NORMAN E. SWANBERG
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OBJECTIVE:

Wireless, RF and Microwave Hardware and System Design

My consulting company, Dome Resonators, provides RF/Microwave, **mm Wave design services (e.g. 5G)** for military and commercial sectors based on >40 years of RF/Microwave hardware and system design experience. Dome Resonators provides a complete suite of RF design tools including Keysight Genesys Integrated GX suite[1](for which I have been named 1 of 13 EDA experts in the US), Ansoft HFSS for accurate and detailed EM modelling, and a state of the art PC workstation to meet the demands of these powerful, yet memory intensive design platforms required by modern wireless design.

I have a broad spectrum of design experience from low frequency Analog to Microwave/mm Wave frequencies to 200 GHz at a component, hardware and system level. I bring to the table excellent verbal and written skill for proposal and/or documentation of development work.

RF design experience includes, system level link budgets, frequency planning, spurious system performance, cascaded behavioral modeling (compression, harmonics, intermodulation), RF components, matching networks, Package and PCB design, signal control networks (Wilkinson Dividers, Couplers, etc.), high speed digital signal distribution networks for signal integrity, as well as discrete and distributed filters including diplexers, triplexers, and quadriplexers. Extensive experience with optimizing matching networks for PA devices including SI, GaAs, GaN, InP.

EM design experience includes package modeling, SiPs (system in package), LTCC[2] (up to 24 layers including embedded matching networks, filters, and RF distribution), QFN, BGA and redistribution networks, and antenna design and simulations.

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[1] (includes linear and non-linear analysis, Spectrasys cascaded system analysis, behavioral modeling, Harmonic Balance , Momentum EM simulations, and Spice based Time Domain analysis

[2] Low Temperature Co-fired Ceramic

I have a proven track record of taking complex RF designs from concept to working models and on to production. I am as comfortable in the lab tuning circuits and working with test equipment as I am behind the computer have developed an efficient balance and integration of the two. I have an extensive network of vendors and manufacturers for PCB design, fabrication, assembly, RF test fixtures, testing, and design verification.

EXPERIENCE/EMPLOYMENT HISTORY

Instructor, PCB West 2015 "An Integrated Approach to RF/MW Design and Manufacturing"

Dome Resonators Consulting, Sep. 2007-Present

CUBIC corporation   **April 2019 to Present**
Senior RF design engineer. Genesys Gain distributions and analysis of various transceivers. HFSS simulations of Various mmWave connector launches, interconnect matching and optimization. Lab configuration and characterization of Ku Band Phase array radar boards. Reconfiguration, testing and characterization of various transceiver test stations through Ku Band.

Vubiq Networks, Inc.   **August 2019 to Present**

Simulation and analysis of 90 GHz commercial transmit/receive chips for Tx to Tx Leakage. HFSS simulations of 60 GHz short range scattering problems using waveguide horns. RCS/ISAR simulations of 60 and 90 GHz radar like configurations for commercial applications.

Accel RF   **Dec. 2018 to 2019**
Development of an RF test fixtures covering 60 to 90 GHz using Microstrip and novel CPWG interconnect.   Matched launches into IC devices for reliability testing. All EM simulation performed ion ANSYS HFSS.

TrellisWare Technologies, Inc.   **Oct. 2018 to 2019**
RF consultant for L and S- Band military and held radios. Tuning and re-optimzation of existing design. RF test and trouble shooting of revised board design. Monte Carlo analysis of Rx and Tx chains for estimation of component sensitivity and overall radio production yield.

Hitem Engineering   April, 2015 to 2019
RF circuit design, WiFi antenna testing, simulation and in situ antenna Matching in support of Skybell Smart Doorbell product.   http://www.skybell.com/

X-Band proximity radar design and test for next generation product. HFS simulation of DRO in conjunction with coupler, filter, mixer design, and DRO oscillator both in EM simulator and Harmonic Balance simulator

Client identity not available by contract agreement   June 2016- April 2018

5G hardware and system level design. Filters, couplers, amplifiers, mixers for Receivers and Transmitters at 19 GHz and 29 GHz. Gain distribution analysis and optimization of circuitry including printed PCB circuit components. Transmission lines (Microstrip, CPWG {coplanar waveguide with ground}), and interconnects including mm wave PCB substrates and metallization. Monte Carlo and yield analysis of RF layers and printed components for production manufacturability. Extensive Genesys RF and HFSS EM simulations to support the development effort. Participation in vendor and internal design team design reviews and weekly status.
These two transceivers have been flight tested and met or exceeded all design goals as a FIRST PASS success!!

Telspan Data, Fall 2012 – Oct. 2016
Managed a multi-discipline design team and designed the RF front end and down converter for a Telemetry Receiver[3] covering Lower L Band, Upper L Band and S band with high dynamic range, high immunity to large signal interferers and state of the art digital signal processing techniques eliminating a broad range of low frequency analog discrete components.
Design and development of Receiver and transmitter for Telemetry applications.

Vox Analyzer April 2015-Oct 2015
Industrial heating of petroleum products through Microwave heating. Novel circular waveguide and Waveguide Tee designs using HFSS EM simulations

Peregrine Semiconductor, Sep. 2014 – Oct.2014, San Diego, CA
Advanced signal and distortion analysis and characterization for high intercept point RF switches in conjunction with digitally modulated signal models.

Google, August 2014 – October 2014
Senior RF Consultant: Consumer electronics development using advanced RF and Microwave techniques. Design and characterization efforts included EM simulations, System performance simulations, Frequency Domain and Time Domain testing up to 20 GHz.

Taconic, Fall 2012
Design of broad band test fixture including launch for board material characterization out to 60 GHz using Momentum EM simulator.

Maxlinear, 2012
Provided diplexer and triplexer design and optimization for European DOCSIS and European Video Bands (~5 to 1000 MHz). Used EM co-simulation techniques to obtain excellent agreement between simulated and measured response resulting in little or no tuning after EM optimization.
Quadriplexer optimization using similar techniques for commercial set top boxes up to 2.15 GHz

Leigh Aerosystems, 2012
Designed and optimized RF front end and patch antenna for GPS receiver.

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[3] IRIG 016-11 Standard

Accel RF, 2008-2012
Provided system level and PCB design for environmental and stress testing of microwave components. Deliverables included broadband matching networks, bias networks, interconnect topologies and stability analysis including detailed frequency domain and EM simulation of key circuit topologies. PCB test fixtures designed for several RF configurations and substrates operating up to 25 GHz. Provided configuration and optimization for a mm Wave (~70 GHz) device thermal test platform. Designed Wilkinson divider, directional coupler, and Branch Line coupler on Rogers Duroid for 24 GHZ commercial automotive radar applications. Provided detailed EM simulations and optimization for RF test fixtures with coax to PCB launches featuring low return loss to 20 GHz.

L-3 Communications, 2009
Provided technical proposal and design support for new business development including a variety of RF, Microwave, and mm wave transceiver and transponder architectures up to Ku (12 to 18 GHz) and Ka Bands (27 to 40 GHz). Designed and optimized filters up to mm Wave frequencies using filter synthesis tools and EM simulations. Provided Harmonic Balance simulations for mixer development investigations, RF Spectrasys analysis for frequency planning, behavioral modeling of cascaded IP3, NF, P1dB, and spurious signal analysis with interferers. Performed HFSS simulations of RF and bond wire and substrate interconnects for hybrid circuits up to 40 GHz.

Dome Resonators, 2009
SBIR proposal to Office of Naval Research to explore contemporary antenna architectures like Dielectric Resonator Antennas (DRA).

Argon ST, 2008-2009
Provided design support for commercial satellite development in the VHF frequency range. Tasks included detailed system level architecture simulations, sensitivity, dynamic range, spurious analysis, and hardware design of filters, Wilkinson Divider, couplers and other components. Performed EM simulations of board circuitry to optimize performance. Provided vendor interface to understand, implement and optimize custom Space Level qualified parts. Also provided multipaction[4] and non-linear behavior analysis of PAs with IQ modulation streams using Keysight SystemVue.

E-Band Communications, 2008-2009
Provided design, modeling and architecture implementation for mm Wave, Point to Point radio covering 71 to 86 GHz, including detailed behavioral modeling in Genesys Spectrasys to establish link margins and RF performance. Modeling of Local Oscillator (LO) leakage paths, sub-harmonic mixing, and spurious product generation were used to establish correlation with existing hardware measurements. Behavioral modeling established correlation between simulation and measured hardware for non-linear effects (P1dB, Psat, IP3 and IP2). Optimized end to end RF performance including eliminating unwanted spurious responses.
Served as the primary contact and liaison for all technical issues related to the mm Wave chip foundry, mm wave IC designers, and a third party assembler for the transceiver chain.

Space Micro, 2007
SBIR proposals and reports including filter design, EM simulations for planar antennas, RF

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[4] **Multipaction** is the phenomenon that can cause breakdown due to high electric fields in a vacuum or near vacuum

component design and optimization as well as gain distribution and link margin simulations for transceivers through KU and K band.

Direct employment

ViaSat, Sept 2010 to April 2012
Senior RF designer for commercial and military products. Performed HFSS EM simulations of high frequency packages to optimize broadband system performance. Optimized Ka band transceiver receiver through gain distribution and spurious analysis. Identified and reduced internal spur generation and susceptibility to outside blockers/interferers. Provided triplexer and diplexer filter design to 2.5 GHz for commercial modem. Modem PCB design, stack up definition, and high speed digital signal integrity calculations. Provided miscellaneous circuit testing and troubleshooting to solve RF board production problems and establish communications link signal integrity. Also performed vibration testing and characterization for yield/production requirements.

STACCATTO COMMUNICATIONS, Apr. 2004 – Aug. 2007
Staff RF Engineer
Provided primary design responsibility for the development of Ceramic and organic substrate material packaging and interconnect solutions. Designed embedded matching and filters in LTCC for Ultra Wide Band (UWB) applications. Brought two fully functional designs from initial concept to working product with two overseas ceramic LTCC vendors. Provided low cost PCB solution for specific UWB applications using precision FR-4 material. In addition to providing most of the fundamental RF calculations and simulations for these projects, I also was the program manager covering all aspects of the business and technical interface with both of these Asian vendors.

Provided ACAD routing and layout design for 24 layer, 10 mm x 10 mm ceramic packaging solution (SiP). These layout models were extracted and imported into EM simulation platforms (Sonnet and Momentum) to validate RF performance. Used a library of Excel programs I have developed over the years to perform detailed calculations and estimations (frequency planning, gain distribution, phase noise calculations, transmission line calculations, thermal resistance, and others.)

DelSigma, Jul. 2002 – Apr. 2004
Director, RF & Systems Engineering
Spearheaded efforts to extract key performance CDMA200 standard requirements, both explicit and implied, in order to generate internal specifications, design, and develop a novel and disruptive technology CDMA2000 transmitter architecture. The design used state of the art Delta Sigma techniques to generate the RF signal directly from base band. This configuration substantially minimized parts count and size while improving PAE (Power Added Efficiency).

Designed a novel RF filter/resonator circuit technique using Stripline and Microstrip distributed transmission lines. First pass prototype was successfully built and tested. The design was further extrapolated to an LTCC packaging configuration in order to further reduce size and discrete component count. The layout and preliminary specification were used to develop potential manufacturing avenues and to establish credible quotations for packaging costs required by the VCs and strategic partners.

Other responsibilities included providing detailed program management and tracking using Microsoft project. I regularly interfaced directly with both VC and strategic partners to provided and presented important business and technical materials.
(note: this venture collapsed when VC funding fell through)

IBM, Sept. '99-June '02
Systems Lead for the development of a complete SiGe Integrated Circuit (IC) chip sets for WCDMA 3GPP Wireless handset/phone applications.

Responsibilities included oversight and coordination of all aspects of system and hardware design including RF receiver front end, down converters, analog baseband signal processing, A to D and D to A converters, transmitter up converter, PA, and signal Synthesizers for on board references and Local Oscillators. Up converters and down converters incorporated leading edge direct conversion techniques to improve efficiency, cost and performance. As the systems lead, I was the primary contact with customers for existing business and new business development, including preparing and presenting all key customer briefings and design reviews. In this capacity, I also coordinated internal technical meetings, developed schedules and coordinated all design reviews for a team that included West and East Coast facilities as well as a design center in France. These efforts lead to highly integrated IC solution and eventual fabrication. Testing with many IC chips met specifications on the first pass and several parts in Japan's WCDMA deployment qualified on this first pass design.As the Systems Lead for the WCDMA development, I was chosen as IBM's West coast representative to an annual seminar held in IBM's Research Triangle to highlight excellence in design for IBM's high visibility development projects throughout the country. Other development projects included Dual Mode (GSM , 3G combined radio) chip sets.
(Note: This venture ended when IBM closed their chip development support sites)

ADC WIRELESS SYSTEMS, July '97- Aug. '99
Senior RF Engineer/Program manager
Cellular Base station development for PHS and GSM protocols.
Developed an original spreadsheet calculation to identify system spurs and define the system RF frequency plan. Responsibilities included establishing receiver gain distribution plan to minimize noise while optimizing spur free dynamic range in the presence of interfering signals in a multi-carrier, broad band signal environment.

I led redesign of PCS 1900 base station to meet GSM 11.21 requirements. Efforts included trouble shooting to component level, RF analysis, detailed PC board layout and complete GSM system level testing. Wrote module level performance and test specifications and the Design Verification test document.

Other responsibilities included Program Manager and RF design engineer for redesign and cost optimization of a 900 MHz, cellular phone repeater sub-station.
Spearheaded Division efforts to identify and purchase state of the art software design tools for module level, time domain, and frequency domain and system level analysis.
(Note: this venture ended when ADC closed the local facility and consolidated efforts back in Wisconsin)

Loral/Lockheed Martin/ L3 Communications, July '95- July '97
Senior RF engineer

Responsibilities included design and development of two, S-Band (2.2 to 2.3 GHz), telemetry transmitters, including one with internal chassis isolation. Design tasks included a broadband VCO, PA and complete RF chain for 5-Watt transmitter with class A and Class C outputs. Spice and S-parameter design techniques were used to meet the transmitter performance specifications with margin. Both transmitters were put into full production.

Attended week long design training classes for RF ASIC development at Maxim (Silicon technology) and Triquint (GaAs technology).

S.A.I.C., Aug. 1989-July '95
Senior Electronics Engineer/Program Manager
High speed analog, RF/Microwave design
- LIDAR   High-speed analog, RF/Microwave design for fast sub nanosecond, optical receiver. Circuits included detectors, amplifiers, and all active and passive filtering. Analysis required unique methodology transforming back and forth between frequency domain (S-parameter) and time domain (Spice) approaches in order to integrate the complete design. (Concurrently participated as a Beta site evaluator for Intusoft's next generation Spice program.)
- Amplifier and active filter design for LIDAR Receiver
- Patent application submitted for a high speed switching circuit used to expand receiver dynamic range to 80 dB and to reduce quantization noise for fast rise time, base band signals. Design incorporated high-speed comparator for switch signal level triggering and novel delay line implementations to capture full dynamic range while eliminating switching glitches.
- Designed and delivered Laser Line Scan receiver using 1 MHz integrator circuit with 12 bit dynamic range used in underwater salvage scanning.
- Designed and implemented a novel IFF (Identify Friend or Foe) system using lasers, ceramic retro-reflectors, analog receiver and UART encoder/decoder.
- Designed high speed, high voltage gating circuits (see Publications) for electro-optic sensors (Digicon Tubes and Photo-Multiplier Tubes).
- Designed high speed ceramic and PCB multi-layer transmission line distribution circuits for 256 channel detector and signal processing.

Program Management, electro-optic LIDAR and imaging systems
- Program manager for the development of Electro-optic sensors and high Quantum Efficiency Digicon tubes (photon level light sensors)
- Quoting, tracking, and managing programs using Microsoft Project.
- Task Manager- Responsible for the design, fab, assembly and integration of 6 nsec. sampling speed, multi-channel LIDAR receiver
- Supervision and design support for 200 MHz A/D converter and associated timing and control electronics
- Management responsibility for multi-layer PCB design, fabrication, assembly, and test

Dome Resonators, Nov.1987-1989
Owner/operator of consulting business
Business areas included the development of PC computer applications including detailed spreadsheet based programs for general engineering calculations and analysis. Developed estimating programs for the construction trades, particularly for residential construction and custom tile installation (see Publications).

PREVIOUS RF/ MICROWAVE EXPERIENCE

REMEC- Microwave switches and filters- Designed active and passive RF/Microwave switches and switch filters. Designs delivered to production included a multi-port switch limiter covering multi-octave frequency range (0.5 to 18 GHz) and a low frequency active switch using a mixture of FET and Bipolar transistors for high input and output impedances and better than 90 dB of isolation.

General Dynamics-VCO Design- Designed and developed a broad band, discrete, varactor tuned GaAs VCO (2500-4500 MHz) for PLL. Developed applications programs for receiver design including cascaded gain, noise figure, and intermodulation distortion. Developed an automatic spur search program incorporated filtering analysis for spur mitigation.

TRW
Functional Management and Section Head: Provided technical guidance, supervision, salary and performance reviews for engineers and technicians in the RF Design Organization. Contributed extensively on RF component and receiver system proposals. Member of the TRW Invention Evaluation Committee assessing the technical merit of new designs submitted for patents.

Program Manager: Complete responsibility for the RF subsystem of a classified, broad band, microwave receiver project. Responsibilities included supervision and coordination of design team, receiver and system performance calculations, component specifications, and proposal writing. Responsibilities included contract tracking, scheduling, customer interface, and technical presentations.

GaAs MMIC R&D- Designed and developed state of the art GaAs MMIC, FET circuits including a monolithic VCO (see publications) and dual gate mixer. Developed monolithic, active, bipolar mixer chip used in a hand held UHF/VHF receiver. Designed and developed broad band (UHF/VHF) bifilar, balun transformers to interface to a MMIC active mixer chip.

Hughes Aircraft and Alpha Industries
Millimeter Wave Circuit Development
Developed Microwave and Millimeter Wave mixers including X-band and Ku-band microstrip balanced mixers, a millimeter wave (~200 GHz) quasi-optical mixer (see publications), and a suspended stripline millimeter wave mixer. Design of X and Ku-band Gunn Oscillators. Developed test stations for evaluating Gunn diode voltage threshold and thermal resistance. Applications engineering support for PIN diode semiconductor development and production.

PUBLICATIONS:

- **"LTCC Packaging for Wireless UWB Applications"**   EE Times Dec. 2004
- **"A Direct-Conversion W-CDMA Front-end SiGe Receiver Chip,"** D.Y. Lie, Jack Kennedy, Norm Swanberg, et. al.- presented IMS2002 June 2002
  "WCDMA Cross Modulation Effects and Implications for Receiver Linearity Requirements" RAWCON Conference, Boston, Mass. August 2002
- **"Architecture and Technology for Multi-Standard Wireless Transceivers" Lawrence E. Larson, Norman Swanberg, Peter Pawlowski, Duljit Mahli, and Paul Chominski 2002**
- **"Short Wavelength Imaging Laser Radar Using a Digicon Detector**," Optical Engineering, Nov. 1992

- **"Gating Techniques for Imaging Digicon Tubes**" Proceedings, SPIE International Symposium & and Optoelectronic Applied Science and Engineering, July 1990
- **"And You Thought Only Eggheads Used Computers!"** Tile and Decorative Surfaces, September 1990
- **"GaAs Monolithic Voltage Controlled Oscillator**," Eighth Biennial Cornell University E.E. Conference, 1981
- **"217 GHz Quasi-optical Mixer**," Microwave System News, May 1979
- **"HP-25 Simplifies Microstrip Calculations**" Microwave System News, June 1978

EDUCATION:

Brown University	SC. B. Physics	1971
Providence, R.I.		
Rutgers University	Full time graduate student	1971-1972
New Brunswick, N.J.	Dept. of Physics	
Northeastern University	M.S.E.E.	1977
Boston, Mass.		

Supplemental Education:

UCLA Microwave Circuit Design I	1979
UCLA Microwave Circuit Design II (Non-linear Circuits)	1985
TRW in house management training program	1984
U.C.S.D. Microcomputer Operating Systems	1988
U.C.S.D. Database Management Systems	1993
MAXIM bipolar MMIC, Triquint GaAs MMIC , Labview training	1996
U.C.S.D. CDMA one	2002
HFSS General Training	2015
HFSS Antenna Design	2016

Associations:
- Keysight certified EDA Expert **(1 of 13 in the US chosen internally by Keysight for significant contributions to the use and development of their Genesys RF Software program**
- **IEEE Senior Member**

COMPUTER SKILLS:

RF analysis: Keysight Genesys Spectrasys certified expert, HP-ADS and SystemVue
EM Simulation Experience: HFSS, ADS-Momentum, Sonnet, EMPRo, and CST

Extensive Library of detailed RF and Microwave spreadsheet calculation developed in Excel (frequency planning, link budget gain distribution, phase noise calculations, transmission line calculations, etc.)

Comprehensive knowledge of Windows based PC applications including:
Microsoft Project   Microsoft Word
Microsoft PowerPoint   Microsoft Access (database)   ACAD

URLs of companies I have worked for and/or supported

Google   www.google.com/
Hi-Tech Electronic Manufacturing, Inc. (HiTEM)   http://www.hitem.com/
        Skybell CONNECT   http://www.skybell.com/
Peregrine Semiconductor: www.psemi.com/
Telspan Data: www.telspandata.com/
Taconic: www.taconic-add.com/
Maxlinear: www.maxlinear.com/
ViaSat: www.viasat.com/
Leigh Aerosystems: www.leighaerosystems.com
Accel RF: www.accelrf.com/
Argon ST (currently Boeing): www.boeing.com/defense-space/argon/
L3 communications: www.l-3com.com/
TRW (Currently Northup Grumman): www.northropgrumman.com/
Science Applications International Corporation (S.A.I.C.): www.saic.com
IBM: www.ibm.com/
ADC Communications (Now a division of TE Connectivity {Tyco Electronics}): http://www.te.com
Staccato Communications (no longer in existence)