MIC2128 Evaluation Board User's Guide

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Object of Declaration: MIC2128 Evaluation Board

EU Declaration of Conformity

Manufacturer: Microchip Technology Inc.
                       2355 W. Chandler Blvd.
                       Chandler, Arizona, 85224-6199
                       USA

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).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

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Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA

Derek Carlson (signature)

Derek Carlson
VP Development Tools

12-Sep-14
Date

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 "XXXXXXX" 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 MIC2128 Evaluation Board. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the MIC2128 Evaluation Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MIC2128 Evaluation Board.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and starting the MIC2128 Evaluation Board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MIC2128 Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MIC2128 Evaluation Board.

MIC2128 Evaluation Board User's Guide

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 the MIC2128 Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

- **MIC2128YML Data Sheet –** *"75V, Synchronous Buck Controllers Featuring Adaptive On-Time Control"* **(DS20005620A)**

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- Technical Support

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

DOCUMENT REVISION HISTORY

Revision A (September 2016)

- Initial release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MIC2128 Evaluation Board and covers the following topics:

• MIC2128 Evaluation Board Overview
• MIC2128 Evaluation Board Features
• What the MIC2128 Evaluation Board Kit Contains

1.2 MIC2128 EVALUATION BOARD OVERVIEW

The MIC2128 Evaluation Board is a constant-frequency, synchronous buck controller featuring a unique adaptive on-time control architecture. The MIC2128 operates over an input supply range of 4.5V to 75V. The output voltage is adjustable down to 0.6V with a guaranteed accuracy of ±1%. The device operates with programmable switching frequency from 270 kHz to 800 kHz.
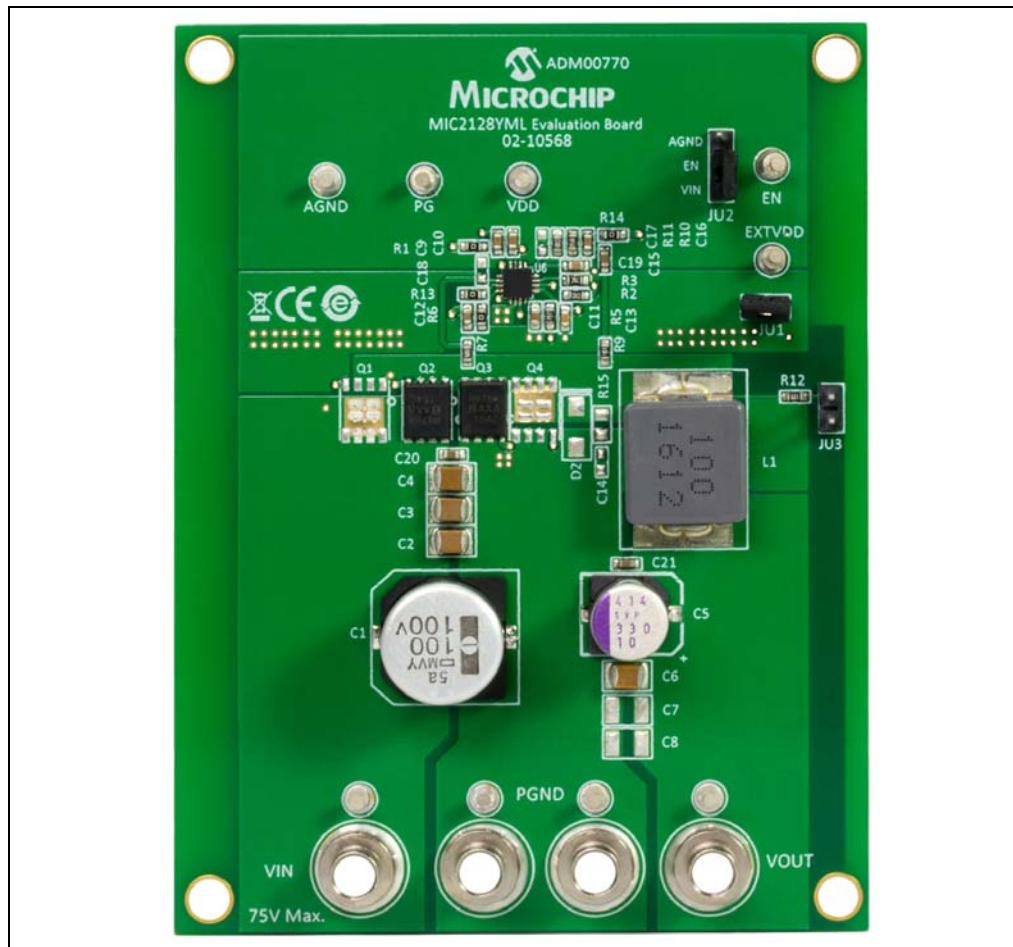
FIGURE 1-1: *MIC2128 Evaluation Board Overview.*

1.3   MIC2128 EVALUATION BOARD FEATURES

The MIC2128 Evaluation Board:

• Features soft-start (SS) time selection pin which allows the user to adjust the output soft-start time to reduce inrush current from mains during startup
• Features an auxiliary bootstrap low-dropout (LDO) which improves the system efficiency by supplying the internal bias power from the output of the converter. A logic level enable (EN) signal can be used to enable or disable the controller.
• Can start up monotonically into a pre-biased output
• Features an open drain power good signal (PG) which signals when the output is in regulation
• Operates in discontinuous conduction mode during soft start at light loads

The basic parameters of the evaluation board are:

• Input: 7V to 75V (Optimized for 48V)
• Output: 5V at 5A
• 300 kHz Switching Frequency (adjustable 270 kHz to 800 kHz)

1.4   WHAT THE MIC2128 EVALUATION BOARD KIT CONTAINS

The MIC2128 Evaluation Board includes the following items:

• MIC2128 Evaluation Board (ADM00770)
• Important Information Sheet

Chapter 2. Installation and Operation

2.1 SYSTEM AND CONFIGURATION REQUIREMENTS

The MIC2128 Evaluation Board requires only a single power supply with at least 10A current capability. The MIC2128 has internal V_{DD} LDO so no external linear regulator is required to power the internal biasing of the IC. In the applications with $V_{IN} < +5.5V$, P_{VDD} should be tied to V_{IN} to by-pass the internal linear regulator. The output load can either be a passive or an active load.

> **Note:** The MIC2128 Evaluation Board does not have reverse polarity protection. Applying a negative voltage to the V_{VIN} and GND terminals may damage the device. The maximum V_{VIN} of the board is rated at 75V. Exceeding 75V on the V_{VIN} could damage the device.

2.2 BOARD SETUP

Follow these steps prior to using the MIC2128 Evaluation Board:

1. Connect a supply to the V_{IN} and GND terminals, paying careful attention to the polarity and the supply range ($7V < V_{VIN} < 75V$). Monitor I_{IN} with a current meter and input voltage at V_{VIN} and GND terminals with voltmeter. Do not apply power until Step 4.
2. Connect a load to the V_{OUT} and GND terminals. The load can be either a passive (resistive) or an active (electronic) type. A current meter may be placed between the V_{OUT} terminal and load to monitor the output current. Ensure the output voltage is monitored at the V_{OUT} terminal.
3. Enable Input. An EN connector is provided on the evaluation board for users to easily access the enable feature. Applying an external logic signal on the EN pin to pull it low, or using a jumper to short the EN pin to GND, will shut off the output of the MIC2128 Evaluation Board.
4. Turn on the V_{VIN} supply and verify that the output voltage is regulated to 5V.

2.3   CIRCUIT DESCRIPTION

This section describes the working principles and limitations that should be taken into account when using the MIC2128 Evaluation Board.

2.3.1   Feedback Resistors

The output voltage on the MIC2128 Evaluation Board, which is preset to 5V, is determined by the feedback divider:

EQUATION 2-1:   EQUATION 1

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R10}{R11}\right)$$

The MIC2128 output is optimized for 5V output. All other voltages other than 5V can be set by modifying R11 value according to:

EQUATION 2-2:   EQUATION 2

$$R11 = \frac{R10 \times V_{REF}}{V_{OUT} - V_{REF}}$$

where:

V_{REF} =   0.6V

Note that the output voltage should not be set to exceed 5V due to the 6.3V voltage rating on the output capacitors.

For output voltage higher than 5V, output capacitors and $EXTV_{DD}$ pin bypass capacitor (C13) of voltage rating higher than the set output voltage should be used.

2.3.2   SW Node

Test point JU3 (V_{SW}) is placed for monitoring the switching waveform, one of the most critical waveforms for the converter.

2.3.3   Current Limit

The MIC2128 Evaluation Board uses the low-side MOSFET $R_{DS(ON)}$ to sense inductor current. In each switching cycle of the MIC2128 converter, the inductor current is sensed by monitoring the voltage across the low-side MOSFET during the OFF period of the switching cycle during which low-side MOSFET is ON. An internal current source of 96 μA generates a voltage across the external current limit setting resistor RCL as show in Figure 2-1.

The ILIM pin voltage (V_{ILIM}) is the difference of the voltage across the low-side MOSFET and the voltage across the resistor (VCL). The sensed voltage VILIM is compared with the power ground (PGND) after a blanking time of 150 ns.

If the absolute value of the voltage drop across the low-side MOSFET is greater than the absolute value of the voltage across the current setting resistor (V_{CL}), the MIC2128 triggers the current limit event. Consecutive eight current limit events trigger the Hiccup mode. The hiccup sequence, including the soft start, reduces the stress on the switching field-effect transistors (FETs) and protects the load and supply from severe short conditions.

The short circuit current limit can be programmed by using the following formula:

EQUATION 2-3:   EQUATION 3

$$R_7 = \frac{(I_{CLIM} + \Delta_{PP} \times 0.5) \times R_{DSON} + V_{CL}}{I_{CL}}$$

where:

I_{CLIM}	=	Desired current limit
Δ_{PP}	=	Inductor current peak-to-peak
$R_{DS(ON)}$	=	On resistance of low-side power MOSFET
V_{CL}	=	Current-limit threshold. The maximum value is +15 mV.
I_{CL}	=	Current-limit source current. The typical value is 96 µA.

The short circuit current limit is depicted in Figure 2-1:
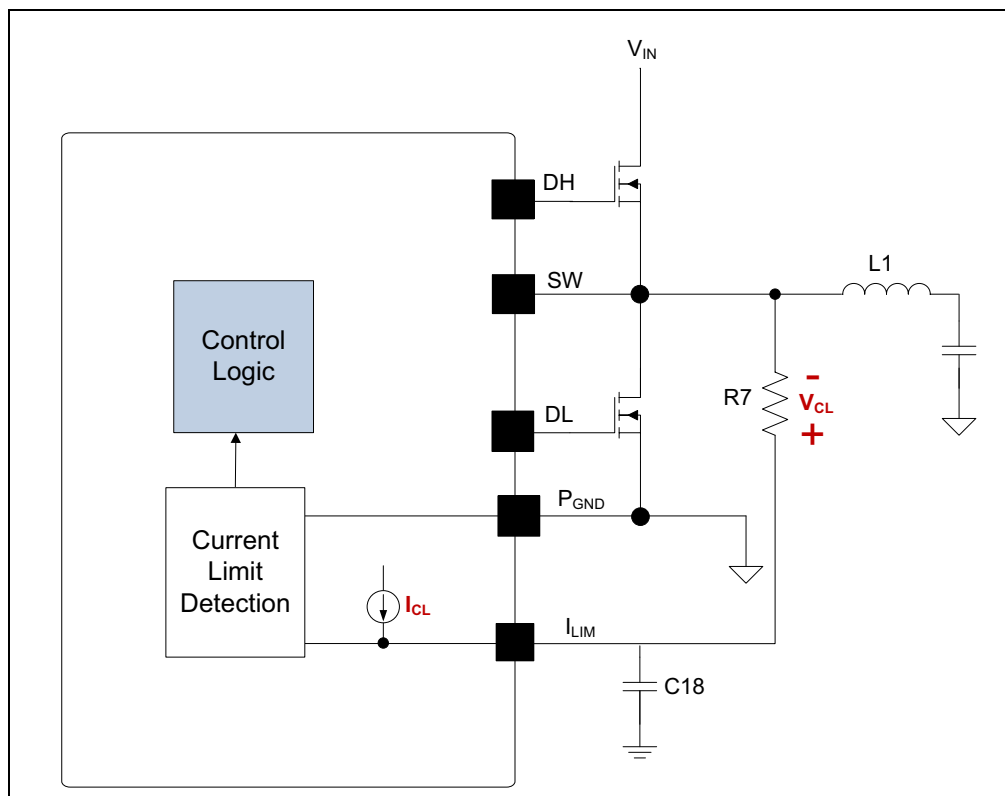
FIGURE 2-1:   *MIC2128 Current-Limiting Circuit.*

It is mandatory to make sure that the inductor current used to charge the output capacitance during soft start is under the current limit, otherwise the supply will go in Hiccup mode and may not finish the soft start successfully.

The MOSFET $R_{DS(ON)}$ varies 30% to 40% with temperature. Therefore, it is recommended to add a 30% margin to ICL in the above equation to avoid false current limiting due to increased MOSFET junction temperature rise. It is also recommended to connect the SW pin directly to the drain of the low-side MOSFET to accurately sense the MOSFET's $R_{DS(ON)}$.

2.3.4 Loop Gain Measurement

Resistor R14 is placed in series with the regulator feedback path. The control loop gain can be measured by connecting an impedance analyzer across the resistor and selecting the resistor value between 20Ω to 50Ω.

2.3.5 Setting the Switching Frequency

The MIC2128 Evaluation Board is an adjustable-frequency, synchronous buck controller featuring a unique adaptive on-time control architecture. The switching frequency can be adjusted between 270 kHz and 800 kHz by changing the resistor divider network consisting of R2 and R3.

The following formula provides the estimated switching frequency:

EQUATION 2-4:   EQUATION 4

$$f_{SW} = f_0 \times \frac{R3}{R2 + R3}$$

where:

f_0 =   Switching Frequency when R2 is 100Ω and R3 is open, f_O is typically 800 kHz. For a more precise setting, it is recommended to use the Switching Frequency graph from the data sheet.

The evaluation board design is optimized for a switching frequency of 300 kHz. If the switching frequency is programmed to either lower end or higher end, the design needs optimization. The switching frequency adjustment is depicted in Figure 2-2:
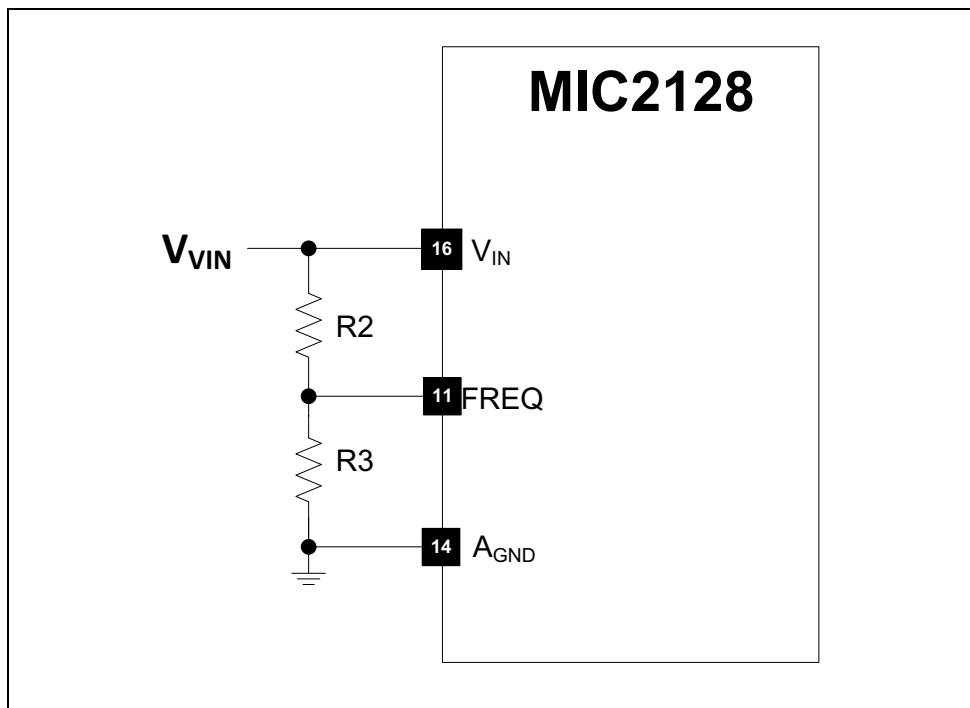
FIGURE 2-2:   *Switching Frequency Adjustment.*

2.3.6 Setting the Soft-Start Time

The output soft-start time can be set by connecting a capacitor from SS to AGND as shown in Figure 2-3.
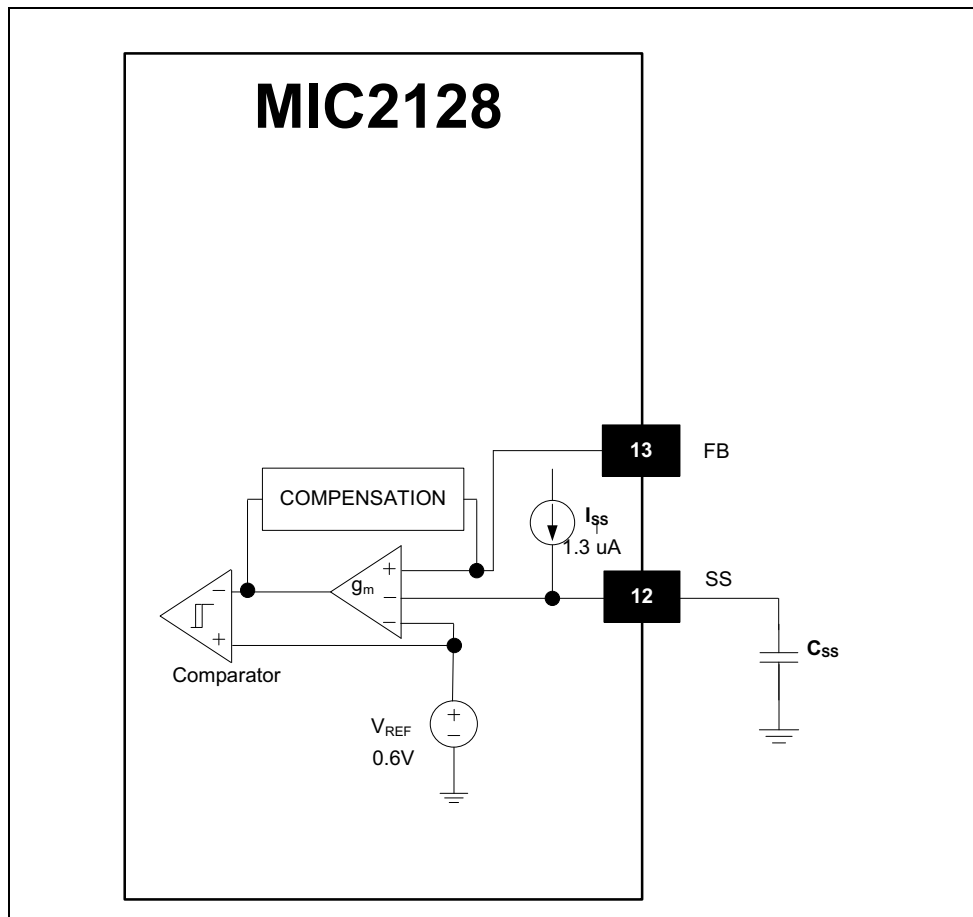
FIGURE 2-3: *Setting the Soft-Start Time.*

The value of the capacitor can be calculated using the following equation:

EQUATION 2-5: EQUATION 5

$$C_{19} = \frac{I_{SS} \times t_{SS}}{V_{REF}}$$

where:

C_{19}	=	Capacitor from SS pin to AGND
I_{SS}	=	Internal soft-start current (1.3 μA typical)
t_{SS}	=	Output soft-start time
V_{REF}	=	Reference voltage (0.6V)

2.3.7 Auxiliary Bootstrap LDO (EXTVDD)

The MIC2128 Evaluation Board features an auxiliary bootstrap LDO which improves the system efficiency by supplying the MIC2128 internal circuit bias power from the converter output voltage. This LDO is enabled when the voltage on the EXTVDD pin is above 4.6V (typical) and at the same time, the main LDO which operates from V_{IN}, is disabled to reduce power consumption. If the regulator output voltage is ≥5V and ≤12V, use output voltage to power the MIC2128, which will increase system efficiency. The JU1 jumper can be shorted to use output voltage as EXTVDD.

Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the MIC2128 Evaluation Board :

- Board – Schematic
- Board – Top Silk Layer
- Board – Top Copper layer
- Board – Mid Copper Layer 1
- Board – Mid Copper Layer 2
- Board – Bottom Copper layer
- Board – Bottom Silk Layer

A.2   BOARD – SCHEMATIC

MIC2128 Evaluation Board Board User's Guide
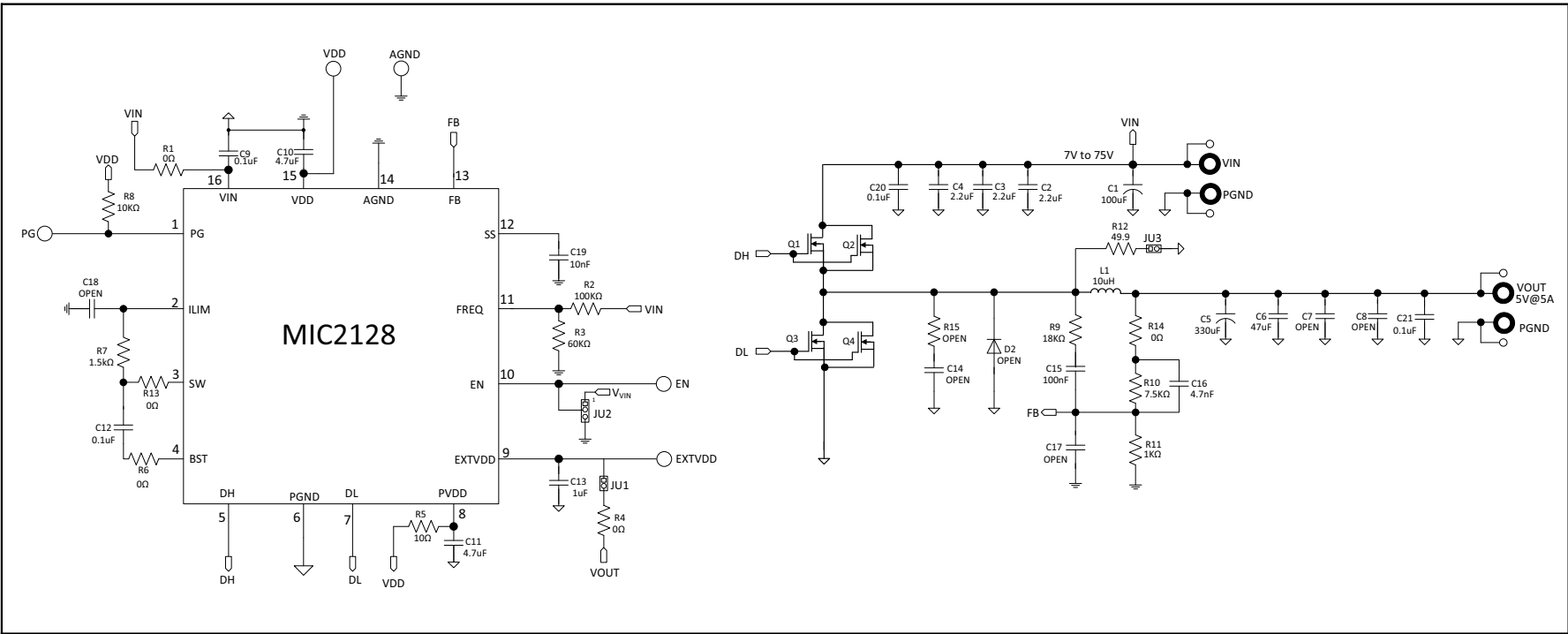
A.3   BOARD – TOP SILK LAYER
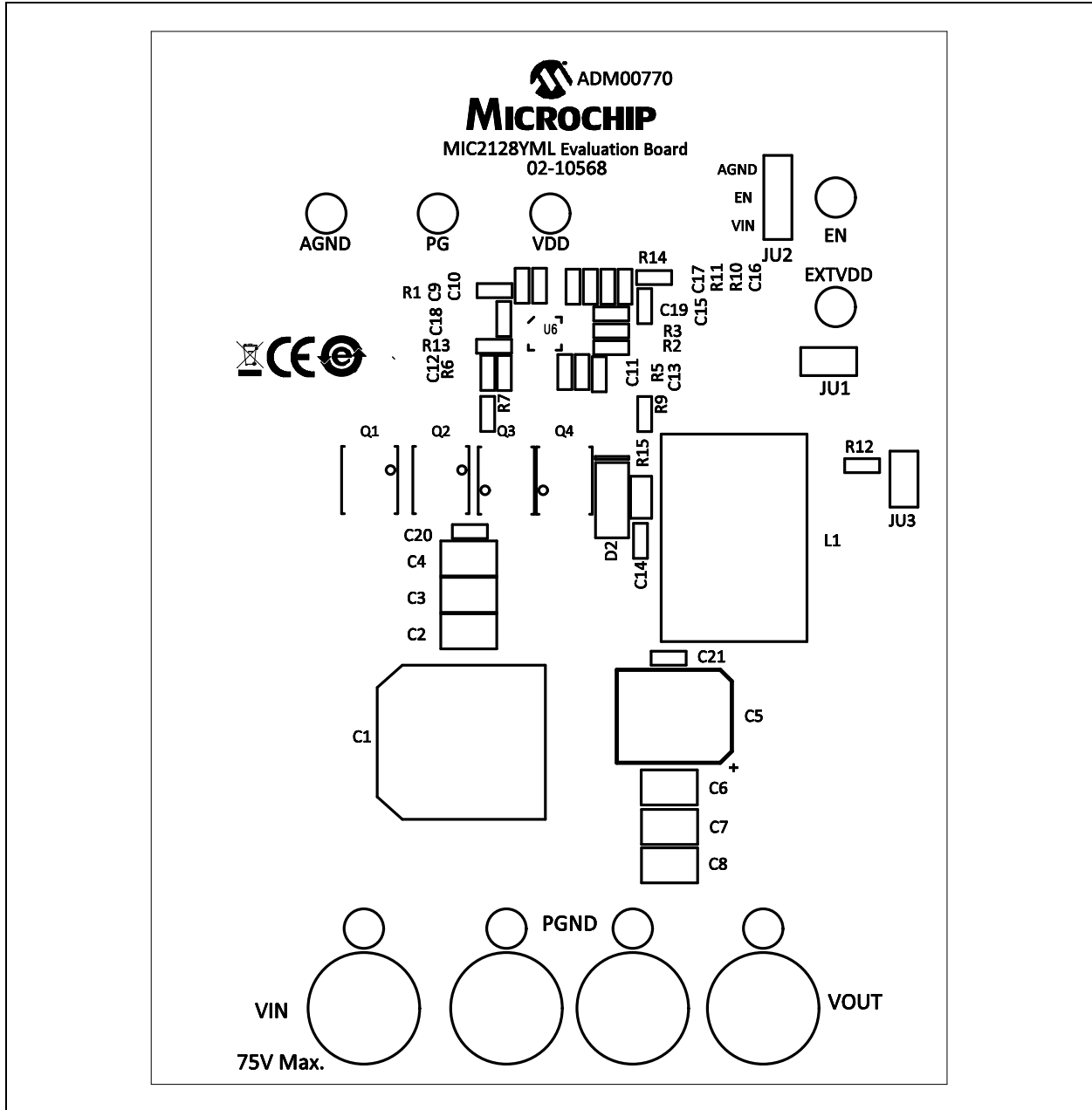
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A.4   BOARD – TOP COPPER LAYER

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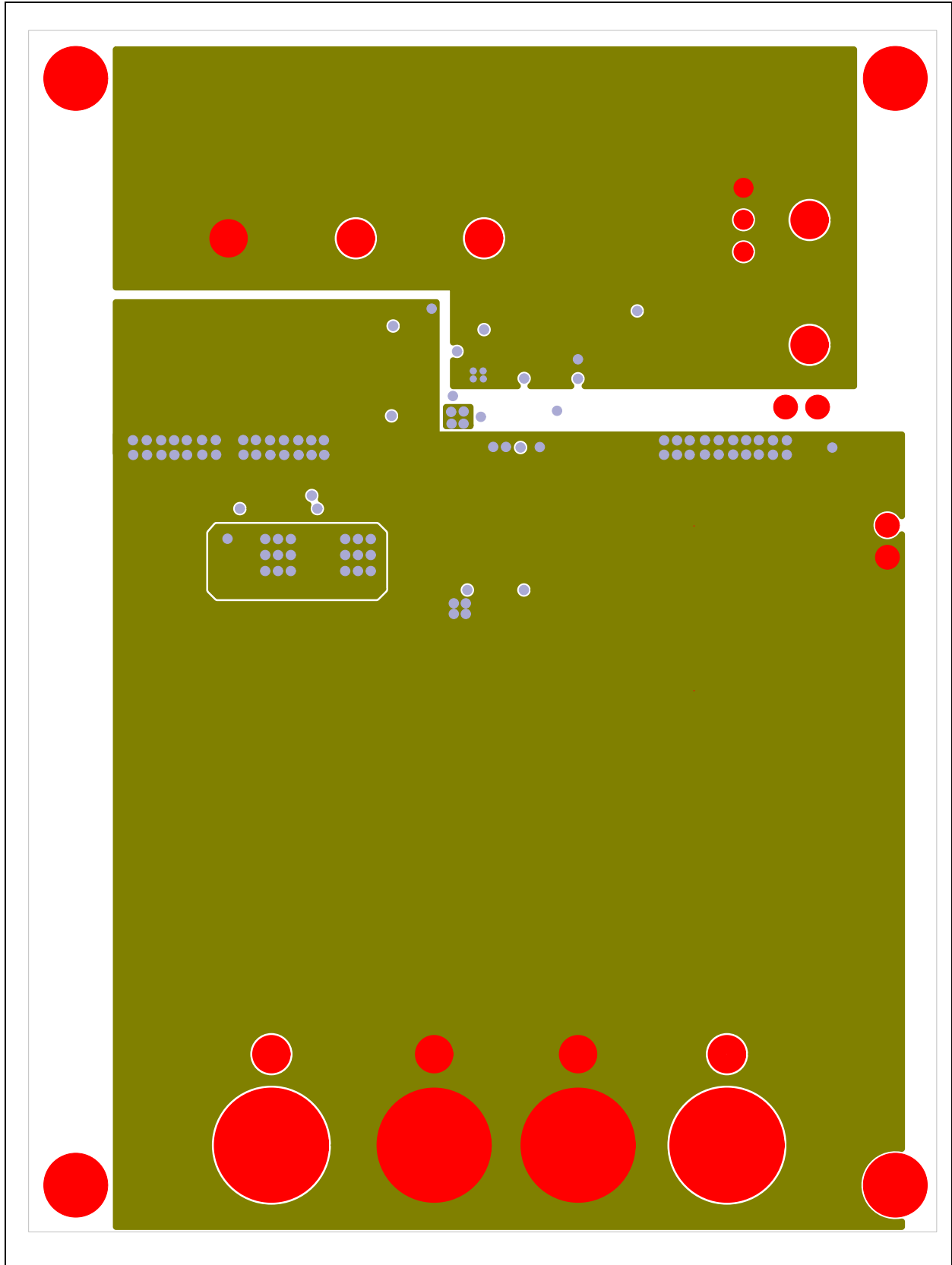
A.5   BOARD – MID COPPER LAYER 1

A.6   BOARD – MID COPPER LAYER 2

A.7   BOARD – BOTTOM COPPER LAYER

A.8   BOARD – BOTTOM SILK LAYER

R8

R4
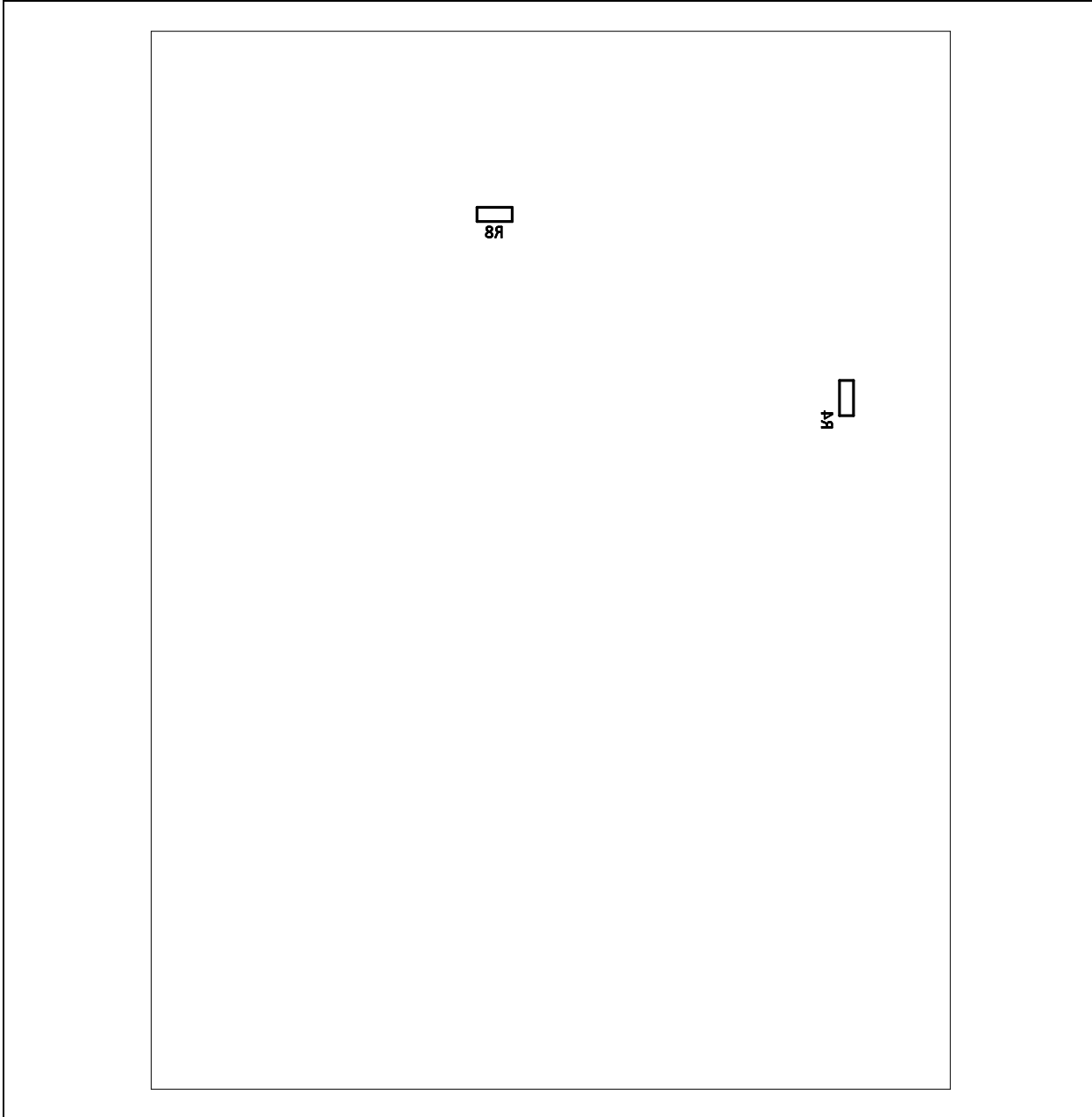
Appendix B. Bill of Materials (BOM)

TABLE B-1:   BILL OF MATERIALS (BOM)

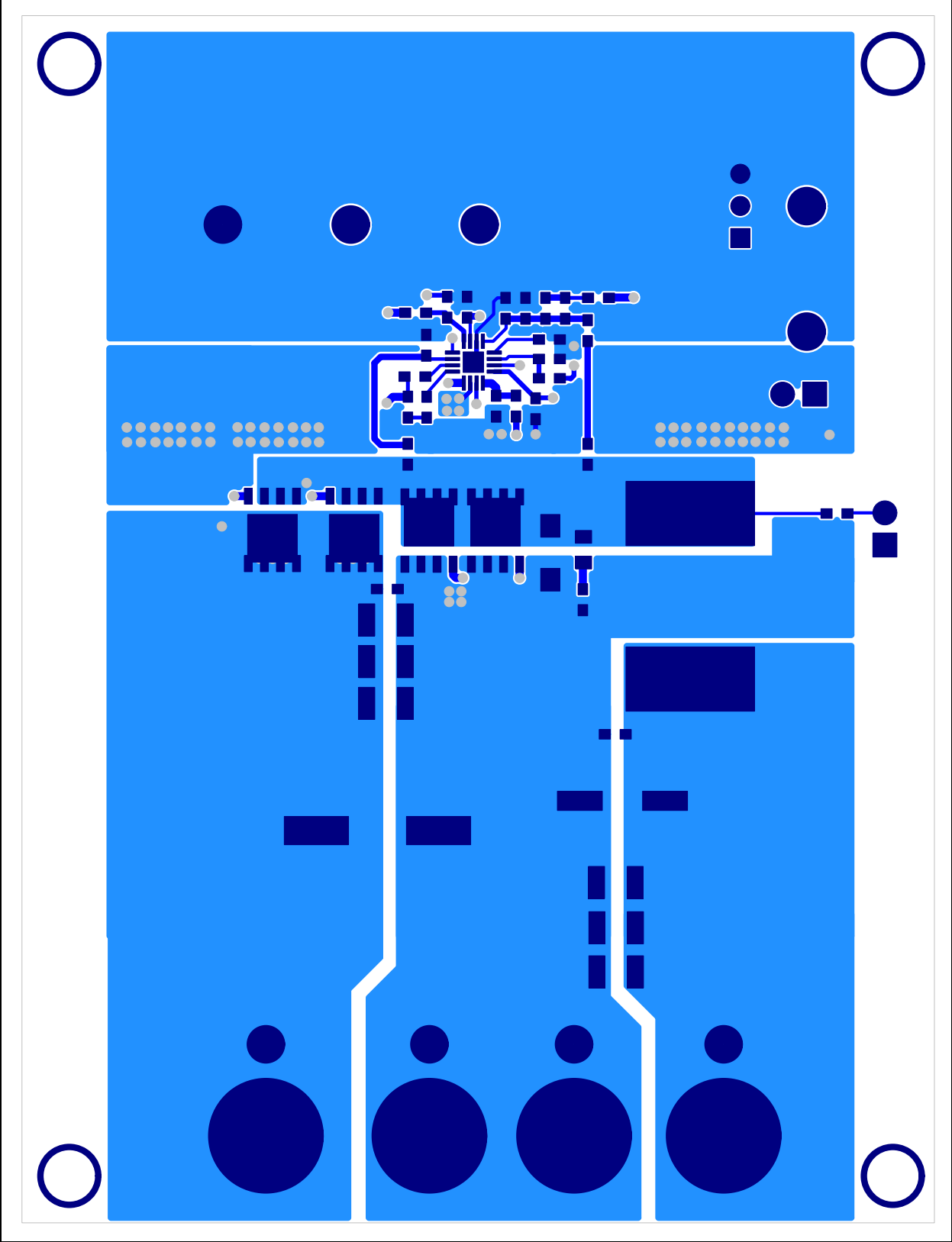| Qty.	Reference	Description	Manufacturer	Part Number
1	C1	100 µF,100V, 20%, 330 mΩ,	United Chemi-Con	EMVY101ARA101MKE0S
3	C2, C3, C4	2.2 µF, X7R, 100V, 10%	Murata Electronics®	GRM32ER72A225K
1	C5	330 µF,10V,17 mΩ,	Panasonic® - ECG	10SVP330M
1	C6	47 µF, X7R, 10V, 10%	Murata Electronics	GRM32ER71A476K
0	C7, C8	1210 mm size MLCC capacitor **DO NOT POPULATE**		
3	C9, C20, C21	0.1 µF, X7R, 100V, 10%	Murata Electronics	GRM188R72A104K
2	C10, C11	4.7 µF, X7R, 10V, 10%	Samsung Electro-Mechanics America, Inc.	CL10B475KQ8NQNC
1	C12	0.1 µF, X7R, 16V, 10%	Murata Electronics	GRM188R71C104K
1	C13	1uF, X7R, 10V, 10%	Murata Electronics	GRM188R71A105K
0	C14	0603 size capacitor **DO NOT POPULATE**		
1	C15	100 nF, 100V, 10%, X7R	Murata Electronics	GRM188R72A104K
1	C16	4.7 nF, X7R,1 6V	Murata Electronics	GRM188R71C472KA
0	C17	0603 size MLCC capacitor **DO NOT POPULATE**		
0	C18	0603 size MLCC capacitor **DO NOT POPULATE**		
1	C19	10 nF, X7R, 6.3V,1 0%	Murata Electronics	GRM188R70J103K
1	PCB	MIC2128 Evaluation Board	**Microchip Technology Inc.**	02-10568
5	R1,R4,R6,R13,R14	0 Ω, 0603 size resistor	Yageo Corporation	RC0603FR-070RL
1	R2	100K, 0603 size resistor	Yageo Corporation	RC0603FR-07100KL
1	R3	60K, 0603 size resistor	Yageo Corporation	RC0603FR-0760K4L
1	R5	10Ω, 0603 size resistor	Yageo Corporation	RC0603FR-0710RL
1	R7	1.3K, 0603 size resistor	Yageo Corporation	RC0603FR-071K3L
1	R8	10K, 0603 size resistor	Yageo Corporation	RC0603FR-0710KL
1	R9	18K, 0603 size resistor	Yageo Corporation	RC0603FR-0718KL
1	R10	7.5K, 0603 size resistor	Yageo Corporation	RC0603FR-077K5L
1	R11	1K, 0603 size resistor	Yageo Corporation	RC0603FR-071KL
	R12	49.9K, 0603 size resistor	Yageo Corporation	RC0603FR-0749R9L
0	R15	0805 size resistor **DO NOT POPULATE**		

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-2: BILL OF MATERIALS (BOM) - MECHANICAL PARTS

Qty.	Reference	Description	Manufacturer	Part Number
0	D2	100V Schottky diode, power PAK S08 (5.15 mm X 6.15 mm) **DO NOT POPULATE**		
2	JU1, JU3	2-pin Header (100 mil pitch)	TE Connectivity, Ltd.	5-146278-2
1	JU2	3-pin Header (100 mil pitch)	TE Connectivity, Ltd.	5-146282-3
9	PG, AGND, VDD, EN, EXTVDD, VIN, PGND, VOUT, PGND	Terminal double turret (through hole, noninsulated)	Keystone Electronics Corp.	1593-2
1	L1	10 µH inductor, size 13.5 mm X 12.5 mm X 6.2 mm	Bourns®, Inc.	SRP1265A-100M
2	Q1, Q4	N-Channel MOSFET, power PAK S08 (5.15 mm X 6.15 mm) **DO NOT POPULATE**		
2	Q2, Q3	100V,40A N-Channel MOSFET, power PAK S08 (5.15 mm X 6.15 mm)	Vishay Intertechnology, Inc.	SIR878ADP
4	VIN, PGND, VOUT, PGND	Noninsulated banana jack	Keystone Electronics Corp.	575-4
2	Shunt	Shunts with closed top, (100 mil pitch)	Sullins Connector Solutions	SPC02SYAN

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.

NOTES:

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