MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board User's Guide

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MTS2916A DUAL FULL-BRIDGE STEPPER MOTOR DRIVER EVALUATION BOARD USER'S GUIDE

Table of Contents

Object of Declaration: MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board User's Guide

EU Declaration of Conformity

This declaration of conformity is issued by the manufacturer.
The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).
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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson
VP Development Tools

16-July-2013
Date

Preface

NOTICE TO CUSTOMERS

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Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXA", where "XXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board. This evaluation board also demonstrates the capabilities of the MTS62C19A, which has the same functionality, but different pin assignments. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Web Site
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board
- **Chapter 2. "Installation and Operation"** – Describes the initial setup of this board and the key components
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and board layouts for the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board
- **Appendix B. "Bill of Materials"** – Lists the parts used to populate the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board
- **Appendix C. "Mode Sequence Diagrams"** – Shows functional and software flowcharts for the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This user's guide describes how to use MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **MTS2916A Data Sheet – *"Dual Full-Bridge Motor Driver"* (DS22259)**

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- Field Application Engineer (FAE)
- Technical Support

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Technical support is available through the web site at:
http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision B (July 2013)

- Corrected minor error in **Section 2.1 "Introduction"**.

Revision A (May 2012)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board and covers the following topics:

- MTS2916A Short Overview
- What is the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board?
- MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board Kit Contents

1.2 MTS2916A SHORT OVERVIEW

The MTS2916A stepper motor driver is a CMOS device capable of driving both windings of a bipolar stepper motor or bidirectionally controlling two DC motors. Only the stepper motor application is covered by this user's guide. Each of the two independent H-Bridge outputs is capable of sustaining 40V and delivering 750 mA of continuous current. The user must ensure that the thermal guidelines are followed and the driver does not exceed the maximum junction temperature of +150°C. The driver will typically enter in thermal shutdown at a junction temperature of +170°C. The output current level is controlled by an internal Pulse-Width Modulation (PWM) circuit that is configured using two logic inputs, a current sense resistor and a selectable reference voltage.

Full, half and microstepping operations are possible with the PWM current control and logic inputs. The maximum output current is set by a sense resistor and a user selectable voltage reference. The evaluation board voltage reference is controlled with the run switch and is detailed in **Section 2.4.1 "Powering the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board"**. Each bridge has an independent phase input that controls the current flow direction for its specific load.

Internal clamp diodes protect against inductive voltage transients. The thermal protection circuitry disables the outputs when the junction temperature exceeds the thermal protection threshold. The thermal protection circuitry typically has 25°C of hysteresis. Undervoltage lockout circuitry prevents the outputs from going active until the logic supply voltage is high enough to assume control. No special power-up sequencing is required.

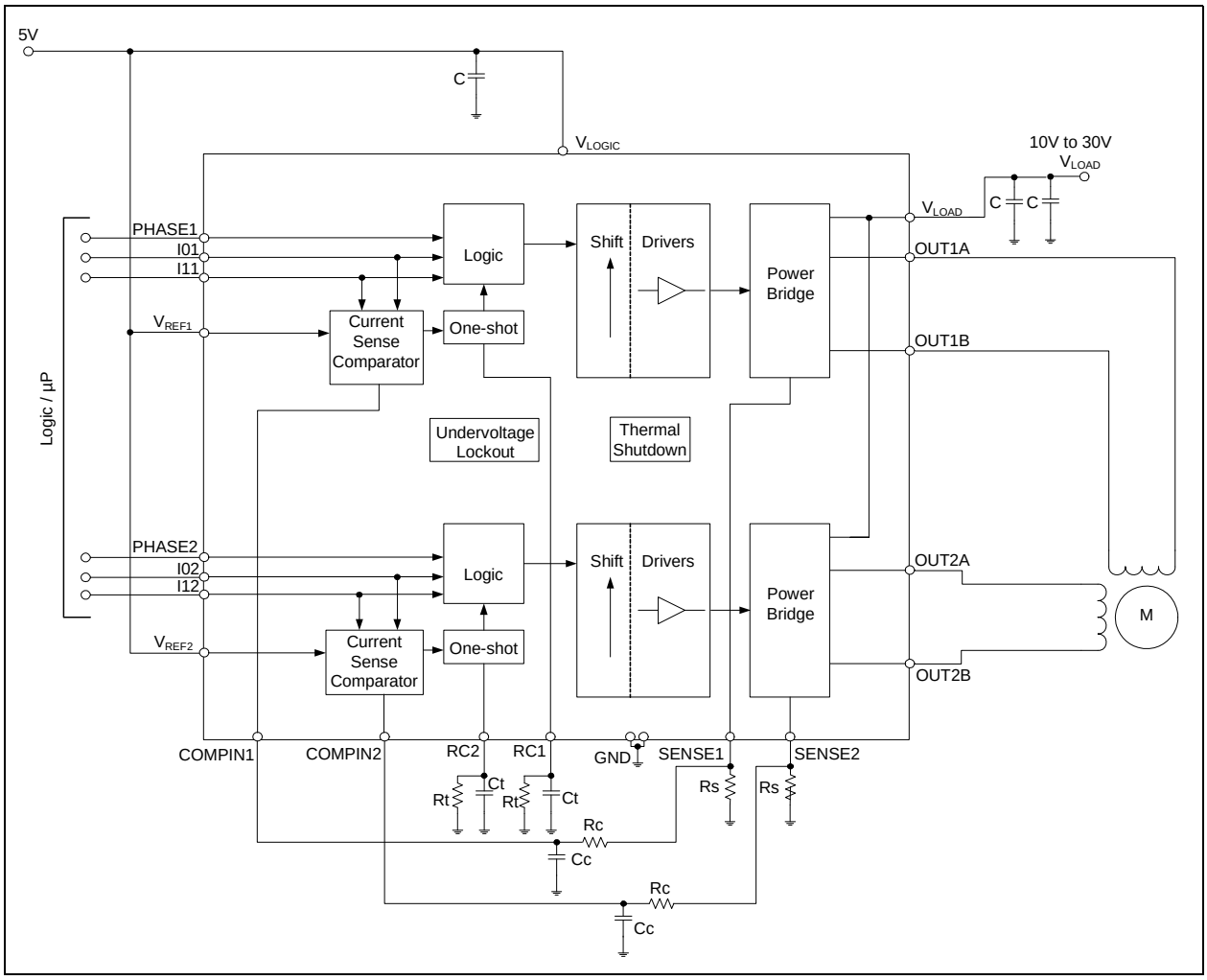


FIGURE 1-1: *Typical MTS2916A Stepper Motor Driver Application.*

1.3 WHAT IS THE MTS2916A DUAL FULL-BRIDGE STEPPER MOTOR DRIVER EVALUATION BOARD?

The MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board control circuitry is designed to typically operate from a 6V to 12V logic input (internally regulated down to 5V) and a 10V to 30V V_{LOAD} input. V_{LOAD} provides power to the motor windings. Test points are generously distributed throughout the evaluation board. This gives the user easy access and visibility, facilitating a better understanding of the MTS2916A operating details.

1.4 MTS2916A DUAL FULL-BRIDGE STEPPER MOTOR DRIVER EVALUATION BOARD KIT CONTENTS

The MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board kit contains the following items:

- MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board (ADM00308)
- Important Information Sheet

Chapter 2. Installation and Operation

2.1 INTRODUCTION

The MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board demonstrates the capabilities of the MTS2916A to control both windings of a bipolar stepper motor. The board also demonstrates the capabilities of the MTS62C19A, which has the same functionality, but different pin assignments. A PIC16F883 is utilized for motor control processing.

This evaluation board incorporates features through the implementation of push-button switches and a variable speed input potentiometer to exercise a stepper motor in Full-Step, Half-Step, Modified Half-Step and Microstepping modes. LEDs indicate a binary representation of which mode has been selected. The evaluation board and the stepper motor can be powered from a single power input J1 (7 VDC to 12 VDC) with jumper JP2 installed. For higher motor voltages, make sure JP2 is *not* installed, and connect V_{LOAD} at J4. Numerous test points have been designed into the board to allow easy access.

2.2 POWER CONNECTIONS

The MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board uses a combination of terminal blocks, test clips and one DC power jack for power connections.

Connections are as follows:

a) Motor Output Connections:
- J2-1(A3), J2-2(A1), J2-3(B1), J2-4(B3), J2-5(TP21)
- TP11(A1), TP12(A3), TP13(B1), TP14(B3)

b) V_{LOAD} (Motor Supply Power):
- J4-1(PGND), J4-2(V_{LOAD})
- TP20(PGND), TP18(V_{LOAD})

WARNING

Do not connect more than 16V to these motor supply connections while Jumper JP2 is installed.

c) V_{LOGIC}:
- J1-1(VLOGIC), J1-2(AGND)
- TP2(VLOGIC), TP5(AGND)

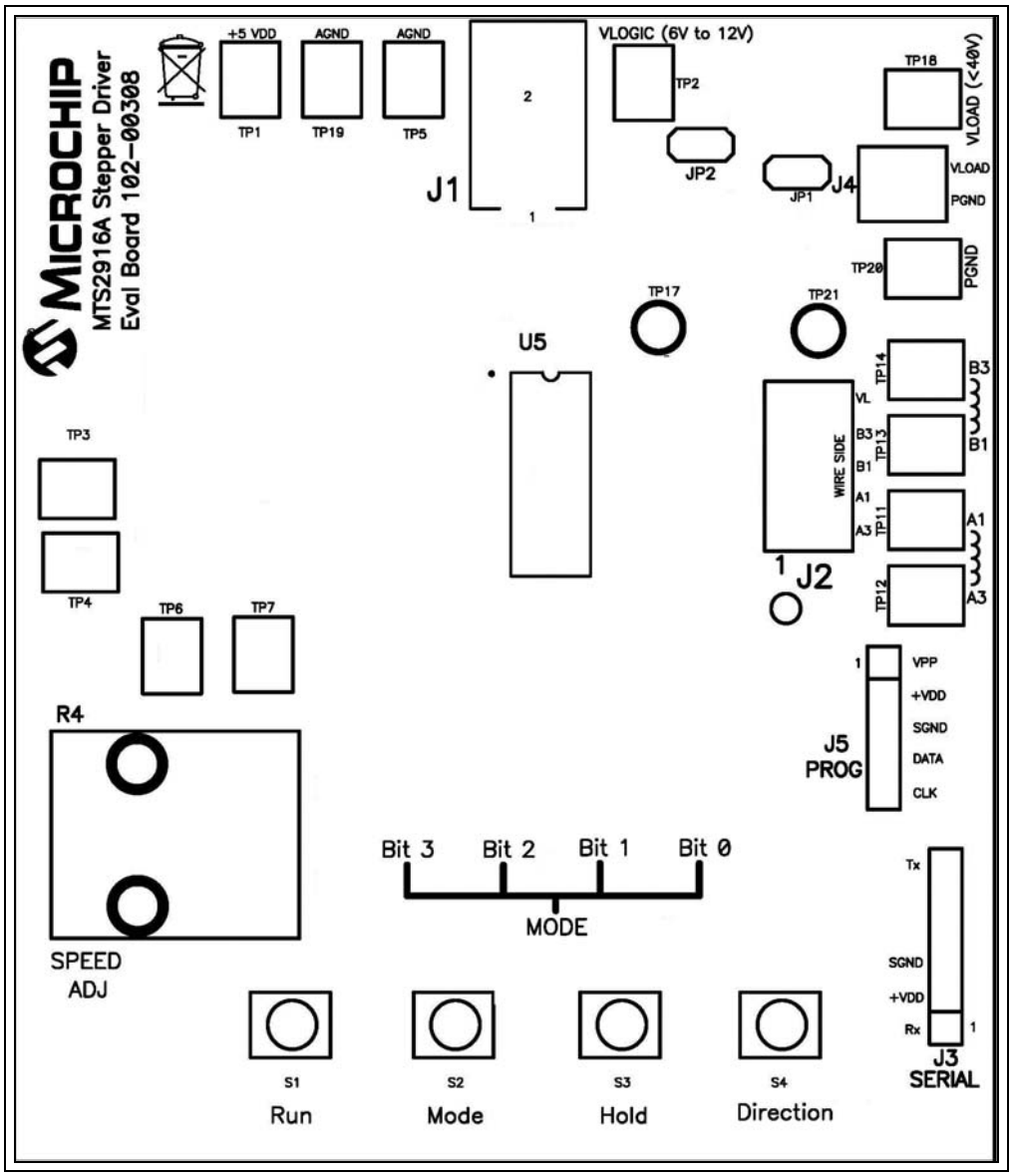


FIGURE 2-1: *Power Connection Diagram.*

2.3 FEATURES

The MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board has the following features:

- Push Button mode, Run, Hold and Direction control
- Potentiometer variable speed adjustment
- LED mode indication
- Maximum winding current with the combination of R_S, V_{REF} and conditioning of I0/I1 logic inputs
- PICkit™ Programming connector (J5) to implement user-created code

2.4 GETTING STARTED

The MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board is fully assembled and tested driving a dual coil bipolar stepper motor.

2.4.1 Powering the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board

Follow these steps to power-up the board:

1. With the supply turned OFF, connect the power to the logic portion of the evaluation board at J1 with the specified voltage (7 VDC to 12 VDC). The logic portion of the evaluation board will typically draw less than 50 mA.
2. If the user's stepper motor requires a voltage that is compatible with the logic supply voltage and the user's source can handle driving the stepper motor windings, install JP2. *DO NOT* connect power at J4. If powering up the stepper from an additional supply, *DO NOT* install JP2 and connect the stepper motor supply to J4. J1 power will still be required for the logic supply.
3. Connect the bipolar stepper windings to J2 per the schematic diagram.
4. Turn ON the power supplies. Power sequencing is not required due to the under-voltage lockout circuitry.
5. Toggle the Mode switch to cycle through the five modes, as indicated by the binary LED count.
6. Press the Run switch once to tell the PIC16F883 to send drive information to the MTS2916A with minimal (1V) V_{REF}. Subsequent Run presses increase V_{REF} by approximately 1V up to 5V maximum. This increases the current regulation threshold.
7. The Hold switch tells the PIC16F883 to command the MTS2916A to hold the motor position.
8. The Direction switch tells the PIC16F883 to command the MTS2916A to change the direction of the motor.
9. The Speed Adjust Potentiometer (R4) varies an analog voltage that is read by the PIC16F883 Analog-to-Digital Converter, and varies the speed accordingly.

Logic inputs I0 and I1 control load current levels are shown in Table 2-1:

TABLE 2-1: CURRENT LEVEL CONTROL

I0	I1	Comparator Trip Voltage	Output Current
0	0	V_{TRIP} = 1/10 x V_{REF}	I_{MAX} = V_{REF}/10 x R_S
1	0	V_{TRIP} = 1/15 x V_{REF}	2/3 x I_{MAX} = V_{REF}/15 x R_S
0	1	V_{TRIP} = 1/30 x V_{REF}	1/3 x I_{MAX} = V_{REF}/30 x R_S
1	1	x	0 (no current)

2.5 KEY COMPONENTS

Some of the key components on the evaluation board may need to be adjusted, depending on the characteristics of the utilized motor. The fixed Off Time (t_{OFF}) is set by the combination of R_t and C_t and is determined by the expression:
$t_{OFF} = 1.1 \times R_t \times C_t$.

The evaluation board is designed with t_{OFF} = 24.2 µs.

The amount of time it takes for the winding current to reach the regulation point is determined by multiple factors, such as motor voltage, inductance, resistance and the set point threshold.

The set point threshold is determined by the states of I0/I1, V_{REF} and the sense resistance value. For details on set point thresholds and component values, see the MTS2916A Data Sheet (DS22259).

Explaining the effects of the motor characteristics is beyond the scope of this user's guide; however, the t_{OFF} time of 24.2 µs was chosen to cover most motor applications while trying to maintain a switching frequency above the 20 kHz audible range.

There is a single pole filter in the sense feedback used to set a break frequency of approximately 80 kHz. Depending on the application, this break frequency may need to be adjusted. This may be apparent when designing to regulate at low currents.

2.6 MODES

The following plots were taken from a single winding of a bipolar stepper motor.

TABLE 2-2: MODE 1 VALUES

Full Step	
CH1: Phase 1	V_{REF} = 1.94V
CH2: I01	Speed = 0.43V
CH3: I11	V_{LOAD} = 24V
CH4: Coil Current	

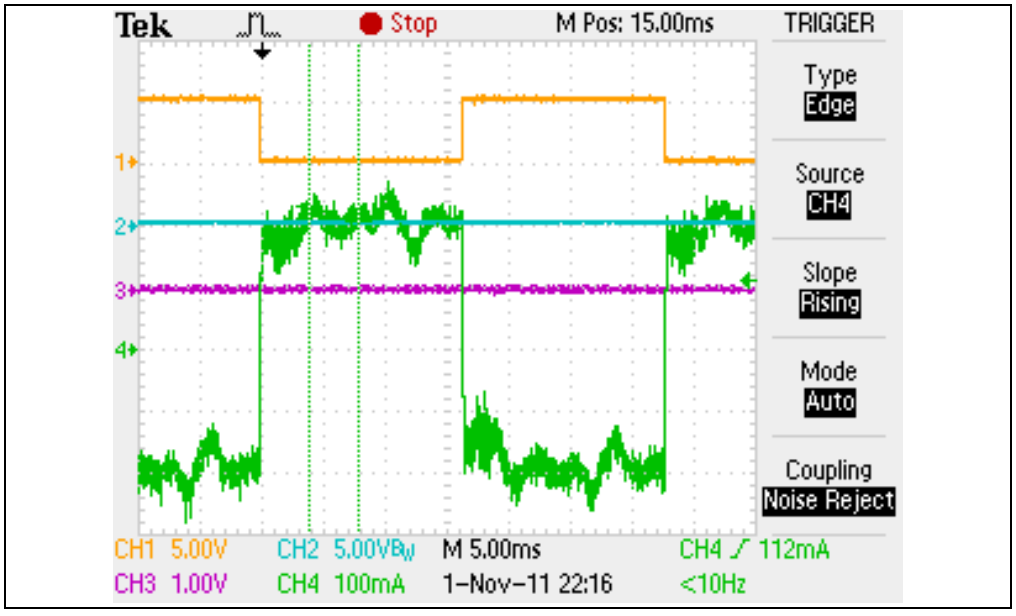


FIGURE 2-2: *Mode 1 Plot.*

TABLE 2-3: MODE 2 VALUES

Half Step	
CH1: Phase 1	V_{REF} = 3.87V
CH2: I01	Speed = 0.43V
CH3: I11	V_{LOAD} = 24V
CH4: Coil Current	

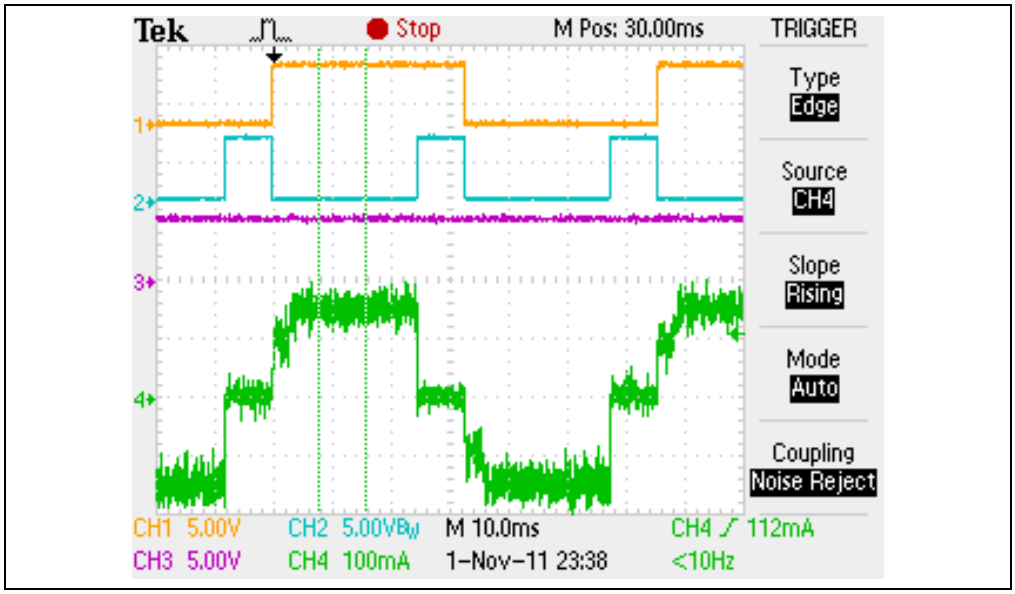


FIGURE 2-3: *Mode 2 Plot.*

TABLE 2-4: MODE 3 VALUES

Modified Half Step	
CH1: Phase 1	V_{REF} = 3.87V
CH2: I01	Speed = 0.43V
CH3: I11	V_{LOAD} = 24V
CH4: Coil Current	

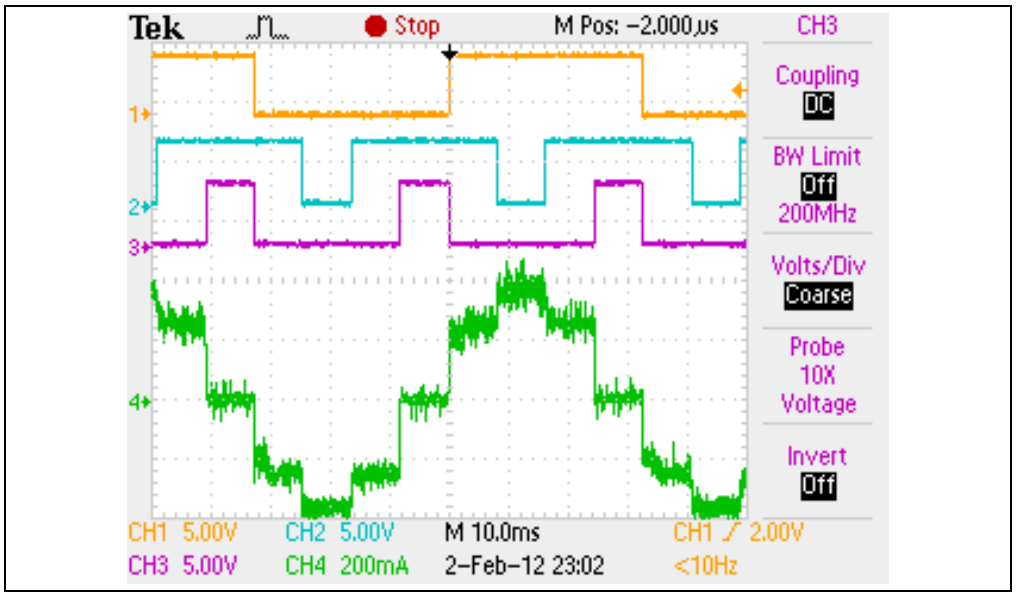


FIGURE 2-4: *Mode 3 Plot.*

TABLE 2-5: MODE 4 VALUES

Micro Step	
CH1: Phase 1	V_{REF} = 3.87V
CH2: I01	Speed = 0.43V
CH3: I11	V_{LOAD} = 24V
CH4: Coil Current	

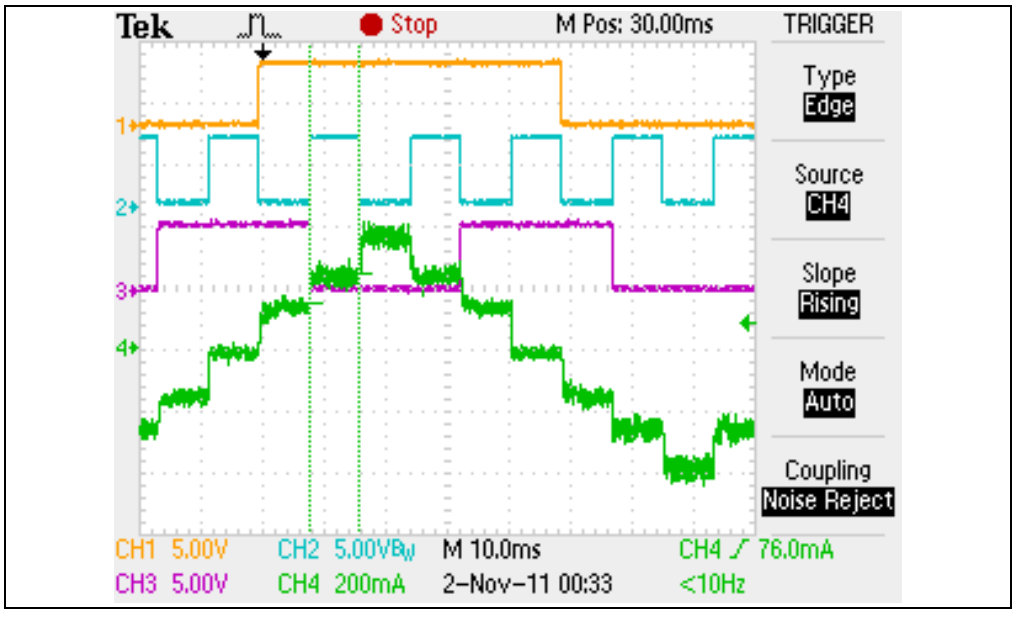


FIGURE 2-5: *Mode 4 Plot.*

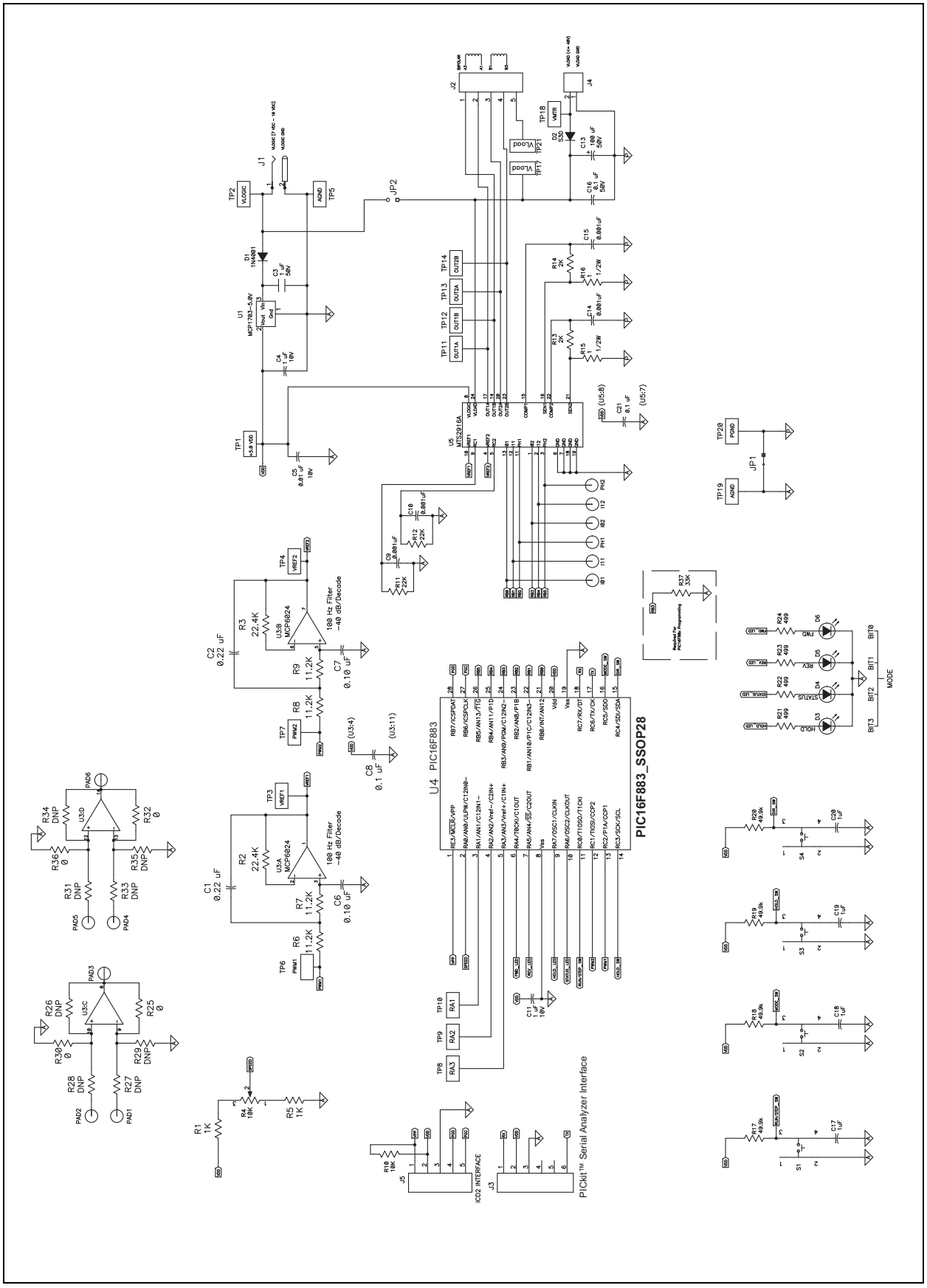
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

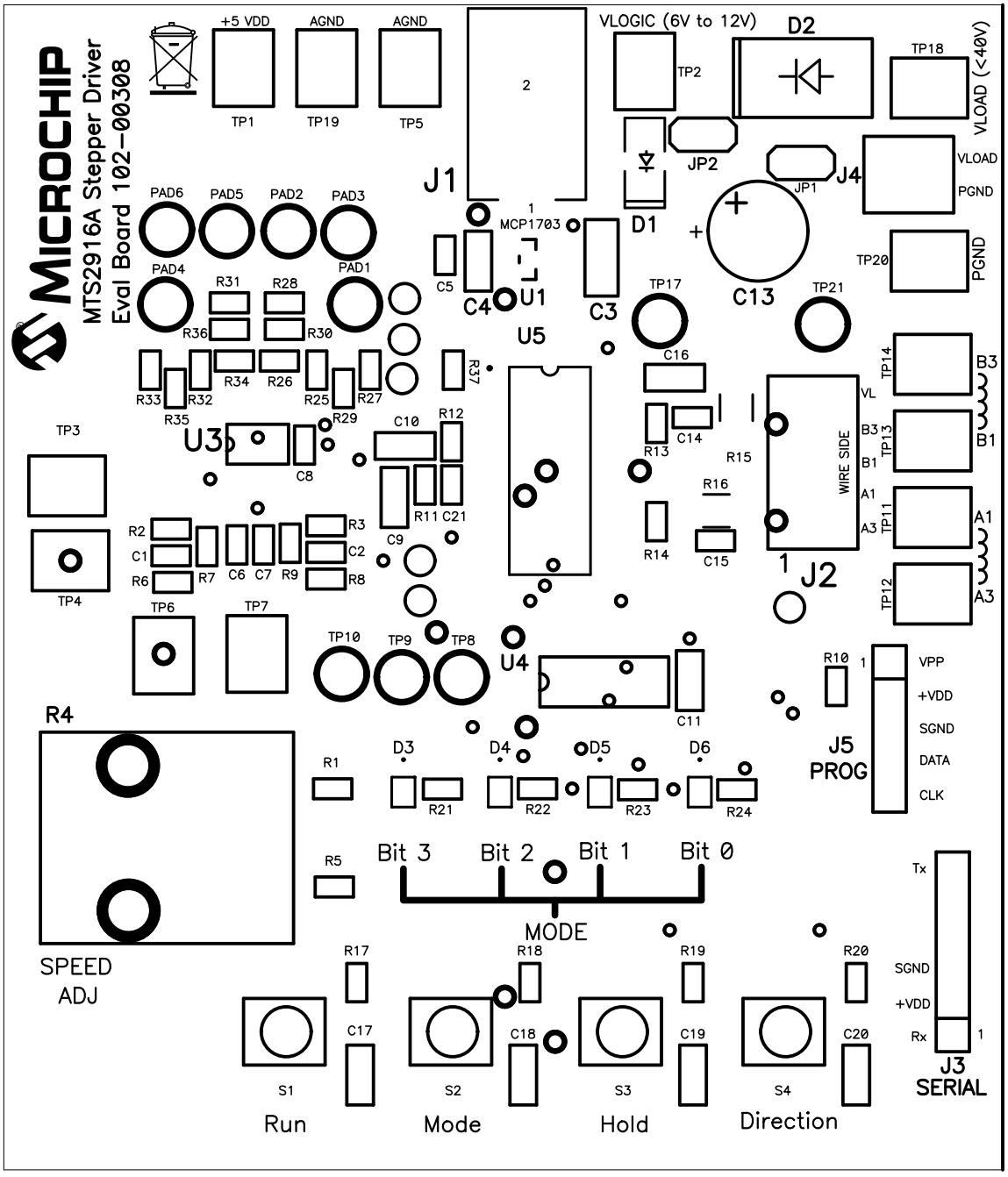
This appendix contains the following schematics and layouts for the MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board:

- Board – Schematic
- Board – Top Silk
- Board – Top Pads and Silk
- Board – Bottom Copper

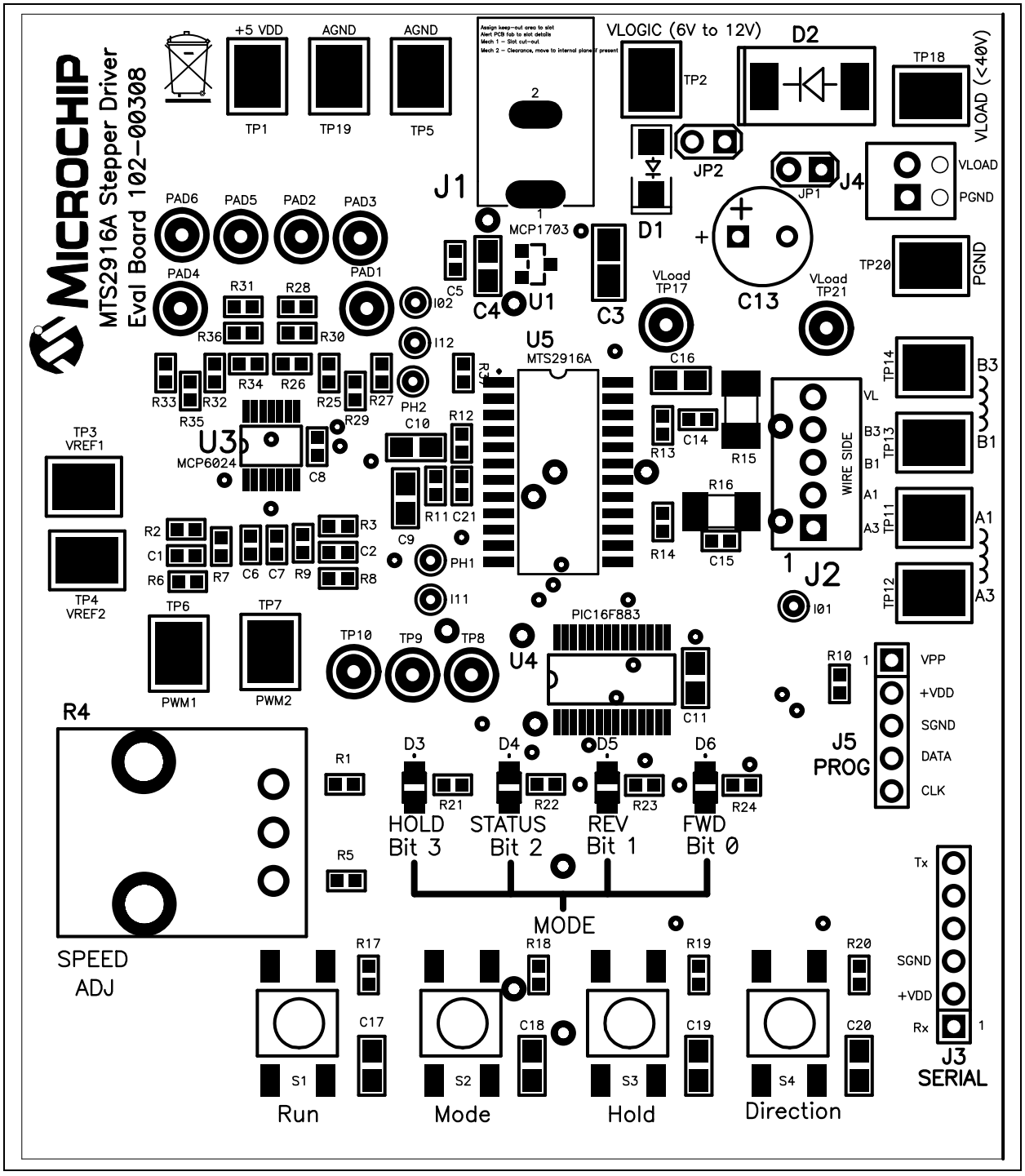
A.2 BOARD – SCHEMATIC



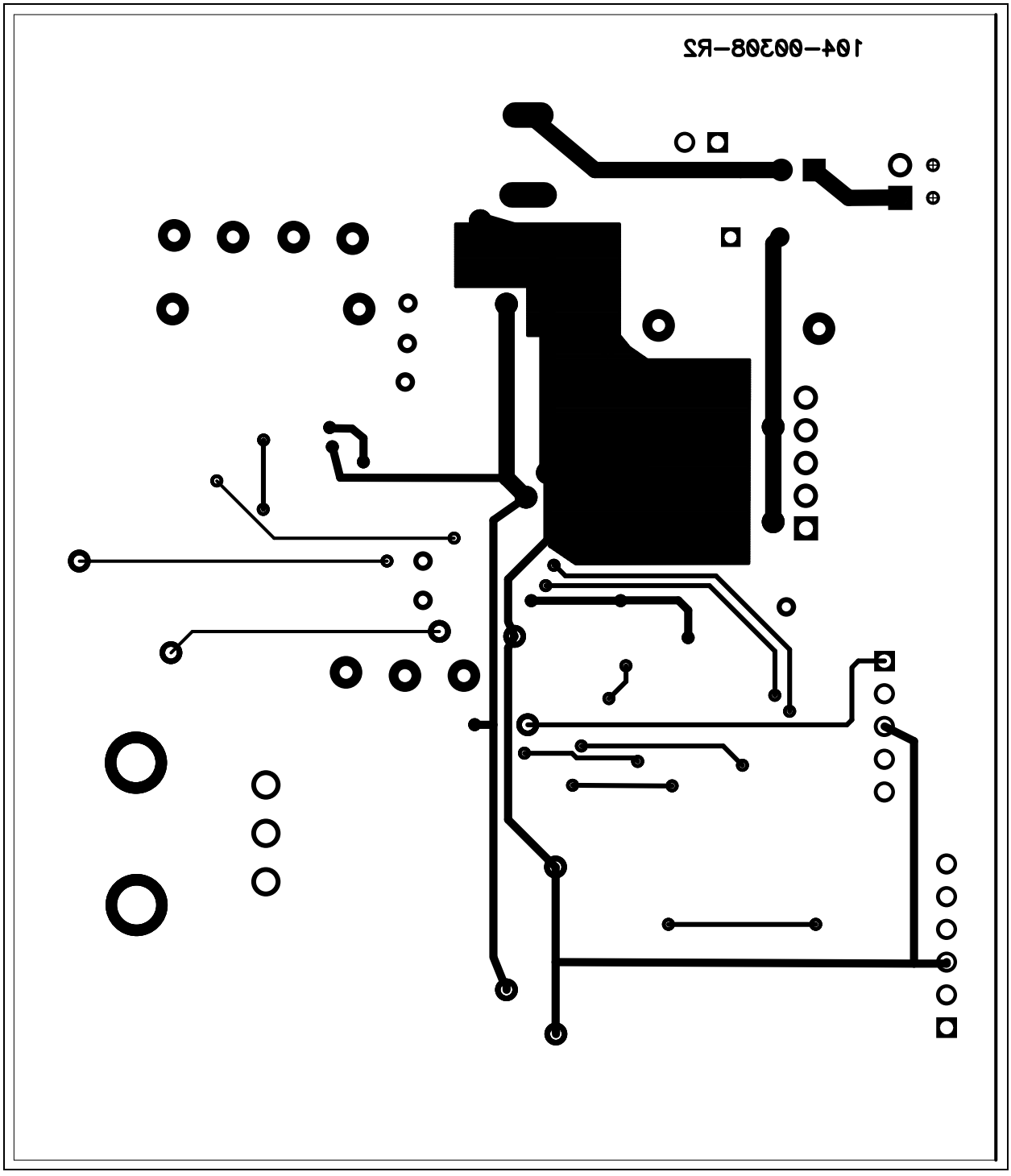
A.3 BOARD – TOP SILK



A.4 BOARD – TOP PADS AND SILK



A.5 BOARD – BOTTOM COPPER



NOTES:

Appendix B. Bill of Materials

TABLE B-1: BILL OF MATERIALS

Qty.	Reference	Description_	Manufacturer	Part Number
2	C1, C2	Cap. 0.22 µF 10V Ceramic X7R 0603 10%	Yageo Corporation	CC0603KRX7R6BB224
1	C3	Cap. 1.0 µF 50V Ceramic X7R 10% 1206	TDK Corporation	C3216X7R1H105K
6	C4, C11, C17, C18, C19, C20	Cap. 1.0 µF 10V Ceramic X7R 0805 10%	Murata Manufacturing Co., Ltd.	GRM21BR71A105KA01L
1	C5	Cap. 0.01 µF 50V Ceramic X7R 0603 10%	Murata Manufacturing Co., Ltd.	GRM188R71H103KA01D
4	C6, C7, C8, C21	Cap. 0.1 µF 25V Ceramic X7R 0603 10%	Murata Manufacturing Co., Ltd.	GRM188R71E104KA01D
1	C13	Cap. 100 µF 50V Elect. EB Radial	Panasonic® – ECG	EEU-EB1H101S
4	C9, C10, C14, C15	Cap. 0.001 µF 50V Ceramic X7R 0603 10%	Murata Manufacturing Co., Ltd.	GRM188R71H102KA01D
1	C16	Cap. 0.1 µF 50V Ceramic X7R 0805 10%	Murata Manufacturing Co., Ltd.	GRM21BR71H104KA01L
1	D1	Diode Rectifier, Standard Recovery 1A 50V DO-214AC SMA	Vishay/General Semiconductor	S1A-E3
1	D2	Diode Rectifier, Standard Recovery 3A 200V DO-214AB SMC	Vishay/General Semiconductor	S3D-E3/57T
4	D3, D4, D5, D6	LED Chipled 570 nm Green 0805 SMD	OSRAM Opto Semiconductors GmbH.	LG R971-KN-1-0-20-R18
1	J1	Connector Pwr. Jack 2.5 X 6.5 mm W/O SW	CUI Inc.	PJ-037B
1	J2	Connector Term. Block 2.54 mm 5 Pos.	Phoenix Contact GmbH & Co.	1725685
1	J3	Connector Header 6 Pos. 0.100 Vert. Tin Breakaway	Molex®	—
1	J4	Connector Term. Block 2.54 mm 2 Pos.	Phoenix Contact GmbH & Co.	1725656
1	J5	Connector Header 5 Pos. 0.100 Vert. Tin Breakaway	Molex	—
1	JP1	Wire Jumper 22 Gauge	—	—
1	JP2	Connector Header 36 Pos. 0.100 Vert. Tin (36 cuts in pairs of 2 = 18 per part number)	Molex	22-28-4360
1	PCB	MTS2916A Dual Full-Bridge Stepper Motor Driver Evaluation Board Printed Circuit Board	Microchip Technology Inc.	104-00308
2	R1, R5	Res.1K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT1K00
2	R2, R3	Res. 22.6K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT22K6
1	R4	Pot. 10K Ohm 1/8W Carb. Vertical	CTS® Corporation	296UD103B1N

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

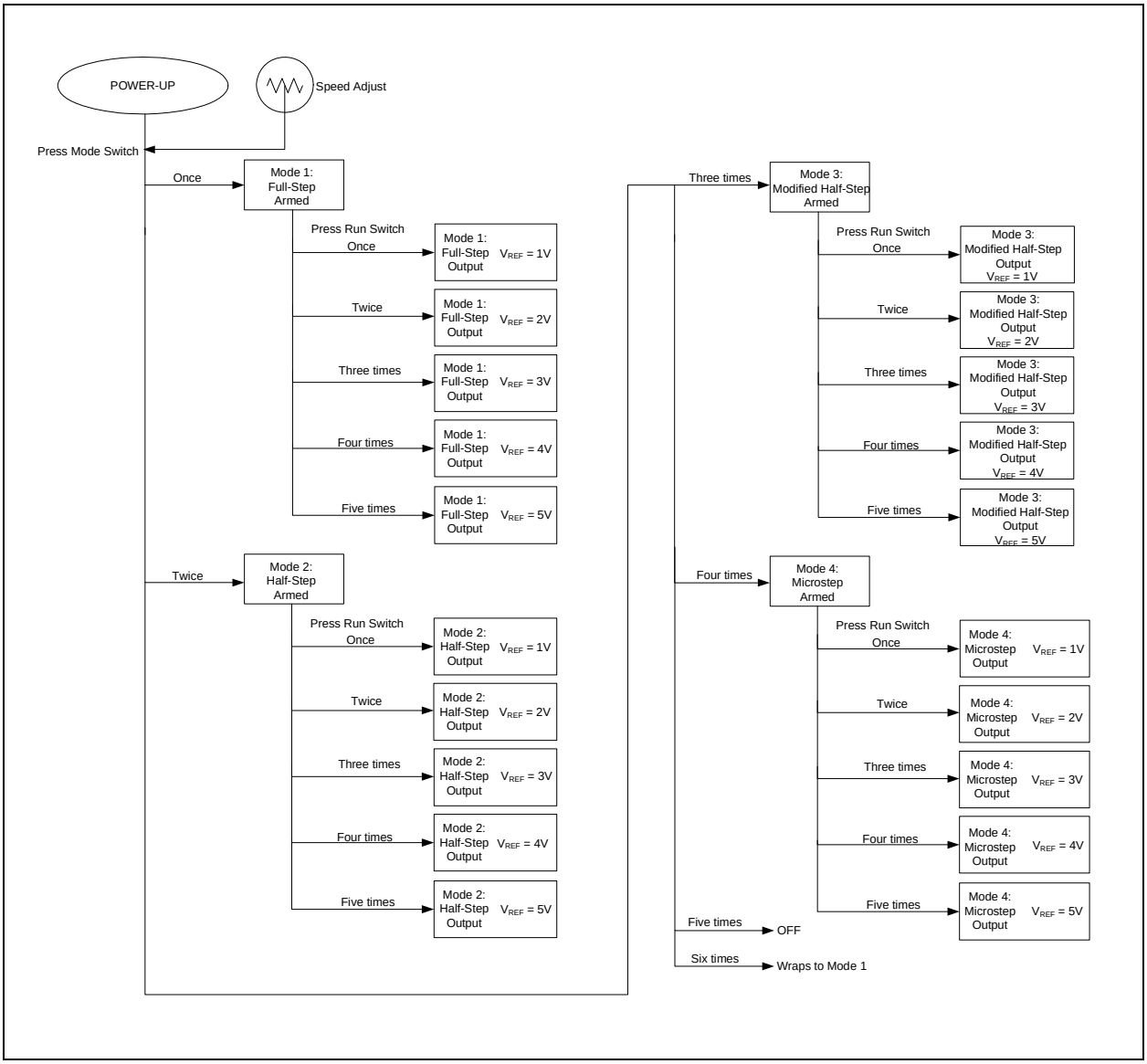
TABLE B-1: BILL OF MATERIALS (CONTINUED)

Qty.	Reference	Description_	Manufacturer	Part Number
4	R6, R7, R8, R9	Res. 11.3K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT11K3
1	R10	Res. 10K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT10K0
2	R11, R12	Res. 22K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT22K0
2	R13, R14	Res. 2K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT2K00
2	R15, R16	Res. 1.00 Ohm 3/4W 1% 2010 SMD	Vishay/Dale	CRCW20101R00FKEF
4	R17, R18, R19, R20	Res. 49.9K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT49K9
4	R21, R22, R23, R24	Res. 499 Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT499
4	R25, R30, R32, R36	Res. 0.0 Ohm 1/10W 5% 0603 SMD	Yageo Corporation	RC0603JR-070RL
1	R37	Res. 33K Ohm 1/10W 1% 0603 SMD	Stackpole Electronics, Inc.	RMCF0603FT33K0
4	S1, S2, S3, S4	Switch Tactile SPST-NO 6 mm 260 GF 0.05A 12V SMT	E-Switch®, Inc.	TL3301NF260QG
14	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP11, TP12, TP13, TP14, TP18, TP19, TP20	Test Point PC Compact SMT	Keystone Electronics Corp.	5016
1	U1	Microchip 5V 250 mA LDO SOT-23A	Microchip Technology Inc.	**MCP1703T-5002E/CB**
1	U3	MCP6024 General Purpose Op Amp 14-TSSOP	Microchip Technology Inc.	**MCP6024-E/ST**
1	U5	MTS2916A IC PWM Stepper Motor Driver 24-SOP	Microchip Technology Inc.	**MTS2916A-HGC1**
1	U4	PIC16F883 MCU Flash 4K X 14 28-SSOP	Microchip Technology Inc.	**PIC16F883-E/SS**

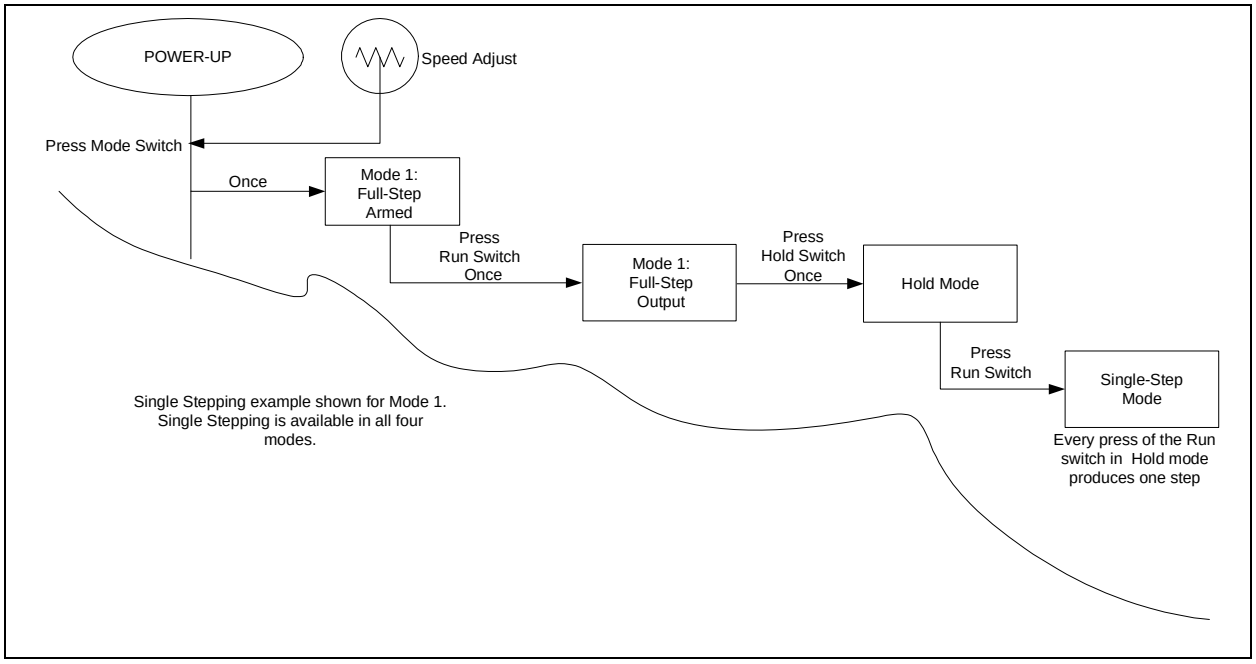
Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

Appendix C. Mode Sequence Diagrams

C.1 MTS2916A DUAL FULL-BRIDGE STEPPER MOTOR DRIVER EVALUATION BOARD FUNCTIONAL FLOWCHART

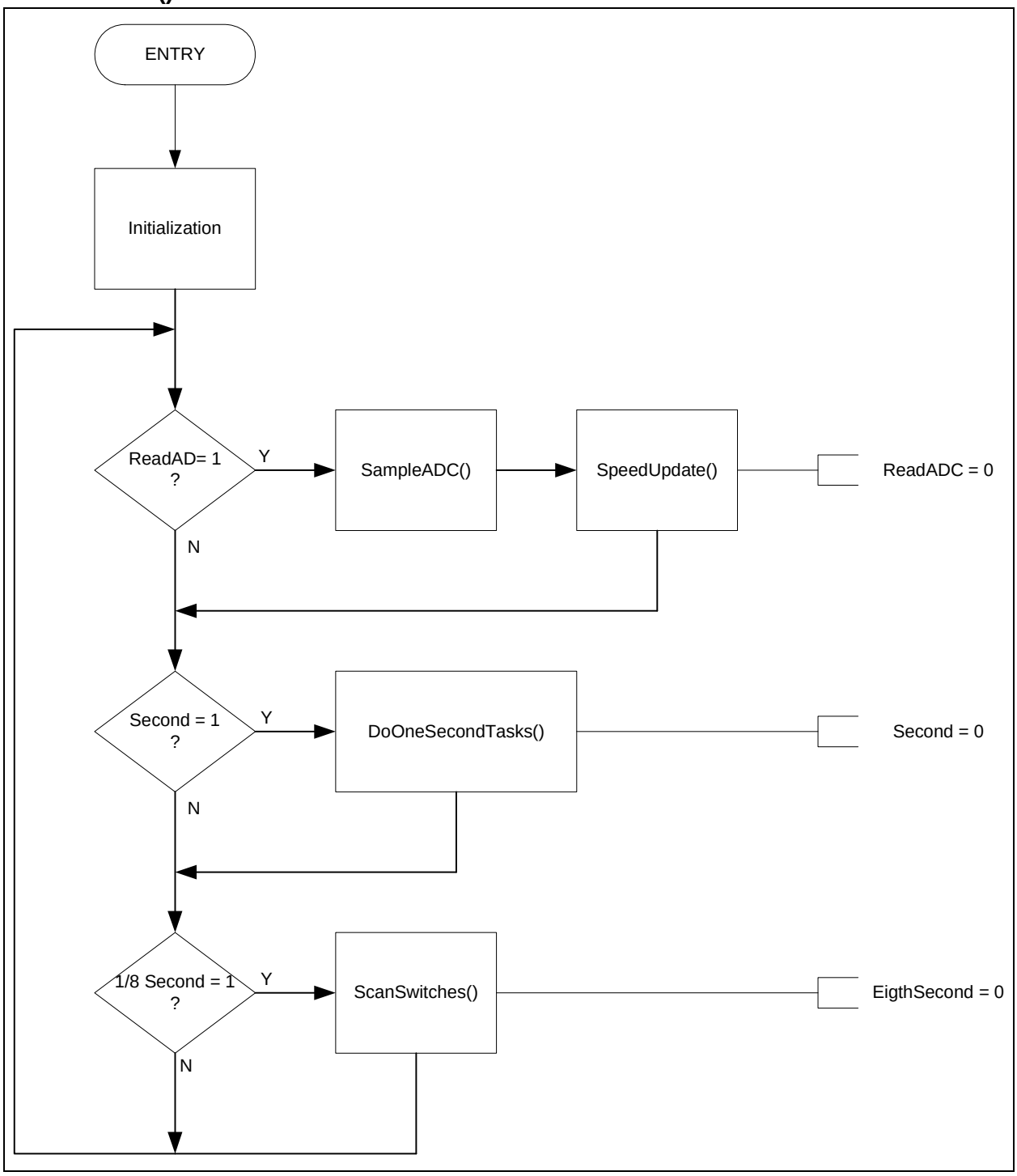


C.2 SINGLE STEPPING EXAMPLE



C.3 MTS2916A DUAL FULL-BRIDGE STEPPER MOTOR DRIVER EVALUATION BOARD SOFTWARE FLOWCHARTS

C.3.1 Main() Mode



C.3.2 Interrupt() Mode

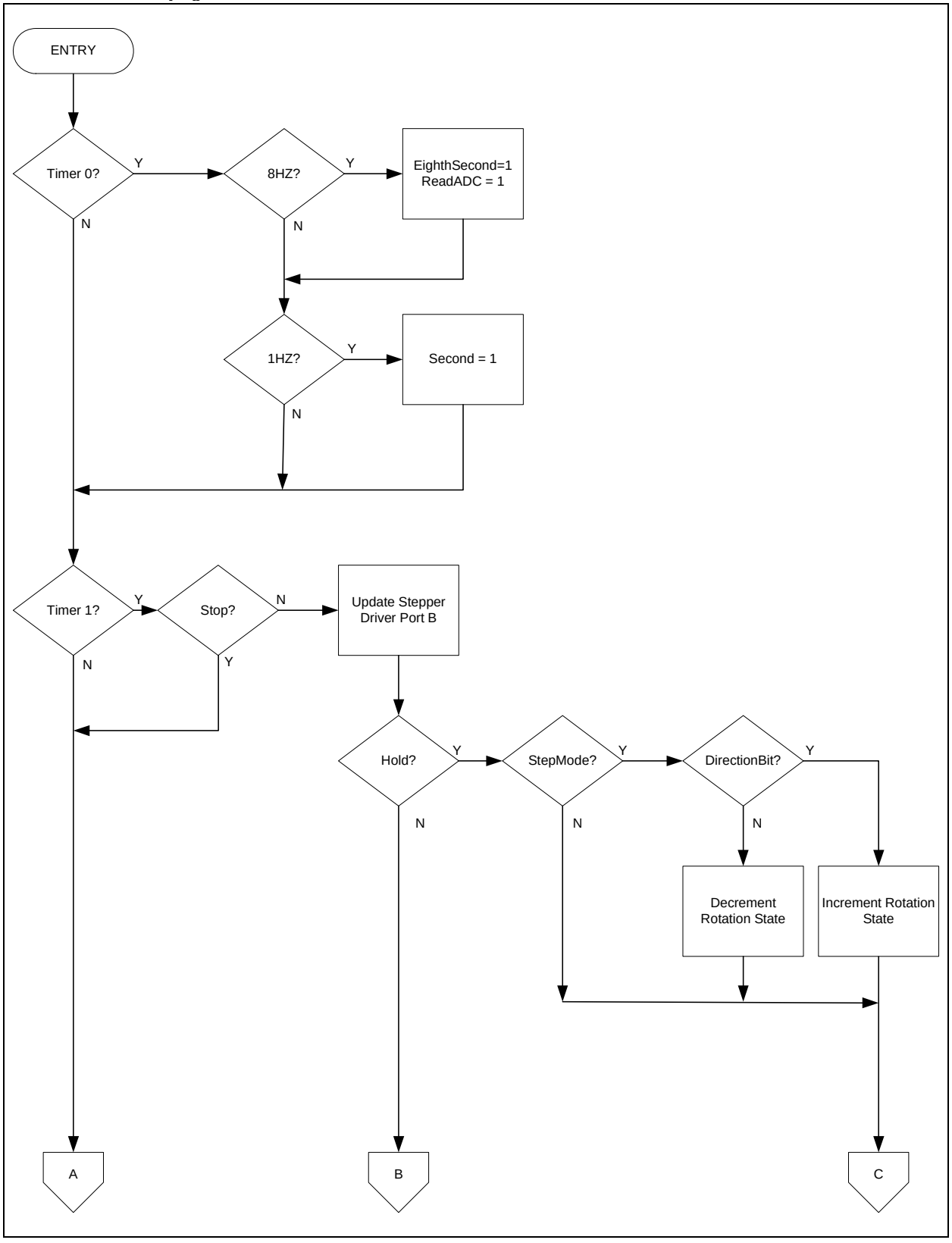


FIGURE C-1: *Interrupt() Mode.*

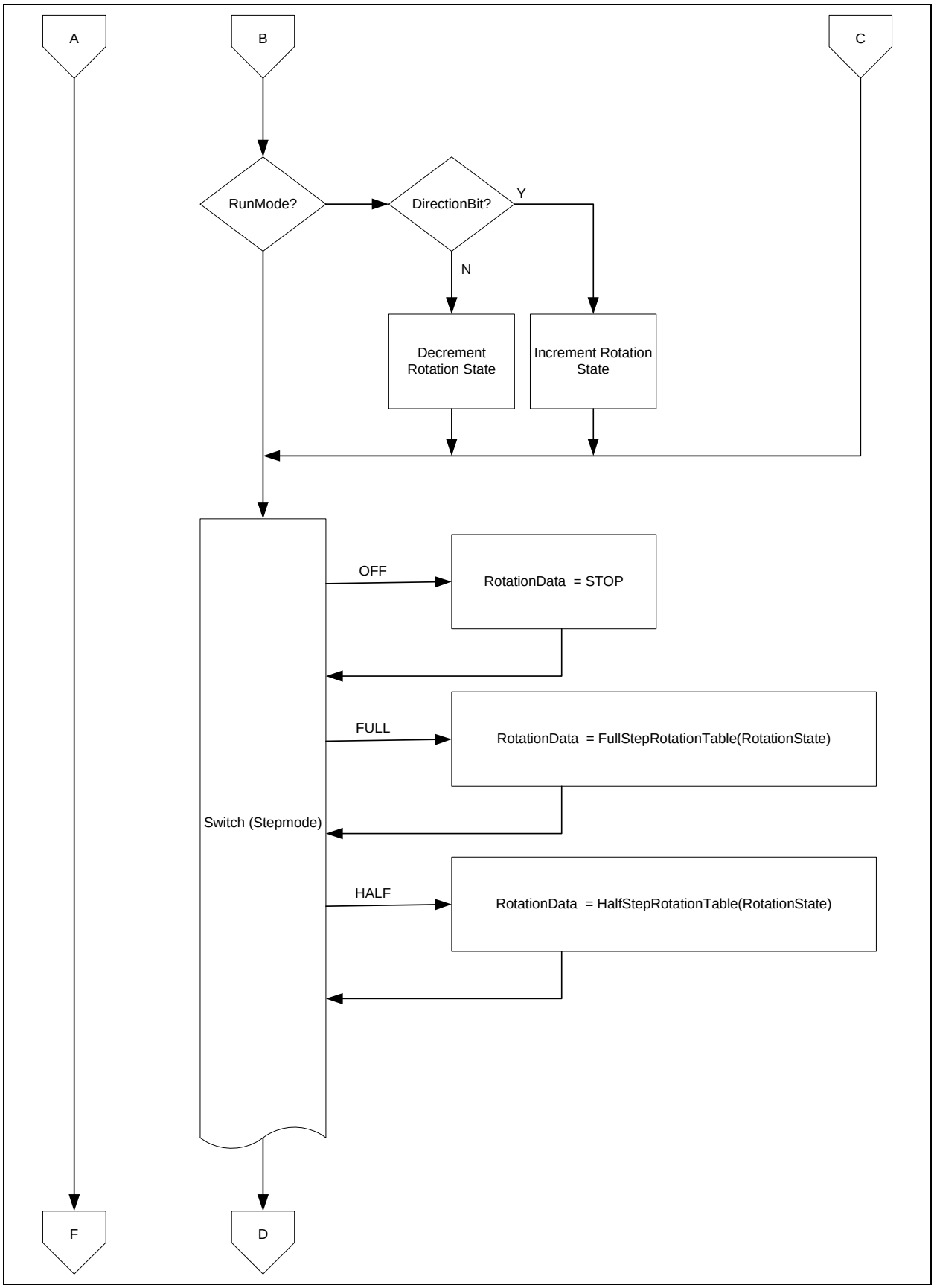


FIGURE C-2: *Interrupt Mode (Continuation).*

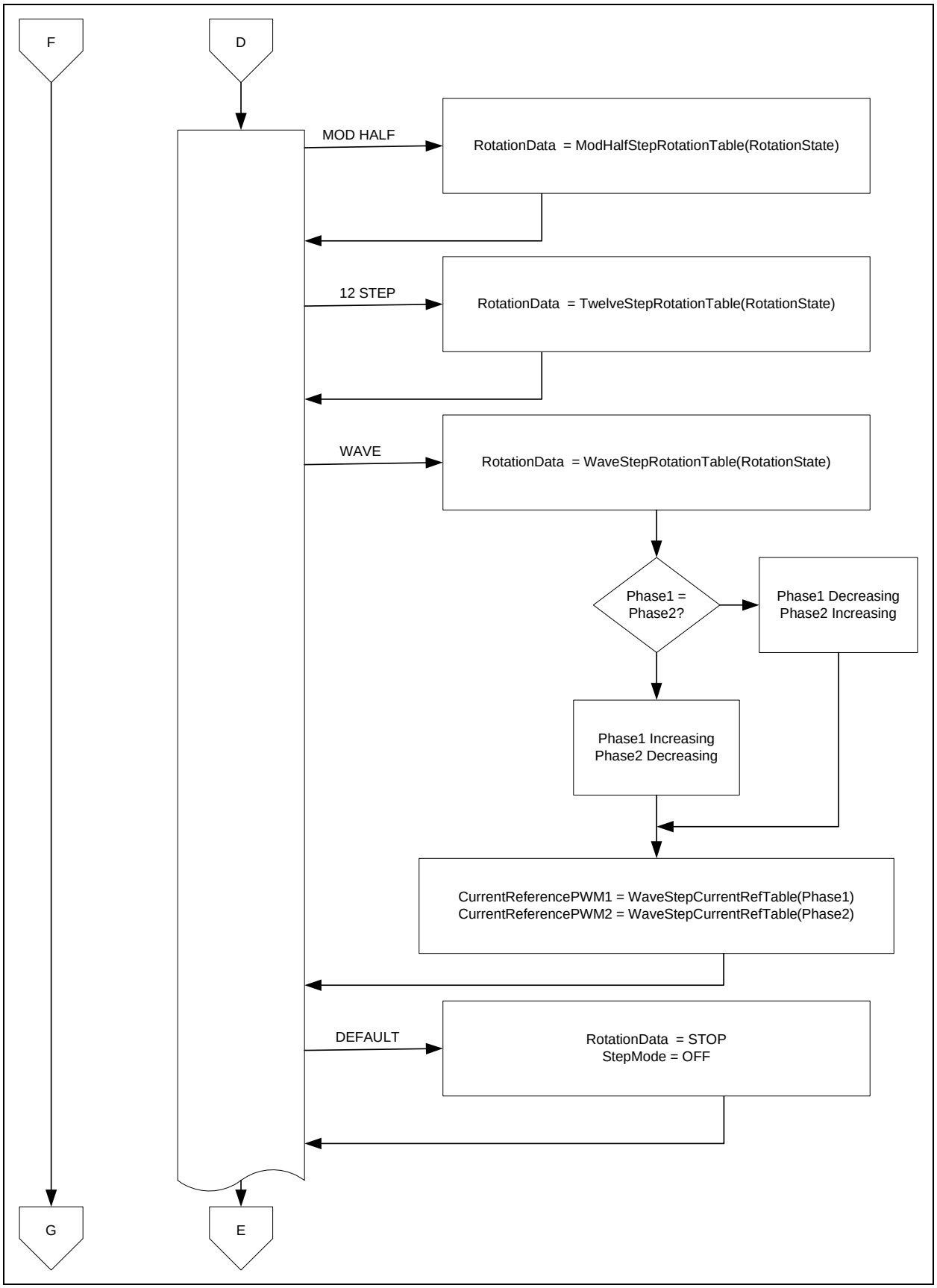


FIGURE C-3: *Interrupt Mode (Continuation).*

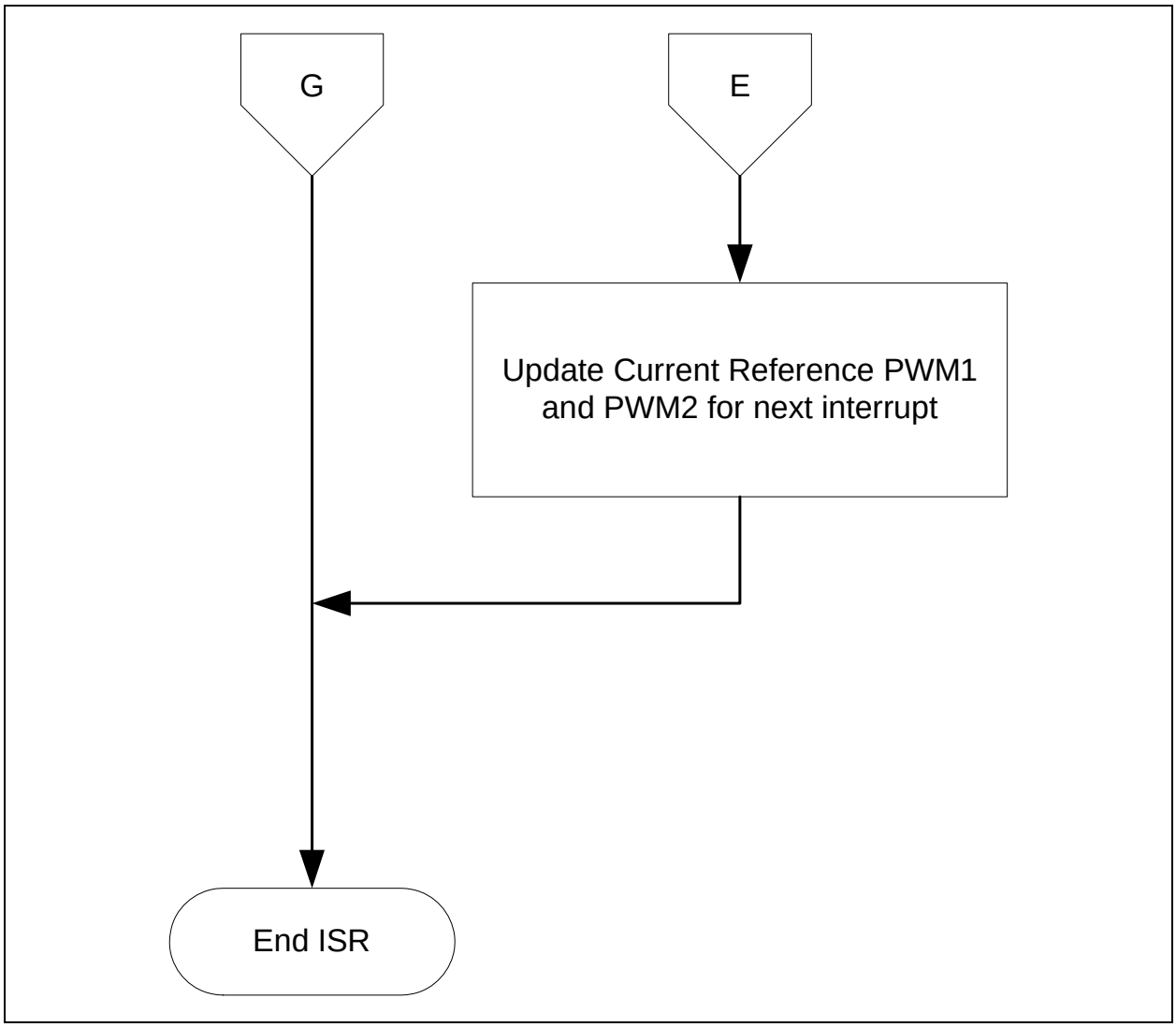
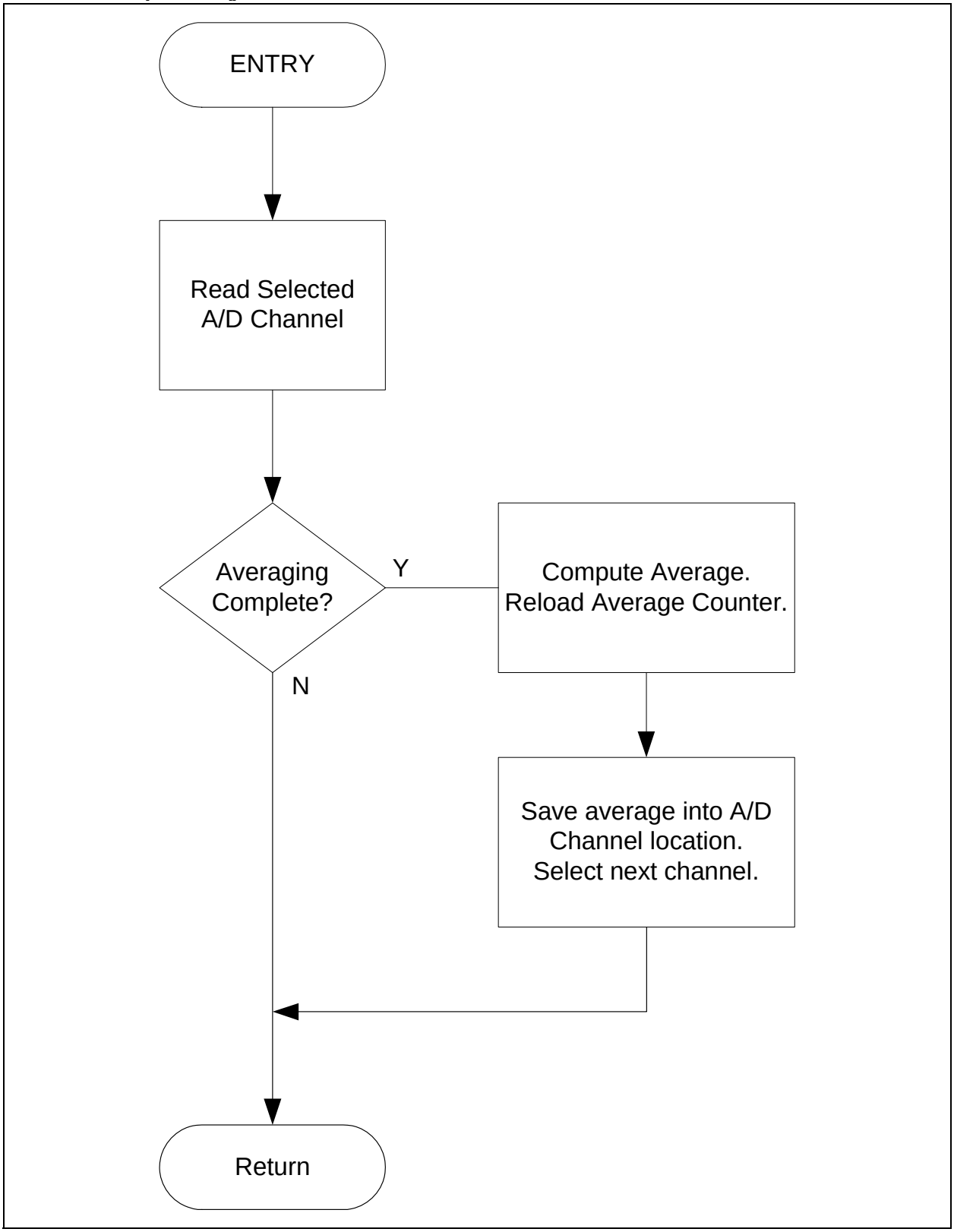
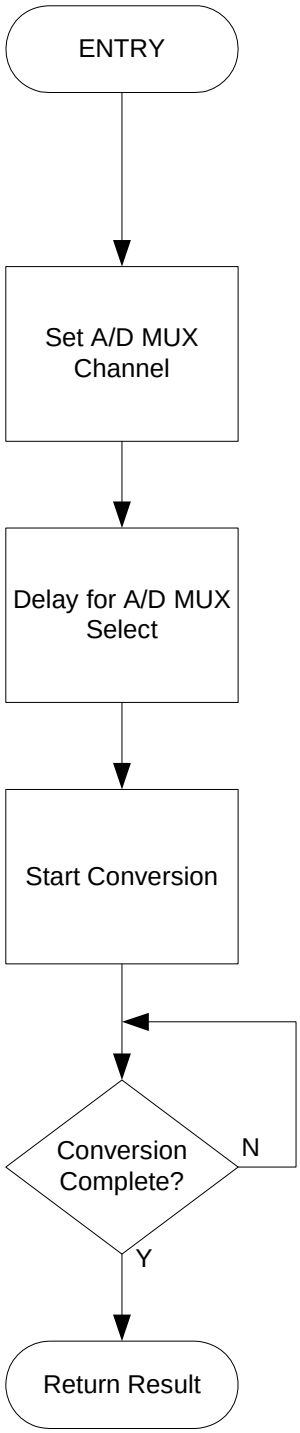


FIGURE C-4: *Interrupt Mode (Last).*

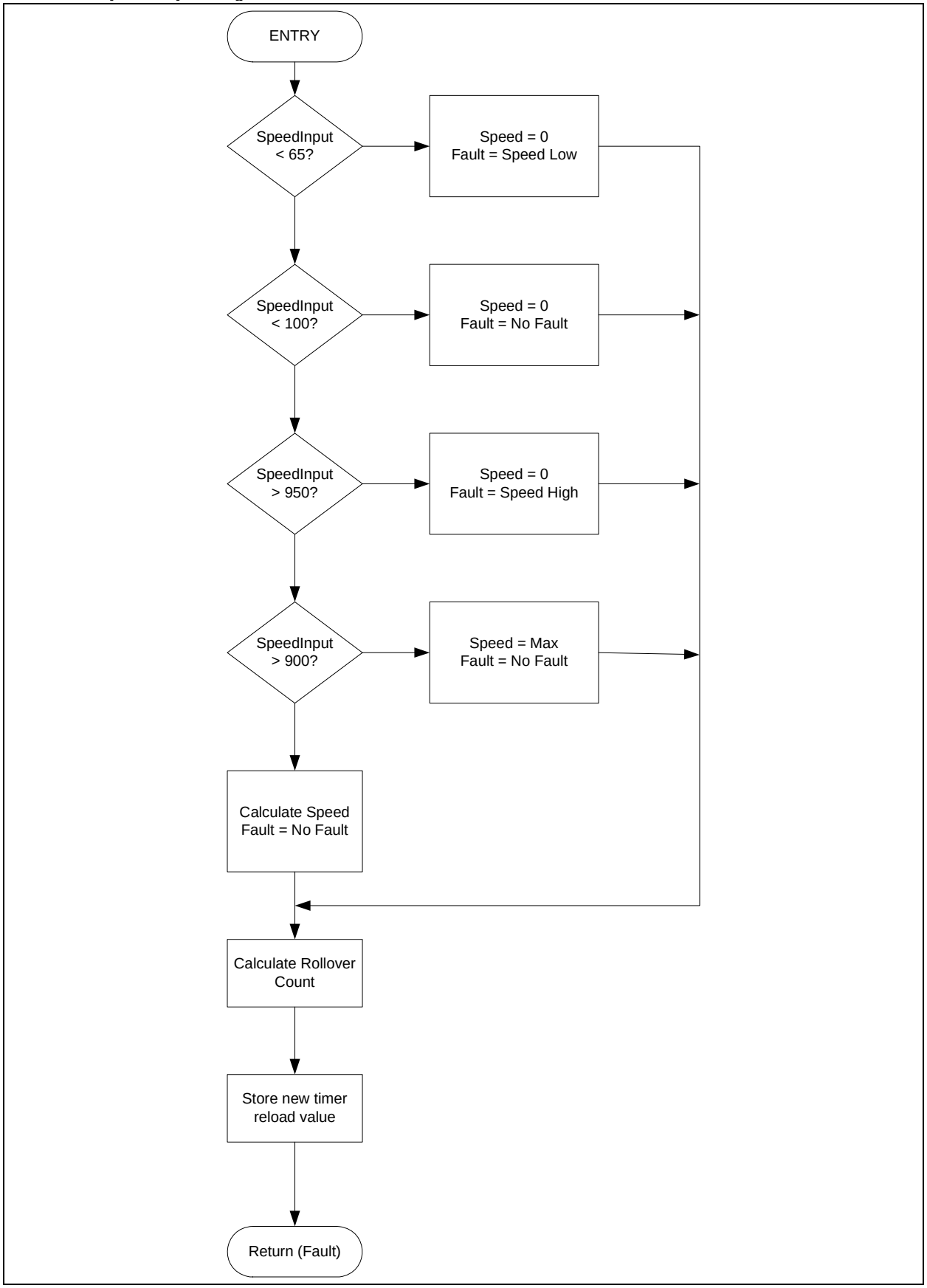
C.3.3 SampleADC() Mode



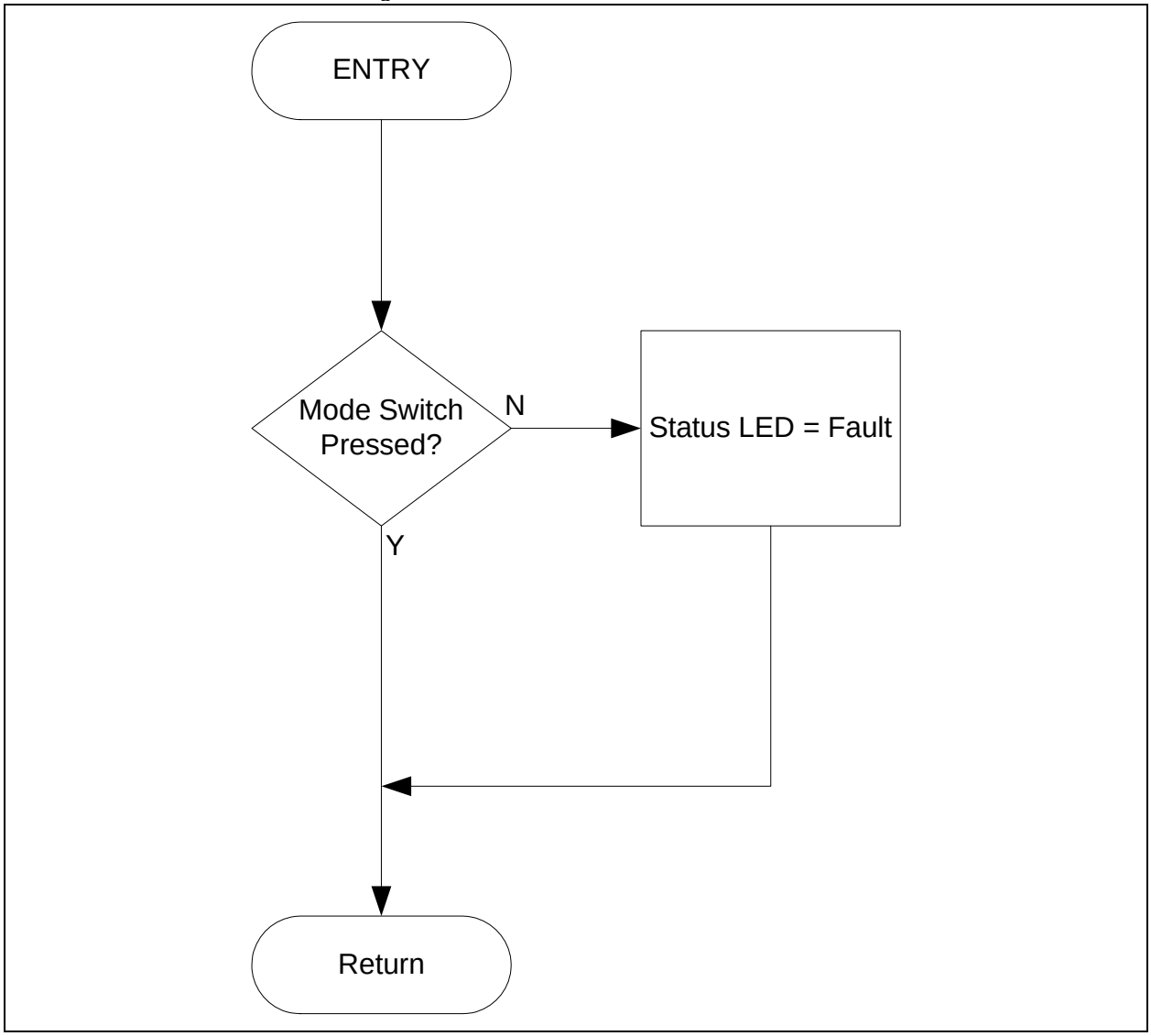
C.3.4 ReadADCChannel (Channel) Mode



C.3.5 SpeedUpdate() Mode



C.3.6 DoOneSecondTasks() Mode



C.3.7 ScanSwitches() Mode

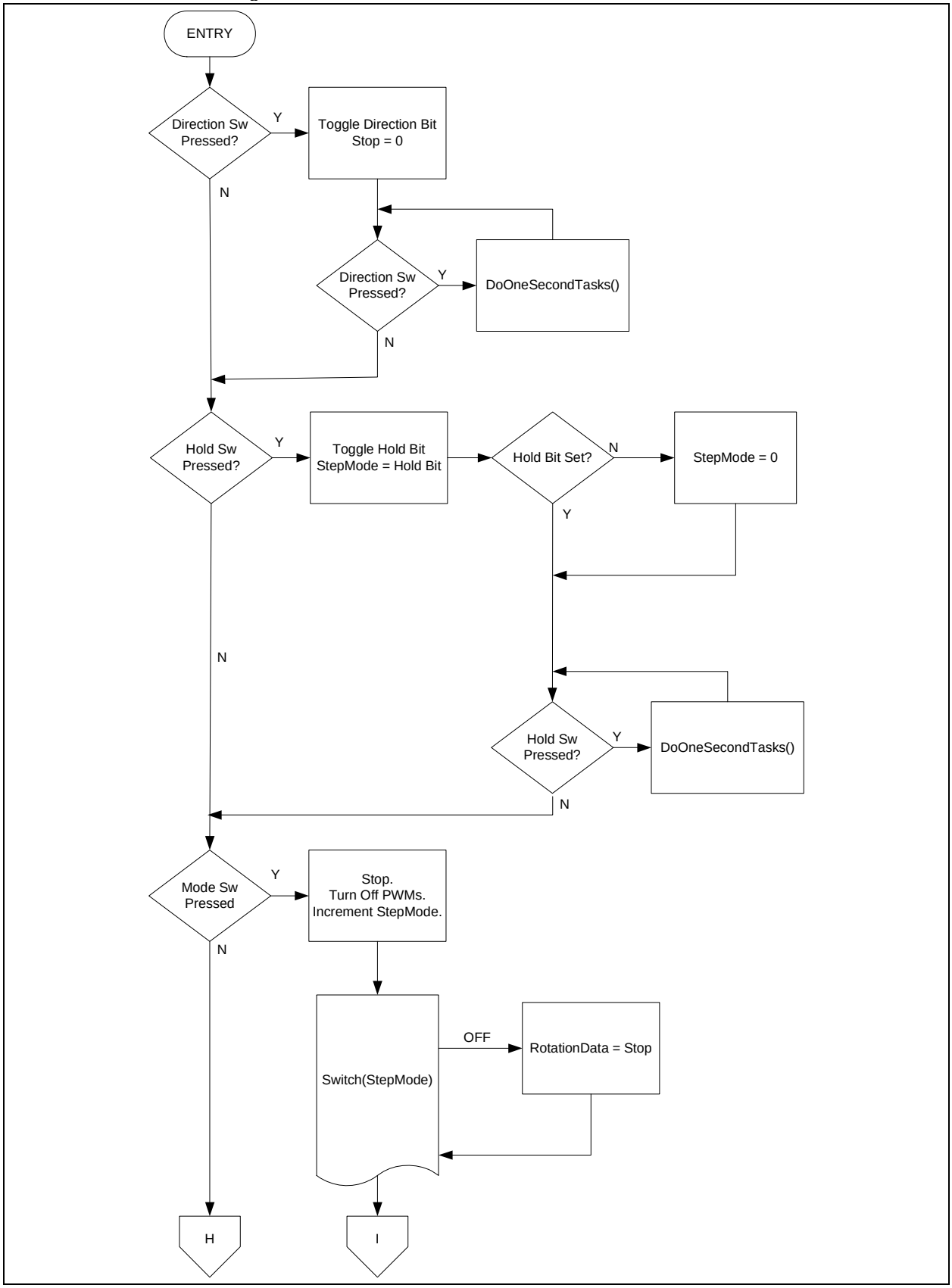


FIGURE C-5: *ScanSwitches() Mode.*

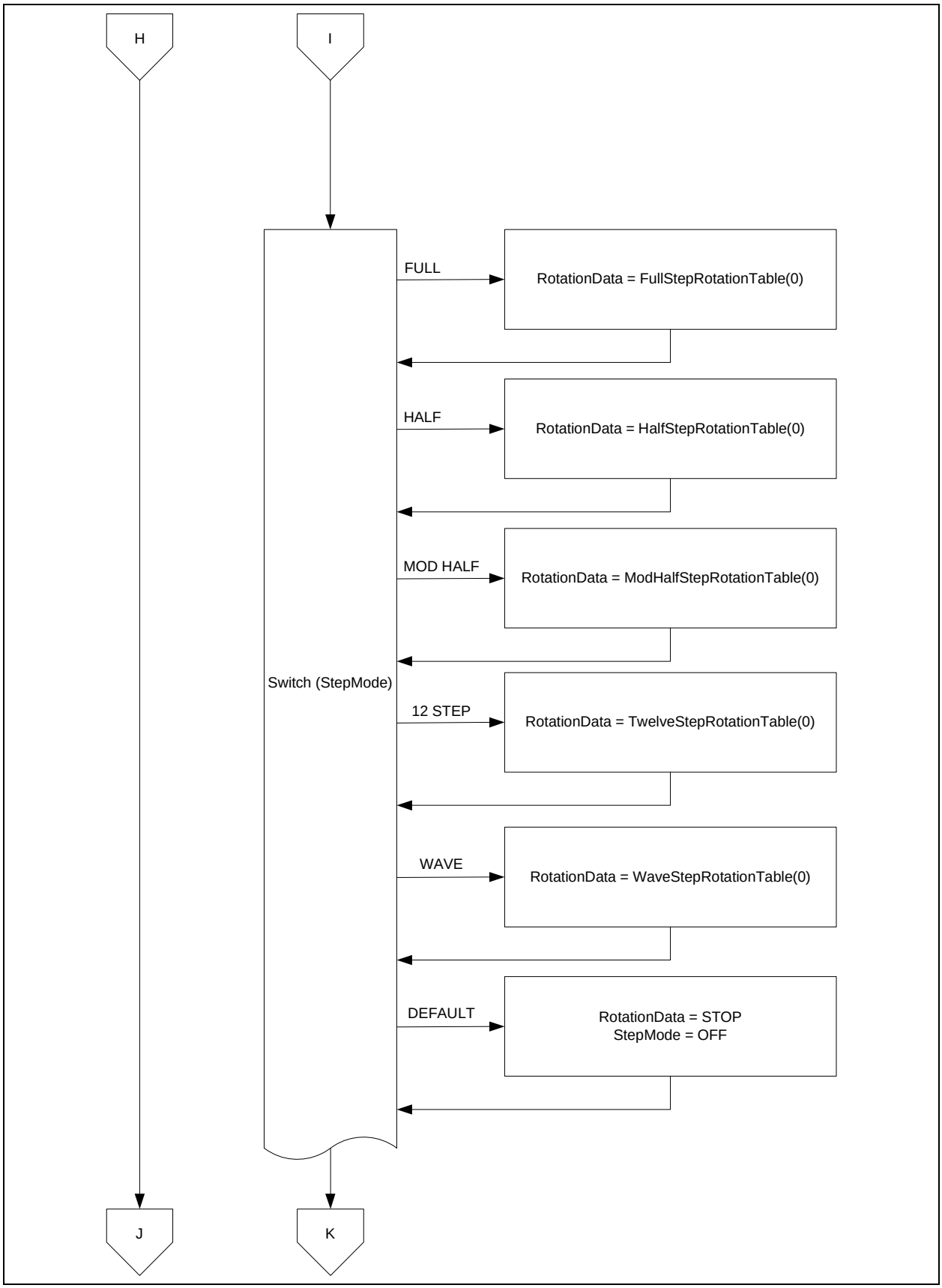


FIGURE C-6: *ScanSwitches() Mode (Continuation).*

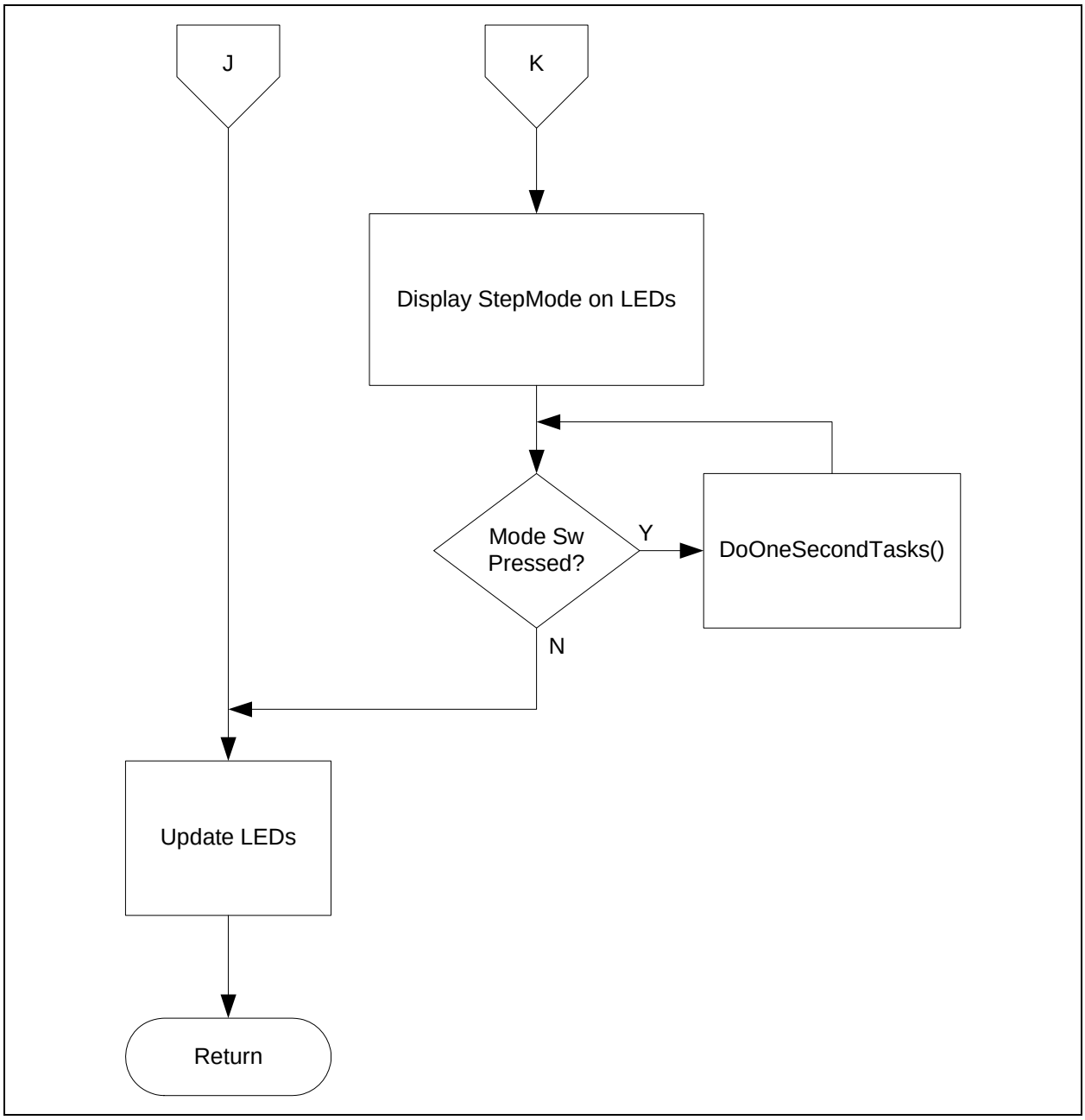


FIGURE C-7: *ScanSwitches() Mode (Continuation).*

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