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Summary — Extensive experience (20+ years) with detailed technology development as well as technical management of communications-related systems and products for commercial, military, and consumer applications. Experience base includes laser-based communications, SERDES, low-noise analog and RF electronic design, RFIC design, synchronization, cellular telephones, manpack radios for the armed forces, cable modems, OFDM-based wireless networking at 5 GHz, GPS related systems, ultra-wideband systems, detailed RF systems engineering, high-efficiency RF power amplifiers, satellite command and telemetry systems, avionics electronics, and a wide range of algorithm and digital signal processing disciplines (e.g., filtering, Δ-Σ converters, digital PLL's). Also an expert technology witness pertaining to cell phone related patent litigation.

Books — *Advanced Phase-Lock Techniques* (2008)
Frequency Synthesizer Design Handbook (1994).

Patents — $\approx$ 21 US patents awarded.

Clearances — Active DoD Secret, and SCI clearances.

Education — University of Southern California, Los Angeles .
Graduate studies in communication systems toward the Ph.D. Emphasis on Error Correction Codes, Estimation Theory, Radar, and Stochastic Processes.

University of Southern California, Los Angeles.
MS in Electrical Engineering. Principle studies in Quantum Electronics, Lasers, Optics.

University of Nebraska, Lincoln.
BS in Electrical Engineering with honors

Tools — Proficient with MATLAB, Mathcad, C/C++/C#, Microwave Office, SPICE, Microsoft Office, Arduino, laboratory equipment like spectrum analyzers, network analyzers, directional couplers, etc.

Related Interests —
o   Radio Amateur, Advanced Class   WB0ZVV
o   Telescope design and fabrication (Lurie-Houghton, Baker-Nunn, Ritchey-Chretien)
o   RF imaging methods
o   Deep-sky Astrophotography (CCD cameras, image processing, statistical optics)
o   Computer numerical control (CNC) machining (with large flat-bed CNC router)
o   Numerical computation (algorithms)
o   Astrophysics (orbit determination)
o   Computer programming C/C++/C# and small machines like Arduino's
o   Electronic design and fabrication (with laboratory, surface mount tools, test equipment)

Key Words — Low-noise mixed-signal design, RF systems engineering, communication systems, RFIC architect, OFDM, DSP, PLL, frequency synthesis, synchronization, control systems, satellite communications, DVB-H, 3GPP, 802.11.

Experience

6/08 – Present	**Consultant, AM1 LLC**

Consultant to industry.

System architect for 3-chip high performance military manpack transceiver including physical layer digital signal processing, high-power antenna tuner, high-efficiency power amplifiers, satellite telemetry digital modem (FPGA) algorithms, FPGA-related ultra-low spurious Δ-Σ DAC's, laser communication link synchronization, RF/DSP architect for shirt-pocket sized UHF SATCOM survival/rescue beacon, many RF system-level architectures, radar RF/DSP elements, cellphone technology patent expert/consultant, proposal writing.

3/06 – 6/08   **Senior Fellow, Sequoia Communications**

Individual contributor to Sequoia's advanced polar transmitter for 3GPP GSM/EDGE/WCDMA. Sole inventor for two of the key signal processing algorithms needed for its success (US_8,111,776, US_7,924,101). Provided design guidance for RFIC designers concerning all frequency sources in multiple chip designs. Member of the executive staff.

11/04 – 3/06   **Consultant, AM1 LLC**

Industry consultant, specializing in RFIC architectures, digital signal processing applied to communication systems, frequency synthesis, and synchronization.

11/99 – 11/04   **Co-Founder, Former VP of Engineering, CTO**
                   Magis Networks, Inc.

As company co-founder and the original VP of Engineering, hired many of the core engineering team including director-level staff as well as his own replacement. Was the primary architect for the complete baseband digital signal processing physical layer solution and also architected the 5 GHz radio transceiver. Played an active role in the RFIC and BBIC developments, antenna development and extensive field-testing. Pioneered improving wireless channel reliability in order to deliver Quality of Service (QoS) for audio/video applications. Authored over 20 patents pertaining to the physical layer and medium access control layer of the system. Played an important role in helping to raise Magis' A-round of financing.

1990 – 11/99	**Founder & Owner, Comfocus Corporation**

Consulting firm focusing on wired and wireless communication systems, including board-level, chip-level and algorithmic system development.

Developed one of the very first software defined radios (SDR) named *Softwave.*

Primary focus on the areas of analog and digital radio communication systems design and subsystem design. Specialization in overall system architecture, digital communication theory, spread spectrum, RF and baseband modems, bit synchronization, digital signal processing, error correction coding, frequency synthesizers, filters, and general RF/analog electronics. See attached appendix for additional detail.

Clients included firms such as Hughes Space & Communications, L-3, Linkabit, Hughes Network Systems, Comstream, Conexant, U.S. Air Force, PCSI, and AMCC.

Prior to 1990   Staff Engineering positions at General Dynamics, Linkabit, TRW, and Hughes.

Patents
- $\approx$ 21 US patents awarded.
- Additional patents pending but not published to date.

Sample Publications
1. "Tunable Bandpass Filters," pending.
2. "Using Companion Models for Time-Domain Simulation of Ordinary Differential Equations," 2016.
3. "Unconventional PLL's Simplify Difficult Designs," Microwaves & RF, May 2011.
4. <u>Advanced Phase-Lock Techniques</u>, Artech House, 2008.
5. <u>Frequency Synthesizer Design Handbook</u>, Artech House, 1994.
6. "Multimode RF Transceiver Advanced WEDGE Radio System," rf design, Jan. 2007.
7. "Multimedia Over 5 GHz Wireless Home Networks," Communication Design Conference, San Jose, September 2003.
8. "Making OFDM Work for High-Performance Wireless Networking Applications," April 2003.
9. "Synthesizer Designs Minimize Phase Noise in Cellular Systems," Microwaves & RF, Jan. 1993.
10. RAM Mobile Data, "Radio/Modem Reference Design Guide," Section 3, "DSP Based GMSK Modem Algorithm Design," Woodbridge NJ, 3 June 1991.
11. "Advanced Manpack Radio Concept for UHF DAMA Satellite Communications," U.S. Air Force Phase I SBIR Final Report, Topic No. AF91-030, Electronics Systems Division, Hanscom AFB, MA, Contract No. F19628-91-C-0154.

Appendix: Project Development Experience (Partial Listing[1])

❖ Small form-factor military wireless communications

- Shirt-pocket UHF rescue beacon including GPS (2017)
- Systems engineer for SINCGARS radio for General Dynamics (30 – 88 MHz).
- Design engineer on PRC-104 HF manpack radio.
- Advanced UHF Plus 900 MHz Cellular Manpack Concept Study for U.S. Air Force, SBIR Phase I Recipient, Topic AF91-030, Contract No. F19628-91-C-0154, Hanscom AFB. Hardware & software.
- System architect UHF manpack radio for 5 kHz/25 kHz MiniDAMA satellite communications.
- Algorithm/hardware design & development for a fully digital UHF SATCOM modem for TDMA OQPSK/BPSK /DPSK modes (Patent awarded January 1994).

❖ Other military systems

- Satellite cross-orbit high-speed laser communication link. Responsible for signal detection, acquisition, and tracking electronics and algorithms. (2017)
- Lead systems architect for a complete family of satellite telemetry, command, and ranging products for commercial satellite users. Responsible for the high-level architecture of both RF and digital signal processing elements. Primary architect for all gate-array and DSP-based signal processing algorithms addressing digital two-way communications (e.g., FSK, QPSK), tone and tone-on-tone ranging, and spread-spectrum based ranging methods.
- System engineering for a fiber optics based ultra wideband radar signal interception platform. RF bandwidths in excess of 10 GHz processed using wavelet-based electro-optical techniques.
- Lead RF Systems Engineer for a 225-400 MHz UHF SATCOM radio used for military service. VME card design, high performance requirements (e.g., input third-order intercept point > +5 dBm, LO phase noise < -90 dBc/Hz @ 1 kHz, switching speed < 100 μsec to 1 kHz). Personally did all of the low-level detailed design for the receiver portion.
- Complete conceptualization of the IF and baseband processing for the Navy USTS base station transceiver developed by Titan Linkabit. The design solution made use of RF systems engineering as well as information theory to deal with severe radar pulse interference and other difficult system issues.
- System architect for multiple Ka / Ku satellite subsystems (for space).
- System architect for ultra-wideband signal interception system (effective 20 GHz sampling rate).

❖ Commercial communication systems

- Satellite-based high-efficiency power amplifier with predistortion algorithms (2017)
- Lead RF Systems engineer for a frequency-agile 900 MHz specialized mobile radio (SMR) hand-held product. TDMA, π/4-DQPSK waveform. Initial production quantity of 100,000 units. Wrote all of the RF system and module performance requirements. Directed a team of RF engineers and technicians from initial conceptualization into manufacturing. Held and directed design reviews. Provided much of the detailed circuit design, and was solely responsible for all of the Mentor-based CAD PWB design for the RF portion. Provided

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[1] Some more recent projects purposely not detailed to protect clients' interests.

assistance to the digital baseband electronics area related to circuit board layout and EMI mitigation. Also provided assistance with the physical layer digital signal processing algorithms.

- Lead RF Systems Engineer for the development of a dual-mode TDMA commercial telephone in the 450 MHz band compliant with IS-54/55. Performed all of the systems engineering and created a design document of roughly 250 pages for Design Engineering. Provided detailed direction to engineering teams in the U.S. and Taiwan. Monthly manufacturing quantities to be in excess of 20,000 units or more.
- Provide RF Systems Engineering for narrow band PCS base station in the 900 MHz band.
- Performed a principle role in developing all of the RF system engineering specifications for the CDPD base station in 900 MHz band (developed by PCSI). This activity included direct day to day involvement and detailed technical direction of engineering staff.
- Algorithm design & development for a DSP-based GMSK modem for Mobitex (RAM Mobile Data). Wrote a modem design guide that was distributed by RAM throughout the industry.
- Chief architect for multiple 5 GHz OFDM high QoS systems.
- Complete prototype development including system definition, system analysis, architecture, detailed design, & algorithms for a multi-channel RF link supporting upwards of 35 Mbps in a standard NTSC bandwidth. Included FEC and completely digital adaptive equalizer. This prototype was the forerunner of the emerging 500+ channel television set top decoder. (1991).
- As Founder and owner of ComFocus, developed the first Microsoft Windows based HF and VHF receiver for the consumer market. The product consisted of an external RF unit, which was cabled via RS-232 cable to a DSP board, which an end user would install in their personal computer. All of the DSP software was downloaded from the PC to the DSP board at run time making the product highly reconfigurable. All demodulation, bandpass filtering, AGC, etc. was performed through the DSP. The hardware provided a number of different user *personalities* including (1) high performance HF receiver with 12 different demodulators, 49 different bandwidths, IF shift, sophisticated blanking, built in real-time spectrum analyzer (2) high speed VHF scanning (> 200 hops per second), (3) wideband spectrum analyzer and (4) an integrated station database and editor for storage of arbitrarily large frequency data base. The product used Analog Devices DSP with the other software layers composed of a C++ DLL and Visual Basic GUI.

❖ RFIC / Digital Chipset Developments

- System architect for multi-chip high performance small form-factor 10 MHz thru C-band transceiver, supporting most military communication standards including Link-16.
- System engineer for the development of product specifications for an IS-136 (U.S. advanced digital cellular) RF chip set for a major semiconductor supplier.
- Architect for a family of bipolar and CMOS integrated circuits for the wireless communications industry.
- System engineer for GSM / 3G cellular telephone chipsets.
- System design and detailed design support for a monolithic bipolar data transmitter and data receiver/clock recovery device for Sonet type applications (Data Rates to 1.5 Gbps).

Appendix: Patents Issued & Published

US_8,111,776	Pulse Insertion Systems and Methods for Polar Modulation
US_7,924,101	Systems and Methods for Improved VCO Gain Tracking Loop
US_7,652,608	Channelized Analog-to-Digital Converter
US_7,551,677	OFDM Pilot Tone Tracking for Wireless LAN
US_6,980,147	Channelized Analog-to-Digital Converter
US_6,879,840	Method and Apparatus for Adaptive QoS-Based Joint Rate and Power Control Algorithm in Multi-Rate Wireless Systems.
US_6,650,616	Transmission Security for Wireless Communications.
US_6,633,616	OFDM Pilot Tone Tracking for Wireless LAN.
US_6,549,583	Optimum Phase Error Metric for OFDM Pilot Tone Tracking in Wireless LAN.
US_6,549,561	OFDM Pilot Tone Tracking for Wireless LAN.
US_6,456,245	Card-Based Diversity Antenna Structure for Wireless Communications.
US_6,456,242	Conformal Box Antenna.
US_6,438,367	Transmission Security for Wireless Communications.
US_6,433,742	Diversity Antenna Structure for Wireless Communications.
US_5,796,783	Digital Transmission System.
US_5,282,227	Communication Signal Detection and Acquisition.
US_4,810,904	Sample-and-Hold Phase Detector Circuit.
US_4,771,248	Fast Phase-Lock Frequency Synthesizer.
US_4,668,922	Fast Phase-Lock Frequency Synthesizer.
US_4,634,998	Fast Phase-Lock Frequency Synthesizer with Variable Sampling Efficiency.
US_4,586,005	Enhanced Analog Phase Interpolation for Fractional-N Frequency Synthesis.
20030181211 (Pub.)	Method and Apparatus for Dynamic Channel Selection in Wireless Modems.
20030109261 (Pub.)	Method and Apparatus for Optimal Rate (PHY Mode) Control in Wireless Modems with Variable Bit Rate (VBR) Capability.
20030104831 (Pub.)	Method and Apparatus for Adaptive QoS-Based Joint Rate & Power Control Algorithm in Multi-Rate Wireless Systems.
20030097623 (Pub.)	Method and Apparatus for Performance Optimization and Adaptive Bit Loading for Wireless Modems with Convolutional Coder, FEC, CRC, and ARQ.
20030063678 (Pub.)	OFDM Pilot Tone Tracking to Reduce Performance Loss Due to Frequency Pulling and Pushing.
20030026197 (Pub.)	Transmission Security for Wireless Communications.
20030002471 (Pub.)	Method for Estimating Carrier-to-Noise-Plus-Interference Ratio (CNIR) for OFDM Waveforms and the Use Thereof for Diversity Antenna Branch Selection.
20020176483 (Pub.)	OFDM Pilot Tone Tracking for Wireless LAN.
20020164968 (Pub.)	Probing Scheme for Diversity Antenna Branch Selection.
20020160737 (Pub.)	Method and Apparatus for Diversity Antenna Branch Selection.
20020159533 (Pub.)	OFDM Pilot Tone Tracking for Wireless LAN.
20020150168 (Pub.)	Optimum Phase Error Metric for OFDM Pilot Tone Tracking in Wireless LAN.
20020122006 (Pub.)	Conformal Box Antenna.
20020101377 (Pub.)	Card-Based Diversity Antenna Structure for Wireless Communications.