Brian A. Floyd

Alton and Mildred Lancaster Professor and University Faculty Scholar
Dept. of Electrical & Computer Engineering, NC State University
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EDUCATION

Ph. D. in Electrical and Computer Engineering, *University of Florida,* Gainesville, FL 2001
Dissertation: "A CMOS Wireless Interconnect System for Multi-GHz Clock Distribution"

M. Eng. in Electrical and Computer Engineering, *University of Florida,* Gainesville, FL 1998

B. S. in Electrical Engineering with Highest Honors, *University of Florida,* Gainesville, FL 1996

EXPERIENCE

Alton and Mildred Lancaster Professor in ECE 2022-present
Professor of ECE 2018-2022
Associate Professor of ECE 2010-2018
North Carolina State University, Raleigh, North Carolina

- Director of the iNtegrated Circuits & Systems lab at NC State (**iNcs2**), researching millimeter-wave (mmWave) and RF integrated circuits for communications, imaging, and radar applications.
- PhD advisor for 21 students (13 of whom graduated); MS advisor for 8 students (6 of whom graduated). All graduated students work at leading companies within the fields of mmWave or analog design, including Samsung, Anokiwave, ADI, SpaceX, TI, Sivers, Intel, plus two start-ups.
- iNcs2 students have demonstrated some of the world's first radios and phased arrays for 5G cellular systems, invented new topologies for 5-50 GHz tunable filters and software-defined receivers, invented techniques for built-in test and calibration of arrays, introduced new topologies for beamforming arrays, introduced a 76-81 GHz automotive radar array that outperforms all other known solutions, and introduced new mixer-first receiver architectures for MIMO arrays.
- Graduate student work has resulted in over 65 peer-reviewed publications and 6 patents.
- iNcs2 radar technology was licensed to an industrial partner, AKM, accomplished through a multi-year joint development including the training of AKM engineers at NC State as visiting scholars.
- iNcs2 built-in self-test approach to arrays is being translated to open-source for use in companies.
- Co-PI of AERPAW, a $9M grant from NSF ($7.5M to date) with significant in-kind equipment donations, to create a unique national facility at NC State that combines 5G and drones.
- Total research funding of $19.8M (Floyd's share is $8.4M). Sponsors include DARPA, NSF, Army, SRC, Samsung, TI, ADI, AKM, Physical Devices, MaXentric, and IDT.
- Graduate-level instructor of Analog Integrated Circuits class (40-60 students/year), RF Integrated Circuits class (~25 students/year), and mmWave Integrated Circuits class (~15 students/year).
- Received multiple teaching awards. Member of the NC State Academy of Outstanding Teachers.

Engineering Consultant and Expert Witness

Expert Witness for Quinn Emanuel Urquhart & Sullivan, LLP 2021-2022
Served as an expert witness for the defendant in a patent infringement lawsuit related to RF circuits.

Expert Witness for Quinn Emanuel Urquhart & Sullivan, LLP 2012-2014
Peregrine Semiconductor Corp. v. RF Micro Devices, Inc.: Served as an expert witness for the defendant in two patent infringement lawsuits related to RF switches. This included activities related to the US ITC as well as a circuit court in California. Wrote multiple expert reports and was deposed.

Engineering Consultant under RWB Consulting 2016-2018
Consulted with a private company on topics related to phased arrays.

Engineering Consultant for private company 2022-present

Manager and Research Staff Member 2007-2009

IBM Thomas J. Watson Research Center, Yorktown Heights, New York

- Manager of the RF and Wireless Circuits and Systems Group at IBM Research, leading 10 IBM researchers and seven visiting scientists while overseeing group's research funding activities.
- Technical lead and manager of a three-yr. joint development project between IBM and MediaTek Inc. This project demonstrated first-of-a-kind 60 GHz phased-arrays and antenna-in-package solutions for 60 GHz while also training the MediaTek team in mmWave development. Tasks Floyd led included RF phased-array transceiver design, phased-array system requirements, antenna and package design, testbed development, and technology transfer. The IP was licensed to multiple partners. This phased array laid the groundwork for many follow-on mmWave activities, including IBM's creation of the industry's *first* 5G phased array deployed by Verizon.
- Principal investigator for two DARPA programs, including a large multi-year program on self-healing mmWave circuits in CMOS (HEALICS), and a program on mmWave transistor development, leading to two new semiconductor foundry technologies (SiGe BiCMOS 8XP and 9HP) now in volume production.

Research Staff Member 2001-2007

IBM Thomas J. Watson Research Center, Yorktown Heights, New York

- Integrated circuit designer for mmWave and RF applications in SiGe and CMOS technologies.
- Created the world's first 60 GHz radios in silicon, proving that silicon technology can be used for mmWave applications. This transformative work established the nascent 60 GHz industry. Additionally, this work laid the foundation for many future mmWave radio applications, including 5G. The IP has been productized and licensed to multiple companies.
- Worked jointly with colleagues to create the current IEEE 802.15.3c standard for 60 GHz.
- Led multiple technology transfer activities for both internal IBM and external client programs.
- Additional details related to 60 GHz research:
  - Created 16-19 GHz frequency synthesizer for the 60-GHz chipset with a novel phase-interpolating sub-integer divider and a VCO with automatic amplitude control.
  - Created broadband LNAs and pre-drivers with embedded image reject filters.
  - Worked jointly with team on receiver and transmitter architecture and characterization.
  - Worked jointly with team on creation of silicon mmWave design methodologies.
  - Demonstrated mmWave circuits, including the first reported SiGe LNAs at 50/60/77 GHz, voltage-controlled oscillators at 20/50/64/85 GHz, and various passive components.
  - Worked with the foundry to refine IBM's mmWave silicon technology by specifying new devices, improvements to existing devices, and improvements to the design kit.
- Supervised six summer interns on mmWave and WCDMA circuit projects, including Arun Natarajan, Brian Welch, Mohan Chirala, Sean Nicolson, and Dicle Ozis.
- Completed a project to compare the performance of IBM's SiGe and RF-CMOS technologies for WCDMA receivers at 0.25 and 0.18 µm. Presented this work to multiple IBM foundry customers.
- Developed three generations of WCDMA receivers in 0.25-µm SiGe BiCMOS technology. Responsible for LNA design and receiver characterization. The chips achieved state-of-the-art noise and linearity performance, exceeding all WCDMA specifications. Technology was licensed.
- Designed 6 and 12-GHz VCOs and a 13Gbps 1:4 demultiplexer in 90-nm CMOS for SerDes core.

Pre-Doctoral Fellow and Graduate Research Assistant 1997-2001

University of Florida, Gainesville, Florida

- Designed and implemented the world's first wireless interconnect system that distributed wireless clock signals across a chip. The system consisted of on-chip antennas, transmitter, and receiver circuitry. The first inter-chip wireless interconnects were demonstrated, providing 7.4 and 15 GHz global clock signals over distances of 3 and 22 mm, respectively.
- Developed design methodologies and circuit demonstrations of 1-20 GHz CMOS LNAs and injection-locked frequency dividers, helping to prove the viability of CMOS for RFICs.

AWARDS AND HONORS

- NC State Innovator of the Year 2023
- Alton and Mildred Lancaster Professorship 2022
- University Faculty Scholar, NC State University 2020
- Best Student Paper Award, 2nd place, IEEE MWC-5G 2019
- Best Student Paper Award, 3rd place, IEEE GSMM 2018
- NC State Outstanding Teacher Award, Member of NC State Academy of Outstanding Teachers 2016
- College of Engineering Outstanding Teacher Award 2016
- William F. Lane Outstand Teacher Award, ECE Department, NCSU 2015
- NC State Thank a Teacher Award (7X) S2012, S2013, F2013, F2014, S2015, F2015, S2016
- NC State Chancellor's Innovation Fund Winner 2015
- IBM Faculty Award 2014
- DARPA Young Faculty Award 2011
- IBM Research Pat Goldberg Memorial Best Paper Award for CS/EE/Math (on 60-GHz package) 2011
- Senior Member, IEEE 2010
- IBM Research Division Outstanding Accomplishment Award 2007
- IBM Research Pat Goldberg Memorial Best Paper Award for CS/EE/Math (on 60-GHz radio) 2006
- ISSCC Lewis Winner Award for Outstanding Paper (on second 60-GHz radio paper) 2006
- ISSCC Lewis Winner Award for Outstanding Paper (on first 60-GHz radio paper) 2004
- IBM Research Division Technical Group Awards 2005, 2006
- Phase-1 winner, Phase-2 first runner-up, SRC Copper IC Design Challenge 2000
- Best Paper Award, Semiconductor Research Corporation (SRC) TechCon 2000
- Semiconductor Research Corporation/Intersil Corp. Graduate Fellow 1998-2001
- Robert C. Pittman Graduate Fellow, U. Florida 1996-1997
- Electrical E Award, the highest award for an ECE undergrad, U. Florida 1996
- Four-Year Scholar, Honorable Mention, U. Florida 1996
- Eta Kappa Nu Honor Society 1996
- Eagle Scout 1989

SELECT PROFESSIONAL SERVICE

- IEEE RF Integrated Circuit Symposium, top international conference with ~800 annual attendees
  - *General Chair (2020-2021)*: Responsible for leading all aspects of conference, including conversion to hybrid conference with both in-person and virtual components to deal with CoVID-19. Oversaw sponsorship, local arrangement coordination, virtual platform, conference program, publicity, attendee experience, and budget. Directed a 15-person steering committee.
  - *Technical Program Chair (2019-2020) and Vice-Chair (2018-2019)*: Responsible for setting the technical agenda, including selecting and leading the program committee, supervising the paper review process, organizing the technical program, and ensuring publication standards. During 2020, responsible for evaluating alternatives due to CoVID-19 and helping transition to virtual.
  - Executive Cmte. (2020-2025), Steering Cmte. (2008-2021), Program Cmte. (2006-2020)
- IEEE AdCom Member for Solid-State Circuits Society, Secretary 2022-present
- IEEE MTTS Ad-Hoc Committee for Restructuring IMS 2022-present
- Associate Editor, IEEE Journal Solid-State Circuits 2011-2016
- IEEE ISSCC Technical Program Committee (our leading conference for all circuits) 2010-2014
- IEEE Bipolar/BiCMOS Circuits & Tech. Mtg. Tech. Program Committee 2017-2018
- Semiconductor Research Corporation (SRC) Technical Advisory Board 2006-2009
- SRC Texas Analog Center of Excellence Security and Safety Thrust Leader 2011-2018

TEACHING EXPERIENCE

Since joining NC State in January 2010, Floyd has taught a total of **1163** graduate students. This includes **191** students who took his classes through Engineering On-Line (EOL). His average teacher ratings are 4.84 out of 5.0 for teaching effectiveness and 4.79 out of 5.0 for course quality.

ECE 511: Analog Integrated Circuits, *NC State* Fall 2010-present

- Instructor. Graduate-level course covering single- and multi-stage amplifiers, biasing, feedback, stability, frequency response, and operational amplifiers.

ECE 712: Integrated Circuits for Wireless Communications, *NC State* Spr. 2010-present

- Instructor. Advanced graduate-level course covering radio architecture, microwave theory, and the design of LNAs, mixers, receivers, VCOs, PAs, transmitters, and PLLs.

ECE 792: Millimeter-Wave Integrated Circuits and Systems, *NC State* Spr. 2018-present

- Instructor and course developer. Advanced graduate-level course covering millimeter-wave integrated circuits for communications and sensing, beamforming, phased arrays, transceivers, and the key mmWave building blocks found within these systems.

GRADUATE-LEVEL MENTORSHIP

- PhD Supervision and Committees: Advisor for **13** PhD (graduated) and **8** PhD (in progress). Committee member for another **21** PhD (graduated) and **3** PhD (in progress).
- MS Supervision and Committees: Advisor for **6** MS (graduated) and **2** MS (in progress). Committee member for another **8** MS (graduated) and **5** MS (in progress).
- Visiting Scientists: Supervised **4** visiting scholars
- Undergraduate Research: Advisor for **5** B.S. students
- Independent Study: Advisor for **13** independent study (MS-level) students

List of PhD Theses either directed or currently directing:

1. **Zhengxin Tong**, PhD (2015), now at ADI Thesis: *Silicon Millimeter-Wave Imaging Systems…*
2. **Anirban Sarkar**, PhD (2016), now at Samsung Thesis: *Efficient Power Amplifiers for mmWave…*
3. **Kevin Greene**, PhD (2017), now at Anokiwave Thesis: *Code-Modulated Embedded Test…*
4. **Yi-Shin Yeh**, PhD (2018), now at Sivers Thesis: *Distributed Beamforming Arrays…*
5. **Weihu Wang**, PhD (2018), now at Anokiwave Thesis: *Systematic Optimization of Phase Noise…*
6. **Charley Wilson**, PhD (2018), now at Lumeova Thesis: *Reconfigurable Passive Mixer-First Recvrs.*
7. **Vikas Chauhan**, PhD (2019), now at SpaceX Thesis: *Code-Modulated Interferometric Imaging…*
8. **Sandeep Hari**, PhD (2023), now at Samsung Thesis: *Widely-Tunable N-path Receivers and Filters*
9. **Jacob Dean**, PhD (2023) , now at Lumeova Thesis: *RF to Millimeter-Wave Receivers…*
10. **Yuan Chang**, PhD (2023), now at Jelicomm Thesis: *Wideband Millimeter-Wave Phased Arrays…*
11. **Cody Ellington**, PhD, (2023), now at ADI Thesis: *Enhanced … N-Path Filters and Receivers*
12. **Zhangjie Hong**, PhD (2023), now at Apple Thesis: *Phased Array … Calibration…*
13. **Tiantong Ren**, PhD (2023), now at Sivers Thesis: *…Phased-array Transmitters for mmWave*
14. **Ian Glenn,** (target 2025) Thesis: *More-than-Massive MIMO Arrays*
15. **Saleh Almahmoud**, (target 2025) Thesis: *Concurrent Communication and Sensing*
16. **Bharadwaj Padmanabhan,** (target 2026) Thesis: *N-path Selective Systems for mmWave*
17. **Ashwini Pondeycherry,** (target 2026) Thesis: *Millimeter-Wave Arrays for UAVs*
18. **Ajit Attarde,** (target 2027) Thesis: *Transmitter… for Direct Antenna Modulation*
19. **Dinup Sukumaran,** (target 2027) Thesis: *Broadband RF to mmWave LNAs*
20. **Greg Medwig,** (target 2028) Thesis: *3D Heterogenous Integration of Arrays*
21. **Jonathan Rabe,** (target 2028) Thesis: *Software-Defined Transmitters, RF to mmW*

List of MS Theses either directed or currently directing:

1. **Ashok Pusuluri**, MS (2013), now at ADI — Thesis: *Tunable Transmission Lines for Microwave…*
2. **Avinash Bhat**, MS (2017), now at Intel — Thesis: *Passive Mixer Design Techniques …*
3. **Aparna Ramakrishna**, MS (2019), now at Itron — Thesis: *Reconfigurable Mixer-First Receivers*
4. **Madhuja Ghosh**, MS (2019), now at Silicon Lab — Thesis: *Behaviorally Modeled Code-Modulation…*
5. **Ayush Malhotra,** MS (2020), now at Qorvo — Thesis: *Widely Tunable Quadrature Generation…*
6. **Sakshi Agrawal,** MS (2023), now at TI — Thesis: *Code-Modulated Embedded Test of …*
7. **Michael Stetzler,** MS (target 2024) — Thesis: *Automatic Calibration of Scalable Hybrid…*
8. **Pranav Mannur,** MS (target 2025) — Thesis: *Cancellation of Receiver Distortion*

CONTRACTS AND GRANTS

Total Grants, Active: $14,359,295 (Floyd's share is $4,010,795)
Total, Active+Complete: $19,817,521 (Floyd's share is $8,409,578)

1. **Title: Scalable Antenna-in-Package Approaches Supporting Heterogeneous Integrated Arrays**
   Source of Support: SRC; Jan 2024 – Dec. 2026
2. **Title: RINGS: WISECOM Wireless Integrated Sensing, Learning and Comm. Networks**
   Source of Support: NSF; Sep 2022 – Aug 2025
3. **Widely Tunable Receivers and Filters for Next-Generation Communications**
   Source of Support: ADI (through BWAC); Oct 2022 – Oct 2023
4. **Title: STTR Phase I&II: Extendable Phased-Array Transceiver Platform**
   Source of Support: MaXentric Tech., US Army (prime); Apr 2020 – Sep 2022
5. **Title: Code-Modulated Embedded Test of Multifunctional Arrays**
   Source of Support: Texas Instruments; May 2018 – May 2023
6. **Title: Scalable and Calibrated Phased Arrays for 5G**
   Source of Support: Analog Devices Inc. (ADI); Aug 2014 – present
7. **Title: Energy Synchronous Direct Antenna Modulation Transmitters**
   Source of Support: IARPA; Jul 2022 – Apr 2026
8. **Title: AERPAW: Aerial Experimentation and Research Platform for Advanced Wireless**
   Source of Support: PAWR Project Office, NSF; Sep 2019 – Aug 2023
9. **Title: Phase II IUCRC, Broadband Wireless Access and Application Center (BWAC)**
   Source of Support: NSF; Sep. 2019 – Aug 2023
10. **Title: High Dimensional Optimization and Inverse Methods for Electronic Design**
    Source of Support: CAEML; Jan. 2021 – Dec. 2022
11. **Multi-Modal Communications for Reliable UAV and UGV Connectivity**
    Source of Support: ADI (through BWAC); Oct. 2021 – Sept 2022
12. **Title: Tunable RF to Millimeter-Wave Receivers and Filters**
    Source of Support: DARPA; Oct 2018 – Mar 2022
13. **Title: Intellectual Property Reuse through Machine Learning**
    Source of Support: NSF I/UCRC: CAEML; Jan 2017 – Aug 2019
14. **Title: SBIR Ph. I&II: W-band Imaging System Using Repurposed Comm. and Radar Chipsets**
    Source of Support: MaXentric Tech. (direct), US Army (prime); Feb 2015 – Dec 2018
15. **Title: EARS: Compact Adaptive MIMO Receivers**
    Source of Support: National Science Foundation; Sep 2013 – Sep 2018
16. **Title: EPIC – Extendable Phased-array Platform ICs (Phase I & II)**
    Source of Support: DARPA; May 2016 – Jan 2018
17. **Title: STTR Ph. I&II: Fully-Integrated Tunable Filters w/ Synthetic Linear Interference Delay**
    Source of Support: Physical Devices LLC (direct), NSF (prime); July 2012 – Oct. 2018
18. **Radios and Arrays for 5G Millimeter-Wave Systems**
    Source of Support: Integrated Device Technology (IDT); Jan 2017 – May2018
19. **Title: Radio Design for Mobile Millimeter-Wave Broadband**
    Source of Support: Samsung; Feb 2012 – Sep 2016
20. **Code-Modulated Imaging with Commercial-Off-The-Shelf Phased Arrays**
    Source of Support: NC State University Chancellor's Innovation Fund; July 2015

21. **Title: Advanced Silicon Circuits and Systems for Emerging Millimeter-Wave Markets**
    Source of Support: Asahi Kasei Microdevices (AKM) Corporation; Nov 2011 – Oct 2014
22. **Title: Efficient Linearized All-Silicon Transmitter ICs (ELASTx)**
    Source of Support: MIT (prime), DARPA (direct); Feb 2013 – May 2014
23. **Title: Imaging Using Reconfigured Millimeter-Wave Phased Arrays in Silicon (IRIS)**
    Source of Support: DARPA; Aug 2011 – July 2014
24. **IBM Faculty Award**
    Source of Support: IBM; Jan 2014
25. **Title: Low Power Potentiostats for Electrochemical Sensing**
    Source of Support: National Science Foundation ASSIST ERC; Sep 2012 – Aug 2013
26. **Title: D-band Integrated with V-band Architecture for sub-THz Wireless Communications**
    Source of Support: MaXentric Tech (direct), US Army (prime); Oct. 2011 – Aug 2012
27. **Title: Built-In Test for Power-Efficient Millimeter-Wave Phased Arrays**
    Source of Support: University of Texas-Dallas (direct), SRC (prime); Mar 2011 – Dec 2014

PUBLICATIONS AND PATENTS

Published Peer-Reviewed Journal Articles	*44*
Published Peer-Reviewed Conf. Papers	*89*
Published Tutorial/Short-Course/Workshops	*14*
Book Chapters/Text Contribution	*4*
Invited Presentations and Panels	*>64*
Patents Issued	*32*
Citations (Google scholar, including self-citations)	*7218*
h-Index (Google scholar, including self-citations)	*44*
i10-Index (Google scholar, including self-citations)	*111*

JOURNAL PUBLICATIONS (PEER REVIEWED)

[J44] C. J. Ellington, S. Hari, and B. A. Floyd, "Improved out-of-band rejection in reflection-mode N-path filters using tunable transmission zeros," *IEEE Trans. Microw. Theory Techn*., DOI 10.1109/TMTT.2024.3395060, 2024.

[J43] J. Dean, S. Hari, and B. A. Floyd, "RF to millimeter-wave receivers employing frequency-translated feedback," *IEEE J. Solid-State Circuits,* vo. 59, no. 5, pp. 1447-1460, May 2024.

[J42] C. J. Ellington, S. Hari, and B. A. Floyd, "Analysis and design of baseband circuits for higher-order reflection-mode N-path filters," *IEEE Trans. Circuits and Systems-I: Reg. Papers*, vol. 70, no. 12, pp. 5152-5165, Dec. 2023.

[J41] Y. Chang and B. A. Floyd, "Reduction of phase and gain control dependencies within a 20 GHz beamforming receiver IC," *IEEE Access*, vol. 11, pp. 68,066-68,078, May 2023.

[J40] S. Hari, C. Ellington, and B. A. Floyd, "A reflection-mode N-path filter tunable from 6 to 31 GHz," *IEEE J. Solid-State Circuits*, vol. 58, no. 7, pp. 1973-1986, July 2023.

[J39] V. Chauhan, Z. Hong, S. Schönherr, and B. A. Floyd, "An X-band code-modulated interferometric imager," *IEEE Trans. Microw. Theory Techn.*, vol. 69, no. 11, pp. 4856-4868, Nov. 2021.

[J38] Y.-S. Yeh, W. Wang, and B. A. Floyd, "75-86 GHz signal generation using a phase-controlled quadrature-push quadrupler driven by a QVCO or a tunable polyphase filter," *IEEE Trans. Microw. Theory Techn.*, vol. 69, no. 10, pp. 4521-4532, Oct. 2021.

[J37] A. Panicker, O. Ozdemir, M. Sichitiu, I. Guvenc, R. Dutta, V. Marojevic, and B. Floyd, "AERPAW emulation overview and preliminary performance evaluation," *Computer Networks*, vol. 194, article 108083, July 2021.

[J36] Z. Hong, V. Chauhan, S. Schönherr, and B. A. Floyd, "Code-modulated embedded test and calibration of phased-array transceivers," *IEEE Trans. Microw. Theory Techn.*, vol. 69, no. 3, pp. 1557-9670, Mar. 2021.

[J35] Y.-S. Yeh and B. A. Floyd, "Multibeam phased arrays using dual-vector distributed beamforming: architecture overview and 28 GHz transceiver prototypes," *IEEE Trans. Circuits and Systems-I: Regular Papers*, vol. 67, no. 12, pp. 5496-5509, Dec. 2020.

[J34] V. Marojevic, I. Guvenc, R. Dutta, M. L. Sichitiu, B. A. Floyd, "Advanced wireless for unmanned aerial systems: 5G standardization, research challenges, and AERPAW experimentation platform," *IEEE Vehicular Tech. Mag.,* vol. 15, no. 2, pp. 22-30, June 2020.

[J33] J. Bonner-Stewart, C. Wilson III, and B. A. Floyd, "Tunable 0.7-to-2.8 GHz reflection-mode N-path filters in 45-nm SOI CMOS," *IEEE Trans. Microw. Theory Tech.* vol. 68, no. 6, pp. 2343-2357, June 2020.

[J32] C. Wilson III, J. Dean, and B. A. Floyd, “Mixer-first MIMO receiver with reconfigurable multi-port decoupling and matching,” *IEEE J. Solid-State Circuits*, vol. 55, no. 5, pp. 1401-1410, May 2020.

[J31] C. Wilson III and B. Floyd, “Harmonic performance of mixer-first receiver with circulant-symmetric baseband,” *IEEE Trans. Circuits Systems-I: Reg. Papers,* vol. 66, no. 1, pp. 161-174, Jan 2019.

[J30] K. Greene, V. Chauhan, and B. Floyd, “Built-in-test of phased arrays using code-modulated interferometry,” *IEEE Trans. Microw. Theory Tech.*, vol. 66, no. 5, pp. 2463-2479, May 2018.

[J29] T. Fujibayashi, Y. Takeda, Y.-S. Yeh, W. Wang, W. Stapelbroek, S. Takeuchi, and B. Floyd, “A 76 to 81 GHz multi-channel radar transceiver,” *IEEE J. Solid-State Circuits*, vol.52, no.9, pp.2226-2241, Sep. 2017.

[J28] A. Sarkar, F. Aryanfar, and B. Floyd, “A 28-GHz SiGe BiCMOS PA with 32% efficiency and 23 dBm output power,” *IEEE J. Solid-State Circuits*, vol. 52, no. 6, pp. 1680-1686, June 2017.

[J27] K. Greene, A. Sarkar, and B. Floyd, “A 60-GHz dual-vector Doherty beamformer,” *IEEE J. Solid-State Circuits*, vol. 52, no. 5, pp. 1373-1387, May 2017.

[J26] Y.-S. Yeh, B. Walker, E. Balboni, and B. Floyd, “A 28-GHz phased-array receiver front-end with dual-vector distributed beamforming,” *IEEE J. Solid-State Circuits*, vol. 52, no. 5, pp. 1230-1244, May 2017.

[J25] A. Sarkar and B. Floyd “A 28-GHz harmonic-tuned power amplifier in 130-nm SiGe BiCMOS,” *IEEE Trans. Microw. Theory Tech.*, vol. 65, no. 2, pp. 522-535, Feb. 2017.

[J24] D. G. Kam, D. Liu, A. Natarajan, S. Reynolds, and B. A. Floyd, “Organic packages with embedded phased-array antennas for 60-GHz wireless chipsets,” *IEEE Trans. Comp. Packag. Manuf. Technol.*, vol. 1, no. 11, pp. 1806-1814, Nov. 2011. [**BEST PAPER AWARD**]

[J23] D. Liu, J.A.G. Akkermans, H.-C. Chen, and B. Floyd, "Packages with integrated 60-GHz aperture-coupled patch antennas," *IEEE Trans. Antennas Prop.*, v 59, n 10, pp. 3607-3616, Oct. 2011.

[J22] A. Natarajan, S. Reynolds, M.D. Tsai, S. Nicolson, J.H.C. Zhan, D. Kam, D. Liu, O. Huang, A. Valdes-Garcia, and B. A. Floyd, “A fully-integrated 16-element phased-array receiver in SiGe BiCMOS for 60-GHz communications,” *IEEE J. Solid-State Circuits*, vol. 46, no. 5, pp. 1059-1075, May 2011.

[J21] A. Valdes-Garcia, S. Reynolds, A. Natarajan, D. Kam, D. Liu, J.-W. Lai, Y.-Lin Huang, P.-Y. Chen, M.-D. Tsai, J.-H. Zhan, S. Nicolson, and B. Floyd, "Single-element and phased-array transceiver chipsets for 60-GHz Gb/s communications," *IEEE Commun. Mag.*, vol. 49, no. 4, pp. 120-131, Apr. 2011.

[J20] D. G. Kam, D. Liu, A. Natarajan, S. Reynolds, H.-C. Chen, B. A. Floyd, “LTCC packages with embedded phased-array antennas for 60-GHz communications,” *IEEE MWCL*, vol. 21, no. 3, pp. 142-144, Mar. 2011.

[J19] A. Valdes-Garcia, S. Nicolson, J.-W. Lai, A. Natarajan, P.-Y. Chen, S. Reynolds, J.-H. Zhan, D. Kam, D. Liu, and B. Floyd, "A fully-integrated 16-element, SiGe BiCMOS phased-array transmitter for 60-GHz communications," *IEEE J. Solid-State Circuits*, vol. 45, no. 12, pp. 2757-2773, Dec. 2010.

[J18] B. Floyd, "Sub-integer frequency synthesis using phase-rotating frequency dividers," *IEEE Trans. Circuits Syst. I, Reg. Papers*, vol. 55, no. 7, pp. 1823-1833, Aug. 2008.

[J17] B. Floyd, "A 16 to 18.8-GHz sub-integer-N frequency synthesizer for 60-GHz transceivers," *IEEE J. Solid-State Circuits*, vol. 43, no. 5, pp. 1076-1086, May 2008.

[J16] B Gaucher, B. Floyd, S. Reynolds, U. Pfeiffer, J. Grzyb, A. Joseph, E. Mina, B. Orner, H. Ding, R. Wachnik, and K. Walter, "Silicon germanium based millimetre-wave ICs for Gbps wireless communications and radar systems," *Semiconductor Science & Tech.*, v22, n1, pp. 236-243, Jan. 2007.

[J15] S. Reynolds, B. Floyd, U. Pfeiffer, T. Beukema, J. Grzyb, C. Haymes, B. Gaucher, and M. Soyuer, "A silicon 60GHz receiver and transmitter chipset for broadband communications," *IEEE J. Solid-State Circuits*, v. 41, no. 12, pp. 2820-2831, Dec. 2006.

[J14] U. R. Pfeiffer, J. Grzyb, D. Liu, B. Gaucher, T. Beukema, B. A. Floyd, S. K. Reynolds, “A chip-scale packaging techn. for 60-GHz wireless chipsets,” *IEEE Trans. Microw. Theory Tech.*, vol. 54, no. 8, pp. 3387-3397, Aug. 2006.

[J13] S. K. Reynolds, B. A. Floyd, T. J. Beukema, T. Zwick, and U. R. Pfeiffer, “Design and compliance testing of a SiGe WCDMA receiver IC with integrated analog baseband,” *Proc. IEEE*, vol. 93, no. 9, pp. 1624-1636, Sept. 2005.

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EXTENSION, ENGAGEMENT, AND ENTREPRENEURSHIP

Below is a summary of Floyd's extension activities over and above sponsored research projects. The first four activities involved direct mentorship of graduate students within the i**Ncs**2 research group, where they have been exposed to either joint industry/university development activities or entrepreneurship initiatives.

Joint Development Program with **Asahi Kasei Microdevices** (AKM), 2011-2014:

- Floyd led a joint development program between NC State and AKM, a Japanese Electronics Company, on the development of mmWave vehicular radar systems. Under this program, the eight-person team jointly created two generations of radars, the last of which achieved the highest published performance.
- He hosted and mentored two visiting scholars from AKM and advised two PhD students in this program. The AKM designers were trained in the fundamentals of mmWave design and now lead radar system development teams at AKM. The PhD graduates now work at leading mmWave companies.
- The Intellectual Property has been productized by AKM. Floyd also continues to work with NC State's Office of Research Commercialization (OFC) to license the IP to additional partners.

Co-PI of **AERPAW**, a $9M intrastructure grant from NSF and the PAWR Platform Office (PPO).

- NC State is one of four sites in the US selected to create city-scale wireless test infrastructure to be used by researchers throughout the country. Grant also includes up to $15M of in-kind donations. Floyd oversees the mmWave radio development, where the team seeks to provide the nation's best capabilities for mobile 5G phased arrays.
- Facility capabilities are being co-developed by staff and graduate students (one mentored by Floyd) and were recently incorporated into a wireless technology class (ECE 578) taught by Prof. Guvenc.

Small Business Technology Transfer (STTR) Programs with **MaXentric Technologies** LLC, 2016-present:

- Floyd collaborated with a small business to create an imaging system for the US Army using iNcs2 vehicular radar chipset and a method developed under the NC State Chancellor's Innovation Fund.
- Floyd currently collaborates with this same company to create novel mmWave phased arrays for scalable satellite communication systems for the US Army that can leverage reusable IP solutions.
- Floyd has mentored four PhD students in these two programs.
- The inventions are protected by two patents. He continues to explore new licensing opportunities.

Small Business Technology Transfer (STTR) Program with **Physical Devices LLC**, 2012-2018:

- Floyd collaborated with a start-up on the investigation, development, and productization of a new class of tunable filters. He mentored two NC State PhD students in this program funded through NSF.
- He served as the main technical advisor for the company, influencing company strategy.
- Floyd's filter and duplexer inventions are protected by four patents licensed by Physical Devices LLC.

Thrust leader (Security/Safety), **Texas Analog Center of Excellence** (TxACE): 2011-2018

- Floyd served as one of four thrust leaders for the center that was jointly funded by SRC member companies (Intel, IBM, Freescale, Texas Instruments, and others) and the state of Texas.
- He was responsible for overseeing and coordinating all center activities related to security and safety research. This research portfolio was focused on mmWave radars, imagers, radios, and spectrometers, totaling ~$1.6M of funding and 16 projects per year.