ZOYA POPOVIĆ
Distinguished Professor
Hudson Moore Jr. Endowed Chair
Department of Electrical, Computer and Energy Engineering
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EDUCATION

Ph.D., Electrical Engineering, Caltech, 1990. Thesis advisor: Prof. David Rutledge.
M.S., Electrical Engineering, Caltech, 1986.
Dipl.Ing. (B.S.), Electrical Engineering, University of Belgrade, Serbia, Yugoslavia, 1985.

Zoya Popović received her Dipl. Ing. degree from the University of Belgrade, Serbia, in 1985, and the M.S. and Ph.D. degrees from Caltech, Pasadena, California, in 1986 and 1990, respectively. Her doctoral thesis was on large-scale quasi-optical microwave power combining. She joined the faculty of the University of Colorado in Boulder in August 1990, where she became a full professor in 1998, and received an endowed professorship in 2006. She has developed five undergraduate and graduate electromagnetics and microwave laboratory courses and co-authored (with her late father) *Introductory Electromagnetics* for the junior-level core course for electrical and computer engineering students, translated to several foreign languages. Her research interests include high-efficiency linear microwave power amplifiers, low-loss broadband microwave and millimeter-wave circuits, millimeter-wave and THz quasi-optical techniques, intelligent RF circuits, active antenna arrays, voltage standards, near field electromagnetic probing, and wireless powering for low-power sensors. She was a Visiting Professor at the Technische Universitat Muenchen, Munich, Germany, in 2001 and 2003.

RECOGNITION

- Holland Teaching Award, University of Colorado, 2011
- Distinguished Professor, University of Colorado, 2010
- Coleman Research Fellow, Coleman Institute, 2008
- Faculty Research Award, College of Engineering and Applied Science, 2007
- Elected Foreign Member of Serbian Academy of Sciences and Arts, 2006
- Microwave Prize, IEEE MTT Society, 2005, best journal paper award and
- Microwave Prize, IEEE MTT Society, 1993, best journal paper award
- Fellow, IEEE, 2002
- ASEE HP/Terman Award 2001, for combined teaching and research excellence
- Humboldt Research Award for Senior Scientists, German Alexander von Humboldt Foundation, 2000/2001
- Margaret Willard Award, University of Colorado, 1997, as female role model
- Eta Kappa Nu professor of the year award, 1997, by student vote
- URSI Issac Koga Gold Medal, Lille, France, 1996, awarded once every three years
- White House NSF Presidential Faculty Fellow Award, 1993
- URSI Young Scientist, Kyoto, Japan, 1993
- Best Student Award for the division of Electronics, University of Belgrade, 1985
- City of Belgrade October Award for the Diploma Thesis in 1985

BOOKS, EDITED BOOKS AND BOOK CHAPTERS

Introductory Electromagnetics, Zoya Popovic and Branko Popovic, Prentice Hall, 2000.
Introductory Electromagnetics, Practice Problems and Labs, Zoya Popovic and Branko Popovic, Prentice Hall, 2000, *Student workbook.*

Active and Quasi-Optical Arrays for Solid-State Power Combining, eds. Robert A. York and Zoya B. Popovic, John Wiley and Sons, 1997.

- "Quasi-optical antenna array amplifiers," Zoya Popovic, Robert York, Emilio Sovero, Jon Schoenberg, Chapter 5 in Active and Quasi-optical Arrays for Solid-State Power Combining, eds. R.A. York and Z. B. Popovic, John Wiley and Sons, 1997, pp. 187-244.
- "Grid oscillators," Zoya Popovic, Wayne A. Shiroma, Robert M. Weikle, II, Chapter 8 in Active and Quasi-optical Arrays for Solid-State Power Combining, eds. R.A. York and Z.B. Popovic, John Wiley and Sons, 1997, pp. 293-330.
- "Quasi-optical subsystems," Zoya Popovic and Gerald Johnson, Chapter 12 in Active and Quasi-optical Arrays for Solid-State Power Combining, eds. R.A. York and Z.B. Popovic, John Wiley and Sons, 1997, pp. 455-484.
- "Analysis and design of oscillator grids and arrays," W. Shiroma, E. Bryerton, Z. Popovic, chapter in Analysis and Design of Integrated Circuit/Antenna Modules, eds. K.C. Gupta and P. Hall, Wiley and Sons, 2000, pp 301-332
- "Power amplifier approaches for high-efficiency and linearity," with Peter Asbeck, Larry Larson and Tatsuo Itoh, Chapter in "RF Technologies for Low-Power Wireless Communications," Eds. T. Itoh, G. Haddad, Wiley and Sons, pp.189-228, Wiley, 2001.
- "Magnetostatics", with B. Popovic and M. Popovic, Chapter 3 in Handbook of Engineering Electromagnetics, ed. Rajeev Bansal, Marcel Dekker, 2004, pp 89-122
- "Electromagnetic induction," with B. Popovic and M. Popovic, Chapter 4 in Handbook of Engineering Electromagnetics, ed. Rajeev Bansal, Marcel Dekker, 2004, pp 122-162
- "Active Antennas," with S. Rondineau and N. Lopez, in Antenna Engineering Handbook, ed. John Volakis, 2007 (30 pages).

FUNDING SUMMARY

- Current funding sources: NSF, NIST, U.S. Air Force, DARPA, NASA, Sandia National Laboratories, Nuvotronics LLC, National Semiconductor, The Coleman Institute, Covidien.
- Recent funding sources: BAE Systems (DARPA), SAIC, Dept. of Education, ONR.
- Average expenditures >$1M/year since 1995.

GRADUATE STUDENTS

- 40 Ph.D. students graduated and happily employed.
- 15 students currently doing their Ph.D. dissertations.
- 2 M.S., 2 undergraduate and 1 high-school research students currently supervised.
- Over 85% of the graduated and 100% of current Ph.D. students are U.S. citizens.
- Former students contributing at MIT Lincoln Labs (8), Sandia (4), ARL, NASA, National Semiconductor, Agilent, various other companies and in academia.

JOURNAL ARTICLES

1. "The THD Characteristics of the Phase Detector," Z. B. Popovic, A. Markovic, *IEEE Trans. on Consumer Electronics, CE-32*, No.1, pp. 20-25, Feb. 1986.
2. "Bow-tie antennas on a dielectric half-space: Theory and Experiment," R. C. Compton, R. C. McPhedran, Z. Popovic, G. M. Rebeiz, P. P. Tong, D. B. Rutledge, *IEEE Trans. on Antennas and Propagation, AP-35*, pp. 622-631, June, 1987.
3. "Grid Oscillators," Z. B. Popovic, M. Kim, D. B. Rutledge, *International Journal for Infrared and Millimeter Waves 9*, pp. 647-654, 1988.
4. "Bar-Grid Oscillators," Z. B. Popovic, R. M. Wiekle, M. Kim, K. A. Potter, D. B Rutledge, *IEEE Transactions on Microwave Theory and Techniques, MTT-38*, No.3, March 1990.
5. "Array Concepts for Solid-State and Vacuum Microelectronics Millimeter-Wave Generation," R. J. Hwu, C. F. Jou, N. C. Luhmann Jr., M. Kim, W. W. Lam, Z. B. Popovic, D. B. Rutledge, *IEEE Transactions on Electron Devices, Vol. 36*, No. 11, Nov. 1989.
6. "A 100-MESFET Planar Grid Oscillator," Z. B. Popovic, R. M. Wiekle, M. Kim, D. B Rutledge, *IEEE Transactions on Microwave Theory and Techniques, Vol. MTT-39*, No. 2, pp. 193-200, Feb. 1991. ***(Winner of IEEE Microwave Prize)***
7. "Transistor Oscillator and Amplifier Grids," R.M. Weikle, II, M. Kim, J.B. Hacker, M.P. DeLisio, Z.B. Popovic, D.B. Rutledge, *Invited paper, Proc. IEEE, Vol. 80*, No. 11, pp 1800-1809, Nov. 1992.
8. "Quasi-Optical VCOs," S. Bundy, T. Mader, Z.B. Popovic, *IEEE Transactions on Microwave Theory and Techniques, Special Issue*, Vol. 41, No. 10, pp 1775-1781, October 1993.
9. "Experimentally Variable Modeling of Coplanar Waveguide Discontinuities," V. Radisic, D. Hjelme, A.R. Mickelson, Z.B. Popovic, *IEEE Transactions on Microwave Theory and Techniques, Special Issue, Vol 41,* No. 9, pp 1524-1533, September 1993.
10. "CPW Oscillator Conjuration for an Electro-Optic Modulator," V. Radisic, V. Jevremovic, Z.B. Popovic, *IEEE Transactions on Microwave Theory and Techniques, Special Issue*, *Vol 41,* No. 9, pp 1645-1647, September 1993.
11. "Planar MESFET Transmission Wave Amplifier," T. Mader, J. Schoenberg, L. Harmon, Z. B. Popovic, *IEE Electronic Letters, Vol. 28*, No. 19, pp. 1699-1701, September 1993.
12. "Time-efficient modeling of the effect of metal packages on electrical circuits," Zoya B. Popovic, B. D. Popovic, *IEEE Transactions on Microwave Theory and Techniques, Special Issue on Packaging and Interconnects, Vol.42*, No.9, pp. 1820-1826, September 1994.
13. "A 100-transistor quadruple grid oscillator," W. A. Shiroma, B. L. Shaw, Z. B. Popovic, *IEEE MTT Microwave and Guided Wave Letters, Vol.4, No.10*, pp. 350-352, October 1994.
14. "Two-level power combining using a lens amplifier," J. S. H. Schoenberg, S. C. Bundy, Z. B. Popovic, *IEEE Transactions on Microwave Theory and Techniques, Vol.42, No.12*, pp. 2480 - 2485, December 1994.
15. "A generalized analysis for grid oscillator design," S. C. Bundy, Z. B. Popovic, *IEEE Transactions on Microwave Theory and Techniques, Vol.42*, No.12, pp. 2486-2491, December 1994.
16. "The transmission-line high-efficiency class-E amplifier," T.B. Mader, Z. B. Popovic, *IEEE MTT Microwave and Guided Wave Letters, Vol.5*, *No.10*, pp. 290-293, October 1995.
17. "Broadband Quasi-Microstrip Antenna," B.D. Popovic, J. Schoenberg, Z.B. Popovic, *IEEE Trans. on Antennas and Propagation, Vol.43, No.10*, pp.1148-1152, October 1995.
18. "Cascaded active and passive quasi-optical grids," W. Shiroma, S. Bundy, S. Hollung, B. Bauernfiend, Z.B. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Vol.43, No.12,* pp. 2904-2909, December 1995.
19. "A quasi-optical isolator," S. Hollung, M. Markovic, W. Shiroma, Z.B. Popovic, *IEEE Microwave and Guided Wave Lett.,* pp. 205-207, April 1996.
20. "A 5-GHz high-efficiency class-E oscillator," E. Bryerton, W. Shiroma, Z.B. Popovic, *IEEE Microwave and Guided Wave Lett., Vol.6, No.12*, pp. 441-443, December 1996.

21. "A bi-directional quasi-optical lens amplifier," S. Hollung, A. Cox, Z. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Vol.45, No.12*, pp. 2352-2357, December 1997.
22. "Analysis and optimization of grid oscillators," W.A. Shiroma, Z. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Vol.45, No.12*, pp. 2380-2386, December 1997.
23. "Switched-mode high-efficiency microwave power amplifiers in a free-space power combining array," T. Mader, E. Bryerton, M. Markovic, M. Forman, Z.B. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Vol.48*, *No.10*, pp. 1391-1398, October 1998.
24. "Quasi-optical transmit/receive front ends," Z. Popovic, A. Mortazawi, *invited paper, IEEE Trans. on Microwave Theory and Techniques, Vol. 48, No. 11*, pp. 1964-1975, November 1998.
25. "Nonlinear modeling of class-E microwave power amplifiers," M. Markovic, A. Kain, Z. Popovic, *Journal of the RF and Microwave Computer-Aided Engineering, Vol.9*, Issue 2, pp 93-103, March/April 1999.
26. "A planar 4.5-GHz DC to DC power converter," S. Djukic, D. Maksimovic, Z. Popovic, *Special Issue on Low-Power/Low-Noise Circuits of the IEEE Trans. Microwave Theory Techn*., pp.1457-1460, July 1999.
27. "Efficiency of chip-level versus external power combining," E. Bryerton, M. Weiss, Z. Popovic, *Special Issue on Low-Power/Low-Noise Circuits of the IEEE Trans. Microwave Theory Techn.*, pp.1482-1485, July 1999.
28. "Incorporating non-linear lumped elements in FDTD: the equivalent source method," J. Mix, J. Dixon, Z. Popovic, M. Piket-May, *International Journal of Numerical Modeling: Electronic networks, devices and fields, Int. J. Numer. Model. 12* , pp.157-170, 1999.
29. "Two Ka-band quasi-optical amplifier arrays," M. Forman, T. Marshall, Z. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Vol.47*, No.12, pp.2568-2573, December 1999.
30. "Time domain optical sampling of nonlinear microwave amplifiers and multipliers," M. Weiss, M. Crites, E. Bryerton, J. Whitacker, Z. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Vol.47*, No.12, pp. 2599-2604, December 1999.
31. "Spectral transmittance of lossy printed resonant-grid terahertz bandpass filters," M. McDonald, R. A. York, E. Grossman, Z. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Special Issue on Terahertz Electronics, Vol 48*, No. 4, pp 712-718, April 2000.
32. "Efficient large-domain MOM solutions to electrically large practical EM problems," B. Notaros, B. Popovic, J. Peeters Weem, R. Brown, Z. Popovic, *IEEE Trans. on Microwave Theory and Techniques, Vol. 49*, No. 1, pp 151-159, Jan 2001.
33. "A transmit/receive active antenna with fast low-power optical switching," J. Vian, Z. Popovic, *IEEE Trans. on Microwave Theory and Techniques Vol 48*, No. 12, pp 2686-2691, Dec. 2000.
34. "Active-amplifier-array diagnostics using high-resolution electrooptic field mapping," K. Yang, T. Marshall, M. Forman, Z. Popovic, J. Hubert, L. Mirth, L.P.B. Katehi, J.F. Whitaker, *IEEE Trans. on Microwave Theory and Techniques, Vol 49*, No. 5, pp 849-857, May 2001.
35. "Linearity of X-band class-F power amplifiers in high-efficiency transmitters," M. Weiss, Z. Popovic, F. H. Raab, *IEEE Trans. on Microwave Theory and Techniques Vol 49*, No. 6, pp 1174-1179, June 2001.
36. "-70dB optical carrier suppression by two-beam coupling in photorefractive media," D.Z Anderson, V Damiao, D. Popovic, Z. Popovic, S. Romisch, A. Sullivan, *Applied Physics B*, 72, pp 743-748, 2001.
37. "Multibeam antennas with polarization and angle diversity," D. Popovic, Z. Popovic, *IEEE Trans. Antennas and Propagation, Special Issue on Wireless Communications*, pp. 651-657, May 2002.
38. "A lens antenna array with adaptive optical processing," D. Anderson, E. Fotheringham, S. Romisch, P. Smith, Z. Popovic, *IEEE Trans. Antennas and Propagation, Special Issue on Wireless Communications*, pp. 607-617, May 2002.
39. "Power amplifiers and transmitters for RF and microwave," F. H. Raab, P. Asbeck, S. Cripps, P.B. Kenington, Z. Popovic, N. Pothecary, J. F. Sevic, N. O. Sokal, *IEEE Trans. Microwave Theory and Techn., Vol. 50, No. 3,* pp. 814-826, Mar 2002.

40. "An efficient 16-element X-band spatial combiner of switched-mode power amplifiers," S. Pajic, Z. Popovic, *IEEE Trans. Microwave Theory and Techn., Vol. 51, No.73,* July 2003.
41. "A dual-band dual-polarized nested Vivaldi slot array with multilevel ground plane," H. Loui, J. Peeters Weem, Z. Popovic, *IEEE Trans. Antennas and Propagation,* Sept. 2003.
42. "Recycling ambient microwave energy with broadband antenna arrays," J.A. Hagerty, F. Helmbrecht, W. McCalpin, R. Zane, Z. Popovic, *IEEE Trans. Microwave Theory and Techn.,* pp. 1014-1024, March 2004. ***(Winner of IEEE Microwave Prize)***
43. "60-% efficient 10-GHz power amplifier with dynamic drain bias control," N. Wang, V. Yousefzadeh, S. Pajic, D. Maksimovic, Z. Popovic, *IEEE Trans. Microwave Theory and Techn,* 2004, Vol 52(3) pp 1077 - 1081, March 2004.
44. "Linearity of X-Band Class-E Power Amplifiers in EER Operation," N. Wang, X. Peng, V. Yousefzadeh, D. Maksimovic, S. Pajic, Z. Popovic, *Microwave Theory and Techniques, IEEE Transactions on*, Vol 53 (3), March 2005 Page(s):1096 – 1102
45. "X-band Two-Stage High-Efficiency Switched-Mode Power Amplifiers," S. Pajic, N. Wang, P.M. Watson, T. K. Quatch, Z. Popovic, *Microwave Theory and Techniques, IEEE Transactions on*, Vol 53 (9), Sept. 2005 Page(s):2899 – 2908
46. "Virtual Channel Space-Time with Dual-Polarization Discrete Lens Antenna Arrays," Y. Zhou, S. Rondineau, D. Popovic, A. Sayeed, Z. Popovic, *IEEE Trans. Antennas and Propagation,* Vol. 53 (8), Aug. 2005, Page(s):
47. "A digitally controlled DC-DC converter for an RF power amplifier," V. Yousefzadeh, N. Wang, Z. Popović, D. Maksimović, *IEEE Transactions on Power Electronics,* Vol.21, No.1, January 2006, pp. 164-172.
48. "Modeling of realistic rectangular micro-coaxial lines," M. Lukic, S. Rondineau, Z. Popovic, D. Filipovic, *IEEE Trans. Microw. Theory Techn.*, vol. 54, no. 5, pp. 2068-2076, May 2006.
49. "Quasi-planar high-Q millimeter wave resonators," K. Vanhille, D. Fontaine, C. Nichols, D. Filipovic, Z. Popovic, *IEEE Trans. Microw. Theory Techn.*, vol.54, no.6, pp.2439-2446, June 2006.
50. "Flip-chip assembled air-suspended inductors," P. Bell, N. Hoivik, R. Saravanan, N. Ehsan, V. Bright, Z. Popovic, *IEEE Trans. On Advanced Packaging, Vol. 30, No. 1,* Feb. 2007.
51. "Ka-band Miniaturized Quasi-Planar High-Q Resonators," K.Vanhille, D. Fontaine, C. Nichols, Z. Popovic, D. Filipovic, *IEEE Trans. Microw. Theory Techn.*, vol.55, no.6, pp. 1272-1279, June 2007.
52. "Active health monitoring of an aircraft wing with an embedded piezoelectric sensor/actuator network: II. Wireless approaches," X. Zhao, T. Qian, G. Mei, C. Kwan, R. Zane, C. Walsh, T. Paing, Z. Popovic, *Smart Materials and Structures,* 16(2007), pp. 1218-1225, June 2007.
53. "A W-band polarization converter and isolator," C. Dietlein, A. Luukanen, Z. Popovic, E. Grossman, *IEEE Trans. Antennas and Prop.,* vol.55, No.6, pp. 1804-1809, June 2007.
54. "Bandwidth control of forbidden transmission gaps in compound structures with subwavelength slits," D. Skigin, H. Loui, E. Kuester, Z. Popovic, *Phys. Rev. E 76,* 016604, 2007.
55. "Measuring transistor large-signal noise figure for low-power and low phase-noise oscillator design," M. Jankovic, J. Breitbarth, A. Brannon, Z. Popovic, *IEEE Trans. Microw. Theory Techn.*, vol. 56, no. 7, pp. 1511-1515, June 2007.
56. "Aqueous blackbody calibration source for millimeter-wave/terahertz metrology," C. Dietlein, Z. Popovic, E. N. Grossman, Applied Optics, Vol. 47, No. 30, pp. 5604-5615, Oct. 2008.
57. "Detection and Segmentation of Concealed Objects in Terahertz Images,"X. Shen, C. Dietlein, E. Grossman, Z. Popovic, F. Meyer, *IEEE Trans. Image Processing,* vol. 17, no. 12, pp. 2465-2475, Dec. 2008.
58. "Resistor Emulator Approach to Low-Power RF Energy Harvesting," T. Paing, J. Shin, R. Zane, Z. Popovic, *IEEE Trans. Power Electronics*, vol. 23, no. 3, pp. 1494-1501 , May 2008.
59. "Microwave-domain analog predistortion based on chirped delay lines for dispersion compensation of 10-Gb/s optical communication signals," L. Ranzani, P. Boffi, R. Siano, S.

Rondineau, Z. Popovic, M. Martinelli, *Journal of Lightwave Techn.*, vol.26, no.15, pp. 2641-2646 , Aug. 2008.

60. "Microwave packaging for applied voltage standard applications," M. Elsbury, C. Burroughs, P. Dresselhaus, Z. Popovic, S. Benz, *IEEE Trans. Superconductivity,* vol. 19, no. 3, pp. 1012-1015, June 2009.
61. "Broadband lumped-element integrated N-way power dividers for voltage standards," M. Elsbury, P. Dresselhaus, N. Bergen, C. Burroughs, S. Benz, Z. Popovic, *IEEE Trans. Microw. Theory Techn.*, vol. 57, no. 8, pp. 2055-2063, Aug. 2009.
62. "Broadband micro-coaxial Wilkinson dividers," N. Ehsan, K. Vanhille, S. Rondineau, E. Cullens, Z. Popovic, *IEEE Trans. Microw. Theory Techn.*, vol. 57, no. 11, pp. 2783-2789, Nov. 2009.
63. "Power Management of Wideband Code Division Multiple Access RF Power Amplifiers With Antenna Mismatch," R. Paul, L. Sankey, L. Corradini, Z. Popovic, D. Maksimovic, *IEEE Trans. Power Electronics,* vol. 25, No. 4, pp. 981-991, Apr. 2010.
64. "Circuit approaches to nonlinear IDI mitigation in noise shaped bandpass D/A conversion," Q. Mu, J. Coleman, S. Scholnik, Z. Popovic, *IEEE Trans. Circuits and Systems I, vol.57,* issue 7, pp. 1559 – 1572, 2010.
65. "Custom IC for Ultra-Low Power RF Energy Scavenging," T. Paing, E. Falkenstein, Z. Popovic, R. Zane IEEE Trans. on Power Electronics, 2010.
66. "Micro-coaxial Impedance Transformers,"N. Ehsan, KJ. Vanhille, S. Rondineau, Z. Popovic, *Microwave Theory and Techniques, IEEE Transactions on*, Vol 58 (11), Nov.2010 Page(s):2908 - 2914
67. "Power Management System for Online Low PowerRF Energy Harvesting Optimization," A. Dolgov, R. Zane, Z. Popovic, *IEEE Transactions on Circuits and Systems -I*, pp. 1802-1811, 2010.
68. "Analysis of High Efficiency Power Amplifiers with Arbitrary Output Harmonic Terminations" M. Roberg, Z. Popovic, *to appear in IEEE T-MTT*, 2011.

SELECTED CONFERENCE PUBLICATIONS (TOTAL NUMBER OVER 200)

1. "The bow-tie antenna on a dielectric - theory versus experiment," R. C. Compton, R. McPhedran, Z. Popovic, G. M. Rebeiz, and D. B. Rutledge, *11th Int. Conference on Infrared and Millimeter Waves,* Pisa, Italy, October 1986.
2. "Diode-grid Oscillators," Z. B. Popovic, and D. B. Rutledge, *1988 IEEE AP-S International Antenna Symposium,* Syracuse, New York, June 1988.
3. "Quasi-Optical Array VCOs," T. Mader, S. Bundy, Z. B. Popovic, *1992 IEEE International Microwave Symposium Digest*, pp. 1539-1543.
4. "Optical Measurements of Microwave Grid Oscillator Power Combiners," K.Y. Chen, P.D. Biernacki, A.R. Mickelson, Z.B. Popovic, *IEEE MTT International Symposium Digest,* pp.313-316, Atlanta, June 1993.
5. "Three-dimensional power combiners," W. A. Shiroma, B. L. Shaw, Z. B. Popovic, *IEEE MTT International Symposium Digest*, pp. 831-834, San Diego, May 1994.
6. "A Ka-band quasi-optical amplifier," J. Hubert, J. Schoenberg, Z. B. Popovic, *1995 IEEE MTT-S Int. Symp. Dig*. (Orlando, FL), pp. 585-588, May 1995.
7. "High-efficiency amplifiers for portable handsets," T. Mader, M. Markovic, Z.B. Popovic, *6th International Symposium on Personal, Indoor and Mobile Radio Communications, PMIRC 95 Digest*, pp.1242-1243, September 1995, Toronto.
8. "A low-profile broadband antenna for wireless communications," R. Brown, B.D. Popovic, Z.B. Popovic, *6th International Symposium on Personal, Indoor and Mobile Radio Communications, PMIRC 95 Digest*, pp.135-139, September 1995, Toronto.

9. "A quasi-optical receiver with angle diversity," W. Shiroma, E. Bryerton, S. Hollung, Z.B. Popovic, *IEEE MTT-S International Symposium Digest,* pp. 1131-1135, June 1996, San Francisco.
10. "A bi-directional quasi-optical lens amplifier," S. Hollung, J. Vian, Z. Popovic, *IEEE MTT-S International Microwave Symposium Digest,* pp. 675-678, June 1997, Denver.
11. "A 10-GHz high-efficiency lens amplifier array," E. W. Bryerton, M. D. Weiss, Z. Popovic, *IEEE MTT-S International Microwave Symposium Digest*, pp. 1461-1464, June 1998, Baltimore.
12. "A 10-GHz high-efficiency active antenna," M. Weiss, Z. Popovic, *1999 IEEE IMS Symposium Digest,* pp.663-666, Anaheim, CA, June 1999.
13. "Large domain MOM solution of complex electromagnetic problems," B. Notaros, B. Popovic, R. Brown, Z. Popovic, *1999 IEEE IMS Symposium Digest*, pp.1665-1668, Anaheim, CA, June 1999.
14. "A planar C-band DC-DC converter," S. Djukic, D. Maksimovic, Z. Popovic*, 1999 IEEE IMS Symposium Digest*, pp.827-830, Anaheim, CA, June 1999.
15. "Optically Smart Active Antenna Arrays" D. Anderson, V. Damiao, E. Fotheringham, D. Popovic, S. Romisch and Z. Popovic, *2000 IEEE IMS Symposium Digest*, pp 843-846, Boston, June 2000.
16. "A Transmit/Receive Active Antenna with Fast Low-Power Optical Switching" J. Vian and Z. Popovic, *2000 IEEE IMS Symposium Digest*, pp 847-850, Boston, June 2000. ***[Received 2nd prize in the Student Paper Competition]***
17. "Vivaldi Antenna Arrays for SKA", J. Peeters Weem and Z. Popovic, *APS-2000 Conference Digest,* Salt Lake City, Utah, July 2000.
18. "A method for determining noise coupling in a phased array antenna," J. Peeters Weem, Z. Popovic, *2001 IEEE International Microwave Symposium Digest,* pp.271-274, Phoenix, Arizona, May 2001.
19. "Smart lens antenna arrays," J. Vian, Z. Popovic, *2001 IEEE International Microwave Symposium Digest,* pp.129-132, Phoenix, Arizona, May 2001.
20. "A Ka-band full-duplex transmit-receive lens array," M. Forman, J. Vian, Z. Popovic, *2001 IEEE International Microwave Symposium Digest,* pp.1831-1834, Phoenix, Arizona, May 2001
21. "An experimental and theoretical characterization of a broadband arbitrarily polarized rectenna array," J. A. Hagerty, Z. Popovic, *2001 IEEE International Microwave Symposium Digest,* pp.1855-1858, Phoenix, Arizona, May 2001
22. "Dual-Polarization Star Microstrip Antennas," Montrose, Brian; Popovic, Darko; Popovic, Branko; Popovic, Zoya; European Microwave Conference, 2001. 31st Oct. 2001 Page(s):1 - 4
23. "Passive millimeter-wave ranging using discrete lenses with wave-front coding," J. Hagerty, Z. Popovic, *2001 European Microwave Conference Digest,* pp. 421-424, London, October 2001.
24. "Dual-polarized star microstrip antennas," B. Montrose, D. Popovic, B. Popovic, Z. Popovic, *2001 European Microwave Conference Digest,* pp. 137-140, London, October 2001.
25. "An X-band class-E high-efficiency frequency doubler," M. Weiss, Z. Popovic, *2001 European Microwave Conference Digest,* pp. 225-229, London, October 2001.
26. "A 10-GHz High-efficiency Active Antenna Sub-Array," S. Pajic, Z. Popovic, *IEEE International Microwave Symposium Digest,* pp.1527-1530, Seattle, June 2002.
27. "Reconfigurable single-feed antennas for diversity wireless communications," Oswald, M.T.; Hagness, S.C.; Van Veen, B.D.; Popovic, Z.; *Antennas and Propagation Society International Symposium, 2002. IEEE , Volume: 1* , 2002 Page(s): 469 -472
28. "A 10 GHz integrated class-E oscillating annular ring element for high-efficiency transmitting arrays," Hagerty, J.A.; Popovic, Z.; *Microwave Symposium Digest, 2002 IEEE MTT-S International , Volume: 2* , 2002 Page(s): 1317 -1320
29. "Radiation from ground plane photonic bandgap microstrip waveguides," Shino, N.; Popovic, Z.; *Microwave Symposium Digest, 2002 IEEE MTT-S International ,* Vol: 2, pp: 1079 -1082
30. "A 10 GHz active annular ring antenna," Hagerty, J.A.; Popovic, Z.; *Antennas and Propagation Society International Symposium, 2002. IEEE , Volume: 2* , 2002 Page(s): 284 -287
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Hardware photographs and main results, along with pdf versions of the papers can be seen or downloaded from http://charon.colorado.edu/microwave

RESEARCH OVERVIEW

Graduated 42 Ph.D. students over the past 18 years, with 15 Ph.D. students currently working in the following areas of microwave/millimeter-wave engineering: (1) high-efficiency PAs and adaptive PAs; (2) three-dimensional heterogeneously integrated microwave circuits; (3) multibeam and diversity antenna arrays for satellite and wireless communications; (4) wireless powering for batteryless sensors; (5) ultra-wideband radar; (6) Josephson Junction voltage standards; (7) near-field microwave probing; and (8) millimeter-wave quasi-optical techniques focused on THz imaging for concealed weapons detection. The funding for these projects comes from NSF, DARPA, U.S. Navy, NASA, NIST, Sandia National Laboratories, Nuvotronics LLC, National Semiconductor, and the Coleman Institute. Recently or currently, PI or Co-PI on several graduate fellowships (GAANN-Hybrid Systems Engineering, IGERT-Optical Science and Engineering Program, Sandia Fellowship, Lincoln Labs Fellowship).

Research interests statement

I am interested in continued work in reducing power consumption in analog front ends with new circuit topologies that give higher efficiency. Our first publications in this area were in 1995, with the first demonstrated microwave-frequency class-E power amplifier. Our results in X-band and UHF power amplifiers had record published efficiencies, and we are continuing a strong effort in this direction at lower microwave frequencies with increased output power. In this area, my group collaborates with the power electronics and analog electronics group at the University of Colorado at Boulder. A new direction that we are expanding in is in maintaining linearity with high efficiency at high power levels, and this work has gained a lot of industry attention. We are also working on broadband and low additive phase noise power amplifiers. My ultimate long-term goal is to address efficiency, linearity and bandwidth in a single transmitter component. Another related area is intelligent transmitters, which involves sensing, control algorithms, dynamic tuners and dynamic biasing. The tuners can be based on existing electronic

technology, or on micro-electromechanical components (RF MEMS) and their packaging and hybrid assembly, and it is a considerable challenge to make these devices practical.

An area in which we have some promising initial results, as well as a best paper award, is in RF energy harvesting and wireless powering of wireless sensors. This is another area with a strong collaboration with the Colorado Power Electronics Center (CoPEC), with strengths in low-power management design. The work resulted in a comprehensive patent application and licensing of the IP by several companies. The applications are for low-maintenance batteryless sensors for manufacturing environments, structural monitoring, and healthcare. We have shown that broadband statistically varying randomly polarized background microwave radiation can be efficiently rectified and the stray energy stored over time for useful electronic applications. We have also shown that FCC-compliant low-power transmitters can be strategically placed to enable constant very low power density energy delivery and storage. My goals related to this research are to improve the integration of our current hybrid demonstrations, and to expand the circuit-antenna library so that we can address many concrete applications with an optimized architecture. This work is mostly industry funded with a small NSF component.

Another active area of research has been in collaboration with Nuvotronics LLC (DAPRA and NASA) in the area of wafer-scale microfabricated coaxial lines and passive and active coaxial-based components. The advantages of these lines, fabricated by Nuvotronics, is extremely low loss into the millimeter-wave range, extremely good isolation of neighboring lines enabling high density circuits, broad bandwidth and low dispersion, and amenability for integration with passive and active surface-mount components. Our research goals are focused on design of completely new components in this technology, in order to push the bandwidth, power handling and flexibility for various communications and sensing applications. Some results include 22:1 bandwidth impedance transformers and 22:1 bandwidth power divider networks which operate up to millimeter-wave frequencies.

I am interested in continuing the work in mulibeam arrays for communication systems, especially taking advantage of the increase in dynamic range, increase in transmitter power with simultaneous increase in reliability, and decrease in sensitivity to multipath fading. Recently, the group has demonstrated multibeam antenna arrays with greatly reduced cost and increased reliability as compared to standard phased arrays, funded by NASA. We hope to continue this work and combine it with micro-coaxial lines for a millimeter-wave satellite active antennas.

Other current areas of research include:

(1) near-field electromagnetic passive probing for defect diagnostics funded by NSF and in collaboration with NIST (Dr. Pavel Kabos);
(2) ultra-wideband (UWB) radar for national security in collaboration with Sandia National Lab,
(3) low-phase noise microwave circuits for miniature atomic clocks and other atomic sensors in collaboration with NIST (Dr. John Kitching);
(4) RF photonics, in particular optical processing of microwave-bandwidth signals for radar and wireless scenarios, in collaboration with Profs. Dana Anderson (physics and JILA) and Bob McLeod (ECEE);
(5) Microwave radiometry for internal body temperature measurements (National Semiconductor and Stanford Medical school);
(6) V-band ISM on-chip Bi-CMOS integrated antennas and low-power transceivers;
(7) High efficiency transmitters for tumor ablation and blood vessel sealing (Covidien).

TEACHING

Courses developed at the University of Colorado

ECEE 1500, *Sustainable energy*, for non-engineering majors. The class will be taught for the first time (with Prof. Tim Brown) in Spring 2010 and was approved as the Arts and Sciences QRMS (quantitative reasoning math and science) elective. The course was taught by Prof. Popovic alone for the second time in Fall 2010, and this course material is currently being used at the University of Washington (Prof. Peyman Arabashahi) and Ohio State University (Prof. Betty Lise Anderson). The course includes experimental group projects focused on energy issues related to engineering.

ECEE 2420, *Electronics for Wireless Communications*, sophomore elective for electrical and computer engineering majors. Taught for the first time in Spring 2011, 40 students (maximum) enrolled. The course has a laboratory component and follows the textbook "The Electronics of Radio" by Prof. David Rutledge. The goal of the course is to motivate later courses in circuits, electromagnetic and communications, while teaching some basic practical and lab skills. The students spend the semester learning about analog electronics through the building of a pcb-based 7-MHz radio. As their final exam, they take the Technician and General Amateur Radio test and get their licenses. 33 students passed their license exams and all radios worked and received Morse code from a beacon.

ECEN 3400, *Electromagnetic Fields and Waves I*, 1st semester junior, 5 credit (lectures, labs, recitations) core course. Annual enrolment about 120. Wrote a textbook (about 450 pages) and workbook (about 200 pages) for the course published by Prentice Hall in 2000. I own the copyright now and it is distributed free to students. Developed a series of 12 labs. Formed partnership with the Motorola Cellular Infrastructure Division, Fort Worth, for internships, class project competitions and lab maintenance funded by Motorola. Obtained funding ($12,000) for the lab from Spectralink, Inc.

ECEN 4363/5634, *Microwave Lab*, senior/beginning graduate level lab, annual enrolment about 40. Developed most of the labs, wrote the lab manual and notes, obtained equipment donations from HP/Agilent over the years (about $500k). Lab emphasis on communications. A design final project is part of the course, ending with a mini-conference with paper presentations. *A digest of the conference is available on request.*

ECEN 5104, *CAD of Microstrip Circuits*, Re-designed completely an existing course in Fall 2003. Typical enrolment is 15-20 graduate students who completed 6 design projects using commercial CAD tools (Agilent ADS, Ansoft Advanced Designer, AWR Microwave Office): matching circuits, couplers, filters, resonators, bias networks and a final larger project in an area of the student's choice.

ECEN 5014, *Active Microwave Circuits*, graduate class with strong design component, taught every other year, enrolment about 25/semester. Wrote a lab manual and lecture notes. Presented conference paper on the class. Class includes six two-week design projects using industry-standard software, circuits are fabricated and measured. Obtained software donations for class from AWR. Each student also does an independent MMIC design final project which is fabricated in the TriQuint GaAs pHEMT TQPED process. Obtained free MMIC TriQuint GaAs foundry fabrication (a $35,000 value per run). The design and final projects from several semesters available on CD ROM in IEEE publication format. Taught a version of this course at the Technische Universitat Muenchen, Munich, Germany in Summer 2003.

- *Special topic*, Practical antenna design, graduate lab, taught irregularly, enrolment about 20/semester. The students use pc-based CAD to design about 15 different kinds of wire and printed antennas that they

fabricate and measure. A part of this course is a field trip to the Very Large Array (VLA), the radio telescope in Socorro, New Mexico.

- *Special topic, RF/optical techniques*, graduate course, taught irregularly. Covers some common methods and components used at both RF and optical frequencies (wavelengths). The objective of the course is to present two different views of the same electromagnetic technique, phenomenon, or circuit component. Examples of methods that are compared include: Fourier optics and antenna analysis; Gaussian beams at optical and millimeter waves; diffraction theory; and basic field theorems. Examples of components that are compared include polarizers, lenses, waveguides, directional couplers, retrore ectors, phase conjugators, and soliton transmission structures. The course concludes with a conference at which students present projects they have worked on during the last month of the course. Industry members judged the presentations, and Best Paper Award was given. A digest of this mini conference was published for assessment purposes. Taught a version of this course at the Technische Universitat Muenchen, Munich, Germany in Spring 2001.

Teaching Statement

My main teaching philosophy is to combine practical and fundamental theoretical knowledge. This is nothing new, but is becoming increasingly difficult to implement, with new students being much more familiar with computers and not interested in hardware or fundamental principles. There is also a trend in education to make classes "fun", whereas my goal is to provide a good learning process so that they can use the knowledge effectively in the future. For example, in most exams, I do not allow use of calculators and require estimation within an order of magnitude with the correct unit. All of the classes I teach have a lab component and most have design projects and technical writing at least once per semester.

I believe the students will gain confidence and enjoyment through true accomplishments, and by receiving respect from their peers. I do not think that anything can replace hard work on the students' part, combined with competent and dedicated technical guidance on the instructor's part. Therefore, I strive to improve as a professional constantly so that I can be a better teacher. I also feel that it is very important for teachers to be good role models. My goal is to show the students that having a passion for learning and being excited about one's field goes a long way towards becoming an expert, and a happy and productive person.

Outreach activities

- K-12 students know little about what engineering is and it is important to get this information out to both students and parents. For the past I have been active in local elementary, middle and high-school science fairs as coach (project advisor), as well as judge.
- I have created lab kits for high-school physics classes, in collaboration with Dr. Helen Petach, the Fairview high school physics teacher.
- I have worked with Jay Donegy and Dr. Helen Petach, the high-school instructors for the senior/junior class "Research Seminar in Science". This all-year class teaches students how to approach a research problem and places them in research labs around Boulder. I hosted several students in the past few years, and they have all received prizes at the State science fairs. The student working with me spent regular weekly times in the lab. All of the students taking this class spent an afternoon in my lab learning about microwaves.
- I organize "a day in the lab" for elementary and middle-school students, where up to 100 students come to visit electrical engineering laboratories with 10-12 hands-on experiments. This is a yearly effort and has so far involved Eisenhower elementary school (3^{rd} and 4^{th} grades), Summit middle school (7^{th} grade), and will this year include High-Peaks elementary school (4^{th} grade).
- Related to a new NSF project, I am making a demo for high-school honors students and WIE recruiting, as well as the lab visits. The demo is called "Electromagnetic eyes" and involves imaging

hidden (buried) metal objects with near-field probing, e.g. a coin covered with paper can be imaged by measuring resonant frequency changes in a near-field probe circuit.

SELECTED SERVICE

- Technical Program Co-Chair (with the late K.C. Gupta) for the IEEE MTT-S International Microwave Symposium in Denver, June 1997 (about 8000 attendees).
- Member of Technical Program Committee, IEEE MTT-S International Symposium, 1994 to present.
- Organized numerous URSI, IMS, AP conference sessions.
- Associate Editor, IEEE Transactions on Antennas and Propagation, 1997.
- Organizer of workshops: WARC '95, Denver; 1997 ARO/DARPA Workshop on Quasi- Optical Combiners, Santa Barbara; Optical and Microwave Packaging Workshop, Estes Park, 1993.
- University of Colorado Chancellor's Committee on Conflict of Interest, 1996 to present, Chair in 1997.
- College of Engineering Diversity Committee, 2009-present
- College of Engineering Dean's FLAG (Future Leaders) committee, 2002-2005
- ECEN department Executive Committee, 1995 to 2000, and 2002-present. Hiring committee 2001-present.
- University of Colorado at Boulder Faculty Teaching Excellence Program, coordinator/mentor for new faculty, College of Engineering, 2004 to present.
- Associate Editor, IEEE Transactions on Microwave Theory and Techniques, January 2005 – December 2010.
- Member of National Academies panel on ARL, Sensors and Electronics, 2006 and 2007.
- Member of Sandia National Laboratories Microsystems (Division 1700) annual review panel, 2007-present.
- Member at Large of URSI, 2009 -2011.

Personal tidbit: wife of physics professor Dana Anderson and mother of three daughters (ages 11 to 19) who can all solder.

SUMMARY OF FUNDING SINCE 2001

Principal Investigator on Grants Received

"Presidential Faculty Fellowship," NSF, $500,000, 08/15/93 to 01/31/01.
"Smart antennas with optical processing," NSF, with Co-PI Dana Anderson, 10/1999 - 9/2002, $250,000
"Active antenna arrays for SKA", Netherlands Foundation for Research in Astronomy (ASTRON), 6/1/98-6/1/02, $200,000
"Multi-beam antennas for fixed-formation satellite links," NASA Lewis, 02/2001- 02/2005, $400,000
"MURI: Quasi-Optical Power Combining," U.S. Dept. of Defense (ARO), MURI, prime contractor; California Institute of Technology, 11/1/97-10/31/02, $695,000
"ITR Collaborative Research: Integrated Signal Processing and Antenna Array Design for Diversity Wireless Links," NSF, with Prof. Akbar Sayeed, Univ. of Wisconsin08/01- 07/04, $250,000
"Adaptive Microwave High-Efficiency Power Amplifiers," DARPA IRFFE, 2002-2005, $450,000
"High-Efficiency Linear Power Amplifiers," Air Force (Wiley), 12/02 – 12/03, $100,000
"MEMS tuners for multiband high-efficiency wireless transmitter front ends," NSF ITR collaborative project, with John Papapolymerou, Georgia Tech, 06/2002-05/2005, $240,000
"Graduate Program in Hybrid-Signal Electronics: DC to THZ (HYSE-GAANN)," Department of Education, 08/04-08/07, $341,740
"Request for a Load-Pull System for Nonlinear Microwave/Millimeter-wave Component Characterization in Support of the DARPA IRFEE Program," DURIP - ARO, 5/1/04 - 4/30/05, $241,092
"Investigation of Space-Time Sigma-Delta Processing for Transmit Phased Array Antennas," ONR, 12/04 - 12/09, $490,000
"Wireless sensor powering on Naval ships", Co-PI Regan Zane, US Navy SBIR Phase 2, Luna Technologies, $100,000
DARPA 3D-ALERT program, BAE Systems, 12/06 – 03/07, $85,000
"Techniques for High Efficiency High Power Solid State RF Amplifiers," SAIC, Co-PI Dragan Maksimovic, 10/06 – 12/09, $440,268
"Wireless sensor powering on Naval ships," Co-PI Regan Zane, US Navy SBIR Phase 2, Luna Technologies, 05/2006 – 05/2007, $100,000
"Wireless powering of tomogrpahic sensors for monitoring aircraft wing health," Intelligent Automation Inc., SBIR Phase 1, 2006, $20,000
"AC Josephson Junction Microwave Frequency Waveform Synthesis," CU/NIST Seed Grant, with Dr. Sam Benz at NIST, 06/2006 – 06/2007, $50,000
"DMT; analysis and design," Rohm and Haas (BAE Systems is lead on this DARPA program - Disruptive Manufacturing Technologies), Co-PI: Dejan Filipovic, 09/2007 – 03/2009, $250,000
"TRUST in ICs," BAE Systems (lead on this DARPA program is Raytheon), Phase I, Co-PI: Dejan Filipovic, Collaborator: Dana Anderson, 10/2007 – 06/2009, $400,000
"Front end for UWB radar," Sandia National Lab, 08/2007 – 08/2010, $195,000
"Millimeter-wave test bench," DURIP ONR, 2007/2008, $430,000
"Wireless Powering (PPEC)," MicroSat (DARPA), with Regan Zane, 03/2008 - 03/2009, $44,000
"Wireless powering for low-power RF transceivers," NSF, Collaborative research with Saeed Mohamadi at Purdue, 2007-2010, $250,000
"Novel Phase Shifterless RF Phased-Array Antenna Systems," Navy STTR Phase I, 9/09 - 3/10, $40,000
"Near-field sub-surface probing for heterogeneous material characterization," NSF, 09/2009 – 08/2012, $300,000
NIST, Funds for senior visiting researcher in the area of superconductive microwave devices, 2009/2010, $50,000

"Tuners for RF power amplifiers with dynamic bias control," CoPEC, with Prof. Dragan Maksimovic," National Semiconductor, $135,000
"High-efficiency linearized transmitters for cell-phone base stations," National Semiconductor, with Prof. Maksimovic, 01/2009 – 05/2010, $200,000
"G-band planetary landing radar," NASA SBIR Phase II with Nuvotronics, 01/2010 – 01/2011, $120,000
NIST MSE Fellowship program, PI, 02/2010, $4,500,000 (moved to Graduate School)
"Frequency-steered G-band antennas for planetary landing," Nuvotronics, LLC, NASA SBIR Phase II, 03/01/2010 – 09/30/2011, $209,000.
"Efficient Linear Transmitters for Amplitude-Modulated Radar," BerrieHill (contractor to US Air Force and DARPA/TriQuint seedling), $560,000/3 years, 09/2010 – 08/2013
"RF transmitter design for Microwave Applicator Miniaturization," CoPEC project, Covidien, $45k/year, 09/2010 – 08/2011

Co-Principal Investigator on Grants Received

"RF Photonic Signal Processing," U.S. Dept. of Defense, Office of Naval Research, P.I. K. Wagner 8/15/97-8/14/02, (my part) $551,038
"High-Performance, Low-Power Wireless Communications," NSF, P.I. M. Varansi, 9/1/97-8/30/01, $1,034,744
"Integrated Antennas," NSF, PI Prof. Louis Sharf, 09/15/99 - 08/31/02 (my part) $407,432.
"MEMS & Packaging for Atomic Clocks," DARPA, PI YC Lee, 06/11/02 – 06/11/04, $312,000
"IGERT: Graduate Training in Optical Science and Engineering," D. Anderson (PI), 9/98-8/04, $2.8 million (my part was about $200k)
"Analysis and Design of 3D RF Multilayer Interconnects," DARPA, D. Filipovic (PI), 1/1/2004 - 6/30/2008, $400,000
"Small Aperture Multiband Microwave Antenna Array Receiver," NASA, PI Dana Anderson, Co-PI Zoya Popovic, 11/04 - 10/08; $12,800,000
"Submillimeter-wave Imaging," NSF, PI: Francois Meyer, NSF, 2006-2009, $240,000
"Wireless Power Delivery for Biosensors," with Regan Zane, Coleman Institute, 2008- 2009, $125,000
"Wireless Power Delivery" with Regan Zane, CoPEC project, PowerCast LLC, 2008, $45,000
"Tuners for RF power amplifiers with dynamic bias control," with Dragan Maksimovic, CoPEC project, National Semiconductor, 2007-2010, $200,000
"Non-linear Context-Aware Prompting System (N-CAPS) for Adults with Cognitive Disabilities in the Workplace," with Regan Zane, RERC, $225,068 / 5 years, start date: February 2010.

Fellowships Received

- "Radio Frequency Research Fellowship", to fund one graduate student (Jacques Hung Loui) for a year, funded by FIRST RF, Fall 2003-Fall 2004, $32,202
- MIT Lincoln Laboratories Fellowship - $15K per year for support of exceptional graduate student, yearly
- Sandia National Laboratory, "Excellence in Science," Fellowship to support graduate student, 8/04 - 8/05, $25,000
- Rohm and Haas Electronics, 1-yer fellowship for a graduate student, $33,500, August 2006 - July 2007
- NSF Graduate Fellowship for Alan Brannon, 2005-2008
- NIST PREP for Ph.D. advisee Alan Brannon, $50,000/year for 3 years, 2006 – 2008
- NIST PREP fellowship for PhD advisee Jonathan Chisum, August 2006 - June 2007
- NIST-PREP for Michael Elsbury, Voltage standards, 2007-2010, $50,000/year
- NIST-PREP, Bryan Babcock, 2009-2010, $50,000
- NIST-PREP post-doctoral fellow, Leonardo Ranzani, 2009-2010, $66,000

- NIST-PREP postdoctoral fellow, Charles Dietlein, Jan.-Dec. 2009, $66,000
- NSF, International supplement (with Finland and Argentina), $20k, 2008-2009
- NSF, REUs totaling over $150,000
- NSF AGEP Minority Fellowship for PhD advisee Mabel Ramirez Velez, August 2006 - June 2007

Gifts and Other Awards

- Nokia Research Center, unrestricted gift towards microwave research, $50k
- National Security Technologies, $35,000 in 2007 and 2009 for access to expertise
- Luna Innovations, $60,000 in 2006 and 2007 for access to expertise
- Rohm and Haas, for commercialization research and design, $33,000
- AWR donated unlimited licenses of their commercial software (~$50k list price) for educational and research use.
- TriQuint Semiconductor, free 1/4 of a GaAs wafer in the Oregon foundry, monthly runs made available to my group. Value is $35k per run.
- TriQuint Semiconductor, free GaN MMIC fabrication in the Texas foundry.