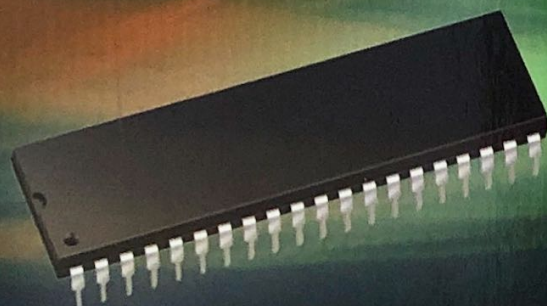




PROGRAMMING THE PROPELLERTM WITH SPINTM

A BEGINNER'S GUIDE TO PARALLEL PROCESSING

Harprit Singh Sandhu



FOR RESALE
NOT FOR SALE

PROGRAMMING THE PROPELLER™ WITH SPIN™: A BEGINNER'S GUIDE TO PARALLEL PROCESSING

OTHER BOOKS BY HARPRIT SINGH SANDHU

An Introduction to Robotics

This book, published in 1996, introduces you to robotics and then shows you how to build a weight-shifting, biped, humanoid robot that you can run from a PC. Complete plans are included and all the work can be done with a few tools at the kitchen table. This is the book that laid the foundation for the now abundant humanoid walking-robot industry.

Making PIC Instruments and Controllers

This is a hands-on tutorial and resource book that teaches you how to build your own instruments and controllers using PICBasic on PIC microcontrollers.

This PIC-based book is aimed at connecting your PIC to real-world measurements and sensors. This 316-page book is laid out in a very clear manner that makes it an excellent reference or textbook.

Running Small Motors with PIC Microcontrollers

This book is a hands-on tutorial and that teaches you how to run all sorts of small motors with PICBasic and PIC microcontrollers. A hands-on approach is brought to this PIC-based book aimed at running small motors of all sorts with these microcontrollers. Over 2,000 lines of PICBasic code you can use are included. This 352-page book is laid out in a very clear manner that makes it an excellent reference or textbook.

Spindles

This book is a treatise on working with the small metal-cutting lathe. It concentrates on making spindles that allow you to do simple milling machine work in the lathe, such as cutting gears and making clockworks.

Convenience Items

Certain items that make experimentation with the Propeller easier are available from Encodergeek.com, which is the support site for this book. Go to this site for book support, more illustrations, prices, and descriptions.

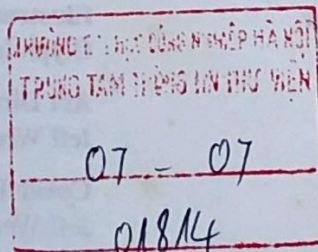
PROGRAMMING THE PROPELLER™ WITH SPIN™: A BEGINNER'S GUIDE TO PARALLEL PROCESSING

Harprit Singh Sandhu



**GIFT OF THE ASIA FOUNDATION
NOT FOR RE-SALE**

**QUÀ TẶNG CỦA QUỸ CHÂU Á
KHÔNG ĐƯỢC BÁN LẠI**



**Mc
Graw
Hill**

**New York Chicago San Francisco Lisbon London Madrid
Mexico City Milan New Delhi San Juan Seoul
Singapore Sydney Toronto**

Library of Congress Cataloging-in-Publication Data

Sandhu, Harprit.

Programming the Propeller with Spin : a beginner's guide to parallel processing /
Harprit Singh Sandhu.

p. cm.

Includes bibliographical references and index.

ISBN 978-0-07-171666-6 (alk. paper)

1. Programmable controllers. 2. Microcontrollers—Programming. 3. Spin
(Computer program language) 4. Parallel processing (Electronic computers) I. Title.

TJ223.P76S373 2010

629.8'95—dc22

2010016896

McGraw-Hill books are available at special quantity discounts to use as premiums and sales promotions, or for use in corporate training programs. To contact a representative, please e-mail us at bulksales@mcgraw-hill.com.

Programming the Propeller™ with Spin™: A Beginner's Guide to Parallel Processing

Copyright © 2010 by The McGraw-Hill Companies. All rights reserved. Printed in the United States of America. Except as permitted under the Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a database or retrieval system, without the prior written permission of publisher, with the exception that the program listings may be entered, stored, and executed in a computer system, but they may not be reproduced for publication.

All trademarks or copyrights mentioned herein are the possession of their respective owners and McGraw-Hill makes no claim of ownership by the mention of products that contain these marks.

The Propeller and Spin are trademarks of Parallax Inc. Where indicated, the author used images with the permission of Parallax.

1234567890 WFR WFR 109876543210

ISBN 978-0-07-171666-6

MHID 0-07-171666-1

Sponsoring Editor

Roger Stewart

Editorial Supervisor

Patty Mon

Project Manager

Vastavikta Sharma, Glyph International

Acquisitions Coordinator

Joya Anthony

Copy Editor

Bart Reed

Proofreader

Claire Splan

Indexer

Jack Lewis

Production Supervisor

George Anderson

Composition

Glyph International

Illustration

Glyph International

Art Director, Cover

Jeff Weeks

Cover Designer

Jeff Weeks

Information has been obtained by McGraw-Hill from sources believed to be reliable. However, because of the possibility of human or mechanical error by our sources, McGraw-Hill, or others, McGraw-Hill does not guarantee the accuracy, adequacy, or completeness of any information and is not responsible for any errors or omissions or the results obtained from the use of such information.

CONTENTS

This effort is dedicated to

Robert A. Hoffswell, BA, MA
Mathematician, Engineer, Scientist, Gentleman

"My first acquaintance from the Age of Information"

"Harvey the Fox" is a mathematician who worked as a physicist at the University of Illinois Particle Accelerator Lab. In the very lab where the cyclotron was invented. Where a copy of the original model hung on the wall.

He is my first acquaintance from the Information Age. A man who knows how to research and understand things he once knew nothing about and how to use the information to create exquisite, useful, and fully functional devices.

He is an Engineer and Scientist of course, but he is also a ham radio operator, a journeyman carpenter, a master woodworker, a maker of musical instruments, like fine guitars, ukuleles, and harpsichords. And exquisite looms and other wonders along the way.

I have learned much about learning from the Fox.

CONTENTS

Preface

xiii

PART I The Propeller/Spin System

1

Introduction for the Beginner 1

Chapter 1 A General Introduction to the Propeller Chip

3

The Propeller Manual 3

Parallax, Inc. 5

Overall System Description 5

The Propeller Tool 7

Instruments Needed to Support Your Experiments 8

Chapter 2 The Propeller Chip: An Overall Description

9

Basic Propeller Specifications 10

Voltage and Amperage Requirements 10

The Operation of the Eight Cogs 10

The Cogs 11

The Hub 12

Forty Pins Total, 32 Pins I/O 12

Connecting to the Propeller 13

The System Counter 14

Program Storage and Execution 14

Objects, Methods, and Other Definitions 15

Chapter 3 The Hardware Setup

19

Setting Up the Hardware 21

A Fundamental Reality We Have to Consider 23

Chapter 4 Software Setup: The "Propeller Tool" Environment

25

Classroom Analogy 27

Getting Ready to Use the Propeller 28

Installing the Software 28

Our First Program 29

The Typical Spin Program 32

Program Structure 34

General Pin Assignments Used in the Book 36

Propeller FAQ* 38

Chapter 5 The Various Propeller Memories

43

Assigning Memory for a New Cog 45

A New Cog Can Be Started to Run a Private or Public Method 45

Chapter 6 The How and Why of Shared Memory	47
Memory Usage	48
Variable Validity	49
Loops	50
Chapter 7 Understanding One Cog	51
Static Versus Dynamic	53
One Cog	55
Counters	58
Counter: General Description	59
Assignment of the 32 Bits in Each of the Counters	59
Using Counter A for PWM Generation	60
Chapter 8 The Eight Cogs	65
The Cogs	65
The Flags	66
Special Memory Locations	66
The System Clock	66
Programming	67
The ROM	67
Chapter 9 Special Terms and Ideas	69
The Hardware	69
The Software	70
New Hardware-Related Definitions	70
New Software-Related Definitions	71
Chapter 10 The Spin Language	75
CON	77
VAR	77
OBJ	78
PUB or PRI	78
Creating a Program with Two Cogs	83
Chapter 11 Tasks Suited to Parallel Processing	85
Parallel Programming Examples	85
Summary	87
PART II Input and Output: The Basic Techniques to Be Mastered—Learning by Doing	89
Chapter 12 General Discussion of Input/Output	91
Chapter 13 Binary Pulsing	95
Chapter 14 Setting Up a 16-Character-by-2-Line Liquid Crystal Display	101
Chapter 15 Binary Input and Output: Reading a Switch and Turning on an LED if the Switch Is Closed	109
Discussion	111
The Repeat Command	112

Chapter 16 Reading a Potentiometer: Creating an Input We Can Vary in Real Time	113
Analog Inputs	114
Advanced Techniques	118
Chapter 17 Creating and Reading Frequencies	129
Creating Audible Frequencies	130
Reading Frequencies	135
Chapter 18 Reading and Creating Pulses	139
Reading Pulse Widths	139
Determining the Pulse Width	140
Pulse Width Creation	146
PART III The Projects: Using What Was Learned to Build The Projects	149
Chapter 19 Seven-Segment Displays: Displaying Numbers with Seven-Segment LED Displays	151
Chapter 20 The Metronomes	159
Chapter 21 Understanding a 16-Character-by-2-Line LCD Display	163
8-Bit Mode	164
Sophisticated Total LCD Control	171
4-Bit Mode	182
Chapter 22 Running Motors: A Preliminary Discussion	189
R/C Hobby Servomotors	190
Stepper Motors (Bipolar)	190
Small Brush-Type DC Motors	191
DC Motors with Attached Encoders	191
Relays and Solenoids	191
Small A/C Motors at 120 Volts, Single Phase	192
Understanding the Concept of the "Response Characteristics" of a Motor	192
So What Does "Compliance" Mean?	192
DC Motor Operation Notes	193
Chapter 23 Motor Amplifiers for Small Motors	195
Amplifier Construction Notes (for Homemade Amplifiers)	197
Detailed "Use Information" for the Xavien Two-Axis Amplifier	198
Detailed "Use Information" for the Solarbotics Two-Axis Amplifier	199
Chapter 24 Controlling R/C Hobby Servos	203
Servo Control	204
Chapter 25 Controlling a Small DC Motor	211
The Software	214

Chapter 26 Running a Stepper Motor: Bipolar, Four-Wire Motors	225
Stepper Motor Power and Speed	226
Details on Bipolar Motors	226
Running the Motor	227
Programming Considerations	229
The Software	231
Chapter 27 Gravity Sensor Based Auto-Leveling Table	247
Sensor Specifications	248
Discussion	248
Chapter 28 Running DC Motors with Attached Incremental Encoders	257
Not about Motors	258
Discussion	258
DC Servo Motors with Encoders	261
Processor Connections	262
The Goal	262
PID Control in Greater Detail	263
Holding the Motor Position	265
Ramping	294
R/C Signal Use	305
Some Advanced Considerations You Should Be Aware Of	312
Chapter 29 Running Small AC Motors: Controlling Inductive Loads	313
PART IV Appendixes	315
Appendix A LCDRoutines4 and Utilities Object Listings	317
Appendix B Materials	327
Appendix C Turning Cogs On and Off	329
Appendix D Experiments Board	331
Appendix E Debugging	335
Debugging and Troubleshooting	335
Dumb Terminal Program	337
Signal Injection Techniques	337
Notes on Solderless Breadboards	338
Debugging at the More Practical Level	339
Writing a Rudimentary Program for Testing the LCD	340
Another List of Simple Checks	341
Epilogue	343
Index	345