MCP1630
+12V In Dual Output Buck Converter Reference Design

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Table of Contents

NOTES:

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our web site (www.microchip.com) to obtain the latest documentation available.

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 on-line help. Select the Help menu, and then Topics to open a list of available on-line help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP1630 Dual Buck Reference Design. 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 MCP1630 Dual Buck Reference Design as a development tool. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP1630 Dual Buck Reference Design.
- **Chapter 2. "Installation and Operations"** – Includes instructions on how to get started with this reference design and a description of the reference design operation.
- **Appendix A. "Schematic and Layouts"** - Shows the schematic and layout diagrams for the MCP1630 Dual Buck Reference Design.
- **Appendix B. "Bill Of Materials (BOM)"** – Lists the parts used to build the MCP1630 Dual Buck Reference Design.
- **Appendix C. "Evaluation Board Firmware"** - Provides information about the application firmware and where the source code can be found.

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 reference guide describes how to use MCP1630 Dual Buck Reference Design. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

MCP1630 Data Sheet, "*High-Speed, Microcontroller-Adaptable, Pulse Width Modulator*", DS21896

MCP1630 NiMH Demo Board User's Guide, DS51505

AN960 - "*New Components and Design Methods Bring Intelligence to Battery Charger Applications*", DS00960

MCP14628 Data Sheet, *"2A Synchronous Buck Power MOSFET Driver"*, DS22083

MCP1703 Data Sheet, "*250 mA, 16V, Low Quiescent Current LDO*", DS22049

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- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

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

DOCUMENT REVISION HISTORY

Revision B (July 2008)

- Changed U2 and U7 to MCP14628;
- Changed U4 to MCP1703.

Revision A (February 2005)

- Inital Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

The MCP1630 Dual Buck Reference Design is used to evaluate the Microchip MCP1630 analog, high-speed Pulse Width Modulator (PWM) used in a dual synchronous, buck regulator, power-converter application. The evaluation board is a complete, stand-alone, dual-output, dc-dc converter with +12V input, adjustable dual output at 20A per output.

This chapter also covers the following topics:

- What is the MCP1630 Dual Buck Reference Design?
- What the MCP1630 Dual Buck Reference Design kit includes.

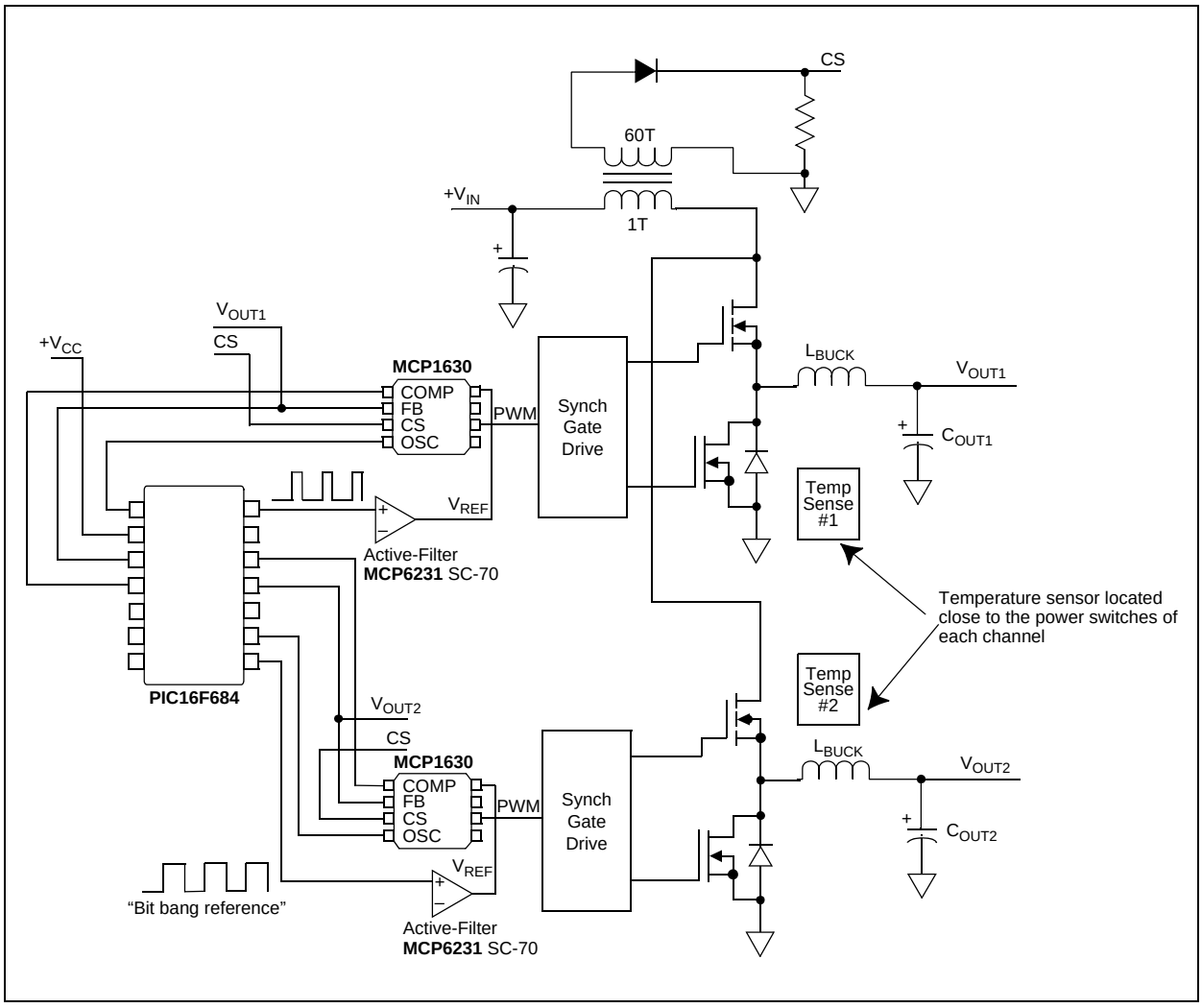


FIGURE 1-1: *Dual Buck Converter Block Diagram.*

1.2 WHAT IS THE MCP1630 DUAL BUCK REFERENCE DESIGN?

The MCP1630 Dual Buck Reference Design is a complete, stand-alone, dual-output power supply capable of 20A per output, powered from a +12V input source. This board utilizes Microchip's MCP1630 (high-speed PIC® MCU PWM MSOP8), MCP1703 (LDO SOT-89), PIC16F684 (MCU Flash TSSOP14), MCP6231U (Op Amp SC-70), TC6501 (Temperature Switch SOT23A-5) and MCP14628 (synchronous MOSFET driver SOIC8). The input voltage range for the reference design is +9.0V to +13.5V. Both adjustable regulated outputs are capable of 20A.

Input terminals are provided to apply an intput voltage to the power supply. Output terminals are also provided as a way to connect the 20A outputs to a load.

1.3 WHAT THE MCP1630 DUAL BUCK REFERENCE DESIGN KIT INCLUDES

This MCP1630 Dual Buck Reference Design Kit includes:

- The MCP1630 Dual Buck Reference Design (102-00035)
- Analog and Interface Product Demonstration Boards CD-ROM (DS21912)
  - MCP1630 Dual Buck Reference Design (DS51531)
  - MCP1630 Data Sheet (DS21896)

Chapter 2. Installation and Operations

2.1 INTRODUCTION

The MCP1630 Dual Buck Reference Design demonstrates Microchip's MCP1630 high-speed PWM, used in an adjustable, dual-output, buck regulator application. The MCP1630 is a high-speed, microcontroller-adaptable, PWM that, when used in conjunction with a microcontroller, will control the power system duty cycle to provide output voltage regulation. The PIC16F684 microcontroller can be used to regulate output voltage or current, switching frequency and setting maximum duty cycle. The MCP1630 generates duty cycle, provides fast overcurrent protection and utilizes variable external inputs. External signals include the input oscillator and the reference voltage. The power train signals include the current sense and the feedback voltage. The output signal is a square-wave pulse. The power train used for the MCP1630 Dual Buck Reference Design is a dual synchronous buck regulator.

2.2 FEATURES

The MCP1630 Dual Buck Reference Design has the following features:

- Input Voltage Range: +9.0V to +13.5V
- Adjustable Output Voltage Capable of Calibration
- Sequencing or Tracking Outputs
- Outputs are180° out of phase, each capable of 20A
- Independent Overcurrent Protection
- Independent Overtemperature Protection
- Input Overvoltage and Undervoltage Lockout (UVLO)
- Power Good Indication (LED) with Adjustable Delay
- Switching Frequency Dithering

2.3 GETTING STARTED

The MCP1630 Dual Buck Reference Design is fully assembled and tested over its range of input voltage, output voltage and output current. This board requires the use of an external input voltage source (+9.0V to +13.5V) and external load (electronic or resistive).

Note: It is recommended that a minimum 300 linear feet per minute of airflow blown directly across the board to cool the power dissipating components when operating above 10A loads.

2.3.1 Power Input and Output Connections

Powering the MCP1630 Dual Buck Reference Design.

1. Apply the input voltage to the connector (J3) provided. Connect the positive side of the input source (+) to the test point (J3-1). Connect the negative (or return side (-)) of the input source to the GND terminal (J3-2). J3 is the center two position terminal block located on the left side of the board. A 14-gauge wire size is recommended for evaluating the board at 20A per output. The power supply input voltage must be in the specified operating range for the board to operate. An undervoltage lockout circuit prevents the converter from running when the input voltage is too low.
2. An on/off push-button switch (SW3) is used to turn the converter outputs on and off. During normal power-up, the outputs are turned on by pressing SW3 once. To turn the outputs off, press SW3 again.
3. In the event of a fault, (input voltage out-of-range, output voltage out-of-range or power train overtemperature), both V_{OUT1} and V_{OUT2} will shut down, indicated by the D1 power good LED flashing. To restart, the input voltage must be brought to 0V and raised back to the specified input voltage range of the converter prior to pressing the on/off button. A solid D1 power good LED indicates that the regulator outputs are operating properly at their programmed values.

Applying the load to the MCP1630 Dual Buck Reference Design.

1. To apply a load to V_{OUT1} of the MCP1630 Dual Buck Reference Design, the positive side of the V_{O1} load (+) should be connected to the terminal $+V_{O1}$ (J2-2). The negative side of the V_{O1} load should be connected to the terminal GND (J2-1).
2. To apply a load to V_{OUT2} of the MCP1630 Dual Buck Reference Design, the positive side of the V_{O2} load (+) should be connected to the terminal $+V_{O2}$ (J4-2). The negative side of the V_{O2} load should be connected to the terminal GND (J4-1).
3. Outputs V_{O1} and V_{O2} are independent of each other and are loaded separately. Both outputs have independent over current protection, overtemperature and short-circuit protection.

Note: The maximum rated load is 20A per output. When loading the board over 10A, airflow is necessary to prevent the overtemperature protection circuitry from automatically turing off the power train that has the overtemperature condition.

2.3.2 Power Present and Power Good Indication

1. The MCP1630 Dual Buck Reference Design has two status LED's. One LED (D3) is used to determine if input voltage is present.
2. The second LED (D1) is used for fault and power good indication. During normal operation, if both regulator outputs are within regulation, D1 is illuminated to provide indication that power is good. If either output is out of regulation, D1 will blink, providing indication that one or both of the outputs are not in regulation.

2.3.3 Programming

1. The MCP1630 Dual Buck Reference Design can be programmed to calibrate V_{OUT1}, V_{OUT2}, output sequencing or tracking and switching frequency dithering on or off.
2. To enter the programming mode, apply input voltage within the specified operating range (9V to 13.5V). Press and hold the M (SW1) button. While still holding the M button, press and release the on/off (SW3) button. The flashing rate of LED D1 should increase, indicating Programming mode.
3. Once in Programming mode, the first variable to set is V_{OUT1}. Press the select S button to increase V_{OUT1}. Keep pressing the S button to increase V_{OUT1} until it wraps around to the minimum setting.

Note: The range of V_{OUT1} is controlled by the value of fixed resistors R_{34}, R_{35} and R_{10}. The range of V_{OUT1} is typically from 2.42V (minimum) to 3.39V (maximum).

4. Press M once to select V_{OUT2}. V_{OUT2} in increased by pressing the S button similar to setting V_{OUT1}.

Note: The range of V_{OUT2} is controlled by the value of fixed resistors R_{14}, R_{15} and R_{42}. The range of V_{OUT2} is typically from 1.22V (minimum) to 2.3V (maximum).

5. Press M once to select between output sequencing or tracking. D1 flashing indicates that sequencing is selected. Press M to change from sequencing to tracking, or from tracking to sequencing.
6. Press M once to select between frequency dithering on and frequency dithering off. D1 flashing indicates that frequency dithering is selected.
7. By pressing and holding the M button, the selected settings will be programmed. The next power-up cycle for the converter will return to the programmed settings.

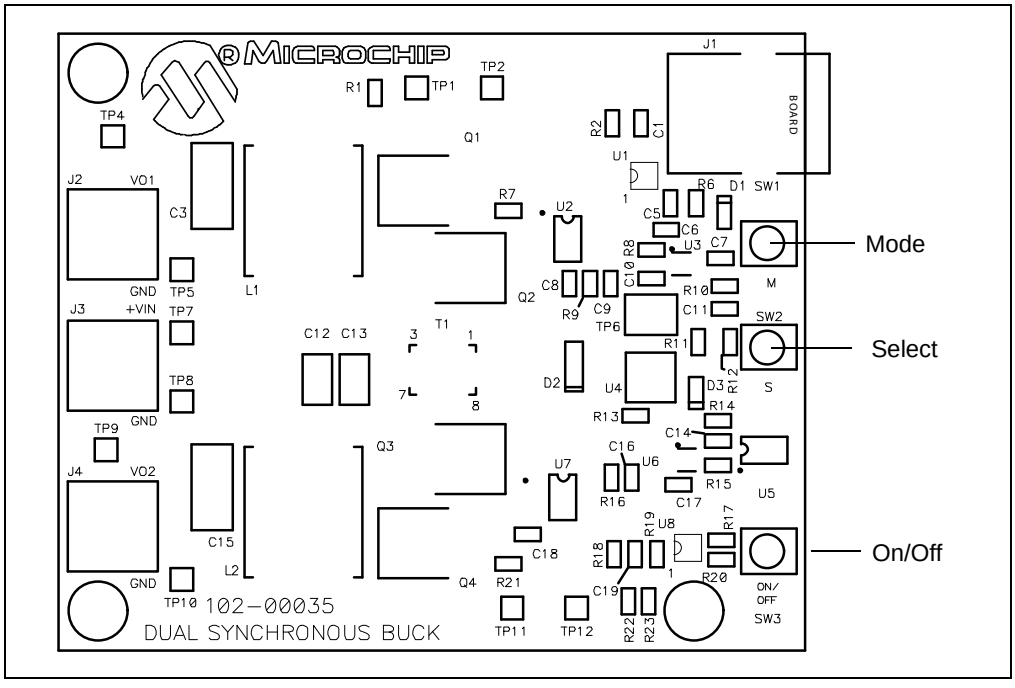


FIGURE 2-1: *Mode, Select and On/Off Switch Location.*

NOTES:

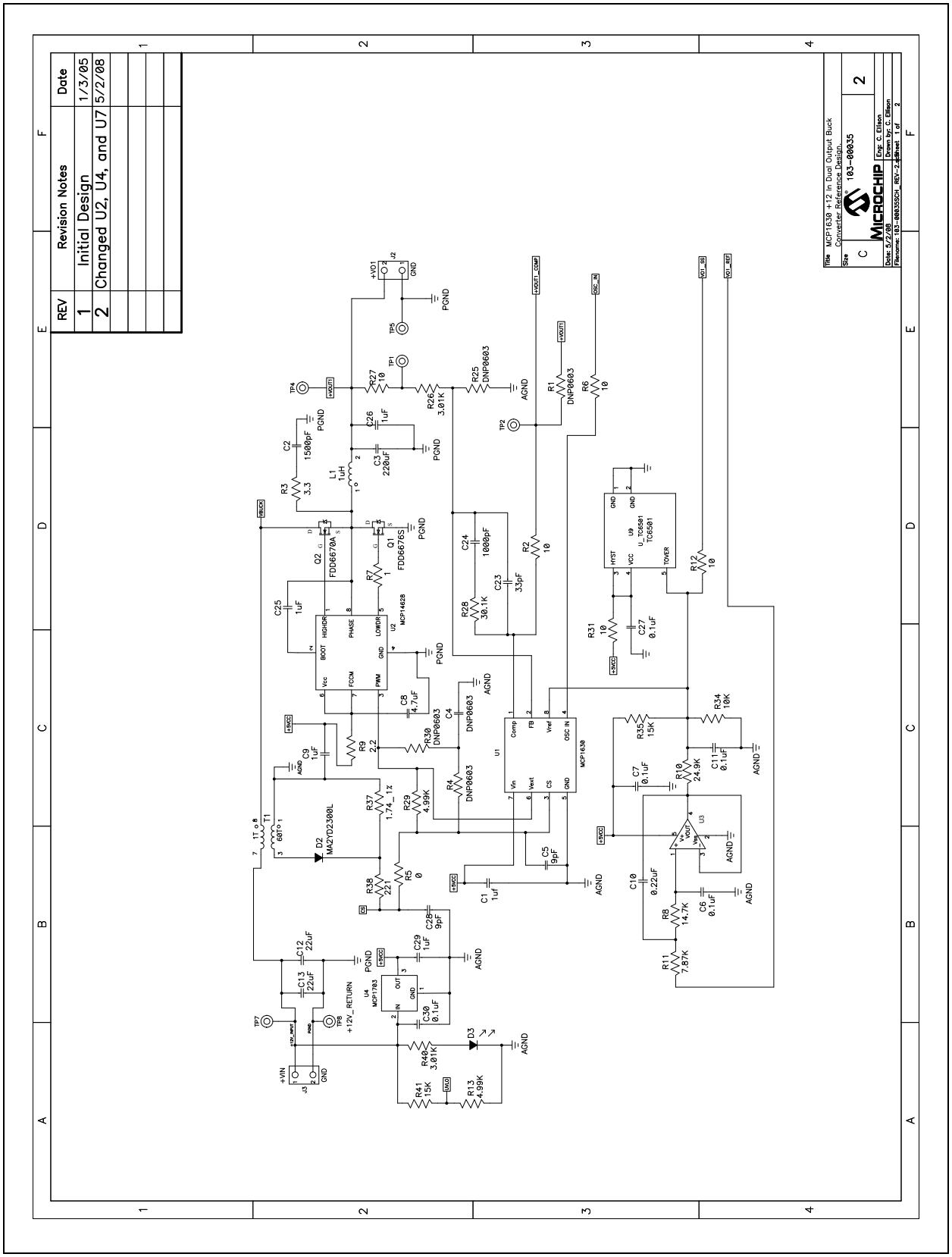
Appendix A. Schematic and Layouts

A.1 INTRODUCTION AND HIGHLIGHTS

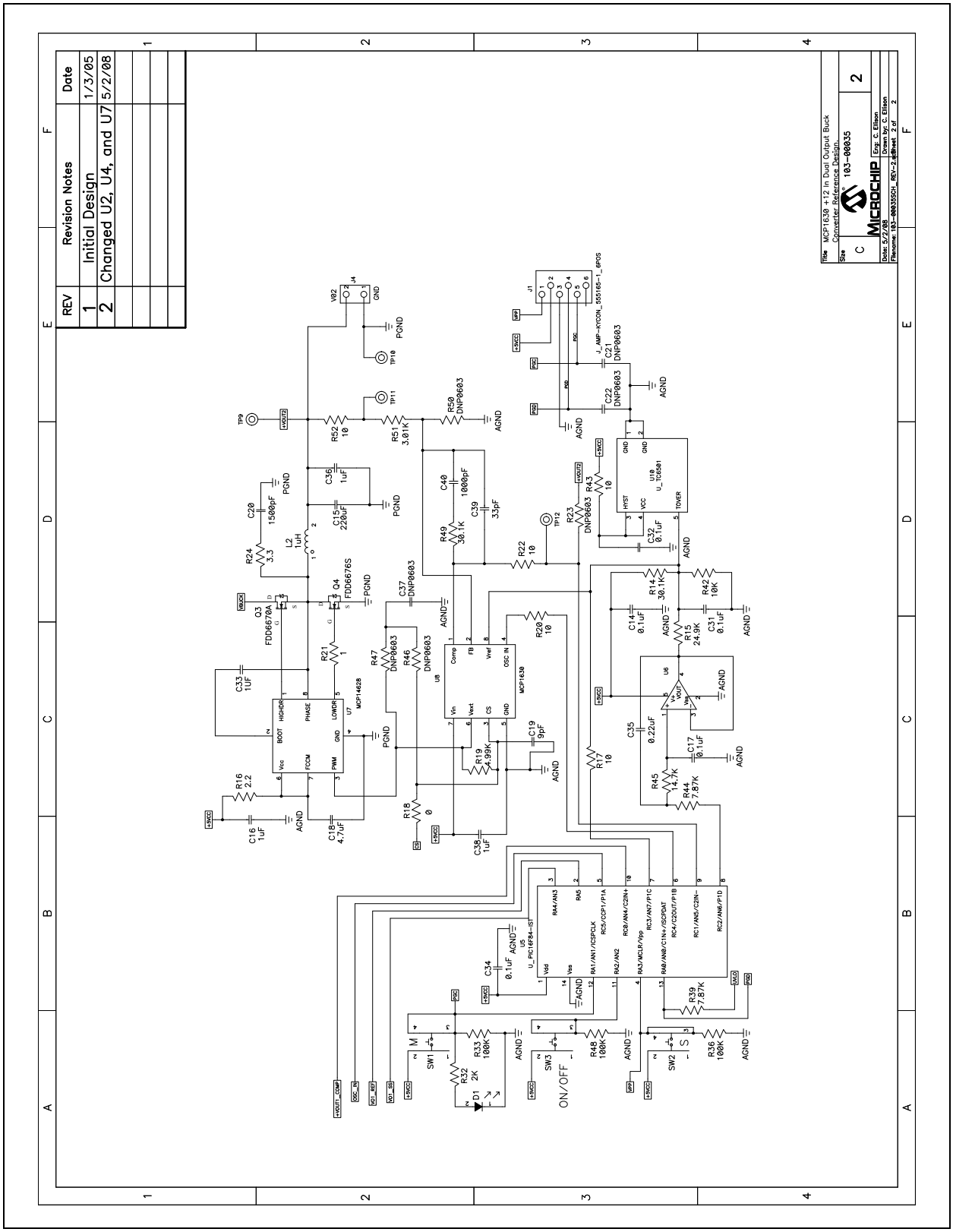
This appendix contains the following schematics and layouts for the MCP1630 Dual Buck Reference Design:

- Board Schematic - Sheet 1
- Board Schematic - Sheet 2
- Board - Top Layer
- Board - Mid-Layer 1
- Board - Mid-Layer 2
- Board - Bottom Layer

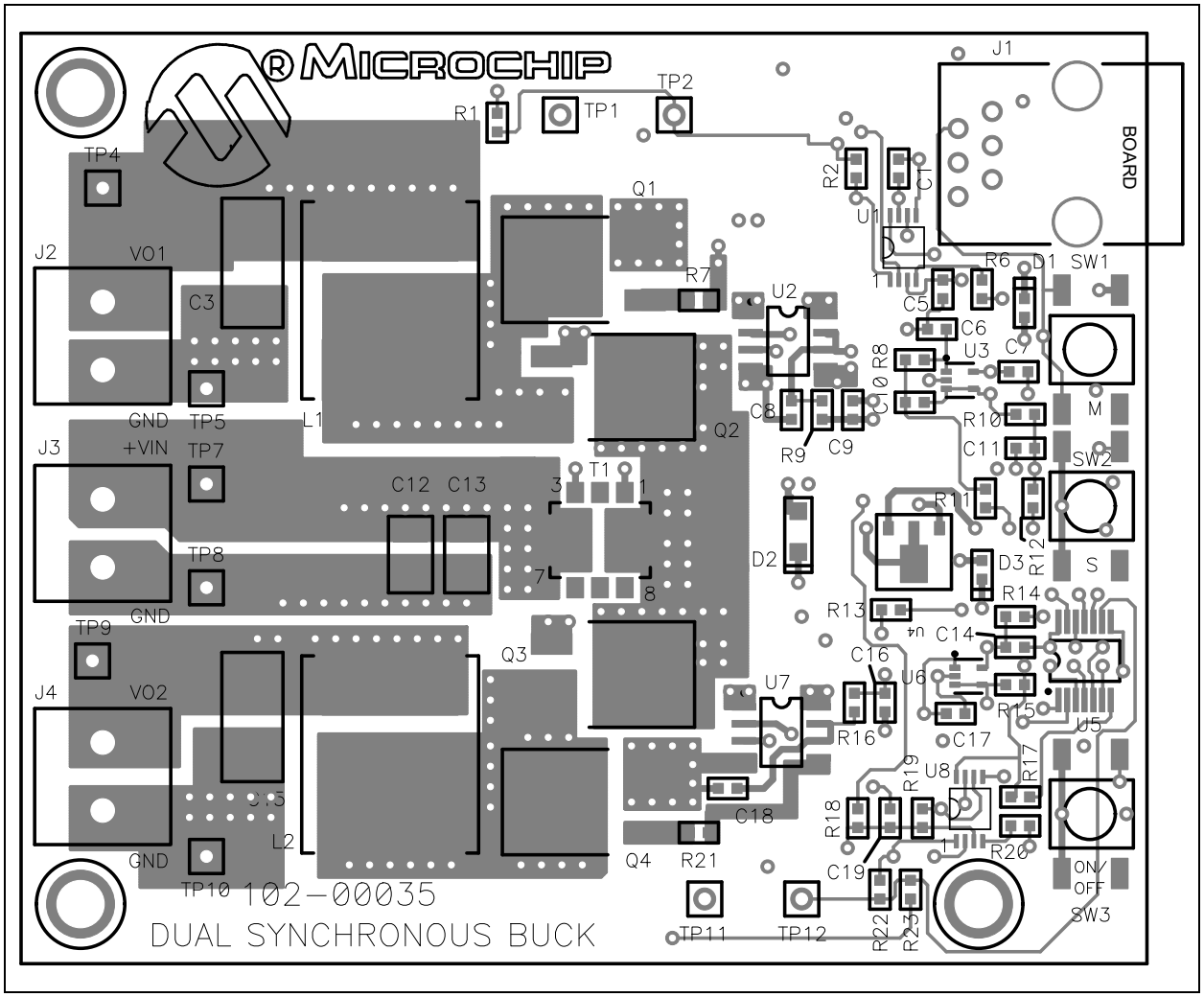
A.2 BOARD SCHEMATIC - SHEET 1



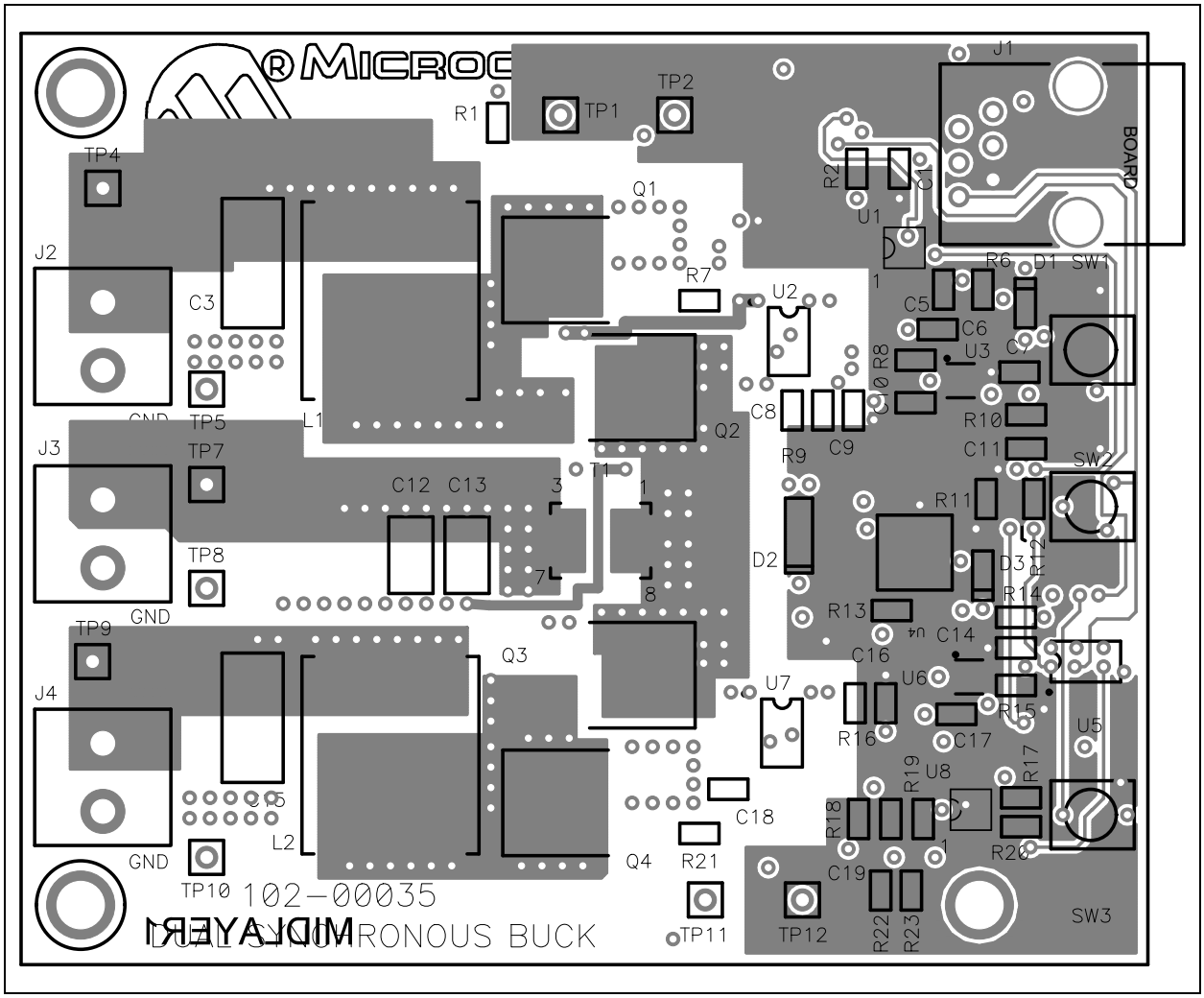
A.3 BOARD SCHEMATIC - SHEET 2



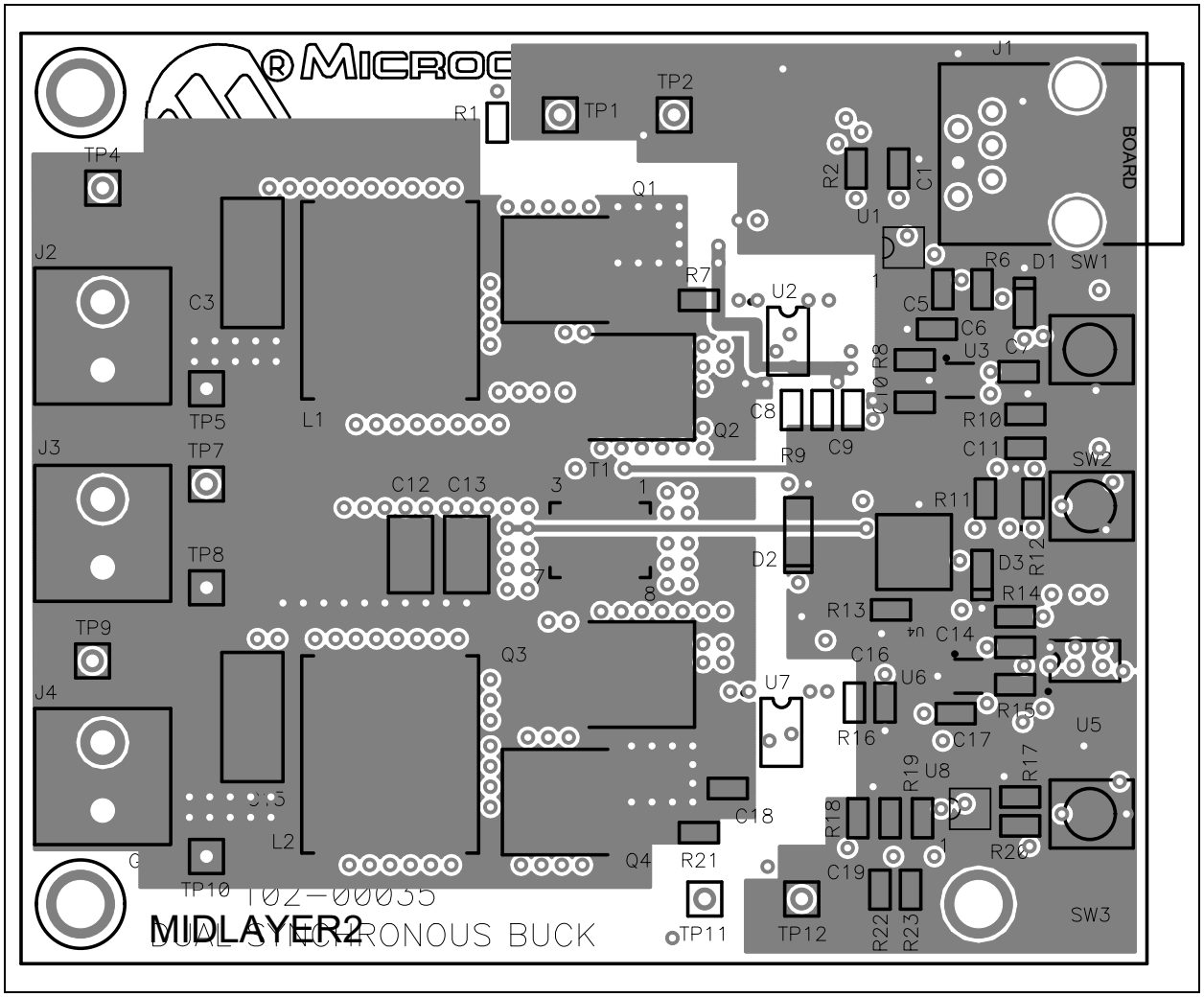
A.4 BOARD - TOP LAYER



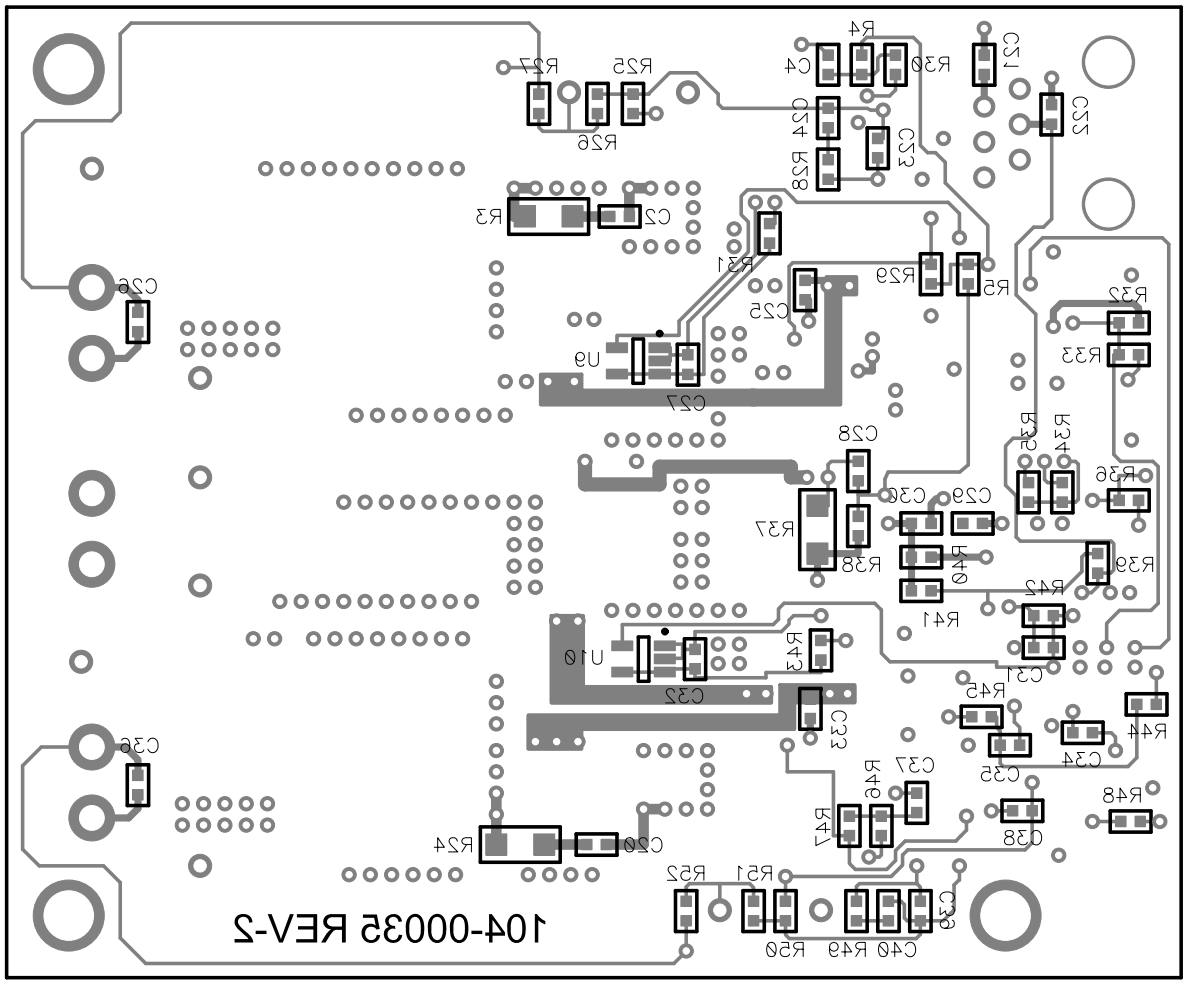
A.5 BOARD - MID-LAYER 1



A.6 BOARD - MID-LAYER 2



A.7 BOARD - BOTTOM LAYER



NOTES:

Appendix B. Bill Of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)

Qty	Reference	Description	Manufacturer	Part Number
9	C1, C9, C16, C25, C26, C29, C33, C36, C38	CAP 1.0UF 10V CERAMIC X5R 0603	Panasonic® - ECG	ECJ-1VB1A105K
4	C2, C4, C20, C37	CAP 1500PF 50V CERAMIC NPO 0603	Panasonic - ECG	ECJ-1VB1H152K
2	C3, C15	CAP 220UF 4V AO X7343	Kemet Electronics®	A700X227M004ATE015
2	C5, C19	CAP 9.0PF 50V CERAMIC NPO 0603	Panasonic - ECG	ECJ-1VC1H090D
10	C6, C7, C11, C14, C17, C27, C30, C31, C32, C34	CAP .10UF 10V CERAMIC X7R 0603	Kemet Electronics	C0603C104K8RACTU
2	C8, C18	CAP 4.7UF 10V CERAMIC X5R 0603	Panasonic - ECG	ECJ-1VB0J475M
2	C10, C35	CAP .22UF 10V CERAMIC X5R 0603	Panasonic - ECG	ECJ-1VB1A224K
2	C12, C13	CAP 22UF 16V CERAMIC X5R 1210	TDK Electronics Corporation	C3225X5R1C226M
2	C21, C22	CAP DNP0603		
2	C23, C39	CAP 33PF 50V CERAMIC NPO 0603	Panasonic - ECG	ECJ-1VC1H330J
2	C24, C40	CAP 1000PF 50V CERAMIC NPO 0603	Panasonic - ECG	ECJ-1VC1H102J
1	C28	CAP CERAMIC 18PF 50V 0603 SMD	Panasonic - ECG	ECJ-1VC1H180J
2	D1, D3	LED 660NM SUPER RED DIFF 0603SMD	Lumex® Opto/ Components Inc.	SML-LX0603SRW-TR
1	D2	DIODE SCHOTTKY 25V 1.0A MINI-2P	Panasonic - SSG	MA2YD2300L
1	J1	CONN MOD JACK 6-6 R/A PCB 50AU	AMP/Tyco Electronics	555165-1
3	J2, J3, J4	CONN TERM BLOCK 2POS 5MM PCB	Phoenix Contact®	1715022
2	L1, L2	HIGH CURRENT SMT 1UH INDUCTORS	Cooper Electronics	HC1-1R1
2	Q1, Q4	N-CHANNEL MOSFET DPAK	Fairchild® Semiconductor	FDD6676S
2	Q2, Q3	N-CHANNEL MOSFET DPAK	Fairchild Semiconductor	FDD6670A
10	R1, R6, R12, R17, R20, R23, R27, R31, R43, R52	RES 10.0 OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF10R0V
6	R2, R19, R22, R25, R29, R50	RES DNP0603		
2	R3, R24	RES 3.30 OHM 1/4W 1% 1206 SMD	Yageo America	9C12063A3R30FGHFT
2	R4, R46	RES 1.00K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	P1.00KHCT-ND
2	R5, R18	RES 221 OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF2210V
4	R7, R9, R16, R21	RESISTOR 1.0 OHM 1/10W 5% 0603	Panasonic - ECG	ERJ-3GEYJ1R0V
2	R8, R45	RES 14.7K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF1472V
2	R10, R15	RES 24.9K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF2492V

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 (BOM) (CONTINUED)

Qty	Reference	Description	Manufacturer	Part Number
3	R11, R39, R44	RES 7.87K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF7871V
1	R13	RES 4.99K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF4991V
1	R14	RES 22.1K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF2212V
3	R26, R40, R51	RES 3.01K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF3011V
2	R28, R49	RES 30.1K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF3012V
1	R30	RES 4.75K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF4751V
1	R32	RES 2.0K OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ202V
3	R33, R36, R48	RES 100K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF1003V
2	R34, R41	RES 15.0K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF1502V
2	R35, R42	RES 10.0K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF1002V
1	R37	RES 2.2 OHM 1/4W 1% 1206 SMD	Panasonic - ECG	ERJ-8RQF2R2V
1	R38	RES 332 OHM 1/16W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF3320V
1	R47	RES 2.21K OHM 1/16W 1% 0603 SMD	Panasonic - ECG	P2.21KHCT-ND
3	SW1, SW2, SW3	SWITCH TACT 6MM 260GF SMT	E-Switch Inc.	TL3301NF260QG
1	T1	SMD Current Sense Transformer	Datatronics™	CT323-060
1	TP6	PC TEST POINT COMPACT SMT	Keystone Electronics	5016
2	U1, U8	High-Speed Analog PWM MSOP8	Microchip Technology Inc.	MCP1630-E/MS
2	U2, U7	2A Synchronous MOSFET Driver	Microchip Technology Inc.	MCP14628-E/SN
2	U3, U6	5 Lead SC70 OP AMP	Microchip Technology Inc.	MCP6231U
1	U4	250 mA Low Iq LDO Regulator	Microchip Technology Inc.	MCP1703-5002E/MB
1	U5	IC PIC® MCU FLASH 2KX14 14TSSOP	Microchip Technology Inc.	PIC16F684-I/ST
2	U9, U10	MCP6501 TEMPERATURE SWITCH 75°C	Microchip Technology Inc.	TC6501P075VCTTR

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. Evaluation Board Firmware

C.1 DEVICE FIRMWARE

For the latest version of the MCP1630 Dual Buck Reference Design firmware, visit the Microchip web site at www.microchip.com.

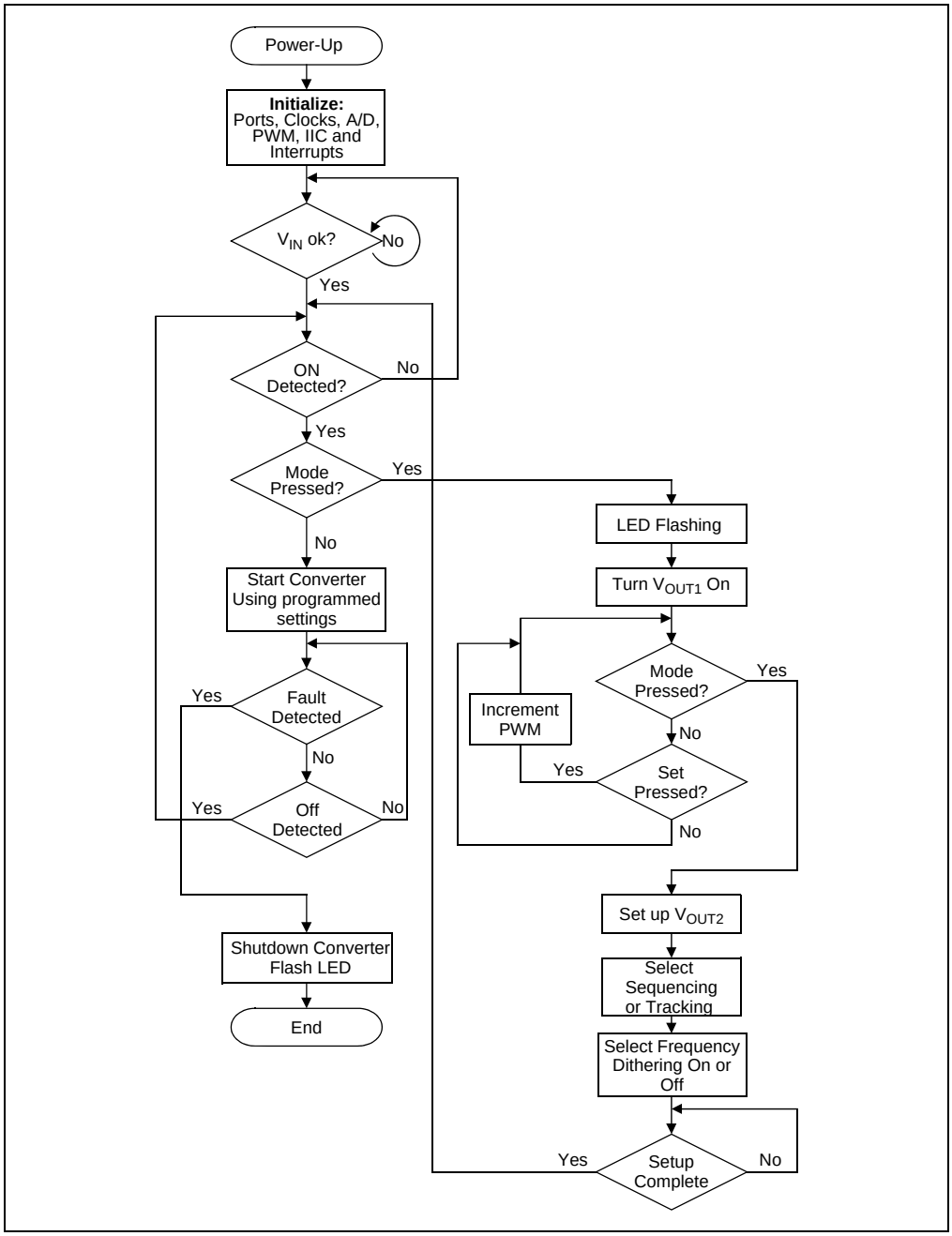


FIGURE C-1: *Firmware Flowcharge - Page 1.*

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