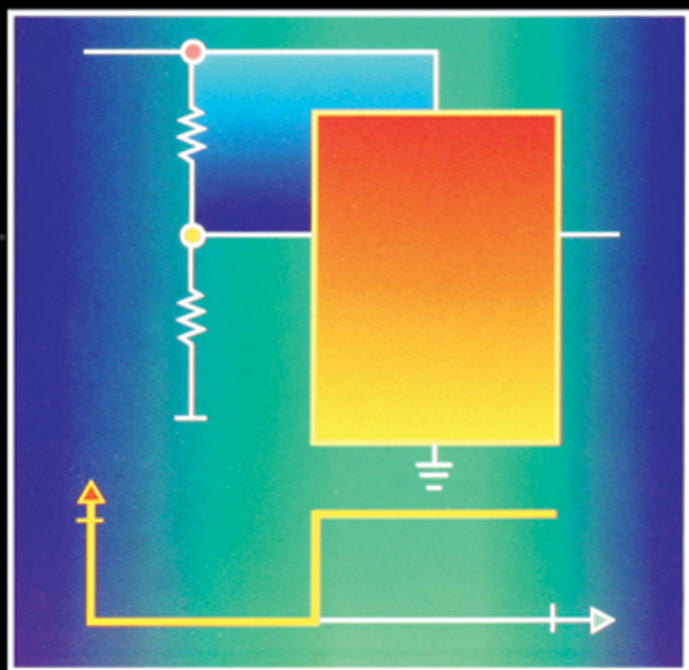


# JOHN D. LENK

## SIMPLIFIED DESIGN OF MICROPROCESSOR- SUPERVISORY CIRCUITS



# **Simplified Design of Microprocessor- Supervisory Circuits**


John D. Lenk

**Newnes**

Boston Oxford Johannesburg Melbourne New Delhi Singapore

Newnes is an imprint of Butterworth-Heinemann.

Copyright © 1998 by Butterworth-Heinemann

 A member of the Reed Elsevier group

All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher.



Recognizing the importance of preserving what has been written, Butterworth-Heinemann prints its books on acid-free paper whenever possible.



Butterworth-Heinemann supports the efforts of American Forests and the Global ReLeaf program in its campaign for the betterment of trees, forests, and our environment.

#### **Library of Congress Cataloging-in-Publication Data**

Lenk, John D.

Simplified design of microprocessor-supervisory circuits / John D.

Lenk.

p. cm.

Includes index.

ISBN 0-7506-9652-4 (pbk. : alk. paper)

1. Microprocessors—Design and construction. 2. Electronic circuit design. I. Title.

TK7895.M5L458 1998

621.39'5—dc21

97-52061

CIP

#### **British Library Cataloguing-in-Publication Data**

A catalogue record for this book is available from the British Library.

The publisher offers special discounts on bulk orders of this book.

For information, please contact:

Manager of Special Sales

Butterworth-Heinemann

225 Wildwood Avenue

Woburn, MA 01801-2041

Tel: 781-904-2500

Fax: 781-904-2620

For information on all Newnes electronics publications available, contact our World Wide Web home page at: <http://www.bh.com>

10 9 8 7 6 5 4 3 2 1

Transferred to digital printing 2006

*Greetings from the Villa Buttercup!*

*To my wonderful wife, Irene: Thank you for being by my side all these years!*

*To my lovely family: Karen, Tom, Brandon, Justin, and Michael.*

*And to our Lambie and Suzzie: Be happy wherever you are!*

*And to my special readers: May good fortune find your doorway,  
bringing good health and happy things. Thank you for buying my books!*

*To Karen Speerstra, Jo Gilmore, Duncan Enright, Pam Boiros, Joan Dargan, Philip Shaw, Elizabeth McCarthy, Vickie Edwards, Pam Chester, the Newnes people, the UK people, and the EDN people: A special thanks for making me an international best seller, again (this is book 90).*

*Abundance!*

This page intentionally left blank

# Contents

Preface	xiii
Acknowledgments	xv

## **1 The Microprocessor-Supervisory Functions 1**

1.1	Power-On Reset	2
1.2	Low-Voltage (Glitch/Brownout) Reset	2
1.3	Memory-Write Protection	2
1.4	Power-Fail Warning	3
1.5	Battery-Backup Switchover	3
1.6	Watchdog Timer	4
1.7	Monitoring Multiple Power Supplies	4
1.8	Manual Reset	4
1.9	Parallel Outputs	5
1.10	Detailed Description of Internal Circuits	6
1.11	Battery-Switchover and $V_{OUT}$ Circuit Operation	6
1.12	Reset Output	9
1.13	Chip-Enable Gating and RAM Write Protection	10
1.14	1.3-V Comparator and Power-Fail Warning	11
1.15	Watchdog Timer and Oscillator	11

## **2 Multifunction 5-V Microprocessor-Supervisory Integrated Circuits 13**

2.1	Basic Characteristics of MAX690A Series	15
2.2	Reset Output for MAX690A Series	15
2.3	Watchdog Input for MAX690A Series	19
2.4	Power-Fail Comparator for MAX690A Series	19

2.5	Backup-Battery Switchover for MAX690A Series	19
2.6	Using Capacitors as Backup Power Sources	21
2.7	Allowable Backup Power-Source Batteries	22
2.8	Operation without a Backup Power Source	22
2.9	Replacing the Backup Battery	22
2.10	Adding Hysteresis to the Power-Fail Comparator	22
2.11	Monitoring a Negative Voltage	23
2.12	Interfacing Microprocessors with Bidirectional Reset	23

### 3 3.0-V/3.3-V Microprocessor-Supervisory Integrated Circuits 25

3.1	Basic Characteristics of MAX690T/S/R Series	25
3.2	Reset Output for MAX690T/S/R Series	26
3.3	Reset Threshold for MAX690T/S/R Series	27
3.4	Watchdog Input for MAX690T/S/R Series	29
3.5	Power-Fail Comparator for MAX690T/S/R Series	32
3.6	Backup-Battery Switchover for MAX690T/S/R Series	32
3.7	Manual Reset for MAX690T/S/R Series	33
3.8	Short Circuit Problems for MAX690 T/S/R Series	33
3.9	Capacitor Backup Power	34
3.10	Eliminating the Backup Power Source	34
3.11	Backup-Battery Replacement	34
3.12	Power-Fail Comparator Hysteresis	34
3.13	Monitoring an Additional Power Supply	35
3.14	Interfacing for Bidirectional Resets	36
3.15	Negative-Going $V_{CC}$ Transients	37
3.16	Basic Manual Reset Circuit with Battery Backup	37

### 4 Microprocessor-Supervisory Integrated Circuits with Chip-Enable 39

4.1	Basic Characteristics of MAX691A Series	39
4.2	General Description of MAX691A Series	39
4.3	$\overline{\text{RESET}}$ and RESET Outputs	40
4.4	The Watchdog Function	44
4.5	Watchdog Input	45
4.6	Watchdog Output	45
4.7	Alternative Watchdog and Reset Timeouts	46
4.8	Chip-Enable Signal Gating	47
4.9	Chip-Enable Input	48
4.10	Chip-Enable Propagation Delay	49
4.11	$\overline{\text{Chip-Enable}}$ Output	50
4.12	$\overline{\text{LOW LINE}}$ Output	50
4.13	Power-Fail Comparator	50

4.14	Power-Fail Input	50
4.15	Power-Fail Output	51
4.16	Battery-Backup Mode for MAX691A Series	51
4.17	Battery-On Output	52
4.18	Input Supply Voltage	52
4.19	Backup-Battery Input	52
4.20	Output Supply Voltage	52
4.21	General Application Notes for MAX691A Series	53
4.22	Capacitor Backup for MAX691A Series	53
4.23	Using Separate Supplies for $V_{BATT}$ and $V_{CC}$	53
4.24	Alternative Chip-Enable Gating	54
4.25	Adding Hysteresis to the PFO	54
4.26	Negative Supply Voltages	54
4.27	Replacing the Backup Battery	56
4.28	Negative $V_{CC}$ Transients	56

## **5 Low-Cost Microprocessor-Supervisory Integrated Circuits with Battery Backup 57**

5.1	Basic Characteristics of MAX703/704	57
5.2	General Description of MAX703/704	59
5.3	RESET Output for MAX703/704	59
5.4	Power-Fail Comparator for MAX703/704	62
5.5	Backup-Battery Switchover for MAX703/704	62
5.6	Manual Reset for MAX703/704	63
5.7	Using Capacitors for Backup	63
5.8	Backup Power Sources	64
5.9	Operating without Backup Power	65
5.10	Ensuring a Valid RESET Output Down to $V_{CC} = 0$	65
5.11	Battery Replacement	65
5.12	Adding Hysteresis	66
5.13	Negative Voltages	66
5.14	Reset with the Power-Fail Comparator	67

## **6 Low-Cost Microprocessor Supervisory Integrated Circuits with Watchdog 69**

6.1	Basic Characteristics for MAX705 Series	69
6.2	General Description of MAX705 Series	71
6.3	Reset Output for MAX705 Series	71
6.4	Watchdog Timer for MAX705 Series	72
6.5	Manual Reset for MAX705 Series	74
6.6	Power-Fail Comparator for MAX705 Series	74
6.7	Valid RESET with a $V_{CC}$ of Zero	75
6.8	Monitoring Voltages Other Than Unregulated DC	76



6.9	Monitoring Negative Voltages	76
6.10	Bidirectional Reset	77

## **7 3-V Low-Cost Microprocessor-Supervisory Integrated Circuits 79**

7.1	Basic Characteristics of MAX706/708	79
7.2	General Description of MAX706/708	81
7.3	RESET and RESET Outputs for MAX706/708	82
7.4	Watchdog Timer for MAX706P/R/S/T	85
7.5	Manual Reset for MAX706/708	86
7.6	Power-Fail Comparator for MAX706/708	86
7.7	Operation with +3-V and +5-V Supplies	86
7.8	Ensuring a Valid RESET Output Down to $V_{CC} = 0$ V	87
7.9	Adding Power-Fail Hysteresis	88
7.10	Monitoring Negative Voltages for MAX706/708	88

## **8 Complete Microprocessor-Supervisory Integrated Circuit 91**

8.1	Basic Characteristics for MAX791	91
8.2	General Description for MAX791	93
8.3	Manual Reset Input	95
8.4	RESET Output for MAX791	96
8.5	Watchdog Function for MAX791	99
8.6	Watchdog Input for MAX791	99
8.7	Watchdog Output for MAX791	99
8.8	Watchdog-Pulse Output	99
8.9	Selecting an Alternative Watchdog Timeout	100
8.10	Chip-Enable Signal Gating	101
8.11	Chip-Enable Input for MAX791	101
8.12	Chip-Enable Output Impedance	102
8.13	LOW LINE Output	102
8.14	Power-Fail Comparator for MAX791	102
8.15	Battery-Backup Mode for MAX791	103
8.16	Output Supply Voltage for MAX791	104
8.17	Low-Battery Monitor for MAX791	105
8.18	Applications Considerations for MAX791	105
8.19	Using Capacitors with the MAX791	106
8.20	Operation with Separate Supplies for $V_{CC}$ and $V_{BATT}$	106
8.21	Alternative Chip-Enable Gating for MAX791	107
8.22	Adding Hysteresis to the MAX791 Power-Fail Comparator	107
8.23	Monitoring Negative Voltages with the MAX791	107
8.24	Backup-Battery Replacement for the MAX791	108

## 9 Microprocessor and Nonvolatile Memory Supervisory Integrated Circuits 109

9.1	Basic Characteristics for MAX792/820	109
9.2	General Description of MAX792/820	111
9.3	Manual-Reset Input for MAX792/820	113
9.4	Monitoring a Regulated Supply	114
9.5	Monitoring a Supply with Internal Threshold	114
9.6	Monitoring a Supply with External Programming	116
9.7	Using the LOW LINE Output	119
9.8	Reset Function for MAX792/820	119
9.9	Reset Outputs for MAX792/820	120
9.10	Overvoltage Comparator for MAX792/802	120
9.11	Watchdog Function for MAX792/820	120
9.12	Watchdog Input for MAX792/820	121
9.13	Watchdog Output for MAX792/820	121
9.14	Consecutive Watchdog Faults	122
9.15	Alternative Watchdog Timeout Periods for MAX792/820	123
9.16	Chip-Enable Signal Gating	123
9.17	Chip-Enable Input for MAX792/820	123
9.18	Chip-Enable Output for MAX792/820	124
9.19	Applications Considerations for MAX792/820	125
9.20	Alternative Chip-Enable Gating for MAX792/820	125
9.21	Interfacing to Bidirectional Resets for MAX792/820	125

## 10 Simplified Design Approaches 127

10.1	MC6800 Interface with Resistive or Inductive Loads	127
10.2	MC68000 Interface with Resistive or Inductive Loads	127
10.3	Serial DRAM Nonvolatizer	128
10.4	Auxiliary Boost Supply for Microprocessor-Based Systems	130
10.5	RS-232 Transceiver for Microprocessor-Based Systems	130
10.6	Power Monitor for Microprocessor-Based Systems	133
10.7	Power Monitor for Microprocessor-Based Systems with Line Isolation	133
10.8	Line-Operated Power Monitor for Microprocessor-Based Systems	134
10.9	Low-Power Microprocessor Monitor with Push Button	134
10.10	Low-Power Microprocessor Monitor with Push Button and Watchdog Timer	135
10.11	Automatic Reset Integrated Circuit for Microprocessor-Based Systems	136
10.12	Microprocessor Power Monitor with Watchdog Timer and Push Button	137
10.13	Microprocessor Power Monitor with Early Warning	137
10.14	Memory Backup for SRAMs	138

10.15	Power Switching for SRAMs	139
10.16	Discrete-Component Watchdog Timer	140
10.17	Discrete-Component Power-On Reset	140
10.18	Microprocessor Supervisory Circuit Design Summary	141
10.19	Alternative Microprocessor-Supervisory Circuit Design Summary	143
10.20	Externally Adjustable Reset Threshold	144
10.21	Reset for Both Overvoltage and Undervoltage	144
10.22	Backup-Battery Monitor with Optional Test Load	145
10.23	Adding Hysteresis to the Power-Fail Circuit	145
10.24	Disabling the Watchdog under Program Control	146
10.25	Extending the Watchdog Timeout Period	147
10.26	Low-Cost Power-On Reset and Watchdog Controller	147
10.27	Power-Supply Monitor with Reset	147
10.28	Universal Voltage Monitors for Microprocessor-Based Systems	148
10.29	Quad Undervoltage Detector	150
10.30	Quad Undervoltage Detector with LED Indicators	150
10.31	Quad Overvoltage Detector with LED Indicators	150
10.32	Quad Undervoltage Detector with Single LED Indicator	151
10.33	Alternative Quad Overvoltage Detector	153
10.34	Overvoltage/Undervoltage Detector (Window Detector)	154
10.35	Dual-Negative Undervoltage Detector	155
10.36	Dual-Negative Overvoltage Detector	156
10.37	Negative Overvoltage-Undervoltage Detector (Window Detector)	156
10.38	Microprocessor Reset Circuit with Time Delay	158
10.39	Alternative Microprocessor Reset Circuit with Time Delay	159
10.40	Undervoltage Monitor for Low Voltages in Microprocessor Systems	159
10.41	Undervoltage Monitoring for 3.3-V Microprocessor-Based Systems	159
10.42	Dedicated Microprocessor Voltage Monitors	160
10.43	Undervoltage-Overvoltage Comparator	160
10.44	Monitoring the Supply for Overvoltage-Undervoltage	161
10.45	Voltage Monitor with Microprocessor Reset	161
10.46	Alternative Voltage Monitor with Microprocessor Reset	161
10.47	Nonvolatile RAM Controller	163
10.48	Three-Pin Microprocessor Reset Monitor	165
10.49	8051 Interface (LTC1090)	165
10.50	MC68HC05 Interface (LTC1090)	169
10.51	HD63705VO Interface (LTC1090)	172
10.52	COP820C Interface (LTC1090)	174
10.53	TMS7742 Interface (LTC1090)	176

10.54	COP402N Interface (LTC1090)	179
10.55	8051 Microprocessor Interface (LTC1091)	181
10.56	68HC05 Interface (LTC1091)	184
10.57	COP820C Interface (LTC1091 DAS)	186
10.58	TMS7742 Interface (LTC1091)	188
10.59	COP402N Interface (LTC1091)	191
10.60	HD63705 Interface (LTC1091)	193
10.61	TMS320C25 Interface	196
10.62	TMS320C25 Interface (LTC1091/92)	201
10.63	Z-80 Interface (LTC1090)	206
10.64	HD64180 Interface (LTC1090)	209
10.65	HA64180 Interface (LTC1091)	212
10.66	Interfacing to a Parallel Bus	214
10.67	8051 Microprocessor 12-Bit Interface	217
10.68	MC68HC05 12-Bit Interface	222
10.69	TMS370 Interface	224

For Further Information      229

Index      231

This page intentionally left blank

# Preface

This book has something for everyone involved in electronics. No matter what your skill level, this book shows you how to design and experiment with microprocessor-supervisory circuits and interfaces.

For experimenters, students, and serious hobbyists, the book provides sufficient information to design and build microprocessor-supervisory circuits from scratch. The design approach is the one used in all my best-selling books on simplified and practical design.

If you are a working engineer responsible for designing microprocessor-supervisory circuits or selecting supervisory integrated circuits, the variety of circuit configurations described herein should generally simplify your task. The book describes supervisory circuit designs and covers the most popular forms of supervisory integrated circuits available. Throughout the book, you will find a wealth of information on supervisory integrated circuits and related components.

In this book, design problems start with circuits that can be put to immediate use as is and include guidelines for selecting components. By using the guideline values in experimental circuits, you can produce the desired results (such as microprocessor reset, memory protection, power-fail warning, battery backup, and watchdog) by varying the experimental component values, if necessary.

Chapter 1 is devoted to primary microprocessor-supervisory functions. Such functions are vital to all microprocessor-based systems because the functions include safeguards against system failure.

Chapter 2 discusses simplified design with supervisory integrated circuits used in 5-V digital systems.

Chapter 3 is devoted to simplified design with supervisory integrated circuits used in 3-V and 3.3-V digital systems.

Chapter 4 covers simplified design with supervisory integrated circuits that have on-board chip-enable functions.