

# **BASIC LINEAR DESIGN**

**Hank Zumbahlen**  
**Editor**



**© 2007 Analog Devices, Inc.**

**All Rights Reserved**

Preface:

This work is based on the work of many other individuals who have been involved with applications and Analog Devices since the company started in 1965. Much of the material that appears in this work is based on work that has appeared in other forms. My major job function in this case was one of editor. The list of people I would like to credit for doing the pioneering work include: Walt Kester, Walt Jung, Paul Brokaw, James Bryant, Chuck Kitchin, and many other members of Analog Devices technical community.

In addition many others contributed to the production of this edition by helping out with the production of this book by providing invaluable assistance by proofreading and providing commentary. I especially want to thank Walt Kester, Bob Marwin and Judith Douville, who also did the indexing.

Again, many thanks to those involved in this project

Hank Zumbahlen  
Senior Staff Applications Engineer

**Copyright © 2007 Analog Devices, Inc.**

**ISBN 0-916550-28-1**

All rights reserved. This book, or any parts thereof, may not be reproduced in any form without the permission of the copyright owner. The information furnished by Analog Devices, Inc. is believed to be accurate and reliable. However no responsibility for its use 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.

# **TABLE OF CONTENTS**

## **CHAPTER 1: THE OP AMP**

- SECTION 1.1: OP AMP OPERATION**
- SECTION 1.2: OP AMP SPECIFICATIONS**
- SECTION 1.2: AC SPECIFICATIONS**
- SECTION 1.3: HOW TO READ DATA SHEETS**
- SECTION 1.4: CHOOSING AN OP AMP**

## **CHAPTER 2: OTHER LINEAR CIRCUITS**

- SECTION 2.1: BUFFER AMPLIFIERS**
- SECTION 2.2: GAIN BLOCKS**
- SECTION 2.3: INSTRUMENTATION AMPLIFIERS**
- SECTION 2.4: DIFFERENTIAL AMPLIFIERS**
- SECTION 2.5: ISOLATION AMPLIFIERS**
- SECTION 2.6: DIGITAL ISOLATION TECHNIQUES**
- SECTION 2.7: ACTIVE FEEDBACK AMPLIFIERS**
- SECTION 2.8: LOGARITHMIC AMPLIFIERS**
- SECTION 2.9: HIGH SPEED CLAMPING AMPLIFIERS**
- SECTION 2.10: COMPARATORS**
- SECTION 2.11: ANALOG MULTIPLIERS**
- SECTION 2.12: RMS TO DC CONVERTERS**
- SECTION 2.13: PROGRAMMABLE GAIN AMPLIFIERS**
- SECTION 2.14: AUDIO AMPLIFIERS**
- SECTION 2.15: AUTO-ZERO AMPLIFIERS**

## **CHAPTER 3: SENSORS**

- SECTION 3.1: POSITIONAL SENSORS**
- SECTION 3.2: TEMPERATURE SENSORS**
- SECTION 3.3: CHARGE COUPLED DEVICES (CCDs)**
- SECTION 3.4: BRIDGE CIRCUITS**
- SECTION 3.5: STRAIN, FORCE, PRESSURE  
AND FLOW MEASUREMENT**

## **CHAPTER 4 RF/IF CIRCUITS**

- SECTION 4.1: MIXERS**
- SECTION 4.2: MODULATORS**
- SECTION 4.3: ANALOG MULTIPLIERS**
- SECTION 4.4: LOGARITHMIC AMPLIFIERS**
- SECTION 4.5: TRU-POWER DETECTORS**
- SECTION 4.6: VARIABLE GAIN AMPLIFIER**
- SECTION 4.7: DIRECT DIGITAL SYNTHESIS**
- SECTION 4.8: PHASE LOCKED LOOPS**

## **CHAPTER 5: FUNDAMENTALS OF SAMPLED DATA SYSTEMS**

- SECTION 5.1: CODING AND QUANTIZING**
- SECTION 5.2: SAMPLING THEORY**

## **CHAPTER 6: CONVERTERS**

- SECTION 6.1: DIGITAL-TO-ANALOG CONVERTER ARCHITECTURES**
- SECTION 6.2: ANALOG-TO-DIGITAL CONVERTER ARCHITECTURES**
- SECTION 6.3: SIGMA-DELTA ( $\Sigma\Delta$ ) CONVERTERS**
- SECTION 6.4: DEFINING THE SPECIFICATIONS**
- SECTION 6.5: DAC AND ADC STATIC TRANSFER FUNCTIONS AND DC ERRORS**
- SECTION 6.6: DATA CONVERTER AC ERRORS**
- SECTION 6.7: TIMING SPECIFICATIONS**
- SECTION 6.8: HOW TO READ A DATA SHEET**
- SECTION 6.9: CHOOSING A DATA CONVERTER**

## **CHAPTER 7: DATA CONVERTER SUPPORT CIRCUITS**

- SECTION 7.1: VOLTAGE REFERENCES**
- SECTION 7.2: ANALOG SWITCHES AND MULTIPLEXERS**
- SECTION 7.3: SAMPLE-AND-HOLD CIRCUITS**
- SECTION 7.4: CLOCK GENERATION AND DISTRIBUTION**

## **CHAPTER 8 ANALOG FILTERS**

**SECTION 8.1: INTRODUCTION**

**SECTION 8.2: THE TRANSFER FUNCTION**

**SECTION 8.3: TIME DOMAIN RESPONSE**

**SECTION 8.4: STANDARD RESPONSES**

**SECTION 8.5: FREQUENCY TRANSFORMATION**

**SECTION 8.6: FILTER REALIZATIONS**

**SECTION 8.7: PRACTICAL PROBLEMS IN FILTER  
IMPLEMENTATION**

**SECTION 8.8: DESIGN EXAMPLES**

## **CHAPTER 9: POWER MANAGEMENT**

**SECTION 9.1: LINEAR VOLTAGE REGULATORS**

**SECTION 9.2: SWITCH MODE REGULATORS**

**SECTION 9.3: SWITCHED CAPACITOR VOLTAGE  
CONVERTERS**

## **CHAPTER 10: PASSIVE COMPONENTS**

**SECTION 10.1: CAPACITORS**

**SECTION 10.2: RESISTORS AND POTENTIOMETERS**

**SECTION 10.3: INDUCTORS**

## **CHAPTER 11: OVERVOLTAGE EFFECTS ON ANALOG INTEGRATED CIRCUITS**

**SECTION 11.1: OVERVOLTAGE EFFECTS**

**SECTION 11.2: ELECTROSTATIC DISCHARGE (ESD)**

**SECTION 11.3: EMI/RFI CONSIDERATIONS**

## **CHAPTER 12: PRINTED CIRCUIT BOARD (PCB) DESIGN ISSUES**

**SECTION 12.1: PARTITIONING**

**SECTION 12.2: TRACES**

**SECTION 12.3: GROUNDING**

**SECTION 12.4: DECOUPLING**

**CHAPTER 12: PRINTED CIRCUIT BOARD (PCB)  
DESIGN ISSUES (cont)**

**SECTION 12.5: THERMAL MANAGEMENT**

**CHAPTER 13: DESIGN DEVELOPMENT TOOLS**

**SECTION 13.1: SIMULATION**

**SECTION 13.2: ON-LINE TOOLS AND WIZARDS**

**SECTION 13.3: EVALUATION BOARDS AND PROTOTYPING**