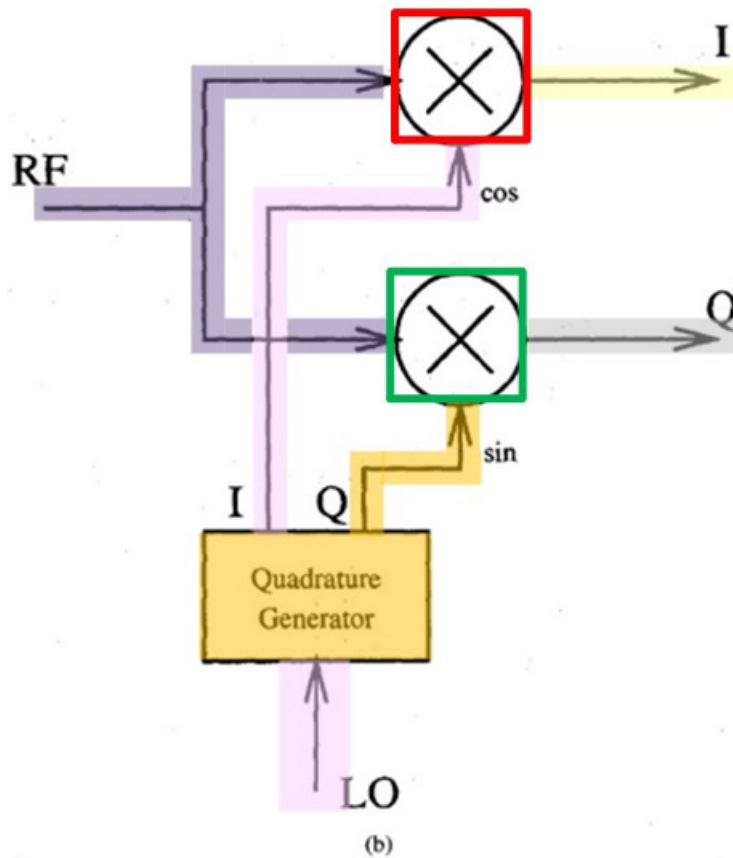


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

93. As depicted in Figure 12(b) above, an RF signal (annotated purple) is received by a modem and applied to a first mixer (annotated red) and a second mixer (green). The local oscillator signal (annotated pink) is applied to a quadrature generator which passes or generates an in-phase (“I”) oscillating signal (annotated pink) and generates a quadrature-phase (“Q”) oscillating signal. The I and Q signals are applied to the first and second mixers respectively to generate in-phase down-converted signals (annotated yellow) and quadrature-phase down-converted signals (annotated gray). Crols further discloses that the in-phase and quadrature phase signals have a 90-degree phase difference. Crols at 1483–1484

(“The conventional realizations use an RC-CR network for the quadrature generation of the LO signal and two Gilbert multipliers for the down-conversion. The generation of the quadrature signal is based on the 90° phase-difference between a pole and zero with the same cutoff frequency.”).

94. While Crols discloses a proposed topology for a low-IF downconverter called a “double quadrature downconverter” designed to put both the RF and LO signals into quadrature (including where both the RF and LO signals were also inverted in a differential configuration), the core components of the low-IF topology were the same as in the “conventional” quadrature downconverter of Figure 12(b), *i.e.*, quadrature generator(s) and mixers. *See* Crols at FIGS. 13 and 15. Crols proposed the “double quadrature downconverter” to address issues known to exist in the field—suppression of “amplitude and phase errors” (e.g., “mirror signal crosstalk”)—but I note these issues did not deter use of the “conventional quadrature downconverter” topology, including for zero-IF applications, something Crols itself notes. *Id.* at 1483 (“The consequence of this evolution is that the zero-IF downconversion topology is used more and more in receivers for mobile wireless telecommunications applications [2], [3].”).

95. Crols further discloses that the mixers in the double quadrature mixer topology were “realized with a recently developed highly linear CMOS topology

for downconverters” as “shown in Fig. 17.” Crols at 1491. Figure 17 (annotated) is set forth the below.

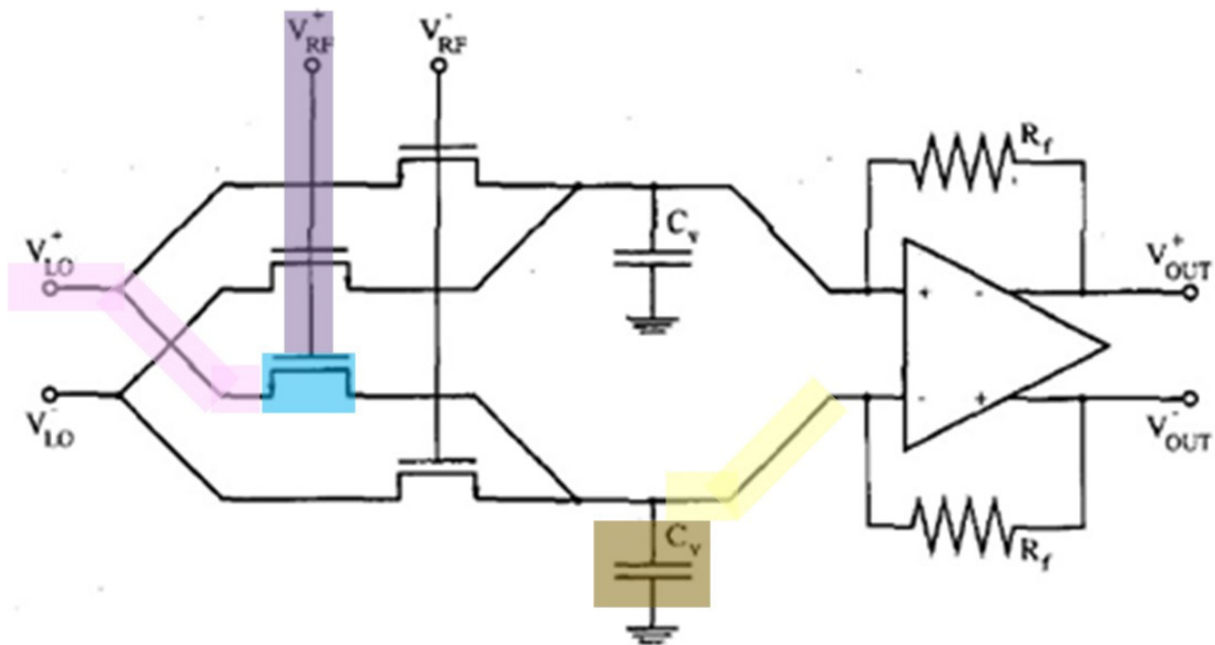


Fig. 17. The highly linear mixer topology.

96. Although Figure 17 depicts a mixer in a differential configuration, a POSITA would have understood that the basic topology of the mixer (a switch followed by a capacitor) could have been applied to a non-differential “conventional quadrature downconverter,” including in that a POSITA would have understood the logical schematic of the downconverter of Figure 12(b) to cover both non-differential and differential designs.

97. The basic structure of Figure 17 discloses that an RF electromagnetic signal (annotated purple) is applied to the “control” node of a CMOS transistor (annotated blue). The local oscillating signal (whether in-phase or quadrature)

(annotated pink) is applied to the source input of the CMOS transistor. The drain of the transistor is coupled to a “large capacitor” (C_V) (annotated brown) and outputs a sampled signal (annotated yellow). Crols at 1491. The “large capacitor” serves as a low pass filter, allowing the drain to pass along the sampled, lower frequency signal. *Id.* (“The large capacitors make that the opamp only has to process low frequency signals. This makes it possible to use an opamp with large input transistors, which results in a low noise despite its low power consumption.”).

98. A POSITA would have understood that while the RF signal is applied to the control (gate) node in Figure 17, it would have been obvious to apply the RF signal to the source input of the CMOS transistor, as suggested by Figure 12(b). In either scenario, the RF signal is between mixed with (multiplied by) the LO signal to downconvert the RF signal to a lower frequency, including to “baseband” in a “zero-IF” circuit.

D. L. Goldberg, *MCNS/DOCSIS MAC Clears a Path for the Cable-Modem Invasion* (Ex. 1007)

99. The ’835 patent acknowledges that “DOCSIS is a Cable Modem Standard that stands for Data Over Cable service Interface Specification (DOCSIS), and defines the interface requirements for cable modems involved in high-speed data transmission over cable television networks.” ’835 patent (Ex. 1001) at 38:27–34, 40:8–12; *id.* at 40:17–35 (“The cable modem receivers,

transmitters, and transceivers of the present invention may be implemented using a variety of well-known devices,” including “a BCM3116 QAMLink™ 64/256-QAM ITU-B Receiver, ... a BCM3037 QAMLink™ QPSK/16-QAM Burst Modulator, ... a BCM3360 QAMLink™ Single Chip MCNS/DOCSIS Cable Modem, a BCM93310 DOCSIS External Cable Modem, a BCM93310i DOCSIS Internal PCI Cable Modem, and/or a BCM3300- QAMLink™ Single-Chip MCNS/DOCSIS Cable Modem, manufactured by Broadcom™ Corporation.”).

100. DOCSIS was first released on March 26, 1997, and was described in patents and printed publications. One of those references is Goldberg (Ex. 1007), which was published in December 1997. I understand that Goldberg is prior art to the Challenged Claims under 35 U.S.C. § 102(b).

101. Goldberg describes that “DOCSIS is designed to employ one or more unused video channels with the 54-to-860 MHz cable broadcast spectrum to transmit IP-base data across hybrid fiber coaxial networks.” Goldberg at 69–70. Goldberg further discloses that DOCSIS required QAM: “Depending on the bit rate selected by the operator, the shared downstream channel uses either 64- or 256-point quadrature-amplitude modulation.” *Id.* at 70. Goldberg also discloses chips—the BCM3116 and BCM3037—that the ’835 patent discloses are well-known devices that may be used to implement a “cable modem.” Goldberg at Figures 2 and 3.

E. U.S. Patent No. 6,011,548 to Thacker (Ex. 1008)

102. Thacker (Ex. 1008) is another reference that describes DOCSIS.

Thacker is titled “System for Integrating Satellite Broadband [sic] Data Distributed Over A Cable TV Network With Legacy Corporate Local Area Networks.”

Thacker was filed on September 4, 1998 and issued on January 4, 2000. Thacker at (22), (45). I understand that Thacker is prior art to the Challenged Claims under 35 U.S.C. § 102(a) and 35 U.S.C. § 102(e)(2). It is a U.S. patent that issued before the Priority Date of the ’835 patent. It also resulted from a U.S. patent application that was filed before the Priority Date of the ’835 patent.

103. Thacker discloses that “MCNS released its Data Over Cable System Interface Specification (DOCSIS) for cable modem products to vendors in March 1997” and that “Many vendors have announced plans to build products based on MCNS DOCSIS.” Thacker at 1:30–40. Thacker, like Goldberg, discloses that DOCSIS mandated QAM. *Id.* at 1:50–62.

F. ITU-T J.83 Recommendation (April 1997) (Ex. 1009)

104. Another international cable data standard that was established prior to the filing of the ’835 patent was the ITU-T J.83 standard. The standard was published in 1997. Appendix B to the standard is known as “J.83b.” I therefore understand that ITU-T J.83b is prior art under 35 U.S.C. § 102(b).

105. As Thacker notes, the ITU-T J.83b standard was used for cable television and mandated 64- or 256-QAM. ITU-T J.83 (Ex. 1009) at 10, 20–21 (“The design of the modulation, interleaving and coding is based upon testing and characterization of cable systems in North America. The modulation is Quadrature Amplitude Modulation with 64-point signal constellation (64-QAM) and with a 256-point signal constellation (256-QAM), transmitter selectable.”); Thacker (Ex. 1008) at 1:50–58 (“The 802.14 specification supports the International Telecommunications Union’s (ITU) J.83 Annex A, B and C standards for 64/256 QAM modulation ... Annex B is the North American standard supported by MCNS ...”).

G. Applicant Admitted Prior Art (“AAPA”)

106. The ’835 patent contains the following applicant admitted prior art:

The cable modem receivers, transmitters, and transceivers of the present invention may be implemented using a variety of well known devices. In embodiments, these receivers, transmitters, and/or transceivers may be implemented by a BCM3415 CMOS Digital Cable Tuner, a BCM3125 QAMLink™ Universal Set-Top Box Transmission Solution, a BCM3120-Set-Top Box Transceiver, a BCM3116-QAMLink™ 64/256-QAM ITU-B Receiver, a BCM3118B-QAMLink™ 64/256-QAM DVB/DAVIC Receiver, a BCM3115-QAMLink™ 64/256-QAM Dual-Channel Receiver, a BCM3037-QAMLink™ QPSK/16-QAM Burst Modulator, a BCM3033-QAMLink™ Universal Modulator, a BCM3137-QAMLink™ QPSK/16-QAM Burst Demodulator, a BCM3360 QAMLink™ Single-Chip MCNS/DOCSIS Cable Modem, a BCM93310 DOCSIS External Cable Modem, a BCM93310i DOCSIS Internal PCI Cable Modem, and/or a BCM3300-

QAMLink™ SingleChip MCNS/DOCSIS Cable Modem,
manufactured by Broadcom™ Corporation.

'835 patent (Ex. 1001) at 40:17–35.

107. I understand that disclosures in a patent such as the foregoing may be used in *Inter Partes* Review proceedings when they evidence the general knowledge possessed by a POSITA, and, at least when used in conjunction with one or more prior art patents or publications, such disclosures can support an obviousness argument.

108. The foregoing AAPA demonstrates evidence that a POSITA would have generally known as of the Priority Date of the Challenged Claims (1) “cable modems” as described by the '835 patent were known, (2) such modems could demodulate QAM signals, and (3) standards-compliant cable modems were known.

XI. COMPARISON OF THE CITED PRIOR ART REFERENCES TO THE CHALLENGED CLAIMS OF THE '835 PATENT

A. Gibson In View Of Schiltz Renders Obvious Claims 1-5

109. As a brief summary of my opinions with respect to Gibson (Ex. 1004) and Schiltz (Ex. 1005), Gibson in view of Schiltz render obvious all of the Challenged Claims (1–5) obvious, under a construction of claim 1 where “cable modem” is not limiting. As explained in Section X.A, at paragraphs 81-85 above, Gibson discloses a quadrature down-conversion circuit for down-converting modulated RF electromagnetic signals to a lower frequency, which comprises a local oscillator, a phase shifter to produce a quadrature-phase oscillator signal, and

two mixers, one of which receives the in-phase local oscillator signal and samples the RF signal at the frequency of the local oscillator signal to output an in-phase down-converted signal on an “I” channel, while the other mixer receives the quadrature-phase oscillator signal and samples the RF signal at the frequency of the local oscillator quadrature-phase signal to output a quadrature-phase down-converted signal on a “Q” channel. Gibson, however, does not disclose details regarding its disclosed mixer 10, 12.

110. As explained in Section X.B, at paragraphs 86-89 above, Schiltz discloses a mixer circuit for use in down-converting RF signals, comprising an RF input, a field effect transistor 76, and a hold capacitor 76. In Section XI.A.1, at paragraphs 112-116 below, I explain that a POSITA would have had reason to combine Gibson with Schiltz, and specifically to incorporate Schiltz’s sample and hold circuit into Gibson’s quadrature down-conversion circuit. In Sections XI.A.2–5, at paragraphs 122–185 below, I explain how this combination renders obvious each and every limitation of Challenged Claims 1–5. Accordingly, it is my opinion that the combination of Gibson and Schiltz renders all of Challenged Claims 1–5 unpatentable.

111. Should the Board determine that “cable modem” in the preamble of claim 1 is limiting, then it is my opinion that Challenged Claims 1–5 are rendered obvious by the combination of Gibson and Schiltz, in further view of one or more

of Goldberg, Thacker, ITU-T J.83b, and the AAPA, as I explain in Section XI.A.1.b, at paragraphs 117–121 below.

1. Motivation to Combine

a. Gibson and Schiltz

112. A POSITA would have been motivated to combine the teachings of Gibson (Ex. 1004) and Schiltz (Ex. 1005). More specifically, A POSITA would have been motivated to use Schiltz’s sample and hold circuit, Ex. 1005, Figures 1 and 5, as a mixer in each of the two branches of Gibson’s receiver, Ex. 1004, Figure 1, items 10, 12.

113. Gibson discloses a first mixer (item 10) that down-converts an electromagnetic signal ($f_c \pm \Delta f$) by mixing it with an in-phase oscillating signal (f_L). Gibson (Ex. 1004) at 2:56–60. Gibson also discloses a second mixer (item 12) that down-converts an electromagnetic signal by mixing it with a quadrature-phase oscillating signal (f_L shifted by 90 degrees). *Id.* at 2:56–60, 65–67 (“Thus in the in-phase channel I the signal is $+\Delta f$ or $-\Delta f$ and in the quadrature channel Q the signal is $+\Delta f - \pi/2$ or $-\Delta f - \pi/2$.”). Gibson, however, does not expressly describe the inner workings of mixers 10 and 12.

114. Schiltz discloses a “sample and hold circuit ... [used] as a mixer” for down-converting an RF electromagnetic signal to a lower frequency. Schiltz (Ex. 1005) at 1:5–10 (“[T]he present invention relates to a high speed sample and hold

circuit and to radios which use such a circuit as a mixer.”), 2:5–9 (“Another advantage is that the present invention provides a radio which uses a sample and hold circuit as a mixer ...”), 3:6–11 (“Radio 10 includes an antenna 12, which provides a first RF signal and an optional antenna 14 which provides a second RF signal. In the preferred embodiment, these RF signals exhibit frequencies in excess of 300 MHz, and quite possibly in excess of 1–7 GHz.”), 10:15–22 (“In summary, the present invention provides an improved radio which uses a sample and hold circuit in various mixing applications, such as down conversion and oscillation signal generation circuits. Due to the use of a sample and hold circuit as a mixer, only a single stage is required to down convert a high frequency RF signal ...”). Like Gibson then, Schiltz teaches the use of a mixer in down-conversion of radio frequency signals, and Schiltz discloses that such a mixer can comprise its “sample and hold circuit.”

115. A POSITA would have recognized the benefits of using a sample and hold circuit, as taught by Schiltz, for each of the mixers in Gibson’s Figure 1. For example, Schiltz discloses that its sample and hold circuit “may be accurately operated at high frequencies,” “may be applied to virtually any frequency RF and IF signals,” and is “preferably implemented as an integrated circuit” within an area less than 0.005 in². Schiltz (Ex. 1005) at 7:46-56, 10:15–48.

116. Additionally, a POSITA would have understood that combining a sample and hold circuit, taught by Schiltz, as the mixers (10, 12) of Gibson's receiver would have yielded only expected, predictable results. This combination would have been (1) the combination of prior art elements according to known methods to yield predictable results, since a POSITA would have understood how to implement a sample and hold circuit, as taught by Schiltz, as the mixers in a quadrature down-conversion receiver, as taught by Gibson; and (2) obvious to try—*i.e.*, Gibson discloses a quadrature down-conversion receiver that uses a “mixer” for down-conversion, and as one of a number of identified, predictable prior art solutions for a mixer, Schiltz discloses a “sample and hold circuit,” which combination a POSITA would have understood to have a reasonable expectation of success.

b. Cable Modem References

117. Should the Board change its previous analysis and determine that “cable modem” in the preamble of claim 1 is limiting, a POSITA would have been motivated to use the down-conversion receiver of Gibson as modified by Schiltz for demodulating signals in a “cable modem,” in view of references that describe cable modems and cable modem applications, and specifically the cable modem references raised here: Goldberg, Thacker, ITU-T J.83b, and AAPA.

118. A POSITA would have understood that the receiver of Gibson (Ex. 1004) as modified by Schiltz (Ex. 1005) is useful for down-converting I/Q modulated electromagnetic signals. Goldberg (Ex. 1007), Thacker (Ex. 1007), and ITU-T J.83b (Ex. 1009) discloses cable data standards that were released before the Priority Date of the Challenged Claims. Each specified the use of I/Q modulation (*e.g.*, QAM) in cable modems. Goldberg (Ex. 1007) at 69–70 (“DOCSIS is designed to employ one or more unused video channels within the 54-to-860 MHz cable broadcast spectrum to transmit IP-based data across hybrid fiber coaxial networks. Complex phase/amplitude modulation enables each 6-MHz down-stream channel to bring data into subscribers’ homes at up to 38 Mbits/s. Depending on the bit-rate selected by the operator, the shared down-stream channel uses either 64- or 256-point quadrature-amplitude modulation (QAM).”); Thacker (Ex. 1008) at 1:30–40 (“Because of the delay in finalizing the IEEE 802.14 standard, certain cable operators, operating under a limited partnership dubbed Multimedia Cable Network System Partners Ltd. (MCNS), proceeded to research and publish their own set of interface specifications for high-speed cable data services. MCNS released its Data Over Cable System Interface Specification (DOCSIS) for cable modem products to vendors in March 1997. ...”), 1:50–62 (“At the physical layer, which defines modulation formats for digital signals, the IEEE and MCNS specifications are similar. The 802.14 specification

supports the International Telecommunications Union's (ITU) J.83 Annex A, B and C standards for 64/256 QAM modulation, providing a maximum 36 Mbps of downstream throughput per 6 MHz television channel. ... Annex B is the North America standard supported by MCNS"); ITU-T J.83 (Ex. 1009) at 10, Table 1 (showing Annex B Modulation as "64- or 256-QAM"). These cable modem standards provided an incentive for a POSITA to use I/Q modulation down-converters such as those taught by the Gibson as part of "cable modems." *See, e.g.,* Goldberg (Ex. 1007) at 69 ("MCNS/DOCSIS MAC Paves The Way For A Cable-Modem Invasion"), 80 ("Broadcom's first silicon implementation of the DOCSIS standard will surely give rise to a first generation of low-cost, interoperable cable modems.").

119. Additionally, the AAPA shows that QAM cable modems had been implemented in a "variety of well known devices," including QAM and QPSK cable modems by Broadcom. '835 patent (Ex. 1001) at 40:17–35 (listing devices by Broadcom also discussed in Goldberg). The AAPA demonstrates that making and using "cable modems" would have been known to a POSITA. As a result, a POSITA would have had further reason to use the receiver of Gibson, as modified in view of Schiltz's teachings, in "cable modem" applications, as taught by the '835 patent, including a non-interactive cable set-top box.

120. Further, from my review of the '835 patent's prosecution history, neither the Patent Owner nor the Examiner placed any importance on the use of "cable modem" in the preamble of Challenged Claim 1, and the body of the claim recites a structurally-complete device capable of being used as a "cable modem" in the context of the '835 patent. The '835 patent's written description discloses a variety of cable modem environments, including wired and wireless cable modems, and interactive and non-interactive cable set top boxes. '835 patent at 36:50–38:34. The patent further discloses that a "cable modem" can be compliant with DOCSIS or not compliant with any standard. *Id.* at 38:28–34 ("DOCSIS is a Cable Modem Standard that stands for Data Over Cable Service Interface Specification (DOCSIS), and defines the interface requirements for cable modems involved in high-speed data transmission over cable television networks. The present invention is not limited to this standard but to additional standards, and non-standard configurations."). Accordingly, it is my opinion that for purposes of the '835 patent, a "cable modem" is a device that includes communication at RF frequencies over cable, whether wired or wireless, and this includes communication of data for television.

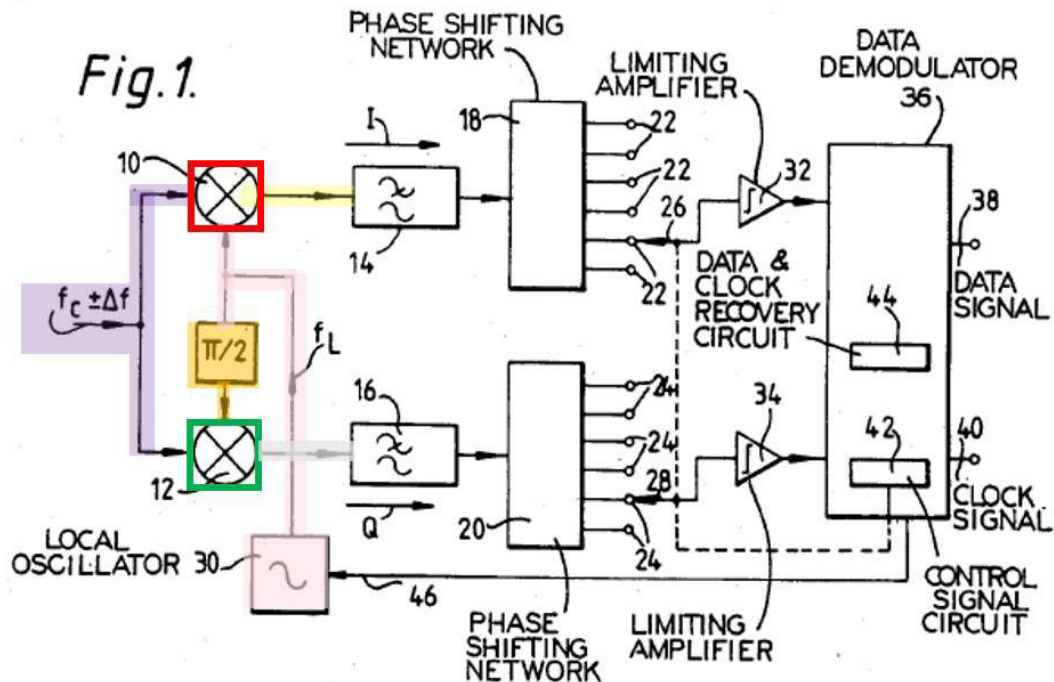
121. In view of the foregoing and for the reasons set forth in Section XI.A.2–5, at paragraphs 122-185 below, it is my opinion that the receiver of Gibson, as modified by Schiltz, has the structure recited in Challenged Claims 1–5,

and that a POSITA would have been motivated use that structure as a “cable modem” in the context of the ’835 patent, in view of Goldberg (Ex. 1007), Thacker (Ex. 1009), ITU-T J.83 (Ex. 1009), and the AAPA. Using Gibson as modified by Schiltz as a “cable modem” in the context of the ’835 patent would have yielded only expected, predictable results. For example, in view of Goldberg, Thacker, and the AAPA, this combination would have been (1) a combination of prior art elements according to known methods to yield predictable results; (2) the use of known work in one field (RF down-conversion) to prompt a variation for use in a related field (cable data communications) in view of market incentives (e.g., DOCSIS); and (3) obvious to try, with a reasonable expectation of success.

2. *Independent Claim 1*

- a. [1Pre] A cable modem for down-converting an electromagnetic signal having complex modulations, comprising:*

122. Gibson (Ex. 1004) discloses a receiver for down-converting an electromagnetic signal have complex modulations. This is shown in Figure 1 of Gibson, which has been annotated below. *See also* Gibson at 1:9 (“The present invention relates to a data receiver.”), 1:35–40 (“According to the present invention there is provided a data receiver including quadrature mixers”), 2:44–46 (“FIG. 1 is a block schematic circuit of an embodiment of a data receiver made in accordance with the present invention.”), 2:56–3:17.



123. The receiver receives and down-converts a modulated input electromagnetic signal (annotated purple). Gibson at 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30.”). The received modulated carrier signal is described, for example, as a 4 MHz signal, and is downconverted to a signal of 4 kHz. *Id.* at 2:56–62 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30. The outputs of the mixers 10, 12 are filtered in low pass filters 14, 16 which will pass the modulation frequency Δf .”), 2:66–3:2 (“By way of example f_c may be 900

MHz and the deviation frequency Δf would be a quarter of the bit rate, e.g. for a bit rate of 16 Kb/s Δf is kHz.”).

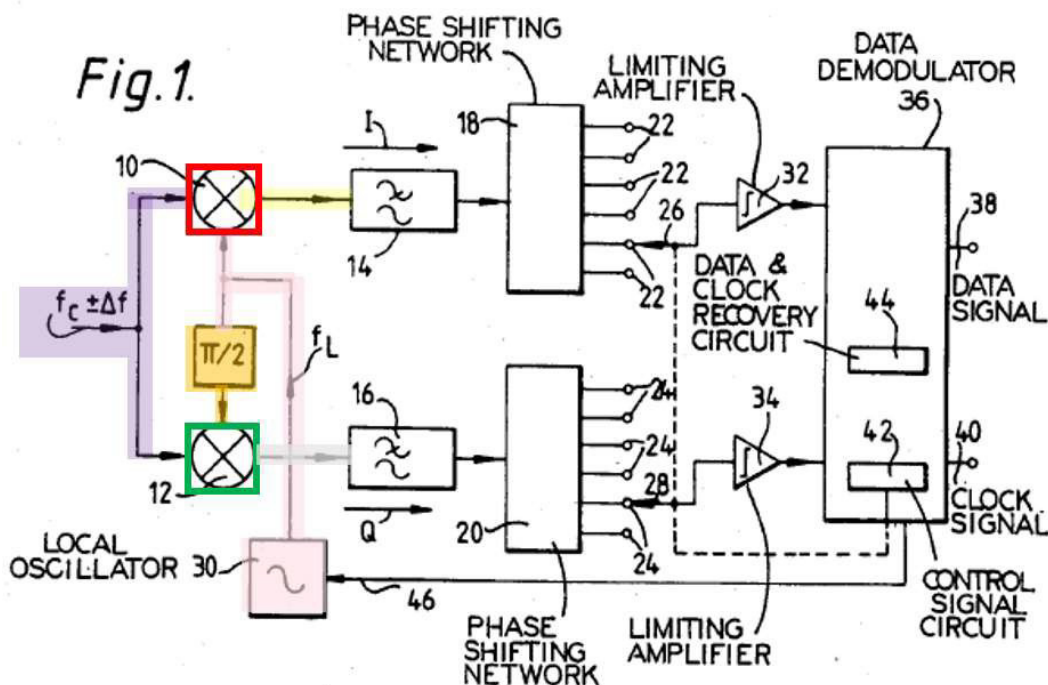
124. To the extent that “complex modulations” in the preamble is limiting, Gibson teaches that its receiver works with I/Q modulation formats, which were complex modulation formats within the general knowledge of a POSITA at the time of the alleged invention. *See* Gibson at Fig. 1, 2:55–3:21. In I/Q modulation formats, two data streams are upconverted (multiplied with a local oscillator signal at a carrier frequency) and then summed for transmission. In that process, one stream is applied to a “I” channel, while the other is applied to a “Q” channel. The “Q” channel local oscillator signal is phase shifted by 90° during the upconversion process before being summed with the upconverted signal on the I channel. Upon being summed, the signal has both an I component and a Q component. Gibson’s receiver effectively performs the reverse of this upconversion process, and so a POSITA would understand Gibson’s receiver could be used to down-convert I/Q modulated signals.

125. Further, as explained in Section XI.A.1.b, at paragraphs 117-121 above, should the Board change its previous analysis and determine that “cable modem” in the preamble of claim 1 is limiting, a POSITA would have been motivated to use the receiver of Gibson as modified by Schiltz as a “cable modem,” as that term is understood in the context of the ’835 patent, in view of

one or more of Goldberg (Ex. 1007), Thacker (Ex. 1008), ITU-T J.83 (Ex. 1009), and the AAPA, prior art references that disclose cable modems and cable modem applications.

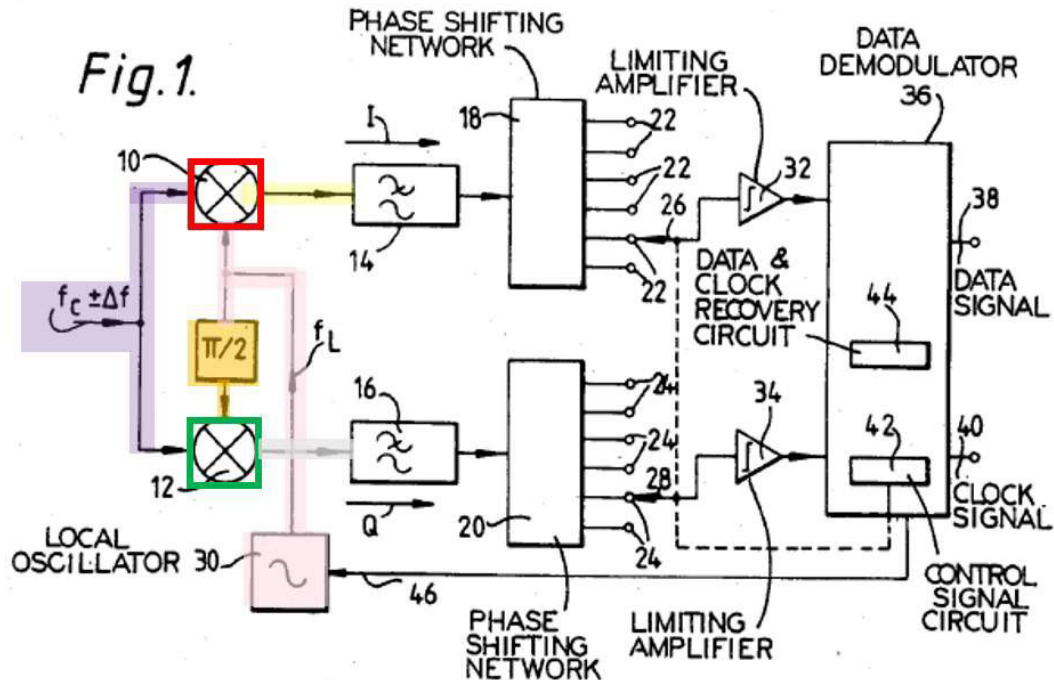
b. [1A] an oscillator to generate an in-phase oscillating signal;

126. Gibson (Ex. 1004) discloses an oscillator (Local Oscillator 30 in Figure 1 below) (annotated pink) to generate an in-phase oscillating signal (f_L) (also annotated pink). Gibson at 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30. ... ”)



- c. *[1B] a phase shifter to receive said in-phase oscillating signal and to create a quadrature-phase oscillating signal;*

127. Gibson (Ex. 1004) discloses a phase shifter ($\pi/2$ in Figure 1 below) (annotated orange) to receive said in phase oscillating signal (f_L) (annotated pink) and to create a quadrature-phase oscillating signal ($\pi/2$ signal to mixer 12) (also annotated orange below). *See also* Gibson at 1:35–36 (“According to the present invention there is provided a data receiver including quadrature mixers ...”), 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30.”), 2:65–67 (“Thus in the in-phase channel I the signal is $+\Delta f$ or $-\Delta f$ and in the quadrature channel Q the signal is $+\Delta f - \pi/2$ or $-\Delta f - \pi/2$.”), 6:12–17 (“A data receiver as claimed in claim 2, comprising local oscillator means for generating quadrature outputs independent of the signals propagating in said signal paths and individually supplying such quadrature outputs to said quadrature mixers for mixing therein with the incoming signals ...”).

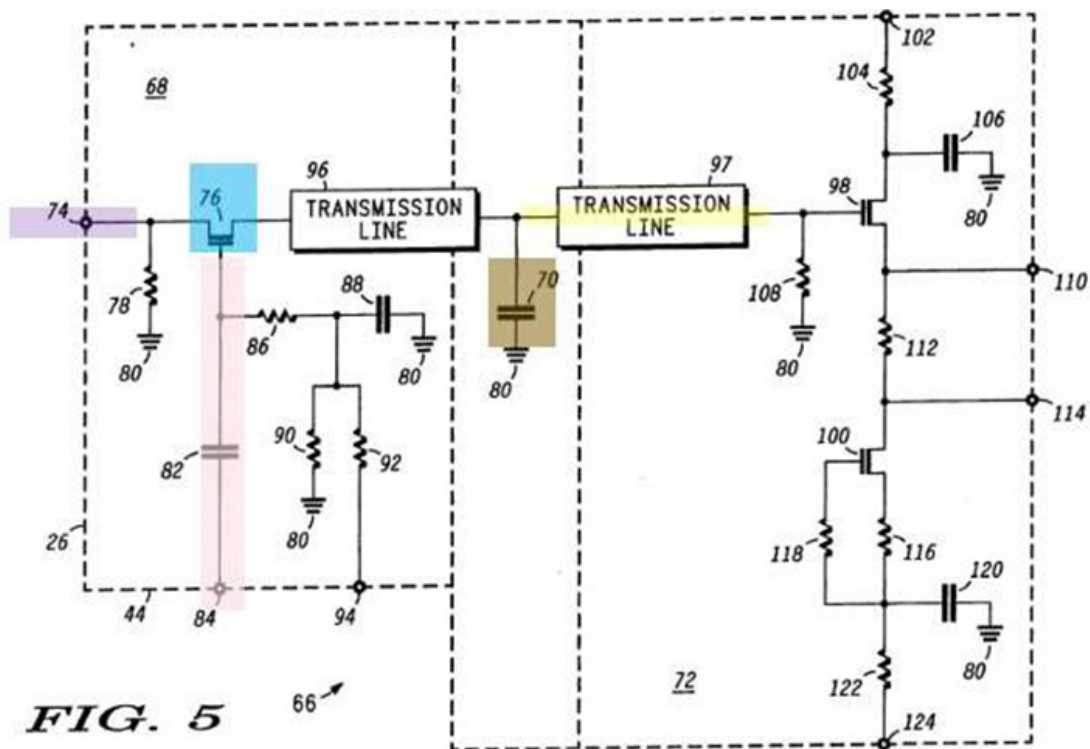


- d. [1C] a first frequency down-conversion module to receive the electromagnetic signal and said in-phase oscillating signal;

128. Gibson (Ex. 1004) discloses a first frequency down-conversion module (mixer 10 in Figure 1 below) (annotated red) to receive the electromagnetic signal (“ $f_c \pm \Delta f$ ”) (annotated purple) and said in-phase oscillating signal (f_L) (annotated pink). *See also* Gibson at 1:35–36 (“According to the present invention there is provided a data receiver including quadrature mixers ...”), 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30.”).

capacitor, and a buffer amplifier 72. ... FET 76 performs the above-discussed sampling of the RF signal.”), 8:21–29 (“A drain of FET 76 serves as the output of sample switch 68. The schematic diagram of FIG. 5 shows a transmission line 96, which couples sample switch 68 to a first node of hold capacitor 70. The schematic diagram of FIG. 5 also shows a transmission line 97, which couples the first node of hold capacitor 70 and sample switch 68 to an input of buffer amplifier 72. A second node of hold capacitor 70 couples to ground terminal 80.”), 10:15–18 (“In summary, the present invention provides an improved radio which uses a sample and hold circuit in various mixing applications, such as down conversion and oscillation signal generation circuits.”), 10:29–31 (“Due to the accurate high frequency operation, a high bandwidth results when the sample and hold circuit is used as a mixer.”), 10:40–45 (“[T]hose skilled in the art will appreciate that radio and other architectures other than those described herein may utilize a sample and hold circuit as a mixer.”).

130. Figure 5 depicts Schiltz’s sample and hold circuit and is shown, as annotated, below. Schiltz discloses that the circuit contains a switch 68, comprised of a field effect transistor 76 (annotated blue), a control input for the FET 76 (annotated pink), and a “hold capacitor 70” (annotated brown).



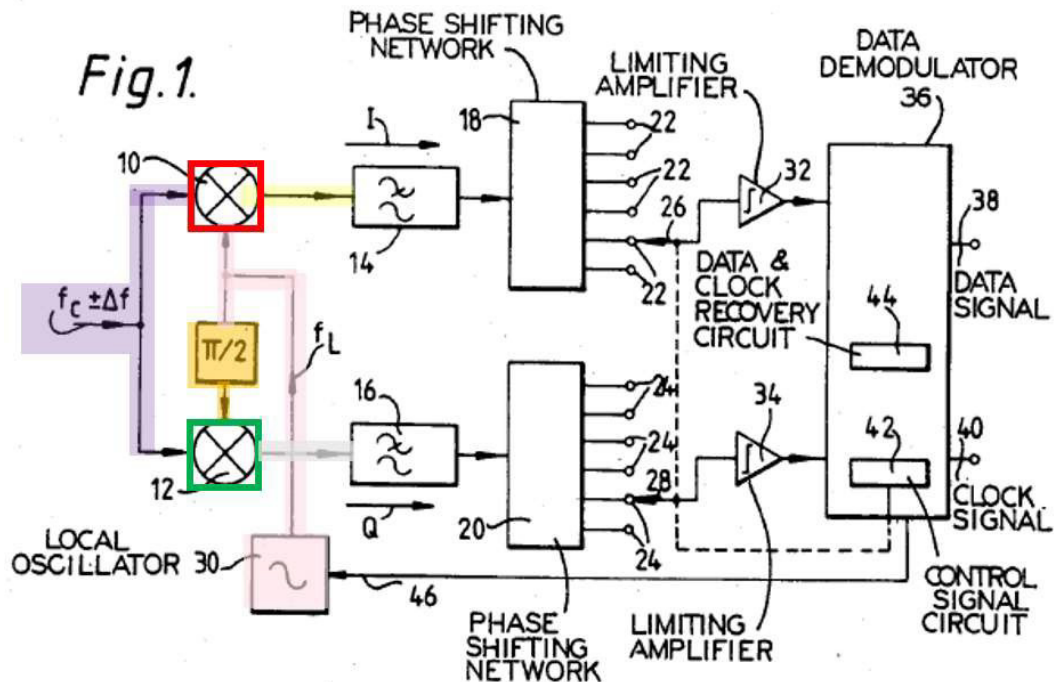
131. Schiltz's frequency down-conversion module (high speed sample and hold circuit) receives an electromagnetic signal and an in-phase oscillating signal. As Schiltz discloses, "an RF signal [annotated purple] is applied to sample and hold circuit 26 at contact 74." Schiltz at 7:61–62. Contact 74 is then coupled to a source input of field effect transistor 76 (annotated blue). *Id.* at 7:62–64. "Contact 84 serves as the control input for sample and hold circuit 26. In other words, the stream of sampling pulses is applied to sample and hold circuit 26 at contact 84." *Id.* at 8:5–7; *see also id.*, FIG. 1 (depicting pulse generator 30), 3:67–4:18. FET 76 thus operates as a switch and samples the incoming signal according to the control input applied at control 84 (annotated pink). *Id.* at 7:64–65, 8:3–8. The "drain of FET 76 serves as the output of sample switch 68," is coupled to a

first node of “hold capacitor 70” (annotated brown), and outputs a sampled signal (annotated yellow). *Id.* at 8:20–24.

132. As I have explained in Section XI.A.1.a, at paragraphs 112–116 above, a POSITA would have been motivated to combine Schiltz’s high speed sample and hold circuit with Gibson’s receiver, and thus would have found that Gibson in view of Schiltz renders obvious element [1C].

e. [1D] a second frequency down-conversion module to receive the electromagnetic signal and said quadrature-phase oscillating signal; wherein

133. Gibson (Ex. 1004) discloses a second frequency down-conversion module (mixer 12 in Figure 1 below) (annotated green) to receive the electromagnetic signal (“ $f_c \pm \Delta f$ ”) (annotated purple) and said quadrature-phase oscillating signal (annotated orange). *See also* Gibson at 1:35–36 (“According to the present invention there is provided a data receiver including quadrature mixers ...”), 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30.”), 2:65–67 (“Thus in the in-phase channel I the signal is $+\Delta f$ or $-\Delta f$ and in the quadrature channel Q the signal is $+\Delta f - \pi/2$ or $-\Delta f - \pi/2$.”).



134. To the extent it is argued or determined that Gibson does not disclose element [1D], then a POSITA would have found element [1D] rendered obvious by the combination of Gibson and Schiltz. More specifically, for the reasons I explained with respect to element [1C], in Section XI.A.2.d, at paragraphs 128–132 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit in place of Gibson’s mixer 12.

f. [1E] said first frequency down-conversion module further comprises a first frequency translation module

135. For the reasons discussed above, Gibson discloses a first frequency down-conversion module (mixer 10), but does not expressly disclose whether mixer 10 comprises a switch (if it is determined that a “frequency translation module” requires one). As discussed above with respect to elements [1C] and

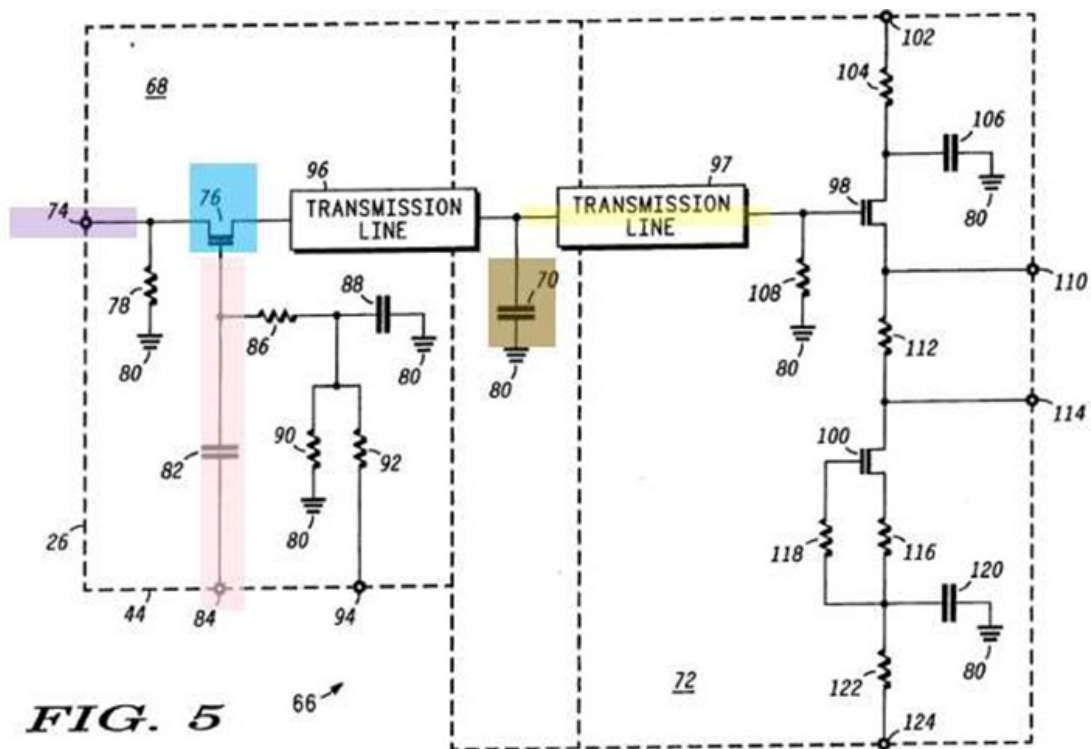
136. To the extent it is argued or determined that Gibson does not disclose element [1E], then a POSITA would have found element [1E] rendered obvious by the combination of Gibson and Schiltz. More specifically, for the reasons I



explained with respect to element [1C], Section XI.A.2.d, at paragraphs 128–132 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “frequency translation module” (FET 76), in place of Gibson’s mixer 12.

g. [1F] and a first storage module,

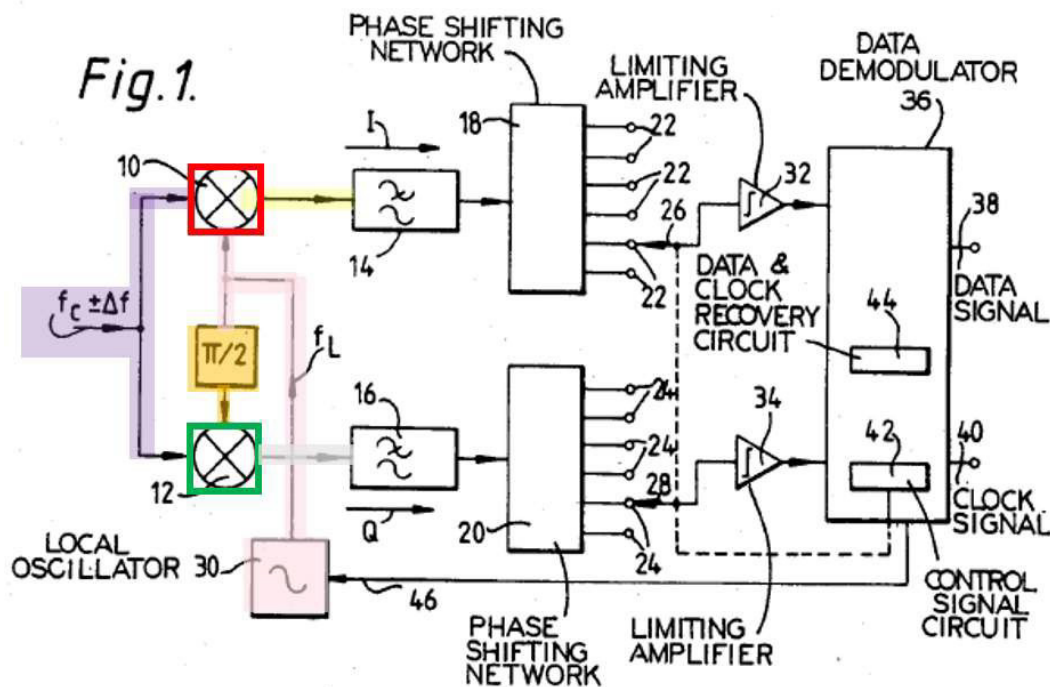
137. For the reasons discussed above, Gibson discloses a first frequency down-conversion module (mixer 10), but does not expressly disclose whether mixer 10 comprises a “storage module.” As discussed above with respect to elements [1C] and [1D], in Sections XI.A.2.d and XI.A.2.e, at paragraphs 128–134 above, Schiltz discloses a mixer (high speed sample and hold circuit) comprising a switch (FET 76) (annotated blue in Schiltz, Figure 5 below), which is coupled to a storage module (capacitor 70) (annotated brown).



138. To the extent it is argued or determined that Gibson does not disclose element [1F], then a POSITA would have found element [1F] rendered obvious by the combination of Gibson and Schiltz. More specifically, for the reasons I explained with respect to element [1C], in Section XI.A.2.d, at paragraphs 128–132 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” (capacitor 70), in place of Gibson’s mixer 12.

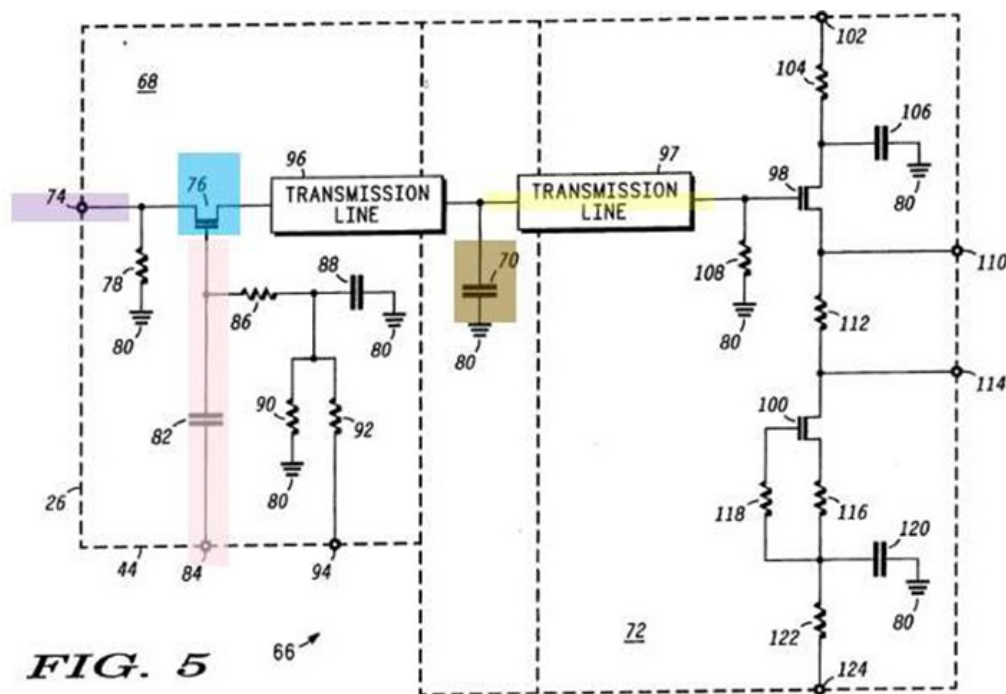
h. [1G] wherein said first frequency translation module samples the electromagnetic signal at a rate that is a function of said in-phase oscillating signal, thereby creating a first sampled signal; and

139. Gibson (Ex. 1001) discloses that the first frequency down-conversion module (mixer 10) mixes the electromagnetic signal (annotated purple in Figure 1 below) with the in-phase oscillating signal (annotated pink below).



140. Gibson does not expressly disclose sampling. As explained in Section X.B, at paragraphs 86–89, Schiltz discloses a mixer (high speed sample and hold circuit) that comprises a FET coupled to a capacitor that samples an RF input signal under the control of an impulse generator. As seen in Figures 1 and 5 of Schiltz, the mixer uses an “input oscillating signal” (annotated pink in Schiltz, Figure 5 below) in order to generate a stream of oscillating sampling pulses to

control switch (FET 76) (annotated blue below), which, in conjunction with “hold capacitor 70,” down-converts the incoming RF signal (annotated purple below) to create a first sampled signal (annotated yellow below). *See also* Schiltz at 7:64–65 (“FET 76 performs the above-discussed sampling of the RF signal.”), 8:21–26 (“A drain of FET 76 serves as the output of sample 68. The schematic diagram of FIG. 5 shows a transmission line 96, which couples sample switch 68 to a first node of hold capacitor 70. The schematic diagram of FIG. 5 also shows transmission line 97, which couples the first node of hold capacitor 70 and sample switch 68 to an input of buffer amplifier 72.”).



141. A POSITA would have found element [1G] rendered obvious by the combination of Gibson and Schiltz. More specifically, as explained in Section

XI.A.1.a and with respect to elements [1C]–[1E], in Sections XI.B.2.d–XI.B.2.f, at paragraphs 112–116 and 128–136 above, a POSITA would have found it obvious to use the mixer of Schiltz (high speed sample and hold circuit) in place of Gibson’s mixer 10.

- i. [1H] said second frequency down-conversion module further comprises a second frequency translation module*

142. A POSITA would have understood that the first and second mixers of Gibson (mixers 10, 12) are structurally identical. *See* Gibson (Ex. 1001) at Fig. 1, 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm Af$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30.”).

143. Accordingly, as explained with respect to element [1E], in Section XI.B.2.f, at paragraphs 135–136 above, to the extent it is argued or determined that Gibson does not disclose element [1H], a POSITA would have found element [1H] rendered obvious by the combination of Gibson in view of Schiltz (Ex. 1005).

144. Gibson discloses a first frequency down-conversion module (mixer 10), but does not expressly disclose whether mixer 10 comprises a switch (if it is determined that a “frequency translation module” requires one). Schiltz discloses a mixer (high speed sample and hold circuit) comprising a switch (FET 76) (annotated blue in Schiltz, Figure 5 below), which is coupled to a storage module

(capacitor 70) (annotated brown), to create a sampled signal (annotated gray). For the reasons I explained with respect to limitation [1C], in Section XI.A.2.d, at paragraphs 128–132 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “frequency translation module” (FET 76), in place of Gibson’s mixer 12.

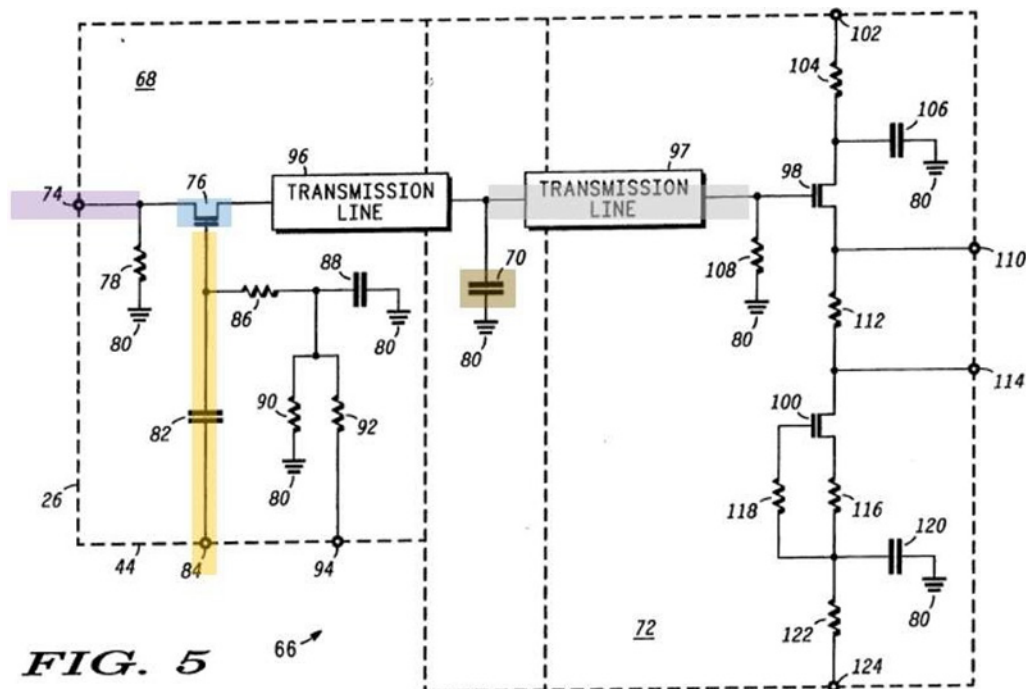


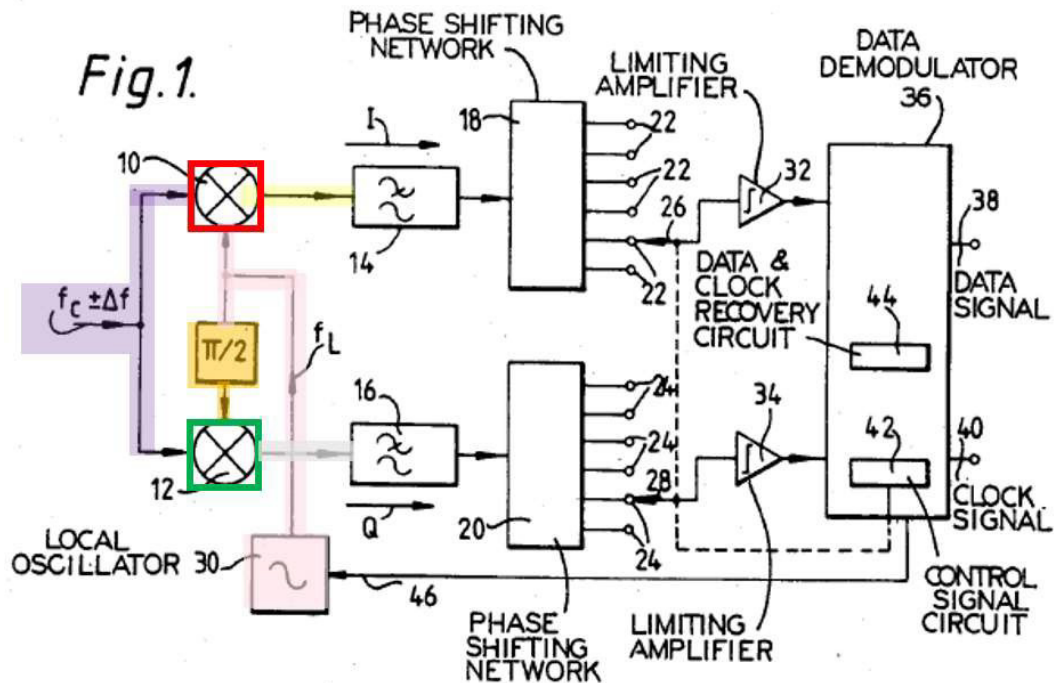
FIG. 5

j. [11] and a second storage module,

145. As explained with respect to element [1F], in Section XI.B.2.g, at paragraphs 137–138, a POSITA would have found element [11] rendered obvious by the combination of Gibson (Ex. 1004) and Schiltz (Ex. 1005). A POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” (capacitor 70), in place of Gibson’s mixer 12.

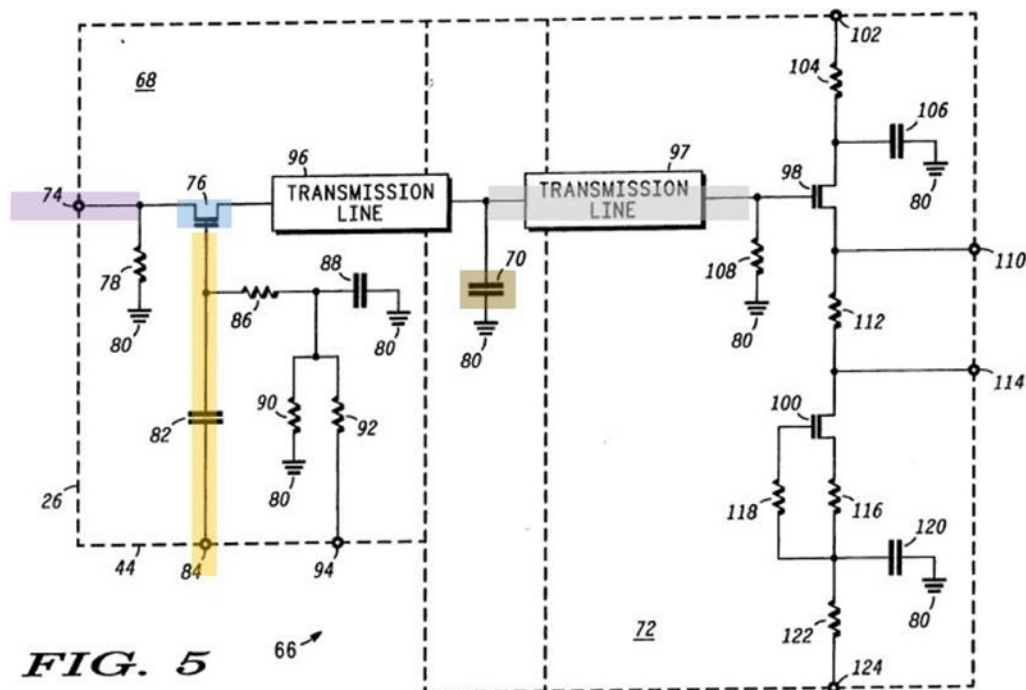
k. [1J] wherein said second frequency translation module samples the electromagnetic signal at a rate that is a function of said quadrature-phase oscillating signal, thereby creating a second sampled signal

146. Gibson (Ex. 1001) discloses that the second frequency down-conversion module (mixer 12) mixes the electromagnetic signal (annotated purple in Figure 1 below) with the quadrature-phase oscillating signal (annotated pink below).



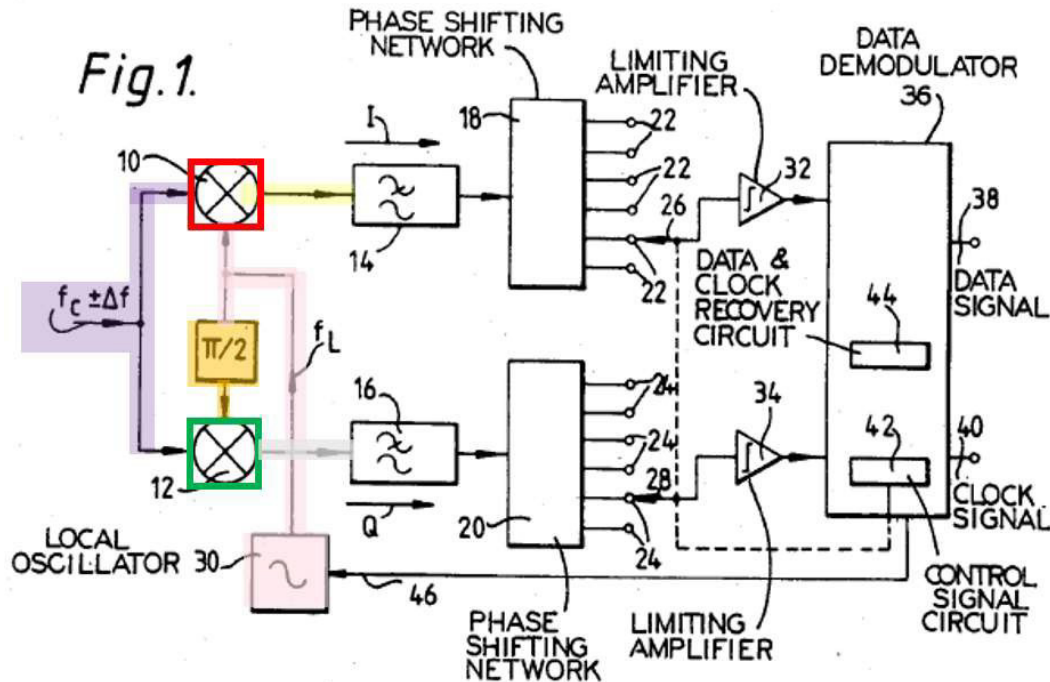
147. Gibson does not expressly disclose sampling. As explained in Section X.B, at paragraphs 86–89, Schiltz discloses a mixer (high speed sample and hold circuit) that comprises a FET coupled to a capacitor that samples an RF input signal under the control of an impulse generator. As seen in Figures 1 and 5 of Schiltz, the mixer uses an “input oscillating signal” (annotated orange in Schiltz,

Figure 5 below) in order to generate a stream of oscillating sampling pulses to control switch (FET 76) (annotated blue below), which, in conjunction with “hold capacitor 70,” down-converts the incoming RF signal (annotated purple below) to create a sampled signal (annotated gray below). *See also* Schiltz at 7:64–65 (“FET 76 performs the above-discussed sampling of the RF signal.”), 8:21–26 (“A drain of FET 76 serves as the output of sample 68. The schematic diagram of FIG. 5 shows a transmission line 96, which couples sample switch 68 to a first node of hold capacitor 70. The schematic diagram of FIG. 5 also shows transmission line 97, which couples the first node of hold capacitor 70 and sample switch 68 to an input of buffer amplifier 72.”).



148. A POSITA would have found element [1J] rendered obvious by the combination of Gibson and Schiltz. More specifically, as explained in Section

XI.A.1.a and with respect to elements [1C]–[1E], in Sections XI.B.2.d–XI.B.2.f, at paragraphs 112–116 and 128–136 above, a POSITA would have found it obvious to use the mixer of Schiltz (high speed sample and hold circuit) in place of Gibson’s mixer 12. In doing so, a POSITA would have understood that Gibson’s quadrature-phase oscillating signal would have been applied at contact 84 of Schiltz’s mixer to control FET 76 (switch), and thus would have understood that Schiltz’s mixer (second frequency down-conversion module) would sample the electromagnetic signal at a rate that is a function of said quadrature-phase oscillating signal (Gibson’s quadrature-phase oscillating signal), thereby creating a second sampled signal, annotated gray in Figure 1 from Gibson below.



3. *Claim 2*

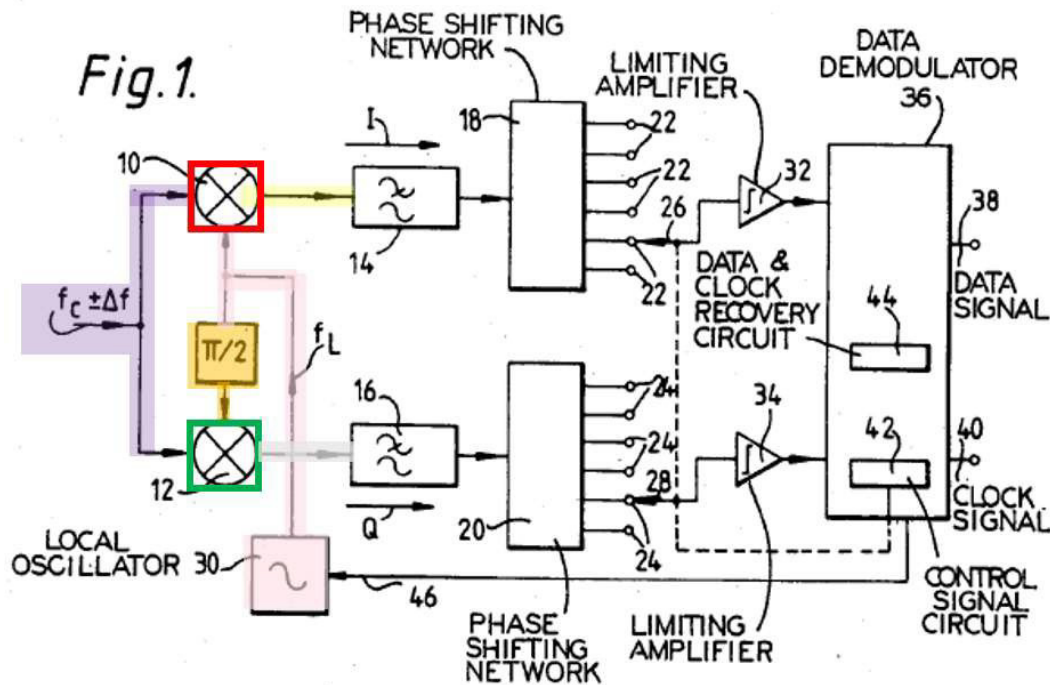
- a. *The cable modem of claim 1, wherein said quadrature-phase oscillating signal is out of phase with said in-phase oscillating signal by substantially 90 degrees.*

149. Gibson (Ex. 1004) in view of Schiltz (Ex. 1006) renders obvious the “cable modem of claim 1” for reasons I explained with respect to claim 1, in Section XI.A.2, at paragraphs 122–148 above.

150. Gibson further discloses “wherein said quadrature-phase oscillating signal is out of phase with said in-phase oscillating signal by substantially 90 degrees,” and therefore Gibson in view of Schiltz renders obvious claim 2.

151. Gibson discloses a phase shifter ($\pi/2$ in Figure 1 below) (annotated orange) to receive said in phase oscillating signal (f_L) (annotated pink) and to create a quadrature-phase oscillating signal ($\pi/2$ signal to mixer 12) (also annotated orange below). *See also* Gibson at 1:35–36 (“According to the present invention there is provided a data receiver including quadrature mixers ...”), 2:56–60 (“Referring to FIG. 1, a signal, which may be a frequency modulated, differentially encoded input signal $f_c \pm \Delta f$, is applied to quadrature mixers 10, 12 to which a frequency f_L , substantially equal to carrier frequency f_c , is applied from a local oscillator 30.”), 2:65–67 (“Thus in the in-phase channel I the signal is $+\Delta f$ or $-\Delta f$ and in the quadrature channel Q the signal is $+\Delta f - \pi/2$ or $-\Delta f - \pi/2$.”), 6:12–17 (“A data receiver as claimed in claim 2, comprising local oscillator means for

generating quadrature outputs independent of the signals propagating in said signal paths and individually supplying such quadrature outputs to said quadrature mixers for mixing therein with the incoming signals”).



152. A POSITA would have recognized that the quadrature-phase oscillating signal (annotated orange above) is out of phase with the in-phase oscillating signal (annotated pink above) by substantially 90 degrees, at least because “ $\pi/2$ ” is the radian representation of, and therefore at least equivalent to, 90 degrees.

4. Claim 3

a. [3Pre]: The cable modem of claim 1,

153. Gibson (Ex. 1004) in view Schiltz (Ex. 1005) renders obvious the preamble of claim 3 for the reasons I explained with respect to claim 1, in paragraphs 122–148 above.

b. [3A] wherein said first storage device has a first storage first port and a first storage second port,

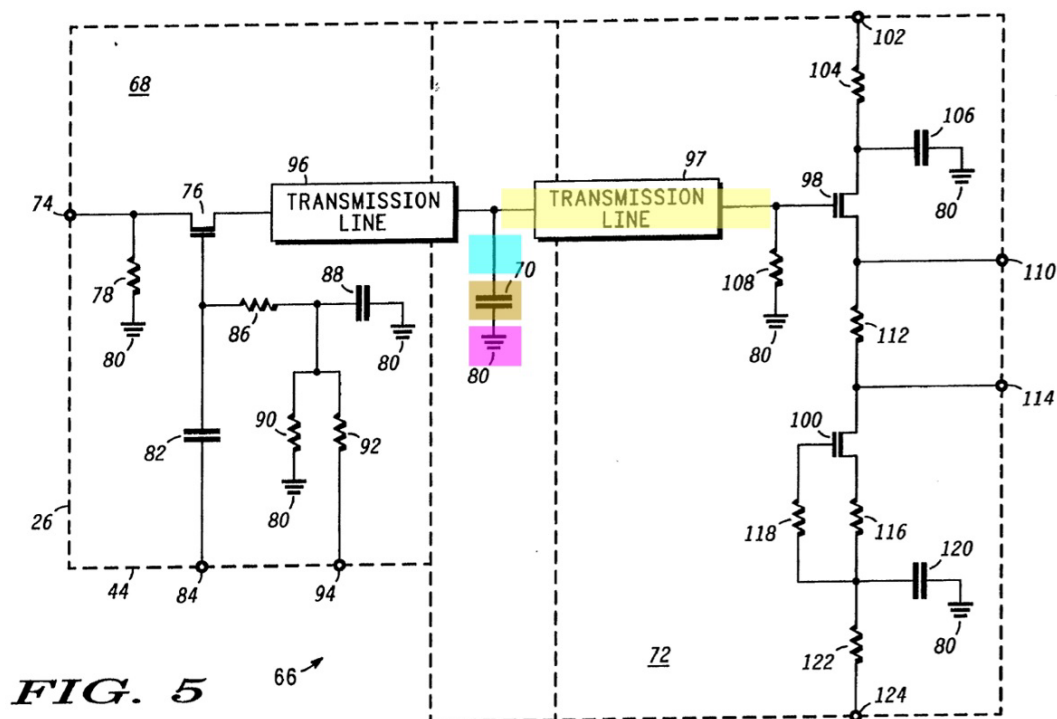
154. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious element [3A].

155. Element [3A] recites a “said first storage device” that has a first storage first port and a first storage second port. Claim 1 does not provide any antecedent basis for “said first storage device,” i.e., it does not recite “first storage device.” That said, a POSITA would have understood “said first storage device” to refer to the “first storage module” recited in Claim 1.

156. As explained with respect to element [1F], in Section XI.A.1.g, at paragraphs 137–138 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” (capacitor 70), in place of Gibson’s mixer 12. Schiltz thus discloses a “first storage module” / “said first storage device.”

157. Schiltz’s capacitor 70 (annotated brown in Schiltz, Figure 5 below) includes a “first storage first port” in the form of the top electrical connection

(annotated cyan below), which couples capacitor 70 to first transmission line 96 and second transmission line 97. Schiltz at 8:20–26 (“A drain of FET 76 serves as the output of sample switch 68. The schematic diagram of FIG. 5 shows a transmission line 96, which couples sample switch 68 to a first node of hold capacitor 70. The schematic diagram of FIG. 5 also shows a transmission line 97, which couples the first node of hold capacitor 70 and sample switch 68 to an input of buffer amplifier 72.”).



158. The capacitor 70 also includes a “first storage second port” in the form of the bottom electrical connection, which is coupled to ground terminal 80 (annotated magenta above). Schiltz at 8:26–28 (“A second node of hold capacitor 70 couples to ground terminal 80.”).

c. [3B] said first storage first port being connected to said first sampled signal,

159. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious element [3B].

160. As explained with respect to element [1G], in Section XI.A.2.h, at paragraphs 139–141 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” (capacitor 70), in place of Gibson’s mixer 12. As further explained with respect to element [1G], at paragraphs 139–141 above, Gibson as modified by Schiltz would have included a “first sampled signal” along transmission line 97 (annotated yellow in Figure 5 of Schiltz below). Schiltz demonstrates in Figure 5 that the top electrical connection (“first storage first port”) (annotated cyan below) of capacitor 70 (“first storage module” / “said first storage device”) (annotated brown below) is “connected” to transmission line 97 (“first sampled signal”) (annotated yellow below).

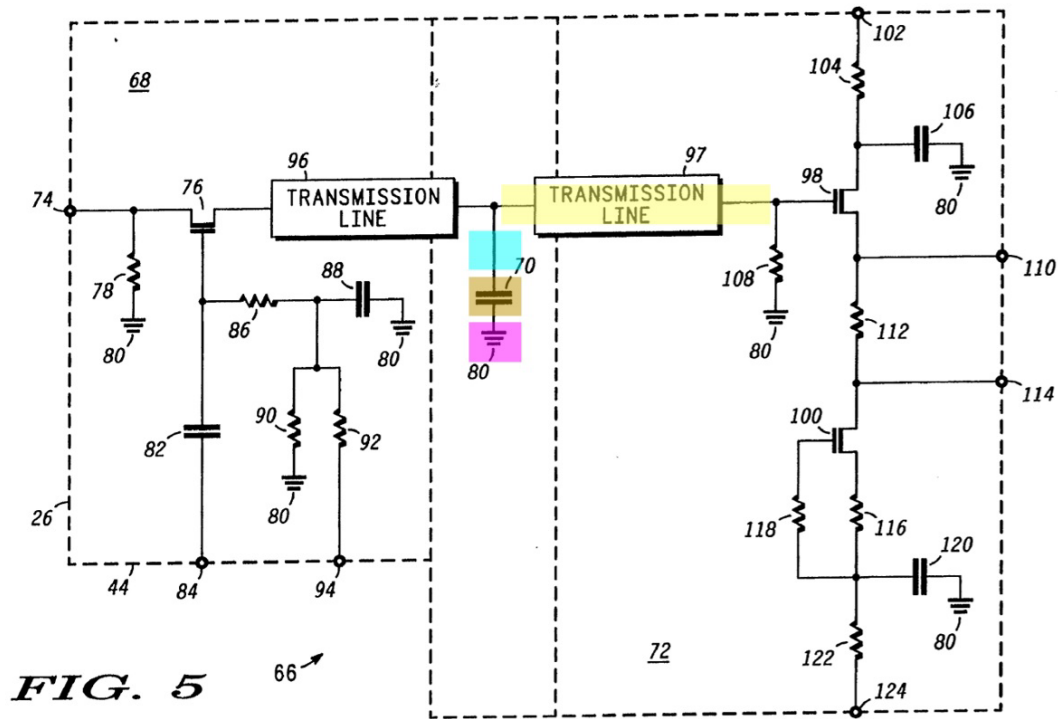


FIG. 5

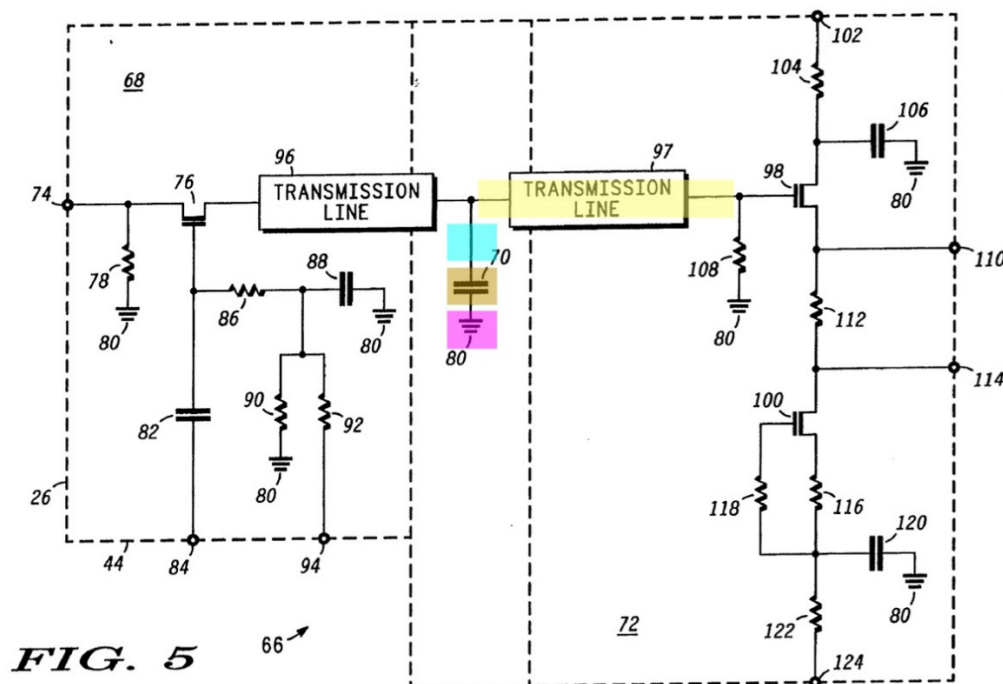
d. [3C] and said first storage second port is connected to a first reference potential,

161. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious element [3C].

162. As explained with respect to element [1F] and [3A], in Sections XI.A.2.g and XI.A.4.b, at paragraphs 137–138 and 154–158 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” / “first storage device” (capacitor 70), in place of Gibson’s mixer 12.

163. Schiltz discloses that the bottom electrical connection of capacitor 70 (“first storage second port”) (annotated magenta in Schiltz, Figure 5 below) is

connected to ground terminal 80. Schiltz at 8:26–28 (“A second node of hold capacitor 70 couples to ground terminal 80.”).



164. A POSITA would have understood that ground terminal 80 is a common type of reference potential in electrical circuits, and is used as a reference potential in Schiltz’s high speed sample and hold circuit 26. Schiltz at 7:65–68 (“A matching resistor 78, preferably around fifty ohms, couples between contact 76 and a ground terminal 80, which is adapted to receive a common potential.”). A POSITA would therefore have understood that Schiltz discloses a “first storage second port connected to a first reference potential,” and thus would have found element [3C] rendered obvious by the combination of Gibson and Schiltz.

e. [3D] and said second storage device has a second storage first port and a second storage second port,

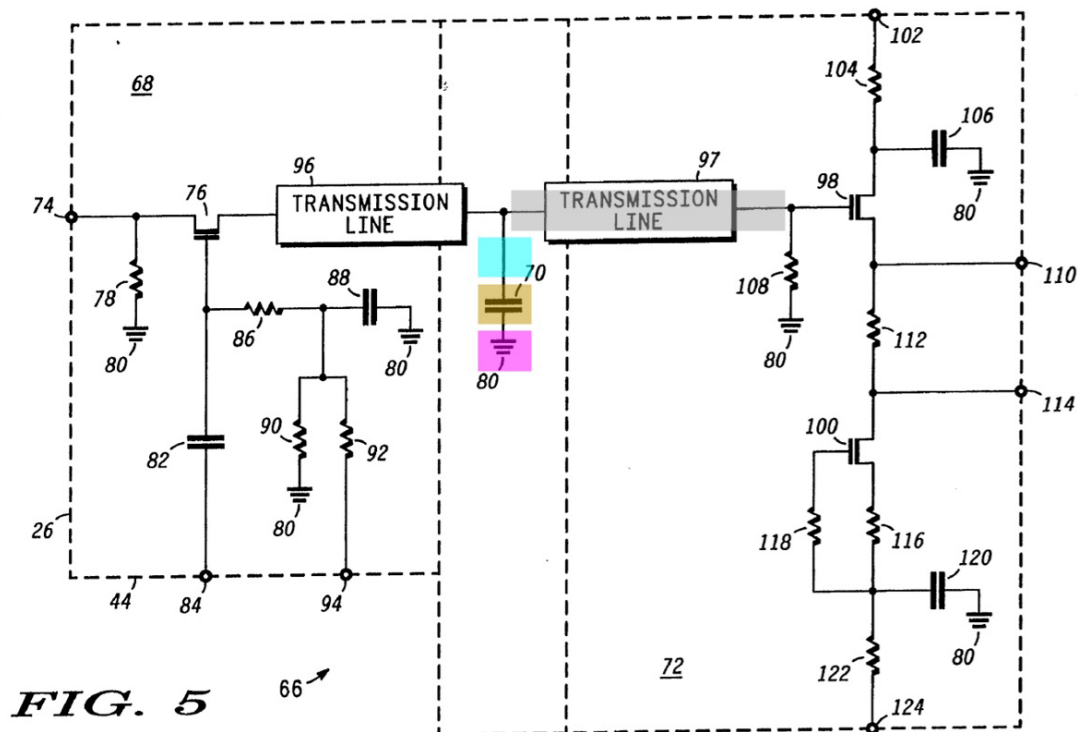
165. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious element [3D].

166. As with element [3A], in Section XI.A.4.b, at paragraph 155, element [3D] recites a “said second storage device” that has a second storage first port and a second storage second port. Claim 1, however, does not provide any antecedent basis for “said second storage device,” i.e., it does not recite “second storage device.” That said, a POSITA would have understood “said second storage device” to refer to the “second storage module” recited in Claim 1.

167. As explained with respect to element [1I], in Section XI.A.2.j, at paragraph 145 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” (capacitor 70), in place of Gibson’s mixer 12. Schiltz thus discloses a “second storage module” / “said second storage device.”

168. Schiltz’s capacitor 70 (annotated brown in Figure 5 below) includes a “second storage first port” in the form of the top electrical connection (annotated cyan below), which couples capacitor 70 to first transmission line 96 and second transmission line 97. Schiltz at 8:20–26 (“A drain of FET 76 serves as the output of sample switch 68. The schematic diagram of FIG. 5 shows a transmission line 96, which couples sample switch 68 to a first node of hold capacitor 70. The

schematic diagram of FIG. 5 also shows a transmission line 97, which couples the first node of hold capacitor 70 and sample switch 68 to an input of buffer amplifier 72.”).

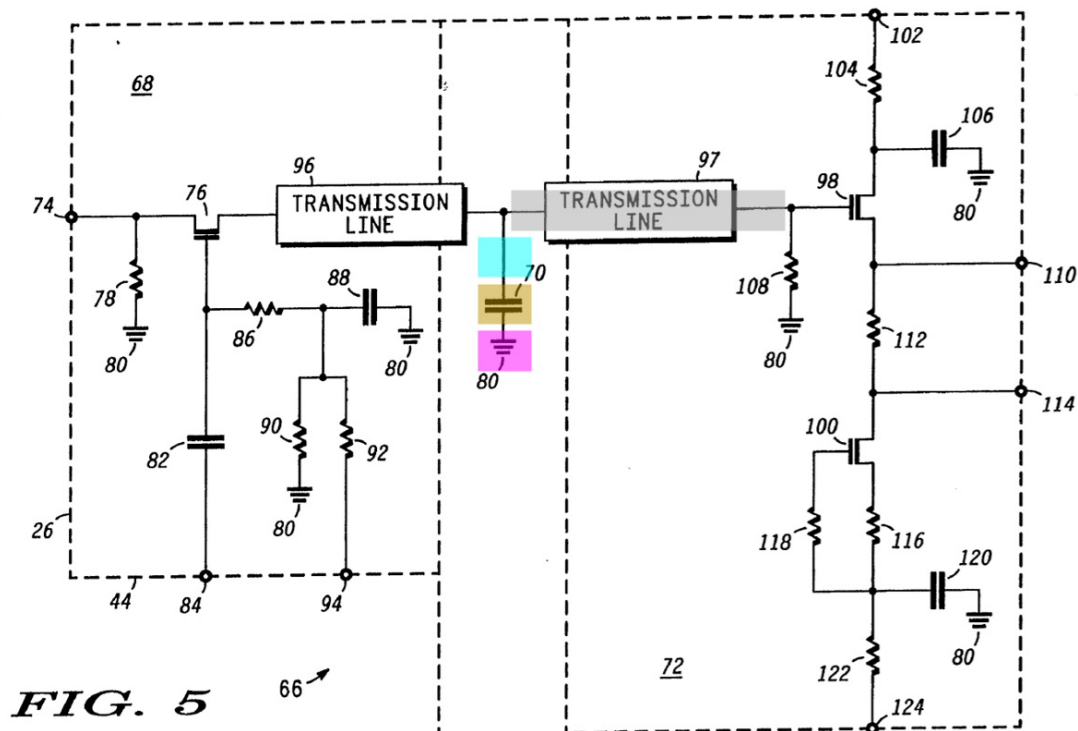


169. The capacitor 70 also includes a “second storage second port” in the form of the bottom electrical connection, which is coupled to ground terminal 80 (annotated magenta above). Schiltz at 8:26–28 (“A second node of hold capacitor 70 couples to ground terminal 80.”).

f. [3E] said second storage first port being connected to said second sampled signal,

170. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious element [3B].

171. As explained with respect to element [1J], in Section XI.A.2.k, at paragraphs 146–148 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” (capacitor 70), in place of Gibson’s mixer 12. As further explained with respect to element [1J], Gibson as modified by Schiltz would have included a “second sampled signal” along transmission line 97 (annotated gray in Figure 5 of Schiltz below). Schiltz demonstrates in Figure 5 that the top electrical connection (“second storage first port”) (annotated cyan below) of capacitor 70 (“second storage module” / “said second storage device”) (annotated brown below) is “connected” to transmission line 97 (“second sampled signal”) (annotated gray below).



g. *[3F] and said second storage second port is connected to a second reference potential.*

172. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious element [3F].

173. As explained with respect to element [1J] and [3A], in Sections XI.A.2.k and XI.A.4.b, at paragraphs 146–148 and 154-158 above, a POSITA would have found it obvious to use Schiltz’s high speed sample and hold circuit, which comprises a “storage module” / “first storage device” (capacitor 70), in place of Gibson’s mixer 12.

174. Schiltz discloses that the bottom electrical connection of capacitor 70 (“second storage second port”) (annotated magenta in Figure 5 of Schiltz below) is connected to ground terminal 80. Schiltz at 8:26–28 (“A second node of hold capacitor 70 couples to ground terminal 80.”).

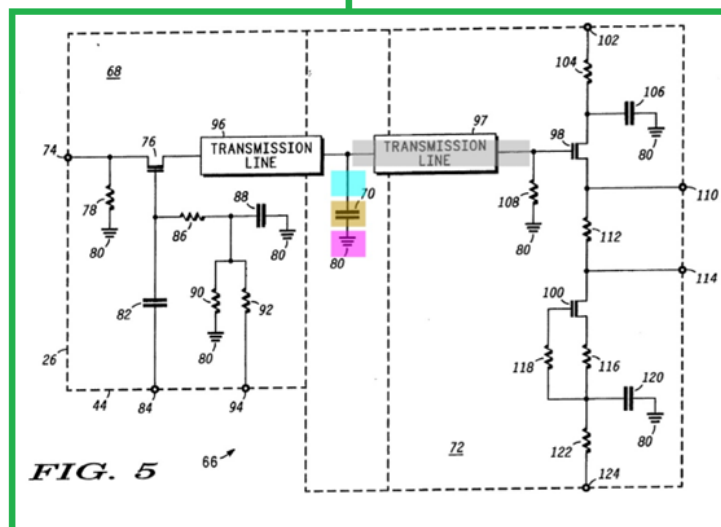
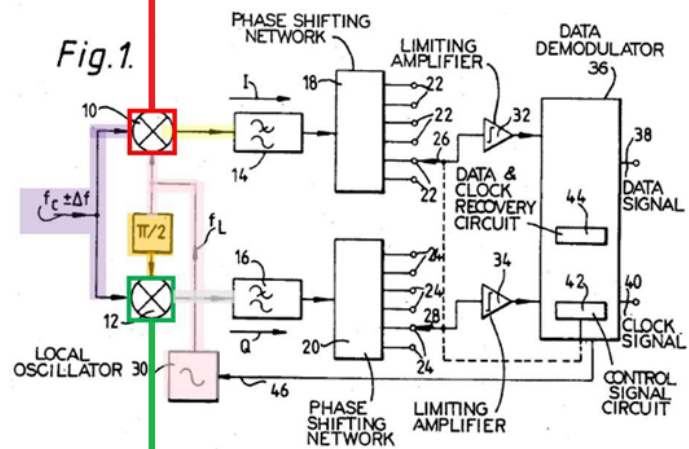
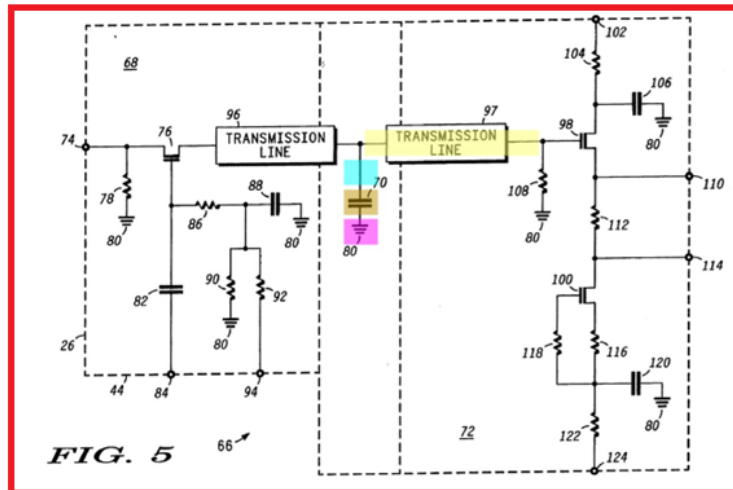
5. ***Claim 4***

- a. *The cable modem of claim 3, wherein said first storage device is a first capacitor, and said second storage device is a second capacitor.*

176. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious claim 4.

177. Gibson in view of Schiltz renders obvious “[t]he cable modem of claim 3” for the reasons I exemplified Section XI.A.4, at paragraphs 153–175 above. More specifically, a POSITA would have found it obvious to use Schiltz’s mixer (sample and hold circuit 26) in place of each of the mixers 10 and 12 in Gibson’s receiver, thus rendering obvious each of the limitations of claim 3.

178. As I explained with respect to elements [1F], [1I], [3A], and [3D], in Sections XI.A.2.g, XI.A.2.j, XI.A.4.b, XI.A.4.e, at paragraphs 137–138, 145, 154–158, and 165–169 above, Gibson in view of Schiltz renders obvious “said first storage device” and “said second storage device.” That is, Gibson as modified by Schiltz would include one instance of Schiltz’s “capacitor 70” as a first storage device in a first frequency down-conversion module (Schiltz’s mixer used in place of Gibson’s mixer 10), and another instance of Schiltz’s “capacitor 70” as a second storage device in a second frequency down-conversion module (Schiltz’s mixer used in place of Gibson’s mixer 12). This is illustrated in the annotated figures from Gibson and Schiltz below.



6. Claim 5

- a. The system of claim 3, wherein said first reference potential is substantially equal to ground, and said second reference potential is substantially equal to ground.*

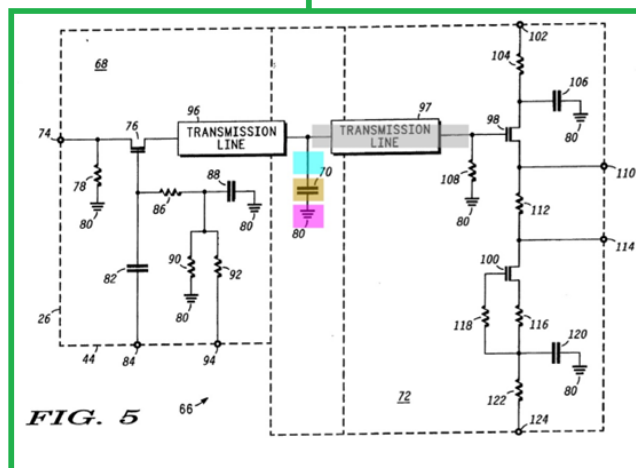
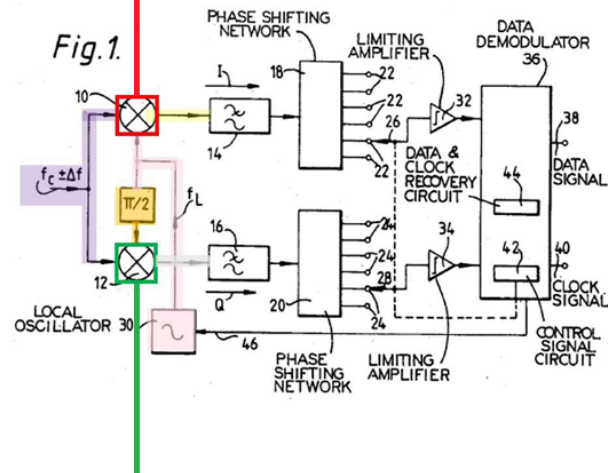
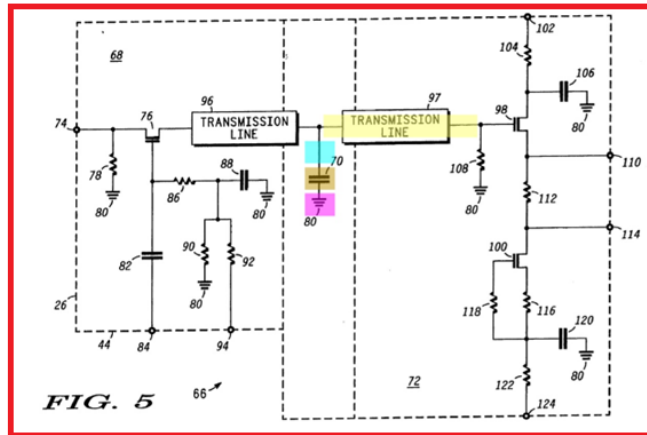
179. Gibson (Ex. 1004) in view of Schiltz (Ex. 1005) renders obvious claim 5.

180. Gibson in view of Schiltz renders obvious “[t]he system of claim 3” for the reasons I exemplified Section XI.A.4, at paragraphs 153–175 above. More specifically, a POSITA would have found it obvious to use Schiltz’s mixer (sample and hold circuit 26) in place of each of the mixers 10 and 12 in Gibson’s receiver, thus rendering obvious each of the limitations of claim 3.

181. As I explained with respect to elements [3C] and [3F], in Sections XI.A.4.d and XI.A.4.g, at paragraphs 161–164 and 172–175 above, Gibson in view of Schiltz renders obvious “said first storage second port is connected to a first reference potential” and “said second storage second port is connected to a second reference potential.”

182. Gibson as modified by Schiltz would include one instance of Schiltz’s “capacitor 70” as a first storage device in a first frequency down-conversion module (Schiltz’s mixer used in place of Gibson’s mixer 10), and another instance of Schiltz’s “capacitor 70” as a second storage device in a second frequency down-

conversion module (Schiltz's mixer used in place of Gibson's mixer 12). This is illustrated in the annotated figures from Gibson and Schiltz below.



183. In both instances, the storage device (capacitor 70) has a second port connected to a reference potential (ground terminal 80). A POSITA would have understood that ground terminal 80 is a common type of reference potential in electrical circuits, and is used as a reference potential in Schiltz's high speed sample and hold circuit 26. Schiltz at 7:65–68 (“A matching resistor 78, preferably around fifty ohms, couples between contact 76 and a ground terminal 80, which is adapted to receive a common potential.”); 8:26–28 (“A second node of hold capacitor 70 couples to ground terminal 80.”). Further, a POSITA would have understood that ground terminal 80 is equal to ground and therefore provides a reference potential that is at least substantially equal to ground.

184. As a result, Gibson as modified by Schiltz renders obvious “said first reference potential is substantially equal to ground, and said second reference potential is substantially equal to ground.” Accordingly, Gibson as modified by Schiltz renders obvious claim 5.

B. Crols Renders Obvious Claim 1-5

1. Motivation to Combine – Cable Modem References

185. As I explained in Section X.C, at paragraphs 90–98 above, Crols (Ex. 1006) discloses a receiver used in a wireless transceiver (a modem) for use in wireless RF applications. Crols at Abstract (“An analog receiver front-end chip

realized in a 0.7 μm CMOS technology is presented.”), 1483 (“One aspect of this evolution is the ever increasing level of integration of the transceivers ...”).

186. Should the Board change its previous analysis and determine that “cable modem” in the preamble of claim 1 is limiting, a POSITA would have been motivated to use the wireless RF modem taught by Crols as a “cable modem,” in view of references that describe cable modems and cable modem applications, and specifically the cable modem references raised here: Goldberg, Thacker, ITU-T J.83, and AAPA.

187. A POSITA would have understood that the modem taught by Crols is useful for down-converting I/Q modulated electromagnetic signals. Crols at 1483 (“The use of multipath topologies is nowadays in analog applications still very limited. In digital and software applications, matching is always perfect, and multipath topologies are used widely. In these applications, two parallel signals are regarded as one complex signal on which different complex signal processing steps are performed. In this paper, it is shown how the complex signal method can be extended to the world of analog systems with its inherent imperfect matching between parallel processing paths.”).

188. Goldberg (Ex. 1007), Thacker (Ex. 1008), and ITU-T J.83b (Ex. 1009) disclose cable data standards that were released before the Priority Date of the Challenged Claims. Each specified the use of I/Q modulation (*e.g.*, QAM) in

cable modems. Goldberg (Ex. 1007) at 69–70 (“DOCSIS is designed to employ one or more unused video channels within the 54-to-860 MHz cable broadcast spectrum to transmit IP-based data across hybrid fiber coaxial networks. Complex phase/amplitude modulation enables each 6-MHz down-stream channel to bring data into subscribers’ homes at up to 38 Mbits/s. Depending on the bit-rate selected by the operator, the shared down-stream channel uses either 64- or 256-point quadrature-amplitude modulation (QAM).”); Thacker (Ex. 1008) at 1:30–40 (“Because of the delay in finalizing the IEEE 802.14 standard, certain cable operators, operating under a limited partnership dubbed Multimedia Cable Network System Partners Ltd. (MCNS), proceeded to research and publish their own set of interface specifications for high-speed cable data services. MCNS released its Data Over Cable System Interface Specification (DOCSIS) for cable modem products to vendors in March 1997. ...”), 1:50–62 (“At the physical layer, which defines modulation formats for digital signals, the IEEE and MCNS specifications are similar. The 802.14 specification supports the International Telecommunications Union’s (ITU) J.83 Annex A, B and C standards for 64/256 QAM modulation, providing a maximum 36 Mbps of downstream throughput per 6 MHz television channel. ... Annex B is the North America standard supported by MCNS”); ITU-T J.83 (Ex. 1009) at 10, Table 1 (showing Annex B Modulation as “64- or 256-QAM”). These cable modem standards provided an incentive for a

POSITA to use I/Q modulation down-converters such as those taught by the Crols as part of “cable modems.” *See, e.g.*, Goldberg (Ex. 1007) at 69 (“MCNS/DOCSIS MAC Paves The Way For A Cable-Modem Invasion”), 80 (“Broadcom’s first silicon implementation of the DOCSIS standard will surely give rise to a first generation of low-cost, interoperable cable modems.”).

189. Additionally, the AAPA shows that QAM cable modems had been implemented in a “variety of well known devices,” including QAM and QPSK cable modems by Broadcom. ’835 patent (Ex. 1001) at 40:17–35 (listing devices by Broadcom also discussed in Goldberg). The AAPA demonstrates that making and using “cable modems” would have been known to a POSITA. As a result, a POSITA would have had further reason to use the modem taught by Crols, in “cable modem” applications, as taught by the ’835 patent.

190. Further, as I noted above in paragraph 120 above, from my review of the ’835 patent’s prosecution history, neither the Patent Owner nor the Examiner placed any importance on the use of “cable modem” in the preamble of Challenged Claim 1, and the body of the claim recites a structurally-complete device capable of being used as a “cable modem” in the context of the ’835 patent. The ’835 patent’s written description discloses a variety of cable modem environments, including wired and wireless cable modems, and interactive and non-interactive cable set top boxes. ’835 patent at 36:50–38:34. The patent further discloses that a

“cable modem” can be compliant with DOCSIS or not compliant with any standard. *Id.* at 38:28–34 (“DOCSIS is a Cable Modem Standard that stands for Data Over Cable Service Interface Specification (DOCSIS), and defines the interface requirements for cable modems involved in high-speed data transmission over cable television networks. The present invention is not limited to this standard but to additional standards, and non-standard configurations.”).

Accordingly, it is my opinion that for purposes of the ’835 patent, a “cable modem” is a device that includes communication at RF frequencies over cable, whether wired or wireless, and this includes communication of data for television.

191. In view of the foregoing and for the reasons set forth in Section XI.B.2–5, at paragraphs 192–266 below, it is my opinion that the modem taught by Crols, would have rendered obvious the structure recited in Challenged Claims 1–5, and that a POSITA would have been motivated use that structure as a “cable modem” in the context of the ’835 patent, in view of Goldberg (Ex. 1007), Thacker (Ex. 1009), ITU-T J.83 (Ex. 1009), and the AAPA. Using the modem taught by Crols as a “cable modem” in the context of the ’835 patent would have yielded only expected, predictable results. For example, in view of Goldberg, Thacker, and the AAPA, this combination would have been (1) a combination of prior art elements according to known methods to yield predictable results; (2) the use of known work in one field (RF down-conversion) to prompt a variation for use in a

related field (cable data communications) in view of market incentives (e.g., DOCSIS); and (3) obvious to try, with a reasonable expectation of success.

2. *Independent Claim 1*

- a. [1Pre] A cable modem for down-converting an electromagnetic signal having complex modulations, comprising:*

192. Crols (Ex. 1006) discloses a receiver used in a wireless transceiver (a modem) that is used for down-converting an RF electromagnetic signal having complex modulations. Crols at Abstract (“An analog receiver front-end chip realized in a 0.7 μm CMOS technology is presented.”), 1483 (“One aspect of this evolution is the ever increasing level of integration of the transceivers, driven by the need for both a better portability and a lower cost prize. ... This has made the zero-IF downconverter the preferred topology in the research towards the fully integrated single-chip transceiver.”). Crols teaches a RF wireless modem with a receiver having a conventional quadrature downconverter as shown in Figure 12(b), annotated below.

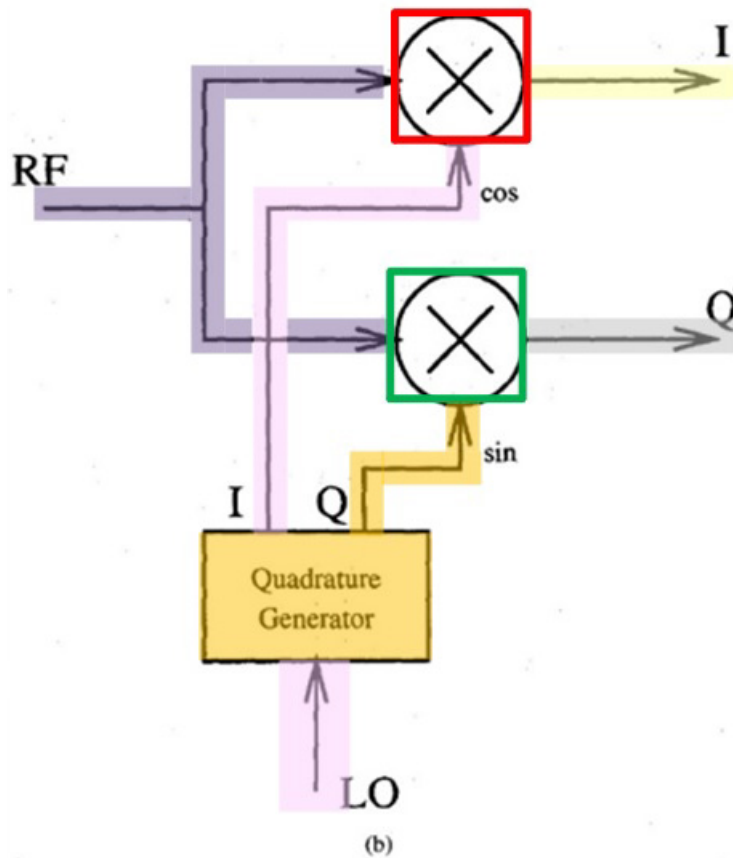


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

193. A POSITA would have understood that the modem taught by Crols down-converts a modulated carrier signal (annotated purple above) from 900 MHz to baseband (or a zero-IF frequency), for example. Crols at Abstract (“An analog receiver front-end chip realized in a 0.7 μm CMOS technology is presented. It uses a new, high performance, downconverter topology, called double quadrature downconverter, that achieves a phase accuracy of less than 0.3° in a large passband around 900 MHz, without requiring any external component or any tuning or trimming.”), 1483 (“The consequence of this evolution is that the zero-IF downconversion topology is used more and more in receivers for mobile wireless

telecommunications applications [2], [3]. The zero-IF receiver can be implemented with a much higher degree of integration than the conventional IF (herterodyne) receiver. This has made the zero-IF downconverter the preferred topology in the research towards the fully integrated single-chip transceiver.”), 1484 (“Its input bandwidth is as high as 900 MHz”), 1489 (“Fig. 12(b) shows an alternative for the conventional quadrature downconverter. The RF signal is now put into quadrature and both the HF I- and Q-signals are downconverted with a sine.”).

194. To the extent that “complex modulations” in the preamble is limiting, Crols teaches that its modem works with I/Q modulation formats, which were complex modulation formats within the general knowledge of a POSITA at the time of the alleged invention. Crols at 1483 (“The use of multipath topologies is nowadays in analog applications still very limited. In digital and software applications, matching is always perfect, and multipath topologies are used widely. In these applications, two parallel signals are regarded as one complex signal on which different complex signal processing steps are performed. In this paper, it is shown how the complex signal method can be extended to the world of analog systems with its inherent imperfect matching between parallel processing paths.”).

195. Further, as explained in Section XI.B.1, at paragraphs 185-191 above, should the Board change its previous analysis and determine that “cable modem”

in the preamble of claim 1 is limiting, a POSITA would have been motivated to use the wireless RF modem taught by Crols as a “cable modem,” as that term is understood in the context of the ’835 patent, in view of one or more of Goldberg (Ex. 1007), Thacker (Ex. 1008), ITU-T J.83 (Ex. 1009), and AAPA.

b. [1A] an oscillator to generate an in-phase oscillating signal;

196. Crols (Ex. 1006) discloses an oscillator to generate an in-phase oscillating signal (“LO”). At Figure 12(b), Crols discloses a conventional quadrature downconverter that has an “LO” signal (annotated pink below). Crols at 1483, 1489. A POSITA would have understood that the “LO” signal is generated by a local oscillator.

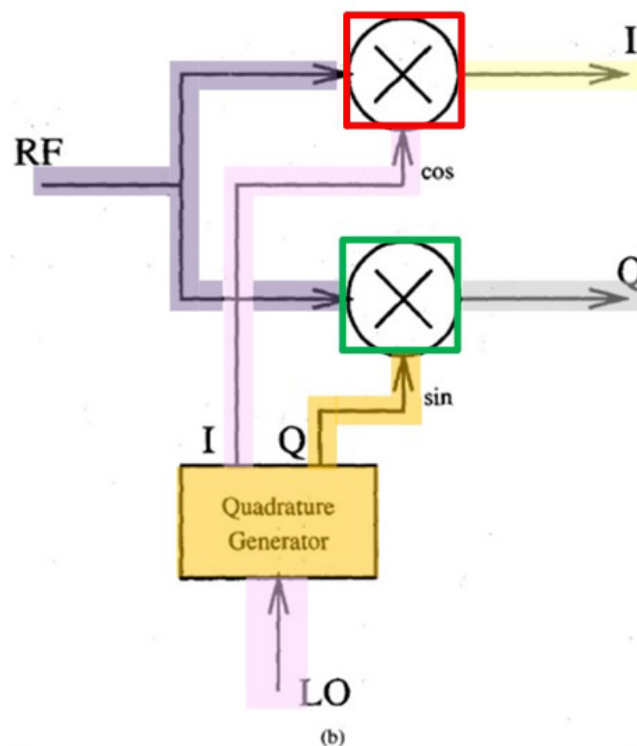


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

c. [1B] a phase shifter to receive said in-phase oscillating signal and to create a quadrature-phase oscillating signal;

197. Crols (Ex. 1006) discloses a phase shifter (“Quadrature Generator”) (annotated orange in Figure 12(b) below) to receive an in phase oscillating signal (“LO”) (annotated pink below) and to create a quadrature-phase oscillating signal (annotated orange signal output from “Quadrature Generator”).

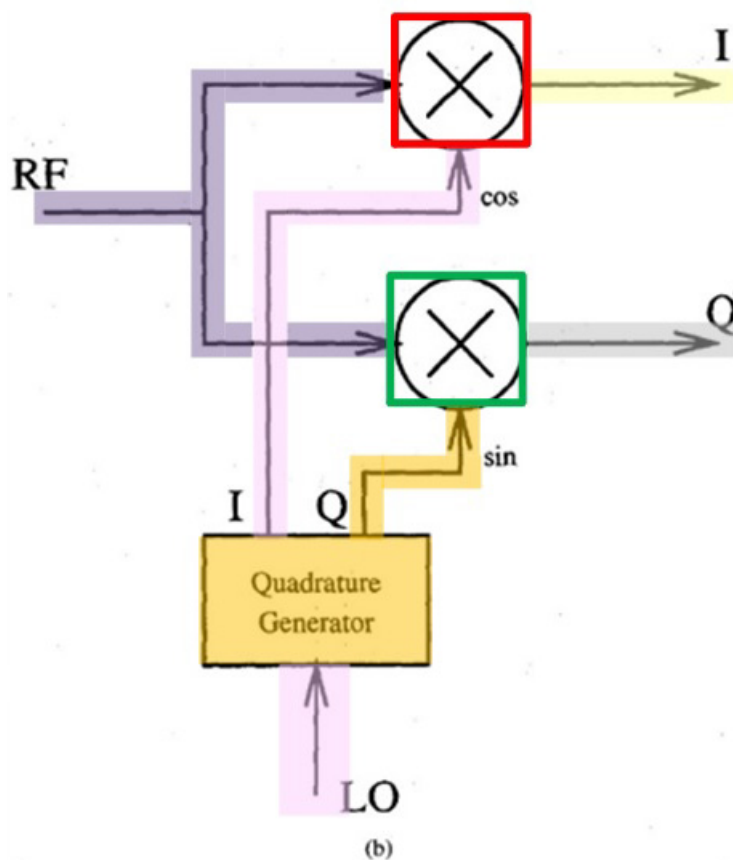


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

d. [1C] a first frequency down-conversion module to receive the electromagnetic signal and said in-phase oscillating signal;

198. Crols (Ex. 1006) discloses a first frequency down-conversion module (mixer on I-channel) (annotated red in Figure 12(b) below) to receive the electromagnetic signal (annotated purple below) and the in-phase oscillating signal (“LO” / “I” signal) (annotated pink below).

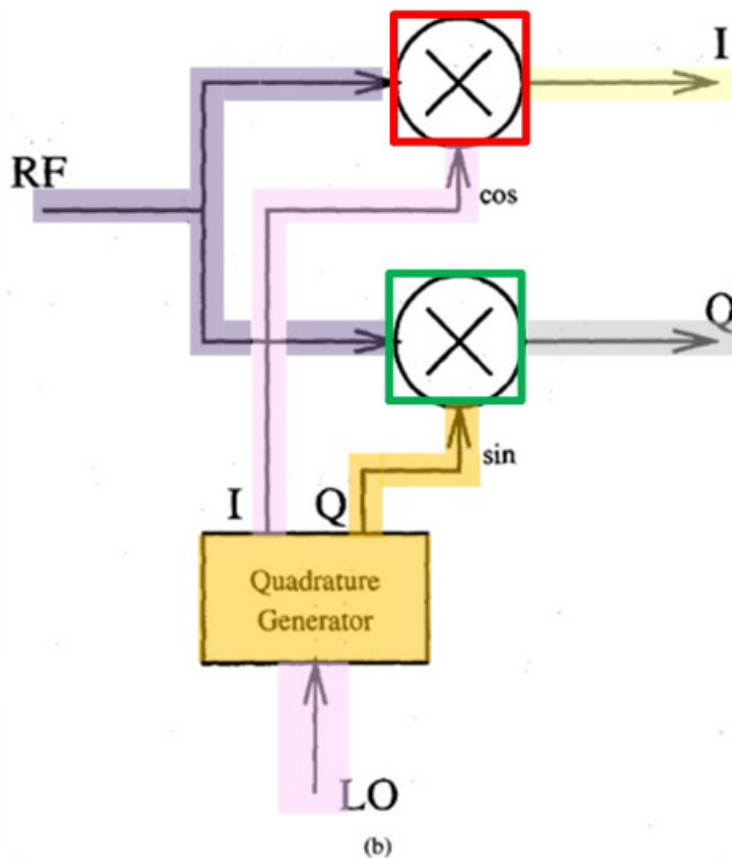


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

199. To the extent that it is argued or determined that the mixers shown in Figure 12(b) do not disclose a frequency down-conversion module, as recited by claim 1 of the '835 patent, Crols discloses a mixer topology in Figure 17 that a

POSITA would have found obvious to apply to each mixer in Figure 12(b), thereby rendering obvious element [1C].

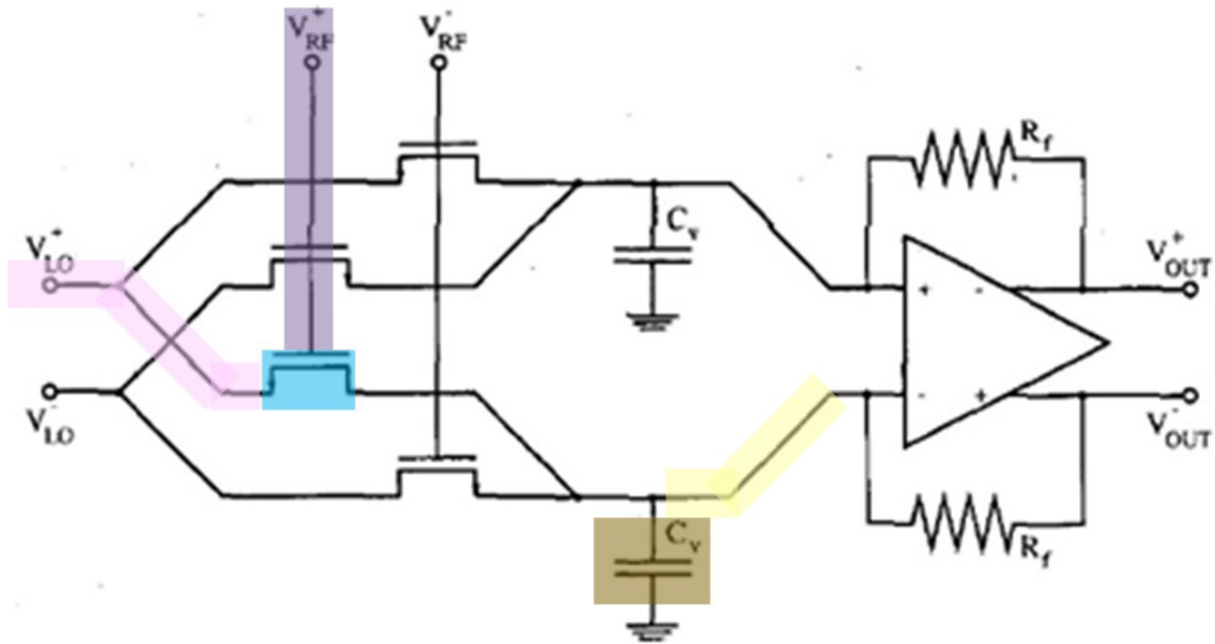


Fig. 17. The highly linear mixer topology.

200. In the mixer shown in Figure 17 (annotated above), an RF electromagnetic signal (annotated purple) is applied to the control node of a CMOS transistor (annotated blue). A local oscillating signal (whether in-phase or quadrature) (annotated pink) is applied to the source input of the CMOS transistor. The drain of the transistor is coupled to a “large capacitor” (C_V) (annotated brown) and outputs a sampled signal (annotated yellow). Crols at 1491. The “large capacitor” serves as a low pass filter, allowing the drain to pass along the sampled, lower frequency signal. *Id.* (“The large capacitors make that the opamp only has to process low frequency signals. This makes it possible to use an opamp with large

input transistors, which results in a low noise despite its low power consumption.”).

201. A POSITA would have understood that while the RF signal is applied to the control (gate) node in Figure 17, it would have been obvious to apply the RF signal to the source input of the CMOS transistor, as suggested by Figure 12(b). In either scenario, the RF signal mixed with (multiplied by) the LO signal to downconvert the RF signal to a lower frequency, including to “baseband” in a “zero-IF” circuit.

202. A POSITA would have had several reasons to use the basic mixer topology for one line, as shown in Figure 17 (a CMOS transistor (FET) followed by a capacitor shunted to ground acting as a low pass filter), in a conventional non-differential quadrature downconverter, as shown in Figure 12(b), or two lines in a conventional quadrature downconverter having a differential configuration.

203. First, while Crols discloses a new, “low-IF” quadrature downconverter (*e.g.*, Figs. 13 and 15) that is described to have improved on conventional quadrature downconverters (*e.g.*, Figs. 12(a), 12(b)), a POSITA would have recognized that conventional quadrature downconverters would have been desired implementations in many applications. Crols discloses that the primary benefit of its new quadrature downconverter (Figs. 13 and 15) was to reduce mirror signal crosstalk due to phase errors in the local oscillator signal.

Crols at 1489. A POSITA would have recognized that the effects of mirror signal crosstalk were effectively inconsequential in many applications, and that their presence could be reduced by improved local oscillator signal generation. In such cases, a POSITA would have been motivated to use conventional quadrature downconverters (Figs. 12(a) or 12(b)).

204. Second, a POSITA would have recognized that the benefits gained by the new quadrature downconverter disclosed in Crols would not have been significant enough to overcome the downsides of that approach, and thus have been motivated to use pre-existing quadrature downconverters (Figs. 12(a) and 12(b)). Crols's new, "low-IF" quadrature downconverter used twice as many mixers (four) and twice as many quadrature generators (two) as the conventional quadrature downconverters. Crols at 1489–1490 (Fig. 15). Doubling the number of components would have effectively doubled the space taken by the downconverter circuit on the chip and doubled the cost for this portion of the downconverter circuit. These increases in size and cost would have discouraged designers from switching from conventional quadrature downconverters (Figs. 12(a) and 12(b)) to the "low-IF" design disclosed in Crols.

205. Third, Crols itself discloses that conventional zero-IF quadrature downconverters like those of Figures 12(a) and 12(b) were widely used in the field and seen as beneficial approaches. Crols at 1483 ("One aspect of this evolution is

the ever increasing level of integration of the transceivers, driven by the need for both a better portability and a lower cost prize. The consequence of this evolution is that the zero-IF downconversion topology is used more and more in receivers for mobile wireless telecommunications applications [2], [3]. The zero-IF receiver can be implemented with a much higher degree of integration than the conventional IF (heterodyne) receiver. This has made the zero-IF downconverter the preferred topology in the research towards the fully integrated single-chip transceiver.”).

The quadrature downconverter of Figure 12(b) was well-known and widely described as a standard arrangement for RF signal downconversion applications, as can be observed not only from Crols’ text but the articles cited, such as “Direct-conversion ratio transceivers for digital communications” by Dr. Abidi and “DECT zero-IF receiver front end” by Dr. Baltus and Dr. Tombeur. I am personally aware of many other publications from before the Priority Date that describe and disclose a conventional quadrature downconverter having the basic topology shown in Crols’ Figure 12(b), including the following publications that I authored: Section 3.7 (“Direct Conversion Transceivers”) in RF AND MICROWAVE CIRCUIT DESIGN FOR WIRELESS COMMUNICATIONS (Artech House, Inc. 1996), L. Sheng et al., *A Si/SiGe HBT sub-harmonic mixer/downconverter*, IEEE Proceedings of the 1999 Bipolar/BiCMOS Circuit & Tech. Meeting, 71–74 (1999), and L. Sheng et al., *A*

wide-bandwidth Si/SiGe HBT direct conversion sub-harmonic

mixer/downconverter, 35 IEEE J. SOLID-STATE CIRCUITS 1329 (Sept. 2000).

206. Fourth, combining the mixer of Figure 17 with the quadrature downconverter of Figure 12(b) would have yielded only expected, predictable results, and a POSITA would have done so with a reasonable expectation of success. As noted above, Crols discloses that the quadrature downconverters of Figures 12(a) and 12(b) were conventional and known in the field. Crols at 1489. And Crols disclosed using the mixer topology of Figure 17 with a more complicated quadrature downconverter (of Figures 13 and 15). Crols at 1489–1490. A POSITA thus would have found it simpler to use the conventional quadrature downconverter topologies of Figures 12(a) and 12(b) while implementing the basic mixer topology of Figure 17 (FET followed by a capacitor acting as a low pass filter), which would have been a predictable implementation with a reasonable expectation of success.

e. [1D] a second frequency down-conversion module to receive the electromagnetic signal and said quadrature-phase oscillating signal; wherein

207. Crols (Ex. 1006) discloses a second frequency down-conversion module (mixer on Q-channel) (annotated green in Figure 12(b) below) to receive the electromagnetic signal (annotated purple below) and the quadrature-phase

oscillating signal (“Q” signal coming from Quadrature Generator) (annotated orange below).

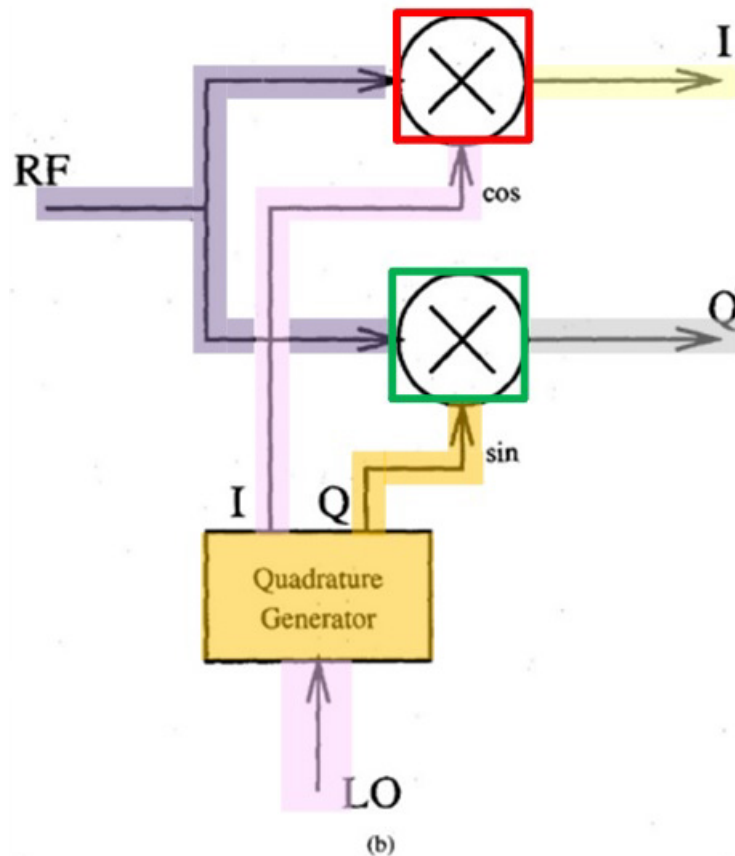


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

208. To the extent that it is argued or determined that the mixers shown in Figure 12(b) do not disclose a frequency down-conversion module, as recited by claim 1 of the '835 patent, Crols discloses a mixer topology in Figure 17 that a POSITA would have found obvious to apply to each mixer in Figure 12(b), thereby rendering obvious element [1D], for the reasons I explained with respect to element [1C], in Section XI.B.2.d, at paragraphs 198–206 above.

f. [1E] said first frequency down-conversion module further comprises a first frequency translation module

209. As I explained with respect to elements [1C] and [1D], in Sections XI.B.2.d and XI.B.2.e, in paragraphs 198–208 above, Crols (Ex. 1006) discloses a mixer topology in Figure 17 that a POSITA would have found obvious to use in the conventional quadrature downconverter topology shown in Figure 12(b) (whether in a differential or non-differential configuration).

210. That mixer topology is shown in annotated Figure 17 below, and comprises a switch (CMOS transistor) (annotated blue) coupled to a storage module (capacitor C_V) (annotated brown) shunted to ground, which acts a low-pass filter. Crols at 1491 (“The large capacitors make that the opamp only has to process low frequency signals. This makes it possible to use an opamp with large input transistors, which results in a low noise despite its low power consumption.”).

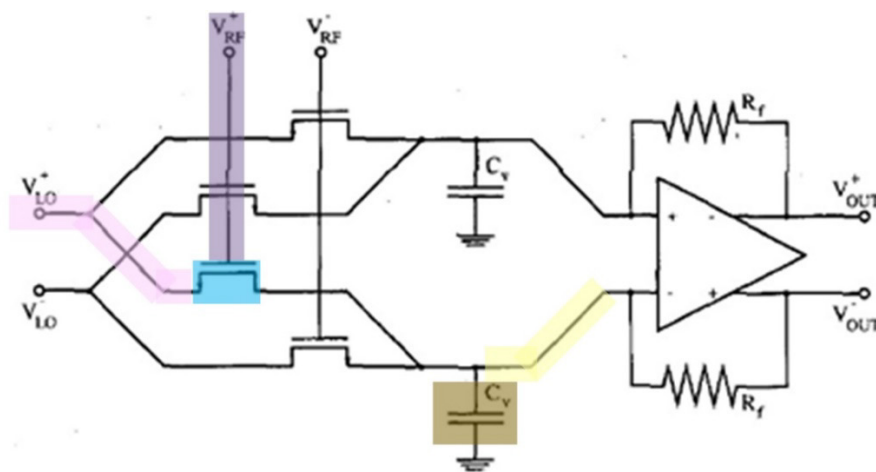


Fig. 17. The highly linear mixer topology.

211. Thus, Crols renders obvious a first frequency down-conversion module (mixer) comprising a first frequency translation module (switch under the control of a control signal). See '835 patent at 6:18–21 (“An exemplary embodiment of UFT module 103 is generally illustrated in FIG. 1B. Generally, UFT module 103 includes a switch 106 controlled by a control signal 108. Switch 106 is said to be a controlled switch.”).

g. [1F] and a first storage module,

212. As I explained with respect to elements [1C]–[1E], in Sections XI.B.2.d–XI.B.2.f, at paragraphs 198–211 above, Crols (Ex. 1006) discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) (annotated blue) coupled to a storage module (capacitor C_v) (annotated brown), and a POSITA would have found it obvious to use the mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b).

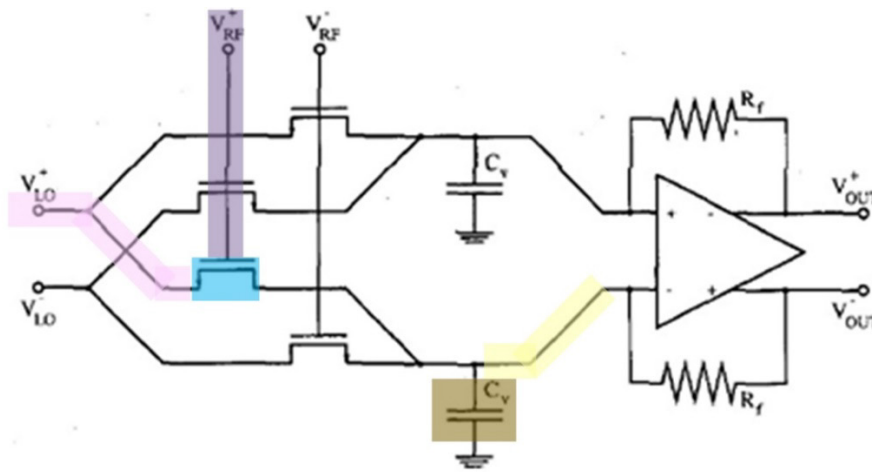


Fig. 17. The highly linear mixer topology.

213. I understand that in the Board’s Final Written Decision in IPR2021-00985, it interpreted “storage module” to mean “a module of a system that stores non-negligible amounts of energy from an input EM signal.” IPR2021-00985, Paper No. 44, at 21, 56. I further understand that the Board determined prior art references met this limitation where they “successfully down-convert” input signals. *Id.* at 56–58. In this regard, I note that Crols describes that its down-conversion receiver and mixer topology (Figure 17) were created and operated successfully. Crols at 1491, Fig. 18 (“Fig. 18 shows a microphotograph of the realized chip. It is realized in a standard 0.7 μ m CMOS process and measures 6 mm². It operates on a single 5 V power supply voltage and consumes 500 mW, mainly dissipated in the HF resistor loaded amplifiers. The measured conversion gain decays from 16.4 dB at low frequencies to 9.2 dB at 900 MHz. This is equivalent to a 3.1 dB HF signal loss for both the RF and LO signal at 900 MHz. The measured output bandwidth is 3.09 MHz. Fig. 19 shows the third-order interception point (IP3) measurement. The IP3 is 27.9 dBm, the measured noise figure (for a 12 dBm LO signal) is 24.0 dB. The measurements of the phase and amplitude errors in function of frequency are given in Fig. 20. The phase error is less than 0.3° in the 500-900 MHz band, which is as expected. In this band, the amplitude error is situated at 0.5 dB. These phase and amplitude errors result, after a digital AGC operation, in a mirror signal suppression of 46 dB. Both phase and

amplitude errors totally depend on matching. This measurement has therefore been performed on several samples, and all samples show the same or better phase and amplitude errors.”). Crols further discloses an earlier publication disclosing the mixer topology of Figure 17. Crols at 1491 (“The mixers are realized with recently developed highly linear CMOS topology for downconverters [12].”), 1492 (“[12] J. Crols and M. Steyart, “A 1.5 GHz highly linear CMOS down-conversion mixer””). That earlier publication (Ex. 1021) likewise disclosed that the mixer topology was created and operated successfully. Ex. 1021 at 741–742 (“The realized mixer is measured via external high frequency baluns for both the RF and LO input. ...”). Accordingly, it is my opinion that the mixer topology of Crols (Ex. 1009) Figure 17 and specifically its capacitor C_V would have met element [1F] under the Board’s prior construction of “storage module.”

h. [1G] wherein said first frequency translation module samples the electromagnetic signal at a rate that is a function of said in-phase oscillating signal, thereby creating a first sampled signal; and

214. As I explained with respect to element [1C], in Section XI.B.2.d, at paragraph 198 above, Crols (Ex. 1006) discloses a conventional quadrature downconverter in Figure 12(b) (annotated below), comprising a first frequency down-conversion module (mixer) (annotated red), an electromagnetic signal (annotated purple), and an in-phase oscillating signal (“LO” / “I” signal) (annotated pink).

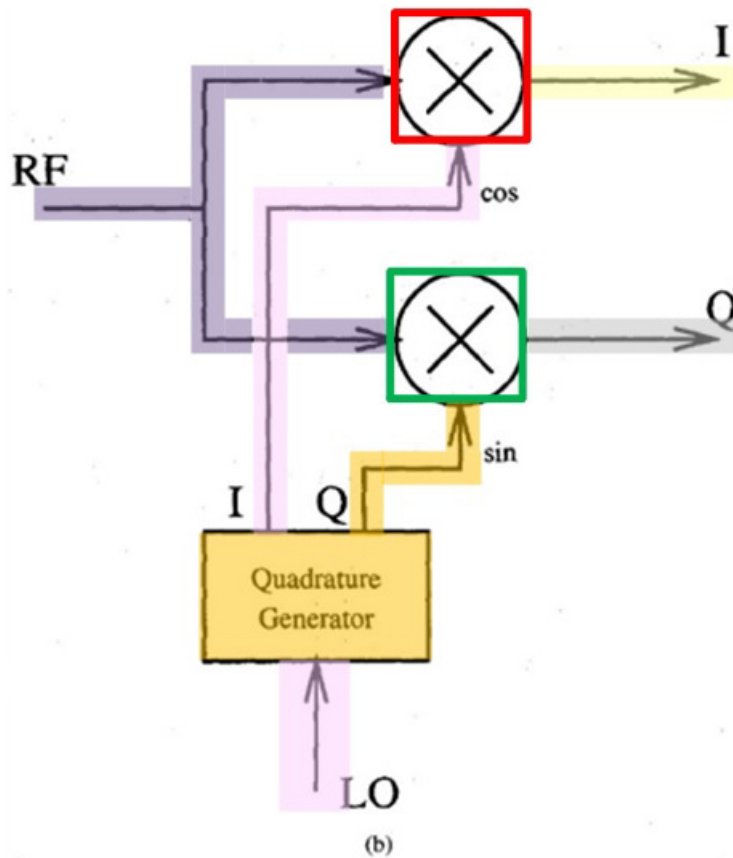


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

215. As I explained with respect to elements [1C]–[1E], in Sections XI.B.2.d– XI.B.2.f, at paragraphs 198–211, Crols discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) (annotated blue) coupled to a storage module (capacitor C_V) (annotated brown), and a POSITA would have found it obvious to use the basic mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b).

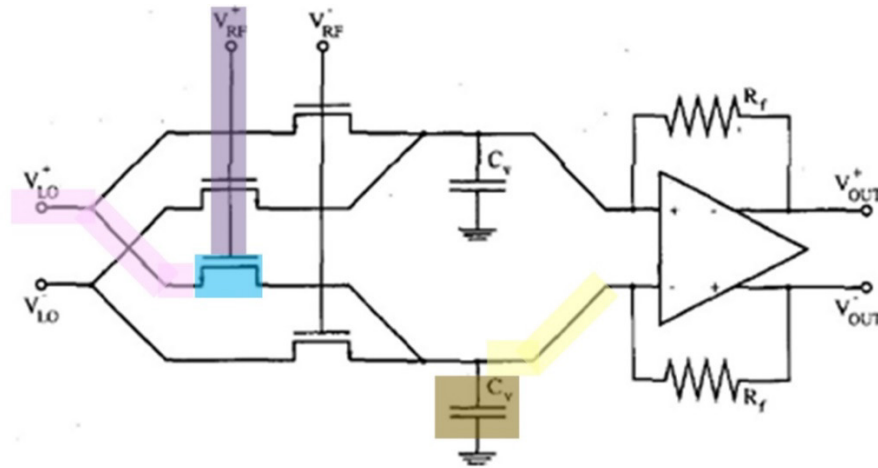


Fig. 17. The highly linear mixer topology.

216. Crols discloses that the quadrature downconverter operates by sampling a signal using mixers. *E.g.*, Crols at 1487–88 (“Fig. 11. Direct sampling of the low-IF signal”), 1490 (“This effect can however easily be eliminated by performing a closely matched digital AGC operation *on the sampled low frequency I- and Q-signals* in the DSP” (emphasis added)).

217. As seen in Figure 17 of Crols, and assuming the mixer topology is being implemented in place of the mixer symbol on the “I” channel of the conventional quadrature downconverter shown in Figure 12(b), the mixer topology receives oscillating in-phase sampling pulses (annotated pink), generated by the local oscillator as disclosed in Figure 12(b). In one configuration, the oscillating in-phase sampling pulses would have controlled the switch (CMOS transistor) (annotated blue) and thus caused the switch to sample the input RF electromagnetic signal (annotated purple) at a rate that is a function of the in-phase

oscillating signal, to create, in conjunction with the storage module (capacitor C_V) (annotated brown) acting as a low pass filter, a first sampled signal (annotated yellow). With respect to “a rate that is a function of,” a POSITA would have understood that sampling the input electromagnetic signal using the mixer topology of Figure 17 under the control of in-phase sampling pulses constituted “sampl[ing] the electromagnetic signal at a rate that is a function of said in-phase oscillating signal” at least because the mixer topology generates an output signal that is a multiplication of the electromagnetic signal and the in-phase oscillating signal, which has a resulting frequency that is the difference between the frequency of the electromagnetic signal (V_{RF}^+) and the in-phase oscillating signal (V_{LO}^+).

218. Accordingly, Crols renders obvious element [1G].

- i. [1H] said second frequency down-conversion module further comprises a second frequency translation module*

219. A POSITA would have understood that the first and second mixers of in Crols’ (Ex. 1006) conventional quadrature downconverter, as shown in Figure 12(b) (annotated red and green below, respectively), are structurally identical.

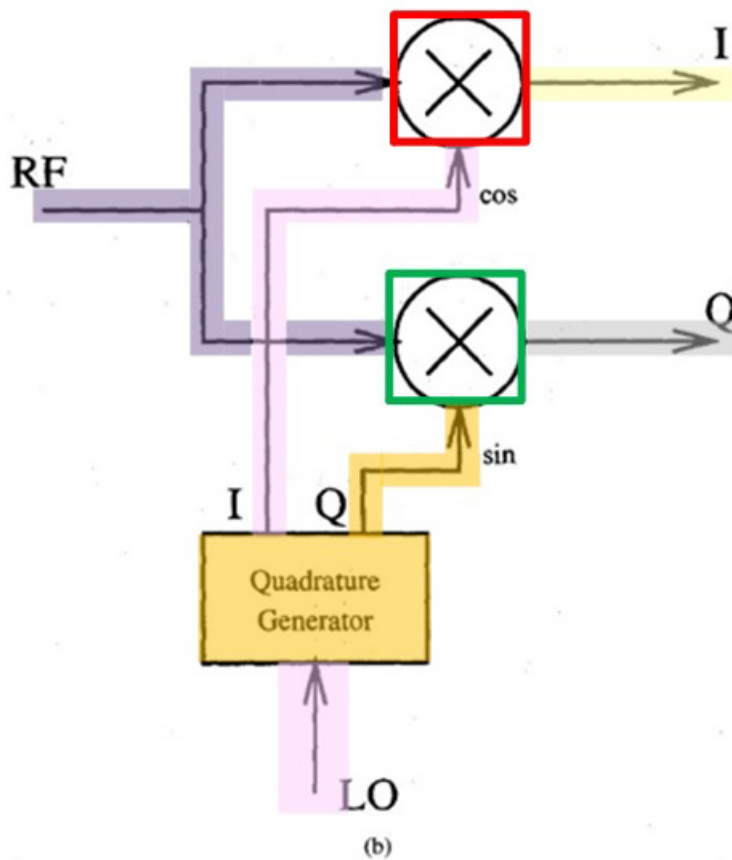


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

220. As I explained with respect to elements [1C] and [1D], in Sections XI.2.B.d and XI.2.B.e, in paragraphs 198–208, Crols discloses a mixer topology in Figure 17 that a POSITA would have found obvious to use in the conventional quadrature downconverter topology shown in Figure 12(b) (whether in a differential or non-differential configuration). Accordingly, for the reasons I explained with respect to limitation [1E], in Section XI.2.B.f, at paragraphs 209–211, Crols would have rendered obvious “said second frequency down-conversion module further comprises a second-frequency translation module.”

221. More specifically, the mixer topology of Figure 17 (annotated blow) comprises a switch (CMOS transistor) (annotated blue) coupled to a storage module (capacitor C_v) (annotated brown) shunted to ground, which acts a low-pass filter. Crols at 1491 (“The large capacitors make that the opamp only has to process low frequency signals. This makes it possible to use an opamp with large input transistors, which results in a low noise despite its low power consumption.”). See ’835 patent at 6:18–21 (“An exemplary embodiment of UFT module 103 is generally illustrated in FIG. 1B. Generally, UFT module 103 includes a switch 106 controlled by a control signal 108. Switch 106 is said to be a controlled switch.”).

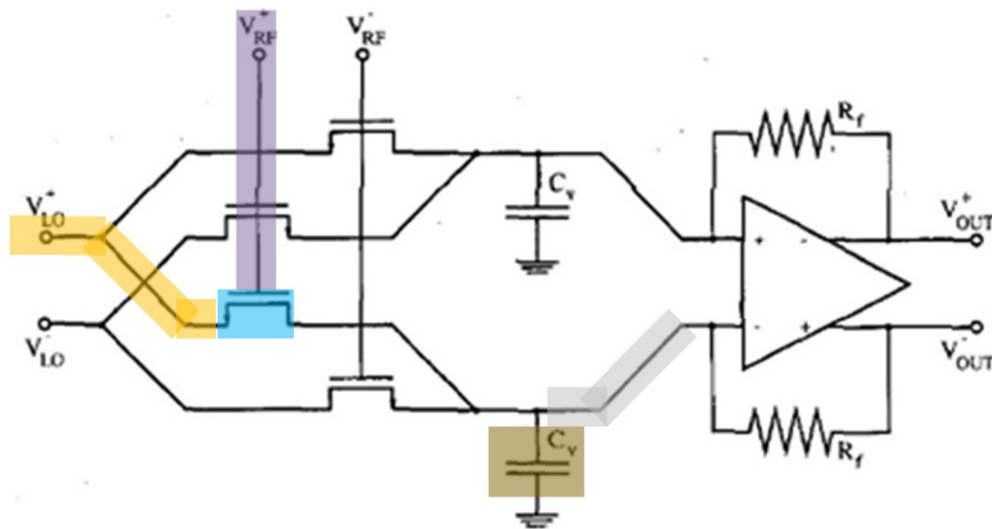


Fig. 17. The highly linear mixer topology.

j. [1I] and a second storage module,

222. As I explained with respect to element [1F], in Section XI.B.2.g, at paragraphs 212–213, Crols (Ex. 1006) discloses a mixer topology in Figure 17

(annotated below) that comprises a switch (CMOS transistor) (annotated blue) coupled to a storage module (capacitor C_V) (annotated brown); and a POSITA would have found it obvious to use the basic mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b), as the recited “said second frequency down-conversion module.” Accordingly, Crols renders obvious “said second frequency down-conversion module further comprises ... a second storage module” (capacitor C_V).

k. [1J] wherein said second frequency translation module samples the electromagnetic signal at a rate that is a function of said quadrature-phase oscillating signal, thereby creating a second sampled signal

223. As I explained with respect to elements [1B] and [1H], in Sections XI.B.2.c and XI.B.2.i, at paragraphs 197 and 219–221 above, Crols (Ex. 1006) discloses a conventional quadrature downconverter in Figure 12(b) (annotated below), comprising a second frequency down-conversion module (mixer) (annotated green), an electromagnetic signal (annotated purple), and a quadrature-phase oscillating signal (“Q” signal from Quadrature Generator) (annotated orange).

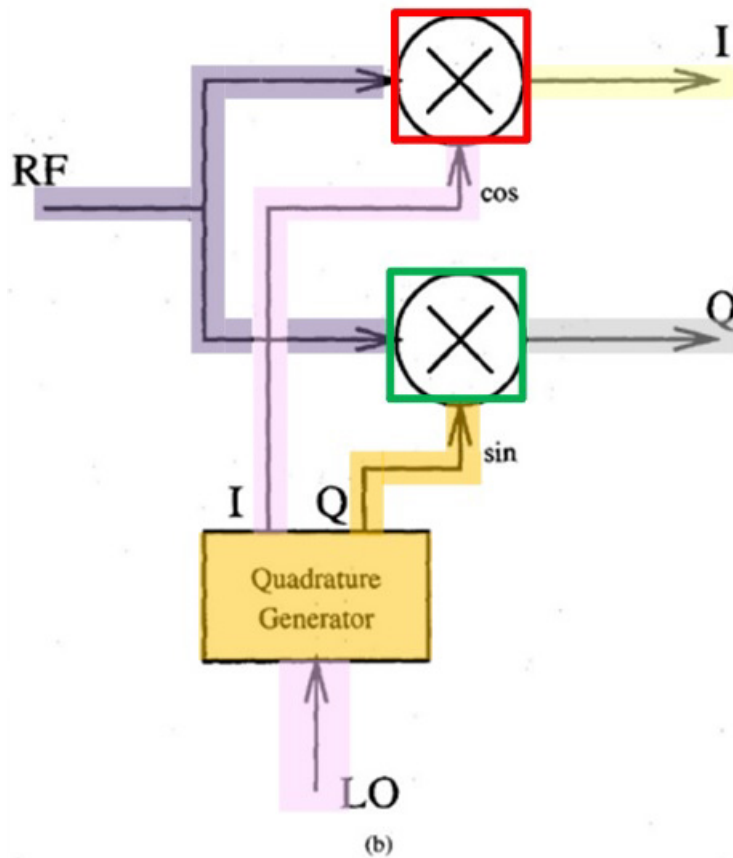


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

224. As I explained with respect to element [1H], in Section XI.B.2.i, at paragraphs 219–221, Crols discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) (annotated blue) coupled to a storage module (capacitor C_V) (annotated brown), and that a POSITA would have found it obvious to use the basic mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b).

of the quadrature-phase oscillating signal, to create, in conjunction with the storage module (capacitor C_V) (annotated brown above) acting as a low pass filter, a second sampled signal (annotated gray above). With respect to “a rate that is a function of,” a POSITA would have understood that sampling the input electromagnetic signal using the mixer topology of Figure 17 under the control of quadrature-phase sampling pulses constituted “sampl[ing] the electromagnetic signal at a rate that is a function of said quadrature-phase oscillating signal” at least because the mixer topology generates an output signal that is a multiplication of the electromagnetic signal and the quadrature-phase oscillating signal, which has a resulting frequency that is the difference between the frequency of the electromagnetic signal (V_{RF}^+) and the in-phase oscillating signal (V_{LO}^+).

227. Accordingly, Crols renders obvious element [1J].

3. *Claim 2*

- a. *The cable modem of claim 1, wherein said quadrature-phase oscillating signal is out of phase with said in-phase oscillating signal by substantially 90 degrees.*

228. Crols renders obvious the “cable modem of claim 1” for reasons I explained with respect to claim 1, in Section XI.B.2, at paragraphs 192–227 above.

229. Crols further discloses “wherein said quadrature-phase oscillating signal is out of phase with said in-phase oscillating signal by substantially 90 degrees,” and therefore Crols renders obvious claim 2.

230. Crols discloses a phase shifter (“Quadrature Generator”) (annotated orange in Figure 12(b) below) to receive an in phase oscillating signal (“LO”) (annotated pink below) and to create a quadrature-phase oscillating signal (annotated orange signal output from “Quadrature Generator”).

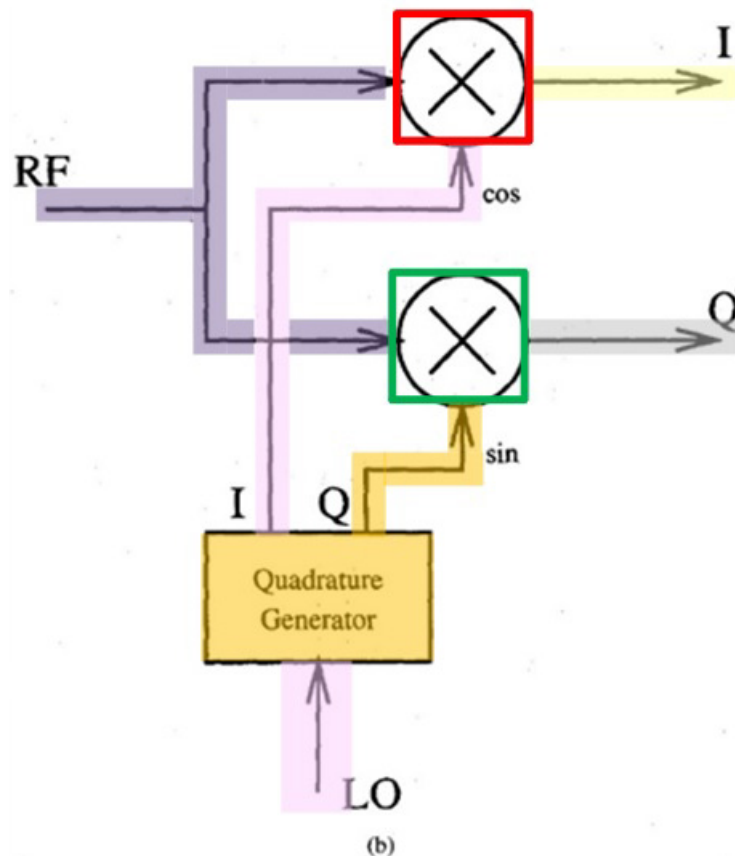


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

231. A POSITA would have recognized that the quadrature-phase oscillating signal (annotated orange above) is out of phase with the in-phase oscillating signal (annotated pink above) by substantially 90 degrees, at least because Crols explains that “generation of the quadrature signal is based on the 90° phase-difference between a pole and zero with the same cutoff frequency,” and it

was common knowledge in the art that a quadrature signal was offset by 90 degrees from the in-phase signal. Crols at 1483–84 (“The conventional realizations use an RC-CR network for the quadrature generation of the LO signal and two Gilbert multipliers for the downconversion. The generation of the quadrature signal is based on the 90° phase-difference between a pole and zero with the same cutoff frequency.”).

4. Claim 3

a. [3Pre]: The cable modem of claim 1,

232. Crols discloses the preamble of claim 3 for the reasons I explained with respect to claim 1, in Section XI.B.2, at paragraphs 192–227 above.

b. [3A] wherein said first storage device has a first storage first port and a first storage second port,

233. Crols renders obvious element [3A].

234. Element [3A] recites a “said first storage device” that has a first storage first port and a first storage second port. Claim 1 does not provide any antecedent basis for “said first storage device,” i.e., it does not recite “first storage device.” That said, a POSITA would have understood “said first storage device” to refer to the “first storage module” recited in Claim 1.

235. As explained with respect to element [1F], in Section XI.B.2.g, at paragraphs 212–213 above, Crols (Ex. 1006) discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) coupled to a

“storage module” (capacitor C_V) (annotated brown), and a POSITA would have found it obvious to use the basic mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b). Crols thus discloses a “first storage module” / “said first storage device.”

236. Crols discloses that capacitor C_V has a “first storage first port” in the form of a top electrical connection (annotated cyan below), which is connected to the sampled signal line (annotated yellow below). Crols at 1491.

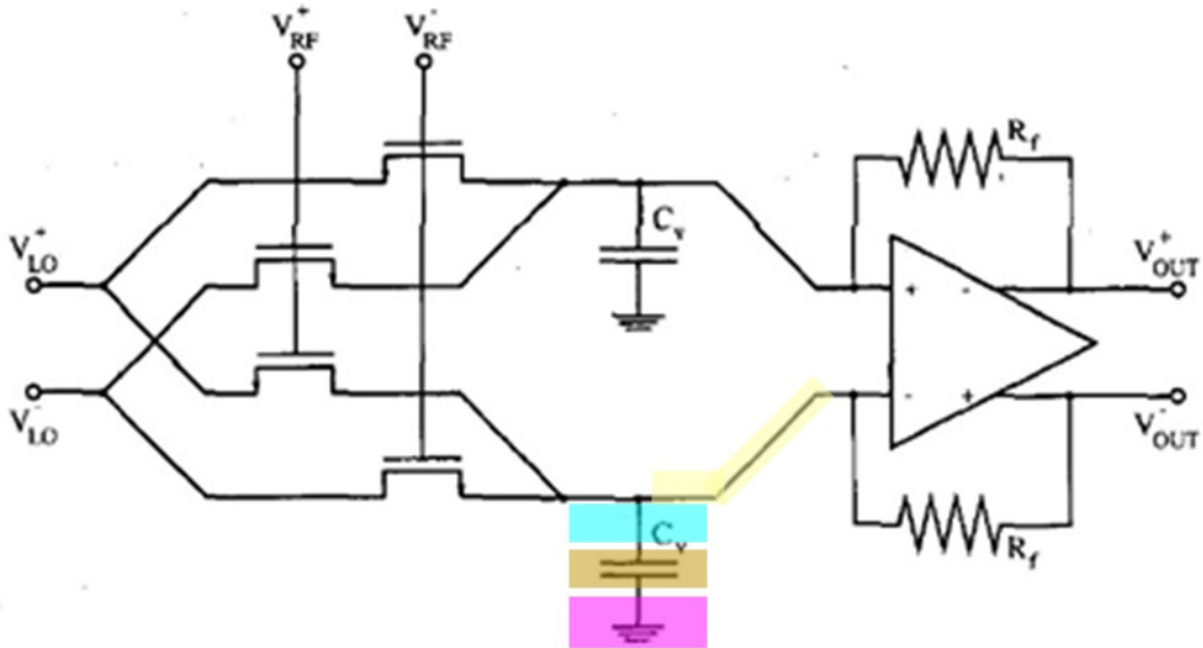


Fig. 17. The highly linear mixer topology.

237. Crols also discloses that Capacitor C_V has a “first storage second port” in the form of a bottom electrical connection (annotated magenta above), which is connected to a ground terminal.

c. [3B] said first storage first port being connected to said first sampled signal,

238. Crols (Ex. 1006) renders obvious element [3B].

239. As explained with respect to element [1G], in Section XI.B.2.h, at paragraphs 214–218 above, Crols discloses a conventional quadrature downconverter in Figure 12(b) (annotated below), comprising a first frequency down-conversion module (mixer) (annotated red), an electromagnetic signal (annotated purple), and an in-phase oscillating signal (“LO” / “I” signal) (annotated pink).

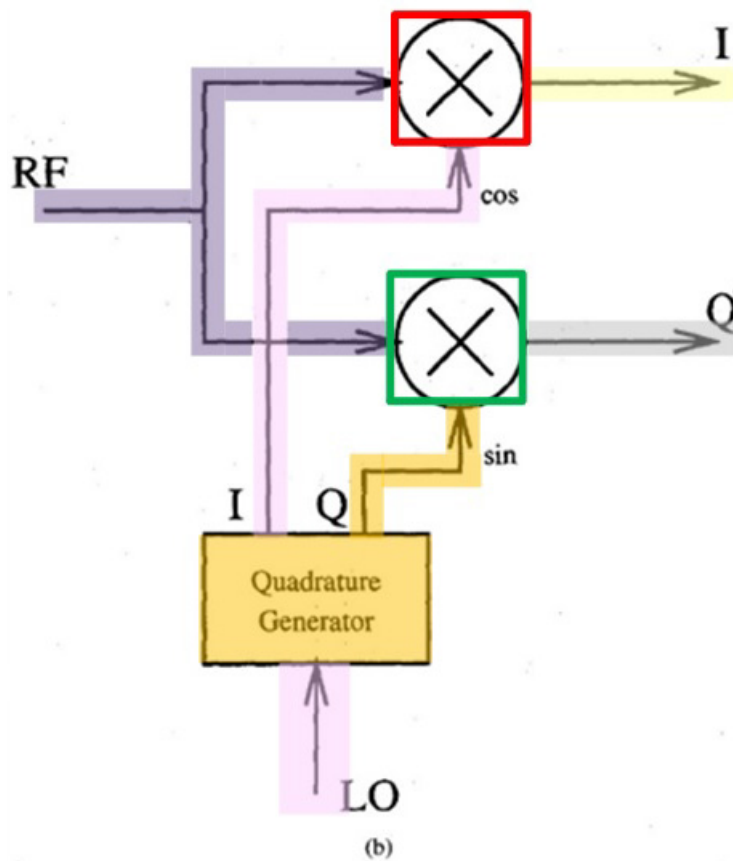


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

240. As I explained with respect to elements [1C]–[1E], in Sections XI.B.2.d–XI.B.2.f, at paragraphs 198–213, Crols discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) coupled to a storage module (capacitor C_V) (annotated brown), and a POSITA would have found it obvious to use the basic mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b).

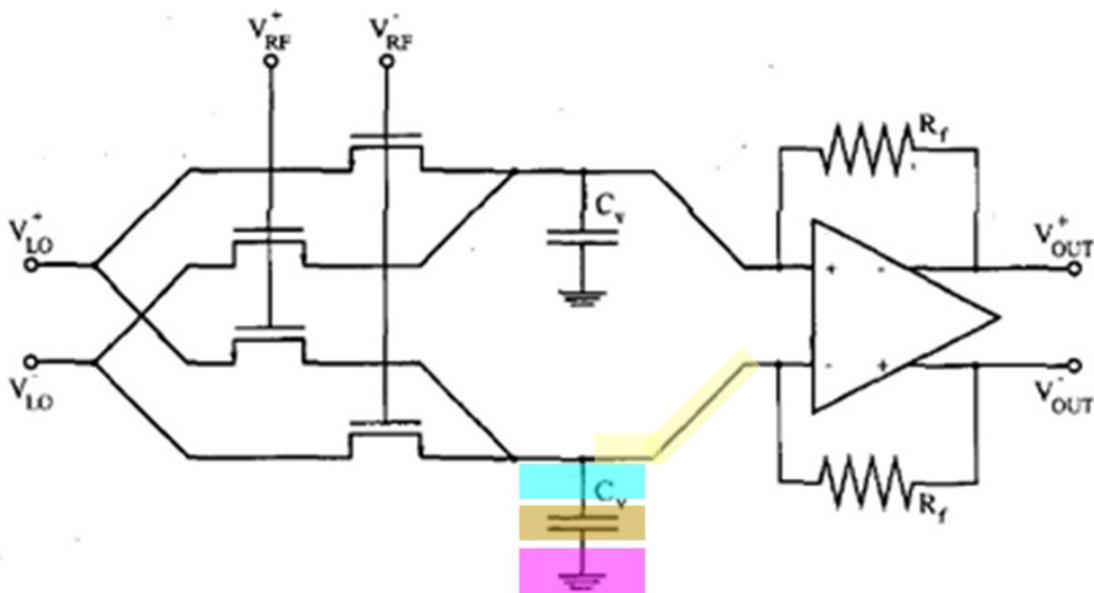


Fig. 17. The highly linear mixer topology.

241. As further explained with respect to element [1G], in Section XI.B.2.h, at paragraphs 214–218 above, Crols discloses the mixer topology of Figure 17 had a “first sampled signal” (annotated yellow above) along the line to which capacitor C_V is coupled. Crols at 1487–88 (“Fig. 11. Direct sampling of the low-IF signal”), 1490 (“This effect can however easily be eliminated by performing a closely matched digital AGC operation *on the sampled low frequency*

I- and Q-signals in the DSP” (emphasis added)), 1491. Crols thus discloses “said first storage first port being connected to said first sampled signal.”

d. [3C] and said first storage second port is connected to a first reference potential,

242. Crols (Ex. 1006) renders obvious element [3C].

243. As explained with respect to element [1F] and [3A], in Sections XI.B.2.g and XI.B.4.b, at paragraphs 212–213 and 233–237 above, Crols discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) coupled to a “storage module” (capacitor C_v) (annotated brown), and a POSITA would have found it obvious to use the mixer topology disclosed in Figure 17 in place of a first mixer in a conventional quadrature downconverter, such as that shown in Figure 12(b) (annotated red above). Crols thus discloses a “first storage module” / “said first storage device.”

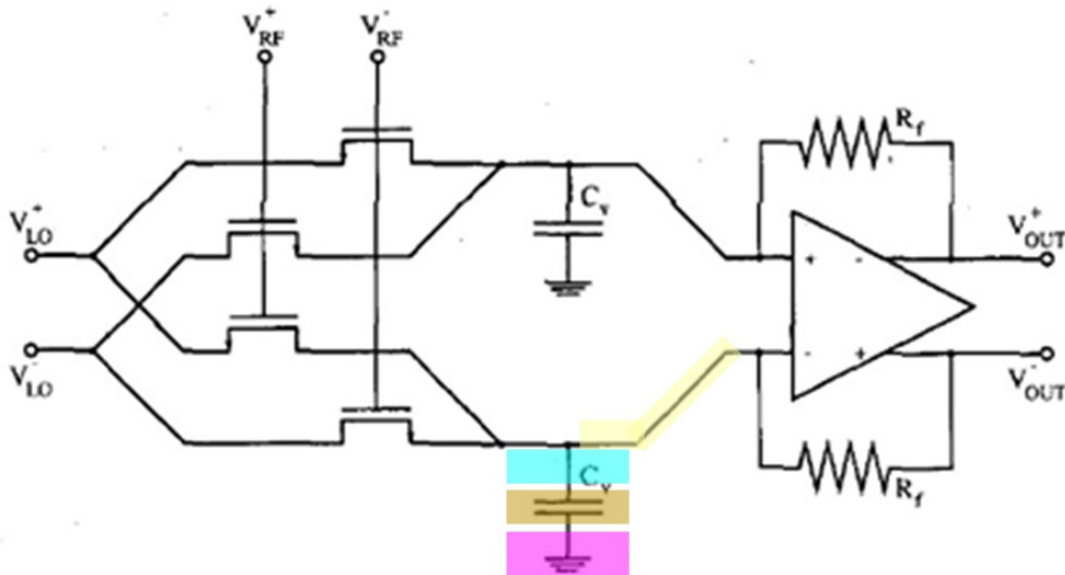


Fig. 17. The highly linear mixer topology.

244. Crols further discloses that Capacitor C_V has a “first storage second port” in the form of a bottom electrical connection (annotated magenta above), which is connected to a ground terminal.

245. A POSITA would have understood that the ground terminal is a common type of reference potential in electrical circuits, and is used as a reference potential in Crols’ mixer topology shown in Figure 17. Crols at 1491. Therefore, a POSITA would have understood that Crols discloses “said first storage second port [] connected to a first reference potential.”

e. [3D] and said second storage device has a second storage first port and a second storage second port,

246. Crols (Ex. 1006) renders obvious element [3D].

247. As with element [3A], element [3D] recites a “said second storage device” that has a second storage first port and a second storage second port. Claim 1, however, does not provide any antecedent basis for “said second storage device,” i.e., it does not recite “second storage device.” That said, a POSITA would have understood “said second storage device” to refer to the “second storage module” recited in Claim 1.

248. As explained with respect to element [1I], in Section XI.B.2.j, at paragraph 222 above, Crols discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) coupled to a storage module (capacitor C_V) (annotated brown); and a POSITA would have found it obvious to

use the basic mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b). Crols thus discloses a “second storage module” / “second storage device.”

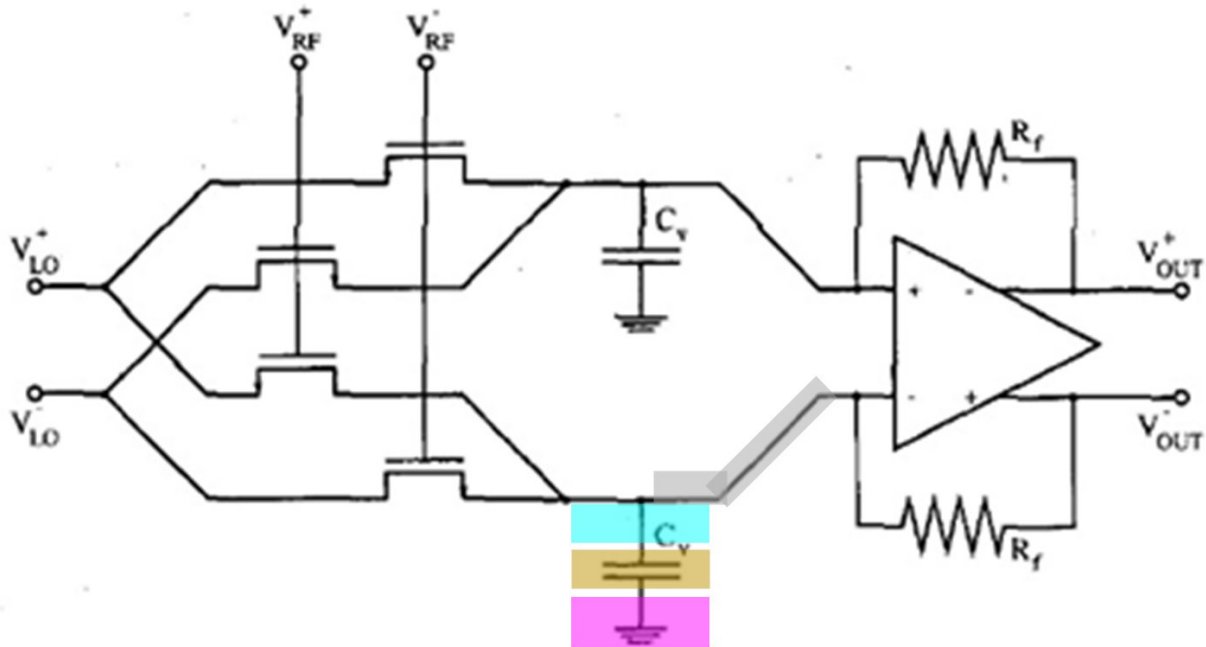


Fig. 17. The highly linear mixer topology.

249. Crols discloses that capacitor C_V has a “second storage first port” in the form of a top electrical connection (annotated cyan above), which is connected to the sampled signal line (annotated gray above). Crols at 1491.

250. Crols also discloses that Capacitor C_V has a “second storage second port” in the form of a bottom electrical connection (annotated magenta above), which is connected to a ground terminal.

f. [3E] said second storage first port being connected to said second sampled signal,

251. Crols (Ex. 1006) renders obvious element [3E].

252. As explained with respect to element [1G], in Section XI.B.2.h, at paragraphs 214–217 above, Crols discloses a conventional quadrature downconverter in Figure 12(b) (annotated below), comprising a second frequency down-conversion module (mixer) (annotated green), an electromagnetic signal (annotated purple), and a quadrature-phase oscillating signal (“Q” signal from Quadrature Generator) (annotated orange).

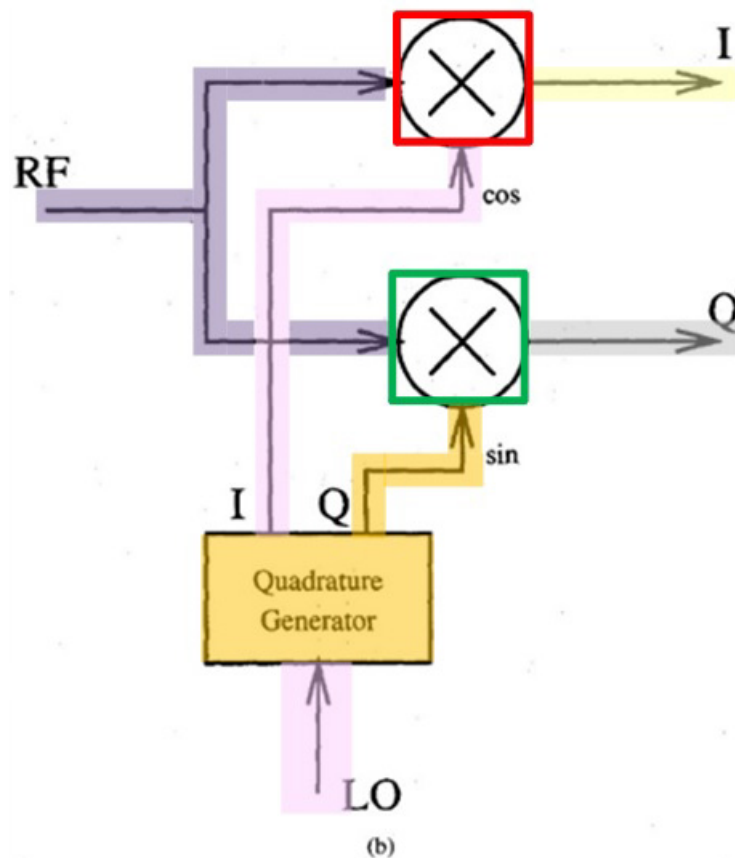


Fig. 12. (a) The conventional quadrature downconverter. (b) an alternative structure.

253. As I explained with respect to elements [1J], in Section XI.B.2.k, at paragraphs 223–227, Crols discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) coupled to a storage module

(capacitor C_V) (annotated brown), and a POSITA would have found it obvious to use the basic mixer topology disclosed in Figure 17 in a conventional quadrature downconverter, such as that shown in Figure 12(b).

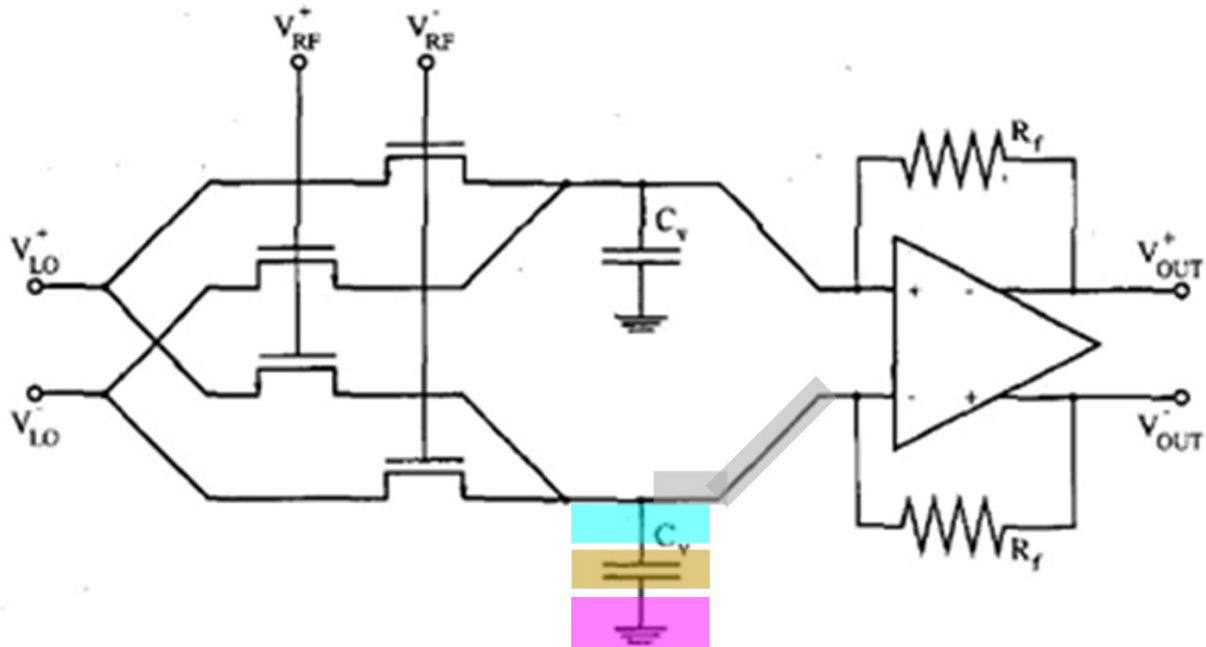


Fig. 17. The highly linear mixer topology.

254. As further explained with respect to element [1J], in Section XI.B.2.k, at paragraphs 223–227 above, Crols discloses the mixer topology of Figure 17 had a “second sampled signal” (annotated gray above) along the line to which capacitor C_V is coupled. Crols at 1487–88 (“Fig. 11. Direct sampling of the low-IF signal”), 1490 (“This effect can however easily be eliminated by performing a closely matched digital AGC operation on the sampled low frequency I- and Q-signals in the DSP” (emphasis added)), 1491. Crols thus discloses “said second storage first port being connected to said second sampled signal.”

g. [3F] and said second storage second port is connected to a second reference potential.

255. Crols (Ex. 1006) renders obvious element [3F].

256. As explained with respect to element [1I] and [3A], in Sections XI.B.2.j and XI.B.4.b, at paragraphs 222 and 233-237 above, Crols discloses a mixer topology in Figure 17 (annotated below) that comprises a switch (CMOS transistor) coupled to a “storage module” (capacitor C_v) (annotated brown), and a POSITA would have found it obvious to use the basic mixer topology disclosed in Figure 17 in place of a second mixer in a conventional quadrature downconverter, such as that shown in Figure 12(b) (annotated green above). Crols thus discloses a “second storage module” / “said second storage device.”

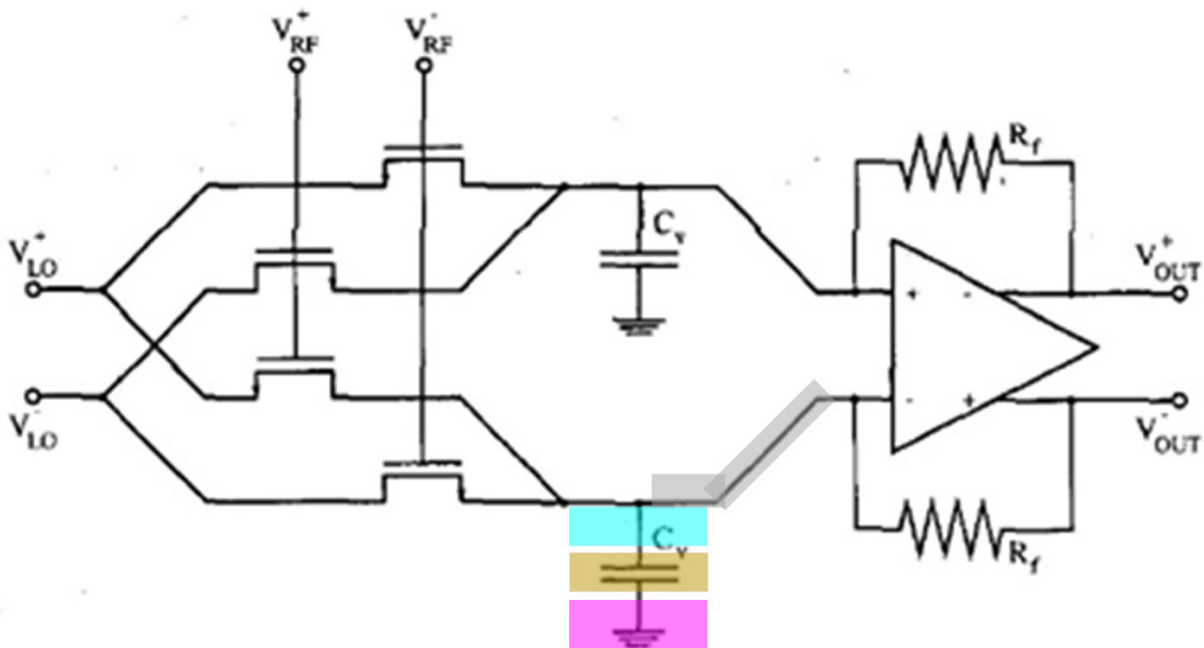


Fig. 17. The highly linear mixer topology.

257. Crols further discloses that Capacitor C_V has a “second storage second port” in the form of a bottom electrical connection (annotated magenta above), which is connected to a ground terminal.

258. A POSITA would have understood that the ground terminal is a common type of reference potential in electrical circuits, and is used as a reference potential in Crols’ mixer topology shown in Figure 17. Crols at 1491. Therefore, a POSITA would have understood that Crols discloses “said second storage second port [] connected to a second reference potential.”

5. Claim 4

- a. The cable modem of claim 3, wherein said first storage device is a first capacitor, and said second storage device is a second capacitor.*

259. Crols (Ex. 1006) renders obvious claim 4.

260. Crols renders obvious “[t]he cable modem of claim 3” for the reasons I exemplified Section XI.B.4, at paragraphs 232–258 above. More specifically, a POSITA would have found it obvious to use the mixer topology of Crols’ Figure 17 in place of each of the mixers in Crols’ conventional quadrature downconverter, shown in Figure 12(b), thus rendering obvious each of the limitations of claim 3.

261. As I explained with respect to elements [1F], [1I], [3A], and [3D], in Sections XI.B.2.g, XI.B.2.j, XI.B.4.b, XI.B.4.e, at paragraphs 212–213, 222, 233–237, and 246–250 above, Crols renders obvious “said first storage device” and

“said second storage device.” That is, the mixer topology of Crols’ Figure 17 includes a capacitor (capacitor C_V), and so in the implementation of that mixer topology in place of each of the mixers in Crols’ conventional quadrature downconverter, Crols’ downconverter would include one instance of capacitor C_V as a first storage device in a first frequency down-conversion modulation (the mixer topology used in place of the “I” channel mixer in Crols’ Figure 12(b)) and another instance of capacitor C_V as a second storage device in a second frequency down-conversion modulation (the mixer topology used in place of the “Q” channel mixer in Crols’ Figure 12(b)).

6. Claim 5

- a. The system of claim 3, wherein said first reference potential is substantially equal to ground, and said second reference potential is substantially equal to ground.*

262. Crols (Ex. 1006) renders obvious claim 5.

263. Crols renders obvious “[t]he system modem of claim 3” for the reasons I exemplified Section XI.B.4, at paragraphs 232–258 above. More specifically, a POSITA would have found it obvious to use the mixer topology of Crols’ Figure 17 in place of each of the mixers in Crols’ conventional quadrature downconverter, shown in Figure 12(b), thus rendering obvious each of the limitations of claim 3.

264. As I explained with respect to elements [3C] and [3F], in Sections XI.B.4.d and XI.B.4.g, at paragraphs 242–245 and 255–258 above, Crols renders obvious “said first storage second port is connected to a first reference potential” and “said second storage second port is connected to a second reference potential.”

265. The mixer topology of Crols’ Figure 17 includes a capacitor (capacitor C_V), and so in the implementation of that mixer topology in place of each of the mixers in Crols’ conventional quadrature downconverter, Crols’ downconverter would include one instance of capacitor C_V as a first storage device in a first frequency down-conversion modulation (the mixer topology used in place of the “I” channel mixer in Crols’ Figure 12(b)) and another instance of capacitor C_V as a second storage device in a second frequency down-conversion modulation (the mixer topology used in place of the “Q” channel mixer in Crols’ Figure 12(b)).

266. In both instances, the storage device (capacitor C_V) has a second port connected to a reference potential (ground terminal). A POSITA would have understood that the ground terminal is a common type of reference potential in electrical circuits, and is used as a reference potential in Crols’ mixer topology shown in Figure 17. Crols at 1491. Further, a POSITA would have understood that the ground terminal is equal to ground and therefore provides a reference potential that is at least substantially equal to ground.

267. As a result, Crols renders obvious “said first reference potential is substantially equal to ground, and said second reference potential is substantially equal to ground.” Accordingly, Crols renders obvious claim 5.

XII. CONCLUSION

268. For all the reasons I have explained above, it is my opinion that (1) all of Challenged Claims 1–5 of the ’835 patent are unpatentable because they are rendered obvious by Gibson in view of Schiltz (and to the extent the Board determines that “cable modem” in the preamble of claim 1 is limiting, then in further view of one or more of Goldberg, Thacker, ITU-T J.83, and the AAPA); and (2) all of Challenged Claims of 1–5 of the ’835 patent are unpatentable because they are rendered obvious by Crols.

269. 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. I further declare that these statements were made with the knowledge that willfully false statements and the like are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code.

Dated: November 14, 2023

By: 

Dr. Lawrence E. Larson

Lawrence E. Larson, Ph.D.

Sorensen Family Dean of Engineering – Emeritus
Professor of Engineering
School of Engineering
Brown University
Providence, RI 02906
401-368-8211

Education

1996	M.B.A.(Exec.)		University of California – Los Angeles
1986	Ph.D.	Electrical Engineering	University of California – Los Angeles
1980	M. Eng.	Electrical Engineering	Cornell University
1979	B.S.	Electrical Engineering	Cornell University

Professional Appointments

1/2023 – 6/2023 Interim Provost, Brown University

The Provost is Chief Academic Officer and Chief Budget Officer for Brown University and is responsible for academic and research excellence; sound budgetary practices; and oversight for all programs in all academic departments, research centers, and interdisciplinary institutes. The annual budget for Brown is \$1.5B, with 10,000 students, 1600 faculty and 3200 staff. The Provost also oversees the academic and fiscal operations of the Undergraduate College, Graduate School, Warren Alpert Medical School, School of Public Health, School of Engineering and School of Professional Studies. The Provost's Office currently is pursuing a significant expansion of Brown's research profile through increased collaborative partnerships, research funding from corporations and new strategic directions.

1/2021– Present Chairman of the Board, Slater Technology Fund, Providence, Rhode Island

The Slater Technology Fund is an evergreen not-for-profit venture development seed fund dedicated to advancing early-stage technology ventures in Rhode Island, with the overall objective of economic growth and workforce development. Slater has invested nearly \$50M in recent years, with follow-on funding raised by portfolio companies close to \$1B.

7/2011 – 8/2022 Sorensen Family Dean and Founding Dean, School of Engineering, Brown University and Professor of Engineering.

The Brown School of Engineering was created in 2010 from the historic Division of Engineering. I was recruited as Founding Dean in 2011, and in that role accomplished the following:

- **Growth of Faculty and Research** – Grew research funding in the School of Engineering from ~\$13M/yr. in 2010 to ~\$27M/yr. in 2022. Led diversification of funding sources from the NSF only to include the DoD, NIH, NIST, DoE, DoT and foundations. Doubled external corporate support for research in the SoE. Grew the tenured/tenure-track faculty from 39 FTE to 56 FTE from 2011-2022. Recruited and hired almost 50% of the current faculty in all areas of the School. Doubled the number of women faculty and recruited the first tenure-track Black and Hispanic faculty in the 150+ year history of engineering at Brown University.

APPENDIX A

- **Fundraising, Design and Construction of New Engineering Research Building** – Led the fundraising, design, architect selection, planning and construction of \$88M, 80,000 sq. ft. laboratory building, doubling the research capacity of the School of Engineering. The building was occupied in Oct. 2017 (four months ahead of schedule). The design process was highly collaborative, involving input from students, staff and faculty; and the results have been outstanding – a highly functional building that invites collaboration and engagement with the community. The design and execution were so innovative that it was one of only five buildings in the nation chosen for the annual *Architectural Record* “Colleges and Universities” issue in Nov2018. This was the first new engineering building in over 50 years on the Brown campus.
- **Growth of Fundraising** – Built the entire School of Engineering fundraising organization “from scratch,” including alumni outreach, targeted communications, campaign development, and donor engagement. Led the team that raised over \$160M as of 10/2022, including entire funding of an \$88M laboratory building, and gifts/pledges for ten endowed Chairs and the Nelson center for Entrepreneurship. Increased the number of annual donors to Brown engineering from ~30 per year in 2011 to over 600 per year in 2022.
- **Growth of the Graduate Program** – Dramatically increased the size of the Engineering Master’s degree program, from 40 students per year to nearly 200 students per year) led PhD program growth of roughly 30%; and created three successful new Master Programs:
 - Master in Technology Leadership (MTL) – Led the development and launch (March 2017) of the Brown Master in Technology Leadership. This “blended” transformational executive course provides leadership training for mid-career professionals in science and technology, grounded in an ethos of liberal learning with a global perspective.
 - Joint Brown-Rhode Island School of Design (RISD) Master Program in Design Engineering (MADE) - Led the creation of the first joint Brown-RISD degree program in the history of the two institutions. This unique program brings together the strengths of the two institutions to train students in the emerging field of Design Engineering. The first cohort started in June of 2021.
 - Master in Data-Enabled Computational Engineering and Science (DECES). - Created a program that provides students with understanding of the significant role that advanced data-driven simulation plays in industry and national laboratories. Students gain technical knowledge of the foundational subjects in computational engineering, including nonlinear finite element analysis and the integration of machine learning and data science. The first cohort started in June of 2022
- **Creation of Innovative Co-Curricular Programs**
 - Led the creation of the Brown Design Workshop (BDW) – one of the leading “maker spaces” in the nation, which has over 1,800 members from Brown and RISD and occupies over 8,000 square feet of workspace. The BDW is a campus hub for innovation, entrepreneurship, hacking and exploring new ideas. Faculty and students from across the campus use the Brown Design Workshop and it is an integral part of courses taught in engineering (8 courses), computer science, visual arts, music, English, history of art and architecture, and American studies.
 - Led the creation of the Nelson Center for Entrepreneurship – which coordinates and enables entrepreneurial efforts in all areas of campus: science, technology, the arts, social sciences,

APPENDIX A

graduate, undergraduate and faculty. Developed the initial proposal as part of a multi-year campus-wide planning, which resulted in a \$25M gift, recruitment of a founding director and launch of the Center in fall 2015.

- Rejuvenation of Student Organizations in the School of Engineering – Doubled funding for student co-curricular funding from 2011-2018, in support of 17 student organizations. Led the efforts to create Brown student chapters of National Society for Black Engineers (NSBE) and Society of Hispanic Professional Engineers (SHPE), which are thriving and serve as important support networks.
- **Creation of a Supportive Environment for Diversity, Equity and Inclusion**
 - Faculty – Initiated a vigorous program for recruiting and retaining a more diverse faculty in engineering. We more than doubled the number of women faculty in engineering, recruited two Black faculty (the first two in Brown engineering history) and three Hispanic faculty members. We fundraised for the first endowed Chairs in Brown's history for three of our distinguished women faculty.
 - Graduate Students – We created one of the most diverse engineering student bodies in American academia. ASEE reported in 2017 that the gender balance of our MS program was the best in the nation. The gender balance of our PhD program is roughly 34% women compared to the national average of roughly 20%. We more than doubled the diversity of our PhD population from historically underrepresented groups (from 3% to 7%).
 - Undergraduate Students – We created a welcoming and supportive environment for all students, and increased the fraction of undergraduates from diverse backgrounds from 10% in 2012 to 28% in 2018 (tops in the Ivy League). And the gender balance has risen to well over 40%. Both of these figures are roughly double the national average.
- **Enhanced Operational Excellence**
 - New Business Model - I developed a completely new business model for the School of Engineering - creating greater incentives for research excellence, more efficient use of research space, and transparent and collaborative budget planning. We did this while maintaining the close and collaborative ties between the School of Engineering and the rest of Brown, and maintained a budget surplus during all subsequent years of operation.
 - School of Engineering Strategic Plan – Developed new five-year plan for the School of Engineering in 2015. Engaged all stakeholders (faculty, staff, alums, industry partners, administration, students) to develop a complete vision of the direction for the School. Identified key areas for School growth and new technical directions for collaborative research at Brown.
 - Staff Reorganization – conducted a thorough staff review and overhaul of the entire School of Engineering in 2013-2014. Realigned administrative responsibilities, removed redundancies, improved customer service and reduced costs.
- **Developed External Partnerships** – Created the School of Engineering Industrial Advisory Board (IAB), with roughly 20 members. The IAB provides strategic advice for the School, research

APPENDIX A

engagement with our faculty, and job and internship opportunities for our students. Created an annual Engineering Career Fair to provide networking and career opportunities for engineering students.

7/2011 – Present Professor of Engineering – Brown University

My research program at Brown University developed integrated circuits and systems for next-generation wireless brain-computer interfaces. Early versions of these devices are in clinical trials; recent versions have achieved unprecedented data rates and functionality. During my career: published ~400 papers in journals, refereed conference proceedings, graduated 31 PhD students, received 43 US patents, and earned a current H-index of 72 (Google Scholar).

7/2007 - 7/2011 Chair, Department of Electrical and Computer Engineering (ECE) – University of California – San Diego, Jacobs School of Engineering

The ECE Department at UCSD is the largest graduate program on the UCSD campus, with over \$25M in funding (2011), 500 graduate students and 600 undergraduates.

- Oversaw faculty development (hiring, promotion and tenure process), educational policy and teaching, a successful accreditation review, resource allocation, and external relations (including fundraising for one endowed chair).
- Led the development (with Computer Science) of the new Executive Master of Advanced Study in Embedded Wireless Systems program.

7/2001 -7/2006 Director – UCSD Center for Wireless Communications

The UCSD Center for Wireless Communications is the largest industry-funded university research centers in the nation. The CWC conducts research in all areas of wireless communications, from fundamental devices and materials to software applications

- I supported the work of over 20 professors and roughly 50 PhD graduate students per year during my tenure, and with an annual budget in excess of \$3M..
- During my tenure as Director we received support from more than 18 corporate members - both domestic and international. I was responsible for all aspects of the Center, from new member development and fundraising, to financial management and establishing the research direction.

7/1996 - 7/2011 CWC Industry Chair Professor in Wireless Communications, Department of Electrical and Computer Engineering, University of California - San Diego.

Research Program at UCSD for Professor Larson:

- I developed improved integrated circuit techniques and novel semiconductor device structures for wireless communications applications. This required development of high-frequency integrated circuits, devices, and packaging techniques for ultra-wide bandwidth telecommunications applications, and development of novel data converter and analog-signal

APPENDIX A

processing architectures that are matched to communications applications. Many of these technologies were licensed to commercial wireless companies.

- Graduated 30 UCSD PhD students since arriving at UCSD in 1996. Published over 350 papers during this period and over 40 US patents.

2004-2005 Distinguished Visiting Professor – TU Delft, Netherlands (on sabbatical from UCSD)

Developed novel new microwave tuning technology, with unparalleled linearity and performance

2000-2001 Director – IBM Research West Coast Design Center of Excellence (on leave from UCSD)

- Led the international team that developed a complete Wideband CDMA chip set for several “first tier” cellular telephone providers, in partnership with Mitsubishi Electric, Osaka, Japan
- Directed development of SiGe Radio Frequency ICs for third-generation wireless cellular applications

1994-1996 Manager, Telecommunications Technology Department, Microwave Devices and Circuits Laboratory, Hughes Research Laboratories, Malibu, CA

- Directed research and development of integrated circuits for commercial RF and microwave communications applications, including DBS, cellular telephone, Very Small Aperture Terminal (VSAT) and PCS
- At Hughes Network Systems (Germantown, MD), I led the development of an RFIC design center for communications applications, including the first high volume DirecTV satellite receiver
- Responsible for the technical direction of the corporate partnership with IBM on Si/SiGe HBT technology. This partnership led to multiple system insertions in defense and commercial systems in subsequent years.
- Led the team that demonstrated the first microwave ICs in SiGe HBT technology (amplifiers, mixers, VCOs, frequency dividers) in the 5-25 GHz frequency range.

1988 – 1994 Manager, HEMT Technology Department, Microwave Devices and Circuits Laboratory, Hughes Research Laboratories, Malibu, CA

Directed research in high-speed III-V materials, devices, and circuits, and was responsible for approximately \$4M/yr. in Corporate IR&D and Government Research Contracts.

- Developed the first space-qualified InP low-noise millimeterwave HEMT. This effort was awarded the 1996 Lawrence Hyland Award - the highest technical achievement award at Hughes Electronics. These devices are still used in defense satellite crosslink communications systems.
- Developed the first micromachining (RFMEMS) switch and tuner applications for RF and microwave applications (1991). This technology has now become an extremely active area of worldwide research and development, is a common feature in many high-end cellular telephones, and I hold many fundamental patents in the field. The market for RF MEMS devices now exceeds \$1B (FY22)

APPENDIX A

- I established and ran a state-of-the-art InP HEMT MMIC foundry at HRL – from materials growth, lithography, device fabrication, process development, packaging and test. Devices and circuits from this foundry had many aerospace and research system insertions, and the foundry continues operation today.
- Developed some of the first advanced RF/Microwave CMOS technology with performance comparable to III-V technology (1991).
- Directed the research program that demonstrated HEMTs with record f_T 's and f_{MAX} 's above 300 GHz (1993). This produced the highest frequency room temperature integrated circuit ever reported - a 210 GHz VCO (1994).

1992– 1994 Assistant Manager - DARPA / Hughes MIMIC Program

Responsible for Program Management of Advanced Technology Portion of DARPA/Hughes MIMIC Program, with a budget of approximately \$8M/yr. I led the systems insertions research roadmap of GaAs PHEMT and MESFET technology into airborne phased-array radar applications.

1988 – 1992 Adjunct Associate Professor – UCLA

Responsible for senior level digital and analog integrated circuit design courses and graduate analog MOS integrated circuit design course; supervised student PhD research

1980– 1988 Member of Technical Staff, Hughes Research Laboratories, Malibu, CA

Responsible for development of CMOS and III-V analog and digital integrated circuits, modeling and characterization of MESFETs and HEMTs, and development of improved III-V process techniques.

Primary Published Work

Refereed Journal Articles

- 1 W. W. Cheng and L. E. Larson, "A Low-Frequency CMOS Triangle Wave Generator", IEEE J. Solid-State Circuits, SC-20 (2), 649-652 (1985).
- 2 L. E. Larson, R. J. Burns, M. E. Levy, and W. W. Cheng, "An Analog CMOS Autopilot", IEEE J. Solid-State Circuits, SC-20 (2), 571-578 (1985).
- 3 L. E. Larson, J. F. Jensen, and P. T. Greiling, "GaAs High-Speed Digital IC Technology: An Overview", (invited) IEEE Computer – special issue on GaAs computer architecture, pp. 85-94 (1986).
- 4 L. E. Larson, G. C. Temes, and S. Law, "Comparison of Amplifier Gain Enhancement Techniques for GaAs MESFET Analogue Integrated Circuits", Electronic Letters, 22 (21), 1138-1139 (1986).
- 5 L. E. Larson and G. C. Temes, "Switched-Capacitor Gain Stage with Reduced Sensitivity to Finite Amplifier Gain and Offset Voltage", Electronic Letters, 22 (24), 1281-1283 (1986).
- 6 L. E. Larson, "An Improved GaAs MESFET Equivalent Circuit Model for Analog Integrated Circuit Applications", IEEE J. of Solid-State Circuits, SC-22 (4), 567-574 (1987).
- 7 L. E. Larson, K. W. Martin, and G. C. Temes, "GaAs Switched-Capacitor Circuits for High-Speed Signal Processing", IEEE J. of Solid-State Circuits, SC-22 (6), 971-981 (1987).
- 8 L. E. Larson, T. Cataltepe, and G. C. Temes, "Multibit Oversampled Σ - Δ A/D Converter With Digital Error Correction", Electronics Letters, 24 (16), 1051-1052 (1988).
- 9 L. E. Larson, C. S. Chou, and M. J. Delaney, "An Ultrahigh-Speed GaAs MESFET Operational Amplifier", IEEE J. Solid-State Circuits, 24 (6), 1523-1528 (1989).
- 10 A. S. Brown, U. K. Mishra, C. S. Chou, C. E. Hooper, M. A. Melendes, M. Thompson, L. E. Larson, S. E. Rosenbaum, and M. J. Delaney, "AlInAs-GaInAs HEMTs Utilizing Low-Temperature AlInAs Buffers Grown by MBE", IEEE Electron Devices Letters, 10 (12), 565-567 (1989).
- 11 M. J. Delaney, C. S. Chou, L. E. Larson, J. F. Jensen, D. S. Deakin, A. S. Brown, W. W. Hooper, M. A. Thompson, L. G. McCray, and S. E. Rosenbaum, "Low-Temperature Buffer GaAs MESFET Technology for High-Speed Integrated Circuit Applications", IEEE Electron Device Letters, 10 (8), 355-357 (1989).
- 12 R. H. Walden, A. E. Schmitz, A. R. Kramer, L. E. Larson, and J. Pacsiecznik, "A Deep-Submicrometer Analog-to-Digital Converter Using Focused Ion Beam Implants", IEEE J. of Solid-State Circuits, 25 (2), 562-571 (1990).
- 13 A. E. Schmitz, R. H. Walden, L. E. Larson, S. E. Rosenbaum, R. A. Metzger, J. R. Behnke, and P. A. MacDonald, "A Deep –Submicrometer Microwave/Digital CMOS/SOS Technology", IEEE Electron Device Letters, 12 (1), 16-17 (1991).
- 14 G. M. Atkinson, R. L. Kubena, L. E. Larson, L. D. Nguyen, F. P. Stratton, L. M. Jelloian, M. V. Le, and H. McNulty, "Self-Aligned High Electron Mobility Transistor Gate Fabrication Using Focused Ion Beams, J. Vac. Sci. Technol. B, 9 (6), 3506-3510 (1991).
- 15 L. D. Nguyen, A. S. Brown, M. A. Thompson, L. M. Jelloian, L. E. Larson, and M. Matloubian, "650-Å Self-Aligned-Gate Pseudomorphic Al_{0.48}In_{0.52}As/Ga_{0.20}In_{0.80}As High Electron Mobility Transistors", IEEE Electron Device Letters, 13 (3), 143-145 (1992).
- 16 L. D. Nguyen, L. E. Larson, and U. K. Mishra, "Ultra-High-Speed Modulation-Doped Field-Effect Transistors: A Tutorial Review", (Invited) Proc. Of the IEEE, 80 (4), 494-518 (1992).
- 17 A. S. Brown, J. A. Henige, A. E. Schmitz, and L. E. Larson, "Effect of Growth Conditions on the Electrical and Optical Properties of Al_xIn_{1-x}As (0.48 < x < 0.7)-Ga_{0.47}In_{0.53}As Heterostructures", Applied Physics Letters, 62 (1), 66-68 (1993).
- 18 M. Matloubian, A. S. Brown, L. D. Nguyen, M. A. Melendes, L. E. Larson, M. J. Delaney, J. E. Pence, R. A. Rhodes, M. A. Thompson, and J. A. Henige, "High-Power V-Band AlInAs/GaInAs on InP HEMTs", IEEE Electron Device Letters, 14 (4), 188-189 (1993).
- 19 J. J. Brown, A. S. Brown, S. E. Rosenbaum, A. S. Schmitz, M. Matloubian, L. E. Larson, M. A. Melendes, and M. A. Thompson, "Study of the Dependence of Ga_{0.47}In_{0.53}As/Al_xIn_{1-x}As Power HEMT Breakdown

- Voltage on Schottky Layer Design and Device Layout”, IEEE Transactions on Electron Devices, 40 (11), 2111-2112 (1993).
- 20 M. Matloubian, L. M. Jelloian, T. Liu, M. Lui, L. Larson, L. Nguyen, and M. Le, “GaInAs/InP Composite Channel HEMTs”, IEEE Transactions on Electron Devices, 40 (11), 2112 (1993).
- 21 L. E. Larson, M. Matloubian, J. J. Brown, A. S. Brown, R. A. Rhodes, D. Crampton, and M. A. Thompson, “AlInAs/GaInAs on InP HEMTs for Low Power Supply Voltage Operation of High Power-Added Efficiency Microwave Amplifiers”, Electronic Letters, 29 (15), 1324-1326 (1993).
- 22 S. E. Rosenbaum, L. M. Jelloian, L. E. Larson, U. K. Mishra, D. A. Pierson, M. A. Thompson, T. Liu, and A. S. Brown, “A 2 GHz Three Stage AlInAs-GaInAs-InP HEMT MMIC Low-Noise Amplifier”, IEEE Microwave and Guided Wave Letters, 3 (8), 265-267 (1993).
- 23 M. Matloubian, A. S. Brown, L. D. Nguyen, M. A. Melendes, L. E. Larson, M. J. Delaney, R. A. Rhodes, M. A. Thompson, R. A. Rhodes, and J. E. Pence, “20-GHz High-Efficiency AlInAs-GaInAs on InP Power HEMT”, IEEE Microwave and Guided Letters, 3 (5), 142-144 (1993).
- 24 L. Larson, L. Jelloian, S. Rosenbaum, A. Schmitz, M. Thompson, M. Lui, L. Nguyen, and U. Mishra, “Manufacturing Study of Yield and Performance Dependence on Gate Length for Submicron AlInAs-GaInAs HEMTs”, IEEE Transactions on Semiconductor Manufacturing, 6 (4), 380-383 (1993).
- 25 M. Matloubian, L. M. Jelloian, A. S. Brown, L. D. Nguyen, L. E. Larson, M. J. Delaney, M. A. Thompson, R. A. Rhodes, and J. E. Pence, “V-Band High-Efficiency High-Power AlInAs/GaInAs/InP HEMTs”, IEEE Transactions on Microwave Theory and Techniques, 41 (12), 2206-2210 (1993).
- 26 W. Lam, M. Matloubian, A. Kurdoghlian, L. Larson, C. Chou, L. Jelloian, A. Brown, M. Thompson, and C. Ngo, “High-Efficiency InP-Based HEMT MMIC Power Amplifier for Q-band Applications”, IEEE Microwave and Guided Wave Letters, 3 (11), 420-422 (1994).
- 27 S. E. Rosenbaum, B. K. Kormanyos, L. M. Jelloian, M. Matloubian, A. S. Brown, L. E. Larson, L. D. Nguyen, M. A. Thompson, L. P.B. Katehi, and G. M. Rebeiz, “155- and 213- GHz AlInAs/GaInAs/InP HEMT MMIC Oscillators”, IEEE Transactions on Microwave Theory and Techniques, 43 (4), 927-932 (1995).
- 28 W. Lam, M. Matloubian, A. Igawa, C. Chou, A. Kurdoghlian, C. Ngo, L. Jelloian, A. Brown, M. Thompson, and L. Larson, “44-GHz High-Efficiency InP-HEMT MMIC Power Amplifier”, IEEE Microwave and Guided Wave Letters, 4 (8), 277-278 (1994).
- 29 K. Kaviani, A. Madhukar, J. J. Brown, and L. E. Larson, “Realisation of Doped-Channel MISFETs with High Breakdown Voltage in AlGaAs/InGaAs Based Material System”. Electronic Letters, 30 (8), 669-670 (1994).
- 30 Lawrence E. Larson, “Integrated Circuit Technology Options for RFIC’s – Present Status and Future Directions”, J. Solid-State Circuits, vol. 33, no. 3, pp. 387-399, (March 1998).
- 31 Lawrence E. Larson, “Applications of Advanced Si/SiGe Technology for High-Frequency Communications Systems”, J. Vac. Sci. Techn. B., 16 (3), 1541-1548, (1998).
- 32 A. Jayaraman, P. Chen, G. Hanington, L. Larson, and P. Asbeck, “Linear High-Efficiency Microwave Power Amplifiers Using Bandpass Delta-Sigma Modulators”, IEEE Microwave and Guided Wave Letters, 8 (3), 121-123, (1998).
- 33 L. Larson, “Radio Frequency Integrated Circuit Technology”, IEEE Personal Communications Magazine, Vol 5, no. 3, pp. 11-19, (June 1998).
- 34 R. Langridge, T. Thornton, P. Asbeck, and L. Larson, “A Power Re-Use Technique for Improved Efficiency of Outphasing Microwave Power Amplifiers,” IEEE Transactions on Microwave Theory and Techniques, August 1999, Vol. 47, No. 8, pp. 1467-1471.
- 35 G. Hanington, P.F. Chen, P. Asbeck, and L. Larson, “High-Efficiency Power Amplifier Using Dynamic Power-Supply Voltage for CDMA Applications,” IEEE Transactions on Microwave Theory and Techniques, August 1999, Vol. 47, No. 8, pp. 1471-1476.
- 36 L.C.N. de Vreede, H.C. de Graaff, J.A. Willenmen, W. van Noort, H.F.F. Jos, L.E. Larson, J.W. Slotboom and J.L. Tauritz, “Bipolar Transistor Epilayer Design Using the MAIDS Mixed Level Simulator,” IEEE Journal of Solid-State Circuits, vol. 34, pp. 1331-1338, no. 34, Sept. 1999.

APPENDIX A

- 37 L. Larson, P. Asbeck, G. Hanington, E. Chen, A. Jayaraman, R. Langridge, and Xuejun Zhang, "Device and Circuit Approaches for Improved Wireless Communications Transmitters," IEEE Personal Communications, vol. 6, no.5, pp. 18-23, Oct. 1999.
- 38 M. Sushchik, N. Pulkov, L. Larson, L. Tsimring, H. Abarbanel, K. Yao, and A. Volkovskii, "Chaotic Pulse Position Modulation: A Robust Method of Communicating with Chaos," IEEE Communication Letters, vol. 4, no. 4, pp. 128-130, April 2000.
- 39 X. Zhang and L. Larson, "Gain and Phase Error-Free LINC Transmitter," IEEE Transactions on Vehicular Technology, vol. 49, no. 5, pp. 1986-94, Sept. 2000.
- 40 L. Sheng, J.C. Jensen, and L. Larson, "A wide-bandwidth Si/SiGe HBT direct conversion sub-harmonic mixer/downconverter," IEEE Journal of Solid-State Circuits, vol. 35, no. 9, pp. 1329-1337, Sept. 2000.
- 41 G. Niu, S. Zhang, J.D. Cressler, A. Joseph, J. Fairbanks, L. Larson, C. Webster, W.E. Ansley, D.L. Hareme, "Noise parameter modeling and SiGe profile design tradeoffs for RF applications (HBT's)." IEEE Transactions on Electron Devices, vol. 47, no. 11, pp. 2037-2044, Nov. 2000.
- 42 D.C. Laney, L. Larson, P. Chan, J. Malinowski, D. Hareme, S. Subbanna, R. Volant, M. Case, "Microwave transformers, inductors, and transmission lines implemented in a Si/SiGe HBT process," IEEE Transactions on Microwave Theory & Techniques. Aug. 2001, pp. 1507-1510
- 43 J.C. Jensen and L. Larson, "A broadband 10 GHz track-and-hold in Si/SiGe HBT technology," IEEE Journal of Solid-State Circuits, vol. 36, pp. 325-330, March 2001.
- 44 M. Iwamoto, A. Jayaraman, G. Hanington, P.F. Chen, A. Bellora, W. Thornton, L. Larson, and P. Asbeck, "Bandpass delta-sigma Class-S amplifier," Electronic Letters, vol. 36, no. 12, pp. 1010-1012, June 2000.
- 45 W.T. Thornton and L. Larson, "An improved 5.7 GHz ISM-band feedforward amplifier utilizing vector modulators for phase attenuation control," Microwave Journal, vol. 42, no. 12, pp. 96,98,102,104,106, Dec. 1999.
- 46 X. Zhang, L. Larson, and P. Asbeck, "Calibration scheme for LINC transmitter," Electronics Letters, vol. 37, no. 5, pp. 317-318, March 2001.
- 47 X. Zhang, L. Larson, P. Asbeck, and P. Nanawa, "Gain/Phase Imbalance-Minimization Techniques for LINC Transmitters," IEEE Transactions On Microwave Theory and Techniques, vol. 49, no. 12, pp. 2507-2516, December 2001.
- 48 P. Asbeck, L. Larson, and I. Galton, "Synergistic Design of DSP and Power Amplifiers for Wireless Communications," IEEE Transactions On Microwave Theory and Techniques, vol. 49, no. 11, pp. 2163-2169, November 2001.
- 49 M. Iwamoto, A. Williams, P.-F. Chen, A. Metzger, L. Larson, and P. Asbeck, "An Extended Doherty Amplifier with High Efficiency over a Wide Power Range," IEEE Transactions On Microwave Theory and Techniques, vol. 49, no. 12, pp. 2472-2479, December 2001.
- 50 M. Vaidyanathan, M. Iwamoto, L. Larson, P. Gudem, and P. Asbeck, "A Theory of High-Frequency Distortion in Bipolar Transistors," IEEE Transactions On Microwave Theory and Techniques, vol. 51, no. 2, Feb, 2003., pp 278-293.
- 51 D. Jessie and L. Larson, "An improved leaded small outline package and equivalent circuit," IEEE Microwave and Wireless Components Letters, Volume 13, Issue 7, July 2003 Pp.:273 – 275 (From A.I.58)
- 52 D. Jessie and L. Larson "Conformal mapping for buried CPW with finite grounds." Electronics Letters, vol.37, (no.25), IEE, 6 Dec. 2001. p.1521-3.
- 53 X. Zhang, L. Larson, P. Asbeck, and R. Langridge, "Analysis of Power Recycling Techniques for RF and Microwave Outphasing Power Amplifiers," IEEE Transactions on Circuits & Systems II-Analog & Digital Signal Processing, vol.49, no.5, May 2002, pp.312-20.
- 54 D. Laney, G. Mario Maggio, F. Lehmann, and L. Larson , "Multiple Access for UWB Impulse Radio with Pseudo-Chaotic Time Hopping," IEEE Journal on Selected Areas in Communications, December 2002, pp. 1692-1700.
- 55 S. Subbanna, G. Freeman, G.; Jae-Sung Rieh; Ahlgren, D.; Stein, K.; Dickey, C.; Mecke, J.; Bacon, P.; Groves, R.; Meghelli, M.; Soyuer, M.; Jagannathan, B.; Schonenberg, K.; Shwu-Jen Jeng; Joseph, A.; Coolbaugh, D.; Volant, R.; Greenberg, D.; Huajie Chen; Brelsford, K.; Hareme, D.; Dunn, J.; Larson, L.; Herman, D., Jr.; Meyerson, B. , "50-200 GHz silicon-germanium heterojunction bipolar transistor BICMOS technology and a computer-aided design environment for 2-50+ GHz very large-scale integration mixed-

- signal IC's," . Japanese Journal of Applied Physics, Part 1, vol.41, (no.2B), Japan Soc. Appl. Phys, Feb. 2002. p.1111-23.
- 56 D. Jessie and L. Larson, "An X-band small outline leaded plastic package for MMIC applications," IEEE Transactions on Advanced Packaging, vol.25, no.3, Aug. 2002, pp.439-47.
- 57 V. Aparin and L. Larson, "Analysis and Reduction of Cross-Modulation Distortion in CDMA Receivers," IEEE Transactions On Microwave Theory and Techniques, vol.51, no.5, May 2003, pp.1591-602.
- 58 R. Tenny, L. Tsimring, L. Larson and H Abarbanel, "Using distributed nonlinear dynamics for public key encryption," Physical Review Letters, vol.90, no.4, 31 Jan. 2003, pp.047.
- 59 L. Larson, "Silicon Technology Tradeoffs for Radio-Frequency/Mixed-Signal "Systems-on-a-Chip" (Invited Paper)" IEEE Transactions on Electron Devices, vol.50, no.3, March 2003, pp.683-9.
- 60 L. Sheng and L. Larson, "An SiGe BiCMOS Direct-Conversion Mixer with 2nd-Order and 3rd-Order Nonlinearity Cancellation for WCDMA Applications" IEEE Transactions On Microwave Theory and Techniques, Volume: 51 , Issue: 11 , Nov. 2003.
- 61 D.Y.C. Lie and L.E. Larson, "RF-SoC: Technology Enablers and Current Design Trends for Highly Integrated Wireless RF IC Transceivers," International Journal of Wireless and Optical Communications, Vol. 1, No. 1, (2003) pp. 1-23.
- 62 D. Mahli, L. Larson, Dawn Wang, C. Demirdag, and V. Pereira, "SiGe W-CDMA Transmitter For Mobile Terminal Application" IEEE Journal of Solid-State Circuits, Volume 38, Issue 9, Sept. 2003 Pp.:1570 – 1574
- 63 J. Jensen and L. Larson, "A 16GHz Ultra High-Speed Si/SiGe HBT Comparator," IEEE Journal of Solid-State Circuits, Volume 38, Issue 9, Sept. 2003 Pp.:1584 – 1589
- 64 V. Leung, L. Larson and P. Gudem, "An Improved Digital-IF Transmitter Architecture for Highly-Integrated W-CDMA Mobile Terminals," IEEE Transactions on Vehicular Technology, Volume 54, Issue 1, Jan. 2005 Pp.:20 – 32
- 65 V. Leung, L. Larson, and P. Gudem, "Digital-IF WCDMA Handset Transmitter IC in 0.25um SiGe BiCMOS," IEEE Journal of Solid-State Circuits. Volume 39, Issue 12, Dec. 2004 Pp.:2215 – 2225
- 66 C. Wang, M. Vaidyanathan and L. Larson, "A Capacitance Compensation Technique for Improved Linearity in CMOS Class-AB Power Amplifiers," IEEE Journal of Solid-State Circuits, Volume 39, Issue 11, Nov. 2004 Pp.:1927 – 1937.
- 67 V. Aparin and L. Larson, "Modified Derivative Superposition Method for Linearizing FET Low-noise Amplifiers," IEEE Transactions on Microwave Theory and Techniques, Volume 53, Issue 2, Feb. 2005 Pp.:571 – 581
- 68 F. Wang, A. Yang, D. Kimball, L. Larson, and P. Asbeck, "Design of Wide Bandwidth Envelope Tracking Power Amplifiers for OFDM Applications," IEEE Transactions on Microwave Theory and Techniques, Volume 53, Issue 4, April 2005 Pp.:1244 – 1255.
- 69 J. Deng, P. Gudem, L. Larson, and P. Asbeck, "High-Average-Efficiency SiGe HBT Power Amplifier for WCDMA Handset Applications," IEEE Transactions on Microwave Theory and Techniques. Volume 53, Issue 2, Feb. 2005 Pp.:529 – 537
- 70 V. Leung, J. Deng, P. Gudem, and L. Larson, "Analysis of Envelope Signal Injection for Improvement of RF Amplifier Intermodulation Distortion", IEEE Journal of Solid-State Circuits, Volume 40, Issue 9, Sept. 2005 Pp.:1888 – 1894 From In Press
- 71 K. Gard, L. Larson, and M. Steer, "The Impact of RF Front-End Characteristics on the Spectral Regrowth of Communications Signals, IEEE Transactions on Microwave Theory and Techniques, Volume 53, Issue 6, Part 2, June 2005, pp. 2179 – 2186
- 72 Wang, F.; Kimball, D. F.; Popp, J. D.; Yang, A. H.; Lie, D. Y.; Asbeck, P. M.; Larson, L. E., "An Improved Power-Added Efficiency 19-dBm Hybrid Envelope Elimination and Restoration Power Amplifier for 802.11g WLAN Applications," , IEEE Transactions on Microwave Theory and Techniques, Volume 54, Issue 12, Part 1, Dec. 2006 Pp.:4086 – 4099
- 73 Neo, W.C.E.; Lin, Y.; Liu, X.-D.; De Vreede, L.C.N.; Larson, L.E.; Spirito, M.; Pelk, M.J.; Buisman, K.; Akhnoukh, A.; De Graauw, A.; Nanver, L.K.; "Adaptive Multi-Band Multi-Mode Power Amplifier Using Integrated Varactor-Based Tunable Matching Networks," IEEE Journal of Solid-State Circuits Volume 41, Issue 9, Sept. 2006, pp. 2166 – 2176

- 74 Junxiong Deng; Gudem, P.S.; Larson, L.E.; Kimball, D.F.; Asbeck, P.M.; "SiGe PA with dual dynamic bias control and memoryless digital predistortion for WCDMA handset applications," IEEE Journal of Solid-State Circuits, Volume 41, Issue 5, May 2006 Pp.:1210 – 1221
- 75 Ranjan, M.; Larson, L. E.; "Distortion Analysis of Ultra-Wideband OFDM Receiver Front-Ends," IEEE Transactions on Microwave Theory and Techniques, Volume 54, Issue 12, Part 2, Dec. 2006 Pp.:4422 – 4431
- 76 Kimball, D.F.; Jeong, J.; Hsia, C.; Draxler, P.; Lanfranco, S.; Nagy, W.; Linthicum, K.; Larson, L.E.; Asbeck, P.M.; "High-Efficiency Envelope-Tracking W-CDMA Base-Station Amplifier Using GaN HFETs" IEEE Transactions on Microwave Theory and Techniques, Volume 54, Issue 11, Nov. 2006 Pp.:3848 – 3856
- 77 Mahim Ranjan; Larson, L.E.; "A Low-Cost and Low-Power CMOS Receiver Front-End for MB-OFDM Ultra-Wideband Systems, IEEE J. of Solid-State Circuits, Volume 42, Issue 3, March 2007 Pp.:592 – 601
- 78 L. Larson, "Technology Enablers for Software-Defined Radios," IEICE Transactions, Vol.E89-B No.12 pp.3174-3178, 2007. Invited Journal Article
- 79 Buisman, K.; de Vreede, L. C. N.; Larson, L. E.; Spirito, M.; Akhnoukh, A.; Lin, Y.; Liu, X.; Nanver, L. K.; "A Monolithic Low-Distortion Low-Loss Silicon-on-Glass Varactor-Tuned Filter With Optimized Biasing," IEEE Microwave and Wireless Components Letters, Volume 17, Issue 1, Jan. 2007 Pp.:58 – 60
- 80 Feipeng Wang; Kimball, D.F.; Lie, D.Y.; Asbeck, P.M.; Larson, L.E.; "A Monolithic High-Efficiency 2.4-GHz 20-dBm SiGe BiCMOS Envelope-Tracking OFDM Power Amplifier," IEEE J. of Solid-State Circuits, Volume 42, Issue 6, June 2007 Pp.:1271 – 1281.
- 81 Jamp, J.I.; Larson, L.E., "A Coding Technique for the Spectral Shaping of Ultra-Wideband Time-Hopping Signals," IEEE Transactions on Vehicular Technology, Volume 56, Issue 4, Part 1, July 2007 pp.:1671 – 1682
- 82 T. Hung, D. Choi, L. Larson, and P. Asbeck, "CMOS Outphasing Class-D Amplifier With Chireix Combiner," IEEE Microwave and Wireless Components Letters, Volume 17, Issue 8, Aug. 2007, pp. 619 – 621.
- 83 Khatri, H.; Gudem, P. S.; Larson, L. E.; "Integrated RF Interference Suppression Filter Design Using Bond-Wire Inductors," IEEE Transactions on Microwave Theory and Techniques, Volume 56, Issue 5, Part 1, May 2008 Pp.:1024 – 1034
- 84 Kodkani, R. M.; Larson, L. E. "A 24-GHz CMOS Passive Subharmonic Mixer/Downconverter for Zero-IF Applications," IEEE Transactions on Microwave Theory and Techniques, Volume 56, Issue 5, Part 2, May 2008 Pp.:1247 – 1256.
- 85 C. Huang, L. De Vreede, F. Sarubbi, M. Popadic, K. Buisman, J. Qureshi, M. Marchetti, A. Akhnoukh, T. Scholtes, L. Larson, L. Nanver, "Enabling Low-Distortion Varactors for Adaptive Transmitters IEEE Transactions on Microwave Theory and Techniques, Volume 56, Issue 5, Part 1, May 2008 Pp.:1149 – 1163.
- 86 T. Hung, J. Rode, , L. Larson and P. Asbeck, "Design of H-Bridge Class-D Power Amplifiers for Digital Pulse Modulation Transmitters," IEEE Transactions on Microwave Theory and Techniques, Volume 55, Issue 12, Part 2, Dec. 2007 pp. 2845 – 2855.
- 87 C. Huang, K. Buisman, L. Nanver, F. Sarubbi, M. Popadić, T. Scholtes, H. Schellevis, L. Larson, and L. de Vreede, "A 67 dBm OIP3 Multi-stacked Junction Varactor," IEEE Microwave and Wireless Components Letters, Vol. 18, Issue: 11, 2008 , pp. 749 – 751
- 88 M. Farazian, P. Gudem, L. Larson, "A CMOS Multi-Phase Injection-Locked Frequency Divider for V-Band Operation," IEEE Microwave and Wireless Components Letters, Vol. 19 , Issue 4, 2009 , pp. 239 – 241.
- 89 H. Khatri, P. Gudem, L. Larson, "Distortion in Current Commutating Passive CMOS Downconversion Mixers," IEEE Transactions on Microwave Theory and Techniques, Volume: 57 , Issue: 11, 2009 , pp. 2671 – 2681
- 90 J. Jeong, D. Kimball, M. Kwak; P. Draxler, C. Hsia; C. Steinbeiser, T. Landon, O. Krutko, L. Larson, P. Asbeck, "High-Efficiency WCDMA Envelope Tracking Base-Station Amplifier Implemented With GaAs HVHBTs," IEEE Journal of Solid-State Circuits, Vol.: 44 , Issue: 10, 2009 , pp. 2629 – 2639

- 91 N. Kim, L. Larson, V. Aparin, "A Highly Linear SAW-Less CMOS Receiver Using a Mixer With Embedded Tx Filtering for CDMA," IEEE Journal of Solid-State Circuits, Volume: 44 , Issue: 8, 2009 , pp. 2126 – 2137
- 92 C. Huang, K. Buisman, M. Marchetti, L. Nanver, F. Sarubbi, M. Popadic, T. Scholtes, H. Schellevis, L. Larson, L. de Vreede, "Ultra Linear Low-Loss Varactor Diode Configurations for Adaptive RF Systems," IEEE Transactions on Microwave Theory and Techniques, Vol. 57 , Issue: 1, 2009 , pp. 205 – 215
- 93 N. Kim, V. Aparin, L. Larson, "A Resistively Degenerated Wideband Passive Mixer With Low Noise Figure and High IIP3," IEEE Transactions on Microwave Theory and Techniques, Vol: 58 , Issue: 4, 2010, pp. 820 – 830
- 94 M. Farazian, P. Gudem, L. Larson, "Stability and Operation of Injection-Locked Regenerative Frequency Dividers," IEEE Transactions on Circuits and Systems I: Regular Papers, 2010, Volume: 57 , Issue: 8, Publication Year: 2010 , Page(s): 2006 - 2019
- 95 S. Kim and L. Larson, "A 44-GHz SiGe BiCMOS Phase-Shifting Sub-Harmonic Up-Converter for Phased-Array Transmitters," IEEE Transactions on Microwave Theory and Techniques, Volume: 58 , Issue: 5 , Part: 1, 2010 , pp. 1089 – 1099
- 96 M. Farazian, B. Asuri and L. Larson, "A Dual-Band CMOS CDMA Transmitter Without External SAW Filtering," IEEE Transactions on Microwave Theory and Techniques, Volume: 58 , Issue: 5 , Part: 2, 2010, pp. 1349 – 1358
- 97 H. Khatri, P. Gudem, L. Larson, "An Active Transmitter Leakage Suppression Technique for CMOS SAW-less CDMA Receivers," IEEE Journal of Solid-State Circuits, Volume: 45 , Issue: 8, 2010 , Page(s): 1590 - 1601
- 98 Y. Hong; D. Kimball, P. Asbeck, J Yook; L. Larson, "Single-Ended and Differential Radial Power Combiners Implemented With a Compact Broadband Probe," IEEE Transactions on Microwave Theory and Techniques, Volume: 58 , Issue: 6, 2010 , pp.1565 – 1572
- 99 S. Park, L. Larson, L. Milstein, "An RF Receiver Detection Technique for Cognitive Radio Coexistence, Circuits and Systems II: Express Briefs, IEEE Transactions on Volume: 57, Issue: 8, 2010 , Page(s): 652 - 656
- 100 A. Afsahi, A. Behzad, V. Magoon, L. Larson, "Linearized Dual-Band Power Amplifiers With Integrated Baluns in 65 nm CMOS for a 2 x 2 802.11n MIMO WLAN SoC," IEEE Journal of Solid-State Circuits, Volume: 45 , Issue: 5, 2010 , pp. 955 – 966.
- 101 S. Park; Larson, L.E.; Milstein, L.B.; "Spectrum Broadening Due to Phase Noise Interaction in Cognitive Radio Systems, Communications Letters, Volume: 14 , Issue: 10, Publication Year: 2010 , Page(s): 891 - 89
- 102 H. Pan, L. Larson, "An Improved Broadband High Linearity SiGe HBT Differential Amplifier" IEEE Transactions on Circuits and Systems I: Regular Papers, vol.58, no.8, pp.1685-1694, Aug. 2011
- 103 N. Kim, V. Aparin and L. Larson, "Analysis of Asymmetry in MOSFET Small-Signal Amplifiers, IEEE Transactions on Circuits and Systems I: Regular Papers, vol.58, no.4, pp.668-676, April 2011
- 104 Kheirkhahi, A.; Naghshtabrizi, P.; Larson, L. E.; , "Stability Analysis of RF Power Amplifier Envelope Feedback," Circuits and Systems II: Express Briefs, IEEE Transactions on , vol.58, no.12, pp.852-856, Dec. 2011
- 105 Myoungbo Kwak; Kimball, D.F.; Presti, C.D.; Scuderi, A.; Santagati, C.; Yan, J.J.; Asbeck, P.M.; Larson, L.E.; , "Design of a Wideband High-Voltage High-Efficiency BiCMOS Envelope Amplifier for Micro-Base-Station RF Power Amplifiers," Microwave Theory and Techniques, IEEE Transactions on , vol.60, no.6, pp.1850-1861, June 2012
- 106 Huang, C.; Buisman, K.; Zampardi, P. J.; Larson, L. E.; de Vreede, L. C. N.; , "On the Compression and Blocking Distortion of Semiconductor-Based Varactors," Microwave Theory and Techniques, IEEE Transactions on , vol.60, no.12, pp.3699-3709, Dec. 2012
- 107 Nakatani, T.; Rode, J.; Kimball, D.F.; Larson, L.E.; Asbeck, P.M.; , "Digitally-Controlled Polar Transmitter Using a Watt-Class Current-Mode Class-D CMOS Power Amplifier and Guanella Reverse Balun for Handset Applications," Solid-State Circuits, IEEE Journal of , vol.47, no.5, pp.1104-1112, May 2012
- 108 Hassan, M.; Larson, L.E.; Leung, V.W.; Asbeck, P.M.; , "A Combined Series-Parallel Hybrid Envelope Amplifier for Envelope Tracking Mobile Terminal RF Power Amplifier Applications," Solid-State Circuits, IEEE Journal of , vol.47, no.5, pp.1185-1198, May 2012

- 109 Hassan, M.; Larson, L.E.; Leung, V.W.; Kimball, D.F.; Asbeck, P.M.; , "A Wideband CMOS/GaAs HBT Envelope Tracking Power Amplifier for 4G LTE Mobile Terminal Applications," Microwave Theory and Techniques, IEEE Transactions on , vol.60, no.5, pp.1321-1330, May 2012
- 110 Afsahi, A.; Larson, L.E., "Monolithic Power-Combining Techniques for Watt-Level 2.4-GHz CMOS Power Amplifiers for WLAN Applications," Microwave Theory and Techniques, IEEE Transactions on , vol.61, no.3, pp.1247,1260, March 2013
- 111 Abdelhalem, S.H.; Gudem, P.S.; Larson, L.E., "Hybrid Transformer-Based Tunable Differential Duplexer in a 90-nm CMOS Process," Microwave Theory and Techniques, IEEE Transactions on , vol.61, no.3, pp.1316,1326, March 2013
- 112 Agah, A.; Dabag, H.-T.; Hanafi, B.; Asbeck, P.M.; Buckwalter, J.F.; Larson, L.E., "Active Millimeter-Wave Phase-Shift Doherty Power Amplifier in 45-nm SOI CMOS," Solid-State Circuits, IEEE Journal of , vol.48, no.10, pp.2338,2350, Oct. 2013
- 113 Kheirkhahi, A.; Yan, J.J.; Asbeck, P.M.; Larson, L.E., "RF Power Amplifier Efficiency Enhancement by Envelope Injection and Termination for Mobile Terminal Applications," Microwave Theory and Techniques, IEEE Transactions on , vol.61, no.2, pp.878,889, Feb. 2013
- 114 Larson, L., "Thoughts on Gabor Temes," Solid-State Circuits Magazine, IEEE , vol.5, no.2, pp.16,17, June 2013
- 115 Abdelhalem, S.H.; Gudem, P.S.; Larson, L.E., "An RF–DC Converter with Wide-Dynamic-Range Input Matching for Power Recovery Applications," Circuits and Systems II: Express Briefs, IEEE Transactions on , vol.60, no.6, pp.336,340, June 2013.
- 116 Abdelhalem, S.H.; Gudem, P.S.; Larson, L.E., "Tunable CMOS Integrated Duplexer With Antenna Impedance Tracking and High Isolation in the Transmit and Receive Bands," Microwave Theory and Techniques, IEEE Transactions on , vol.62, no.9, pp.2092,2104, Sept. 2014.
- 117 Kheirkhahi, A.; Yan, J.J.; Asbeck, P.M.; Larson, L.E., "Improved Envelope Injection and Termination (EIT) RF Power Amplifier With Envelope Equalization for Mobile Terminal Applications," Microwave Theory and Techniques, IEEE Transactions on , vol.62, no.2, pp.341,351, Feb. 2014
- 118 Agah, A.; Jayamon, J.A.; Asbeck, P.M.; Larson, L.E.; Buckwalter, J.F., "Multi-Drive Stacked-FET Power Amplifiers at 90 GHz in 45 nm SOI CMOS," Solid-State Circuits, IEEE Journal of , vol.49, no.5, pp.1148,1157, May 2014
- 119 Thomas, C.M.; Larson, L.E., "A CMOS Broadband Distributed N-Path Tunable Bandpass Filter," Microwave and Wireless Components Letters, IEEE , vol.24, no.8, pp.542,544, Aug. 2014
- 120 Ming Yin, David A. Borton, Jacob Komar, Naubahar Agha, Yao Lu, Hao Li, Jean Laurens, Yiran Lang, Qin Li, Christopher Bull, Lawrence Larson, David Rosler, Erwan Bezard, Gregoire Courtine, and Arto V. Nurmikko, Wireless Neurosensor for Full-Spectrum Electrophysiology Recordings during Free Behavior, Neuron, (2014)
- 121 Larson, L., "RF and Microwave Hardware Challenges for Future Radio Spectrum Access," Proceedings of the IEEE , vol.102, no.3, pp.321,333, March 2014 (Invited Proceedings Paper).
- 122 Thomas, C.M.; Larson, L.E., "Broadband Synthetic Transmission-Line N-Path Filter Design," in Microwave Theory and Techniques, IEEE Transactions on , vol.63, no.10, pp.3525-3536, Oct. 2015
- 123 Bagheri, M.; Bagheri, R.; Buckwalter, J.F.; Larson, L.E., "Tuning-Range Enhancement Through Deterministic Mode Selection in RF Quadrature Oscillators," in Microwave Theory and Techniques, IEEE Transactions on , vol.63, no.11, pp.3713-3726, Nov. 2015.
- 124 C. Kim, S. Joshi, C. M. Thomas, S. Ha, L. E. Larson and G. Cauwenberghs, "A 1.3 mW 48 MHz 4 Channel MIMO Baseband Receiver With 65 dB Harmonic Rejection and 48.5 dB Spatial Signal Separation," in IEEE Journal of Solid-State Circuits, vol. 51, no. 4, pp. 832-844, April 2016.
- 125 M. Bagheri, R. Bagheri, J. F. Buckwalter and L. E. Larson, "Temperature Sensitivity of Non-Degenerate Modes in CMOS LC Quadrature Oscillators," in IEEE Transactions on Circuits and Systems II: Express Briefs, vol. 65, no. 8, pp. 1004-1008, Aug. 2018.
- 126: A. R. Wichman and L. E. Larson, "A Background Spread-Spectrum Radio Frequency Nonlinear Parameter Measurement Technique," in IEEE Transactions on Signal Processing, vol. 66, no. 17, pp. 4516-4526, Sept.1, 2018.

127. J Jeong, F Laiwalla, J Lee, R Ritasalo, M Pudas, L Larson, V Leung, A. Nurmikko, “Conformal hermetic sealing of wireless microelectronic implantable chiplets by multilayered atomic layer deposition (ALD) *Advanced Functional Materials* 29 (5), 1806440, 62,2019.
128. J Lee, V Leung, AH Lee, J Huang, P Asbeck, PP Mercier, S Shellhammer, L. Larson, F. Laiwalla, “Wireless ensembles of sub-mm microimplants communicating as a network near 1 GHz in a neural application,” *bioRxiv*, 2020.09. 11.293829, 13, 2020
129. J Lee, V Leung, AH Lee, J Huang, P Asbeck, PP Mercier, S Shellhammer and L.E. Larson, “Neural recording and stimulation using wireless networks of microimplants,” in *Nature Electronics* vol. 4 (8), pp.604-614, 2021.

Books and Book Chapters

- 1 L. E. Larson, P. T. Greiling, and J. F. Jensen, “GaAs Device Physics and Circuit Design”, in **Microprocessor Design for GaAs Technology**, V. Milutinovic, Ed., (Prentice Hall, York, 1989), Chapter 1, pp. 1-47. BOOK CHAPTER
- 2 L. E. Larson, “High-Speed Analog-to-Digital and Digital-to-Analog Conversion with GaAs Technology: Prospects, Trends, and Obstacles”, in **GaAs Technology and Devices and Their Impact on Circuits and Systems**, D. Haigh, Ed., (Peter Peregrinus, Ltd, 1989). 22 pages. BOOK CHAPTER
- 3 L. E. Larson and G. C. Temes, “Signal Conditioning and Interface Circuits”, in **McGraw-Hill Handbook of Digital Signal Processing**, S. Mitra, Ed., 1993. 44 pages. BOOK CHAPTER
- 4 L. E. Larson, “GaAs Operational Amplifier Design”, in **High-Speed Analog Integrated Circuits**, R. Goyal, Ed., (Wiley Interscience, York, 1995), Chapter 7. 34 pages. BOOK CHAPTER
- 5 L. E. Larson, **RF and Microwave Circuit Design for Wireless Communications** (Artech House, Inc., 1996). 380 pages. EDITED BOOK
- 6 M. Matloubian and L. E. Larson, “InP-Based Power HEMTs”, in **Pseudomorphic HEMT Technology and Applications**, Ed. R. L. Ross et al., (Kluwer Academic Publishers, Netherlands, 1996), pp. 275-299. BOOK CHAPTER
- 7 J. Groe, and L. E. Larson, **CDMA Mobile Radio Design: Systems, Algorithms, and Circuits** (Artech House, Inc., 2000). 346 pages. BOOK
- 8 L. Larson and F. Chang, “Si/SiGe HBT Technology for Low-Power Mobile Communications Systems Applications,” in **RF Technologies for Low-Power Wireless Communications**, Ed. T. Itoh, G. Haddad, and J. Harvey, Wiley Interscience, 2001. 35 pages. BOOK CHAPTER
- 9 X. Zhang, L. Larson, and P. Asbeck, **Design of Linear Outphasing Power Amplifiers for Wireless Communications**, Artech House, 2002. 196 pages. BOOK
- 10 **Digital Communications Using Chaos and Nonlinear Dynamics**, Larson, Lawrence E; Liu, Jia-Ming; Tsimring, Lev S. (Eds.) 2006, XIV, 382 pages, 196 illus., Hardcover, Springer. EDITED BOOK
- 11 **Circuits and Systems for Future Generations of Wireless Communications**, A. Tasic, W. Serdijn, L. Larson, G. Setti, G. (Eds.), 2009, VIII, 308 pages, Hardcover, Springer. EDITED BOOK
- 12 **Fast Hopping Frequency Generation in Digital CMOS**, Mohammad Farazian, Lawrence E. Larson, Prasad S. Gudem. 165 pages, Hardcover, 2012 Springer. BOOK
- 13 **Next generation microscale wireless implant system for high-density, multi-areal, closed-loop brain computer interfaces** F Laiwalla, VW Leung, J Lee, P Mercier, P Asbeck, R Rao, L Larson, *Brain-Computer Interface Research: A State-of-the-Art Summary* 9, 39-51, 2021, BOOK CHAPTER

Refereed Conference Proceedings (full peer committee review of submitted manuscript with feedback and full article published in conference proceedings along with accompanying presentation at conference)

- 1 L. E. Larson, J. F. Jensen, H. M. Levy, P. T. Greiling, and G. C. Temes, "GaAs Differential Amplifiers", Proc. IEEE GaAs IC Symposium, pp. 19-22 (November 1985).
- 2 L. E. Larson, J. F. Jensen, P. T. Greiling, and M. Waldner, "GaAs Technology for High-Speed Digital Computation", Proc. Intl. Conf. on Computer Design, pp. 713-716 (October 1985). INVITED RESEARCH ARTICLE
- 3 L. E. Larson, K. W. Martin, and G. C. Temes, "GaAs Switched-Capacitor Circuits for Video Signal Processing", Proc. 1987 Intl. Solid-State Circuits Digest., 30, pp. 40-41 (1987).
- 4 L. E. Larson and G. C. Temes, "Switched-Capacitor Building-Blocks With Reduced Sensitivity to Finite Amplifier Gain, Bandwidth and Offset Voltage", Proc. 1987 Intl. Symp. on Circuits and Systems, pp. 334-338 (1987).
- 5 L. E. Larson, "Gallium Arsenide MESFET Modeling for Analog Integrated Circuit Design", Proc. 1987 Intl. Symp. on Circuits and Systems, pp. 1-5 (1987).
- 6 L. E. Larson and G. C. Temes, "Filter Design Strategies for GaAs Switched-Capacitor Circuits", Proc. 1987 Intl. Symp. on Circuits and Systems, pp. 199-203 (1987).
- 7 L. Kunsage, L. E. Larson, K. W. Martin, and G. C. Temes, "Switched-Capacitor Circuits With Reduced Sensitivity to Finite Amplifier Gain, Bandwidth and Offset Voltage", Proc. ECCTD, pp. 351-355 (September 1987).
- 8 A. S. Brown, U. K. Mishra, L. E. Larson, and S. E. Rosenbaum, "The Elimination of dc I-V Anomalies in GaInAs-AlInAs HEMT Structures", Intl. Symp. on GaAs and Related Compounds, pp. 445-448 (1988).
- 9 G. C. Temes, L. E. Larson, and K. W. Martin, "State-of-the-Art and Future Prospects for Analog Signal Processing: A Tutorial", Proc. 1988 IEEE Intl. Symp. on Circuits and Systems, pp. 1655-1660 (1988). INVITED RESEARCH ARTICLE
- 10 L. E. Larson, "High-Speed Analog-to-Digital Conversion With GaAs Technology: Prospects, Trends, and Obstacles", Proc. 1988 IEEE Intl. Symp. on Circuits and Systems, pp. 2871-2878 (1988). INVITED RESEARCH ARTICLE
- 11 R. H. Walden, A. Schmitz, and L. E. Larson, "A 4-Bit Sub-Half Micrometer CMOS/SOS Flash Analog-to-Digital Converter Using Focused Ion Beam Implants", IEEE Custom Integrated Circuits Conf., pp. 18.7.1 - 18.7.4 (1988).
- 12 M. J. Delaney, A. S. Brown, U. K. Mishra, C. S. Chou, L. E. Larson, L. D. Nguyen, and J. F. Jensen, "Low-Temperature MBE Growth of GaAs and AlInAs for High-Speed Devices", Proc. IEEE/Cornell Conference on Advanced Concepts in High-Speed Semiconductor Devices and Circuits, pp. 64-72 (August 1989).
- 13 L. E. Larson, C. S. Chou, D. S. Deakin, W. W. Hooper, J. F. Jensen, M. A. Thompson, M. J. Delaney, L. G. McCray, S. E. Rosenbaum, and D. A. Pierson, "A 10 GHz MESFET Operational Amplifier in GaAs MESFET Technology", Proc. 1989 IEEE Intl. Solid State Circuits Digest, 32, pp. 72-73 (1989).
- 14 L. Nguyen, A. Brown, M. Delaney, U. Mishra, L. Larson, L. Jelloian, M. Melendes, C. Hooper, and M. Thompson, "Vertical Scaling of Ultra-High-Speed AlInAs-GaInAs HEMTs", Proc. 1989 Intl. Electron Devices Meeting, pp. 105-108 (1989).
- 15 T. Cataltepe, A. R. Kramer, L. E. Larson, G. C. Temes, and R. H. Walden, "Digitally Corrected Multi-Bit Σ - Δ Data Converters", Proc. 1989 Intl. Symp. on Circuits and Systems, pp. 647-650 (1989).
- 16 A. S. Brown, C. S. Chou, M. J. Delaney, C. E. Hooper, J. F. Jensen, L. E. Larson, U. Mishra, L. D. Nguyen, and M. S. Thompson, "Low-Temperature Buffer AlInAs/GaInAs on InP HEMT Technology for Ultra-High-Speed Integrated Circuits", Proc. 1989 IEEE GaAs IC Symp. Digest, pp. 143-146 (1989).
- 17 M. J. Delaney, C. S. Chou, L. E. Larson, J. F. Jensen, D. S. Deakin, A. S. Brown, W. W. Hooper, M. A. Thompson, L. G. McCray, and S. E. Rosenbaum, "GaAs MESFET Digital Integrated Circuits Fabricated With Low Temperature Buffer Technology", IEEE 1989 Custom Integrated Circuits Conference, pp. 18.3.1-18.3.4 (1989)

APPENDIX A

- 18 J. A. Bishop, M. M. Hashemi, K. Kiziloglu, L. E. Larson, N. Dagli, and U. K. Mishra, "Monolithic Coaxial Transmission Lines for mm-Wave ICs", 1991 Cornell Conference on High-Speed Semiconductor Devices , (August 1991). pp.252-60 .
 - 19 C . S. Chou, K. Litvin, L. E. Larson, S. E. Rosenbaum, L. D. Nguyen, U. K. Mishra, M. Lui, M. Thompson, C. Ngo, and M. Melendes, "Coplanar Waveguide InP-Based HEMT MMICs for Microwave and Millimeter Wave Applications", 1991 SPIE Conference, (June 1991). pp.151-156.
 - 20 G. M. Atkinson, R. L. Kubena, L. E. Larson, L. D. Nguyen, F. P. Stratton, L. M. Jelloian, M. V. Le, and H. McNulty, "Self-Aligned HEMT Gate Fabrication Using Focused Ion Beams", Intl. Electron, Ion, and Photon Beams Symp., (June 1991). 4 pages.
 - 21 M. A Thompson, L. M. Jelloian, L. D. Nguyen, A. S. Brown, and L. E. Larson, "50 nm Long "Y" Shaped Gate Structures Incorporated into a Super Self-Aligned HEMT Process for Terahertz Operation", Intl. Electron, Ion, Photon Beams Symp., (June 1991). 4 pages
 - 22 L. M. Jelloian, L. E. Larson, S. E. Rosenbaum, A. E. Schmitz, M. A. Thompson, M. Lui, L. D. Nguyen, and U. Mishra, "Manufacturing Study of Yield and Performance Dependence on Gate Length for Nanometer Scale AlInAs/GaInAs HEMTs", Proc. 1991 Mantech Symp., pp. 5-8 (1991).
 - 23 L. D. Nguyen, A. S. Brown, and L. E. Larson, "Sub-Millimeter Wave InP-Based High Electron Mobility Transistors", Proc. 2nd Intl. Symp. on Space THz Technology, pp. 302-306 (February 1991).
 - 24 S. E. Rosenbaum, K. Litvin, C. S. Chou, L. E. Larson, L. D. Nguyen, C. Ngo, M. Lui, J. Henige, M. A. Thompson, U. K. Mishra, and D. Pierson, "AlInAs/GaInAs on InP HEMT Low Noise MMIC Amplifiers", IEEE MIT-S Digest., pp. 815-818 (1991).
 - 25 M. Matloubian, L. D. Nguyen, A. S. Brown, L. E. Larson, M. A. Melendes, and M. A. Thompson, "High Power and High Efficiency AlInAs/GaInAs on InP HEMTs", 1991 IEEE MTT-S Digest., pp. 721-724 (1991).
 - 26 R. H. Walden, W. W. Hooper, C. S. Chou, C. Ngo, R. WongQuen, R. A. Metzger, F. Williams, L. E. Larson, and R. Blumgold, "Multigigahertz Monolithic GaAs Optoelectronic Receivers Using 0.2 μ m Gate-Length MESFETs", 1991 IEEE MIT-S Digest., pp. 491-494 (1991).
 - 27 L. E. Larson, R. H. Hackett, M. A. Melendes, and R. F. Lohr, "Micromachined Microwave Actuator Technology - A Tuning Approach for Microwave Integrated Circuits", Proc. 1991 Microwave and Millimeter Wave Monolithic Circuits Symp., pp. 27-30 (1991).
 - 28 L. E. Larson, R. H. Hackett, and R. F. Lohr, "Microactuators for GaAs-Based Microwave Integrated Circuits", Proc. 1991 Transducers Conference, pp. 743-746 (1991).
 - 29 R. H. Hackett, L. E. Larson, and M. A. Melendes, "The Integration of Micro-Machine Fabrication With Electronic Device Fabrication on III-V Semiconductor Materials", Proc. 1991 Transducers Conference, pp. 51-54 (June 1991).
 - 30 W. E. Stanchina, R. A. Metzger, D. B. Rensch, L. M. Burns, J. F. Jensen, R. H. Walden, L. E. Larson, and P. T. Greiling, "InP Based Technology for Monolithic Multiple-Device, Multiple-Function ICs", Proc. GOMAC-91 Digest of Papers, (1991). 4 pages.
 - 31 R. Hackett and L. Larson, "Alternative Materials for Micro-Electro-Mechanical Device Construction", Proc. MRS, pp. 241-252 (June 1992).
 - 32 L. E. Larson and J. J. Brown, "InP Integrated Circuit Technology for Microwave, Digital, and Optoelectronic Applications", IEEE 14th GaAs IC Symp. Technical Digest, pp. 247-250 (October 1992).
- INVITED RESEARCH ARTICLE
- 33 M. Matloubian, L. Larson, A. Brown, L. Jelloian, L. Nguyen, M. Lui, T. Liu, J. Brown, M. Thompson, W. Lam, A. Kurdoghlian, R. Rhodes, M. Delaney, and J. Pence, "InP-Based HEMTs for the Realization of Ultra-High Efficiency Millimeterwave Power Amplifiers", Proc. 1993 IEEE Cornell Conference on Advanced Concepts in High-Speed Semiconductor Devices and Circuits, pp. 520-527 (1993).
 - 34 A. Brown, J. Brown, J. Henige, R. Wilson, R. Metzger, M. Melendes, M. Matloubian, L. Jelloian, and L. Larson, "The Growth of High Performance GaInAs-AlInAs Power HEMT Devices by MBE: Si Segregation and Activation and Strained Layer Structural Quality", Proc. of 1993 EMC Meeting, (1993). 4 pages.

APPENDIX A

- 35 M. Matloubian, L. M. Jelloian, A. S. Brown, L. D. Nguyen, L. E. Larson, M. J. Delaney, M. A. Thompson, R. A. Rhodes, and J. E. Pence, "V-Band High-Efficiency High-Power AlInAs/GaInAs/InP HEMTs", 1993 IEEE MTT-S Digest., 2, pp. 535-538 (1993).
- 36 S. E. Rosenbaum, C. S. Chou, C. M. Ngo, L. E. Larson, T. Liu, and M. A. Thompson, "A 7 to 11 GHz AlInAs/GaInAs/InP MMIC Low-Noise Amplifier", 1993 IEEE MTT-S Digest, 2, pp. 1103-1104 (1993).
- 37 A. Kurdoghlian, W. Lam, C. Chou, L. Jelloian, A. Igawa, M. Matloubian, L. Larson, A. Brown, M. Thompson, and C. Ngo, "High-Efficiency InP-Based HEMT MMIC Power Amplifier", Proc. 1993 15th IEEE GaAs IC Symp. Digest, pp. 375-377 (1993).
- 38 S. E. Rosenbaum, L. M. Jelloian, A. S. Brown, M. A. Thompson, M. Matloubian, L. E. Larson, R. F. Lohr, B. K. Kormanyos, G. M. Rebeiz, and L. P. B. Katehi, "A 213 GHz AlInAs/GaInAs/InP HEMT MMIC Oscillator", Proc. 1993 Intl. Electron Devices Technical Digest, pp. 924-926 (1993).
- 39 M. Matloubian, L. M. Jelloian, M. Lui, T. Liu, L. E. Larson, M. V. Le, D. M. Jang, and R. A. Rhodes, "GaInAs/InP Composite Channel HEMTs for Millimeter Wave Power Applications", International Conference on Millimeter and Submillimeterwaves and Applications, (1994). 4 pages.
- 40 M. Case, S. Rosenbaum, C. Ngo, M. Matloubian, A. Brown, J. Henige, M. Thompson, and L. Larson, "High Efficiency, High Gain K- and Ku-Band InP-Based HEMT MMIC Amplifiers for Array Applications", 1994 IEEE MTT-S European Topical Congress, pp. 49-54 (1994).
- 41 J. Pusi, M. Rodwell, M. Case, L. Nguyen, M. Thompson, and L. Larson, "Ultra-Wideband Monolithic HEMT Distributed Amplifiers", 1995 IEEE MTT Symp., (1995). pp. 1661-1664.
- 42 J. J. Brown, M. Matloubian, T. K. Liu, L. M. Jelloian, A. E. Schmitz, R. G. Wilson, M. Lui, L. E. Larson, M. A. Melendes, and M. A. Thompson, "InP-Based HEMTs with AlIn_{1-x}P Schottky Barrier Layers Grown by Gas-Source MBE", Proc. 6th International Indium Phosphide and Related Materials Conference, pp. 419-422 (1994).
- 43 A. S. Brown, A. E. Schmitz, L. D. Nguyen, J. A. Henige, et al., "The Growth of High Performance In_xGa_{1-x}As (0.52 < x < 0.9)-(Al_{0.48}In_{0.52}As) High Electron Mobility Transistors by MBE", Proc. 6th International Conference on Indium Phosphide and Related Materials, pp. 263-266 (1994).
- 44 M. Case, S. Knorr, L. Larson, D. Rensich, D. Harame, B. Meyerson, and S. Rosenbaum "A 23 GHz Static 1/128 Frequency Divider Implemented in a Manufacturable Si/SiGe HBT Process". Proc. 1995 Bipolar/BiCMOS Circuits and Technology Meeting, pp. 121-124 (1995).
- 45 M. Case, P. MacDonald, M. Matloubian, M. Chen, L. Larson, and D. Rensch, "High Performance Microwave Elements for SiGe MMICs", Proc. IEEE/Cornell Conference on Advanced Concepts in High Speed Semiconductor Devices and Circuits, pp. 85-92 (1995).
- 46 D. Harame, L. Larson, M. Case, S. Kovacic, S. Voinigescu, T. Tewksbury, D. Nguyen-Ngoc, K. Stein, J. Cressler, S-J. Jeng, J. Malinowski, R. Groves, E. Eld, D. Sunderland, D. Renach, M. Gilbert, K. Schonenberg, D. Ahlgren, S. Rosenbaum, J. Glenn, and B. Meyerson, "SiGe HBT Technology: Device and Application Issues", International Electron Devices Meeting Technical Digest, pp. 731-734 (1995).
- 47 J. Pusi, B. Agarwal, R. Pallela, L. D. Nguyen, M. V. Le, M. J. W. Rodwell, L. Larson, J. F. Jensen, R. Y. Yu, and M. G. Case, "Capacitive-Division Traveling-Wave Amplifier With 340 GHz Gain/Bandwidth Product", Proc. 1995 Microwave and Millimeter-Wave Monolithic Circuits Symp. Digest, 3, 1661 (1995). pp. 175-178.
- 48 L. Larson, M. Case, S. Rosenbaum, D. Rensch, P. MacDonald, M. Matloubian, M. Chen, D. Harame, J. Malinowski, B. Meyerson, M. Gilbert, and S. Maas, "Si/SiGe HBT Technology for Low-Cost Monolithic Microwave Integrated Circuits", 1996 IEEE International Solid-State Circuits Digest, pp. 80-82 (1996).
- 49 M. Case, S. A. Maas, L. Larson, D. Rensch, D. Harame, and B. Meyerson, "An X-Band Monolithic Active Mixer in SiGe HBT Technology", 1996 IEEE MTT-S International Microwave Symp. Digest, 2, pp. 655-658 (1996).
- 50 L. E. Larson, "Silicon Bipolar Transistor Design and Modeling for Microwave Integrated Circuit Applications", Invited Paper, Proc. 1996 IEEE Bipolar/BiCMOS Circuits and Technology Meeting, pp. 142-148 (1996). INVITED RESEARCH ARTICLE
- 51 L. Larson, "Integrated Circuit Technology Options for RFIC's - Present Status and Future Directions", Proc. Custom Integrated Circuits Conference, Vol. 1, pp. 169-176 (1997). INVITED RESEARCH ARTICLE

APPENDIX A

- 52 C. Baringer, L. Larson, and J. Shealy, "A Silicon Bipolar Broadband PLL Building Block Integrated Circuit", Proc. 1997 IEEE Bipolar Circuits and Technology Meeting, (September 1997). pp. 80-83.
- 53 S. Rosenbaum, C. Baringer, and L. Larson, "Design of a High Dynamic Range Variable Gain Amplifier for a DBS Turner Front-End", Proc. First Annual IEEE UCSD Center for Wireless Communications Conference, pp. 83-89, (March 1998).
- 54 D. Laney, L. Larson, J. Malinowski, D. Harame, S. Subbanna, R. Volant, M. Case, and P. Chan, "Low-Loss Microwave Transmission Lines and Inductors Implemented in a Si/SiGe HBT Process", 1998 IEEE Bipolar Circuits and Technology Meeting, (1998). pp. 101-104.
- 55 L. Larson, "Low-Power Radio Frequency Circuit Architectures for Portable Wireless Communications", Proc. IEEE International Symposium on Circuits and Systems, pp. 1518-1522, (June 1998).
- 56 J. Pulver, D. Rowe, and L. Larson, "A 16x16 Si/SiGe HBT Cross-Point Switch Architecture for High-Speed Switching Applications", IEEE Hot Interconnects Symposium, pp. 52-56, (August 1998).
- 57 P. Asbeck, G. Hanington, P. Chen, and L. Larson, "Efficiency and Linearity Improvements in Power Amplifiers for Wireless Communications," Proceedings of 1998 IEEE GaAs IC Symposium pp. 15-18, (October 1998). INVITED RESEARCH ARTICLE
- 58 L. Larson, "Si/SiGe and III-V Integrated Circuit Technology for Next Generation High-Speed Systems: Comparisons & Tradeoffs," Proc. 1998 MRS Meeting, pp. 433-435, (Dec. 1998).
- 59 W.T. Thornton and L. Larson, "Improved Design Techniques for the Realization of Linear Power Amplifiers for Wireless Transmitters," Proc. 1999 Southwest Symposium on Mixed-Signal Design, pp. 151-155, April 11-13, (1999).
- 60 L. Sheng and L. Larson, "Nonlinearity Analysis of a Homodyne Receiver in a Multichannel Wireless Communications System" Proc. Second Annual IEEE UCSD Center for Wireless Communications Conference, pp. 33-39, (March 1999).
- 61 D. Rowe, B. Pollack, J. Pulver, W. Chon, P. Jett, L. Fullerton, and L. Larson, "A Si/SiGe HBT Timing Generator IC for High-Bandwidth Impulse Radio Applications," IEEE 1999 Custom Integrated Circuits Conference, pp. 221-224 (1999).
- 62 S. Vora and L. Larson, "Noise Power Optimization of Monolithic CMOS VCOS," 1999 Radio Frequency Integrated Circuit Symp. Digest, 2, pp. 163-166 (1999).
- 63 W. Xiong and L. Larson, "An S-band Low-Noise Amplifier with Self-Adjusting Bias for Improved Power Consumption and Dynamic Range in a Mobile Environment," 1999 IEEE MTT-S International Microwave Symp. Digest, pp. 497-500, (1999).
- 64 D.C. Laney, L. Larson, P. Chan, J. Malinowski, D. Harame, Seshadri Subbanna, R. Volant, and M. Case, "Lateral Microwave Transformers and Inductors Implemented in a Si/SiGe HBT Process," 1999 IEEE MTT-S International Microwave Symp. Digest, pp. 855-858, (1999).
- 65 L. Larson, "Microwave MEMs Technology for Next-Generation Wireless Communications," 1999 IEEE MTT-S International Microwave Symp. Digest, pp. 1073-1076 (1999). INVITED RESEARCH ARTICLE
- 66 L. Larson and M. J. Delaney, "Applications of Si/SiGe Technology for High-Speed Communications Systems," 1999 IEEE MTT-S International Microwave Symp. Digest, pp. 1077-1080 (1999). INVITED RESEARCH ARTICLE
- 67 L. Larson, P. Asbeck, and Wei Xiong, "Energy Constrained RF Transceivers for Mobile Wireless Communications," Proc. 1999 IEEE Wireless Communications and Networking Conference, vol. 1, pp. 197-200, Sept 21-24, 1999.
- 68 L. Sheng, J. Jensen, and L. Larson, "A Si/SiGe HBT Harmonic Mixer/Downconverter," Proc. 1999 Bipolar/BiCMOS Circuits and Technology Meeting, pp. 71-74, Sept. 26-28, 1999.
- 69 L. Larson, P. Asbeck, and W. Xiong "Adaptive Hardware Techniques for Improved Power Management of Radio Receivers," Proc. 1999 International Symposium on Advanced Radio Technologies, Sept. 8-10, 1999. 4 pages.
- 70 G.M Maggio, N. Rulkov, M. Sushchik, L. Tsimring, A. Volkovskii, H. Abarbanel, L. Larson, and K. Yao, "Chaotic Pulse-Position Modulation for Ultrawide-Band Communication Systems," Proc. 1999 International Ultra Wideband Conference, Washington, DC, Sept. 28-30, 1999. 4 pages.

APPENDIX A

- 71 M. Sushchik, N. Rulkov, L. Tsimring, A. Volkovskii, H. Abarbanel, L. Larson, K. Yao, "Chaotic Pulse Trains in Digital Communications," Proc. of the 5th Experimental Chaos Conference, Orlando, FL, June 28 – July 1, 1999. pp. 101-111.
- 72 L. Larson, and L. DeVreede, "The Impact of Silicon Technology on Future Microwave Systems" Proc. 1999 European Microwave Conference, Munich, Germany, pp. 752-756, October 1999. INVITED RESEARCH ARTICLE
- 73 G. Niu, S. Zhang, J. Cressler, A. Joseph, J. Fairbanks, L. Larson, C. Webster, W. Ansley, and D. Hareme, "SiGe Profile Design Tradeoffs for RF Circuit Applications" 1999 International Electron Devices Meeting Technical Digest, pp. 573-576, Dec. 1999.
- 74 G. Niu, S. Zhang, J.D. Cressler, A. Joseph, J. Fairbanks, L. Larson, C. Webster, W.E. Ansley, D.L. Hareme, "Noise parameter modeling and SiGe profile design tradeoffs for RF applications." 2000 Topical Meeting on Silicon Monolithic Integrated Circuits and RF Systems. Digest of Papers, Garmisch Germany, pp. 9-14, April 26-28, 2000.
- 75 P. Asbeck and L. Larson, "Synergistic design of DSP and power amplifiers for wireless communications," 2000 Asia-Pacific Microwave Conference, Sydney, Australia, pp. 899-903, Dec. 3-6, 2000. INVITED RESEARCH ARTICLE
- 76 Larson, L., "Device and technology requirements for next generation communications systems," 2000 International Electron Devices Meeting San Francisco, CA, pp. 737-740, Dec. 10-13, 2000. INVITED RESEARCH ARTICLE
- 77 L. Larson & P. Gudem, "Design of fully monolithic voltage controlled oscillators for wireless communications," Proceedings of MWE 2000, Yokohama, Japan, pp. 287-293.
- 78 R. Volant, R. Groves, S. Subbanna, E. Begle, D. Laney, L. Larson, "Fabrication of high frequency passives on BiCMOS silicon substrates," 2000 RF Integrated Circuit Symposium, Anaheim, CA, pp. 209-212, June 13-19, 2000
- 79 D. Jessie and L. Larson, "Improved techniques for the measurement and modeling of plastic surface mount packages to 20 GHz, Proceedings RAWCON 2000, 2000 IEEE Radio and Wireless Conference, pp. 243-246.
- 80 K.H. Kuo, M.S. Jung, J.S. Park, and Larson, L., "ACPR comparison of low pass and band pass type power amplifier for 22 Mbps wireless LAN application," RAWCON 2000, 2000 IEEE Radio and Wireless Conference, pp. 231-234, Sept. 2000.
- 81 J.C. Jensen and L. Larson, "A broadband 10 GHz track-and-hold in Si/SiGe HBT technology," 2000 IEEE Custom Integrated Circuits Conference, Orlando, FL., pp. 245-248, May 21-24, 2000.
- 82 K. Gard, L. Larson, and M. Steer, "Autocorrelation analysis of distortion generated from bandpass nonlinear circuits, Proceedings of 2001 Custom Integrated Circuits Conference (CICC), pp. 345-348.
- 83 D. Greenberg, D. Ahlgren, G. Freeman, S. Subbana, V. Radisc, D. Harvey, C. Webster, and L. Larson, "HBT low-noise performance in a 0.18 um SiGe BICMOS Technology, Proceedings of the 2000 IEEE MTT-S Conference, vol. 1, no. 3, pp. 9-12.
- 84 X. Zhang P. Nanawa, L. Larson, and P. Asbeck, "A gain/phase imbalance minimization technique for LINC transmitter," Proceedings of the IMS 2001, pp. 803-805, May 2001.
- 85 S. Subbana, L. Larson, G. Freeman, D. Ahlgren, K. Stein, C. Dickey, J. Mecke, A. Rincon, P. Bacon, R. Groves, M. Soyuer, D. Hareme, J. Dunn, D. Rowe, W. Chon, D. Herman, and B. Meyerson, "Silicon-Germanium BICMOS Technology and a CAD environment for 2-40 GHz VLSI Mixed Signal ICS," Proceedings of the 2001 Custom Integrated Circuits Conference (CICC), pp. 559-566. INVITED RESEARCH ARTICLE
- 86 Wild, N.C.; Coakley, P.G.; Doft, F.; Thornton, T.; Larson, L.; Asbeck, P.M.; Iguartua, F. "Low-cost miniature unattended RF sensor suite," Proceedings of the SPIE - The International Society for Optical Engineering, vol.4232, (Enabling Technologies for Law Enforcement and Security, Boston, MA, USA, 5-8 Nov. 2000. pp.391-8.
- 87 K. Gard, L. Larson, and M. Steer, "Generalized autocorrelation analysis of spectral regrowth from bandpass nonlinear circuits," 2001 IEEE MTT-S International Microwave Symposium Digest, Phoenix, AZ, IEEE 2001, pp. 9-12, vol. 1, May 2001

- 88 C. Wang; L. Larson, P. Asbeck, "A nonlinear capacitance cancellation technique and its application to a CMOS class AB power amplifier," 2001 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium pp. 20-22, May 2001.
- 89 M. Iwamoto, A. Williams, P. Chen, A. Metzger, C. Wang, L. Larson, P. Asbeck, "An extended Doherty amplifier with high efficiency over a wide power range," 2001 IEEE MTT-S International Microwave Symposium Digest, pp. 540-543, Phoenix, AZ.
- 90 N.F. Rulkov, M.M. Sushchik, L.S. Tsimrng, A.R. Volkovskii, H.D.I. Abarbanel, L. Larson, K. Yao, "Digital communication using chaotic pulse generators," Proceedings of the 7th International Conference on Advances in Communications and Control (COMCON7), Athens, Greece, June 28 - July 2, 1999, Telecommunications/Signal Processing, pp. 715-724, 2000.
- 91 P. Asbeck, I. Galton, L. Larson, X Zhang, M. Iwamoto, J. Hinrichs, and J. Keyzer, "Digital control of power amplifiers for wireless communications," Proceedings of the EuMC 2001 Conference. pp. 71-74. INVITED RESEARCH ARTICLE
- 92 D.Y.C. Lie, J. Kennedy, D. Livezey, B. Yang, T. Robinson, N. Sornin, T. Beukema, L.E. Larson, A. Senior, C. Saint, J. Blonski, N. Swanberg, P. Pawlowski, D. Gonya, X. Yuan, and H. Zamat, "A Direct-Conversion W-CDMA Front-End SiGe Receiver Chip," 2002 IEEE MTT-S International Microwave Symposium Digest, pp. 540-543, Seattle, WA.
- 93 C. Wang, L.E. Larson and P.M. Asbeck, "Improved Design Technique of a Microwave Class-E Power Amplifier with Finite Switching-on Resistance," Proceedings of 2002 Radio and Wireless Conference (RAWCON), Aug. 2002. pp. 241-4.
- 94 D. Jessie, L. Larson, "Design techniques for improved microwave performance of small outline packages," 2002 IEEE MTT-S International Microwave Symposium, Seattle, WA, USA, 2-7 June 2002. pp. 297-300.
- 95 P. Asbeck, H. Kobayashi, M. Iwamoto, G. Hanington, S. Nam, and L. Larson, "Augmented behavioral characterization for modeling the nonlinear response of power amplifiers," 2002 IEEE MTT-S International Microwave Symposium Digest, Seattle, WA. pp. 135-138.
- 96 D. Jessie and L. Larson, "An improved characterization method for the dielectric properties of RFIC encapsulating plastics," Proceedings of 2002 Radio and Wireless Conference (RAWCON), Aug. 2002. pp. 197-200.
- 97 D.C. Laney, G.M. Maggio, F. Lehmann, L.E. Larson, "BER for multi-access UWB radio using pseudo-chaotic time hopping," IEEE Radio and Wireless Conference (RAWCON), August 11-14, 2002, pp. 91-94
- 98 G.M. Maggio, D.C. Laney, F. Lehmann, L.E. Larson, "A multi-access scheme for UWB radio using pseudo-chaotic time hopping," Ultra Wideband Systems and Technologies Conference (UWBST), May 2002, pp. 225-229.
- 99 G. Maggio, D. Laney, and L. Larson, "BER and error-floor calculation for multi-access PCTH," Global Telecommunications Conference, 2002. GLOBECOM '02. Volume 2, 2002 Pp.:1324 – 1328.
- 100 J. Jensen and L. Larson, "A 16 GHz Ultra High-Speed Si/SiGe Comparator," in Proceedings IEEE Bipolar Circuits and Technology Meeting, 2002, pp.120-123
- 101 D.Y.C. Lie, X. Yuan, L.E. Larson, M. Case, T. Robinson, A. Senior, X. Wang, and J. Mecke, "Phase Noise Analysis of Fully-Integrated Digitally-Tuned Wideband Si/SiGe BiCMOS VCOs," in Proceedings IEEE Bipolar Circuits and Technology Meeting 2002. pp. 65-68.
- 102 D. Malhi, H. Joba, C. Demirdag, Y. Takahashi, D. Wang, L. Larson, S. Shinjo, W. Gao, N. Suematsu, J. Glasser, P. Chominski, V. Pereira, L. Prestia, K. Schelkle, P. Bacon, K. Itoh and J. Comfort, "SiGe W-CDMA Transmitter For Mobile Terminal Application" in Proceedings IEEE Bipolar Circuits and Technology Meeting 2002. pp. 177-180.
- 103 P. Chominski, D. Malhi, L. Larson, J. Park, P. Gudem, R. Kloczkowski, C. Demirdag, A. Garlapati, and V. Pereira, "A Highly Integrated Si/SiGe BiCMOS Upconverter RFIC For 3G WCDMA," in Proc. IEEE European Solid-State Circuits Conference, Sept. 2002. pp. 447-50.
- 104 P. Asbeck, H. Kobayashi, M. Iwamoto, G. Hanington, S. Nam, and L. Larson, "Augmented behavioral characterization for modeling the nonlinear response of power amplifiers. 2002 IEEE MTT-S International Microwave Symposium Digest, vol.1, 2002, pp.135-8 vol.1.
- 105 D. Lie, J. Kennedy, D. Livezey, B. Yang, T. Robinson, N. Sornin, T. Beukema, L. Larson, A. Senior, C. Saint, J. Blonski, N. Swanberg, P. Pawlowski, D. Gonya, X. Yuan, H. Zamat "A direct-conversion W-

- CDMA front-end SiGe receiver chip,” 2002 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium. Digest of Papers. IEEE. 2002, pp.31-4.
- 106 R. Tenny, L. Tsimring, H. Abarbanel, L. Larson, “Using chaotic bidirectional transmission for asymmetric private/public key encryption,” AIP. American Institute of Physics Conference Proceedings, no.676, 2003, pp.373-4.
 - 107 D. Laney, G. Maggio, F. Lehman, and L. Larson, “BER performance and spectral properties of interleaved convolutional time hopping for UWB impulse radio, Global Telecommunications Conference, 2003. GLOBECOM '03. IEEE, Volume 4, 1-5 Dec. 2003 Pp.:1994 - 1998 vol.4
 - 108 R. Tenny, L. Tsimring, H. Abarbanel, L. Larson, “Asymmetric Key Encryption using Distributed Chaotic Nonlinear Dynamics.”” Proceedings of the IASTED International Conference on Communications Internet and Information Technology, St. Thomas, US Virgin Islands, pp.338-345, November 2002.
 - 109 X. Yuan, D. Lie, L. Larson, J. Blonski, J. Gross J, M. Kumar, J. Mecke, A. Senior, Y. Chen, A. Poh, D. Haramé, “RF linearity study of SiGe HBTs for low power RFIC design. Part I.” 2002 3rd International Conference on Microwave and Millimeter Wave Technology, IEEE. 2002, pp.70-3.
 - 110 X. Yuan, D. Lie, L. Larson, J. Blonski, J. Gross J, M. Kumar, J. Mecke, A. Senior, Y. Chen, A. Poh, D. Haramé. “RF linearity study of SiGe HBTs for low power RFIC design. Part II, Analysis.” 2002 3rd International Conference on Microwave and Millimeter Wave Technology, IEEE. 2002, pp.74-7.
 - 111 D. Lie, X. Yuan, L. Larson, Y. Wang, A. Senior, J. Mecke, “RF-SoC: low-power single-chip radio design using Si/SiGe BiCMOS technology,” 2002 3rd International Conference on Microwave and Millimeter Wave Technology IEEE. 2002, pp.30-7.
 - 112 J. Fairbanks and L. Larson, “Analysis of optimized input and output harmonic termination on the linearity of 5 GHz CMOS radio frequency amplifiers,” Proceedings RAWCON 2003 IEEE Radio and Wireless Conference, pp.293-296.
 - 113 L. Larson, “Advances in Silicon Semiconductor Device Technology for Radio and Wireless Applications,” Proceedings RAWCON 2003. IEEE Radio and Wireless Conference, pp.353-356 INVITED RESEARCH ARTICLE
 - 114 L. Larson and D. Jessie, “Advances in RF Packaging Technologies for Next-Generation Wireless Communications Applications (Invited Paper)” 2003 IEEE Custom Integrated Circuits Conference. pp. 323-330 INVITED RESEARCH ARTICLE. BEST INVITED PAPER AWARD
 - 115 V. Aparin and L. Larson, “Linearization of Monolithic LNAs using low-frequency low-impedance input termination,” Proceedings of IEEE ESSCIRC 2003, pp. 137-140.
 - 116 K. Gard, L. Larson, and M. Steer, “AM-AM and AM-PM Measurement of Baseband to RF Integrated Circuits for ACPR Calculations,” Proceedings of Radio and Wireless Conference, RAWCON 2003 Pp.:273 - 276
 - 117 V. Leung, L. Larson, and P. Gudem, “An improved digital-IF transmitter architecture for highly-integrated W-CDMA mobile terminals,” IEEE Vehicular Technology Conference, 2003. VTC 2003-Spring. Pp.:1335 - 1339 vol.2
 - 118 J. Fairbanks and L. Larson, “Analysis of termination impedance effects on the linearity of 5 GHz CMOS radio frequency amplifiers,” 2003 Topical Meeting on Silicon Monolithic Integrated Circuits and RF Systems. Digest of Papers, Munich Germany, pp. 196-199
 - 119 L. Larson, “The impact of emerging “4G” systems on the performance and complexity requirements of RFICs,” 2003 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium. Digest of Papers IEEE. 2003, pp.15-18. INVITED RESEARCH ARTICLE
 - 120 L. Larson, D. Laney and J. Jamp, “An Overview of Hardware Requirements for UWB Systems: Interference Issues and Transceiver Design Implications,” MILCOM 2003. IEEE, 13-16 Pp.:863 - 867 Vol.2
 - 121 T. Johansen and L. Larson, “Optimization of SiGe HBT VCOs for wireless applications. 2003 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium. Digest of Papers IEEE. 2003, pp.273-6.
 - 122 L. Sheng and L. Larson, “A Si/SiGe BiCMOS mixer with 3rd-order nonlinearity cancellation for WCDMA applications,” 2003 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium. Digest of Papers, IEEE. 2003, pp.417-20.

APPENDIX A

- 123 L. Sheng, and L. Larson, "A general theory of third-order intermodulation distortion in common-emitter RF circuits," Proc. 2003 IEEE International Symposium on Circuits and Systems, pp. I-177-I-180.
- 124 Y. Zhao, M. Iwamoto, L. Larson, P. Asbeck, "Doherty amplifier with DSP control to improve performance in CDMA operation," 2003 IEEE MTT-S International Microwave Symposium Digest, IEEE. Part vol.2, 2003, pp.687-90 vol.2.
- 125 W. Ni, X. Yuan, R. Groves, L. Larson, "Design and Modeling of a High-Q On-Chip Hairpin Inductor for RFIC Applications," 2003 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium. Digest of Papers, IEEE. 2003, pp. 547-550.
- 126 L. Larson, "Si/SiGe HBT Technology as an Enabler for Advanced Communications Systems" Proceedings of 3rd International Conference on SiGe," Santa Fe, NM, March, 2003, 3 pages, INVITED RESEARCH ARTICLE
- 127 L. Larson, "Millimeter-Wave Applications of SiGe Devices," Proceedings of The International Joint Conference of the 6th Topical Symposium on Millimeter Waves (TSMW2004) and the 5th MINT Millimeter-Wave International Symposium (MINT-MIS2004), Yokohama, Japan, Feb., 2004., 4 pages, INVITED RESEARCH ARTICLE
- 128 V. Leung, L. Larson, P. Gudem, "Digital-IF WCDMA Handset Transmitter IC in 0.25 μ m SiGe BiCMOS," IEEE International Solid-State Circuits Conference, 2004, pp. 182-183.
- 129 J. Deng, P. Gudem, and L. Larson, "Linearity Analysis of SiGe HBT Amplifiers Using a Power-Dependent Coefficient Volterra Technique," Proceedings of 2004 IEEE Radio and Wireless Conference (RAWCON), pp. 479-482.
- 130 V. Aparin and L. Larson, "Modified Derivative Superposition Method for Linearizing FET Low-noise Amplifiers," Proceedings of 2004 IEEE RFIC Conference, pp. 105-108, 1st PLACE BEST STUDENT PAPER AWARD
- 131 J. Deng, P. Gudem, L. Larson, and P. Asbeck, "A High-Efficiency SiGe BiCMOS WCDMA Power Amplifier with Dynamic Current Biasing for Improved Average Efficiency," Proceedings of 2004 IEEE RFIC Conference, pp. 361-364.
- 132 V. Aparin and L. Larson, "Analysis of Cross Modulation in WCDMA Receivers," Proceedings of 2004 IEEE International Microwave Symposium, pp. 787-790.
- 133 F. Wang, A. Ojo, D. Kimball, P. Asbeck and L. Larson, "Envelope Tracking Power Amplifier with Pre-Distortion Linearization for WLAN 802.11g," Proceedings of 2004 IEEE International Microwave Symposium, pp. 1543 – 1546, 2nd PLACE BEST STUDENT PAPER AWARD
- 134 V. Aparin, G. Brown, and L. Larson, "Linearization of CMOS LNA's via Optimum Gate Biasing, Proceedings of 2004 International Symposium on Circuits and Systems, pp. 748-751.
- 135 K. Gard, L. Larson, and M. Steer, "Statistical Analysis of Spectral Regrowth in Wireless Nonlinear Circuits," IEEE European Microwave Conference, 2004, Volume 2, Pp.:697 - 700.
- 136 V. Leung, J. Deng, P. Gudem and L. Larson, "Analysis of Envelope Signal Injection for Improvement of RF Amplifier Intermodulation Distortion," Proceedings 2004 IEEE Custom Integrated Circuits Conference. 2004. pp. 133 – 136.
- 137 M. Li, I. Galton, L. Larson and P. Asbeck, "Correlation techniques for estimation of amplifier nonlinearity," Radio and Wireless Conference, 2004 pp. 179 – 182.
- 138 J. Jamp and L. Larson, "A Coding Technique for Spectral Shaping UltraWideband Pulse Position Modulated Signals" Proc. 2004 IEEE Vehicular Technology Conference, Vehicular Technology Conference, 2004. pp. 1188 – 1191.
- 139 Y. Sun, P. Gudem, L. Larson, "A Multiple Sub-carrier Selection (MSCS) Diversity Architecture with Reduced Receiver Complexity for Wireless OFDM Applications" Proc. 2004 IEEE Vehicular Technology Conference, , 26-29 Sept. 2004 Pp.:439 - 442 Vol. 1.
- 140 J. Jensen, and L. Larson, "An 8bit 3GHz Si/SiGe HBT Sample-and-Hold," Proceedings of 2004 Custom Integrated Circuits Conference, 2004. Pp.:655 – 658.
- 141 L. Larson, "SiGe HBT BiCMOS Technology as an Enabler for Next Generation Communications Systems," Proceedings of 2004 IEEE European Microwave Conference, pp. 783-787.

APPENDIX A

- 142 J. Deng, P. Gudem, L. Larson, D. Kimball and P. Asbeck, "A SiGe PA with Dual Dynamic Bias Control and Memoryless Digital Predistortion for WCDMA Handset Applications," 2005 IEEE RFIC Conference, 4 pages. pp. 247-250
- 143 L. Larson, P. Asbeck, and D. Kimball, "Next Generation Power Amplifiers for Wireless Communications – Squeezing More Bits Out of Fewer Joules," 2005 IEEE RFIC Conference, pp. 417 - 420. INVITED RESEARCH ARTICLE
- 144 K. Buisman, L.C.N. de Vreede, L.E. Larson, M. Spirito, A. Akhnoukh, Y. Lin, X. Liu, and L.K. Nanver, "Low-Distortion, Low-Loss Varactor-Based Adaptive Matching Networks, Implemented in a Silicon-on-Glass Technology," 2005 IEEE RFIC Conference, pp. 389 – 392
- 145 L. Larson, "Circuit and System Design for Future Microwave Systems," 2005 IEEE International Microwave Symposium, 4 pages. INVITED RESEARCH ARTICLE
- 146 K. Buisman, L.C.N. de Vreede, L.E. Larson, M. Spirito, A. Akhnoukh, Y. Lin, X. Liu, and L.K. Nanver, "'Distortion-Free' Varactor Diode Topologies for RF Adaptivity," 2005 IEEE International Microwave Symposium-, 4 pages.
- 147 L. Larson, P. Asbeck, and D. Kimball, "Digital control of RF power amplifiers for next-generation wireless communications," Proceedings of 35th European Solid-State Device Research Conference, 2005. ESSDERC 2005, pp. 39-44 INVITED PLENARY ARTICLE
- 148 D. Kimball, P. Draxler, J. Jeong, C. Hsia, S. Lanfranco, W. Nagy, K. Linthicum, L. Larson, and P. Asbeck, "50% PAE WCDMA base-station amplifier implemented with GaN HFETs," IEEE Compound Semiconductor Integrated Circuit Symposium, 2005. 4 pages.
- 149 L. Larson, P. Asbeck, and D. Kimball "Challenges and opportunities for compound semiconductor devices in next generation wireless base station power amplifiers," IEEE Compound Semiconductor Integrated Circuit Symposium, 2005. CSIC '05. pp. 1-4. INVITED PLENARY ARTICLE
- 150 W. Neo, X. Liu, Y. Lin, L. de Vreede, L. Larson, S. Spirito, A. Akhnoukh, A. de Graauw, and L. Nanver, "Improved hybrid SiGe HBT class-AB power amplifier efficiency using varactor-based tunable matching networks," Proceedings of the Bipolar/BiCMOS Circuits and Technology Meeting, 2005, pp. 108 – 111
- 151 M. Spirito, M van der Heijden, M. Pelk, L. de Vreede, P. Zampardi, L. Larson, and J. Burghartz, "Experimental procedure to optimize out-of-band terminations for highly linear and power efficient bipolar class-AB RF amplifiers," Proceedings of the Bipolar/BiCMOS Circuits and Technology Meeting, 2005, pp. 112 – 115.
- 152 M. Li, I. Galton, L. Larson, and P. Asbeck, "Nonlinearity estimation and spectral regrowth prediction of power amplifiers using correlation techniques," 2005 IEEE Annual Conference on Wireless and Microwave Technology, 2005. pp. 170 – 173.
- 153 M. Ranjan and L. Larson, "An Analysis of Cross-modulation Distortion in Ultra Wideband OFDM Receivers" IEEE International Microwave Symposium, June 2006, pp. 872 – 875.
- 154 Y. Han, L. Larson and D. Lie, "A low-voltage 12GHz VCO in 0.13 um CMOS for OFDM applications" 2006 Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems, 4 pages, 3rd Place BEST STUDENT PAPER AWARD
- 155 R. Kodkani and L. Larson, "A 25 GHz quadrature voltage controlled ring oscillator in 0.12 um SiGe HBT," 2006 Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems, 4 pp.
- 156 L. Larson, D. Kimball, P. Asbeck, P. Draxler, J. Deng, and M. Li, "Digital Predistortion Techniques for Linearized Power Amplifiers," Proceedings of 2006 IEEE Asai-Pacific Microwave Conference (APMC) INVITED RESEARCH ARTICLE
- 157 B. Nejati and L. Larson, "An Area Optimized 2.5-V 10-b 200-MS/s CMOS DAC," 2006 IEEE Custom Integrated Circuits Conference, pp. 161 – 164
- 158 J. Jamp and L. Larson, "Hardware Considerations for Spectral Encoded UWB Transmitters," IEEE 2006 International Conference on Ultra-Wideband, Sept. 2006, pp. 623 – 628.
- 159 S. Park, L. Larson and L. Milstein, "Hidden Mobile Terminal Device Discovery in a UWB Environment," IEEE 2006 International Conference on Ultra-Wideband, Sept. 2006, pp. 417 - 421
- 160 J. Popp, D. Lie, F. Wang, D. Kimball, and L. Larson, "Fully-integrated highly-efficient RF Class E SiGe power amplifier with an envelope-tracking technique for EDGE applications," 2006 IEEE Radio and Wireless Symposium pp. 231 – 234.

- 161 D. Lie, J. Kennedy, D. Livezey, B. Yang, T. Robinson, N. Sornin, C. Saint, C. and L. Larson, "Circuit and System Design for a Homodyne W-CDMA Front-End Receiver RF IC," International Symposium on VLSI Design, Automation and Test, 2006, 4 pages.
- 162 H. Khatri, L. Larson, D. Lie, "On-chip monolithic filters for receiver interference suppression using bond-wire inductors," 2006 Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems, 4 pages.
- 163 P. Asbeck, L. Larson, D. Kimball, Y. Zhao; F. Wang, and D. Qiao, "High dynamic range, high efficiency power amplifiers for wireless communications," Proceedings of the 2006 IEEE Bipolar/BiCMOS Circuits and Technology Meeting, pp. 103 - 107 INVITED RESEARCH ARTICLE
- 164 M. Li, I. Galton, L. Larson, and P. Asbeck, "Nonlinearity estimation and spectral regrowth prediction of power amplifiers using correlation techniques," The 2005 IEEE Annual Conference on Wireless and Microwave Technology, 2005. pp. 170 – 173
- 165 M. Ranjan, and L. Larson, "A Sub-1mm² Dynamically Tuned CMOS MB-OFDM 3-to-8GHz UWB Receiver Front-End," IEEE International Solid-State Circuits, 2006 Conference Digest of Technical Papers, pp. 438 – 445
- 166 M. Li, J. Deng, L. Larson, and P. Asbeck, "Nonideal effects of reconstruction filter and I/Q imbalance in digital predistortion," 2006 IEEE Radio and Wireless Symposium, pp. 259 – 263
- 167 L. Larson, P. Asbeck, and D. Kimball, "Multifunctional RF Transmitters for Next Generation Wireless Transceivers IEEE International Symposium on Circuits and Systems (ISCAS) 2007. , May 2007 Pp.:753 - 756 INVITED RESEARCH ARTICLE
- 168 H. Pan and L. Larson "Highly Linear Bipolar Transconductor For Broadband High-Frequency Applications with Improved Input Voltage Swing," IEEE International Symposium on Circuits and Systems, (ISCAS) 2007, Pp.:713 – 716
- 169 H. Pan, and L. Larson "Improved Dynamic Model of Fast-Settling Linear-in-dB Automatic Gain Control Circuit" IEEE International Symposium on Circuits and Systems, (ISCAS) 2007, pp. 681 – 684
- 170 R. Kodkani and L. Larson, "An Integrated 50-GHz SiGe Sub-Harmonic Mixer/Downconverter with a Quadrature Ring VCO," 2007 IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems, Pp.:223 – 226. 3rd Place BEST STUDENT PAPER AWARD
- 171 B. Nejati, and L. Larson, "Power/Area Trade-Offs in Low-Power/Low-Area Unary-R-2R CMOS Digital-to-Analog Converters," IEEE International Symposium on Circuits and Systems, (ISCAS) 2007, Pp.:1473 – 1476
- 172 P. Kolinko and L. Larson, "Passive RF Receiver Design for Wireless Sensor Networks," IEEE/MTT-S International Microwave Symposium, 2007, Pp.:567 – 570.
- 173 K. Buisman, C. Huang, A. Akhnoukh, M. Marchetti, L. de Vreede, L. Larson, and L. Nanver, "Varactor Topologies for RF Adaptivity with Improved Power Handling and Linearity," IEEE/MTT-S International Microwave Symposium, 2007, Pp.:319 – 322
- 174 T. Hung, J. Rode, L. Larson and P. Asbeck, "H-Bridge Class-D Power Amplifiers for Digital Pulse Modulation Transmitters," IEEE 2007 Intl. Microwave Symposium, pp. 1091 - 1094
- 175 J. Qureshi, S. Kim, K. Buisman, C. Huang, M. Pelk, A. Akhnoukh, L. Larson, L. Nanver, and L. de Vreede, "A Low-Loss Compact Linear Varactor Based Phase-Shifter," 2007 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, Pp.:453 - 456
- 176 Y. Han and L. Larson, "A Low-Power 5GHz Transceiver in 0.13 μ m CMOS for OFDM Applications with Sub-mm² Area" 2007 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, Pp.:361 - 364 – 3rd Place BEST STUDENT PAPER AWARD
- 177 R. Kodkani, L. Larson, "A 24-GHz CMOS Direct-Conversion Sub-Harmonic Downconverter," IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, 2007, Pp.:485 - 488
- 178 J. Jamp, J. Deng, and L. Larson, "A 10GS/s 5-bit Ultra-Low Power DAC for Spectral Encoded Ultra-Wideband Transmitters," 2007 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, Pp.:31 - 34
- 179 T. Hung; J. Rode, L. Larson, and P. Asbeck, "H-Bridge Class-D Power Amplifiers for Digital Pulse Modulation Transmitters," IEEE/MTT-S International Microwave Symposium, 2007, Pp.:1091 – 1094
- 180 T. Wooten and L. Larson, "A Decade Bandwidth, Low Voltage, Medium Power Class B Push-Pull Si/SiGe HBT Power Amplifier Employing Through-Wafer Vias," 2008 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, pp. 519-522.

- 181 Y. Han, K. Carter, L. Larson, A. Behzad, "A Low Insertion Loss, High Linearity, T/R Switch in 65 nm Bulk CMOS for WLAN 802.11g Applications," 2008 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, pp. 681-684.
- 182 S. Kim, J.H. Qureshi, K. Buisman, L.E. Larson, and L.C.N. de Vreede, "A Low-Distortion, Low-Loss Varactor Phase-Shifter Based on a Silicon-on-Glass Technology," 2008 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, pp. 175-178.
- 183 N. Kim, V. Aparin, and L. Larson, "A Resistively Degenerated Wide-Band Passive Mixer with Low Noise Figure and +60dBm IIP2 in 0.18 μ m CMOS," 2008 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, pp. 185-188.
- 184 D. Kimball, M. Kwak, P. Draxler, J. Jeong, C. Hsia, C. Steinbeiser, T. Landon, O. Krutko, L. Larson, P. Asbeck, "High Efficiency WCDMA Envelope Tracking Base-Station Amplifier Implemented with GaAs HVHBTs," 2008 IEEE Compound Semiconductor and Integrated Circuits Symposium (CSICS).
- 185 L. Larson, D. Kimball, and P. Asbeck, "Linearity and Efficiency Enhancement Strategies for 4G Wireless Power Amplifier Designs," 2008 IEEE Custom Integrated Circuits Conference (CICC). Pp. 741-748.
- INVITED RESEARCH ARTICLE
- 186 N. Kim, L. Larson, V. Aparin, "A Highly Linear CMOS Inductor-less Embedded Filtering Receiver for a SAW-less Cellular System," 2008 IEEE Custom Integrated Circuits Conference (CICC). Pp. 729-732.
- 187 P. Kolinko, L. Larson, "Background estimation of power amplifier nonlinearities for OFDM signals" 2009 Radio Frequency Integrated Circuits Symposium, pp. 405 – 408.
- 188 P. Asbeck, L. Larson, D. Kimball, S. Pornpromlikit, J. Jeong, C Presti, T. Hung, F. Wang, Y. Zhao, "Design Options for High Efficiency Linear Handset Power Amplifiers," 2009 IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems. INVITED RESEARCH ARTICLE
- 189 A. Afsahi, A. Behzad, V. Magoon, and L. Larson, "Fully integrated dual-band power amplifiers with on-chip baluns in 65nm CMOS for an 802.11n MIMO WLAN SoC," 2009 IEEE Radio Frequency Integrated Circuits Symposium, pp. 365 - 368
- 190 S. Park, L. Larson, L. Milstein, "Phase noise effects on signal detection for UWB/WiMAX coexistence," 2008 IEEE Military Communications Conference, pp. 1 – 7
- 191 H. Khatri, L. Liu; T. Chang, P. Gudem, and L. Larson, "A SAW-less CDMA receiver front-end with single-ended LNA and single-balanced mixer with 25% duty-cycle LO in 65nm CMOS." 2009 IEEE Radio Frequency Integrated Circuits Symposium, pp. 13 – 16
- 192 M. Farazian, B. Asuri, Y. Zhao and L. Larson, "A dual-band CMOS CDMA transmitter without SAW and Driver Amplifier," IEEE 2009 Radio Frequency Integrated Circuits Symposium, pp. 523 – 526.
- 193 H. Khatri, P. Gudem, L. Larson, "Simulation of intermodulation distortion in passive CMOS FET mixers," 2009 IEEE Microwave Symposium Digest, pp. 1593 – 1596
- 194 T. Wooten, and L. Larson, Wooten, "A 1 Watt 1-5 GHz Class B push-pull Si/SiGe HBT power amplifier," 2009 IEEE Custom Integrated Circuits Conference, pp. 387 – 390
- 195 R. Kodkani and L. Larson, "A 24-GHz CMOS sub-harmonic mixer based zero-IF receiver with an improved active balun," 2009 IEEE Custom Integrated Circuits Conference, pp. 673 – 676
- 196 H. Khatri, P. Gudem, L. Larson, "A SAW-less CMOS CDMA receiver with active Tx filtering," 2009 IEEE Custom Integrated Circuits Conference, pp. 379 – 382
- 197 Y. Hong; D. Kimball, J. Yook, and L. Larson, "Decade-bandwidth planar balun using CPW-to-slotline transition for UHF applications," 2009 IEEE European Microwave Conference, pp. 061 – 064
- 198 L. Larson, D. Kimball, P. Asbeck, "Advanced digital linearization approaches for wireless RF power amplifiers," 2008 IEEE Dallas Circuits and Systems Workshop: System-on-Chip - Design, Applications, Integration, and Software, pp. 1 – 7. INVITED RESEARCH ARTICLE
- 199 C. Huang, K. Buisman, P. Zampardi, L. Nanver, L. E. Larson, L. de Vreede, "Low Distortion Tunable RF Components, a Compound Semiconductor Opportunity," 2010 CS Mantech Conference, pp. 13-20.
- INVITED PLENARY TALK
- 200 A. Afsahi, A. Behzad, L. Larson, "A 65nm CMOS 2.4GHz 31.5dBm power amplifier with a distributed LC power-combining network and improved linearization for WLAN applications," 2010 IEEE Solid-State Circuits Conference, pp. 452 - 453
- 201 S. Park, V. Leung, L. Larson, "An Improved Wide-Dynamic Range Tunable RF

APPENDIX A

- Interference Suppression Notch Filter,” 2010 IEEE International Symposium on Circuits and Systems, 2010
- 202 Y. Hong, D. Kimball, J. Yook, P. Asbeck, L. Larson, “Switch-Controlled Multi-Octave Bandwidth Radial Power Divider/Combiner,” 2010 IEEE Microwave Symposium Digest
- 203 H. Pan, L. Larson, “A linear-in-dB SiGe HBT wideband high dynamic range RF envelope detector,” 2010 IEEE Radio Frequency Integrated Circuits Symposium pp. 267 – 270
- 204 S. Kim, P. Gudem, L. Larson, “A 44-GHz 8-element phased-array SiGe HBT transmitter RFIC with an injection-locked quadrature frequency multiplier,” 2010 IEEE Radio Frequency Integrated Circuits Symposium pp. 453 – 456
- 205 L. Larson, P. Asbeck and D. Kimball, “4th Generation Wireless Transceiver Design,” 2010 IEEE Bipolar Circuits and Technology Meeting, accepted for publication, INVITED RESEARCH ARTICLE
- 206 M. Farazian, P. Gudem, L. Larson, “Fast hopping carrier generation for 14-band multi-band OFDM UWB in digital CMOS,” 2010 IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF), pp. 251 – 254, 2nd Place BEST STUDENT PAPER AWARD
- 207 A. Afsahi, L. Larson, “An Integrated 33.5dBm Linear 2.4GHz Power Amplifier in 65nm CMOS for WLAN Applications,” 2010 IEEE Custom Integrated Circuits Conference, accepted for publication.
- 208 C. Huang, K. Buisman, L. Nanver, P. Zampardi, L. Larson, L.C.N. de Vreede, “Design concepts for semiconductor based ultra-linear varactor circuits (invited), IEEE Bipolar/BiCMOS Circuits and Technology Meeting (BCTM), 2010, Page(s): 204 – 211 INVITED RESEARCH ARTICLE
- 209 A. Arriagada, H. Pan, Jonmei Yan; D. Kimball, L. Larson, “A wideband high dynamic range frequency hopping transceiver for the Joint Tactical Radio System” MILCOM 2010, Page(s): 2009 - 2013
- 210 Pornpromlikit, S.; Dabag, H.; Hanafi, B.; Kim, J.; Larson, L.E.; Buckwalter, J.F.; Asbeck, P.M.; , "A Q-Band Amplifier Implemented with Stacked 45-nm CMOS FETs," Compound Semiconductor Integrated Circuit Symposium (CSICS), 2011 IEEE , vol., no., pp.1-4, 16-19 Oct. 2011
- 211 Nakatani, T.; Rode, J.; Kimball, D.F.; Larson, L.E.; Asbeck, P.M.; , "Digital polar transmitter using a watt-class current-mode class-D CMOS power amplifier," Radio Frequency Integrated Circuits Symposium (RFIC), 2011 IEEE , vol., no., pp.1-4, 5-7 June 2011
- 212 Hassan, M.; Myoungbo Kwak; Leung, V.W.; Chin Hsia; Yan, J.J.; Kimball, D.F.; Larson, L.E.; Asbeck, P.M.; "High efficiency envelope tracking power amplifier with very low quiescent power for 20 MHz LTE," Radio Frequency Integrated Circuits Symposium (RFIC), 2011 IEEE , vol., no., pp.1-4, 5-7 June 2011
- 213 Bagheri, M.; Bagheri, R.; Larson, L.E.; "A CMOS quadrature oscillator with deterministic output sequence," Silicon Monolithic Integrated Circuits in RF Systems (SiRF), 2011 IEEE 11th Topical Meeting on , vol., no., pp.1-4, 17-19 Jan. 2011
- 214 Kheirkhahi, A.; Asbeck, P. M.; Larson, L. E.; "Enhanced class-A/AB mobile terminal power amplifier efficiency by input envelope injection and ‘self’ envelope tracking," Microwave Symposium Digest (MTT), 2011 IEEE MTT-S International , vol., no., pp.1, 5-10 June 2011
- 215 Dabag, H.-T.; Joohwa Kim; Larson, L.E.; Buckwalter, J.F.; Asbeck, P.M.; , "A 45-GHz SiGe HBT amplifier at greater than 25 % efficiency and 30 mW output power," Bipolar/BiCMOS Circuits and Technology Meeting (BCTM), 2011 IEEE , vol., no., pp.25-28, 9-11 Oct. 2011
- 216 Korol, V.; Larson, L.E.; "A UWB CMOS SoC RF transmitter with analog baseband predistortion and on-package printed balun," Silicon Monolithic Integrated Circuits in RF Systems (SiRF), 2011 IEEE 11th Topical Meeting on , vol., no., pp.45-48, 17-19 Jan. 2011
- 217 Kheirkhahi, A.; Asbeck, P.M.; Larson, L.E.; "Enhanced Class-A/AB mobile terminal power amplifier efficiency by input envelope injection and “self” envelope tracking," Microwave Symposium Digest (MTT), 2011 IEEE MTT-S International , vol., no., pp.1-4, 5-10 June 2011.
- 218 Asbeck, P.; Larson, L.; Kimball, D.; Kwak, M.; Hassan, M.; Hsia, C.; Presti, C.; Scuderi, A.; , "Si IC development for high efficiency envelope tracking power amplifiers," Silicon Monolithic Integrated Circuits in RF Systems (SiRF), 2012 IEEE 12th Topical Meeting on , vol., no., pp.1-4, 16-18 Jan. 2012
- 219 Asbeck, P.; Larson, L.; Kimball, D.; Buckwalter, J.; , "CMOS handset power amplifiers: Directions for the future," Custom Integrated Circuits Conference (CICC), 2012 IEEE , vol., no., pp.1-6, 9-12 Sept. 2012 INVITED RESEARCH ARTICLE

APPENDIX A

- 220 Hassan, M.; Olson, C.; Kovac, D.; Yan, J.J.; Nobbe, D.; Kelly, D.; Asbeck, P.M.; Larson, L.E.; , "An Envelope-Tracking CMOS-SOS Power Amplifier with 50% Overall PAE and 29.3 dBm Output Power for LTE Applications," Compound Semiconductor Integrated Circuit Symposium (CSICS), 2012 IEEE , vol., no., pp.1-4, 14-17 Oct. 2012
- 221 Myoungbo Kwak; Kimball, D.; Presti, C.; Scuderi, A.; Santagati, C.; Jonmei Yan; Asbeck, P.; Larson, L.; , "Wideband high efficiency envelope tracking integrated circuit for micro-base station power amplifiers," Radio Frequency Integrated Circuits Symposium (RFIC), 2011 IEEE , vol., no., pp.1-4, 5-7 June 2011
- 222 Bagheri, Mahdi; Bagheri, Rahim; Larson, Lawrence E.; , "Wide tuning range CMOS LC quadrature oscillators based on quadrature mode switching," Circuits and Systems (ISCAS), 2012 IEEE International Symposium on , vol., no., pp.1752-1755, 20-23 May 2012
- 223 Agah, Amir; Hanafi, Bassel; Dabag, Hayg; Asbeck, Peter; Larson, Lawrence; Buckwalter, James; , "A 45GHz Doherty power amplifier with 23% PAE and 18dBm output power, in 45nm SOI CMOS," Microwave Symposium Digest (MTT), 2012 IEEE MTT-S International , vol., no., pp.1-3, 17-22 June 2012
- 224 Agah, A.; Dabag, H.; Hanafi, B.; Asbeck, P.; Larson, L.; Buckwalter, J.; , "A 34% PAE, 18.6dBm 42–45GHz stacked power amplifier in 45nm SOI CMOS," Radio Frequency Integrated Circuits Symposium (RFIC), 2012 IEEE , vol., no., pp.57-60, 17-19 June 2012
- 225 Myoungbo Kwak; Jinseong Jeong; Hassan, M.; Yan, J.J.; Kimball, D.F.; Asbeck, P.M.; Larson, L.E.; , "High efficiency wideband envelope tracking power amplifier with direct current sensing for LTE applications," Power Amplifiers for Wireless and Radio Applications (PAWR), 2012 IEEE Topical Conference on , vol., no., pp.41-44, 15-18 Jan. 2012
- 226 Hassan, M.; Larson, L.E.; Leung, V.W.; Asbeck, P.M.; , "Effect of envelope amplifier nonlinearities on the output spectrum of Envelope Tracking Power Amplifiers," Silicon Monolithic Integrated Circuits in RF Systems (SiRF), 2012 IEEE 12th Topical Meeting on , vol., no., pp.187-190, 16-18 Jan. 2012
- 227 Abdelhalem, S.H.; Gudem, P.S.; Larson, L.E.; , "A tunable differential duplexer in 90nm CMOS," Radio Frequency Integrated Circuits Symposium (RFIC), 2012 IEEE , vol., no., pp.101-104, 17-19 June 2012
- 228 Larson, L.; Abdelhalem, S.; Thomas, C.; Gudem, P.; , "High-Performance Silicon-Based RF Front-End Design Techniques for Adaptive and Cognitive Radios," Compound Semiconductor Integrated Circuit Symposium (CSICS), 2012 IEEE , vol., no., pp.1-4, 14-17 Oct. 2012 INVITED RESEARCH ARTICLE
- 229 Bagheri, M.; Bagheri, R.; Larson, L.E.; , "CMOS LC quadrature oscillators with enhanced tuning range by selective mode switching," Radio Frequency Integrated Circuits Symposium (RFIC), 2012 IEEE , vol., no., pp.297-300, 17-19 June 2012
- 230 Agah, A.; Dabag, H.; Asbeck, P.; Larson, L.; Buckwalter, J., "High-speed, High-efficiency millimeter-wave transmitters at 45 GHz in CMOS," Microwave Symposium Digest (IMS), 2013 IEEE MTT-S International , vol., no., pp.1,3, 2-7 June 2013
- 231 Kimball, D.; Yan, J.J.; Theilman, P.; Hassan, M.; Asbeck, P.; Larson, L., "Efficient and wideband envelope amplifiers for envelope tracking and polar transmitters," Power Amplifiers for Wireless and Radio Applications (PAWR), 2013 IEEE Topical Conference on , vol., no., pp.13,15, 20-20 Jan. 2013 (Invited Paper)
- 232 Ming Yin; Hao Li; Bull, C.; Borton, D.A.; Aceros, J.; Larson, L.; Nurmikko, A.V., "An externally head-mounted wireless neural recording device for laboratory animal research and possible human clinical use," Engineering in Medicine and Biology Society (EMBC), 2013 35th Annual International Conference of the IEEE , vol., no., pp.3109,3114, 3-7 July 2013
- 233 Abdelhalem, S.H.; Gudem, P.S.; Larson, L.E., "Hybrid transformer-based tunable integrated duplexer with antenna impedance tracking loop," Custom Integrated Circuits Conference (CICC), 2013 IEEE , vol., no., pp.1,4, 22-25 Sept. 2013
- 234 Hassan, M.; Asbeck, P.M.; Larson, L.E., "A CMOS dual-switching power-supply modulator with 8% efficiency improvement for 20MHz LTE Envelope Tracking RF power amplifiers," Solid-State Circuits Conference Digest of Technical Papers (ISSCC), 2013 IEEE International , vol., no., pp.366,367, 17-21 Feb. 2013
- 235 Agah, A.; Wei Wang; Asbeck, P.M.; Larson, L.; Buckwalter, J.F., "A 42 to 47-GHz, 8-bit I/Q digital-to-RF converter with 21-dBm Psat and 16% PAE in 45-nm SOI CMOS," Radio Frequency Integrated Circuits Symposium (RFIC), 2013 IEEE , vol., no., pp.249,252, 2-4 June 2013

- 236 Thomas, C.M.; Larson, L.E., "A 65 nm CMOS tunable 0.1-to-1.6 GHz distributed transmission line N-path filter with +10 dBm blocker tolerance," Custom Integrated Circuits Conference (CICC), 2014 IEEE Proceedings of the , vol., no., pp.1,4, 15-17 Sept. 2014.
- 237 Chul Kim; Sohmyung Ha; Thomas, C.; Joshi, S.; Jongkil Park; Larson, L.; Cauwenberghs, G., "A 7.86 mW +12.5 dBm in-band IIP3 8-to-320 MHz capacitive harmonic rejection mixer in 65nm CMOS," European Solid State Circuits Conference (ESSCIRC), ESSCIRC 2014 - 40th , vol., no., pp.227,230, 22-26 Sept. 2014
- 238 Larson, L.; Kimball, D.; Asbeck, P., "Wideband envelope tracking power amplifiers for wireless communications," Silicon Monolithic Integrated Circuits in Rf Systems (SiRF), 2014 IEEE 14th Topical Meeting on , vol., no., pp.32,37, 19-23 Jan. 2014 (Invited Talk)
- 239 Li, Hao; Thomas, Chris M.; Cauwenberghs, Gert; Larson, Lawrence E., "A BiCMOS 50 MHz input bandwidth, 1-to-16 channelizer optimized for low power analog signal classification," Bipolar/BiCMOS Circuits and Technology Meeting (BCTM), 2014 IEEE , vol., no., pp.76,79, Sept. 28 2014-Oct. 1 2014
- 240 Sarker, Subhradip; Nurmikko, Arto; Larson, Lawrence, "Comparative study of ultra-miniature RF coupling structures for intrabody networking applications," Biomedical Circuits and Systems Conference (BioCAS), 2014 IEEE , vol., no., pp.596,599, 22-24 Oct. 2014
- 241 Thomas, C.M.; Leung, V.W.; Larson, L.E., "A pseudorandom clocking scheme for a CMOS N-path bandpass filter with 10-to-15 dB spurious leakage improvement," in Radio and Wireless Symposium (RWS), 2015 IEEE , vol., no., pp.105-107, 25-28 Jan. 2015.
- 242 Thomas, C.M.; Larson, L.E., "A GaN HEMT N-path filter with +17 dBm jammer tolerance," in Radio and Wireless Symposium (RWS), 2015 IEEE , vol., no., pp.71-73, 25-28 Jan. 2015.
- 243 Chul Kim; Joshi, S.; Thomas, C.; Sohmyung Ha; Akinin, A.; Larson, L.; Cauwenberghs, G., "A CMOS 4-channel MIMO baseband receiver with 65dB harmonic rejection over 48MHz and 50dB spatial signal separation over 3MHz at 1.3mW," in VLSI Circuits (VLSI Circuits), 2015 Symposium on , vol., no., pp.C304-C305, 17-19 June 2015.
- 244 Larson, L., "RF and microwave technology challenges for Internet-of-Things applications," in Silicon Monolithic Integrated Circuits in RF Systems (SiRF), 2015 IEEE 15th Topical Meeting on , vol., no., pp.61-62, 26-28 Jan. 2015
- 245 C. M. Thomas, T. Quach, I. Telliez, T. Nakatani, D. Kimball and L. E. Larson, "A 250 nm GaN N-Path Filter IC with +27 dBm Blocker Tolerance," 2016 IEEE Compound Semiconductor Integrated Circuit Symposium (CSICS), Austin, TX, 2016, pp. 1-4.
- 246 L. Larson and A. Nurmikko, "Microwave communication links for brain interface applications," 2016 IEEE 16th Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF), Austin, TX, 2016, pp. 73-76.
- 247 A.R. Wichman; L. E. Larson, "Background measurement of RF system nonlinearity using spread-spectrum methods," 90th ARFTG Microwave Measurement Symposium (ARFTG), 2017, pp. 1-4.
- 248 J. Lee et al., "Wireless Power and Data Link for Ensembles of Sub-mm scale Implantable Sensors near 1GHz," 2018 IEEE Biomedical Circuits and Systems Conference (BioCAS), Cleveland, OH, 2018, pp. 1-4.
- 249 V. W. Leung; J. Lee; S. Li; S. Yu; C. Kilfoyle; L. Larson; A. Nurmikko; F. Laiwalla., "A CMOS Distributed Sensor System for High-Density Wireless Neural Implants for Brain-Machine Interfaces," ESSCIRC 2018 - IEEE 44th European Solid State Circuits Conference (ESSCIRC), Dresden, 2018, pp. 230-233.
250. J. Lee; F. Laiwalla; J. Jeong; C. Kilfoyle; L. Larson; A. Nurmikko; S. Li; S. Yu; V. W. Leung, "Wireless Power and Data Link for Ensembles of Sub-mm scale Implantable Sensors near 1GHz," 2018 IEEE Biomedical Circuits and Systems Conference (BioCAS), 2018, pp.1-4.
251. J. Lee; E. Mok; J. Huang; L. Cui; A. Lee; V. Leung; P. Mercier; S. Shellhammer; L. Larson; P. Asbeck; R. Rao; Y. Song; A. Nurmikko; F. Laiwalla, "An Implantable Wireless Network of Distributed Microscale Sensors for Neural Applications," 9th International IEEE/EMBS Conference on Neural Engineering (NER) 2019 pp. 871-874.
252. F. Laiwalla; J. Lee; A. Lee; E. Mok; V. Leung; S. Shellhammer; Y. Song; L. Larson; A. Nurmikko, "A Distributed Wireless Network of Implantable Sub-mm Cortical Microstimulators for Brain-Computer Interfaces," 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) pp. 6876-6879.

APPENDIX A

253. VW Leung, L Cui, S Alluri, J Lee, J Huang, E Mok, S Shellhammer, R Rao, L. Larson, A. Nurmikko, F. Laiwalla, “Distributed microscale brain implants with wireless power transfer and Mbps bi-directional networked communications,” 2019 IEEE Custom Integrated Circuits Conference (CICC), 1-4, 16, 2019

Patents

- 1 U.S. Patent # 4,682,149: "High Resolution Pipelined Digital-to-Analog Converter" (July 1987).
- 2 U.S. Patent # 4,872,010: "Analog-to-Digital Converter Made with Focused Ion Beam Technology", with J. Jensen, R. Walden, and A. Schmitz (October 1989).
- 3 U.S. Patent # 4,896,121: "Current Mirror for Depletion-Mode Field Effect Transistor Technology" (January 1990).
- 4 U.S. Patent # 4,951,303: "High Speed Digital Programmable Frequency Divider" (August 1990).
- 5 U.S. Patent # 4,977,403: "Digital Correction Circuit for Data Converters" (December 1990).
- 6 European Patent #E91303050.8: "HEMT Structure with Passivated Donor Layer", with M. Delaney, U. Mishra, and L. Nguyen (June 1991).
- 7 U.S. Patent # 5,049,522: "Semiconductive Arrangement Having Dissimilar, Laterally Spaced Layer Structures, and Process for Fabricating the Same", with W. Stanchina (September 1991).
- 8 U.S. Patent # 5,087,482: "Improved Electrostatically Movable Planar Transmission Line for Microwave Integrated Circuits" (March 1992).
- 9 U.S. Patent # 5,121,089: "Micro-Machined Switch and Method of Fabrication" (June 1992).
- 10 U.S. Patent # 5,146,117: "FET Logic Gate Whose Function is Determined by Ion Implantation" (September 1992).
- 11 U.S. Patent # 5,164,688: "Miniature Microwave and Millimeter Wave Tuner" (November 1992).
- 12 U.S. Patent # 5,168,249: "Miniature Microwave and Millimeter Wave Tunable Circuit" (December 1992).
- 13 U.S. Patent # 5,172,197: "HEMT Structure With Passivated Donor Layer" (December 1992).
- 14 U.S. Patent # 5,175,521: "Miniature Dynamically Tunable Microwave and Millimeter Wave Device" (December 1992).
- 15 "Hybrid Bipolar/Field-Effect Power Transistor in Group III-V Material System" with P. Asbeck and J. Brown (September 1994).
- 16 U.S. Patent # 5,420,422: "N-Type Antimony-Based Strained Layer Superlattice", with T. Hasenberg and A. Brown (May 1995).
- 17 U.S. Patent # 5,489,549: "Method of Fabricating N-Type Antimony-Based Strained Layer Superlattice", with T. Hasenberg, A. Brown (February 1996).
- 18 U.S. Patent # 5,528,209: "Monolithic microwave integrated circuit and method for fabricating same," with P. MacDonald, M. Case, M. Chen, and D. Rensch (July, 1996).
- 19 U.S. Patent # 5,757,074: "Microwave/millimeter Wave Circuit Structure with Discrete Flip-Chip Mounted Elements" (1998). (From A.IV.20)
- 20 U.S. Patent # 5,629,241: "Microwave/millimeter Wave Circuit Structure with Discrete Flip-Chip Mounted Elements, and Method of Fabricating the Same" (1998). (From A.IV.21)
- 21 U.S. Patent # 5,835,128: "Wireless redistribution of television signals in a multiple dwelling unit" (1998). (From A.IV.22)
- 22 U.S. Patent # 5,554,865: "Integrated transmit/receive switch/low noise amplifier with dissimilar semiconductor devices" (1996). (From A.IV.19)
- 23 U.S. Patent # 6,310,906: "Chaotic Carrier Pulse Position Modulation Communication System and Method" H. Abarbanel, N. Rulkov, M. Suschik, L. Tsimring, L. Larson and A. Volkovskii (2001).
- 24 U.S. Patent # 6,304,623: "Precision timing generator system and method" (2001). J. Richards; P. Jett; L. Fullerton; W. Larry; L. Larson and D. Rowe.
- 25 US Patent #6,396,347: "Low-Power, Low-Noise Dual-Gain Amplifier Topology and Method," (2002), D. Lie and L. Larson
- 26 US Patent #6,421,389: "Baseband signal converter for a wideband impulse radio receiver", (2002)P. Jett, L. Larson, B. Pollack and D. Rowe.
- 27 United States Patent 6,504,447, "Microelectromechanical RF and microwave frequency power limiter and electrostatic device protection," D. Laney; M. Matloubian and L. Larson (2003)
- 28 US Patent 6,577,691, "Precision timing generator apparatus and associated methods," J. Richards, P. Jett, L. Fullerton, L. Larson, and D. Rowe (2003)

APPENDIX A

- 29 US Patent 6,636,573, "Precision timing generator system and method," J. Richards, P. Jett, L. Fullerton, L. Larson and D. Rowe, (2003)
- 30 US Patent 6,735,424, "S-band low-noise amplifier with self-adjusting bias for improved power consumption and dynamic range in a mobile environment," L. Larson and W. Xiong (2004)
- 31 US Patent 6,847,266, "Microelectromechanical RF and microwave frequency power regulator," D. Laney, M. Matloubian, and L. Larson (2004)
- 32 US Patent 6,915,117, "Multistage modulation architecture and method in a radio," P. Chominski; J. Kennedy, L. Larson; J. Park, (2005)
- 33 US Patent 6,917,268, "Lateral microelectromechanical system switch," H. Deligianni; C. Jahnes, J. Lund, L. Larson (2005)
- 34 US Patent 6,937,663, "Baseband signal converter for a wideband impulse radio receiver," P. Jett, L. Larson, B. Pollack; D. Rowe (2005)
- 35 US Patent 6,950,485, "Precision timing generator apparatus and associated methods," P. Jett, L. Larson, B. Pollack; D. Rowe (2005)
- 36 US Patent 6,977,569 "Lateral microelectromechanical system switch," H. Deligianni; C. Jahnes, J. Lund, L. Larson, (2005)
- 37 US Patent 7,567,123, "Adaptive bias current circuit and method for amplifiers," V. Leung, P. Gudem, and L. Larson, (2010)
- 38 US Patent 7,652,532, "Correlation method for monitoring power amplifier," M. Li, P. Asbeck, I. Galton, and L. Larson, (2010)
- 39 US Patent 6,828,858, "CMOS class AB power amplifier with cancellation of nonlinearity due to change in gate capacitance of a NMOS input transistor with switching," L. Larson, C. Wang, (2008)
- 40 US Patent 7,902,585 "Linear variable voltage diode capacitor and adaptive matching networks", L. Larson and LC deVreede.
- 41 US Patent 8,242,868 "Multiple sub-carrier selection diversity architecture and method for wireless OFDM, L. Larson, Y. Sun and P. Gudem (2013)
- 42 US Patent 9,876,518: "Capactive Passive Mixer Baseband Receiver with Harmonic Rejection," C. Kim, G. Cauwnbergh, C. Thomas and L. Larson. 2018
- 43 US Patent 9,853,623, "High-Selectivity Passive Low-Loss Duplexer Filter." 2018, L. Larson

Disclosures not issued:

US Patent Disclosure "U.S. Application No.: 61/724,255, 11/8/2012, "Broad-Band Lumped Transmission Line N-Path Filter ," Chris Michael Thomas and Lawrence E. Larson.

Other Conference Proceedings Unpublished Plenary Talks

L. Larson, D. Kimball, and P. Asbeck, "Intelligent Transmitter Technology for Next Generation Wireless Transceivers," IEEE 2008 International Gigahertz Conference, Chalmers, Sweden, 4 pages, INVITED PLENARY TALK

Abstracts of Non-refereed Conference Proceedings (research workshops or talks where a full proceedings is not published)

- 1 M. Iwamoto, J. Arun, G. Hanington, A. Abellora, P. Asbeck, and L. Larson, "Class S Delta-Sigma Amplifiers for Linear Applications: Efficiency Considerations," *Proc. 1999 IEEE Topical Workshop on Power Amplifier for Wireless Communications*, Sept. 13-14, 1999.
- 2 C. Wang and L. Larson, "Analysis of a Microwave Class-E Power Amplifier with Finite Switching On-Resistance," *Proc. 1999 IEEE Topical Workshop on Power Amplifier for Wireless Communications*, Sept. 13-14, 1999.
- 3 W. T. Thornton, D. Morgan, and L. Larson, "Results Presented for a Novel Predistortion Linearizer Designed for Use in the LMDS Transmit Band," *Proc. 1999 IEEE Topical Workshop on Power Amplifier for Wireless Communications*, Sept. 13-14, 1999.
- 4 X. Zhang and L. Larson, "Gain and Phase Error Free LINC Transmitter," *Proc. 1999 IEEE Topical Workshop on Power Amplifier for Wireless Communications*, Sept. 13-14, 1999.
- 5 H. Kobayashi, J. Hinrichs, L. Larson, and P. Asbeck, "The current-mode Class-D amplifier for microwave frequencies: fundamental analysis and simulations," *2000 IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 11-12, 2000.
- 6 C. Wang, L. Larson, and P. Asbeck, "Linear Class-AB power amplifier with nonlinear capacitor compensation," *2000 IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 11-12, 2000.
- 7 M. Iwamoto, J. Hinrichs, J. Arun, L. Larson, and P. Asbeck, "A push-pull bandpass delta-sigma class-S amplifier," *2000 IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 11-12, 2000.
- 8 M. Iwamoto, P. Chen, H. Kobayashi, L. Larson, P. Asbeck, "950 MHz HBT Extended Doherty for Wireless Handsets: Linearity Characteristics and CDMA Operation," *2001 IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 10-11, 2001.
- 9 M. Iwamoto, A. Williams, C. Wang, L. Larson, and P. Asbeck, "Analysis of Doherty amplifiers with finite output impedance effects," *2000 IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 11-12, 2000.
- 10 P. Asbeck, H. Kobayashi, M. Iwamoto, G. Hanington, S. Nam, and L. Larson, "Augmented Band-pass nonlinearity model for power amplifier characterization," *2001 IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 10-11, 2001.
- 11 Y. Zhao, M. Iwamoto, P. Asbeck, and L. Larson, "Using DSP to Improve PA Performance," *IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 2002.
- 12 J. Deng, P. Gudem, L. Larson, and P. Asbeck, "High-Efficiency SiGe BiCMOS WCDMA Power Amplifiers with Dynamic Biasing Techniques," *IEEE Topical Workshop on Power Amplifiers for Wireless Communications*, Sept. 2003.
- 13 Feipeng Wang, Donald Kimball, Lawrence Larson, and Peter Asbeck, "Envelope Tracking Efficiency Enhancement for 802.11 g Power Amplifier", *2003 IEEE Topical Workshop on Power Amplifiers for Wireless Communications, San Diego, CA, 2003*.

APPENDIX A

- 14 Y. Zhao, M. Iwamoto, D. Kimball, L. E. Larson, and P. M. Asbeck, "A 900MHz Doherty Amplifier Implemented with Lumped Elements," *2003 IEEE Topical Workshop on Power Amplifiers for Wireless Communications, San Diego, CA, 2003*.
- 15 M. Ranjan, S. Rosenbaum, J. Pusi, B. Coy, L. Larson, "A 5.2GHz SiGe Power Amplifier for Wireless Data and Media Applications," *2003 IEEE Topical Workshop on Power Amplifiers for Wireless Communications, San Diego, CA, 2003*.
- 16 V. Leung, P. Gudem, L. Larson, "Dynamically-Biased Driver Amplifier for W-CDMA Mobile Phone Transmitter Applications," *2003 IEEE Topical Workshop on Power Amplifiers for Wireless Communications, San Diego, CA, 2003*.
- 17 J. Deng, P. Gudem, and L. Larson, "Intermodulation Distortion Analysis in SiGe HBT Amplifiers Using a Power-Dependent Coefficient Volterra Technique," *IEEE Topical Workshop on Power Amplifiers for Wireless Communications, Sept. 2004*.
- 18 M. Li, I. Galton, L. Larson and P. Asbeck, UCSD, "Power Amplifier Nonlinearity Estimation and Predistortion with Correlation Techniques," *IEEE Topical Workshop on Power Amplifiers for Wireless Communications, Sept. 2004*.
- 19 T. Hung, L. Larson, P. Asbeck, "CMOS Outphasing Class-D Power Amplifiers with Chireix Combiners" *IEEE Topical Workshop on Power Amplifiers for Wireless Communications, Sept. 2007*
- 20 Y. Hong, J. Jeong, D. Kimball, J. Yook, P. Asbeck, L. Larson, "Two-Stage Envelope Tracking Power Amplifiers for Basestation Application," *IEEE Topical Workshop on Power Amplifiers for Wireless Communications, Sept. 2009*

Other Presentations/Works (invited workshops, presentations, or short courses of a tutorial or overview nature)

1. L. Larson, "Research directions in chaotic digital communications devices," *SIAM Conference on Applications of Dynamical Systems*, Snowbird, Utah, May 2001. WORKSHOP PRESENTATION
2. L. Larson, "The Impact of Semiconductor Technology Evolution on Communication Systems," Plenary Talk, International High-Tech Forum, Zhuhai, China, 2002 Plenary Speech
3. L. Larson, "The role of power amplifier in wireless telecommunications," IEEE International Solid-State Circuits Conference Short Course Presentation, 2000. Short Course Presentation at International Conference
4. L. Larson, "Emerging Semiconductor Technologies and their Effect on the Communications Industry, Presentation to San Diego Telecom Council, June 2002. Industry Group Presentation
5. L. Larson, "Implementation of VCO design," *2000 IEEE Radio Frequency Integrated Circuit Symposium*, Anaheim, CA, June 13-19, 2000. WORKSHOP PRESENTATION
6. L. Larson, "Improved Techniques Utilizing Harmonic Termination Methods for Microwave and RF Circuit Design," at "Introducing New Concepts in Nonlinear Network Design," Workshop at 2002 IEEE MTT-S International Microwave Symposium, Seattle, WA. WORKSHOP PRESENTATION
7. L. Larson, "RF and Microwave Oscillator Design," Workshop at 2003 IEEE International Microwave Symposium, Philadelphia, Pennsylvania. WORKSHOP PRESENTATION
8. L. Larson, "Next Generation Transmitter Architecture and Design," Workshop at 2003 IEEE International Microwave Symposium, Philadelphia, Pennsylvania. WORKSHOP PRESENTATION
9. L. Larson, "Wireless System Design and Measurement Accuracy: State-of-the-Art and Future Needs for the Communications", Workshop at 2004 IEEE International Microwave Symposium, Fort Worth, Texas. WORKSHOP PRESENTATION
10. L. Larson, "Analog/RF design in SiGe Processes," IEEE International Solid-State Circuits Conference Short Course Presentation, 2004. Short Course Presentation at International Conference
11. P. Asbeck, J. Rode, I. Galton and L. Larson, "Algorithms and Amplifiers for Digital Generation of Microwave Signals with Time-varying Envelope" Workshop at 2005 IEEE International Microwave Symposium, Long Beach, CA WORKSHOP PRESENTATION
12. "Enabling RF Technologies for Software Defined /Cognitive Radios" Larry Larson, Workshop Presentation at International European Solid-State Circuits Research Conference, 2006 WORKSHOP PRESENTATION

APPENDIX A

- 13 "Power Supply Modulation Techniques for Power Amplifier Efficiency Enhancement," Larry Larson, Feipeng Wang, Donald Kimball, and Peter Asbeck," Workshop Presentation at International Microwave Symposium (IMS) 2006. WORKSHOP PRESENTATION
- 14 "Multi-Standard RFIC Transmitter Technology," Lawrence Larson, Peter Asbeck, and Donald Kimball, Workshop Presentation at International Microwave Symposium (IMS) 2006. WORKSHOP PRESENTATION
- 15 "Efficiency Enhancement Techniques for WiMAX Power Amplifiers," Lawrence Larson, Peter Asbeck, and Donald Kimball, Workshop Presentation at International Microwave Symposium (IMS) 2007. WORKSHOP PRESENTATION
- 16 "Software Defined /Cognitive Radios: RF and System Considerations" Lawrence Larson, Workshop Presentation at International Microwave Symposium (IMS) 2007. WORKSHOP PRESENTATION
- 17 "Reconfigurable Transmitters and Power Amplifiers" Lawrence Larson, Peter Asbeck, and Donald Kimball, Workshop Presentation at IEEE Radio Frequency Integrated Circuit Symposium (2007) WORKSHOP PRESENTATION
- 18 "Linearization of Highly-Efficient Monolithic Class E SiGe Power Amplifiers with Envelope-Tracking (ET) and Envelope-Elimination-and-Restoration (EER) at 900MHz," D. Lie, J. Popp, F. Wang, D. Kimball, and L. Larson, 6th IEEE Dallas Circuits and Systems Workshop on System-on-Chip, 2007. DCAS 2007. WORKSHOP PRESENTATION
- 19 "Digital-Assisted Compensation of RF-Front-end Limitations," Larry Larson Workshop Presentation at IEEE International Solid-State Circuits Conference (2008) WORKSHOP PRESENTATION
- 20 "Digitally Enhanced" RF Circuits, Lawrence Larson, Peter Asbeck, and Donald Kimball, Panel Presentation at IEEE International Solid-State Circuits Conference (2007) WORKSHOP PRESENTATION
- 21 "Power Supply Modulation Techniques for Power Amplifier Efficiency Enhancement," Lawrence Larson, Peter Asbeck, and Donald Kimball, Workshop Presentation at IEEE International Solid-State Circuits Conference (2007) WORKSHOP PRESENTATION
- 22 "Digital Signal Processing Techniques for Linearity and Efficiency Enhancement of Envelope Tracking, EER, and Doherty Amplifiers," Lawrence Larson, Peter Asbeck, and Donald Kimball, Workshop Presentation at IEEE Radio Frequency Integrated Circuit Symposium (2008) WORKSHOP PRESENTATION
- 23 "Low-Power Reconfigurable Transmitter Architectures" Lawrence Larson, Peter Asbeck, and Donald Kimball Workshop Presentation at IEEE Radio Frequency Integrated Circuit Symposium (2008) WORKSHOP PRESENTATION
- 24 "Bipolar-Based Power Amplifier Design Beyond Handsets and into MMIC: Design, Modeling, Characterization, Packaging, Reliability," Larry Larson, Workshop Presentation at IEEE Bipolar Circuits and Technology Meeting (2007) WORKSHOP PRESENTATION
- 25 "Digitally Enhanced" RF Circuits" Lawrence Larson, Peter Asbeck and Don Kimball, Workshop Presentation at International Microwave Symposium (IMS) 2009. WORKSHOP PRESENTATION
- 26 "Packaging Options for Wireless Systems-on-a-Chip" Lawrence Larson, Workshop Presentation at International Microwave Symposium (IMS) 2009. WORKSHOP PRESENTATION
- 27 "Power Amplifier Integration Challenges for Highly Integrated Multi-Mode Transceivers," L. Larson, Workshop Presentation at International Microwave Symposium (IMS) 2009 WORKSHOP PRESENTATION
- 28 "Power Amplifiers" Lawrence Larson, Peter Asbeck and Don Kimball, Workshop Presentation at IEEE Custom Integrated Circuits Conference (CICC) 2009. WORKSHOP PRESENTATION
- 29 "Packaging Options for Wireless Systems-on-a-Chip", Lawrence Larson, Panel Presentation, IEEE International Solid-State Circuits Conference (2009) WORKSHOP PRESENTATION
- 30 "Ubiquitous Wireless Communications," L. Larson, Presentation to La Jolla Venture Capital Forum, April 2009 PRESENTATION
- 31 "Ubiquitous Wireless Communications," June, 2009, SPAWAR TechBoard Presentation, PRESENTATION
- 32 "Design Techniques for Broadband Efficient Linear Power Amplifiers for Multi-Mode Wireless Applications" Lawrence Larson, Workshop Presentation at International Microwave Symposium (IMS) 2010 WORKSHOP PRESENTATION

APPENDIX A

- 33 "Low-Power Transmitters in Nanoscale CMOS "Lawrence Larson, Peter Asbeck, and Donald Kimball, Workshop Presentation at IEEE Radio Frequency Integrated Circuit Symposium (2010) WORKSHOP PRESENTATION
- 34 "Ubiquitous Wireless Communications," Presentation to Qualcomm Ventures 5/28/09 PRESENTATION
- 35 "Digital Signal Processing Techniques for Linearity and Efficiency Enhancement of Envelope Tracking, EER, and Doherty Amplifiers" Presentation at UCSB, April 2008 PRESENTATION
- 36 "Linearization of Power Amplifiers," Csics 2010 Short Course WORKSHOP PRESENTATION
- 37 "Improving RF Transmitter Energy Efficiency for Future Generation Wireless Systems" Presentation to UC Irvine ECE Department Irvine, May, 2010. PRESENTATION
- 38 "RF and Microwave Challenges for Cognitive Radio and TV White Space Devices," Presentation at GHz Center, annual Review, Chalmers University, Sweden, November, 2009. PRESENTATION
- 39 "Power Amplifier Technology" Panasonic 7/20/09 PRESENTATION
- 40 "Power Amplifier Technology" Huawei 7/28/09 PRESENTATION
- 41 "RF and Microwave Challenges for Cognitive Radio and TV White Space Devices" Huawei Cognitive Radio Panel 4/17/09 PRESENTATION
- 42 "Improving RF Transmitter Energy Efficiency for Future Generation Wireless Systems" Presentation to UC Riverside ECE Department 2/17/09 PRESENTATION
- 43 "Low-Power RF Circuit Trends for Wireless Communications" Broadcomm, 4/20/09. PRESENTATION
- 44 "RF and Microwave Challenges for Cognitive Radio and TV White Space Devices," Presentation at California Institute of Technology, December, 2009. PRESENTATION
- 45: Wouk Lecture – Cal. Tech. June 2013. This is the main invited lecture given by the Division of Engineering at Cal Tech every year. PRESENTATION
- 46: "Envelope Tracking Power amplifiers for wireless Communications," Huawei Power Amplifier Workshop, May, 2014.
- 47:"RF and microwave technology challenges for Internet-of-Things applications" was an invited talk at the 2015 IEEE 15th Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems, Jan., 2015.
- 48: "RF and Microwave Challenges for Future Radio Spectrum Access", Northeastern ECE Distinguished Speaker Series, December 3, 2015.
- 49: "RF and Microwave Challenges for Future Radio Spectrum Access" Invited talk at the Radio Club of America's Technical Symposium, San Jose, CA, Nov. 2015.
- 50: "Overview of the School of Engineering at Brown," Presentation to Rhode Island Professional Engineers, Nov. 4, 2015
- 51: TBP Annual National Convention - Overview of the School of Engineering at Brown, Oct. 30, 2015
- 52: "Design Fundamentals for RF Receivers and Transmitters," IEEE BCTM short course, Oct. 2015
- 53: "Transformer-based duplexers for wireless communications," Presentation to Skyworks, Woburn, Mass, May, 2015,
- 54: "Internet-of-Things" IMS Panel Discussion, May, 2015.

APPENDIX A

Contracts and Grants (period 7/1/11- 2/1/23) Brown University

		Funding Agency	Total Funding	Period of Performance		Percent Effort
1	Efficient Linear All-Silicon Transmitter IC's (ELASTX)	DARPA	\$1,550,000	3/11-12/13	Co-PI	20%
2	Cognitive radio Low-energy signal Analysis Sensor ICs (CLASIC)	DARPA/SAIC	\$350,000	1/12-1/15	PI	100%
3	Wide Tuning Range RF Front-End	DARPA/Maxcentric	\$30,000	7/12-7/13	PI	100%
4	Neural Engineering System Design (Nurmikko PI)	DARPA	~\$1,300,000	4/17-10/18	Co-PI	~10%
5	NIST Prep - Boulder	NIST	~\$6,600,000	1/18-1/22	PI	5%

Service

University Service

Brown University Committees:

- Knowledge District Working Group: Fall 2011
- COE Review Committee: Fall 2011
- Nelson Center RPG Fall 2015
- Ex-Officio Member of President's Cabinet, Provost Senior Deans, Capital Planning, Tenure and Promotion, University Resource Committee and Academic Planning Committee
- Provost Search Committee, Fall 2022

University of California (system-wide) Committees:

- UCSD representative on the UC MICRO Steering Committee from 1999-2000. This group met three times per year in Oakland to establish MICRO policy, review proposals, and plan MICRO strategy for the future.
- UCSD representative on the UC Discovery Grant "Communications and Networking" Steering Committee 2001-2006. This group met three times per year in Oakland. Reviewer of Discovery Grant proposals.

University of California – San Diego Committees:

- Department representative to the Academic Senate (1999-2000)
- Member of the *ad-hoc* committee to review Professor Craig as provost of the Eleanor Roosevelt College (2000).
- Member of the *ad-hoc* ethics review committee for Professor Michael Karin (1997-2000).
- Member of the UCSD Institute for Nonlinear Studies Steering Committee (1999-2005).
- Member of Five-Year Review Committee for Rady School Dean Sullivan (2008)

UCSD Jacobs School of Engineering Committees:

- Representative of Center for Wireless Communications to Jacobs School Council of Advisors, 2002-2006.

APPENDIX A

- Chair of the committee that nominated Professor Peter Asbeck for the Conexant Chair of Electrical and Computer Engineering (2002).
- Member of the Chair committee for Professor Rajesh Gupta (2002)
- Member of the Chair committee for Professor Larry Smarr (2002).
- Member of SAIC Chair Committee for Professor Ahmin Vahdat (2008)
- Chair of CMRR Chair Committee for Professor Paul Siegel (2007)
- UCSD JSOE Diversity Advisory Council – Chair of Working Group on Student Recruiting 2010-2011

UCSD California Institute for Telecommunications and Information Technology Committees:

- Member of the CALIT² Communications committee (2005) .
- Member of the CALIT² Building Dedication committee (2005) .
- Member of CALIT NRI Committee (2006-2008)
- Member of CALIT Steering Committee (2005-2007)

UCSD Center for Wireless Communications:

- Director, July 2001-July 2006. Co-Director January 2000-July 2001. The Director of the CWC is responsible for all aspects of Center operation, including budgeting, resource allocation, interaction with member companies, recruiting new members, organizing technical reviews, and helping to determine technical direction. The CWC had roughly 12 Member Companies, 25 faculty members, and an annual budget of approximately \$2.5M and supported roughly 45 PhD students during my tenure as Director. The Center Director is responsible for organizing the semi-annual research review, as well as hosting the semi-annual Board meeting. I was also responsible for member interactions and recruitment, which typically involved meetings with over 40 companies per year, as well as many visits to our Member companies.
- Member, CWC Executive Steering Committee for 1998-2000.
- CWC Entre/Intra-preneurship Workshop Organizer (w. Professor Alon Orlitsky). Nov. 2007. Professor Orlitsky and I organized this highly successful CWC Workshop. It required solicitation of distinguished international invited speakers, organizing the venue location, promotion of the event, etc.

UCSD ECE Department Committees:

- Member Department Space Committee(1998-2000)
- Member Graduate Affairs Committee (2000-2001)
- Member Faculty Council (1997-1999 and 2001-2003)
- Member Center for Wireless Communications Five Year Review Committee (2000)
- Host ECE294 Friday Lecture series: Fall 1999.
- Chair Search Committee for Prof. G. Rebeiz (2003)
- Chair Search Committee for Prof. B. Song. (1999)
- Member Search Committee for Prof. J. Buckwalter (2006)
- Member Search Committee Computer Engineering (2007)
- Chair, ECE Space Committee (2007)
- Chair and/or Member of Five Department Ad-Hoc Review Committees (2005-2008)
- MS and M.Eng Advisor: Electronic Circuits and Systems : (2005-2011)

UCSD ECE Department Service:

- ECE Department Vice Chair (2007)
- ECE Department Chair (2007-2011)

Host of Visiting Scholars and Professors at UCSD:

I have acted as host to several visitors, who were resident Visiting Scholars or Visiting Professors, including Mr. Eriji Iriyama from Matsushita Electric Works(1998-2000), Professor Leo DeVreede from Technical University Delft (1999), and Professor KH Koo from the University of Inchon (2000), and Mr. Thomas Johansen, from TU Copenhagen (2001-2002) Prof. Hyun-Chang Park from Dongguk University (2002-2003), Professor Carlo Samori: Politecnico Milano (2006-2007) and Professor Jong-Gwan Yook: Yonsei University (2007-2008). As Director of the UCSD CWC, I played official host to approximately 10 CWC visiting scholars.

Professional Service

Editor:

- Associate Editor IEEE Transactions on Circuits and Systems (2008-2010)

Guest Editor:

- Guest Editor of the August 1999 Issue of the *IEEE Transactions on Microwave Theory and Techniques*. This involved solicitation of manuscripts, and coordinating the review and publication process.
- Guest Editor of the October 2000 Issue of the *IEEE Journal of Solid-State Circuits*. This involved solicitation of manuscripts, and coordinating the review and publication process.
- Guest Editor Special Issue on Multifunctional Circuits and Systems for Future Generations of Wireless Communications, with A. Tasic, and W Serdijn, 2009 *IEEE Transactions on Circuits and Systems II*, Volume: 55 , Issue: 4

IEEE Committees:

- Member Program Committee for the 1999 IEEE Custom Integrated Circuits Conference (CICC).
- Member Program Committee for the 1997-2002 IEEE Bipolar Circuits and Technology Meeting (BCTM) (Chair of the RF committee and panel session organizer)
- Member Program Committee for the 1999 IEEE Radio Frequency Integrated Circuits Conference,
- Member Program Committee for the 1998 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits.
- Founding Chairman, 1998 UCSD Center for Wireless Communications Conference in cooperation with the IEEE.
- Technical Program Chair 1999(founding), 2001, and 2003 IEEE Workshop on Power Amplifiers for Wireless Communications.
- General Chair 2000, 2002, 2004 and 2006 IEEE Workshop on Power Amplifiers for Wireless Communications.
- Member Program Committee for the 2004 IEEE Radio and Wireless Conference.
- Member Program Committee for the 2004 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits.
- Member Program Committee for the 2007 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits.
- Member Program Committee for the 2008 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits.

APPENDIX A

- Member Program Committee for the 2009 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits.
- Member Program Committee for the 2009 IEEE International conference on Ultra-Wideband
- IEEE Communications Society 2009 Administrative Committee Member – Technical Directions Sub-Committee
- Member Program Committee for the 2010 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits
- Member Program Committee for the 2011 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits
- Member Program Committee for the 2012 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits
- Member Program Committee for the 2013 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits
- Member Program Committee for the 2014 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits
- Member Program Committee for the 2015 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits
- Member Program Committee for the 2016 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits
- Member Program Committee for the 2017 IEEE Topical Symposium on High-Frequency Silicon Devices and Circuits

NAE Committees:

- National Academy of Engineering Computer Science and Telecommunications Board's Committee on Wireless Technology Prospects and Policy Options. (2003-2011). This study committee was established by the National Academies at the request of the National Science Foundation to conduct a comprehensive assessment of wireless technology and service and application trends and their implications for wireless spectrum management and policy, and published its final report in 2011.
- A member (2019) of the NAE visiting committee reviewing the NIST Boulder Communications Laboratory, whose findings were published January 2020. I led the Metrology Section group during the review, and drafted that Section of the final report

Paper and Proposal Reviewer:

- Paper Reviewer (1998-Present):
 - IEEE Transactions on Microwave Theory and Techniques,
 - IEEE Microwave and Guided Wave Letters,
 - IEEE Transactions on Vehicular Technology,
 - IEEE Communications Letters,
 - IEEE Journal of Solid-State Circuits,
 - IEEE Transactions on Circuits and Systems,
 - IEEE Transactions on Electron Devices,
 - IEE Electronics Letters.
- NSF Proposal Reviewer: (2003, 2004, 2009, 2010, 2011, 2012)
- NSF ECCS Program Review Panel Member 2011

Diversity Training

Attended the NSA ADVANCE/PAID Chair Retreat, October 10 to 12, 2007. This three day event provided me with intensive training on removing bias and promoting diversity in the recruiting, tenure and advancement process. I took the lessons of this training back to the ECE department and used it to implement improved recruitment and promotion policies.

Other Activities (Entrepreneurship, Consulting, etc).

Co-Founder: Aethercomm, Inc. (1999-Present, BOD Member). Co-Founder Renaissance Wireless (2004-2007), Co-Founder Nurlink (2017-2021)

Technical Advisory Board Member: Resonant Communication (2020-2022), LintrinsicIC (2021-present).

Consultant to Sierra Monolithics (1996-2011), Consultant for Qualcomm in 2015-2016.

I also taught several short courses (1988-2011) through UCLA Extension, UCSD Extension, Mead Microelectronics, and Besser and Associates.

Academic Honors, Fellowships, and Honorary Societies

Memberships

Fellow, IEEE -1999, Life Fellow, IEEE - 2022
Member, Eta Kappa Nu, Sigma Xi, Tau Beta Pi

Honors and Awards

Howard Hughes Doctoral Fellow: 1982 - 1986.

Hughes Research Laboratories Sector Patent Award: 1995 for my work on RF MEMS technology.

Co-Recipient of Lawrence Hyland Award - 1996: This is the highest technical achievement award at Hughes Electronics, for development of InP-based low-noise HEMTs for satellite communications in the years 1989-1994.

IBM Faculty Development Award: 2002

Co-Recipient of IBM Microelectronics General Managers Excellence Award (1999) for Development of Si/SiGe HBT Technology. This was for my research on the development of Si/SiGe HBT technology during the years from 1993-1998.

“Wireless Influencers 2002” one of the top 200 people selected internationally as the top influencers in the wireless industry for 2002. One of only 11 people selected from academia.

Co-Recipient (w. D. Jessie): IEEE Custom Integrated Circuits Conference: Best Invited Paper 2003

Co-Recipient (w. V. Leung and P. Gudem): 2nd place Semiconductor Research Corporation SiGe Design Competition 2003

Co-Recipient (w. V. Aparin): Best Student Paper Award – 1st place: IEEE Radio Frequency Integrated Circuits Conference 2004

Co-Recipient (w. F. Wang, P. Asbeck and D. Kimball): Best Student Paper Award – 2nd place: IEEE International Microwave Symposium 2004

Co-Recipient (w. Yiping Han) Best Student Paper Award – 3rd Place: 2006 Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems

Co-Recipient (w. Yiping Han) Best Student Paper Award – 3rd place: IEEE Radio Frequency Integrated Circuits Conference 2007

APPENDIX A

Co-Recipient (w. Rahul Kodkani) Best Student Paper Award – 3rd Place: 2007 Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems
Co-Recipient (w. Mohammad Farazian) Best Student Paper Award – 2nd Place: 2010 Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems
Mohammad Farazian (PhD Student) – Analog Devices Best Student Designer Award 2008
Ali Afsahi (PhD Student) – Analog Devices Best Student Designer Award 2010
Co-Recipient (w. Mahdi Bagheri) Best Student Paper Award – 3rd Place: 2011 Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems

Teaching

Regular Courses and Enrollment Figures at Brown University

Engn 0020 – Spring 2013 (w. Prof. E. Powell). Enrollment was 131. Score on “Teaching Effectiveness” was 1.71 (1 being best and 5 being worst).
ENGN 0020 Spring 2014 (w. Prof. E. Powell). Enrollment was 125. Score on “Teaching Effectiveness” was 1.75 (1 being best and 5 being worst).
ENGN 0020 Spring 2016 (w. Prof. Jason Harry). Enrollment was 108. Score on “Teaching Effectiveness” was 1.9 (1 being best and 5 being worst).
ENGN 0020 Spring 2017 (w. Prof. Jason Harry). Enrollment was 118. Score on “Teaching Effectiveness” was 2.17 (1 being best and 5 being worst).
ENGN 0520 Spring 2018 (w. Professor Jacob Rosenstein) Enrollment was 94. Score on “Teaching Effectiveness” was 1.75 (1 being best and 5 being worst).
ENGN 0520 Spring 2019 (w. Professor Jacob Rosenstein) Enrollment was 98. Score on “Teaching Effectiveness” was 1.69 (1 being best and 5 being worst).
ENGN 0520 Spring 2020 (w. Professor Farah Laiwalla) Enrollment was 97. Score on “Teaching Effectiveness” was 1.62 (1 being best and 5 being worst).
ENGN 0520 Spring 2021 (w. Professor Farah Laiwalla) Enrollment was 92. Score on “Teaching Effectiveness” was 1.46 (1 being best and 5 being worst).

Independent Studies at Brown University

- Three independent studies projects advised in Fall Semester 2011.
- One independent studies project advised in Fall Semester 2012.
- I supervised one undergraduate student research during 2013 and 2014 – Mr. Subhradip Sarkar. He also did an Honor’s thesis with me in 2015.

APPENDIX A

Honors, Master's and PhD theses directed

- Master's Students Completed: 24 (UCSD) One (Brown University)
- Doctoral Students Completed: 30 (UCSD) One (Brown University)

S. Vora	Thesis and Research Advisor	MS (Degree Granted 98)
R. Langridge	Thesis and Research Advisor	MS (Degree Granted 99)
K. Yang	Thesis and Research Advisor	MS (Degree Granted 99)
W. Sun	Thesis and Research Advisor	MS (Degree Granted 00)
Y. Song	Research Advisor (w. B. Song)	MS (Degree Granted 01)
J. Roan	Research Advisor	MS (Degree Granted 02)
P. Nanawa	Research Advisor	MS (Degree Granted 02)
R. Apte	Research Advisor	MS (Degree Granted 03)
H. Ghajari	Research Advisor	MS (Degree Granted 03)
S. Sivakumar	Research Advisor	MS(Degree Granted 03)
Dayo Ojo	Research Advisor	MS(Degree Granted 04)
P. Sagazio	Research Advisor	MS(Degree Granted 04)
A. Ebaad	Research Advisor	MS(Degree Granted 04)
A. Yang	Research Advisor	MS(Degree Granted 04)
H. Ng	Research Advisor	MS(Degree Granted 04)
P. Lee	Research Advisor	MS(Degree Granted 04)
P. Yu	Research Advisor	MS(Degree Granted 04)
R. Pera	Research Advisor	MS (Degree Granted 05)
D. Cheng	Research Advisor	MS(Degree Granted 07)
John Keeler	Research Advisor	MS(Degree Granted 07)
Javier Molina	Research Advisor	MS (Degree Granted 09)
Howard Liu	Research Advisor	MS (Degree Granted 09)
Tony Lo	Research Advisor	MS (Degree Granted 09)
Anton Arrigada	Research Advisor	MS (Degree Granted 10)
Akaninyene Umoh	Research Advisor	MS (Degree Granted 11)
C. Kilfoyle	Research Adviser	ScM (Degree Granted 17)

Doctoral Students:

Name of Student/Your Role (thesis adviser, research adviser, etc.)

X. Zhang	Dissertation and Research Advisor	PhD (Degree Granted 2001)
C. Wang	Dissertation and Research Advisor	PhD(Degree Granted 2003)
D. Jessie	Dissertation and Research Advisor	PhD(Degree Granted 2003)
D. Laney	Dissertation and Research Advisor	PhD(Degree Granted 2003)
J. Fairbanks	Dissertation and Research Advisor	PhD (Degree Granted 2003)
K. Gard	Dissertation and Research Advisor	PhD(Degree Granted 2003)
L. Sheng	Dissertation and Research Advisor	PhD(Degree Granted 2003)
R. Tenny	Dissertation and co-Advisor (w/ H. Abarbanel)	PhD(Degree Granted 2003)
V. Leung	Dissertation and Research Advisor	PhD(Degree Granted 2004)
V. Aparin	Dissertation and Research Advisor	PhD(Degree Granted 2005)
J. Jensen	Dissertation and Research Advisor	PhD(Degree Granted 2005)
J. Deng	Dissertation and Research Advisor	PhD(Degree Granted 2005)
M. Ranjan	Dissertation and Research Advisor	PhD(Degree Granted 2006)
F. Wang	Dissertation and Research Advisor	PhD (Degree Granted 2006)
J. Jamp	Dissertation and Research Advisor	PhD (Degree Granted 2007)
R. Kodkani	Dissertation and Research Advisor	PhD (Degree Granted 2009)

APPENDIX A

H. Khatri	Dissertation and Research Advisor	PhD (Degree Granted 2009)
M. Farazian	Dissertation and Research Advisor	PhD (Degree Granted 2009)
H. Pan	Dissertation and Research Advisor	PhD (Degree Granted 2010)
N. Kim	Dissertation and Research Advisor	PhD (Degree Granted 2010)
S. Kim	Dissertation and Research Advisor	PhD (Degree Granted 2010)
S. Park	Dissertation and Research Advisor	PhD (Degree Granted 2010)
M. Kwak	Dissertation and Research Advisor	PhD (Degree Granted 2011)
M. Hassan	Dissertation and Research Advisor	PhD (Degree Granted 2012)
A.Kheirkhi	Dissertation and Research Advisor	PhD (Degree Granted 2013)
A. Afsahi	Dissertation and Research Advisor	PhD (Degree Granted 2013)
A. Agah	Dissertation and Research Advisor	PhD (Degree Granted 2013)
S. Abdelhalem	Dissertation and Research Advisor	PhD (Degree Granted 2013)
C. Thomas	Dissertation and Research Advisor	PhD (Degree Granted 2015)
M. Bagheri	Dissertation and Research co-Advisor	PhD (Degree Granted 2018)
A. Wichman	Dissertation and Research Advisor	PhD (Degree Granted 2018)