dsPIC33C Digital Power Starter Kit User's Guide

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ISBN: 978-1-5224-4726-9

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NOTES:

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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 website (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 "DSXXXXXXXXA", where "XXXXXXXX" 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 dsPIC33C Digital Power Starter Kit. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Product Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This user's guide provides an overview of the dsPIC33C Digital Power Starter Kit. The document is organized as follows:

- Chapter 1. "Introduction" – This chapter introduces the dsPIC33C Digital Power Starter Kit and provides a brief overview of its features.
- Appendix A. "Board Layout and Schematics" – This appendix provides diagrams of the hardware layout, as well as schematic diagrams for the dsPIC33C Digital Power Starter Kit.
- Appendix B. "Bill of Materials (BOM)" – This appendix presents the Bill of Materials for the dsPIC33C Digital Power Starter Kit.
- Appendix C. "Demonstration Program Operation" – This chapter describes the demonstration software that is preloaded on the device that accompanies the dsPIC33C Digital Power Starter Kit.

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) { ... }`

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RECOMMENDED READING

This user's guide describes how to use the dsPIC33C Digital Power Starter Kit. Other useful document(s) are listed below. The following Microchip document(s) are recommended as supplemental reference resources.

MPLAB® C Compiler for PIC24 MCUs and dsPIC® DSCs User's Guide (DS51284)

This comprehensive guide describes the usage, operation and features of Microchip's MPLAB C compiler (formerly MPLAB C30) for use with 16-bit devices.

MPLAB® X IDE User's Guide (DS50002027)

This document describes how to set up the MPLAB X IDE software and use it to create projects and program devices.

Readme Files

For the latest information on using the dsPIC33C Digital Power Starter Kit board, read the `Readme.txt` text file in the Readme subdirectory of the MPLAB X IDE installation directory from the dsPIC33C Digital Power Starter Kit code example. The Readme file contains updated information and known issues that may not be included in this user's guide.

dsPIC33 'CK' Data Sheet

Refer to these documents for detailed information on the dsPIC33 'CK' SMPS Digital Signal Controllers (DSCs). Reference information found in these data sheets includes:

- Device memory maps
- Device pinout and packaging details
- Device electrical specifications
- List of peripherals included on the devices

dsPIC33/PIC24 Family Reference Manual Sections

Family Reference Manual (FRM) sections are available, which explain the operation of the dsPIC® DSC and PIC® MCU family architecture and peripheral modules. The specifics of each device family are discussed in the individual family's device data sheet.

Microchip SMPS Resources

- AN1114, *"Switch Mode Power Supply (SMPS) Topologies (Part I)"* (DS01114)
- AN1207, *"Switch Mode Power Supply (SMPS) Topologies (Part II)"* (DS01207)
- TB062, *"Frequently Asked Questions (FAQs) About dsPIC® DSC SMPS Devices"* (DS93062)

To obtain any of these documents, visit the Microchip website at www.microchip.com.

THE MICROCHIP WEBSITE

Microchip provides online support via our website at www.microchip.com. This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events; and listings of Microchip sales offices, distributors and factory representatives

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CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Corporate Application Engineer (CAE)
- Embedded Solutions Engineer (ESE)
- Field Application Engineer (FAE)

Customers should contact their distributor, representative or Embedded Solutions Engineer (ESE) 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 website at:

http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (April 2019)

This is the initial release of this document.

Revision B (June 2019)

- Revised Section 1.4 "Powering the Board".

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Chapter 1. Introduction

This chapter introduces the dsPIC33C Digital Power Starter Kit and provides an overview of its features. The topics covered include:

- Overview
- Kit Contents
- Components
- Powering the Board
- Electrical Specifications
- Hardware Description
- Starter Kit Functionality and Features
- dsPIC33C Digital Power Starter Kit System Diagram

1.1 OVERVIEW

Modern power supplies are becoming smaller, more efficient, more flexible and less expensive. These desirable enhancements have come about as Digital Signal Controllers (DSCs) are incorporated into Switch Mode Power Supply (SMPS) designs. The board provided in the kit is intended to introduce and demonstrate the capabilities and features of the Microchip SMPS families of devices. The dsPIC33C Digital Power Starter Kit features an on-board dsPIC33CK256MP505 DSC device, SMPS power stages, resistive loads, LCD display, USB/UART bridge, and includes a programmer/debugger, which eliminates the need for any additional hardware.

The software for the demonstration application that is preprogrammed into the on-board dsPIC33C Digital Signal Controller (DSC) is available for download from the Microchip website at: http://www.microchip.com.

Note: Refer to the Readme file provided with the dsPIC33C Digital Power Starter Kit demonstration software for instructions on how to run the demonstration application. Refer to the Information Sheet that is provided with the starter kit package for additional resources and instructions on how to use the starter kit for programming and debugging application software.

1.2 KIT CONTENTS

The dsPIC33C Digital Power Starter Kit contains the following:

- dsPIC33C Digital Power Starter Kit Board
- 9V Power Supply
- USB Cable

Note: If you are missing any part of the kit, contact a Microchip sales office for assistance. A list of worldwide Microchip offices for sales and service is provided at the end of this document.

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1.3 COMPONENTS

1.3.1 Top and Bottom View

The top and bottom assembly of the board are shown in Figure 1-1 and Figure 1-2. Table 1-1 and Table 1-2 provide a description of the components.

FIGURE 1-1: dsPIC33C DIGITAL POWER STARTER KIT (TOP VIEW)

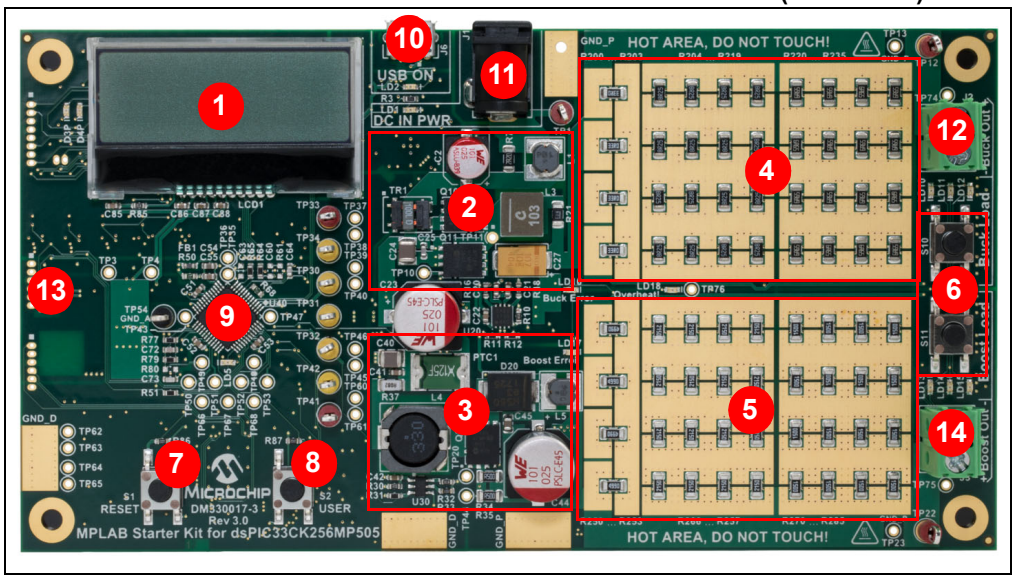

TABLE 1-1: dsPIC33C DIGITAL POWER STARTER KIT COMPONENTS (TOP VIEW)

Number	Description
1	2x16 Character LCD
2	Buck Converter Stage
3	Boost Converter Stage
4	Buck Load
5	Boost Load
6	Push Buttons for Controlling Resistive Loads
7	Reset Push Button
8	User Push Button
9	dsPIC33C Digital Signal Controller (DSC)
10	USB Connector
11	DC Power Input
12	Buck Converter Output
13	Programming Connection for dsPIC® DSC
14	Boost Converter Output

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FIGURE 1-2: dsPIC33C DIGITAL POWER STARTER KIT (BOTTOM VIEW)

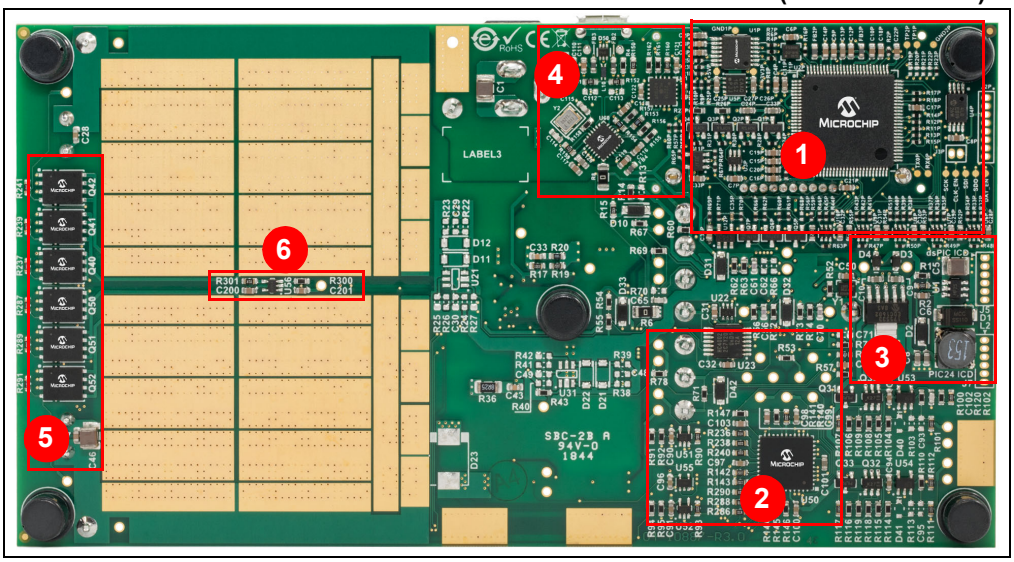

TABLE 1-2: dsPIC33C DIGITAL POWER STARTER KIT COMPONENTS (BOTTOM VIEW)

Number	Description
1	PICkit™ On-Board (PKOB) Programmer/Debugger Circuit
2	PIC24F Auxiliary Microcontroller
3	Auxiliary Power Supply
4	USB/UART Hub and Bridge
5	Buck/Boost Load Control Switches
6	Temperature Sensor

1.4 POWERING THE BOARD

The dsPIC33C Digital Power Starter Kit is designed to be a self-contained power supply. On-board power stages are:

- One Asynchronous Boost Converter Power Stage
- One Synchronous Buck Converter Power Stage

To power the board, use connectors J1 and/or J6 as follows:

- +9V power connector (J1) supplies power to the dsPIC33C Digital Power Starter Kit, which includes: power stages and auxiliary power supply. Therefore, all building blocks on the board are powered by applying voltage (> 6V) at this input. Once the voltage is provided to this connector, the power conversion starts immediately.
- USB connection jack (J6) supplies power to the auxiliary supply, and connection to the USB/UART bridge and PKOB (programmer/debugger), making it possible to communicate, program and debug the microcontrollers on the board without powering the Buck/Boost Converters.

Note: Buck and Boost Converters are both operated in Peak Current mode (default), but can also be reprogrammed to operate in Average Current mode or Voltage mode control; this requires minor firmware and/or hardware changes as different sensing source signals are used. *Powering the board via a USB connector using a +5V only supply (without USB communication connections), such as wall chargers or USB power banks, is currently not supported. With a power supply with non-communication ports, the USB PICkit™ On-Board 4 (PKOB4) debugger/programmer will hold the target device in Reset.*

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1.5 ELECTRICAL SPECIFICATIONS

TABLE 1-3: DC INPUT RATING (J1)

Parameter	Minimum	Typical	Maximum	Unit
Voltage	6.0	9	13.8	V
Current	—	0.9	—	A

TABLE 1-4: BUCK CONVERTER ELECTRICAL SPECIFICATIONS

Parameter	Minimum	Typical	Maximum	Unit
Output Voltage (default programmed)	—	3.3	—	V
Output Voltage (programmable range)	1	—	3.8	V
Output Voltage Ripple	—	—	40	mV (pk-pk)
Output Current	—	1	2	A
Load Regulation: V_{OUT} = 3.3V, I_{OUT} = 0.1 – 1.0A, V_{IN} = 9V	—	13	—	mV/A
Switching Frequency	—	500	—	kHz
Output Power	—	3.3(1)	7.6(2)	W

Note 1: Maximum power of on-board resistive loads should not exceed 3.3W.

2: Can be achieved only with an external load.

TABLE 1-5: BOOST CONVERTER ELECTRICAL SPECIFICATIONS

Parameter	Minimum	Typical	Maximum	Unit
Output Voltage (default programmed)	—	15	—	V
Output Voltage (programmable range)	10(3)	—	17.8	V
Output Voltage Ripple	—	10	—	mV (pk-pk)
Output Current	—	0.2	0.4	A
Load Regulation: V_{OUT} = 15V, I_{OUT} = 0.03 – 0.2A, V_{IN} = 9V	—	4	—	mV/A
Switching Frequency	—	500	—	kHz
Output Power	—	3(1)	6(2)	W

Note 1: Maximum power of on-board resistive loads should not exceed 3W.

2: Can be achieved only with external load.

3: Input voltage must always be lower than the output voltage.

1.6 HARDWARE DESCRIPTION

Topics covered in this section include:

- Signal Configuration
- Board Connectors
- Indicators and Human Interfaces
- Test Points

1.6.1 Signal Configuration

Table 1-6 provides a full list of the dsPIC33C DSC connections and a brief functional description of the pins used in the dsPIC33C Digital Power Starter Kit.

TABLE 1-6: dsPIC33C CONFIGURATION DETAILS

dsPIC33C Digital Power Starter Kit Signal Label	Pin Number	Device Pin Name	Description/Function
RB14_PWM1H_BUCK	1	RB14	Buck Converter High Drive Signal
RB15_PWM1L_BUCK	2	RB15	Buck Converter Low Drive Signal
RC12_RP60_UART1_TX	3	RC12	USB/Serial Communication Output Pin
RC13_RP61_UART1_RX	4	RC13	USB/Serial Communication Input Pin
SW_RESET	5	$\overline{\text{MCLR}}$	Master Clear (Reset) Input
—	6	RD13	Not Used
RC0_AN12_VIN_MEAS	7	RC0	Analog – Input Voltage Sense
RA0_AN0	8	RA0	Analog – Buck Current Sense Transformer
RA1_ANA1	9	RA1	Analog – Buck Current Sense Shunt
—	10	RA2	Not Used
RA3_DAC_OUT	11	RA3	Analog – DAC Output
RA4_AN4_OA3_OUT	12	RA4	Analog – Internal Op Amp 3 Output
—	13	AVDD	Analog Positive Supply
—	14	AVSS	Analog Ground
RC1_OA3-_AN13_BUCK_VFB	15	RC1	Analog – Buck Voltage Feedback
RC2_OA3+	16	RC2	Analog – Internal Op Amp 3 Positive Input, DAC_OUT, TP35
—	17	RC6	Not used
—	18	VDD	Positive Supply for Peripheral Logic and I/O Pins
—	19	VSS	Ground
—	20	RC3	Not Used
RB0_CLKI	21	RB0	Clock Input Pin
—	22	RB1	Not Used
RD10_AN18_BOOST_VFB	23	RD10	Analog – Boost Voltage Feedback
—	24	RC7	Not Used
RB2_AN1_OA2_OUT	25	RB2	Analog – Boost Current Sense Shunt
RB3_OA2-	26	RB3	Analog – Internal Op Amp 2 Negative Input
RB4_OA2+	27	RB4	Analog – Internal Op Amp 2 Positive Input
LCD_Reset	28	RC8	LCD Active-Low Reset Signal
LCD_SEL	29	RC9	LCD Register Select Signal
LCD_CSB	30	RD8	LCD Chip Select Signal
—	31	VSS	Ground

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TABLE 1-6: dsPIC33C CONFIGURATION DETAILS (CONTINUED)

dsPIC33C Digital Power Starter Kit Signal Label	Pin Number	Device Pin Name	Description/Function
—	32	VDD	Positive Supply for Peripheral Logic and I/O Pins
DSP_GPIO1	33	RB5	General Purpose I/O
DSP_GPIO2	34	RB6	General Purpose I/O
RB7_AN2	35	RB7	Analog – Temperature Sensor Input
TARGET_RB8_PGD1	36	RB8	Device Programming/Debug Data Pin
TARGET_RB9_PGC1	37	RB9	Device Programming/Debug Clock Pin
LCD_DATA	38	RC4	LCD Data Signal
LCD_CLOCK	39	RC5	LCD Clock Signal
PIC24_UART_RX	40	RC10	I/O Controller Communication Pin
PIC24_UART_TX	41	RC11	I/O Controller Communication Pin
—	42	VSS	Ground
—	43	VDD	Positive Supply for Peripheral Logic and I/O Pins
SW_USER	44	RD1	User Push Button Input Pin
—	45	RB10	Not Used
DSP_GPIO3	46	RB11	General Purpose I/O
DSP_GPIO4	47	RB12	General Purpose I/O
RB13_PWM2L_BOOST	48	RB13	Boost Converter PWM Drive Signal

1.6.2 Board Connectors

Table 1-7 describes the hardware connections available on the dsPIC33C Digital Power Starter Kit.

TABLE 1-7: HARDWARE CONNECTIONS

Label	Hardware Element Description
J1	9V power supply.
J2	Terminal block for Buck Converter output; can be used for external load.
J3	Terminal block for Boost Converter output; can be used for external load.
J5	Unpopulated header for external programmer/debugger targeting the dsPIC® device.
J6	Micro-USB connector for communication and programming/debugging.
J7	Unpopulated header for external programmer/debugger targeting the PIC24F device.

1.6.3 Indicators and Human Interfaces

Table 1-8 describes the user interfaces available on the dsPIC33C Digital Power Starter Kit.

TABLE 1-8: INDICATORS AND HUMAN INTERFACES

Label	Hardware Element Description
LCD1	User-Programmable LCD Display
LD1	Power-on Status LED, which indicates that the dsPIC33C Digital Power Starter Kit is powered by the 9V supply
LD2	Power-on Status LED, which indicates that the dsPIC33C Digital Power Starter Kit is powered by the USB supply
LD5	User-Programmable LED
LD10, LD11, LD12	Buck Converter Load LEDs
LD13, LD14, LD15	Boost Converter Load LEDs
LD16	Buck Converter Error
LD17	Boost Converter Error
LD18	Thermal Error or Warning
S1	dsPIC® Device Reset Push Button
S2	User Push Button
S10	Buck Load Control Push Button
S11	Boost Load Control Push Button

1.6.4 Test Points

Table 1-9 describes the test points that are available on the dsPIC33C Digital Power Starter Kit.

TABLE 1-9: TEST POINTS

Test Point	Description
TP1	+9V DPSK Board Input Voltage (red)
TP10	Buck Low-Side MOSFET Gate (via)
TP11	Switching Node of the Buck Converter
TP12	Buck Output Node (red)
TP13	Ground
TP20	Boost MOSFET Gate
TP21	Switching Node of the Boost Converter
TP22	Boost Output Node (red)
TP23	Ground
TP3	Input Voltage into the 3.3V LDO
TP30	PWM1L Drive Signal Buck Low (yellow)
TP31	PWM1H Drive Signal Buck High (yellow)
TP32	PWM2L Drive Signal Boost (yellow)
TP33	Buck Converter Bode Test Point (red)
TP34	Buck Converter Bode Test Point (yellow)
TP35	OA3+/DAC Out
TP36	OA3-/Feedback Voltage Buck
TP37	Buck Current Sense (CS) Transformer
TP38	Buck CS Transformer after Low-Pass Filter
TP39	Buck CS Shunt Amplifier

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TABLE 1-9: TEST POINTS (CONTINUED)

Test Point	Description
TP4	Output Voltage of the 3.3V LDO
TP40	Buck CS Shunt Amplifier after Low-Pass Filter
TP41	Boost Converter Bode Test Point (red)
TP42	Boost Converter Bode Test Point (yellow)
TP43	Feedback Voltage Boost
TP44	Boost CS Low-Side Shunt
TP45	Boost CS High-Side Shunt
TP46	Boost CS High-Side Shunt after Low-Pass Filter
TP47	Input Voltage Sense
TP48	OA3 Output
TP49	Boost CS/OA2 Output
TP50	DSP_GPIO1
TP51	DSP_GPIO2
TP52	DSP_GPIO3
TP53	DSP_GPIO4
TP60	Buck OVP Comparator
TP61	Boost OVP Comparator
TP62	Buck OCP Comparator
TP63	Buck OCP Gate
TP64	Boost OCP
TP65	Boost OCP Gate
TP66	PROT_GPIO2
TP67	PROT_GPIO3
TP68	PROT_GPIO4
TP74	Buck Load 3
TP75	Boost Load 3
TP76	Temperature Sensor

1.7 STARTER KIT FUNCTIONALITY AND FEATURES

The dsPIC33C Digital Power Starter Kit is a Switch Mode Power Supply (SMPS) board that consists of one independent DC/DC synchronous Buck Converter, one independent DC/DC Boost Converter, independent resistive loads, protection circuitry, USB/UART converter/bridge and on-board programmer/debugger circuitry. Both power stages are controlled by the dsPIC33C device. Loads and protection circuitry are controlled by an auxiliary PIC24F microcontroller. The PIC24F microcontroller and the dsPIC33C device communicate over UART, exchanging information, such as: load temperature, load status and protection status. These messages can be adapted or extended by the user.

1.7.1 Buck Converter

The Buck Converter stage is rated for a maximum of 7.6W. However, the maximum on-board configurable resistive load is 3.3W. The output voltage and output current should remain within their Safe Operating Area (SOA) to avoid protection circuitry tripping. The output voltage of the Buck Converter (Buck_Out) can be programmed from a 1V to 3.8V output, with a default programmed voltage of 3.3V. The hardware gain, $1k/(1k + 1k + 20)$, of the voltage feedback from the Buck_Out is provided by the resistor divider network, R62 and R63. Additionally, a 20 Ohm resistor, R60, for bode plot measurements is also in series with the feedback network. The hardware gain of the current feedback is provided by the Current Transformer (T1) with turns ratio (1:100) and burden resistor, R14. In total, this voltage will have a gain of 1V/Amp.

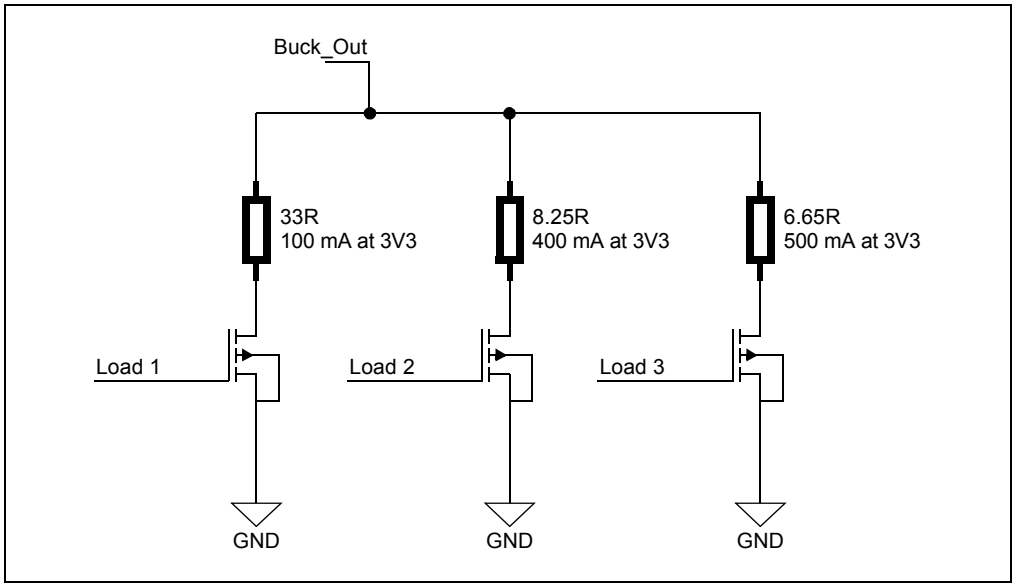
Figure 1-3 shows the load configuration. The load consists of three parallel resistor networks, with each network having its own equivalent resistance, as indicated in Figure 1-3. Therefore, each network will draw different current and dissipate different power at different output voltages. The board is supplied with pre-programmed 3.3V at the buck output with 3.3W load. The power dissipation causes 40°C ΔT on the board.

Note: With current firmware supported by the auxiliary PIC24F microcontroller, the following options are possible to operate the loads: 0% (no load), 10%, 50%, 100% load (1A max). Press the push button, "Buck Load" (No. 6 in Figure 1-1), shortly to increase the load. In addition, the LEDs (LD10, 11 and 12) will turn on to signalize the load status. Once 100% is reached, pushing the button again will result in jumping to 0%; that is, turning off the load. All LEDs will be off and the process can start from the beginning.The load step generator is working at 100 Hz and 50% duty cycle. The supported load step schema is:

10% → 50%
50% → 100%
10% → 100%

Press and hold push button, "Buck Load", for two seconds in order to change from Static Load to Load Step mode and vice versa.

FIGURE 1-3: BUCK CONVERTER – ON-BOARD RESISTIVE LOAD CONFIGURATION OPTION



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1.7.2 Boost Converter

The Boost Converter stage is rated for a maximum power of 6W. However, the maximum on-board configurable resistive load is 3W. The output voltage and output current should remain within the Boost Converter Safe Operating Area (SOA) to avoid damage to the board. The output voltage of the Boost Converter (Boost_Out) can be programmed from a 10V to 17.8V output, with a default programmed voltage of 15V. The hardware gain, $1k/(1k + 6.98k + 20)$, of the voltage feedback from the Boost_Out is provided by the resistor divider network of R72 and R73. Additionally, a 20 Ohm resistor, R71, for bode plot measurements is also in series with the feedback network. The hardware gain of the current feedback is provided by the current sense resistors, R34 and R35, and an internal op amp gain of four. In total, this voltage will have an offset voltage of 1V and a gain of 1V/A.

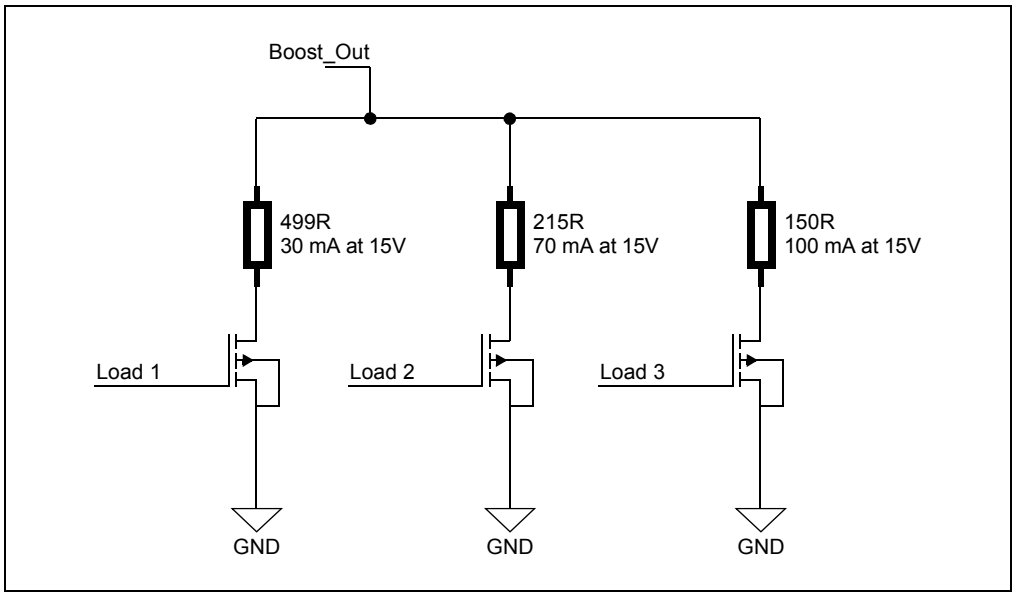
Figure 1-4 shows load configuration. The load consists of three parallel resistor networks with each network having its own equivalent resistance, as indicated in Figure 1-4. Therefore, each network will draw different current and dissipate different power at different output voltages. The board is supplied with pre-programed 15V at the boost output, with 3W load. The power dissipation causes 40°C ΔT on the board.

Note: With current firmware, supported by the auxiliary PIC24F microcontroller, the following options are possible to operate the loads: 0% (no load), 15%, 50%, 100% load (200 mA max). Press the push button, “Boost Load” (No. 6 in Figure 1-1), shortly to increase the load. In addition, the LEDs (LD13, 14 and 15) will turn on to signalize the load status. Once 100% is reached, pushing the button again will result in jumping to 0%, that is, turning off the load. All LEDs will be off and the process can start from the beginning. The load step generator is working at 100 Hz and 50% duty cycle. The supported load step schema is:

15% → 50%
50% → 100%
15% → 100%

Press and hold push button, “Boost Load”, for two seconds in order to change from Static Load to Load Step mode and vice versa.

FIGURE 1-4: BOOST CONVERTER – ON-BOARD RESISTIVE LOAD CONFIGURATION OPTION



1.7.3 Additional Features

- On-Board Temperature Sensor: Located in the area of the resistive loads; this enables the user to program a temperature protection limit and a high-temperature fail-safe shutdown. Temperature threshold levels are as follows:
  - 65°C: Warning; LD18 (overheat) is permanently on
  - 75°C: LD18 (overheat) is blinking
    Please note that under this condition, the loads will permanently be switched off until the board temperature drops to the Safe Operating Area of < 65°C.

> **Note:** Taking into account the physical dimensions, the ambient temperature, the power dissipation and the protection threshold of the board, there are two possible combinations:
>
> 1. Single power stage running at full power, 3.3W maximum.
> 2. Both power stages running at 50% load.
>
> **Running both stages at 100% load would mean 6.3W power dissipation. This will drive the board to an overheat condition after a short period of time (within several minutes)**.

- Input Voltage Sense: Used to monitor the rail and detect under/overvoltage conditions.
- Input Voltage LED Indicators:
  - LD1: USB voltage indicator
  - LD2: AUX bias voltage indicator
- Load Indication LEDs:
  - LD (10,11,12): Buck Converter loads
  - LD (13,14,15): Boost Converter loads
- Error Indication LEDs:
  - LD 16: Buck Converter error
  - LD 17: Boost Converter error
- On-Board Protection Circuitry is permanently monitoring currents and voltages in the system. Trip levels are adjusted as follow:
  - 3 A_{PEAK} Buck Converter input current
  - 4V Buck Converter output voltage
  - 1.6A Boost Converter input current
  - 18V Boost Converter output voltage

> **Note:** Once the signal exceeds the threshold level, the protection circuitry will latch this information and disable the related gate driver. The power flow will stop and the related LED will blink, indicating that a latched Fault occurred. The auxiliary microcontroller will reset this status every second after the Fault event and the related LED will be back to an OFF state.

- LD18: Thermal Error
- Reset Push Button: Press and release this button for the dsPIC device to go though a Reset routine.
- User Push Button: Press this button to change the information page on the LCD.
- On-Board LCD 2x16 Character Display: Shows different system relevant data, such as voltages, currents, temperature, internal load setting and converter status (enabled/disabled). Press push button, "USER" (No. 8 in Figure 1-1), to jump from one information page to another page.

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1.7.4 Programmer/Debugger

The dsPIC33C Digital Power Starter Kit includes an on-board programmer/debugger circuit that provides connectivity over USB. This circuit is hard-wired to the dsPIC® DSC device to provide ICSP™ debugging/programming capability.

TABLE 1-10: PROGRAMMER/DEBUGGER COMPONENTS

Component	Label	Description
On-Board Programmer/ Debugger	N/A	Controls the programming/debugging operations of the target dsPIC33C DSC.
Programmer/Debugger USB Connector	J6	Provides power to the programmer/debugger, and bidirectional communication between the host PC and the dsPIC33C Digital Power Starter Kit. For UART communication, a USB/UART hub and bridge are on board, hard-wired to the dsPIC33C device. It is possible to communicate over a UART channel to the PIC24F through the dsPIC33C DSC.

1.8 dsPIC33C DIGITAL POWER STARTER KIT SYSTEM DIAGRAM

The dsPIC33C Digital Power Starter Kit provides Closed-Loop Peak Current mode control using a 2-Pole, 2-Zero (2P2Z) compensator, implemented in software, to maintain the desired load step response and converter stability criteria. The dsPIC DSC device provides the necessary memory and peripherals for ADC conversion, PWM generation, analog comparison and general purpose I/Os, preventing the need to perform these functions in external circuitry.

dsPIC DSC SMPS devices are specifically designed to provide low-cost and efficient control for a wide range of power supply topologies. The specialized peripherals facilitate closed-loop feedback control of Switch Mode Power Supplies, providing communication for remote monitoring and supervisory control.

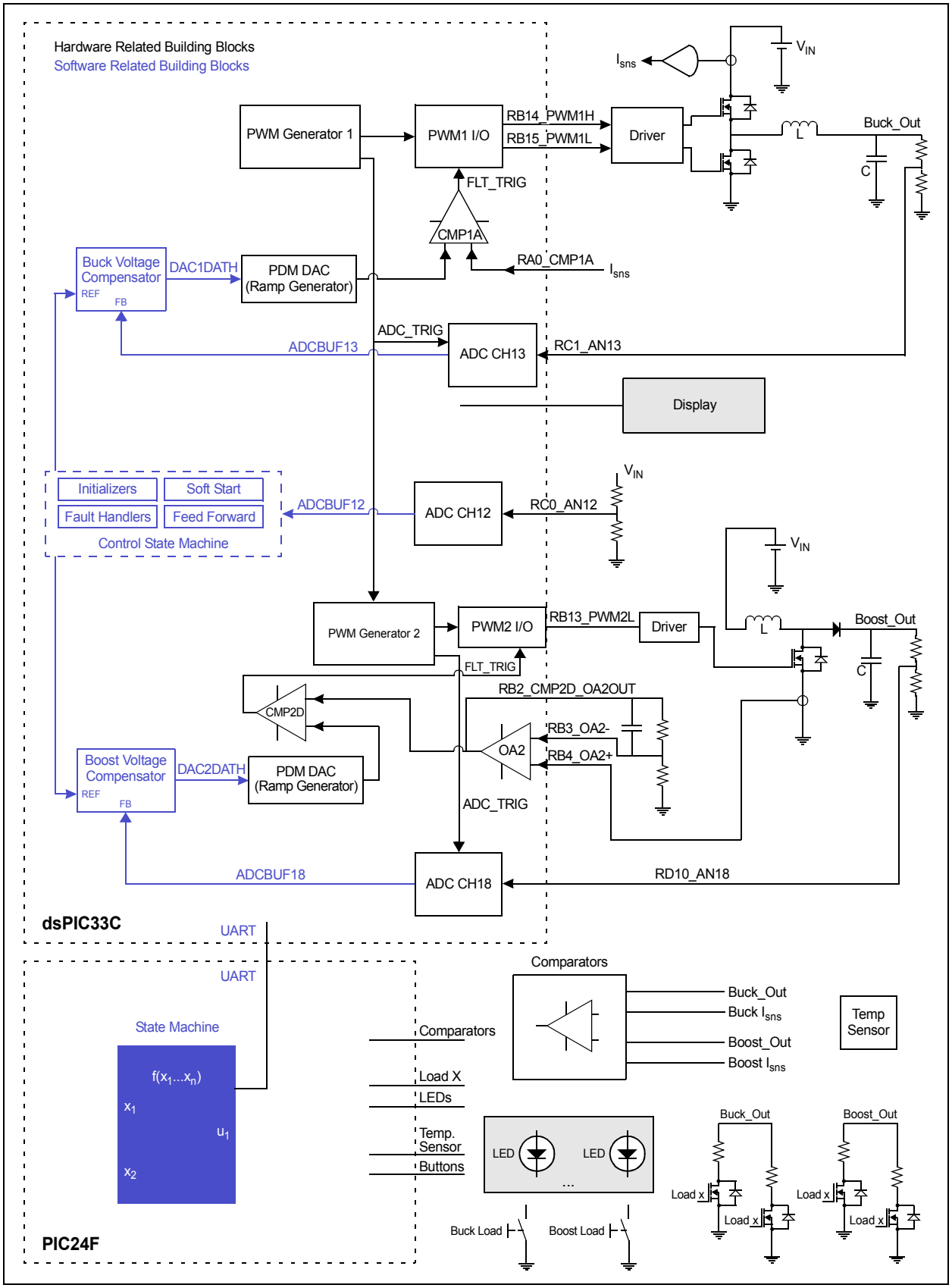
The dsPIC33C family of devices provides the following features:

- Integrated program and data memory on a single chip
- Ultra-fast interrupt response time with interrupt priority logic
- High-speed ADC with multiple Sample-and-Hold (S&H) circuits
- High-resolution PWM generators, specially designed to support different power topologies
- High-speed analog comparators for control loop implementation and system protection
- On-chip system communications (I^2C/SPI/UART)
- Internal PDM DAC slope compensation
- On-chip Fast RC (FRC) oscillator for lower system cost

Note: Buck and Boost Converters are both operated in Peak Current mode (default), but can also be reprogrammed to operate in Average Current or Voltage mode control; this requires minor firmware and/or hardware changes if different sensing source signals are used.

Figure 1-5 illustrates a high-level block diagram of the dsPIC33C Digital Power Starter Kit.

FIGURE 1-5: dsPIC33C DIGITAL POWER STARTER KIT SYSTEM DIAGRAM



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Appendix A. Board Layout and Schematics

This appendix contains the board layouts and the schematics for the dsPIC33C Digital Power Starter Kit.

FIGURE A-1: dsPIC33C DIGITAL POWER STARTER KIT LAYOUT (TOP)

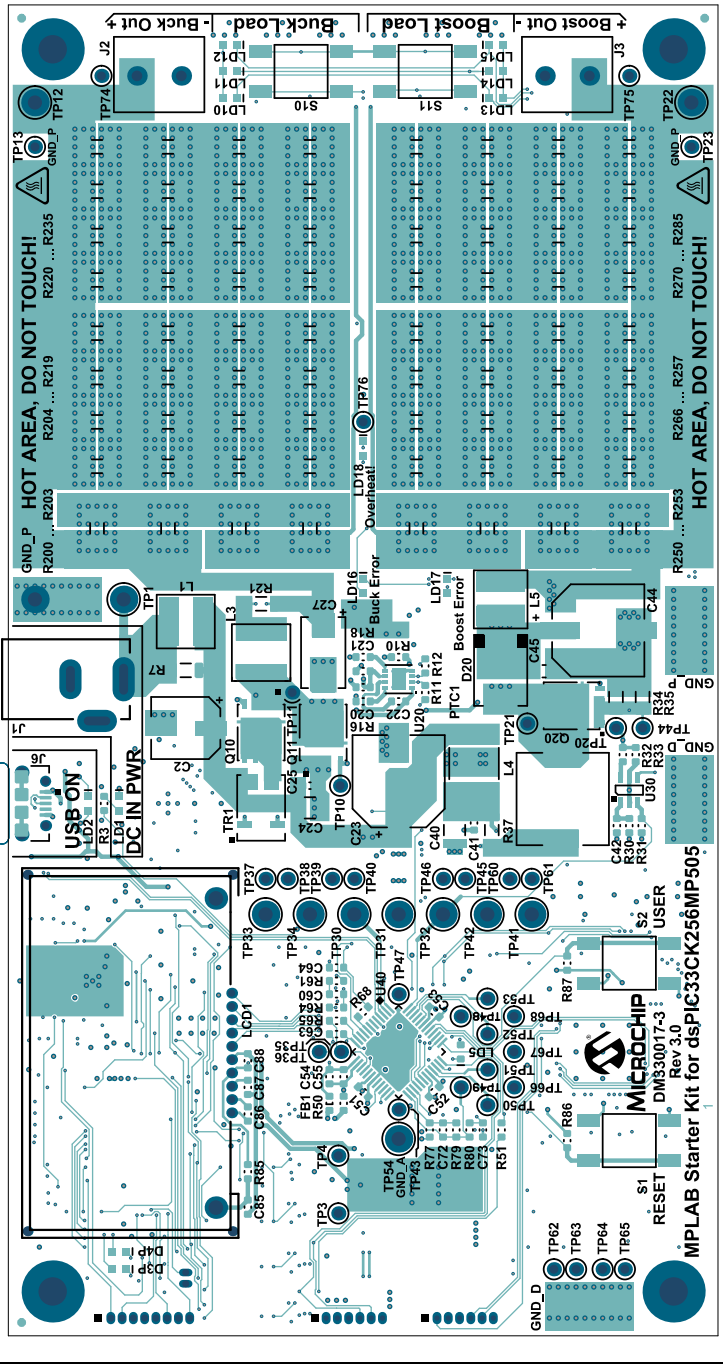

FIGURE A-2: dsPIC33C DIGITAL POWER STARTER KIT LAYOUT (BOTTOM)

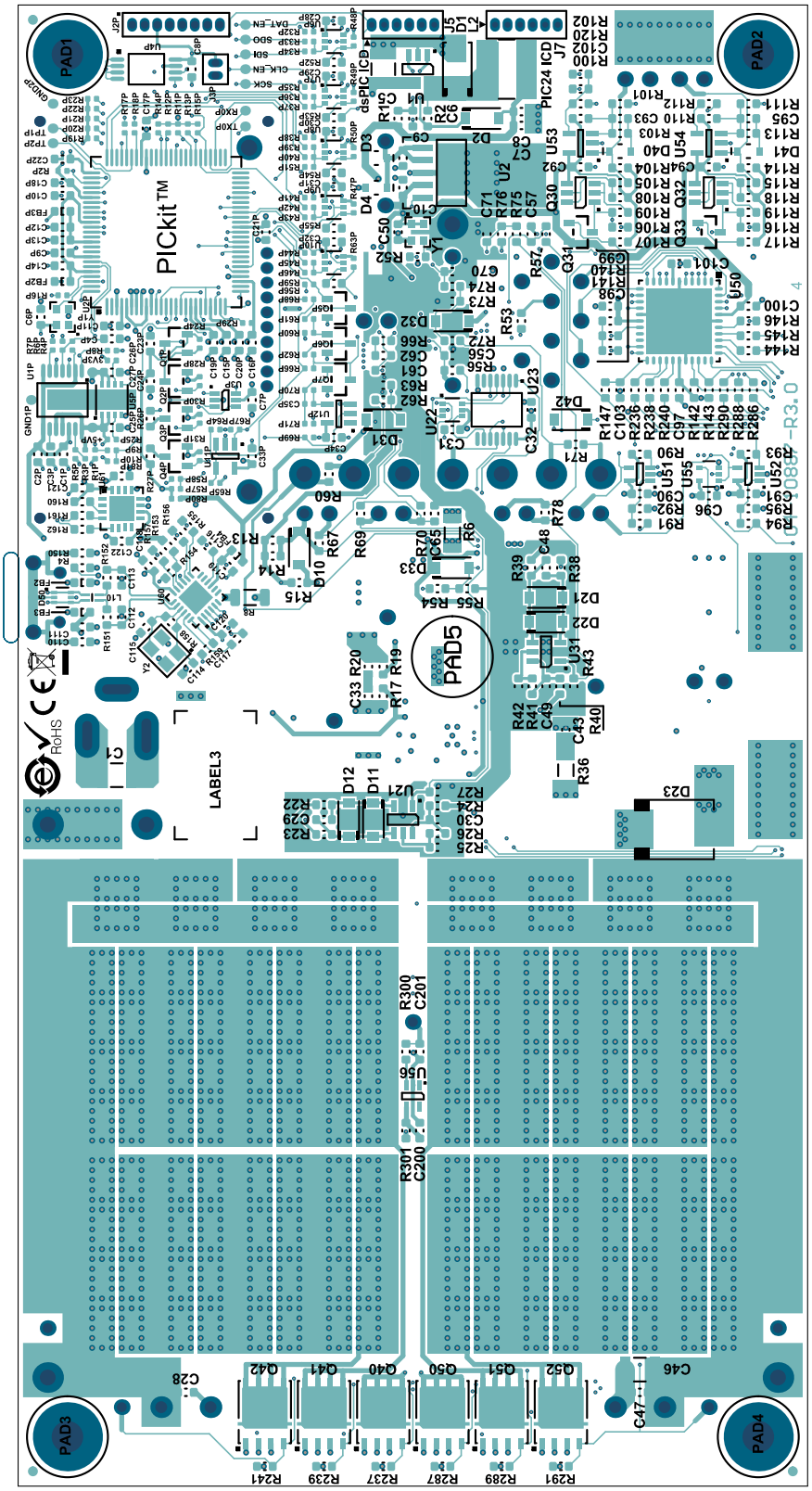

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FIGURE A-3: BLOCK DIAGRAM

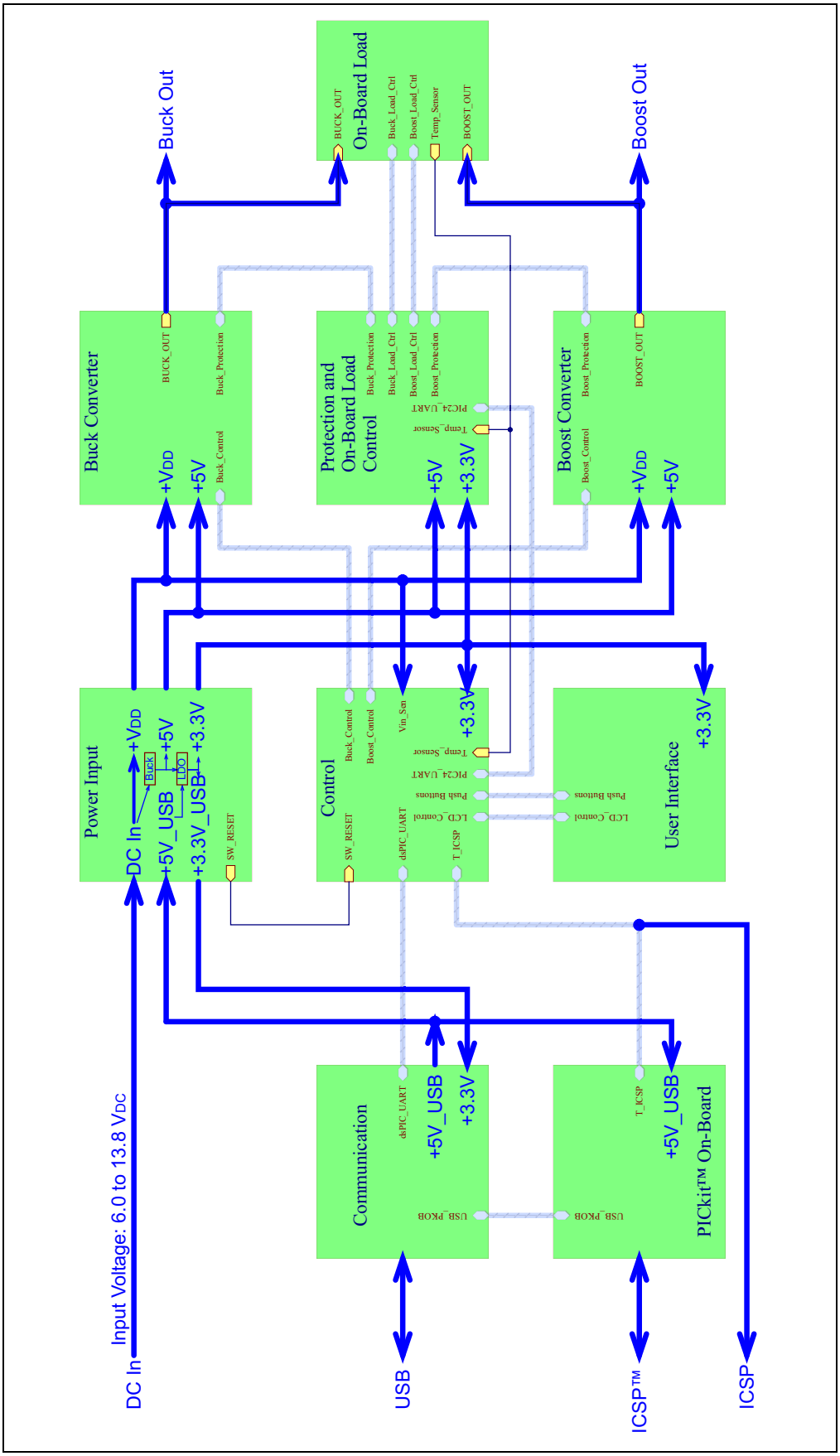

FIGURE A-4: POWER INPUT

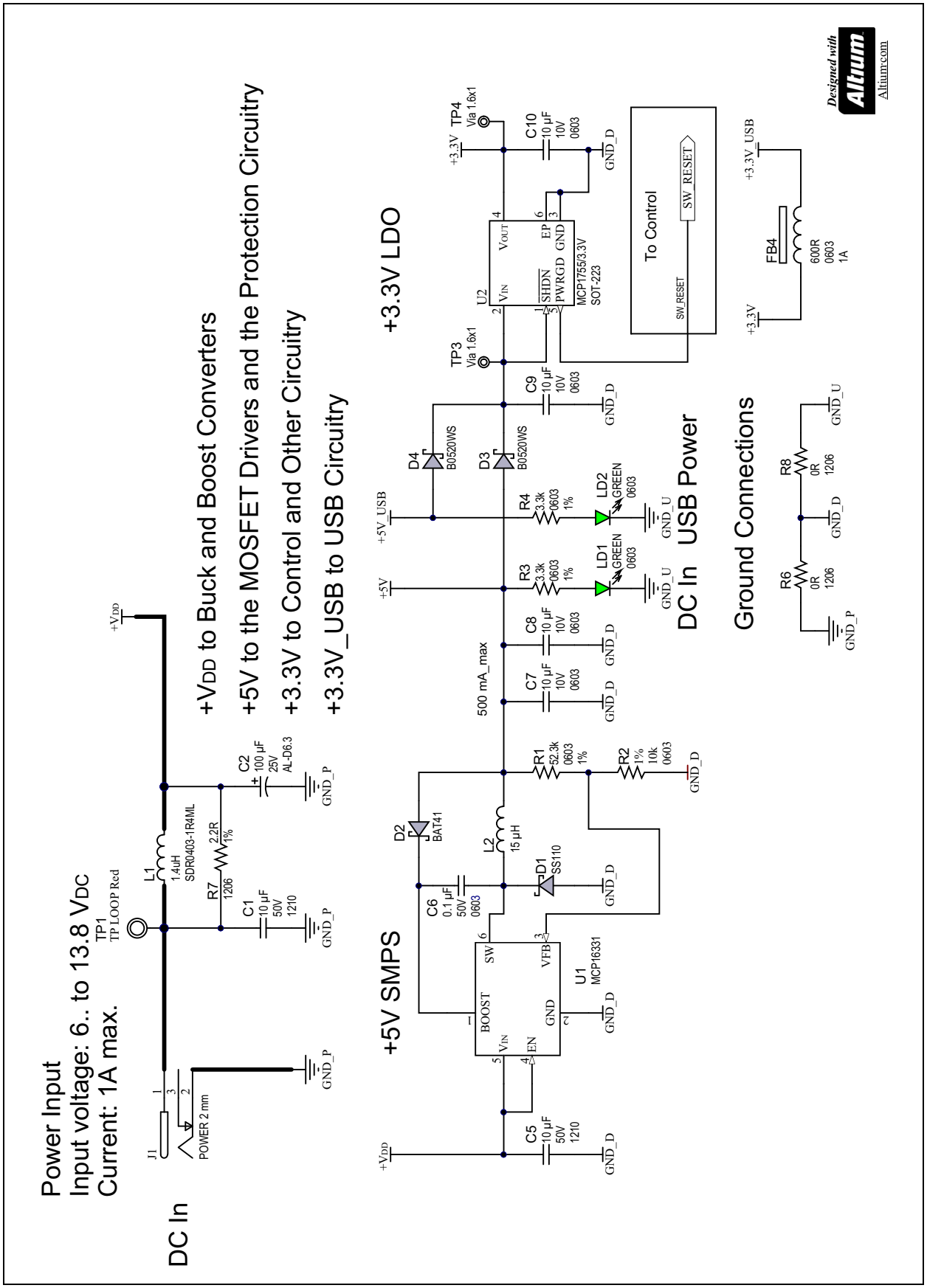

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FIGURE A-5: dsPIC33C DIGITAL POWER STARTER KIT SCHEMATIC REV. 3.0 (BUCK CONVERTER)

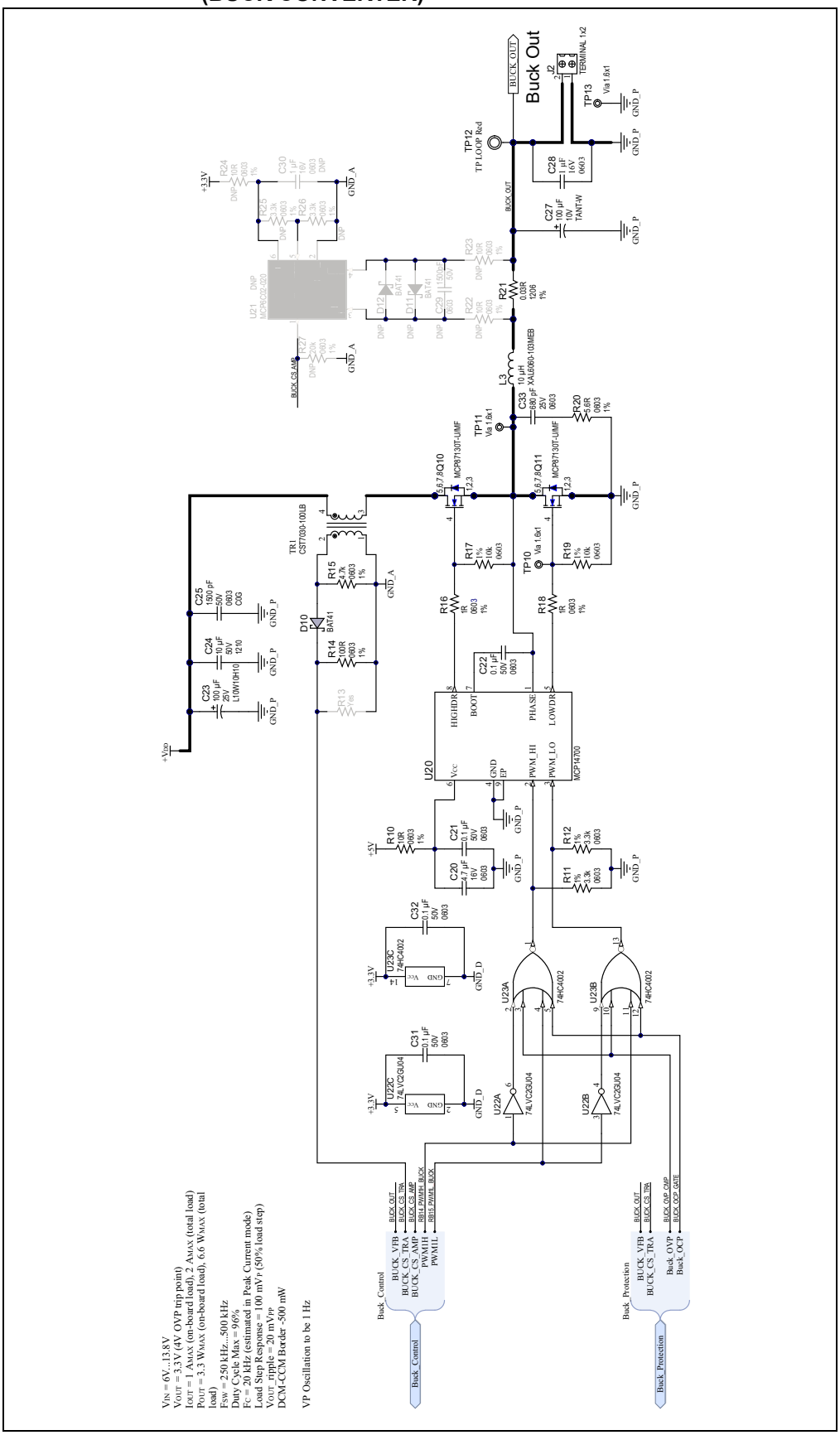

FIGURE A-6: dsPIC33C DIGITAL POWER STARTER KIT SCHEMATIC REV. 3.0 (BOOST CONVERTER)

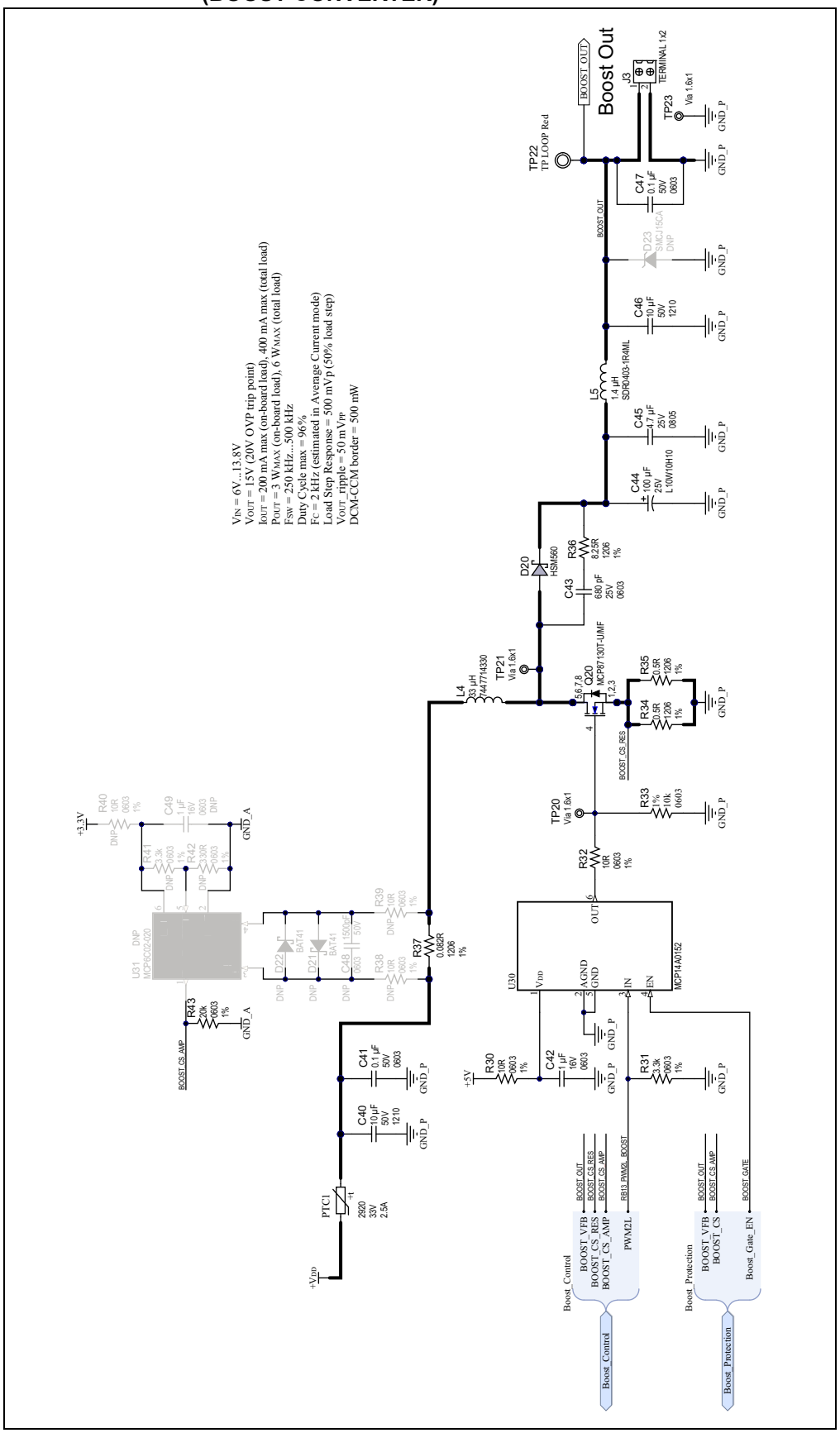

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FIGURE A-7: dsPIC33C DIGITAL POWER STARTER KIT SCHEMATIC REV. 3.0

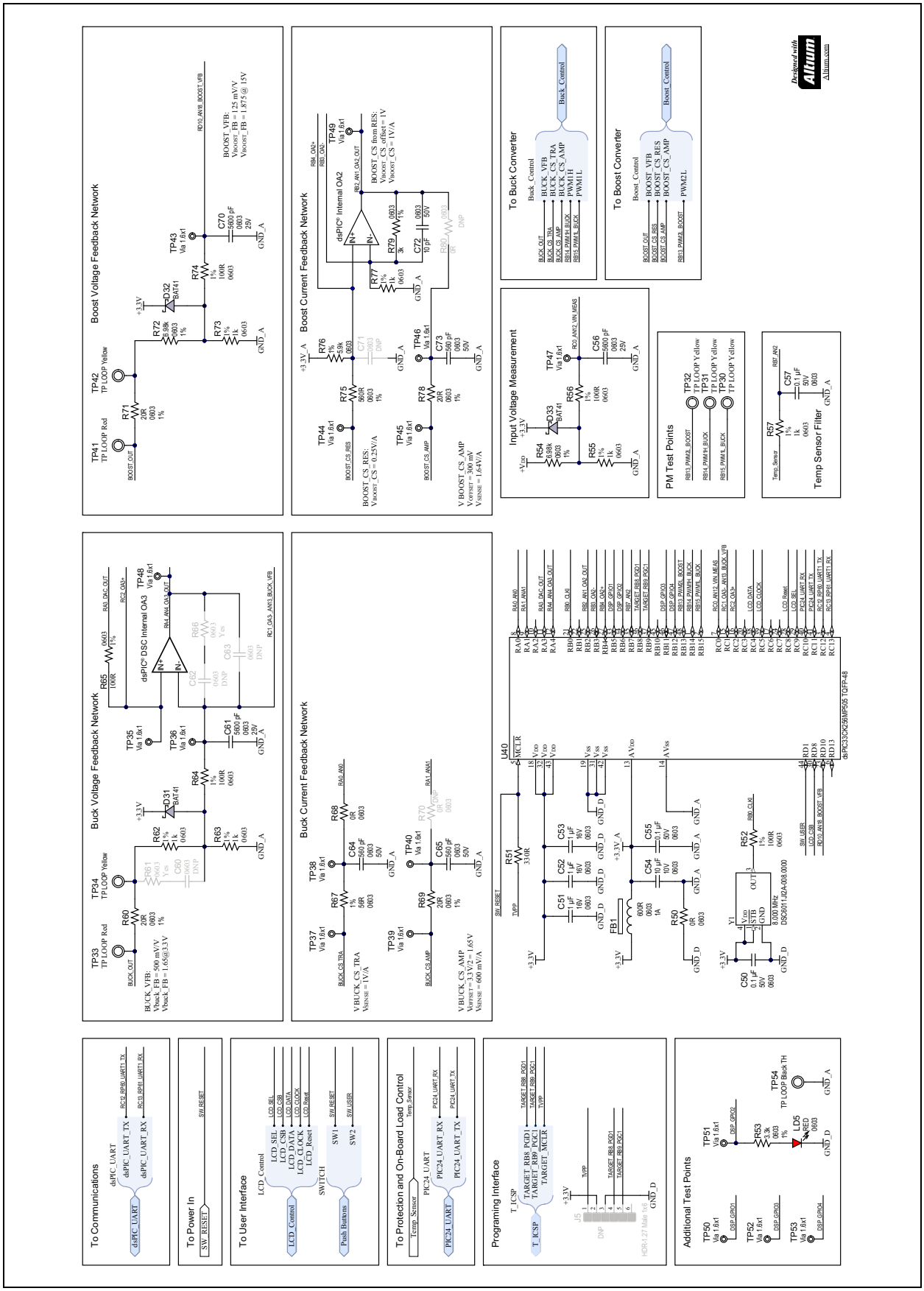

FIGURE A-8: USER INTERFACE

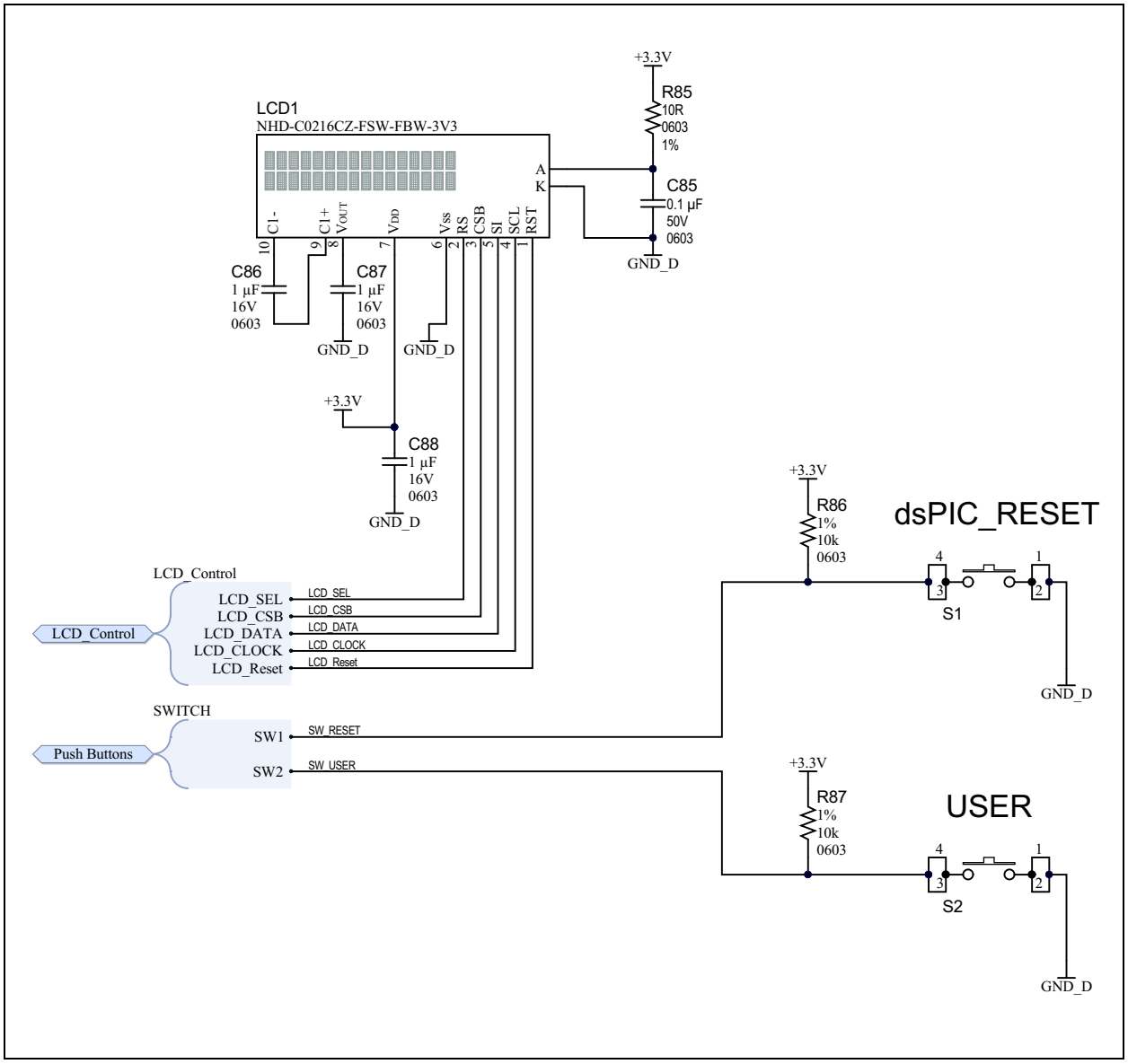

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FIGURE A-9: PROTECTION AND ON-BOARD LOAD CONTROL

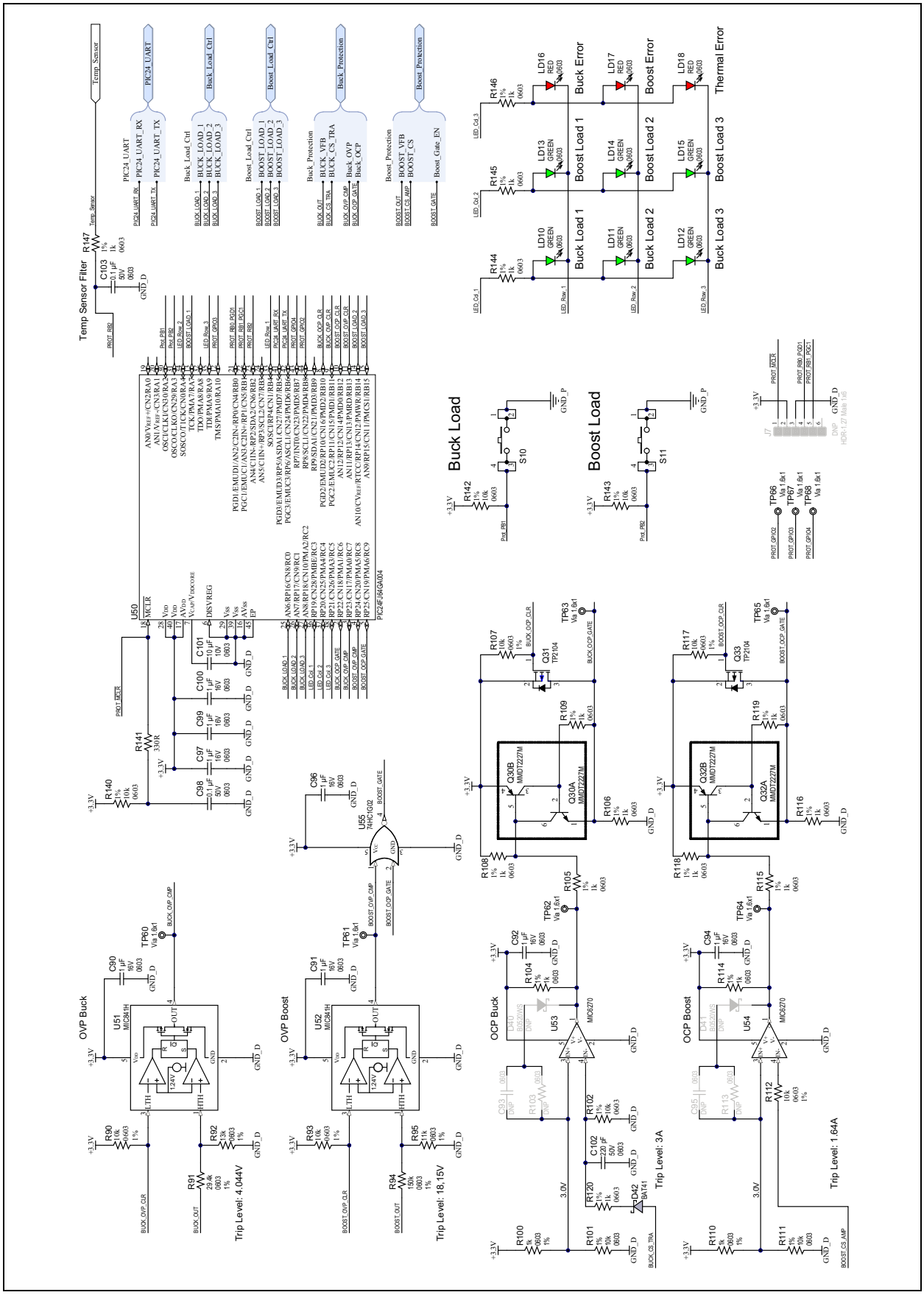

FIGURE A-10: ON-BOARD LOAD AND TEMPERATURE SENSOR

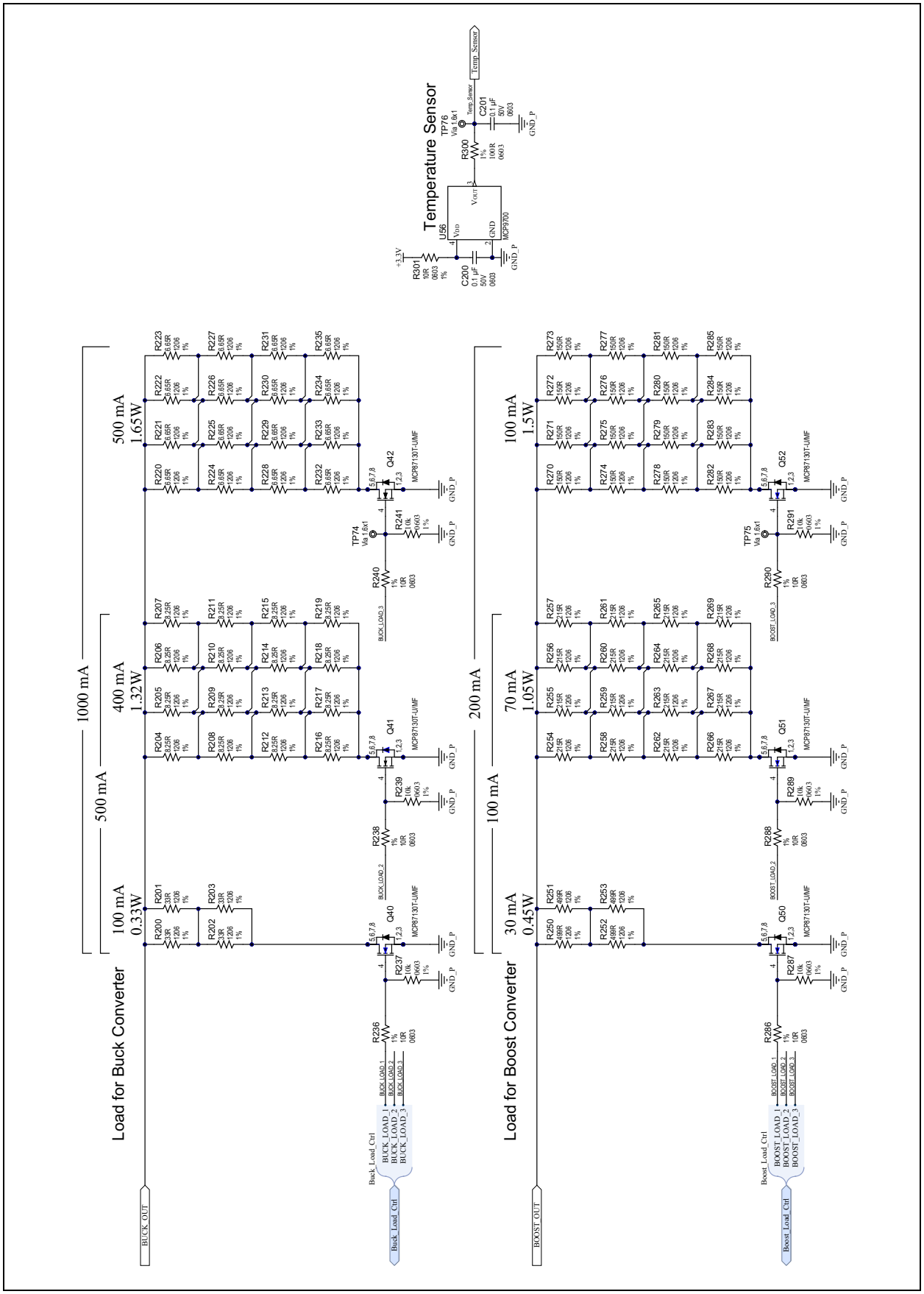

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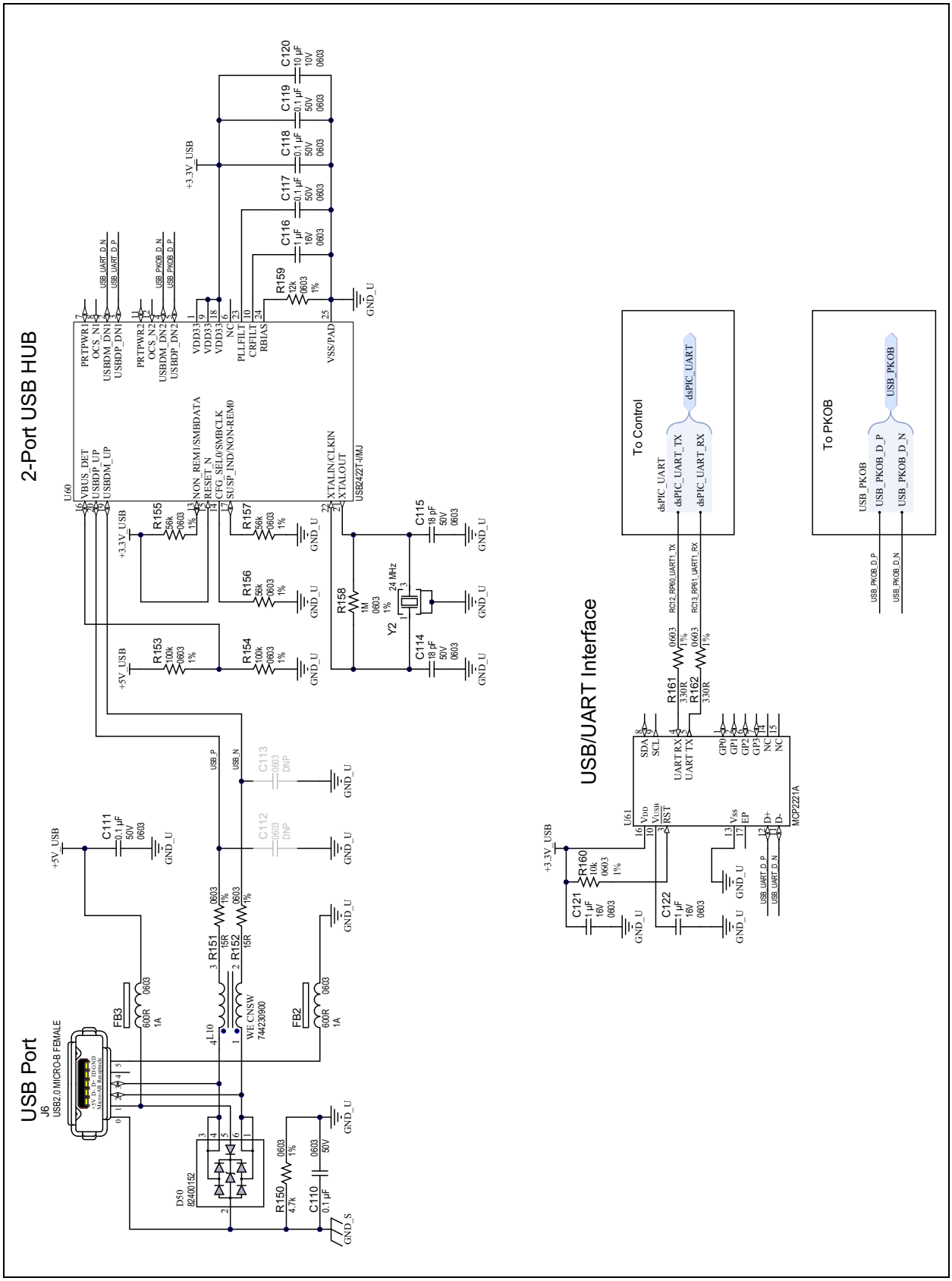
FIGURE A-11: POWER INPUT AND COMMUNICATIONS



NOTES:

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Appendix B. Bill of Materials (BOM)

This appendix contains the Bill of Materials (BOM) for the dsPIC33C Digital Power Starter Kit.

• Bill of Materials

B.1 BILL OF MATERIALS

Table B-1 shows the Bill of Materials for the dsPIC33C Digital Power Starter Kit.

TABLE B-1: dsPIC33C DIGITAL POWER STARTER KIT BILL OF MATERIALS (BOM)

Qty	Designator	Description	Manufacturer	Manufacturer Part Number
5	C1, C5, C24, C40, C46	Capacitor, Ceramic, 10 µF, 50V, 20%, X7R, SMD, 1210	TDK Corporation	C3225X7R1H106M250AC
1	C2	Capacitor, Aluminium, 100 µF, 25V, 20%, SMD, W6.6L6.6H7.7	Wurth Elecktronik	865090445008
20	C6, C21, C22, C31, C32, C41, C47, C50, C55, C57, C85, C98, C103, C110, C111, C117, C118, C119, C200, C201	Capacitor, Ceramic, 0.1 µF, 50V, 20%, X7R, SMD, 0603	TDK Corporation	C1608X7R1H104M
7	C7, C8, C9, C10, C54, C101, C120	Capacitor, Ceramic, 10 µF, 10V, 20%, X5R, SMD, 0603	Samsung Group	CL10A106MP8NNNC
1	C20	Capacitor, Ceramic, 4.7 µF, 16V, 10%, X5R, SMD, 0603	TDK Corporation	C1608X5R1C475K080AC
2	C23, C44	Capacitor, Aluminium, Polymer, 100 µF, 25V, 20%, SMD	Wurth Elecktronik	875075561005
1	C25	Capacitor, Ceramic, 1500 pF, 50V, 5%, C0G, SMD, 0603	Murata Electronics®	GRM1885C1H152JA01D
1	C27	Capacitor, Tantalum, Polymer, 100 µF, 10V, 20%, 40 mR, SMD, 2917	KEMET	T520W107M010ATE040
19	C28, C42, C51, C52, C53, C86, C87, C88, C90, C91, C92, C94, C96, C97, C99, C100, C116, C121, C122	Capacitor, Ceramic, 1 µF, 16V, 10%, X5R, SMD, 0603	AVX Corporation	0603YD105KAT2A
2	C33, C43	Capacitor, Ceramic, 680 pF, 25V, 10%, X7R, 0603	Wurth Elecktronik	885012206058
1	C45	Capacitor, Ceramic, 4.7 µF, 25V, 20%, Y5V, SMD, 0805	TDK Corporation	C2012Y5V1E475Z
3	C56, C61, C70	Capacitor, Ceramic, 5600 pF, 25V, 5%, C0G, SMD, 0603	TDK Corporation	C1608C0G1E562J080AA
3	C64, C65, C73	Capacitor, Ceramic, 560 pF, 50V, 5%, C0G, NP0, SMD, 0603	KEMET	C0603C561J5GACTU

TABLE B-1: dsPIC33C DIGITAL POWER STARTER KIT BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Designator	Description	Manufacturer	Manufacturer Part Number
1	C72	Capacitor, Ceramic, 10 pF ±0.5 pF, 50V, C0G, SMD, 0603	TDK Corporation	C1608C0G1H100D
1	C102	Capacitor, Ceramic, 220 pF, 50V, 5%, NP0, SMD, 0603	KEMET	C0603C221J5GACTU
2	C114, C115	Capacitor, Ceramic, 18 pF, 50V, 5%, NP0, SMD, 0603	KEMET	C0603C180J5GACTU
1	D1	Diode, Schottky, SS110, 850 mV, 1A, 100V, DO-214AC_SMA	Micro Commercial Components	SS110-TP
6	D2, D10, D31, D32, D33, D42	Diode, Schottky, BAT41, 1V, 200 mA, 100V, SOD-123	STMicroelectronics	BAT41ZFILM
2	D3, D4	Diode, Schottky, B0520WS, 430 mV, 500 mA, 20V, SOD-323	Diodes Incorporated®	B0520WS-7-F
1	D50	Diode, TVS Array, 82400152, 5V, USB 2.0, SMD, SOT-563	Wurth Elecktronik	82400152
4	FB1, FB2, FB3, FB4	Ferrite, 600R at 100 MHz, 1A, SMD, 0603	Bourns®, Inc.	MH1608-601Y
1	J1	Connector, Power, 2 mm, 5.5 mm, Switch, TH, R/A	CUI Inc.	PJ-002A
2	J2, J3	Connector, Terminal, 5 mm, 1x2 Female, 12-26AWG, 18A, TH, R/A	PHOENIX CONTACT	1935161
1	J6	Connector, USB 2.0, Micro-B, Female, TH/SMD, R/A	FCI	10118194-0001LF
2	L1, L5	Inductor, 1.4 µH, 3.3A, 38 mR, SMD, SDR0403	Bourns, Inc.	SDR0403-1R4ML
1	L2	Inductor, 15 µH, 1.16A, 20%, SMD, MSS6132	Coilcraft	MSS6132-153ML
1	L3	Inductor, 10 µH, 7A, 20%, SMD, L6.56W6.36H6.1	Coilcraft	XAL6060-103MEB
1	L4	Inductor, 33 µH, 2.9A, 20%, SMD, L10W10H5	Wurth Elecktronik	7447714330
1	L10	CM Choke, 90R, 100 MHz, 0.145R, 550 mA, SMD, 0603	Wurth Elecktronik	744230900
1	LCD1	LCD COG Character, 2x16, White, Transflective	Newhaven Display International, Inc.	NHD-C0216CZ-FSW-FBW-3V3
8	LD1, LD2, LD10, LD11, LD12, LD13, LD14, LD15	Diode, LED, Green, 2V, 30 mA, 35 mcd, Clear, SMD, 0603	Lite-On®, Inc.	LTST-C190KGKT
4	LD5, LD16, LD17, LD18	Diode, LED, Red, 1.8V, 40 mA, 10 mcd, Clear, SMD, 0603	Lite-On, Inc.	LTST-C190KRKT
1	PTC1	Resettable Fuse, 1.25A, 2.5A, 33V, PTC, SMD, 2920	Littelfuse®	SMDC125F/33-2
2	Q30, Q32	Transistor, BJT Dual, NPN+PNP, MMDT2227M, 40V-60V, 0.6A, -0.6A, 0.3W, SOT-23-6	Diodes Incorporated	MMDT2227M-7

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TABLE B-1: dsPIC33C DIGITAL POWER STARTER KIT BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Designator	Description	Manufacturer	Manufacturer Part Number
1	R1	Resistor, TKF, 52.3k, 1%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3EKF5232
22	R2, R17, R19, R33, R86, R87, R90, R93, R102, R107, R112, R117, R140, R142, R143, R160, R237, R239, R241, R287, R289, R291	Resistor, TKF, 10k, 1%, 1/10W, SMD, 0603	Vishay Intertechnology, Inc.	CRCW060310K0FKEA
6	R3, R4, R11, R12, R31, R53	Resistor, TKF, 3.3k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3301V
2	R6, R8	Resistor, TKF, 0R, SMD, 1206	Yageo Corporation	RC1206JR-070RL
1	R7	Resistor, TKF, 2.2R, 1%, 1/4W, SMD, 1206	Yageo Corporation	RC1206FR-072R2L
11	R10, R30, R32, R85, R236, R238, R240, R286, R288, R290, R301	Resistor, TKF, 10R, 1%, 1/10W, SMD, 0603	Stackpole Electronics Inc.	RMCF0603FT10R0
7	R14, R52, R56, R64, R65, R74, R300	Resistor, TKF, 100R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1000V
2	R15, R150	Resistor, TKF, 4.7k, 1%, 1/10W, SMD, 0603	Vishay Intertechnology, Inc.	CRCW06034K70FKEA
2	R16, R18	Resistor, TKF, 1R, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-071RL
1	R20	Resistor, TKF, 5.6R, 1/10W, 1%, SMD, 0603	Vishay Intertechnology, Inc.	CRCW06035R60FKEA
1	R21	Resistor, MS, 0.03R, 1%, 1W, SMD, 1206	Vishay Intertechnology, Inc.	WSLP1206R0300FEA
2	R34, R35	Resistor, TKF, 0.5R, 1%, 1/2W, SMD, 1206	Stackpole Electronics Inc.	CSR1206FKR500
17	R36, R204, R205, R206, R207, R208, R209, R210, R211, R212, R213, R214, R215, R216, R217, R218, R219	Resistor, TKF, 8.25R, 1%, 1/4W, SMD, 1206	Vishay Intertechnology, Inc.	CRCW12068R25FKEA
1	R37	Resistor, MFO, 0.082R, 1%, 3/4W, SMD, 1206	Susumu Co., Ltd.	KRL1632E-M-R082-F-T5
1	R43	Resistor, TKF, 20k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF2002V
2	R50, R68	Resistor, TKF, 0R, 1/10W, SMD, 0603	NIC Components	NRC06Z0TRF
4	R51, R141, R161, R162	Resistor, TKF, 330R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3300V
2	R54, R72	Resistor, TKF, 6.98K, 1%, 1/10W, SMD, 0603, AEC-Q200	Panasonic - ECG	ERJ-3EKF6981V
23	R55, R57, R62, R63, R73, R77, R100, R104, R105, R106, R108, R109, R110, R114, R115, R116, R118, R119, R120, R144, R145, R146, R147	Resistor, TKF, 1k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1001V
4	R60, R69, R71, R78	Resistor, TKF, 20R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF20R0V

TABLE B-1: dsPIC33C DIGITAL POWER STARTER KIT BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Designator	Description	Manufacturer	Manufacturer Part Number
1	R67	Resistor, TKF, 56R, 1%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3EKF56R0V
1	R75	Resistor, TKF, 560R, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-07560RL
1	R76	Resistor, TKF, 5.9k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF5901V
1	R79	Resistor, TKF, 3k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3001V
1	R91	Resistor, TKF, 29.4k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF2942V
1	R92	Resistor, TKF, 13k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1302V
1	R94	Resistor, TKF, 150k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1503V
1	R95	Resistor, TKF, 11k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1102V
2	R101, R111	Resistor, TKF, 10k, 1%, 1/10W, SMD, 0603	ROHM Semiconductor	MCR03EZPFX1002
2	R151, R152	Resistor, TKF, 15R, 1%, 1/16W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT15R0
2	R153, R154	Resistor, TKF, 100k, 1%, 1/4W, SMD, 0603	Vishay Intertechnology, Inc.	CRCW0603100KFKEAHP
3	R155, R156, R157	Resistor, TKF, 56k, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF5602V
1	R158	Resistor, TKF, 1M, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1004V
1	R159	Resistor, TKF, 12k, 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT12K0
4	R200, R201, R202, R203	Resistor, TKF, 33R, 1%, 1/4W, SMD, 1206, AEC-Q200	Panasonic - ECG	ERJ-8ENF33R0V
16	R220, R221, R222, R223, R224, R225, R226, R227, R228, R229, R230, R231, R232, R233, R234, R235	Resistor, TKF, 6.65R, 1%, 1/4W, SMD, 1206	Yageo Corporation	RC1206FR-076R65L
4	R250, R251, R252, R253	Resistor, TKF, 499R, 1%, 1/4W, SMD, 1206, AEC-Q200	Panasonic - ECG	ERJ-8ENF4990V
16	R254, R255, R256, R257, R258, R259, R260, R261, R262, R263, R264, R265, R266, R267, R268, R269	Resistor, TKF, 215R, 1%, 1/4W, SMD, 1206 AEC-Q200	Panasonic - ECG	ERJ-8ENF2150V
16	R270, R271, R272, R273, R274, R275, R276, R277, R278, R279, R280, R281, R282, R283, R284, R285	Resistor, TKF, 150R, 1%, 1/4W, SMD, 1206, AEC-Q200	Panasonic - ECG	ERJ-8ENF1500V
4	S1, S2, S10, S11	Switch, Tactile, SPST, 12V, 50 mA, TL3301AF160QG, SMD	E-Switch®, Inc.	TL3301AF160QG

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TABLE B-1: dsPIC33C DIGITAL POWER STARTER KIT BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Designator	Description	Manufacturer	Manufacturer Part Number
5	TP1, TP12, TP22, TP33, TP41	Connector, TP Loop, Red, TH	Keystone Electronics Corp.	5010
5	TP30, TP31, TP32, TP34, TP42	Connector, TP Loop, Yellow, TH	Keystone Electronics Corp.	5014
1	TP54	Connector, TP Loop, Black, TH	Keystone Electronics Corp.	5011
1	TR1	Transistor, Current, 1:100, 1 MHz, 20A, SMD	Coilcraft	CST7030-100LB
1	U22	IC Logic, Inverter, 2 CH, 74LVC2G04, SOT-363	Nexperia	74LVC2GU04GW,125
1	U23	IC Logic, NOR, 4-INP, 2 CH, 74HC4002, TSSOP-14	Nexperia	74HC4002PW,118
1	U55	IC Logic, 74AHC,1G02SE-7, NOR, 1 CH, 2-INP, SOT-353	Diodes Incorporated®	74AHC1G02SE-7
1	Y2	Crystal, 24 MHz, 18 pF, SMD, L3.2W2.5H0.6	Epson®	TSX-3225 24.0000MF10Z-C3
1	D20	Diode, Schottky, HSM560JE3, 650 mV, 5A, 60V, DO-214AB_SMC	Microchip Technology Inc.	HSM560JE3/TR13
9	Q10, Q11, Q20, Q40, Q41, Q42, Q50, Q51, Q52	Microchip Analog MOSFET, N-CH, 25V, 43A, MCP87130T-U/MF PDFN-8	Microchip Technology Inc.	MCP87130T-U/MF
2	Q31, Q33	Microchip Analog MOSFET, P-CH, TP2104, 40V, 160 mA, 360 mW, 6R, SOT23-3	Microchip Technology Inc.	TP2104K1-G
1	U1	Microchip Analog Switcher Buck, 2 to 24V MCP16331T-E/CH SOT-23-6	Microchip Technology Inc.	MCP16331T-E/CH
1	U2	Microchip Analog LDO, 3.3V, MCP1755T-3302E/DC, SOT-223-5	Microchip Technology Inc.	MCP1755T-3302E/DC
1	U20	Microchip Analog FET Driver, Single, Noninverting MCP14700-E/MF	Microchip Technology Inc.	MCP14700-E/MF
1	U30	Microchip Analog FET Driver Single, Noninverting, MCP14A0152 6L SOT-23	Microchip Technology Inc.	MCP14A0152T-E/CH
1	U40	dsPIC33CK256MP505	Microchip Technology Inc.	dsPIC33CK256MP505-I/PT
1	U50	Microchip MCU, 16-bit, 32 MHz, 64 KB, 8 KB, PIC24FJ64GA004-I/ML, QFN-44	Microchip Technology Inc.	PIC24FJ64GA004T-I/ML
2	U51, U52	IC Comparator, W/Ref, 1.25%, MIC841H, SC-70-5	Microchip Technology Inc.	MIC841HYC5-TR
2	U53, U54	Microchip Analog Comparator, 1-CH, MIC6270YM5-TR, SOT-23-5	Microchip Technology Inc.	MIC6270YM5-TR
1	U56	Microchip Analog Temperature Sensor, -40°C to +150°C, MCP9700T-E/LT, SC-70-5	Microchip Technology Inc.	MCP9700T-E/LT

TABLE B-1: dsPIC33C DIGITAL POWER STARTER KIT BILL OF MATERIALS (BOM) (CONTINUED)

Qty	Designator	Description	Manufacturer	Manufacturer Part Number
1	U60	Microchip Interface, USB 2.0, High-Speed, 2-Port HUB Controller, QFN-24	Microchip Technology Inc.	USB2422T-I/MJ
1	U61	Microchip Interface, USB, I^2C/UART, MCP2221A-I/ML, QFN-16	Microchip Technology Inc.	MCP2221A-I/ML
1	Y1	Microchip Clock Oscillator, Single, 8.000 MHz, DSC6011JI2A-008.0000, VDFN-4	Microchip Technology Inc.	DSC6011JI2A-008.0000

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Appendix C. Demonstration Program Operation

The dsPIC33C device on the dsPIC33C Digital Power Starter Kit is preprogrammed with Peak Current mode control application software that illustrates simultaneous 2-Pole, 2-Zero (2P2Z) compensator control of the output voltage for the two DC/DC Converter circuits. This code can be downloaded from the Microchip website (www.microchip.com).

This section covers the following topics:

- Program Demonstration
- Code Demonstration
- Other Code Examples

C.1 PROGRAM DEMONSTRATION

The demonstration program provides simultaneous closed-loop control of the output voltage for both DC/DC Converter stages of the dsPIC33C Digital Power Starter Kit. The high-level block diagram is shown in Figure C-1 and the program flow chart is shown in Figure C-2.

The 2P2Z control loop controls the Buck Converter output voltage to 3.3V and the Boost Converter output voltage to 15V.

The 2P2Z control scheme consists of the following parameters:

- Reference – Desired set point for the output voltage.
- Error – Calculation of (Reference – Feedback). This is the value the compensator acts upon.
- System Plant – This is the converter being controlled.
- Output – Either the output voltage or current.
- Feedback – The measured output signal level.

Please refer to **Section C.2.4 "2P2Z SW Control Compensator"** for further details.The demonstration program requires no manual preparation, except to connect 9V to the J2 connector.

FIGURE C-1: PEAK CURRENT MODE CONTROL LOOP BLOCK DIAGRAM

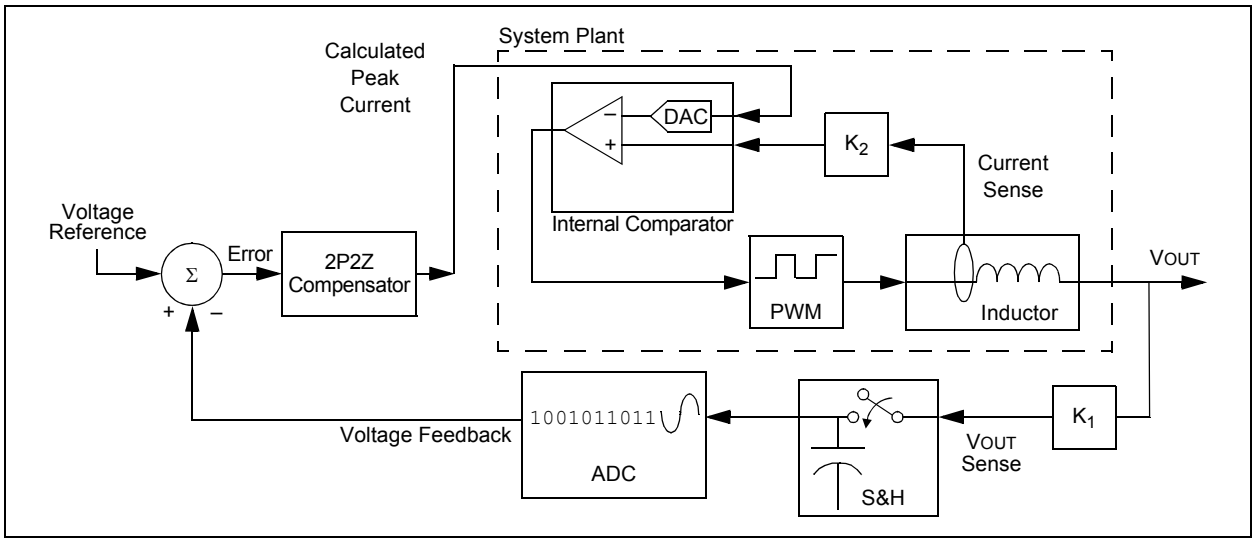
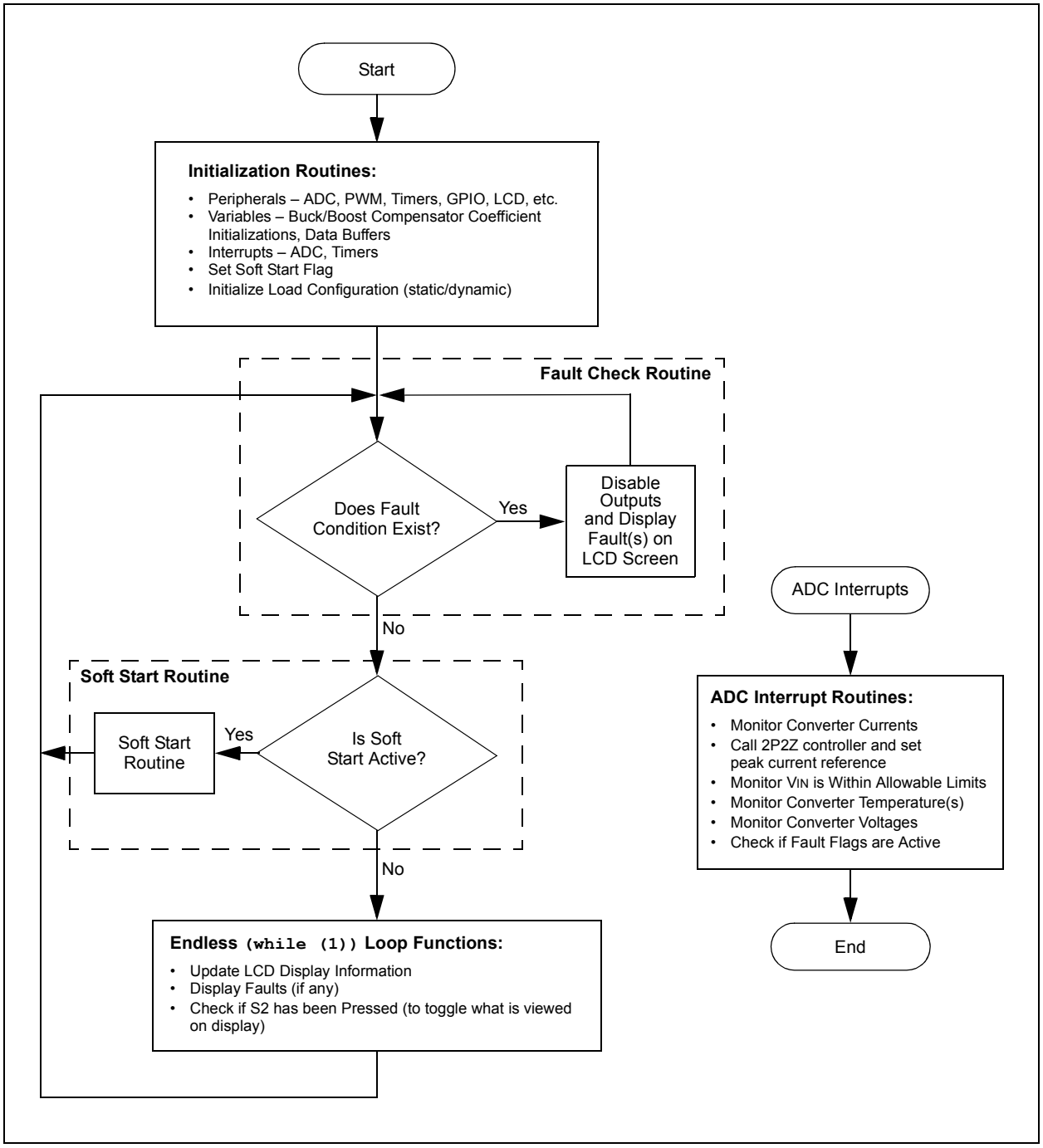


FIGURE C-2: SMPS DEMONSTRATION PROGRAM FLOW CHART



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C.2 CODE DEMONSTRATION

C.2.1 System Initialization

When power is applied to the board, the program starts by executing the following system initialization routines:

- Peripherals – The required peripherals (PWM, ADC, comparators, I^2C module, timers and GPIO) are configured and enabled.
- Interrupts – Include ADC(s), timer(s), comparator(s) interrupts.
- Loads – Can be configured for either Static mode or Dynamic mode. If Dynamic mode is selected, a switching frequency can be configured in application SW.

C.2.2 Fault Check

The program checks for any Faults that might have occurred during program operation. The Fault checks include the following:

- Input Over/Undervoltage
- Buck/Boost Converter Overtemperature
- Buck/Boost Soft Start

If any of the listed Faults occur, the corresponding Fault will be shown on the LCD display. The corresponding PWM signals and loads are disabled until the Fault condition has been cleared. Fault checks are dispersed throughout all the interrupts. If no Fault condition is detected, the program proceeds.

C.2.3 Soft Start

The Soft Start routine ramps up the output voltage in a closed-loop fashion until it is at the programmed output voltage value. This routine ensures that the output does not overshoot the desired voltage.

C.2.4 2P2Z SW Control Compensator

The 2-Pole, 2-Zero (2P2Z) Controller, implemented in SW, is the digital implementation of the Analog Type II Controller. This filter maintains regulation of the output voltage and ensures stability during different line/load conditions. This controller requires three feedback errors, multiplied by their associated coefficients, plus the two latest controller output values, multiplied by their associated coefficients, along the delay line to provide proper compensation of the power converter. The coefficients are determined externally using simulation tools.

Reference the `smps_2p2z_dspic_v2` source file and `smps_control.h` header files in the DPSK software package for further implementation details.

C.2.5 System `While (1)` Loop

The LCD refresh functions are called within the system Idle routine. The routine refreshes the LCD screen based on both user input (S2) and converter feedback (Fault flags/V_{IN} measurement/converter output voltage). All Fault display updates are performed in the system Idle loop routine, as well as the toggling of the displayed measurements as the results of pressing S2.

C.3 OTHER CODE EXAMPLES

There are several other SMPS code examples available on the Microchip website. Refer to the Readme files located in each code example folder for details on what each code example demonstrates. Check the Microchip website (www.microchip.com/SMPS) for the latest updates to the code examples and for additional code examples.

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China - Wuhan
Tel: 86-27-5980-5300

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