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S.P. BHATTACHARYYA

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Birthdate: June 23, 1946
Citizenship: U.S.

PROFESSIONAL INTERESTS: Automatic Control Systems
Multivariable Control System Analysis and Design
Computer Aided Control System Design (CACSD)
Robust Control Theory and Applications

EDUCATION

- Ph.D., Electrical Engineering, Rice University, 1971 (Advisor: Prof. J.B. Pearson)
- M.S., Electrical Engineering, Rice University, 1969 (Advisor: Prof. J.B. Pearson)
- B. Tech. (Honors), Electrical Engineering, Indian Institute of Technology, Bombay, India, 1967.

ACADEMIC POSITIONS

2004 – Present	Robert M. Kennedy Professor, Texas A&M University
1984 – Present	Professor, Electrical Engineering Department
1990-92	Area Leader, Telecommunications, Control and Signal Group, Electrical Engineering Dept., Texas A&M University
1992-93	Director, Systems and Control Institute, Texas Engineering Experiment Station, Texas A&M University
1980-84	Associate Professor, Electrical Engineering Department, Texas A&M University
1978-80	Chairman, Electrical Engineering Department, Federal University, Rio de Janeiro, Brazil
1976-80	Professor, Electrical Engineering Department, Federal University, Rio de Janeiro, Brazil
1972-76	Associate Professor, Department of Systems Engineering and Computation, Federal University, Rio de Janeiro, Brazil
1971-72	Assistant Professor, Department of Systems Engineering and Computation, Federal University, Rio de Janeiro, Brazil

HONORS, AND AWARDS

- **Government of India Scholar** 1962 - 67.
- **National Academy of Sciences- NASA Research Fellow**, 1974 - 1975 held at the Marshall Space Flight Center.
- **Fellow of the IEEE**, 1989. Awarded for contributions to the analysis and design of linear control systems.
- **Fullbright Lecturing Award**, March 1989 held at IIT, Delhi, Sept. - Dec. 1989.
- Texas A & M University, Texas Engineering Experiment Station (**TEES**) Fellow, 1989, 1999.
- Halliburton Professor, 1991.
- Texas A & M University, **Dresser Industries Professor**, 1992.
- **Boeing Welliver Faculty Fellow**, Boeing Corporation, Seattle, 1998.
- Texas A & M University, **TEES Senior Fellow** 2000.
- **Robert M. Kennedy Endowed Professorship**, Texas A & M University, 2004 - Present.
- Texas A & M University **Outstanding ECEN Professor Award**, 2009.
- International Federation of Automatic Control, **IFAC Fellow** Award. For fundamental contributions to Robust Control and Controller Synthesis. September, 2011.
- Elected **Foreign Member of Academia Brasileira de Ciencias (Brazilian Academy of Sciences)** for distinguished contributions to Science and to Science and Engineering in Brazil, December 16, 2011.
- Awarded the **Professor Visitante Especial** in September 2013 by the Brazilian Research Council for collaborative research with Brazilian universities during 2014-2017.
- Elected **Foreign Member of the National Academy of Engineering, Brazil** for contributions to Control Theory, for establishing the first PhD program in Control Systems in Brazil and for promoting Brazil through Study Abroad programs in Brazil based from Texas A & M University, November, 2015.
- Texas A & M University, College of Engineering Texas A & M, **Outstanding Teaching Award**, May 2016.
- **Appointed Adjunct Professor at National Cheng Kung University**, Taiwan, August 2016-2019.
- **Kenneth L. Clinton Award for contributions to the Study Abroad program**

LANGUAGES SPOKEN

English – Fluent
Portuguese – Fluent
Hindi – Fluent
Bengali – Fluent

LISTINGS

- Who's Who in Frontier Science and Technology, 1984 –
- American Biographical Institute, 1985 –
- American Men and Women of Science 1986 –
- Who's Who in America 1986 –

- Who's Who Among Asian Americans 1996 -

TEACHING EXPERIENCE

1. Developed and headed the graduate program in automatic control at the Federal University in Rio de Janeiro, Brazil from 1971 - 1980; served as Electrical Engineering Department Head 1978 - 80.
2. Developed graduate courses at Texas A&M University in the automatic controls area and regularly teach undergraduate (EE 420, Linear Control Systems, Fall and Spring, EE 421 Digital Control Systems, EE 422 Control Engineering Laboratory) and graduate courses (EE 605, Linear Systems, Fall and EE 628, Robust Control, Spring) in this field.
3. Supervised 12 Ph.D. theses and 20 M.S. theses in control systems as thesis advisor.
4. Developed an undergraduate Control Engineering Laboratory and the corresponding course in the Electrical Engineering Department, Texas A &M University, Fall 1997.
5. Developed a new undergraduate course on Intelligent Control, Spring 1999.
6. Developed and established the COE Study Abroad Brazil Engineering program and have taken 13 batches of Aggies to Brazil for study abroad, 2005- 2017.
7. Developed the new Control Engineering Laboratory (ECEN 422) based on Quanser and National Instruments equipment (Fall, 2013)

RESEARCH GRANTS

1. S.P.Bhattacharyya and J.W.Howze, National Science Foundation "The Structure of Robust Disturbance Rejection Control" ECS-82000852, \$42,000, 1982 - 1983.
2. S.P.Bhattacharyya and J.W.Howze, National Science Foundation "Multivariable Controller Design via the Generalized Disturbance Rejection Problem" ECS-8309792, \$151,000, 1983 - 1987.
3. S.P.Bhattacharyya, National Science Foundation, "Robust Control of Multivariable Systems Subject to Structured Real Parameter Variations" ECS-8613315, \$128,000, 1987 - 1990.
4. S.P.Bhattacharyya, National Science Foundation "Synthesis of Robust Controllers for Parameter Variations" ECS-8914357, \$20,000, 1990 - 1991.
5. S.P.Bhattacharyya and L.H.Keel, Air Force Office of Scientific Research and National Science Foundation "International Workshop on Robust Control" ECS-9107295 \$39,000, 1991.
6. S.P.Bhattacharyya, National Science Foundation "Synthesis of Robust Controllers for Parameter Variations" ECS-8914357, \$40,000, 1991 - 1992.
7. S.P.Bhattacharyya, National Science Foundation "International Workshop on Robust Control at Ascona" ECS-9209486, \$8,000, 1992.
8. S.P.Bhattacharyya, National Science Foundation "Synthesis of Robust Controllers for Perturbations of Mixed Type" ECS-9106312 \$180,000, 1992 - 1995.
9. S.P.Bhattacharyya and A.Datta, National Science Foundation "Robust Adaptive Control based on Kharitonov Theory and its Extension" ECS-9417004, \$282,802, 1995 - 1998.
10. S.P.Bhattacharyya and L.H.Keel, National Science Foundation "A New Approach to Optimal and Robust Control" HRD-9706268, \$ 1,091,911, 1998 - 2003.
11. S.P.Bhattacharyya and A.Datta, National Science Foundation "Synthesis of Fixed Order Controllers" NSF-9906268, \$ 220,000, 1999 - 2004.

12. S.P.Bhattacharyya and A.Datta, Texas Advanced Technology Program, "PID Controller Design for Industrial Applications: A Novel Approach" \$87,000, Jan. 2000 - 2002.
13. A.Datta (P.I.), S.P.Bhattacharyya (co-P.I.) and E.Dougherty (co-P.I.), National Science Foundation, "Control Issues in Cancer Therapy" ECS-0355227, \$240,000, June 2004 - 2007.
14. S.P.Bhattacharyya, National Instruments, \$61,000, gift, 2004.
15. S.P.Bhattacharyya, National Instruments, \$51,000, gift, 2005.
16. S.P.Bhattacharyya, National Instruments, \$51,000, gift, 2006.
17. S.P.Bhattacharyya and C.Verde, TAMU-CONACYT Grant, \$24,000, Sept. 2006 - August 2007.
18. S.P.Bhattacharyya, National Instruments, \$25,000, gift, 2007.
19. S.P.Bhattacharyya, National Instruments, \$25,000 gift, 2008.
20. S.P.Bhattacharyya, National Science Foundation, "New Approaches to the Design of Fixed Order Controllers" ECS-03308000, \$80,000, 2003 - 2007.
21. S.P.Bhattacharyya and L.H.Keel, National Science Foundation, "Multivariable Fixed Order Controller Synthesis From Data" NSF CMMI-0927652, \$375,000, October 1, 2010 - September 30, 2013.
22. S.P.Bhattacharyya, A.Datta, H.Nounou and M.Nounou, Qatar National Research Foundation, "Model Free Data Based Design of Adaptive Control Systems: A New Approach" \$1,035,951.57, Oct. 1, 2010 - Sept. 30,2014.
23. S.P.Bhattacharyya and Vilma A. Oliveira "A New Measurement Based Approach to Engineering Design", \$187,500, Brazilian Research Council, Oct. 1, 2013-Sept. 30, 2016.

SHORT COURSES AND LECTURES

1. Gave short courses on Advanced Control Theory in Brazil (1984, two weeks), Mexico (1986, 1 week); two short courses on recent developments in Robust Control in Brazil (August 1988, 2 weeks). short courses on Robust Control in University of Florence, Italy (June 1988, 1 week; May 1990, 1 month); short course on Robust Parametric Stability and Control at Chiba University, and Tokyo Institute of Technology, Japan (June 1991).
2. Lectured at the Indian Institute of Technology, Delhi from September 1989 to December 1989 on Robust Control as a Senior Fullbright Visiting Lecturer.
3. Taught a short course at the University of Florence in May 1990.
4. Organizer and lecturer of the one day Tutorial Workshop on Robust Control given at the 1990 IEEE Conference on Decision and Control, Dec.1990, Hawaii, USA.
5. Visited the Indian Institute of Science for six weeks in 1990 under a grant from the United Nations Development Program.
6. Gave a plenary talk at the SIAM Conference on Linear Algebra in Signals, Systems and Control on "Robust Stability of Interval Dynamic Systems" November 1990, San Francisco, USA. Organizer of the International Workshop on Robust Control held in March 1991 in San Antonio, and supported by the National Science Foundation and the Air Force Office of Scientific Research.
7. Lectured at Tokyo Institute of Technology, and Kyoto University in June 1991, supported by the International Information Science Foundation of Japan.
8. Invited speaker at the International Workshop on Robust Control held in Tokyo in June 1991.
9. Invited lecturer at the First Quantitative Feedback Theory Symposium organized by the Air Force Office of Scientific Research at the Wright Patterson Air Force Base, June 1992.

10. Invited lecturer at the 12th IMACS International Conference held in Bangalore, India, December 1992.
11. Invited to lecture at the Indian Institute of Technology, Delhi in summer 1992 under the NSF US-India program.
12. Organizer and lecturer of a short course on Robust Control at the AIAA Guidance and Control Conference, August 1992, South Carolina.
13. Plenary Lecture on "Robust Control" at the 1993 SIAM Conference on Linear Algebra in Signals, Systems and Control, August 1993, Seattle, Washington.
14. Invited to give a Plenary Lecture at the 1994 Latin American Control Conference, Rio de Janeiro, Brazil, September 1994.
15. Invited Lecture at the 1994 IFAC International Symposium on Robust Control, September 1994.
16. Invited short course on Robust Control in Universidad Nacional Autonoma of Mexico, August 1995.
17. Plenary lecture at the 1995 Quantitative Feedback Theory Symposium, Purdue University, August 1995.
18. Invited lecture at the Bernoulli Workshop on Control of Uncertain Systems, University of Groningen, Netherlands, August 1995.
19. Invited speaker at the International Workshop on Robust Control, June 1996, Napa Valley, CA.
20. Invited lecturer at the International Conference of Nonlinear Analysts, July 1996, Athens, Greece.
21. Invited tutorial Workshop on Robust Control at the IEEE Conference on Decision and Control, Kobe, Japan, December 1996.
22. Invited lecturer at the Universities of Manchester, Leicester and Warwick in the UK, October 1997.
23. Invited lecture at the Indian Statistical Institute and short course at the B.E. College, Calcutta, India, December 1997.
24. Plenary lecturer at the All-India Control Engineers' Meeting, New Delhi, India, January 1998.
25. Invited speaker at the International Workshop on Robust Identification and Control, Siena, Italy, July 1998.
26. Invited tutorial course at the Brazilian Congress on Automatic Control, September 1998, Uberlandia, Brazil.
27. Invited one-day tutorial course at the 1999 American Control Conference, June 2-4, 1999, San Diego, CA.
28. Invited speaker at the International Workshop on Robust Control, June 30-July 4, 1999, Hong Kong.
29. Invited speaker, International Workshop on Control Theory, March 9-10, 2001, Rice University, Houston, TX.
30. Invited plenary speaker, SIAM Conference on Linear Algebra in Signals, Systems and Controls, August 13-15, 2001, Boston, MA.
31. Invited plenary speaker, International Conference on Energy, Automation and Information Technology, Dec. 10-13, 2001, IIT Kharagpur, India.
32. Invited plenary speaker, International Conference on Control, Instrumentation and Information Communication, Dec. 13-15, 2001, Kolkata, India.
33. Invited speaker, Utah State University, Center for Intelligent Control, Nov. 6, 2002.

34. Invited tutorial speaker, National Power Systems Conference, IIT, Kharagpur, Dec. 26-29, 2002.
35. Invited tutorial short course, Latin American Conference on Control, Sept. 2-5, 2002, Natal, Brazil.
36. Invited plenary speaker, National Biomedical Engineering Conference, Vizakhapatnam, India, Dec. 23, 2004.
37. Invited speaker, National Instruments Control Design Workshop, August 17-19, 2004, Austin, TX.
38. Invited plenary speaker, First International Workshop on Dynamical systems, Control and Applications, Mexico, Dec 3-5, 2004.
39. Invited short course on Robust Control, Hyderabad, India organized by International Institute of Information Technology, Bharat Heavy Electricals, Ltd and IEEE, December 16-17, 2004, Hyderabad, India.
40. Invited lecturer at the International Conference on Control and Optimization, Institute of Control Science, Moscow to honor Prof. Boris Polyak on his 70th birthday, May 2005.
41. Invited lectures at LAAS, Toulouse, France and Supelec, Paris, June 2005.
42. Invited speaker at Dalhousie University, Halifax, Canada, July 2005.
43. Invited keynote speaker at International Conference on Computers and Information Technology, December 22, 2005, Bhubaneswar, India.
44. Invited speaker at the IEEE Signal Processing Society, Dallas, November 2005.
45. Invited speaker at Wright-Patterson Air Force Base, October 23, 2006.
46. Invited Plenary Speaker at International Conference on Trends in Manufacturing and Automation (TIMA), Jan. 4-6, 2007, Trichy, India.
47. Invited Plenary Speaker at the International Conference on Numerical Linear Algebra in Systems, Signals and Controls, Jan. 9-11, IIT Kharagpur, India.
48. Invited speaker at the European Control Conference, July 2-4, 2007, Kos, Greece.
49. Invited speaker at University of Sao Paulo, Sao Carlos, May 22, 2007.
50. Invited short course on Robust Control Design in Workshop on Robust Control of Linear Systems and Its Applications, Mexico Nov. 28-30, 2007.
51. Plenary Speaker at the Second Workshop on Dynamical Systems, Control and Applications (DySCA-II) Mexico, Nov.30-Dec 2, 2007.
52. Invited plenary speaker at the National Conference on Instrumentation and Control, Trichy, India, Dec 27-29, 2007.
53. Invited Keynote Address, International Conference on Trends in Manufacturing and Automation, Chennai, India, Jan. 5, 2009.
54. Plenary Speaker, Workshop on Goal Oriented System Modelling and Identification, Annamalai University, India, Jan. 7, 2009.
55. Invited Speaker, NIT Workshop on Control, Trichy, India, Jan.8-11, 2009.
56. Organizer and Instructor, Short Course on "Advanced PID Control" at the IFAC World Congress, Seoul, Korea, July 2008.
57. Invited Speaker, Symposium to honor Prof. W.A.Wolovich, Dec. 8, 2008, Cancun, Mexico.
58. Invited Speaker, International Conference on Energy, Power Systems and Control (EPSCICON) Thrissur Kerala, Jan 3-6, 2010.
59. Invited Speaker at UC Berkeley, Stanford University and University of Santa Clara, Oct.23-30, 2009.

60. Invited Speaker at "Advanced Short Course on Estimation and Control" Dec 27-28, 2009 at IIT, Kharagpur, India.
61. Distinguished Lecture Series, City University of Hong Kong, Dec 6-15, 2009.
62. Invited Keynote Speaker, Iranian Electrical Engineering Conference, Isfahan, Iran, May 2010. (Was unable to go because of visa problems).
63. Invited lecture and speaker, Universidade de Sao Paulo, Sao Carlos, Brazil, August 16-18, 2010.
64. Invited lectures, COPPE, Federal University of Rio de Janeiro, Brazil, August 23-27, 2010.
65. Invited Speaker, International Symposium on Electronic Design, Dec 21-23, 2010, Bhubaneswar, India
66. Invited Speaker, International Conference on Automation and Control, Dec 16-20, 2010, Trivandrum, Kerala, India.
67. External Research Evaluator for University of Jordan Faculty, 2011.
68. Invited Workshop (IEEE Control Systems Society. Bangalore) at Indian Institute of Science, Bangalore, Dec. 23. 2011.
69. Plenary Speaker, International Symposium on Electronic Design (ISED), Kochi, India. Dec. 19, 2011.
70. Plenary Speaker, EPSCICON, Kerala, India, Jan. 5, 2012.
71. Invited Speaker, UC Berkeley, February 11, 2013.
72. Short course on "Modern PID Control" UC, Berkeley, March 2013.
73. Invited Speaker, IASTED Asian Conference on Modelling, Identification and Control, Thailand, April 10-12, 2013.
74. Invited Speaker, IIT Bombay, Dec. 19, 2013.
75. Keynote Speaker, Trends in Manufacturing and Automation (TIMA), Chennai, India, Dec. 23, 2013.
76. Invited Speaker, Indian Institute of Science, Bangalore, Dec. 26, 2013.
77. Invited Speaker and Short Course at NIT, Trichy, Dec. 31, 2013.
78. Plenary Speaker, EPSCICON, Kerala, India, Jan. 8, 2014
79. Invited Speaker and Special Session Organizer, International Symposium on Communications, Control and Signal Processing, Athens, Greece, May 23-26, 2014.
80. Short Course on "Linear Systems: A Measurement Based Approach" at the 19th International Federation of Automatic Control, World Congress, Aug. 23, 2014, Cape Town, South Africa.
81. Invited Lecture at Southwest Symposium on Contemporary Engineering Topics, Sept. 19, 2014 in New Orleans, LA.
82. Invited Speaker at the International Conference on Robustness in Identification and Control in honor of Prof. Antonio Vicino's 60th birthday, Sept. 25-26, 2014, Siena, Italy.
83. Invited Speaker at the International Conference on Optimization in Robustness and Control in honor of Academician Boris Polyak's 80th Birthday, Institute of Control Science. Moscow, Russia, May 17-19, 2015.
84. Invited Lectures at National Cheng Kung University, Taiwan supported by the Ministry of Science and Technology, Taiwan, Dec. 19, 2015-Jan 2, 2016.
85. Invited Short Course, International Conference on Automatic Control and Dynamic Optimization of Systems, Trichy, India, Feb. 1-5, 2016.
86. Organizer of a Special Session on Robust and PID Control at the IEEE Multi Systems Conference in Buenos Aires, Argentina, September 18-21, 2016.

87. Invited Lecturer at IIT Silchar through the Govt. of India supported GIAN Program. Short Course on ``Robustness, Fragility, Optimality and Modern PID Control’’ Dec. 2017.
88. Plenary Talk on ``Modern Design of Classical Controllers’’ at the Asociacion Mexicana de Controle Automatico Annual Meeting, Monterrey, Mexico, October 2017.
89. Plenary Talk at EPSICON, Thrissur, India on “Modern Design of PID Controllers”. Jan 2018.
90. Tutorial Workshop titled “Modern PID Control” given at the IEEE sponsored Indian Control Conference, Jan 9, 2019, IIT Delhi, New Delhi, India.

PROFESSIONAL ACTIVITIES

- Associate Editor, IEEE Transactions on Automatic Control, 1985 - 1986.
- Board of Governors, IEEE Control Systems Society 1986.
- IEEE Control Systems Society, Fellow Evaluation Committee, 1990.
- International Advisory Committee, IEEE International Conference, Region 10, August 1991.
- International Federation of Automatic Control, Technical Committee on Theory, 1991, 2003, 2004.
- Editorial Board, International Journal on Mathematics and Computation in Control, Signals and Systems.
- Editorial Board, Journal of the Systems Science Society of India, 1992 - 94.
- Served on 1991 NSF panel for reviewing Research Initiation proposals in Engineering Systems.
- International Program Committee, Symposium on Implicit and Nonlinear Systems, Dec. 1992, Fort Worth, Texas.
- Served on 1992 NSF panel for reviewing Presidential Young Investigator Awards in Engineering Systems.
- International Program Committee, IFAC Symposium on Robust Control, 1994, Rio de Janeiro, Brazil.
- Served as an external consultant to the Ontario Council on Graduate Studies to evaluate the M.S. degree program in Control Engineering at Lakehead University, Thunder Bay, Ontario, Canada, Sept. 1993.
- Editorial Board, Applied and Computational Circuits, Systems and Signals, Birkhauser, 1996.
- Served on NSF panel to review proposals for Knowledge Modelling and Computational Intelligence Program, June 1997.
- Associate Editor, Systems and Controls Letters, October 1998 - 2003.
- International Program Committee, IFAC Symposium on Robust Control Design, 1999-2000, Prague, Czechoslovakia.
- International Program Committee, International Conference on Interval Analysis, December 1999, India.
- Organizer, International Workshop on Control Theory in honor of Boyd Pearson, March 2001, Rice University, Houston, Texas (Sponsored by NSF).
- Program Committee, International Conference on Energy, Automation and Information Technology, IIT Kharagpur, India, Dec. 10-13, 2001.
- Served on NSF panel for reviewing proposals submitted to the Electrical and Communications Systems Division, June 2005.

- Program Committee, International Conference on Trends in Manufacturing and Automation, Trichy, India, Jan. 4-6, 2007.
- Program Committee, International Conference on Control and Applications, Montreal, Canada, May 30-June 1, 2007.
- Program Committee, International Conference on Control and Applications, IASTED, 2008, 2009, 2010, 2011, 2012.
- Editorial Board, Springer Volume on Numerical Linear Algebra in Control, Signals and Systems 2007-2010.
- External Reviewer of Controls Curricula, Ministry of Education, Govt. of India, 2010.
- External Reviewer, Ph.D. Program in EE, UT, San Antonio, February, 2010.
- External Reviewer, School of Engineering, Simon Fraser University, Vancouver, B.C. Canada, April 2010.
- Program Committee, PID Control 2012, International Conference.
- Associate Editor, Mathematical Problems in Engineering, 2011.
- Program Committee and Associate Editor, IFAC Conference on PID Control, 2018, Ghent, Belgium.
- Associate Editor, International Journal on Modelling and Simulation.

INDUSTRIAL EXPERIENCE

- National Academy of Sciences Research Fellow, System Dynamics Laboratory, Dynamics and Control Division, NASA, Marshall Space Flight Center, 6/74 - 8/75.
- A.D.Welliver Faculty Fellowship, Boeing Corporation, 1998.
- Consultant to National Instruments, Austin, 2004-2008.

UNIVERSITY AND DEPARTMENTAL COMMITTEES

- Chairman, Electrical Engineering Curriculum Committee 1982 - 85.
- Chairman, Salary and Awards Committee 1985 - 86.
- University Distinguished Alumni Selection Committee 1988.
- Electrical Engineering Tenure and Promotion Committee 1988, 1990, 1991, 1995, 2004, 2005, 2008, 2009, 2010.
- Electrical Engineering Department Head Search Committee 1990, 1991.
- Electrical Engineering Microelectronics Chair Search Committee 1990 - 1995.
- Electrical Engineering Department, Distinguished Lecturer Committee, 1996 - 2004.
- Electrical Engineering Department Awards Committee, 2000, 2005, 2011, 2012.
- Performing and Visual Arts Task Force, 2000 – 2001
- College of Engineering Tenure and Promotion Committee, 2004 - 2006.
- Faculty Advisor to SPICMACAY, Indian Classical Music Society 1983-Present.
- Faculty Advisory Committee, ECE Department, 2015,2016,2017
- External Awards Committee, ECE Department 2015, 2016,2017,2018.
- Seminar Committee, ECE Department 2015, 2016,2017,2018.

REFERENCES

Prof. Boris Polyak
Institute of Control Sciences
Russian Academy of Science
Moscow, Russia
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Prof. Antonio Vicino
Dipartimento di Ingegneria dell'Informazione
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Dean of the College of Engineering and Computational Sciences
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Prof. J.W. Howze
Department of Electrical Engineering
Texas A&M University
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RESEARCH CONTRIBUTIONS

Bhattacharyya's research career began with his first paper in 1969. All his research work has been in the field of Control Systems. At several points in his career he discovered along with co-researchers, fundamental and surprising results that have had a transformative and path changing effect on the direction of the field. A brief description of each of these follows:

- A. In 1971, he was the first researcher to solve the Linear Multivariable Servomechanism problem, a central open problem in the field at that time. His solution used the newly emerging Geometric Approach to Multivariable Systems being developed by W.M. Wonham, was complete and general and was published with his Ph.D. advisor, J.B. Pearson. (Papers [1] [2] and [3] below).
1. S.P. Bhattacharyya and J.B. Pearson, "On the Linear Servomechanism Problem," Int. J. Control, Vol. 12, No.5, 1970, 795 - 806
 2. S.P. Bhattacharyya, J.B. Pearson, and W.M. Wonham, "On Zeroing the Output of a Linear System," Information and Control, Vol. 20, No.2, March 1972, pp. 135 - 142.
 3. S.P. Bhattacharyya and J.B. Pearson, "On Error Systems and the Servomechanism Problem," Int. J. Control, Vol. 15, No.6, 1972, pp. 1041 - 1062.
- B. In 1984, Kharitonov's Theorem, a new and startling result, inspired him to dive into the field of Robust Control. He pursued this subject for over ten years and developed many original and sharp results, including a useful generalization of Kharitonov's Theorem. The results were published in a research monograph, which has received glowing reviews, and is highly and

consistently cited ([Book [4] below, 816 citations, which is significant in a highly specialized field]).

4. S.P. Bhattacharyya, H. Chapellat, and L.H. Keel, *Robust Control: The Parametric Approach*, Prentice Hall, 1995.
- C. In 1997, he and his former student Keel published the seminal paper "Robust, Fragile or Optimal?" ([5] below) which proved the extreme fragility of most of the modern high order optimal controller designs. One positive effect of this was a substantial and critical rethinking of the modern control philosophy and its pitfalls. This well-cited paper (416 citations) changed the course of the field, revived the control community's interest in low order and low complexity controllers which continues till today and which will be an important and fundamental factor in large-scale systems.
5. L.H. Keel and S.P. Bhattacharyya, "Robust, Fragile or Optimal?" *IEEE Transactions on Automatic Control*, Vol. AC-42, No.8, pp. 1098-1106, August 1997. (Nominated for Axelby Prize.)
- D. Since the late 1990's he and his co-researchers have developed an extensive array of results on the low order control problem. The central place is occupied by the PID controller accounting for 99\% of the controllers in use in all industries. They have changed the landscape of PID control by introducing new and sharp theory and its computer-aided implementation to allow designers to automatically satisfy multiple specifications. These results are reported in three monographs (Books [6], [7], [8] below) and have generated much renewed interest in this area in the community.
6. A.Datta, M.T. Ho, and S.P. Bhattacharyya, *Structure and Synthesis of PID Controllers*. Springer-Verlag, *Advances in Industrial Control*, 2001.
 7. Guillermo J. Silva, A. Datta, and S.P. Bhattacharyya, *PID Controllers for Time-Delay Systems*, Birkhaeuser (*Control Engineering Series*), 2005.
 8. S.P. Bhattacharyya, A. Datta, and L.H. Keel, *Linear Control Theory: Structure, Robustness and Optimality*, Birkhauser, 2010.
- E. His current emphasis in research is to develop a model-free, data-driven approach to engineering design. In this area he and his coworkers have had two spectacular successes i) controller design directly from frequency response data without constructing an identified model ([9] below) and ii) a measurement based approach to circuits, systems and block diagrams which is a generalization and extension of Thevenin's Theorem to general linear systems [10]. This approach will have a large impact on the engineering field which is currently mired in models which are often unavailable in the real world.
9. L.H. Keel and S.P. Bhattacharyya, "Controller Synthesis Free of Analytical Models: Three Term Controllers," *IEEE Trans. Aut. Contr.*, Vol. 53(6), pp. 1353 - 1369, 2008 (Nominated for Axelby Prize, 2009 and 2010).

10. R.Layek, A.Datta and S.P.Bhattacharyya, "Linear Circuits: A Measurement Based Approach," Proc. of European Conference on Circuit Theory and Design, 2011, pp. 505 - 508, Linkoping, Sweden, September 2011.
- F. An important current line of research is Multivariable Controller design using low order output feedback control, without state variable models. State variables more often than not lack physical significance or even physical units and state feedback designs are in such cases unimplementable and meaningless. Recent results in this direction have been reported below in [11],[12],[13] and [14]. work is ongoing in this field which aims to bring the design capabilities of single-input single output systems to multivariable control systems:
11. L.H.Keel and S.P.Bhattacharyya "On the Stability of Multivariable Feedback Systems" Proc. Of the IEEE Conf. on Decision and Control, Osaka, Japan, Dec. 2015
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