

# Preface

This book gives engineers and other technical innovators the foundation and facts they need to construct and implement fast Fourier transforms (FFTs) that synthesize, recognize, enhance, compress, modify, or analyze signals. Because of special integrated circuits, known as digital signal processing (DSP) chips, a wide array of applications is affordably done, from magnetic resonance imaging (MRI) to Doppler weather radar. Increased demand for wireless communication, multimedia, and consumer products has created the need for high-volume, low-cost, multifunction, DSP-based products that use FFTs for their signal processing or data manipulation.

In 1974, E. Oran Brigham lived and worked in the small East Texas town of Greenville. He was employed by a little-known aerospace company named E-Systems, Inc. when his 230-page book, *The Fast Fourier Transform* [1], was published. Over the years it has helped thousands of engineers learn the fundamentals of that analytical tool. After moving to Greenville in 1991 for Win to join E-Systems, we decided to write a book that continued the efforts begun here two decades before—putting practical information about FFTs into the hands of practicing professionals and engineering students.

The explosion of digital products, ignited by the proliferation of integrated circuits in the 21 years since Brigham's book came out, marks the coming of age for computing FFTs. Because of personal computers, with chips or plug-in boards for doing DSP functions, including FFTs, thousands of engineers, scientists, and students now work with and develop new FFT techniques and products. The National Information Infrastructure, popularly called "The Information Superhighway," and other digital-based goods and services now provide the impetus for sophisticated new products, once driven by the Department of Defense.

The book addresses the following areas of real-time FFT implementation:

- How to compute an FFT of any length with a wide variety of algorithms
- How to convert algorithms to assembly or high-level language code
- How to map algorithms onto several architectures

- How to select DSP chips and commercial off-the-shelf (COTS) boards for FFT applications
- How to detect and isolate errors in every phase of development

The goal of the book is to provide a single-source reference for the elements used in programming real-time FFT algorithms on DSP and special-purpose chips. It uses a building-block approach to constructing several FFT algorithms. Extensive use is made of examples and spreadsheet-style comparison charts. With hundreds of figures, tables, and Algorithm Steps, its practical features are geared to assist design engineers, scientists, researchers, and students. The book may even open the design of FFT-based products to innovators with no prior FFT experience, if they have microprocessor programming, engineering, or mathematics backgrounds. Though useful as a handy reference book by topic, it is laid out in a logical sequence that can be a textbook for a course on applied FFTs.

Sid Burrus's and Tom Park's book *DFT/FFT and Convolution Algorithms* [2], written a decade ago, met the mushrooming hunger of engineers for TMS32010 code, which would make it easier to use the new Texas Instruments chip for computing FFT algorithms. Mainstream applications for consumer products incorporating FFTs, precipitated by recent advances in integrated circuits, especially ASICs, have fostered a need to:

- Create versatile FFT algorithms of any length, to overcome the power-of-two constraints
- Understand how to map algorithms efficiently onto single and multiprocessor architectures
- Program in assembly language to optimize [3] code, in order to reduce power consumption and lower the cost of high-volume consumer products
- Shorten the design cycle and lower development costs to compete in global markets

Unique features include:

- Performance measure Comparison Matrices for selection of weighting functions, algorithm building blocks, algorithms, algorithm mappings, arithmetic formats, and DSP chips
- Extensive algorithm examples, with step-by-step instructions for memory mapping and conversion to high-level or assembly language code
- A "generic" programmable DSP chip block diagram, to which 24 chip vendor block diagrams are standardized and compared, to illustrate differences that affect FFT performance
- Unbiased description of the FFT-related features of 51 fixed-point DSP chips, including ASIC and multiple-processor chips, 13 floating-point DSP chips, and 6 dedicated FFT chips
- Test signals with instructions and examples for detecting and isolating errors during FFT algorithm development, code development and debugging, and product operation
- A list of questions and answers for selecting COTS boards
- Four design examples that do frequency analysis, power spectrum estimation, linear filtering, and two-dimensional processing

Win's 28-year DSP career in both military and commercial companies, teaching courses and seminars nationwide, has repeatedly shown him that engineers need to be able to work easily with any length of FFTs to do real-time signal conversion and analysis. Joanne's 12 years experience as founder and president of two DSP companies has given her exposure to the rapidly changing technology, market, and economic realities of this industry. Coauthoring a book seemed the logical way to combine our diverse talents and complementary perspectives to comprehensively address the topic of real-time fast Fourier transform algorithms.

This book is only one of several tools for expanding the knowledge base of the DSP community. A service called DSP Net provides access to the latest vendor information in this field through InterNet. *DSP and Multimedia Technology* magazine addresses this growing market, as do two annual applications-oriented conferences—DSPx and the International Conference on Signal Processing Applications & Technology. The IEEE International Conference on Acoustics, Speech and Signal Processing holds its 20th annual gathering in 1995. The chip vendors have free bulletin boards for algorithms, code, and other pertinent information. Additional information on resources available to design engineers should be sent to the authors, in care of the publisher, for possible inclusion in follow-up publications.

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## REFERENCES

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