

ZOYA POPOVIĆ
Hudson Moore Jr. Chaired Professor
Department of Electrical and Computer Engineering
University of Colorado, Boulder

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 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 and linearity microwave power amplifiers, microwave and millimeter-wave quasi-optical techniques, THz imaging, low phase noise circuits for atomic clocks, intelligent RF circuits, active antenna arrays, RF-optical techniques, voltage standards, near field electromagnetic probing, and wireless powering of sensors.

RECOGNITION

- Coleman Research Fellow, Coleman Institute, 2008
- Faculty Research Award, College of Engineering and Applied Science, 2007
- 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).

Current funding sources: DARPA, ONR, NIST, BAE Systems, Department of Education, NSF, Sandia National Laboratories, Nuvotronics LLC, MicroSat Corp., National Semiconductor, The Coleman Institute.

Graduate student profile:

- 31 Ph.D. students graduated and happily employed.
- 14 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.

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. Wickle, 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. Wickle, 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 Conjugation 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. Picket-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. Potheary, 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. "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.
56. "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.
57. "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.
58. "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.

SELECTED CONFERENCE PUBLICATIONS (TOTAL NUMBER OVER 150)

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 Power-Combining Arrays," D. B. Rutledge, Z. B. Popovic, R. M. Weikle, M. Kim, K. A. Potter, R. C. Compton, R. A. York, *Invited paper at the 1990 IEEE MTT Conference*, Dallas, June 1990.
4. "Quasi-Optical Array VCO's," T. Mader, S. Bundy, Z. B. Popovic, *1992 IEEE International Microwave Symposium Digest*, pp. 1539-1543.
5. "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.
6. "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.
7. "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.
8. "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.
9. "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.
10. "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.
11. "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.
12. "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.
13. "A 10-GHz high-efficiency active antenna," M. Weiss, Z. Popovic, *1999 IEEE IMS Symposium Digest*, pp.663-666, Anaheim, CA, June 1999.
14. "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.
15. "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.
16. "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.
17. "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]**
18. "Vivaldi Antenna Arrays for SKA", J. Peeters Weem and Z. Popovic, *APS-2000 Conference Digest*, Salt Lake City, Utah, July 2000.
19. "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.
20. "Smart lens antenna arrays," J. Vian, Z. Popovic, *2001 IEEE International Microwave Symposium Digest*, pp.129-132, Phoenix, Arizona, May 2001.
21. "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

22. "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
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*
31. "A compact prototype optical processor for X-band arrays," Anderson, D.Z.; Fotheringham, E.; Romisch, S.; Smith, P.C.; Popovic, Z.; *Microwave Photonics, 2001. MWP '01. 2001 International Topical Meeting on , 2002 Page(s): 227 -230*
32. "A 10-GHz high-efficiency active antenna sub-array," Pajic, S.; Popovic, Z.; *Microwave Symposium Digest, 2002 IEEE MTT-S International , Volume: 3 , 2002 Page(s): 1527 -1530*
33. "Multibeam planar discrete millimeter-wave lens for fixed-formation satellites," Romisch, S., Bell, P., Popovic, D., Shino, N., Popovic, Z., *Digest of 27th URSI General Assembly, Maastricht, Amsterdam, Aug 2002. – Young Scientist Award (S. Romisch)*
34. "Spatial Processing with Lens Antenna Arrays for Direction-of-Arrival Estimation," Do-Hong, Tuan; Hagerty, Joseph A.; Popovic, Zoya; Russer, Peter: *Digest of 27th General Assembly of the International Union of Radio Science (2002) Aug.*
35. "Active and Smart Antenna Arrays," *Invited plenary talk at the Annual Meeting of the Argentine Physical Association, Cordoba, Argentina, Sept 2002*
36. "A Frequency Tunable Half-Wave Resonator using a MEMS Variable Capacitor," Bell, P., Hoivik, N., Bright, V., Popovic, Z., *35th International Symposium on Microelectronics – IMAPS 2002, Denver, CO, Sept 2002 [Received 2nd Best Student Paper Prize]*
37. "Multibeam planar lens antenna arrays," D. Popovic, S. Romisch, N. Shino, Z. Popovic, *GOMAC 2003 – lens2003 GOMAC Digest*, pp. , Tampa, Apr 2003.
38. "Adaptive optical signal processing for microwave-carrier broadband signals," E. Fotheringham, D. Anderson, P. Smith, Z. Popovic, *2003 GOMAC Digest*, Tampa, Apr 2003.
39. "High-efficiency X-band amplifiers and spatial combiners with impedance tuners using MEM inductors and variable capacitors," S. Pajic, P. Bell, N. Hoivik, V. Bright, Z. Popovic, *2003 GOMAC Digest*, Tampa, Apr 2003.
40. "Micro-bias Tees using micromachined flip-chip inductors," P. Bell, N. Hoivik, V. Bright, Z. Popovic, *IEEE 2003 Intern. Microwave Symp. Digest*, Philadelphia, June 2003.
41. "Multibeam lens antenna arrays with amplitude controlled steering," S. Römisch, D. Popović, N. Shino, R. Lee, Z. Popović, *IEEE 2003 Intern. Microwave Symp. Digest*, Philadelphia, June 2003.
42. "Rectenna arrays for recycling statistical broadband radiation," J. A. Hagerty, Z. Popovic, *2003 Antennas Application Symp. Diges., Allerton, Sept 2003.*

43. "Multibeam spatially-fed antenna arrays with amplitude-controlled beam steering," S. Rondineau, S. Romisch, D. Popovic, Z. Popovic, *2003 Antennas Application Symp. Digest.*, pp. , Allerton, Sept 2003.
44. "70% efficient switched-mode microwave power amplifiers," Z. Popovic, S. Pajic, N. Wang, P. Bell, *Invited paper, IEEE GaAs IC Symposium Digest*, pp. 125-129, San Diego, Nov 2003.
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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 31 Ph.D. students over the past 18 years, with 14 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 millimeter-wave 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 DARPA, NSF, DARPA, ONR, NIST, BAE Systems, Sandia National Laboratories, Nuvotronics LLC, MicroSat Corp., National Semiconductor, and the Coleman Institute. Prof. Popovic is also 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 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, 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 interesting area is in intelligent front ends, 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 compliant low-power transmitters can be strategically placed to enable constant very low power density energy delivery and storage. My goals of this research is 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 and BAE Systems 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.

I am interested in continuing the work in multibeam 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 JPL satellite active antenna (proposal pending).

Other current areas of research include:

- (1) voltage standards using Josephson Junctions, in collaboration with NIST (Dr. Sam Benz),
- (2) near-field electromagnetic passive probing for defect diagnostics in collaboration with NIST (Dr. Pavel Kabos),
- (3) ultra-wideband (UWB) radar for national security in collaboration with Sandia National Lab,
- (4) low-phase noise microwave circuits for miniature atomic clocks,
- (5) 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).
- (6) Another area of interest that I do not have current funding for, but have some results, is antenna and receiver design modeled after animal hearing systems. For example, we have demonstrated a dual-frequency dual-pattern antenna scaled after the acoustical model of bat ears that behaved at 2 and 10 GHz exactly like the bat ear at 10 and 50 kHz. Combined with signal processing, this could yield a very effective two-element direction finding (angle-of arrival) system.

TEACHING

Courses developed at the University of Colorado

- 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. 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, Microwave (Transmission) lab, senior lab, annual enrolment about 50. Developed most of the labs, wrote the lab manual and notes, obtained equipment donations from HP (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. 20 graduate students completed 8 design projects using commercial CAD tools (Agilent ADS, Ansoft Advanced Designer): directional couplers and filters, small-signal amplifiers, broad-band amplifiers, resonators, three-port oscillators, low-noise amplifiers, mixers and a final larger project in an area of the student's choice. All material was prepared and posted on the class web page.
- 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. Each student also does an independent MMIC design final project. 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 semester 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, retroreflectors, 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.

New Course Development schedule for the Spring 2010 semester

Electrical Engineering Sophomore Elective: Radio. This course will cover basics of wireless communications and the electronics of radio. Students have not yet had circuits and linear systems, so this will be the first time they learn about circuit elements and how they come together in a working device. The course is designed to have a practical part in which the students slowly build up a 7-MHz radio with Morse code. I plan to have all the students get radio amateur licenses as part of the course requirement, and as a concrete outcome they can tell their friends about. The goal of the class is to get students interested in electrical engineering through an applied project, and in the process teach them some fundamentals and give them an overview of topics they will learn during the rest of their studies. I plan to use the text “Electronics of Radio” by Dave Rutledge (Caltech) as a starting point.

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. 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.

SELECTED SERVICE

- Technical Program Co-Chair (with 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 Dean’s FLAG (Future Leaders) committee, 2002-present
- 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 2007.
- Member of National Academies panel on ARL, Sensors and Electronics, 2006 and 2007.
- Member of Sandia National Laboratories Microsystems (Division 1700) review panel, 2007 and 2008.

Personal tidbit: Prof. Popovic is a mother of three daughters (ages 9 to 17) who can all solder.