

Jordan S. Besnoff

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Education

Duke University

Doctor of Philosophy (PhD) in Electrical Engineering, GPA: 3.94

Dissertation Title: “Exploiting Near Field and Surface Wave Propagation for Implanted Devices”

Advisor: Matthew S. Reynolds

Durham, NC

December 2014

Duke University

Master of Science (MS) in Electrical Engineering, GPA: 3.94

Durham, NC

September 2012

Tufts University

Bachelor of Science in Electrical Engineering (BSEE), summa cum laude

Minor: Mathematics

GPA: 3.90

Meford, MA

2005–2009

Research Interests

- RFID
- Backscatter radios & communication
- Wireless power transfer (WPT)
- Low-power high-bandwidth radio design/communication
- Antenna design
- Applied Electromagnetics

Awards and Honors

2013: Student Competition Winner 2013 IEEE RFID Conference

“Rectenna Shootout”

2012: Best Paper Award 2012 IEEE RFID Conference

“Near Field Modulated Backscatter for in vivo Biotelemetry”

2009: Amos Emerson Dolbear Scholarship

Tufts University

2006: Howard Sample Physics Award

Tufts University

2005: Bausch and Lomb Science Award

Branford High School, Branford, CT

Professional Experience

North Carolina State University (NCSU)

Assistant Research Professor

Raleigh, NC

February 2021–Present

Assistant Research Professor in the ECE department responsible for leading research projects, teaching upper-level undergraduate courses, and mentoring graduate students in Dr. David Rickett's lab.

- Co-PI on the Radio Disruption of Electronic Systems (RADES) project, an SBIR Phase II grant
 - Investigating the effect of targeted RF and acoustic waveforms on drones in flight and developing behavioral simulations
- Leading research project for a passive Bluetooth backscatter body-worn sensor.
 - Developing backscatter architecture and microprocessor implementation of Bluetooth stack for passive backscatter
 - Investigating ambient RF harvesting for sensor power
 - Designing an IC implementation of an ultra-low power Bluetooth backscatter radio equipped with ambient RF energy harvesting

North Carolina State University (NCSU)

Raleigh, NC

Research Scientist

July 2020–Present

Senior staff member in Dr. David Ricketts' lab, responsible for leading research projects and mentoring graduate students.

- Leading research project for a passive Bluetooth backscatter body-worn sensor.
 - Developing backscatter architecture and microprocessor implementation of Bluetooth stack for passive backscatter
 - Investigating ambient RF harvesting for sensor power
 - Designing an IC implementation of an ultra-low power Bluetooth backscatter radio equipped with ambient RF energy harvesting

Sensus

Morrisville, NC

Senior RF Development Engineer

September 2018–July 2020

Member of the International Infrastructure and Smart Cities group responsible for development of wireless smart water and electric meters as well as wireless smart lighting modules

- Designed, analyzed and fabricated a novel wideband NB-IoT antenna for use in a water meter in an "RF unfriendly" potted environment with coverage for multiple cellular bands
 - Continuing support for antenna development by holding weekly meetings and providing design and analysis guidance to colleagues and interdisciplinary teams
- Designing a low-cost, compact, wideband, and efficient antenna for adding NB-IoT functionality to smart lighting units that currently utilize expensive COTS antennas that provide sub-optimal performance
 - Antenna supports multiple cellular bands from 699 - 960 MHz as well as 1.7 - 2.7 GHz
- Aided in simulation analysis of wireless M-bus 169 MHz antenna re-design for water meter products
- Provide RF layout and antenna guidance as well as RF test and measurement expertise
 - Developed RF measurement automation in on-site anechoic chamber for 2D and 3D antenna measurements
- Investigated and solved de-sense issues for various smart lighting products

Oak Ridge National Laboratory

Oak Ridge, TN

R&D Staff

January 2017–August 2018

Member of the RF, Communications, and Cyber-Physical Security group within the Electrical and Electronics Systems Research Division (EESRD)

- Designed, analyzed, and fabricated a UHF antenna that was directly printed onto a LiNbO₃ wafer for use in a passive wireless surface acoustic wave (SAW) chemical sensor for HF gas
- US ITER (International Thermonuclear Experimental Reactor)
 - Designing and analyzing the phase detection of the feedback control system for the high power (20 MW) RF system used in feeding the antennas for the plasma driven fusion reactor
 - Phase detection system includes clock distribution to approximately 180 channels, and specification of an RF reference and master oscillator
 - Sub-degree phase detection accuracy
 - Performed detailed RF analysis of various transmission line components (elbows, gas elbows, etc) using Ansys HFSS, and altered RF design to meet design and safety criteria such as dielectric breakdown
- Designed an inductive RF coupler based on near-field magnetic coupling at 4 GHz for simultaneous power transmission and high-bandwidth communication for an active gate-driver system for high-density power electronics
 - Coupler design focused on isolation, minimal capacitance, and high efficiency of 90%
- Analysis of the effect of electromagnetic pulses (EMP's) on the grid via electromagnetic theory and 3D EM simulation software to aid in the proper protection of grid components
- RFID tag design at 2.4 GHz optimized for tamper evidence of stable isotopes via a specialized printed tag on glass that has the ability to alter the reflected signal when the radiating element is severed/damaged at any location

Potomac Technologies, LLC

Durham, NC

Senior Electrical Engineer/Senior RF Engineer

September 2015–January 2017

Startup company founded by former postdoctoral advisor Dr. David Ricketts specializing in consulting for wireless power transfer (WPT) and simultaneous high data-rate communication systems, as well as small scale wireless localization.

- Investigated solution for small-scale wireless localization of a coil antenna
 - Fabricated prototype robust CW transmitting device to be localized as well as sensing antennas and circuitry capable of localizing with an average error of $\sim 3 \text{ cm} \left(\frac{\lambda}{1000} \right)$ after system calibration
- Researched and developed high efficiency near-field WPT and simultaneous communication system in an RF unfriendly environment
 - Mitigated WPT efficiency loss incurred by close proximity to metal through the use of properly placed ferrite
 - Demonstrated high efficiency WPT ($\sim 85\%$) and wireless communication (both downlink and uplink) with 2 separate nodes over the same wireless link

North Carolina State University (NCSU)

Raleigh, NC

Postdoctoral Research Scholar

October 2014–September 2015

Worked in the lab of Dr. David Ricketts on wireless power transfer (WPT) systems, resonant WPT and simultaneous high-bandwidth communications, WPT enhancement using metamaterials, low-power high-bandwidth communications, and LF QAM systems.

- High data-rate near-field communication and simultaneous high efficiency WPT
 - Demonstrated the use of higher order modulation to achieve passive high data-rate communication and simultaneous high efficiency WPT over a shared link in the near field
 - Developed an experimental prototype utilizing 16 QAM modulation, capable of transmitting greater than 480 kbps on a 2.38 MHz carrier ($\sim 19.8\%$ fractional bandwidth), as well as an additional prototype using 4 PSK capable of transmitting ~ 256 kbps ($\sim 10.7\%$ fractional bandwidth) with an average WPT efficiency reduction of only 4%.
 - Demonstrated the use of additional transmitting and receiving coils coupled with active 16 QAM communication and channel equalization for an ultra high-data rate of 3.39 Mbps over a 13.56 MHz link while simultaneous performing WPT with an efficiency loss of 2.3% at most.
- Low frequency (LF) Quadrature Amplitude Modulated (QAM) Systems
 - Developed theory for determining the loads for a desired QAM constellation on a LF carrier for magnetoquasistatic fields for a semi-passive communication device
 - Fabricated communication boards, and showed semi-passive communication rates up to 409.6 kbps on a 2.4 MHz carrier (17% bandwidth usage) at a distance of 0.5-coil diameter using loop antennas
- Wireless Power Transfer (WPT) Enhancement
 - Aided in experimental demonstration of LF metamaterials – nominal frequency of 2.4 MHz – as a method of wireless power transfer enhancement
 - Demonstrated experimentally that magnetic resonant field enhancement (MR-FE) can provide a greater wireless power transfer efficiency enhancement than metamaterials under certain conditions. MR-FE enhancement can provide a 15% efficiency enhancement over metamaterials in the LF frequency range.

Duke University

Research Assistant

Durham, NC

2009–September 2014

Worked in the lab of Matthew S. Reynolds on RFID, wireless power, high-bandwidth low-power RFID devices, low-power sensing, biotelemetry, and waveform aware harvesting

- High-bandwidth, low-power, passive wireless biotelemetry devices
 - Taking advantage of transition zone between near field and far field to achieve high-bandwidth backscatter communication for implanted devices
 - Designed specialized transmitting antenna for efficient operation in the UHF ISM band in the vicinity of high loss dielectrics
 - Proved through measurements that data transmission of 5 Mbps is possible using modulated backscatter in the radiating near field with a biotelemetry chip capable of sensing 16 simultaneous channels of data at 1.23 mW power consumption
- Single-wire RF transmission line in high loss dielectrics
 - Developed theory for insertion loss of single-wire RF transmission lines in highly lossy dielectrics
 - Designed efficient launching device for converting TEM signals to TM surface waves
 - Insertion loss theory and launcher efficiency verified through measurements; bend radius analyzed
- Waveform aware harvesting
 - Designed 1st generation distributed element matching network and single stage harvester for efficient harvesting of ambient WiFi energy at 2.45 GHz
- Localization and way finding for the visually impaired using a cane-mounted RFID antenna
 - Designed antenna to be placed on cane for localization purposes using floor mounted RFID tags
 - Developed software package for a bluetooth RFID reader to determine location and heading

MIT Lincoln Laboratory

Research Assistant

Lexington, MA

2008–2009

- Verified and tested S, C, and X-band RADAR receivers to be used in an array of receiving sensors for missile defense purposes
- Analyzed and improved phase noise in receiving units

Consulting

General Motors (GM)

Wireless power transfer and simultaneous communication

Herzliya, Israel

2015–2017

bMuse

Magnetoquasistatic positioning

New York, NY

2015–2016

Teaching

North Carolina State University

Instructor

Raleigh, NC

Spring 2022

ECE 424/524: Radio System Design

- Course focuses on communication theory and radio system design, the design and analysis of radio systems such as heterodyne transceivers, and effects of noise and nonlinearity.
- Design and analysis of radio circuits: amplifiers, filters, mixers, baluns and other transmission line and discrete circuits.
- Final project involves designing and building a 16 QAM radio receiver by hand including a Yagi-Uda antenna, Wilkinson combiner, branchline coupler, branchline mixer, and LNA using discrete components and transmission lines.

North Carolina State University

Instructor

Raleigh, NC

Fall 2021

ECE 426: Analog Design Laboratory

- Re-vamped hands-on laboratory-based course with a final construction project of a working drone.
 - Students will replace parts of a working hobby drone with their own custom-designed parts and components
- Course focuses on analog design in the following areas with applications towards a bigger picture of an operating drone: amplifiers, integrators, differentiators, active filters, amplifier classes and RF amplifiers, PID controllers, wireless & RF control, PCB design and fabrication

Duke University

Teaching Assistant (TA), Digital Communications

Durham, NC

2011–2012

ECE 483: Introduction to Digital Communication Systems

- Provided weekly office hours
- Graded homework, exams, and final project
- Aided in development and structuring of hands-on final project

Tufts University

Lab Teaching Assistant (TA)

Medford, MA

2007–2009

ES3: Introduction to Electronics

ES4: Digital Logic Design

EE14: Microprocessor Architecture

- Aided in development of lab sessions and exit quizzes
- Ran and supervised lab sessions
- Provided sample VHDL and assembly code for M68HC12 microprocessor

Tufts University Academic Resource Center (ARC)

Head Tutor

Medford, MA

2008–2009

- Held open office hours as well as private 1-on-1 tutoring sessions for students in physics, math, and engineering courses.
- Developed and ran additional study sessions.

Publications

Journal Papers.....

[J1] **J. Besnoff**, M. Abbasi and D. S. Ricketts, "Ultrahigh-Data-Rate Communication and Efficient Wireless Power Transfer at 13.56 MHz," in *IEEE Antennas and Wireless Propagation Letters*, vol. 16, pp. 2634-2637, 2017.

- [J2] M. Chabalko, **J. Besnoff**, M. Laifenfeld, and D. S. Ricketts, "Resonantly Coupled Wireless Power Transfer for Non-Stationary Loads With Application in Automotive Environments," in *IEEE Transactions on Industrial Electronics*, vol. 64, no. 1, pp. 91-103, Jan. 2017.
- [J3] **J. Besnoff**, M. Abbasi, and D. S. Ricketts, "High Data-Rate Communication in Near-Field RFID and Wireless Power Using Higher Order Modulation," in *IEEE Transactions of Microwave Theory and Techniques*, vol. 64, no. 2, pp. 401-413, February 2016.
- [J4] M. J. Chabalko, **J. Besnoff**, and D. S. Ricketts, "Magnetic Field Enhancement in Wireless Power With Metamaterials and Magnetic Resonant Couplers," *IEEE Antennas and Wireless Propagation Letters*, vol. 15, pp. 452-455, February 2016.
- [J5] **J. Besnoff**, M. Chabalko, and D. Ricketts, "A Frequency Selective Zero-Permeability Metamaterial Shield for Reduction of Near-Field Electromagnetic Energy," in *IEEE Antennas and Wireless Propagation Letters*, vol. 15, pp. 654-657, 2016.
- [J6] **J.S. Besnoff** and M.S. Reynolds, "Single-Wire Radio Frequency Transmission Lines In Biological Tissue," in *Applied Physics Letters*, 2015, vol. 106, no. 18.

Conference Papers.....

- [C1] **J. Besnoff**, Y. Buchbut, K. Scheim, and D. S. Ricketts, "A 50% Fractional Bandwidth, Wireless Power Communication System Achieving 6.78 Mbps at 13.56 MHz Carrier," *2018 48th European Microwave Conference (EuMC)*, Madrid, 2018, pp. 178-181.
- [C2] **J. Besnoff**, Y. Buchbut, K. Scheim, and D. S. Ricketts, "Dynamic Impedance Matching of Multiple Loads in Wireless Power Transfer using a Genetic Optimization Approach," *2018 IEEE/MTT-S International Microwave Symposium - IMS*, Philadelphia, PA, 2018, pp. 1272-1274.
- [C3] **J. Besnoff**, D. S. Ricketts, Y. Buchbut, G. Castillo, M. Laifendfeld and K. Scheim, "Smart Wireless Power: A Wireless Power and Bi-Directional LIN Communication System," *2017 IEEE International Conference on Microwaves, Antennas, Communications and Electronic Systems (COMCAS)*, Tel-Aviv, 2017, pp. 1-3.
- [C4] **J. Besnoff** and D.S. Ricketts, "Near Field Wireless Power Transfer and Quadrature Amplitude Modulated (QAM) Communication Link," *2015 IEEE Wireless Power Transfer Conference (WPTC)*, Boulder, CO, 2015, pp. 1-4.
- [C5] **J. Besnoff** and D. S. Ricketts, "Wide Bandwidth for High-Speed Communication in Mid-Range, Resonant WPT and RFID Systems," *2015 European Microwave Conference (EuMC)*, Paris, 2015, pp. 147-150.
- [C6] **J. S. Besnoff**, D. S. Ricketts, "Quadrature Amplitude Modulated (QAM) Communication Link for Near and Mid-Range RFID Systems," in *2015 IEEE International Conference on RFID (RFID)*, April 2015, pp. 151-157.
- [C7] **J. S. Besnoff**, M. S. Reynolds, "Single-Wire RF Transmission Lines for Implanted Devices," in *2013 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, October 2013, pp. 222-225.
- [C8] **J. S. Besnoff**, T. Deyle, R. R. Harrison, M. S. Reynolds, "Battery-Free Multichannel Digital ECG Biotelemetry Using UHF RFID Techniques," in *2013 IEEE International Conference on RFID (RFID)*, April 2013, pp. 16-22.
- [C9] S. Thomas, **J. S. Besnoff**, M. Reynolds, "Modulated Backscatter for Ultra-Low Power Uplinks From Wearable and Implantable Devices," in *2012 ACM MedCOMM: Workshop on Medical Communication Systems*, pp. 1-6.
- [C10][†] **J. S. Besnoff**, M. Reynolds, "Near Field Modulated Backscatter for *in vivo* Biotelemetry," in *2012 IEEE International Conference on RFID (RFID)*, April 2012, pp. 135-140.

[†] Indicates Best Paper Award

Invited Talks

1. "Leveraging the Near Field for High Bandwidth Communication with Applications to Wireless Biotelemetry and Wireless Power Transfer (WPT)," Oak Ridge National Laboratory, Oak Ridge, TN. November 2016.

Patents & Patents Pending

1. "Self-Powered Bluetooth Backscatter Sensor System," filed on April 29, 2022, USPTO Serial No. 63/336,430 [Patent Pending]

Poster Presentations

2014 IEEE International Conference on RFID (RFID)

- "Exploiting Near Field and Surface Wave Propagation for UHF Backscatter Biotelemetry"

2013 IEEE Biomedical Circuits and Systems Conference (BioCAS)

- "Single-Wire RF Transmission Lines for Implanted Devices"

2011 IEEE International Conference on RFID (RFID)

- "Near Field UHF Modulated Backscatter for *in vivo* Biotelemetry"

Professional Activities

Technical Program Committee (TPC) Member, IEEE RFID: 2010–2015

Member, IEEE: January 2015–Present

Student Member, IEEE: 2008–December 2014

Eta Kappa Nu (HKN) Association: 2008–Present

Tau Beta Pi (TBPi), Delta Chapter of Massachusetts: 2007–Present

Programming Languages and Software

Programming Languages.....

Matlab, Python, L^AT_EX, VHDL, Verilog, Assembly, C++

Software.....

EMPro, Agilent Advanced Design System (ADS), AWR Microwave Office, CST Microwave Studio, High Frequency Structural Simulator (HFSS), Cadence

Other Activities

August 2014–October 2014: Head Coach, Durham Academy Middle School Boys JV Soccer Team

2010–2016: Volunteer at Animal Protection Society of Durham (APS)

- Walk and socialize dogs at local animal shelter to help them get adopted

2010–Present: Habitat for Humanity

- Experience with siding, shelving, and installing windows

2010–2011: Soccer coach, Rainbow Soccer based in Chapel Hill, NC

- Fall 2010 – U12 Assistant Coach
- Spring 2011 – U15 Assistant Coach
- Fall 2011 – U15 Head Coach