

**Dr. P. MOHANA SHANKAR**

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Citizenship: US

| <u>Degree</u> | <u>Institution</u>                            | <u>Subject</u>         |
|---------------|---|------------------------|
| Ph. D(1980)   | Indian Institute of Technology, Delhi (India) | Electrical Engineering |
| M. Tech(1975) | Indian Institute of Technology, Delhi (India) | Applied Optics         |
| M. Sc. (1972) | Kerala University, India.                     | Physics                |

#### **Academic Positions**

**Allen Rothwarf Professor** of Electrical and Computer Engineering, **July 1, 2001** onwards

**Adjunct Professor of Radiology**, Jefferson Medical College, Thomas Jefferson University, Philadelphia, **November 1998** onwards

**Professor**, Dept. of Electrical and Computer Engineering, and Affiliated faculty member of the School of Biomedical Engineering, Science and Health Systems, Drexel University, **September 1995** onwards

**Associate Professor**, Dept. of Electrical and Computer Engineering, and the School of Biomedical Engineering, Science and Health Systems, Drexel University, 1991 to 1995

**Assistant Professor**, Dept. of Electrical and Computer Engineering, and School of Biomedical Engineering, Science and Health Systems, Drexel University, 1986 to 1991

**Visiting Assistant Professor**, Dept. of Electrical and Computer Engineering, and School of Biomedical Engineering, Science and Health Systems, Drexel University, Sept. 1985, to Aug., 1986

**Drexel Fellow**, Dept. of Electrical and Computer Engineering, and Biomedical Engineering & Science Institute, Drexel University, Sept., 1983, to Aug., 1985

Postdoctoral Fellow, Biomedical Engineering, Drexel University, Nov. 1982, to Aug. 1983.

The William Girling Watson Traveling Fellowship in Electrical Engineering, University of Sydney, Australia, July, 1981, to October, 1982; August, 8-22, 1997.

#### **Administrative Positions**

**Interim Department Head**, Electrical and Computer Engineering Department, Drexel University, July 1, 2006 –June 30, 2007.

**Director**, Graduate Programs, College of Engineering (CoE), July 1, 1996-December 31, 2000

**Program Director**, Telecommunications Engineering, CoE, Jan. 1996 –Dec. 31, 2000

**Director**, Off-Campus Programs, Dept. of Elec. and Comp. Engineering, September 1998 to 2001

**Assistant Head** of Dept. for Graduate Affairs and Graduate Advisor, Dept. of Elec. and Comp. Engineering, Drexel University, Sept. 1, 1993 to Dec. 31, 1997, and Sept. 1999 to June 30, 2004.

**Coordinator**, MSEE on\_line program, July 1, 2004 –June 30, 2009.

### Awards and Honors

- 2023 Provost Award for Pedagogical Innovation
- 2019 University Award for Pedagogy and Assessment
- 2006 Christian R. and Mary F. Lindback Foundation Award for Distinguished Teaching
- Recognized by the Institute of Physics (IOP), U. K. as one of 100 authors who have published papers that were key to the advancement of physics research in their particular subject area (April 2006) [http://www.iop.org/ej/authors\\_edition/](http://www.iop.org/ej/authors_edition/)
- Martin Kaplan distinguished service award, ECE department 2005
- Outstanding Service Award, College of Engineering, 2003.
- Named Allen Rothwarf Professor of Electrical and Computer Engineering, July 1, 2001
- Faculty Achievement award, College of Engineering, 1999.
- William Girling Scholarship, University of Sydney, 1981, 1997

### Programs Developed

- Master of Science in EE/Telecommunications Engineering
- Master of Engineering
- Master of Science in Software Engineering
- Special Programs: Dean's Fellowship, Career-Integrated-Education (CIE), Fellowship for B.S./M.S. students
- BS in Software Engineering

### Courses and Laboratories Developed

1. Interdisciplinary UG course in **Probability for Engineers**;  
P. M. Shankar (Coordinator), A. Reddy (Civil and Arch. Engg.), A. Wang (Mech. Engg.) and M. Grady (Chem. Engg.)
2. Engineering Horizons (with Raj Mutharasan of Chem. Engg.) UG Junior/Senior Level
3. Wireless Communications UG *Junior Level*
4. Lightwave Engineering I, II and III UG *Senior Level*
5. Fiberoptics and Optical Communications I, II, III *Graduate Level*
6. Fiber optic and Integrated Optic Devices *Graduate Level*

### Laboratories

Lightwave Engineering Laboratory UG *Senior Level*

### Courses Taught

#### Undergraduate

Communication Theory (Junior Level), 1983/84 to 1988/89, 1995/96, 1996/97  
Communications (Senior Level) 1998/99, Winter 2004-2005  
Dynamic Engineering Systems (Sophomore level) 2010/11, 2011/12, 2012/13, 2013/2014  
E M Theory (Junior Level), 1984/85  
Electronics I (Junior Level), 1986/87  
Engineering Applications of Probability (Junior Level) 1997/98-2001/2002  
Engineering Horizons (Junior Level) 2000/'01 and 2001/2002  
Freshmen Design 2005-2006, 2006-2007, 2008  
Lightwave Engineering I, II and III (Senior Level), 1987/88 to 1995/96  
Linear Engineering Systems (Sophomore level) 2010/11, 2011/12, 2012/13, 2013/2014  
Nondeterministic Systems (Junior Level), 1983/84, 1984/85, 1987/88, 1995/96, 1996/97  
Probability for Engineers-3 Cr (Junior Level) 2014-2015

Probability for Engineers-4 Cr (ECE 361 Pre-Junior/Junior Level) Spring 2016-2017, Summer 2016-2017, 2017-2018 (F/W/S), 2018-2019 (F/W/S)

University Seminar (Undergraduate Freshmen), 1991/92, 1992/93, 2003/2004, 2004/2005

Wireless Communications (Junior Level) 1997/98 onwards

#### Graduate

Advanced Wireless Channel modeling 2011/2012

Stochastic Systems I 1997/98, 1999/2000, 2004/2005

Electrooptics and Optical Processing, 1983/84

Fiber Optic and Integrated Optic Devices, 1989/90

Fiber Optics and Optical Communications--I, II, and III, 1985/86 to 1994/95, Fall 1994, Fall 2008 , 2010/11, 2014/2015

#### Graduate Students Supervised

##### Doctoral

10. Angela Leung (Chem. Engg.) *Detection of cells, proteins, and DNA using Tapered Fiber Optics Biosensors (TFOBS)*, (Joint advising with Dr. R. Mutharasan, Dept. of Chemical & Biological Engg.) June 2007.

9. V. A. Dumane (Elec. Engg.) *Diversity and Compounding for Enhanced Discrimination of Breast Masses in Ultrasonic B-Scan Images*, November 2002.

8. P. Dala Krishna (Biomed. Engg.) *Modeling and characterization of ultrasound contrast agents*, August 1998.

7. J. Koshy (Elec. Engg.) *Modeling and evaluation of fiber-fed microcellular systems*, June 1997.

6. R. Molthen (Biomed. Engg.) *Ultrasonic tissue characterization using non-Rayleigh statistics*, June 1996.

5. V. M. Narayanan (Biomed. Engg.) *Non-Rayleigh statistics of ultrasonic backscattered echoes*, June 1996.

4. Y. Q. Wu (Biomed. Engg.) *Development of a fiberoptic sensor using light diffraction technique*, (Joint advising with Dr. P. Lewin, School of Biomedical Engineering, Science and Health Systems) Sept. 1993

3. T. J. Brophy (Elec. Engg.) *Optical fiber tapers: formation, modeling, and characterization*, June 1993.

2. D. P. Koller (Elec. Engg.) *Characterization of acoustical noise from bubble clouds in the ocean*, Dec. 1992.

1. Yue Li (Biomed. Engg.) *First order statistics of speckle around a scatterer volume density edge*, (Joint advising with Dr. V. L. Newhouse), July 1990.

##### Masters

H. Haddock (Chem. Engg); G. Bhagavatheeswaran (Biomed. Engg); T. George (EE); V. Dumane (EE); G. Prabhu (EE); J. Koshy (EE); Gijo George (Biomed. Engg); D. Koller (EE); B. Schroppe (Biomed. Engg)

### Book(s)/Chapters Published

- P. M. Shankar, [\*Probability, Random Variables, and Data Analytics with Engineering Applications\*](#), Springer, March 2021.
- P. M. Shankar, [\*Differential Equations: A Problem Solving Approach Based on MATLAB\*](#), CRC Press, April 2018.
- P. M. Shankar, [\*Fading and Shadowing in Wireless Systems, Second Edition\*](#), Springer, 2017.
- P. M. Shankar, [\*Fading and Shadowing in Wireless Systems\*](#), Springer, 2012
- P. M. Shankar, [\*Introduction to Wireless Systems\*](#), John Wiley & Sons, 2001.
- P. M. Shankar, A. Reddy, A. Wang, and M. Grady, [\*Statistical Analysis of Engineering Systems\*](#), Gateway Coalition, Drexel University, 2001.
- P. M. Shankar, 'Propagation characteristics of wireless channels,' Chapter in the [\*Internet Encyclopedia on Wireless\*](#), H. Bidgoli (Ed.) John Wiley& Sons, 2003.
- P. M. Shankar and R. Mutharasan, 'Tapered Fibers for Cell Studies,' in [\*Reviews in Fluorescence 2005\*](#), Vol. 2, pp. 63-74, Chris Geddes and Joseph Lakowicz (Ed.), Springer, New York 2005.
- P. M. Shankar, 'Wireless Channels,' in [\*Handbook on Wireless Information Security\*](#), H. Bidgoli (Ed.), John Wiley, July 2005.

### List of Publications since joining Drexel University

#### Papers in Refereed Journals

119. P. M. Shankar, "Integration of data analytics into the engineering probability course: Direct and indirect assessment studies", Accepted for publication in *The Journal of Assessment and Institutional Effectiveness*.
118. P. M. Shankar, "Pedagogy of transformation of a random variable, censoring and truncation of data", *Computer Applications in Engineering Education*, Vol 30, pp. 1673–1682, 2022. <https://doi.org/10.1002/cae.22549>
117. P. M. Shankar, "Introduction of data analytics in the engineering probability course: Implementation and lessons learnt," *Computer Applications in Engineering Education*, Vol. 28, No. 5, pp. 1072-1082, 2020. <https://doi.org/10.1002/cae.22284>
116. P. M. Shankar, "Tutorial overview of simple, stratified, and parametric bootstrapping," *Engineering Reports* (Wiley), Vol.2, Issue 1, p. 1-11, 2020 <https://doi.org/10.1002/eng2.12096>
115. P. M. Shankar, "Outcomes Assessment Methodology for a course in probability and random variables," *The Journal of Assessment and Institutional Effectiveness*, Vol. 8, No. 1-2, pp. 71-85, 2018. <https://www.jstor.org/stable/10.5325/jasseinsteffe.8.1-2.0071?seq=1>
114. P. M. Shankar, "Pedagogy of diversity and data analytics: theory to practice," *Computer Applications in Engineering Education*, Vol. 27, No. 5, pp. 1277–1285, 2019. <https://doi.org/10.1002/cae.22151>
113. P. M. Shankar, "Pedagogy of chi square goodness of fit test for continuous distributions," *Computer Applications in Engineering Education*, Vol. 27, No. 3, pp. 679-689, 2019. <https://doi.org/10.1002/cae.22107>

112. P. M. Shankar, "Pedagogy of Bayes' rule, confusion matrix, transition matrix and receiver operating characteristics," *Computer Applications in Engineering Education*, Vol. 27, No. 2, pp. 510-518, 2019. <https://doi.org/10.1002/cae.22093>
111. P. M. Shankar, "Pedagogy of random variable transformations: A Matlab workbook," *Journal of the Indian Society for Probability and Statistics*, Vol. 18, No. 2, pp. 281-294, 2017. <https://doi.org/10.1007/s41096-017-0018-8>
110. P. M. Shankar, "A Matlab workbook on the pedagogy of generalized eigenvectors," *Computer Applications in Engineering Education*, Vol. 25, No. 3, pp. 411-419, 2017.
109. P. M. Shankar, "Pedagogy of solutions to a set of linear equations using a Matlab workbook," *Computer Applications in Engineering Education*, Vol. 25, No. 3, pp. 345-351, 2017.
108. P. M. Shankar, "Pedagogy of Cramer's Rule and beyond: A Matlab workbook," *Mathematics & Computer Education*, Fall 2016, Vol. 50 Issue 3, pp. 207-215, 2016.
107. P. M. Shankar, "Pedagogy of wireless fading channels: A Matlab demo," *International Journal of Electrical Engineering Education*, Vol. 53, No. 4, pp. 291-304, 2016.
106. P. M. Shankar, "Performance of cognitive radio in N\*Nakagami cascaded channels," *Wireless Personal Communications*, Vol. 88, Issue 3, pp. 657-667, 2016.
105. P. M. Shankar, "Pedagogy of autonomous differential equations and equilibria using a Matlab workbook," *Mathematics & Computer Education*, Vol. 50 Issue 1, p. 57-72, 2016.
104. P. M. Shankar, "Pedagogy of second order homogeneous differential equations: A holistic approach using a Matlab workbook," *Computer Applications in Engineering Education*, Vol. 24, No. 1, pp. 114-121, 2016.
103. P. M. Shankar, "An overview of shadowed fading wireless channels in terms of a cascaded approach," *Physical Communication*, Vol. 15, pp. 59-65, 2015.
102. P. M. Shankar, "A composite shadowed fading model based on the McKay distribution and Meijer G functions," *Wireless Personal Communications*, Vol. 81, Issue 3, pp. 1017-1030, 2015.
101. P. M. Shankar, "Statistics of boundaries in ultrasonic B scan images," *Ultrasound in Medicine and Biology*, vol. 41, No. 1, pp. 268-280, 2015.
100. P. M. Shankar, "Error rates in dual hop wireless links operating in cascaded fading channels," *Wireless Personal Communications*, Vol. 75, Issue 1, pp. 1-9, 2014
99. P. M. Shankar, "Computational study of the effects of shadowing in double scattering wireless channels," *Australian J. of Electrical & Electronics Engg.*, Vol. 10, No. 4, pp. 542-55, Dec. 2013.

98. P. M. Shankar, "Diversity in cascaded N\*Nakagami channels," *Annals of Telecommunications*, Vol. 68, Issue 7, pp. 477-483, July 2013.
97. P. M. Shankar, "A statistical model for the ultrasonic backscattered echo from tissue containing microcalcifications," *IEEE Trans. UFFC*, Vol. 60, No. 5, pp. 932-942, May 2013
96. P. M. Shankar, "Use of phase diversity and modified phase congruence for edge enhancement in ultrasonic imaging," *Signal, Image and Video Processing*, Vol. 7, Issue 2, pp. 317-324, 2013.
95. P. M. Shankar, "Maximal ratio combining (MRC) in shadowed fading channels in presence of shadowed fading cochannel interference (CCI)," *Wireless Personal Communications*, Vol. 68, Issue 1, pp. 15-25, Feb. 2013.
94. P. M. Shankar, "A pedagogic approach to cascaded fading channels and diversity in wireless systems," *Australian J. of Electrical & Electronics Engg.*, Vol. 9, No. 4, pp. 439-45, Dec. 2012.
93. P. M. Shankar, "A Nakagami-N-gamma model for shadowed fading channels," *Wireless Personal Communications*, Vol. 64, Issue 4, pp. 665-680, June 2012.
92. P. M. Shankar, "Statistical models for fading and shadowed fading channels in wireless systems: a pedagogical perspective," *Wireless Personal Communications*, Vol. 60, No. 2, pp. 191-213, Sept. 2011.
91. P. M. Shankar, "Maximal ratio combining in independent identically distributed N\*Nakagami fading channels," *Proc. IET Communications*, Vol. 5, No. 3, pp. 320-326, Feb 2011.
90. P. M. Shankar, "Use of two dimensional phase-only-filters (POF) and compounding for speckle reduction and edge detection in ultrasonic B scan images," *Applied Optics*, Vol. 48, No. 29, pp. 5589-5597, December 2009.
89. P. M. Shankar, "Quantitative measures of boundary and contrast enhancement in speckle reduction in ultrasonic B mode images using spatial Bessel filters," *IEEE Trans. UFFC*, Vol. 56, No. 10, pp. 2086-2096, October 2009.
88. P. M. Shankar, "Contrast enhancement and phase sensitive boundary detection in ultrasonic speckle using Bessel spatial filters," *Proc. IET Image Processing*, Vol. 3, No. 2, pp. 41-51, April 2009.
87. P. M. Shankar, "Macro- and micro diversity in correlated shadowed fading channels," *IEEE Trans. Vehicular Technology*, Vol. 58, No. 2, pp. 727-732, Feb. 2009.
86. P. M. Shankar, "Outage probabilities of a MIMO scheme in shadowed fading channels with micro- and macrodiversity reception," *IEEE Trans. on Wireless Communications*, Vol. 7, No.6, pp. 2015-2019, June 2008.
85. P. M. Shankar, "Analysis of microdiversity and dual channel macrodiversity in shadowed fading channels using a compound fading model," *AEUE (International Journal of Electronics and Communications)*, Vol. 62, No.6, pp. 445-449, 2 June 2008.

84. A. Leung, P. M. Shankar and R. Mutharasan, "Label-free detection of DNA hybridization using gold-coated tapered fiber optic biosensors (TFOBS) in a flow cell at 1310 nm and 1550 nm," *Sensors and Actuators B-Chemical*, 131(2), 640-645, May 14, 2008.
83. A. Leung, P. M. Shankar and R. Mutharasan, "Model protein detection using antibody immobilized tapered fiber optic sensors (TFOBS) in a flow cell at 1310 nm and 1550 nm," *Sensors and Actuators B*, Vol. B 129, 716-725, February 2008.
82. A. Leung, P. M. Shankar and R. Mutharasan, "A review of fiber-optic biosensors," *Sensors and Actuators (Chemical)*, Vol. B 125, Issue 2, pp. 688-703, 8 August 2007.
81. A. Leung, P. M. Shankar, R. Mutharasan, "Real time monitoring of bovine serum albumin at femtogram/mL levels on antibody immobilized tapered fiber sensors," *Sensors and Actuators (Chemical)*, Vol. B 123, Issue 2, pp. 888-895, May 2007.
80. P. M. Shankar, "Outage performance in wireless systems with multiple interferers subject to shadowing and fading using a compound fading model," *AEUE (International J. of Electronics and Communications)*, Vol. 61, No. 4, pp. 255-261, April 2, 2007.
79. P. M. Shankar, "Speckle reduction in ultrasonic images through a maximum likelihood based adaptive filter," *Phys. Med. Biol.*, Vol. 51, pp. 5591-5602, 7 November, 2006
78. P. M. Shankar, "Performance analysis of diversity combining algorithms in shadowed fading channels," *Wireless Personal Comm.*, Vol. 37 (No. 1-2), pp. 61-72, April 2006.
77. P. M. Shankar, "Comments on the effect of logarithmic compression on the estimation of the Nakagami parameter for ultrasonic tissue characterization," *Phys. Med. Biol.*, Vol. 51, No 8, pp. L23-L26, April 2006.
76. A. Leung, K. Rijal, P. M Shankar and R. Mutharasan, "Effects of geometry on transmission and sensing potential of tapered fiber sensors," *Biosensors and Bioelectronics*, Vol. 21, No. 12, pp. 2202-2209, June 2006.
75. D. Maraldo, P. M Shankar and R. Mutharasan, "Measuring Bacterial Growth by Tapered Fiber and Changes in Evanescent Field," *Biosensors and Bioelectronics*, Vol. 21, No. 7, pp. 1339-1344, January 2006.
74. P. M. Shankar, "Outage probabilities in shadowed fading channels using a compound statistical model," *IEE Proc. Comm.*, Vol. 152, No.6, pp. 828-832, December 2005.
73. K. Rijal, A. Leung, P. M Shankar and R. Mutharasan, "Detection of pathogen *E. Coli* O157:H7 using antibody immobilized biconical tapered fiber sensors," *Biosensors and Bioelectronics*, Vol. 21, No.6, pp. 871-880, December 2005.
72. P. M. Shankar, C. W. Piccoli, J. M. Reid, F. Forsberg, B. B. Goldberg, "Application of the compound pdf for characterization of breast masses in ultrasonic B scans," *Phys. Med. Biol.*, Vol. 50, pp. 2241-2248, April 2005.

71. P. M. Shankar, "Error rates in generalized shadowed fading channels," *Wireless Personal Comm.*, Vol. 28, pp. 233-238, February 2004.
70. G. Bhagavatheeshwaran, W. T. Shi, F. Forsberg, and P M Shankar, "Subharmonic signal generation from contrast agents in simulated neovessels," *Ultrasound in Medicine and Biology*, Vol. 30, pp. 199-203, February 2004.
69. P. M. Shankar, "The use of the compound pdf in ultrasonic tissue characterization," *Phys. Med. Biol.*, Vol. 49, pp. 1007-1015, February 2004.
68. P. J. Wiejata, P. M. Shankar, and R. Mutharasan, "Fluorescent Sensing Using Biconical Tapers," *Sensors and Actuators*, Vol. B 96, pp. 315-320, November 2003.
67. H. S. Haddock, P. M. Shankar, and R. Mutharasan, "Fabrication of biconical tapered optical fibers using hydrofluoric acid," *Material Science & Engineering – B*, Vol. B 97, pp. 87-93, January 2003.
66. H. S. Haddock, P. M. Shankar, and R. Mutharasan, "Evanescent Sensing of biomolecules and cells," *Sensors and Actuators B*, Vol. 88, pp. 67-74, 2003.
65. P. M. Shankar, F. Forsberg, and L. Lown, "Statistical modeling of atherosclerotic plaque in carotid B mode images - A feasibility study," *Ultrasound in Medicine and Biology*, Vol. 29, No. 9, pp. 1305-1309, September 2003.
64. P. M. Shankar, V. A. Dumane, C. W. Piccoli, J. M. Reid, F. Forsberg and B. B. Goldberg, "Computer-aided classification of breast masses in ultrasonic B scans using a multiparameter approach," *IEEE Trans. on UFFC*, Vol. 50, No. 8, pp. 1002-1009, August 2003.
63. P. M. Shankar, V.A. Dumane, T. George, C. W. Piccoli, J. M. Reid, F. Forsberg, B. B. Goldberg, "Classification of breast masses in ultrasonic B scans using Nakagami and K distributions," *Phys. Med. Biol.*, Vol. 48, No. 14, pp. 2229-2240, 21 July 2003.
62. P. M. Shankar, "Estimation of the Nakagami parameter from log-compressed ultrasonic backscattered envelopes," *J. Acoustical Soc. of Amer.*, Vol. 114, pp. 70-72, July 2003.
61. P. M. Shankar, "A compound scattering pdf for the ultrasonic echo envelope and its relationship to K and Nakagami distributions," *IEEE Trans. on UFFC*, Vol. 50, No. 3, pp. 339-343, March 2003.
60. S. Gefen, O. J. Tretiak, C. W. Piccoli, K. D. Donohue, A. P. Petropulu, P. M. Shankar, V. A. Dumane, L. Huang, M. A. Kutay, V. Genis, F. Forsberg, J. M. Reid, B. B. Goldberg, "ROC analysis of tissue characterization classifiers for breast cancer detection," *IEEE Trans. on Medical Imaging*, Vol. 22, No. 2, pp. 170-177, Feb. 2003.
59. G. S. Prabhu and P. M. Shankar, "Performance Analysis of Fiber-Fed Microcellular Networks using  $\pi/4$ -DQPSK in a Frequency Selective, CCI-limited, Nakagami Fading Environment," *IEEE Trans. on Vehicular Technology*, Vol. 51, No. 5, pp.1258-1264, September 2002.



58. G. S. Prabhu and P. M. Shankar, "Simulation of flat fading using MATLAB for classroom instruction," *IEEE Trans. on Education*, Vol. 45, No. 2, pp. 19-25, February 2002.
57. P. M. Shankar, V. A. Dumane, C. W. Piccoli, J. M. Reid, F. Forsberg and B. B. Goldberg, "Classification of breast masses in ultrasonic B-mode images using a compounding technique in the Nakagami distribution domain," *Ultrasound in Medicine and Biology*, Vol. 28, No. 10, pp. 1295-1300, 2002.
56. V. A. Dumane, P. M. Shankar, C. W. Piccoli, J. M. Reid, F. Forsberg and B. B. Goldberg, "Computer aided classification of masses in ultrasonic mammography," *Medical Physics*, Vol. 29, No. 9, pp. 1968-1973, September 2002.
55. V. A. Dumane, P. M. Shankar, C. W. Piccoli, J. M. Reid, V. Genis, F. Forsberg and B. B. Goldberg, "Classification of ultrasonic B-scan images of breast lesions using frequency diversity and Nakagami statistics," *IEEE Trans. on UFFC*, Vol. 49, No. 5, pp. 664-668, May 2002.
54. P. M. Shankar, "Ultrasonic tissue characterization using a generalized Nakagami model," *IEEE Trans. on UFFC*, Vol. 48, No. 6, pp. 1716-1720, November 2001.
53. V. A. Dumane and P. M. Shankar, "Use of frequency diversity and Nakagami statistics in ultrasonic tissue characterization," *IEEE Trans. on UFFC*, Vol. 48, No. 4, pp. 1139-1146, July 2001.
52. P. M. Shankar, V. A. Dumane, J. M. Reid, V. Genis, F. Forsberg, C. W. Piccoli, and B. B. Goldberg "Classification of ultrasonic B mode images of breast masses using Nakagami distribution," *IEEE Trans. on UFFC*, Vol. 48, No. 2, pp. 569-580, March 2001.
51. P. M. Shankar, V. A. Dumane, J. M. Reid, V. Genis, F. Forsberg, C. W. Piccoli, and B. B. Goldberg, "Classification of masses in B-scan images of the breast using K-distribution," *Ultrasound in Medicine and Biology*, Vol. 26, No. 9, pp. 1503-1510, 2000.
50. P. M. Shankar and B. A. Eisenstein, "Project based Instruction in Wireless Communications at the Junior Level," *IEEE Trans. on Education*, Vol. 43, No. 3, August 2000, pp. 245-249.
49. P. M. Shankar, "A general statistical model for ultrasonic scattering from tissues," *IEEE Trans. on UFFC*, Vol. 47, No. 3, pp. 727-736, May 2000.
48. J. Koshy and P. M. Shankar, "Spread-Spectrum Techniques for Fiber-Fed Microcellular Networks," *IEEE Trans. on Vehicular Technology*, Vol. 48, No. 3, pp. 847-857, May 1999.
47. P. M. Shankar, P. D. Krishna, and V. L. Newhouse, "Subharmonic scattering properties of ultrasound contrast agents," *JASA*, Vol. 106, No. 4, pp. 2104-2110, October 1999.
46. P. D. Krishna, P. M. Shankar and V. L. Newhouse, "Subharmonic generation from Ultrasonic Contrast agents," *Physics in Med. Biology*, Vol. 44, March 1999, pp. 681-694.

45. J. Koshy and P. M. Shankar, "Effect of Nonlinearities on Outage Performance of Fiber-Fed Microcellular Networks for GMSK Systems," *IEEE Trans. on Vehicular Technology*, Vol. 47, No. 3, pp. 819-829, Aug. 1998.
44. P. M. Shankar, P. Dala Krishna, and V. L. Newhouse, "Advantages of Subharmonic over Second Harmonic Backscatter for Contrast-to-Tissue Echo Enhancement," *Ultrasound in Medicine & Biology*, Vol. 24, No. 2, pp. 395-399, 1998.
43. R. C. Molthen, V. M. Narayanan, P. M. Shankar, J. M. Reid, V. Genis, F. Forsberg, E. J. Halpern, and B. B. Goldberg, "Using Phase Information in Ultrasonic Backscatter for In Vivo Liver Analysis," *Ultrasound in Medicine & Biology*, Vol. 24, No. 1, pp. 79-91, 1998.
42. R. C. Molthen, P. M. Shankar, J. M. Reid, F. Forsberg, E. J. Halpern, C. W. Piccoli, and B. B. Goldberg, "Comparisons of the Rayleigh and  $K$ -distribution models using *in vivo* breast and liver tissue," *Ultrasound in Medicine & Biology*, Vol. 24, No. 1, pp. 93-100, 1998.
41. B. J. Koshy and P. M. Shankar, "Performance Analysis of GMSK in Microcellular Mobile Systems Employing Fiberoptic Feeders," *IEEE J. of SAC*, Vol. 15, No. 4, pp. 694-706, May 1997.
40. V. M. Narayanan, R. C. Molthen, P. M. Shankar, L. Vergara and J. M. Reid, "Studies on ultrasonic scattering from quasi-periodic Structures," *IEEE Trans. on UFFC*, Vol. 44, pp. 114 – 124, January 1997.
39. P. M. Shankar, R. Molthen, V. M. Narayanan, J. M. Reid, V. Genis, F. Forsberg, C. W. Piccoli, A. E. Lindenmayer and B. B. Goldberg, "Studies on the use of non-Rayleigh statistics for ultrasonic tissue characterization," *Ultrasound in Medicine & Biology*, Vol. 22, No. 7, 1996, pp. 873-882.
38. P. M. Shankar, "A model for ultrasonic scattering from tissues based on  $K$  distribution," *Phys. Med. Biol.*, Vol. 40, pp. 1633-1649, October 1995.
37. R. C. Molthen, P. M. Shankar and J. M. Reid, "Tissue Characterization in Ultrasonic B scans using Non-Rayleigh Statistics," *Ultrasound in Med. & Biol.*, Vol. 21, No. 2, pp. 161-170, 1995.
36. Y. Q. Wu, P. M. Shankar, and P. A. Lewin, "Characterization of Ultrasonic Transducers using a Fiberoptic Sensor," *Ultrasound in Medicine & Biology*, Vol. 20, pp. 645-653, Oct. 1994.
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G. W. Hislop, S. Mancoridis and P. M. Shankar, 'A Collaborative Bachelor's degree in software engineering,' 33rd ASEE/IEEE Frontiers in Education Conference, Nov. 5-8, 2003, Boulder, CO.

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#### [Conference Presentations in EDUCATION](#)

R. Mutharasan and P. M. Shankar, 'Upper Level Interdisciplinary Courses: Drexel Experiment,' 2002 AIChE Meeting, Nov. 3-8, Indianapolis, Indiana.

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#### [Conference Presentations in OPTICS](#)

A. Leung, P. M. Shankar, R. Mutharasan, Tapered fiber optic biosensor detects 10 fg/mL BSA At 1310 nm and 1550 nm in a flow cell configuration, The Ninth World Congress on Biosensors, May 10 – 12, 2006, Sheraton Centre Toronto, Ontario, Canada

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P. M. Shankar, "Coupling of modes in on-fiber devices," Presented at the 1988 OSA Annual Meeting, Nov. 1988, Santa Clara, CA.



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### Areas of interest

Biophotonics, Fiber optics, Ultrasonic Contrast Agents, Medical Ultrasound, Wireless Communication. Engineering Education. Matlab pedagogy.

### Research Proposals Funded

Department of Education, "GAANN Fellowships to Develop Renaissance Engineers," September 1, 2006, for three years; \$504K; One of nine (9) investigators

NSF, "Ultra Sensitive Continuous Tapered Fiber Biosensors for Pathogens and Bioterrorism Agents," September 1, 2003-August 31; 2008. \$450K, R. Mutharasan (PI) and P. M. Shankar (Co-PI)

NIH R01, "Ultrasound Hydrophone and Its Calibration up to 100 MHz," October 1, 2001, for three years; \$700 K, P. A. Lewin (PI) and P. M. Shankar (Co-PI)

US Army, "Estimation of tumor angiogenesis with contrast enhanced subharmonic ultrasound imaging" July 2000 June 2002 \$ 62K, P. M. Shankar (Thomas Jefferson University, PI)

NIH Program Project, "Developing Ultrasonic Tissue Characterization methods", Project Director and On-site Project Coordinator, \$3.5M, July 1998-June 2002 Co-Project Directors: J. M. Reid and B. Goldberg

Ultrasonic Tissue Characterization Using non-Rayleigh statistics: Principal Investigator, P. M. Shankar, \$170K, NSF, 1992-1995.

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\$375K, ONR, 1989-1991