#### Introduction

### Part 1–Digital

#### A. Fundamentals

- 1. The Equivalence of Digital and Analog Signal Processing, K Information and Control, 1965
- 2. Design Methods for Sampled Data Filters, J. F. Kaiser Proceedings of the 1st Annual Allerton Conference on Circ
- 3. The Design of Digital Filters, A. J. Gibbs Australian Telecommunications Research Journal, May 1
- 4. Digital Filter Design Techniques in the Frequency Domain, *Proceedings of the IEEE*, February 1967
- Nonlinear Filtering of Multiplied and Convolved Signals, A Jr.

#### Proceedings of the IEEE, August 1968

- 6. Theory and Implementation of the Discrete Hilbert Transfor Proceedings of the Polytechnic Institute of Brooklyn Sym
- 7. Spectral Transformations for Digital Filters, A. G. Constantin Proceedings of the Institute of Electronics Engineers, Aug
- 8. A Note on Digital Filter Synthesis, B. Gold and K. L. Jordan Proceedings of the IEEE, October 1968
- 9. Digital Filtering Via Block Recursion, H. B. Voelcker and E. IEEE Transactions on Audio and Electroacoustics, June 1
- 10. A General Theorem for Signal-flow Networks, with Applicat Archiv für Elektronik und Übertragungstechnik, 1971

#### B. Basic Design-Infinite Impulse Response Filters

- 1. Digital Filters with Equiripple or Minimax Responses, H. D. IEEE Transactions on Audio and Electroacoustics, March
- 2. Time Domain Design of Recursive Digital Filters, C. S. Burru IEEE Transactions on Audio and Electroacoustics, June 1
- 3. Computer-Aided Design of Recursive Digital Filters, K. Steig IEEE Transactions on Audio and Electroacoustics, June 1

### C. Basic Design-Finite Impulse Response Filters

- 1. Techniques for Designing Finite-Duration Impulse-Response IEEE Transactions on Communication Technology, April
- 2. An Approach to the Approximation Problem for Nonrecur McGonegal
  - IEEE Transactions on Audio and Electroacoustics, June 1
- 3. Design of Nonrecursive Digital Filters with Linear Phase, O. *Electronics Letters*, May 28, 1970
- 4. Design of Nonrecursive Digital Filters with Minimum Phase, Electronics Letters, May 28, 1970
- 5. A New Technique for the Design of Nonrecursive Digital Fil Proceedings of the 5th Annual Princeton Conference on I
- 6. On Optimum Nonrecursive Digital Filters, E. Hofstetter, A. V Proceedings of the 9th Annual Allerton Conference on Cir
- 7. On the Approximation Problem in Nonrecursive Digital Filte IEEE Transactions on Circuit Theory, May 1971
- 8. The Design of Wide-Band Recursive and Nonrecursive Digital Dif IEEE Transactions on Audio and Electroacoustics, June 1970

# Contents

	1
l Filters	
Steiglitz	7
rouit and Sustam Theory, 1062	20
	35
970 C. M. Rader and B. Gold	43
A. V. Oppenheim, R. W. Schafer, and T. G. Stockham,	66
rm, B. Gold, A. V. Oppenheim, and C. M. Rader apposium on Computer Processing in Communications	94
nides ust 1970	110
1	116
E. Hartquist 970	118
cions, A. Fettweis	126
Helms	131
1971 us and T. W. Parks	138
970 glitz 970	143
Digital Filters, L. R. Rabiner	150
sive Digital Filters, L. R. Rabiner, B. Gold, and C. A.	158
970 Herrmann	182
O. Herrmann and W. Schüssler	185
ters, E. Hofstetter, A. V. Oppenheim, and J. Siegel nformation Sciences and Systems, 1970	187
V. Oppenheim, and J. Siegel rcuit and System Theory, 1971	195
er Design, O. Herrmann	202
I Differentiators, L. R. Rabiner and K. Steiglitz	204

D. Structures	
1. An Approach to the Implementation of Digital Filters, L. B. Jackson, J. F. Kaiser, and H. S. McDonald IEEE Transactions on Audio and Electroacoustics, September 1968	210
2. Variable Digital Filters, W. Schüssler and W. Winkelnkemper	219
Archiv für Elektronik und Übertragungstechnik, 1970	
Part 2—The Fast Fourier Transform	
A. History and Fundamentals	
1. An Algorithm for the Machine Calculation of Complex Fourier Series, J. W. Cooley and J. W. Tukey <i>Mathematics of Computation</i> , 1965	223
<ol> <li>A Guided Tour of the Fast Fourier Transform, G. D. Bergland IEEE Spectrum, July 1969</li> </ol>	228
3. What is the FFT?, IEEE Group on Audio and Electroacoustics Subcommittee on Measurement Concepts IEEE Transactions on Audio and Electroacoustics, June 1967	240
<ol> <li>The Finite Fourier Transform, J. W. Cooley, P. A. Lewis, and P. D. Welch IEEE Transactions on Audio and Electroacoustics, June 1969</li> </ol>	251
5. Historical Notes on the Fast Fourier Transform, J. W. Cooley, P. A. Lewis, and P. D. Welch IEEE Transactions on Audio and Electroacoustics, June 1967	260
B. Programming and Algorithms	
<ol> <li>A Method for Computing the Fast Fourier Transform with Auxiliary Memory and Limited High-Speed Storage, R. C. Singleton</li> </ol>	263
IEEE Transactions on Audio and Electroacoustics, June 1967	
2. The Fast Fourier Transform Algorithm: Programming Considerations in the Calculation of Sine, Cosine, and Laplace Transforms, J. W. Cooley, P. A. Lewis, and P. D. Welch	2/1
3. An Algorithm for Computing the Mixed Radix Fast Fourier Transform, R. C. Singleton	294
4. An Adaptation of the Fast Fourier Transform for Parallel Processing, M. C. Pease	305
<ol> <li>A Linear Filtering Approach to the Computation of Discrete Fourier Transform, L. I. Bluestein IEEE Transactions on Audio and Electroacoustics. December 1970</li> </ol>	317
6. The Chirp Z-Transform, L. R. Rabiner, R. W. Schafer, and C. M. Rader IEEE Transactions on Audio and Electroacoustics, June 1969	322
7. Discrete Fourier Transforms When the Number of Data Samples Is Prime, C. M. Rader Proceedings of the IEEE, June 1968	329
C. Correlation, Convolution, and Spectral Analysis	
1. High-Speed Convolution and Correlation, T. G. Stockham, Jr. AFIPS Conference Proceedings, 1966 Spring Joint Computer Conference	330
2. The Use of Fast Fourier Transform for the Estimation of Power Spectra: A Method Based on Time Averaging Over Short, Modified Periodograms, P. D. Welch	335
IEEE Transactions on Audio and Electroacoustics, June 1967	
3. An Improved Algorithm for High Speed Autocorrelation with Applications to Spectral Estimation, C. M. Rader IEEE Transactions on Audio and Electroacoustics, December 1970	339
4. Computation of Spectra with Unequal Resolution Using the Fast Fourier Transform, A. V. Oppenheim, D. Johnson, and K. Steiglitz	342
Proceedings of the IEEE, February 1971	~ • •
5. A Bound on the Output of a Circular Convolution with Application to Digital Filtering, A. V. Oppenheim and C. J. Weinstein	344
D. Hardware	0.10
1. Fast Fourier Transform Hardware Implementations—An Overview, G. D. Bergland IEEE Transactions on Audio and Electroacoustics, June 1969	349
2. A Pipeline Fast Fourier Transform, H. L. Groginsky and G. A. Works IEEE Transactions on Computers, November 1970	354

## Part 3–Effects of Finite Word Lengths

1. Effect of Finite Word Length on the Accuracy of Digital Filte
2 Some Practical Considerations in the Realization of Linear Did
Proceedings of the 3rd Annual Allerton Conference on Circ
3 Effects of Parameter Quantization on the Poles of a Digital Fil
Proceedings of the IEEE. May 1967
4. On the Approximation Problem in the Design of Digital Filt
Schüssler
Archiv für Elektronik und Übertragungstechnik, 1970
5. On the Accuracy Problem in the Design of Nonrecursive Digit
Archiv für Elektronik und Übertragungstechnik, 1970
6. On the Interaction of Roundoff Noise and Dynamic Range in
Bell System Technical Journal, February 1970
7. Roundoff-Noise Analysis for Fixed-Point Digital Filters Realiz
IEEE Transactions on Audio and Electroacoustics, June 19
8. A Comparison of Roundoff Noise in Floating Point and Fixe
and A. V. Oppenheim
Proceedings of the IEEE, June 1969
9. Realization of Digital Filters Using Block-Floating-Point Arith
10 An Analysis of Limit Cycles Due to Multiplication Rounding
Proceedings of the 7th Annual Allerton Conference on Circ
11 Overflow Oscillations in Digital Filters P M Ebert I E Maz
Rell System Technical Journal November 1969
12 A Fixed-Point Fast Fourier Transform Error Analysis, P. D. W
IEEE Transactions on Audio and Electroacoustics. June 19
13. Roundoff Noise in Floating Point Fast Fourier Transform Con
IEEE Transactions on Audio and Electroacoustics, Septem
14. A-D and D-A Converters: Their Effect on Digital Audio Fideli
Proceedings of the 41st Convention of the Audio Engineeri
15. A Digital Frequency Synthesizer, J. Tierney, C. M. Rader and
IEEE Transactions on Audio and Electroacoustics, March 1
Bibliography
Author Index
Subject Index
Editors' Biographies

ers—A Review, B. Liu	361
igital Filters, J. F. Kaiser cuit and Svstem Theory . 1965	369
ilter, C. M. Rader and B. Gold	381
ters with Limited Wordlength, E. Avenhaus and W.	383
tal Filters, O. Herrmann and W. Schüssler	385
n Digital Filters, L. B. Jackson	387
ized in Cascade or Parallel Form, L. B. Jackson 970	413
ked Point Digital Filter Realization, C. J. Weinstein	429
hmetic, A. V. Oppenheim 970	432
in Recursive Digital (Sub) Filters, L. B. Jackson <i>cuit and System Theory</i> , 1969	439
zo, and M. G. Taylor	448
Velch 969	470
omputation, C. J. Weinstein Iber 1969	477
lity, T. G. Stockham, Jr.	484
d B. Gold 1971	497
	506
	513
	514
	518