

MIXED SIGNAL PROCESSING DESIGN SEMINAR

INTRODUCTION TO MIXED SIGNAL PROCESSING OF
REAL-WORLD SIGNALS AND SIGNAL CONDITIONING

1

LINEAR AND NON-LINEAR ANALOG SIGNAL PROCESSING

2

FUNDAMENTALS OF SAMPLED DATA SYSTEMS

3

ADCs FOR DSP APPLICATIONS

4

DACs FOR DSP APPLICATIONS

5

SIGMA-DELTA ADCs AND DACs

6

DIGITAL SIGNAL PROCESSING TECHNIQUES

7

DSP HARDWARE

8

INTERFACING ADCs AND DACs TO
DIGITAL SIGNAL PROCESSORS

9

MIXED SIGNAL PROCESSING APPLICATIONS

10

MIXED SIGNAL CIRCUIT TECHNIQUES

11

INDEX

ACKNOWLEDGEMENTS

Thanks are due the many technical staff members of Analog Devices in Engineering and Marketing who provided invaluable inputs during the preparation of this seminar. Particular credit is due Bob Fine for his contributions to the DSP material, James Bryant for the Techniques section, and Hank Zumbahlen for the analog filtering section. Principal technical reviewers were James Bryant, Bob Clarke, Bob Fine, Doug Grant, Chris Hyde, Ron Mancini, Paul Brokaw, and Hank Zumbahlen. Personal thanks goes to Dave Kress and Chris Hyde who both provided much-needed guidance and encouragement during this project.

Layout, typesetting, and many of the illustrations were prepared by Linda Grimes Brandon of Brandon's WordService. Camera-ready artwork was supplied by Ernie Lehtonen of the Analog Devices' art department. Printing was done by R. R. Donnelley and Sons, Inc.

Walt Kester
1991

Copyright © 1991 by Analog Devices, Inc.
Printed in the United States of America

All rights reserved. This book, or parts thereof, must not be reproduced in any form without permission of the copyright owner.

Information furnished by Analog Devices, Inc., is believed to be accurate and reliable. However, no responsibility is assumed by Analog Devices, Inc., for its use.

Analog Devices, Inc., makes no representation that the interconnections of its circuits as described herein will not infringe on existing or future patent rights, nor do the descriptions contained herein imply the granting of licenses to make, use, or sell equipment constructed in accordance therewith.

Specifications are subject to change without notice.

ISBN-0-916550-08-7

ANALOG DEVICES MIXED SIGNAL PROCESSING DESIGN SEMINAR

SECTION I

INTRODUCTION TO MIXED SIGNAL PROCESSING OF REAL-WORLD SIGNALS AND SIGNAL CONDITIONING

ORIGINS OF REAL-WORLD SIGNALS AND THEIR UNITS OF MEASUREMENTS

REASONS FOR PROCESSING REAL-WORLD SIGNALS

GENERATION OF REAL-WORLD SIGNALS

**METHODS AND TECHNOLOGIES AVAILABLE FOR PROCESSING REAL-WORLD
SIGNALS**

ANALOG VERSUS DIGITAL SIGNAL PROCESSING

AMPLIFIERS USED AS SIGNAL CONDITIONERS

DIFFERENTIAL AND INSTRUMENTATION AMPLIFIERS

LINE DRIVERS AND RECEIVERS

ISOLATION AMPLIFIERS

SECTION II

LINEAR AND NON-LINEAR ANALOG SIGNAL PROCESSING

AMPLIFIERS USED AS ANALOG SIGNAL PROCESSORS

DISK DRIVE READ AMPLIFIERS

ANALOG MULTIPLIERS

RMS TO DC CONVERTERS

LOGARITHMIC AMPLIFIERS

VARIABLE GAIN AMPLIFIER (ULTRASOUND APPLICATION)

PASSIVE AND ANALOG FILTERING:

ANTIALIASING FILTER DESIGN EXAMPLE, A PROGRAMMABLE STATE VARIABLE FILTER, SEVEN-POLE FDNR 20KHZ ANTIALIASING FILTER, WIDEBAND SALLEN-KEY FILTER

SECTION III

FUNDAMENTALS OF SAMPLED DATA SYSTEMS

A TYPICAL DSP SAMPLED DATA SYSTEM

DISCRETE TIME SAMPLING OF ANALOG SIGNALS

SELECTION OF ANTIALIASING FILTER

OVERSAMPLING AND DECIMATION

UNDERSAMPLING AND ITS APPLICATIONS

EFFECTS OF FINITE AMPLITUDE RESOLUTION DUE TO QUANTIZATION

QUANTIZATION THEORY, SIGNAL TO NOISE RATIO, AND EFFECTIVE BITS

SELECTION OF ADC RESOLUTION BASED ON SIGNAL DYNAMIC RANGE

ADC STATIC TRANSFER CHARACTERISTICS

DAC STATIC TRANSFER CHARACTERISTICS

ADC DYNAMIC PERFORMANCE:

SIGNAL TO NOISE RATIO AND EFFECTIVE BITS, PEAK SPURIOUS, PEAK HARMONIC

CONTENT, SPURIOUS FREE DYNAMIC RANGE, TOTAL HARMONIC DISTORTION, FULL POWER BANDWIDTH, FULL-LINEAR BANDWIDTH, INTERMODULATION DISTORTION (IMD), AC LINEARITY PLOTS USING HISTOGRAMS, APERTURE DELAY TIME (OR EFFECTIVE APERTURE DELAY TIME), APERTURE JITTER, TRANSIENT RESPONSE OR SETTLING TIME, OVERVOLTAGE RECOVERY

DAC DYNAMIC PERFORMANCE:

SETTLING TIME, GLITCH IMPULSE AREA, HARMONIC DISTORTION, DEGLITCHING DACs USING SHAs, $\sin(X)/X$ FREQUENCY ROLLOFF EFFECT

SWITCHED CAPACITOR FILTERS

SECTION IV

ADCs FOR DSP APPLICATIONS

SUCCESSIVE APPROXIMATION ADCs

FLASH ADCs

SUBRANGING ADCs

INTEGRATING (DUAL SLOPE) ADCs

SECTION V

DACs FOR DSP APPLICATIONS

DAC ARCHITECTURES

GLITCH REDUCTION BY SEGMENTATION

GLITCH REDUCTION BY DIGITAL OFFSET

DEGLITCHING DACs WITH TRACK-AND-HOLDS

MULTIPLYING DACs

LOGDACs

SECTION VI

SIGMA-DELTA ADCs AND DACs

SIGMA-DELTA OVERVIEW

OVERSAMPLING

SIGMA-DELTA MODULATORS AND QUANTIZATION NOISE SHAPING

DIGITAL FILTERING AND DECIMATION

IDLING PATTERNS AND TONAL CONSIDERATIONS FOR SIGMA-DELTA ADCs

HIGHER ORDER MODULATOR LOOPS

DESCRIPTION OF AD1879 18 BIT SIGMA-DELTA AUDIO ADC

SIGMA-DELTA ADCs FOR LOW FREQUENCY MEASUREMENT APPLICATIONS

SIGMA-DELTA DACs

THE ADSP-28msp02 SIGMA-DELTA CODEC

MULTISTAGE NOISE SHAPING (MASH) SIGMA-DELTA CONVERTERS

MULTI-BIT SIGMA-DELTA CONVERTERS

SIGMA-DELTA SUMMARY

SECTION VII

DIGITAL SIGNAL PROCESSING TECHNIQUES

DIGITAL FILTERING:

FINITE IMPULSE RESPONSE (FIR) FILTERS, THE DUALITY OF THE TIME AND FREQUENCY DOMAIN, FIR FILTER IMPLEMENTATION IN DSP HARDWARE USING CIRCULAR BUFFERING, FIR FILTER DESIGN TECHNIQUES, FILTER DESIGN USING CAD TECHNIQUES, DESIGN EXAMPLE FOR AN FIR DIGITAL AUDIO FILTER USING CAD PROGRAM, INSURING LINEAR PHASE IN FIR FILTERS, DECIMATION USING FIR FILTERS, INFINITE IMPULSE RESPONSE (IIR) DIGITAL FILTERS, SUMMARY: FIR VERSUS IIR FILTERS

FAST FOURIER TRANSFORMS:

FFT HARDWARE IMPLEMENTATION, FFT DESIGN CONSIDERATIONS, SPECTRAL LEAKAGE AND WINDOWING, DATA SCALING AND BLOCK FLOATING POINT

SECTION VIII

DSP HARDWARE

RISC VERSUS CISC VERSUS DSP ARCHITECTURES

RISC AND DSP APPLICATIONS

DSP PROCESSOR REQUIREMENTS:

FAST ARITHMETIC, ZERO OVERHEAD LOOPING, EXTENDED DYNAMIC RANGE, DUAL OPERAND FETCH, CIRCULAR BUFFERS

ADSP-2101 MICROCOMPUTER GENERAL DESCRIPTION

ADSP-2101 ARCHITECTURE OVERVIEW:

ARITHMETIC LOGIC UNIT (ALU), MULTIPLIER/ACCUMULATOR (MAC),
SHIFTER, DATA ADDRESS GENERATORS (DAGS), PROGRAM SEQUENCER,
SERIAL PORTS, SYSTEM INTERFACE

DEVELOPMENT SYSTEM

SECTION IX

INTERFACING ADCs AND DACs TO DIGITAL SIGNAL PROCESSORS

**PARALLEL INTERFACING TO DSP PROCESSORS: READING DATA FROM
MEMORY-MAPPED PERIPHERAL ADCs**

PARALLEL ADC TO DSP INTERFACE

**PARALLEL INTERFACING TO DSP PROCESSORS: WRITING DATA TO
MEMORY-MAPPED DACs**

PARALLEL DAC TO DSP INTERFACE

SERIAL INTERFACING TO DSP PROCESSORS:

SERIAL ADC TO DSP INTERFACE, SERIAL DAC TO DSP INTERFACE

INTERFACING I/O PORTS AND CODECS TO DSPs

SERIAL VERSUS PARALLEL DSP INTERFACE SUMMARY

SECTION X

MIXED SIGNAL PROCESSING APPLICATIONS

HIGH PERFORMANCE MODEMS:

V.32 MODEM OVERVIEW, V.32 MODEM TRANSMITTER, V.32 MODEM
RECEIVER, I/O PORTS AND CODECS FOR V.32 MODEMS

DIGITAL MOBILE RADIO:

OVERVIEW, THE GSM SYSTEM, SPEECH CODEC, DISCONTINUOUS
TRANSMISSION (DTX), GSM SYSTEM UPCONVERSION AND
DOWNCONVERSION

DIGITAL AUDIO STUDIO RECORDING

COMPACT DISC (CD) PLAYER ELECTRONICS

SECTION XI MIXED SIGNAL CIRCUIT TECHNIQUES

INTRODUCTION

RESISTANCE:

RESISTANCE OF CONDUCTORS, SKIN EFFECT, VOLTAGE DROP IN SIGNAL LEADS-KELVIN FEEDBACK, LEAKAGE IN INSULATORS, GUARD RINGS, ELECTROSTATIC DAMAGE, PARASITIC EFFECTS IN RESISTORS, INDUCTANCE, THERMOELECTRIC EFFECTS, STABILITY AND MATCHING, VOLTAGE VARIATION OF RESISTANCE, JOHNSON NOISE

CAPACITANCE:

STRAY CAPACITANCE, FARADAY SHIELDS, NOISE, PARASITIC EFFECTS IN CAPACITORS, CAPACITOR LEAKAGE, SERIES/LOSS RESISTANCE, INDUCTANCE OF CAPACITORS, DIELECTRIC ABSORPTION

INDUCTANCE:

STRAY INDUCTANCE, MUTUAL INDUCTANCE, RINGING, PARASITIC EFFECTS IN INDUCTORS, QUALITY FACTOR (Q)

GROUNDING AND SIGNAL ROUTING:

SIGNAL RETURN CURRENTS, GROUND NOISE AND GROUND LOOPS, STAR (MECCA) GROUNDS, SEPARATE ANALOG AND DIGITAL GROUNDS, GROUND PLANES, TRANSMISSION LINES, SYSTEM GROUNDS, SIGNAL ROUTING

POWER SUPPLIES:

POWER SUPPLY NOISE, SWITCHING-MODE POWER SUPPLIES

ELECTROMAGNETIC INTERFERENCE:

RADIO FREQUENCY INTERFERENCE, PHOTOELECTRIC EFFECTS

LOGIC:

FAN-OUT, TIMING VARIATIONS, SAMPLING CLOCK NOISE, LOGIC NOISE

PROBLEM AREAS:

LIMITATIONS OF SPICE MODELLING, SOCKETS, PROTOTYPING HIGH PERFORMANCE ANALOG CIRCUITRY

INDEX

MIXED SIGNAL PROCESSING DESIGN SEMINAR

INTRODUCTION TO MIXED SIGNAL PROCESSING OF
REAL-WORLD SIGNALS AND SIGNAL CONDITIONING

1

LINEAR AND NON-LINEAR ANALOG SIGNAL PROCESSING

2

FUNDAMENTALS OF SAMPLED DATA SYSTEMS

3

ADCs FOR DSP APPLICATIONS

4

DACs FOR DSP APPLICATIONS

5

SIGMA-DELTA ADCs AND DACs

6

DIGITAL SIGNAL PROCESSING TECHNIQUES

7

DSP HARDWARE

8

INTERFACING ADCs AND DACs TO
DIGITAL SIGNAL PROCESSORS

9

MIXED SIGNAL PROCESSING APPLICATIONS

10

MIXED SIGNAL CIRCUIT TECHNIQUES

11

INDEX


