

Clifford T. Mullis
Professor of Electrical and Computer Engineering
University of Colorado, Boulder, CO 80309

Education:

1971	Ph.D., University of Colorado, Boulder, (Thesis: "On Control with Limited Memory")
1968	M.S., University of Colorado, Boulder, (Thesis: "Finite Memory Decision Processes")
1966	B.S., University of Colorado, Boulder

Professional Career:

1999 – present	Associate Chair, Electrical and Computer Engineering University of Colorado, Boulder, CO
1990 - present	Professor of Electrical and Computer Engineering, University of Colorado, Boulder, CO
1977 - 1989	Associate Professor of Electrical and Computer Engineering, University of Colorado, Boulder, CO
1976 - 1977	Assistant Professor of Electrical and Computer Engineering, University of Colorado, Boulder, CO
1971 - 1973	Assistant Professor of Electrical Engineering, Princeton University, Princeton, NJ
1966 - 1970	Research Assistant, University of Colorado, Boulder, CO
1966	Engineer, Missiles and Space Systems Division, Douglas Aircraft Company, Huntington Beach, CA

Consulting:

U.S. Bureau of Mines, Denver Mining Research Center
Cobe Cardiovascular, Golden, CO
Colorado State University, Fort Collins, Colorado

Honors:

"Senior Award" of the IEEE Professional Group on Acoustics, Speech, and Signal Processing, 1976.

Graduate Students:

Richard V. Cox	Ph.D. 1974	Analysis and Design of Air Traffic Control Algorithms in the Near Terminal Area
David P. Kjosness	M.S. 1979	Control of High Speed Arithmetic Processor Applied to Digital Signal Processing
Thomas P. Chu	M.S. 1979	Local Optimization and the L_2 Approximation Problem
Ahmed F. Said	M.S. 1980	On Realizations for the Circulant Markov Chain Signal

Berel Barkeley	Ph.D. 1980	Three Tier Lattice Structures Generation Problem
Allan O. Steinhardt	M.S. 1981	Hybrid Spectral Estimation
William G. Smith	M.S. 1981	An Implementation of the Intel 2920 Signal Processor
Abdul Eshmawi	M.S. 1981	Low Roundoff Noise Digital Compensation for Control Systems
Mark Whitney	M.S. 1981	A Digital Filter Implementation
Lawrence P. Germann	M.S. 1981	Design of Real-Time Processors for Applications in Digital Signal Processing
Denis Henrot	Ph.D. 1982	Generalized Lattice Structures for Digital Filters
Lytle Johnson	M.S. 1984	Spectral Estimation
Jeffrey Best	M.S. 1985	Use of Wicat Unix System for Signal Processing Applications
Jean-Paul Franchitti	M.S. 1985	All-pass Filter Interpolation and Frequency Transformation Problems
Belkacem Derras	M.S. 1985	The Approximation of Discrete Time Linear Systems based on the use of Projections
John Godwin	M.S. 1986	Anaylsis of Guitar Spectra
Chris Zook	M.S. 1986	Spectral Analysis of Magnetic Recording Tape
Issa Mahboobi Panahi	Ph.D. 1988	Positivity Tests and a Class of Fir Filters: Applications in Spectral Estimation and System Identification
German Feyh	Ph.D. 1988	Newton Raphson Algorithms for Finite Parametric Problems
Belkacem Derras	Ph.D. 1988	Use of Projections & Performance Criteria in the Approximation of Linear Systems
Christian Fajre	M.S. 1991	Application of Hankel Forms in the L_∞ Approximation Problem
Knut C. Aas	Ph.D. 1993	Analysis and Synthesis of Filter Banks for Wavelet Decompositions and Subband Coding
Kenneth Duell	Ph.D. 1994	Statistical Techniques for Processing Nonstationary Signals: Wavelets and Decision Theory
Fed Ziel	Ph.D. 1995	Lattice Structures in Wavelet Analysis
Martin Renken	Ph.D. 1999	The Use of Signal Processing Techniques to Estimate Phase Response of Mechanical Materials

Grants:

Army Research Office, \$58,000/2 years -
 "Efficient Memory Systems" - September 1975 - October 1977.

Army Research Office, \$29,800/1 year -
 "Digital Filter Structures" - October 1977 - October 1978

NSF Equipment Grant, \$20,000/2.5 years -
 Experimental Signal Processing" - September 1977 - February 1979

Army Research Office, \$80,000/2 years -
 "Efficient Hardware Realizations of Digital Signal Processing" -
 October 1978 - October 1980

Army Research Office, \$230,000/4 years -
 "Efficient Realizations and Hardware Structures for Digital Signal Processing" -
 September 1980 - August 1983

Army Research Office, \$347,000/3 years -

“Digital Processing Structures for VLSI” - January 1984 - December 1986.

Army Research Office, \$345,000/3 years -

“Efficient VLSI Implementations of DSP Algorithms” - January 1983 - August 1987
(with R. A. Roberts).

Army Research Office, \$120,000/3 years -

“Real-Time Signal Processing” - January 1987 - December 1989
(with R. A. Roberts).

Office of Naval Research, \$407,000/3 years -

“Matched Subspace Filtering for Detection, Estimation, and Time Series Analysis” -
December 1992 - September 1995 (with L. L. Scharf).

Publications and Presentations:

“Memory Limitation in Decision Theory,” *Proc Hawaii Conf on Systems Science*, (January 1968).

“Memory

Limitation and Multistage Decision Processes,” *IEEE Trans on Systems Science and Cybernetics* **SSC-4**,
pp. 307 - 316 (September 1968) with R. A. Roberts.

“ M -ary Sequential Detection,” *Proc Hawaii Conf on Systems Science*, (January 1969).

“A Bayes Sequential Test of M Hypotheses,” *IEEE Trans on Inform Th* **IT-6**, pp. 91 - 93 (January 1970)
with R. A. Roberts.

“Sequential M -ary Detection with Finite Memory,” *Proc Princeton Conf on Information Sciences and
Systems*, Princeton, RI (April 1970).

“Time Optimal Discrete Regulator Gains,” *IEEE Trans Auto Contr* **AC-17**, pp. 265 - 266 (April 1972).

“Comments on Determining Whether Two Polynomials are Relatively Prime,” *IEEE Trans Auto Contr*
AC-17, pp. 271 - 272 (April 1972).

“Circulant Markov Chains as Digital Signal Sources,” *IEEE Trans Audio and Electro Acoustics* **AU-20**,
pp. 271 - 272 (October 1972) with K. Steiglitz.

“On the Controllability of Discrete Linear Systems with Output Feedback,” *IEEE Trans Auto Contr* **AC-
18**, pp. 608 - 617 (December 1973).

“Finite Memory Problems and Algorithms,” *IEEE Trans Inform Th* **IT-20**, pp. 440 - 455 (July 1974) with
R. A. Roberts.

“Filter Structures which Minimize Roundoff Noise,” *Proc IEEE Int Conf on Acoustics, Speech, and Signal
Processing*, Philadelphia (April 1976).

“The Use of Second Order Information in the Approximation of Discrete-Time Linear Systems,” *IEEE
Trans ASSP* **ASSP-24**, pp. 226 - 238 (June 1976) with R. A. Roberts.

“Synthesis of Minimum Roundoff Noise Fixed Point Digital Filters,” *IEEE Trans Circ Sys* **CAS-23**, pp.
551 - 562 (September 1976) with R. A. Roberts.

“New Invariants for the Design of Low Roundoff Noise Digital Filters,” *Proc Tenth Asilomar Conf on
Circuits, Systems, and Computers* (November 1976) with R. A. Roberts.

“Roundoff Noise in Digital Filters: Frequency Transformations and Invariants,” *IEEE Trans ASSP ASSP-24*, pp. 538 - 550 (December 1976) with R. A. Roberts.

“On Digital Filter Realizations and Overflow Oscillations,” *Proc Int Conf on Acoustics, Speech, and Signal Processing*, (April 1978).

“Digital Filters without Overflow Oscillations,” *IEEE Trans ASSP ASSP-26:4*, pp. 334 - 338 (August 1978) with W. L. Mills and R. A. Roberts.

“Normal Realizations of Fixed Point Digital Filters,” *Proc Twelfth Asilomar Conf on Circuits, Systems and Computers*, (November 1978).

“Normal Realizations of IIR Digital Filters,” *Proc 1979 Intl Conf on Acoustics, Speech, and Signal Processing*, pp. 340 - 343 (April 1979) with R. A. Roberts and W. Mills.

“On Weak Equivalence of Linear Systems and Finite State Machines,” *SIAM Journal on Mathematical Analysis* **10** (May 1979) with R. A. Roberts.

“An Iterative Estimation Technique for Power Spectra by an ARMA Model,” *Proc Intl Conf on Acoustics, Speech, and Signal Processing*, Denver, CO, pp. 622 - 625 (April 1980).

“A Modular Hardware Structure for Digital Filtering,” *Proc Intl Conf on Acoustics, Speech, and Signal Processing*, Denver, CO, pp. 780 - 783 (April 1980) with R. A. Roberts and M. Arjmand.

“Low Roundoff Noise and Normal Realizations of Fixed Point IIR Digital Filters,” *IEEE Trans ASSP ASSP-29*, pp. 893 - 903 (August 1981) with W. L. Mills and R. A. Roberts.

“A Microseismic System for Monitoring Slope Stability,” Report # RI 8641 U.S. Bureau of Mines (January 1982) with M. Lepper and A. Poland.

“Power Spectral Estimation Using ARMA Models,” *Proc Inst of Acoustics*, “Spectral Analysis and Its Use in Underwater Acoustics,” Imperial College, London (April 1982) with R. A. Roberts.

“Digital Filter Structures for VLSI,” *Proc USC Workshop on VLSI and Modern Signal Processing*, Los Angeles (November 1982).

“An Interpretation of Error Spectrum Shaping in Digital Filters,” *IEEE Trans ASSP ASSP-30:6*, pp. 1013 - 1016 (December 1982) with R. A. Roberts.

“A Modular and Orthogonal Digital Filter Structure for Parallel Processing,” *IEEE Int Conf on Acoustics, Speech, and Signal Processing*, pp. 623 - 626 (April 1983) with D. Henrot.

“Digital Processing Structures for VLSI,” *Proceedings of the ICASSP '84 Conference*, San Diego, CA (March 1984) with R. A. Roberts.

“Digital Processing Algorithms for VLSI,” *VLSI Signal Processing*, (New York: IEEE Press, 1984) with R. A. Roberts.

Three day short course in Digital Signal Processing, presented at GTE Network Systems, Aurora, CO (June 1984).

“Digital Processing Structures for VLSI,” *Proceedings of the ICASSP '85 Conference*, Tampa, FL (April 1985) with R. A. Roberts.

“Orthogonal Filters for VLSI Implementation,” *Proceedings of the 19th Asilomar Conference on Circuits, Systems, and Computers*, Pacific Grove, CA (November 1985) with R. A. Roberts.

“Internal Projections for Rank Reduction in Linear Dynamical Systems,” *Proceedings of the 19th Asilomar Conference on Circuits, Systems, and Computers*, Pacific Grove, CA (November 1985) with L. L. Scharf.

“The Jury Matrix and a Newton-Raphson Procedure for MA Spectral Fabrication,” *Proceedings of the 20th Asilomar Conference on Circuits, Systems, and Computers*, Pacific Grove, CA (November 1986) with C. J. Demeure.

“All-Pass Filter Interpolation Frequency Transformation Problem,” *Proceedings of the 20th Asilomar Conference on Circuits, Systems, and Computers*, Pacific Grove, CA (November 1986) with G. Feyh and J. Franchitti.

Digital Signal Processing, Addison-Wesley 1987; 600 pages, with R. A. Roberts.

“Wiener, Newton, Euclid, Spectral Factorization,” presented at the ECE Graduate Seminar (March 1987).

“An Extension of the Schur Algorithm for Frequency Transformations,” *Proceedings of the MTNS-87*, with W. B. Jones and G. Feyh (1987).

“Efficient Algorithms & Structures for Digital Signal Processing,” short course at the Universitat Politecnica de Catalunya, Barcelona, Spain (September 1987).

“Rational Approximation with Internal Projections,” *Proceedings of the Twenty-First Annual Asilomar Conference on Circuits, Systems, and Computers*, Pacific Grove, CA (November 1987).

“A Technique for the Construction of Fast Algorithms for Linear Equation Solving and LV Factorization,” *Proceedings of the Twenty-First Annual Asilomar Conference on Circuits, Systems, and Computers*, Pacific Grove, CA (November 1987) (with G. Feyh).

“IIR Filter Design Using a Parallel Connection of Orthogonal Allpass Filters,” *Proceedings of the Twenty-First Annual Asilomar Conference on Circuits, Systems, and Computers*, Pacific Grove, CA (November 1987) (with S. Palm and R. A. Roberts).

“Moving Average Separation,” *Transactions of the International Conference on Acoustics, Speech, and Signal Processing*, New York (April 1988) (with G. Feyh).

“Inverse Eigenvalue Problem for Real Symmetric Toeplitz Matrices,” *Transactions of the International Conference on Acoustics, Speech, and Signal Processing*, New York (April 1988) (with G. Feyh).

“On the Fast Computation of Cross-Covariance and Auto-Covariance Sequences,” *Transactions of the International Conference on Acoustics, Speech, and Signal Processing*, New York (April 1988) (with C. Demeure).

“On the Design of Orthogonal Digital Filters,” *Proceedings of the Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA (November 1988) with R. A. Roberts.

“The Euclid Algorithm and the Fast Computation of Cross-Covariance and Auto-Covariance Sequences,” *IEEE Trans ASSP ASSP-37*:4, pp. 545 - 552, April 1989 (with C. Demeure).

“Fast Newton-Raphson Method for Moving Average Spectral Factorization,” *Proceedings of XIIth GRETSI Colloque*, Juan-Les-Pins, France, June 1989 (with C. Demeure).

“State-Space Model Reduction Using Internal Projections,” submitted to *IEEE Trans Automatic Control*, November 1989 (with B. Derras).

“Quadratic Estimators of the Power Spectrum,” Digital Signal Processing Technical Report, University of Colorado (January 1990), with L. Scharf.

“Generalized Moving Average Spectral Factorization,” submitted to the Vth Eusipco Conference, Barcelona, Spain, September 1990 (with C. Demeure).

“A Newton-Raphson Method for Moving-Average Spectral Factorization,” *IEEE Trans on ASSP* **38**:10, pp. 1697 - 1709 (October 1990), with C. J. Demeure.

“Quadratic Estimators of the Power Spectrum,” Chapter One of *Advances in Spectrum Estimation*, Simon Haykin, ed., Englewood Cliffs, NJ: Prentice Hall, 1990 (with L. L. Scharf).

“Quadratic Estimators of the Frequency-Wavenumber Spectrum,” *Proc 1990 ICASSP Conf*, Toronto, Ont. (May 1991), with M. Clark and L. Scharf.

“A Computational Toolkit for Applied V-Transforms,” *Proc Asilomar Conf on Signals, Systems, and Computers*, Asilomar, CA (November 1991), with M. Spurbeck.

“Characterization and Design of Wavelet Generating Filters,” submitted to *IEEE Trans Signal Proc* (December 1991), with K. Aas and K. Duell.

“The Application of the Spectral Decomposition of Hankel Matrices to L^∞ Extension and Approximation Problems,” submitted to *IEEE Trans Signal Proc* (December 1991), with C. Fajre.

Digital Signal Processing, Second Edition, (Englewood Cliffs, NJ: Prentice Hall, 1991), with R. Roberts.

“A Unified Approach to System Approximation,” *AMSE Journ* **23**:1, 29 - 48 (1991), with B. Derras.

“The L^∞ Wiener Problem: An Application of the L^∞ Extension Problem,” EUSIPCO 92 Conference, Brussels, Belgium (August 1992), with C. Fajre.

“Quadratic Estimators of the Power Spectrum using Orthogonal Time-Division Multiple Windows,” *IEEE Trans Signal Proc* **41**:1, 222 - 231 (January 1993), with M. Clark.

“Synthesis of Extremal Wavelet-Generating Filters Using Gaussian Quadrature,” *IEEE Trans Signal Proc* **43**:5, 1045 - 1058 (May 1995), with K. Aas and K. Duell.

“Minimum Mean-Squared Error Transform Coding and Subband Coding,” *IEEE Trans Information Theory* **42**:4, 1179 - 1192 (July 1996), with K. Aas.

“Least Squares Approximation of Perfect Reconstruction Filter Banks,” *IEEE Trans Signal Proc* **46**:4, 968-978 (April 1998), with M. Spurbeck.

“Lag-Windowing and Multiple-Data-Windowing Are Roughly Equivalent for Smooth Spectrum Estimation”, *IEEE Trans Signal Proc* **47**:3, 839-842 (March 1999), with L. L. Scharf and M. L. McCloud.

“Canonical Coordinates and the Geometry of Inference, Rate, and Capacity”, *IEEE Trans Signal Proc* **48**:3, 824-831 (March 2000), with L. L. Scharf

