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**MCP1012 15W
Reference Design**

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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 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 “DSXXXXA”, where “XXXX” 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 MCP1012 15W Reference Design. 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 MCP1012 15W Reference Design as a development tool. The manual layout is as follows:

- **Chapter 1. “Product Overview”** – Important information about the MCP1012 15W Reference Design.
- **Chapter 2. “Installation and Operation”** – Includes instructions on how to get started with this reference design and a description of the reference design.
- **Appendix A. “Schematic and Layouts”** – Shows the schematic and layout diagrams for the MCP1012 15W Reference Design.
- **Appendix B. “Bill of Materials (BOM)”** – Lists the parts used to build the MCP1012 15W Reference Design.
- **Appendix C. “Board Performance Curves and Waveforms”** – Shows the typical performance graphs.

MCP1012 15W Reference Design

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	<i>MPLAB[®] IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> 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	<u><i>File>Save</i></u>
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	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets []	Optional arguments	mcc18 [options] <i>file</i> [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 design describes how to use the MCP1012 15W Reference Design. Another useful document is the Microchip document listed below, which is available and recommended as a supplemental reference resource.

- **MCP1012 Data Sheet - “Primary-Side Start-up IC for Isolated Converters” (DS20006277)**

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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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- 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 website at:

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

DOCUMENT REVISION HISTORY

Revision A (December 2020)

- Initial release of this document.

MCP1012 15W Reference Design

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP1012 Reference Design and covers the following topics:

- [MCP1012 Device Overview](#)
- [MCP1012 Device Key Features](#)
- [What Does the MCP1012 15W Reference Design Kit Include?](#)

1.2 MCP1012 DEVICE OVERVIEW

The MCP1012 15W Reference Design provides a hardware and software platform to evaluate a novel method of isolated secondary side control. Two key components enable the startup and secondary side regulation of an isolated power supply, the Microchip MCP1012 and the Microchip patented integrated magnetic winding transformer built by Würth Electronic. The MCP1012, when connected directly to the AC mains, provides a controlled startup power transfer to the secondary side. Once the secondary side is powered, the Microchip MCU SAMD is used as the system controller for voltage regulation, load switching, dynamic output voltage, dynamic current limit and driving a graphical user interface for monitoring as well as control of the intelligent power supply. Additional MCP1012 features provide system protection from overcurrent and overvoltage conditions in addition to a proprietary sleep mode for ultra-low power in standby. This reference design can be used as a platform to develop USB, IoT or other power system applications that need advanced features.

The primary function of the MCP1012 is to provide the startup of the flyback converter using an internal open-loop peak current-mode current regulator. The MCP1012 becomes a purely primary side gate driver by accepting PWM commands via an isolation medium (such as a pulse transformer or a digital optocoupler) from a secondary-side controller. It integrates various protection features, including an undervoltage lockout (UVLO) and overvoltage lockout (OVLO) protection for its bias supply, and overtemperature protection (OTP). Additionally, the MCP1012 provides peak cycle-by-cycle current limiting both when under control of its internal current regulator or under control of the secondary-side controller.

Note 1: The firmware and GUI features mentioned in this document may not be the current versions. Updates are available. Please check the Reference Design webpage for the latest versions.

1.3 MCP1012 DEVICE KEY FEATURES

The MCP1012 Device offers the following key features:

- **High Voltage (HV) Startup Capability** (500V Continuous, 700V Transient with series 10K Resistor)
- **Internal Open-Loop**, Peak Current-Mode (PCM) Current Regulator for Start-up (Few External Components) w/Integrated Robust Gate Driver
- **Current Regulator** (Constant Off Time, 21 μ s typical)
- **Protection** against Continuous Conduction Mode (CCM) of Operation

MCP1012 15W Reference Design

- **Programmable Low-Frequency Oscillator (LFO)** Period to Set Startup Power
- **Able to Accept External PWM Commands** from a Secondary Side Controller via Isolator
- **Undervoltage Lockout (UVLO)** and **Overvoltage Lockout (OVLO)** VDD Protections, **Cycle-by-Cycle Current Limiting**, **Overtemperature Protection** (Thermal Shutdown)
- **Sleep and Wake-up Commands**, with Low Standby Power (<15 mW)

1.4 WHAT DOES THE MCP1012 15W REFERENCE DESIGN KIT INCLUDE?

This MCP1012 Reference Design Kit includes:

- MCP1012 15W Reference Design
- MCP1012 15W User's Guide
- Important Information Sheet

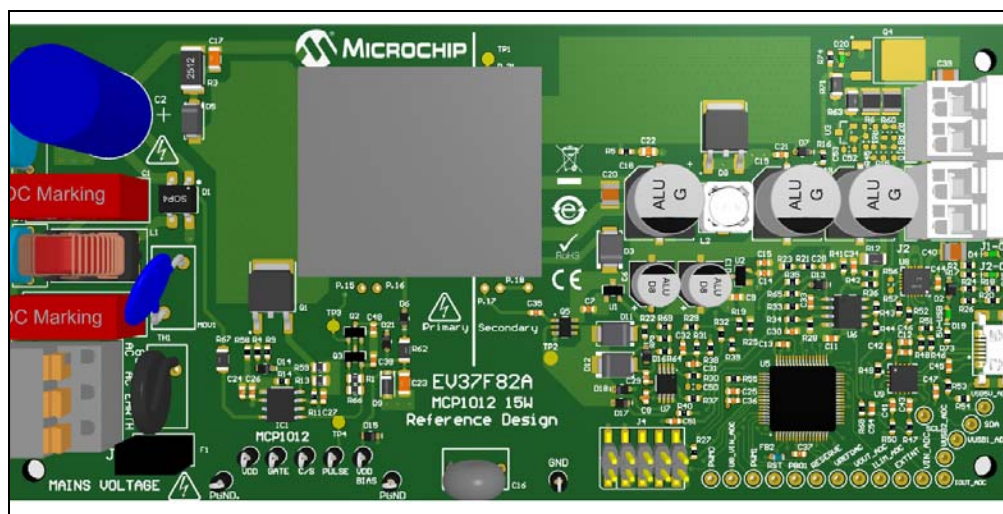


FIGURE 1-1: MCP1012 Reference Design.

Chapter 2. Installation and Operation

2.1 GETTING STARTED

The MCP1012 15W Reference Design is fully assembled and tested, and ready for evaluation and demonstration of the MCP1012 controller. The board's flyback topology is capable of delivering a galvanically isolated output voltage between 3.3V and 5.3V, and a maximum current of 3A. The Graphic User Interface (GUI) developed for the application uses a USB connection between the board and PC, and allows the user to read and control the functional parameters of the board, starting with output voltage, switching frequency and output current limit.

The EV37F82A board features the use of an Inde-Flux™ Integrated Magnetic feedback solution as galvanic isolation barrier between the primary and secondary side of the main transformer. The Inde-Flux Integrated Magnetic is patented and has been licensed to Würth Elektronik, who provide the transformer (and other components) for EV37F82A.

The Integrated Magnetic replaces the need for a separate Isolator (magnetic, capacitive or optical) in order to transmit PWM commands from the secondary to the primary.

The Integrated Magnetic is designed to have two independent flux paths:

- A power flux path using power windings on the center leg of an E-Core
- A signal flux path using signal windings on the outer legs of an E-Core.

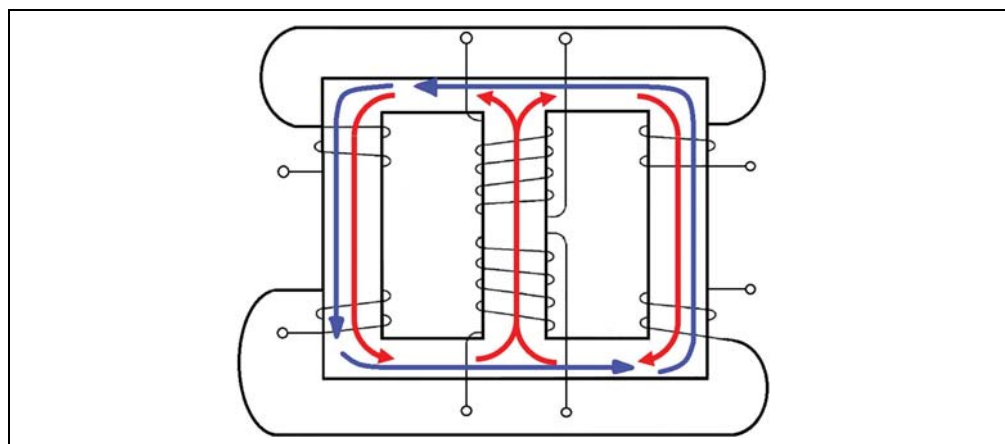


FIGURE 2-1: Integrated Transformer Flux Path - Power Flux in Red, Signal Flux in Blue.

2.1.1 Powering the MCP1012 15W Reference Design

The board can be powered from an 85-265 VAC. A variable AC power supply is needed for testing and evaluation in the laboratory. The power supply requires an output capability of at least 1A and a voltage range of 85 to 265 VAC. This can be obtained from an autotransformer supplied from the mains or an electronic AC/AC power supply.

MCP1012 15W Reference Design

Note: For faster start-up of the power supply (in low input voltage, around 85 VAC), two ballast resistors (RBD and RBE, see [A.2 “EV37F82A Board – Schematic Page 1”](#)) are recommended. This will provide a better opening for the auxiliary windings T1E and T1D. The VDD Bias circuit for MCP1012 is provided by T1D.

The output voltage of the flyback converter can be set using the GUI between 3.3V and 5.3V. This output is routed to the UCS2113, which provides two output paths to external loads. The flyback converter's output is rated for 3A, but the GUI can set its current limit lower. The GUI is used to set the current limits of the two channels of the UCS2113 such that the sum total does not exceed the current limit setting of the flyback converter.

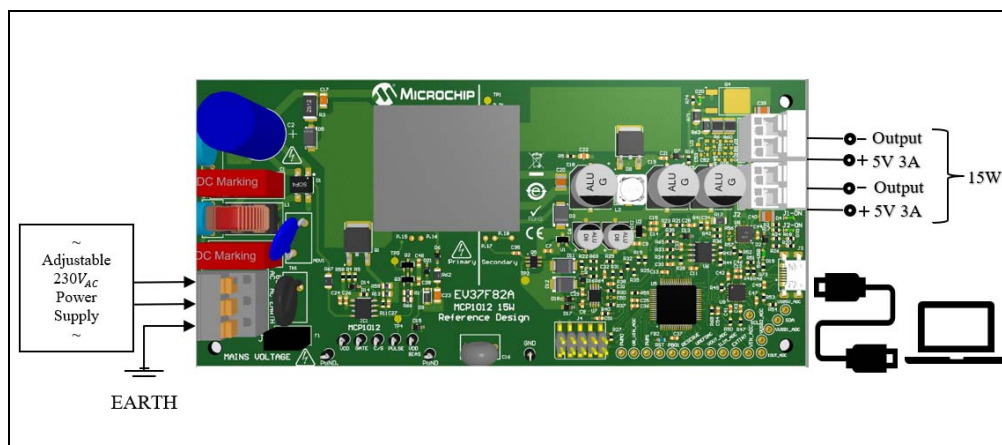


FIGURE 2-2: EV37F82A Board - Connection Diagram.

2.2 SETUP/CONFIGURATION

The MCP1012 15W Reference Design functions in either External Controller Mode, when control is made by means of a USB connection using a laptop with running GUI, or Standalone Mode, when the board runs without external connection to a laptop. The SAMD20 reads the USB5V_ADC pin to determine which mode to enter.

When the SAMD20 detects 5V provided through the USB connector, it lights the green LED D20, enters External Controller Mode and waits to receive command from the GUI to apply load using UCS2113. The GUI displays a "Connection Status: Connected" message in the bottom left of the window. Accessing External Controller Mode can be done using the two corresponding Turn ON/OFF buttons from the two ports, Port1 and Port2 respectively. The GUI is ready to deliver data about the board, for example, the Input Voltage, Output Voltage and the Output Current.

Referring to Figure 2-3, the GUI's "Flyback Converter" tab allows access to the following:

- Displays
 - Output Voltage
 - Flyback Converter Output Current
 - The AC input voltage to the Flyback Converter
 - The status of the flyback converter's current error amplifier
 - The status of the pre-load circuit (in development)
 - GUI connection status
- Selections
 - Flyback converter output voltage
 - Flyback converter switching frequency

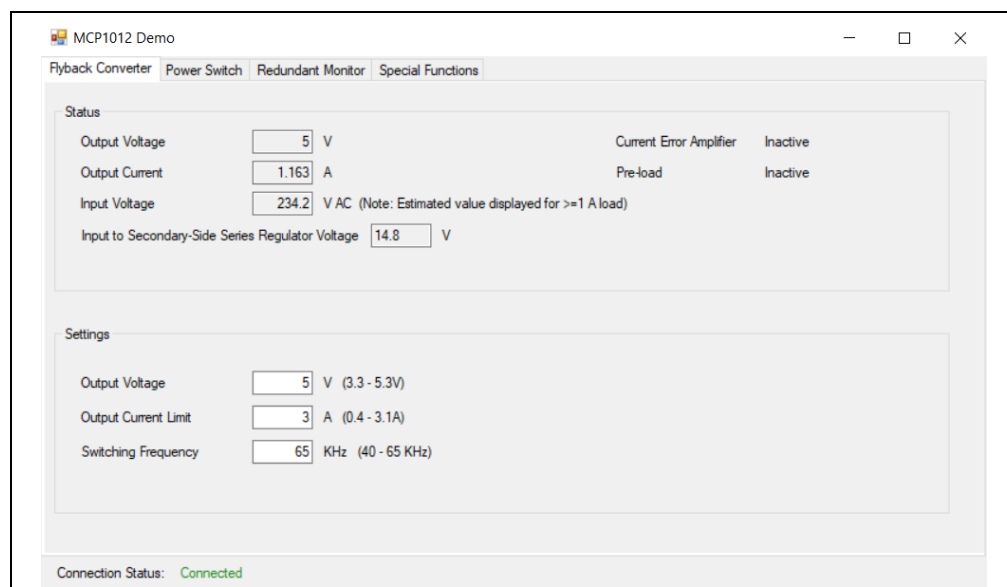


FIGURE 2-3: GUI Flyback Converter Tab.

Figure 2-4, the GUI's "Power Switch" tab allows access to the following:

- Displays
 - Status of the thermal protection from UCS load switch
 - Status of input UV
 - Port 1 and Port 2
 - Output voltage
 - Output current

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- Alert status
- OC status
- Discharge Error Status
- Back-Bias Voltage Status
- Selections
 - Enable Latch Error State
 - Enable Automatic Output Discharge
 - Port 1 and Port 2
 - ON/OFF
 - Current Limit
 - Enable Charge Rationing"

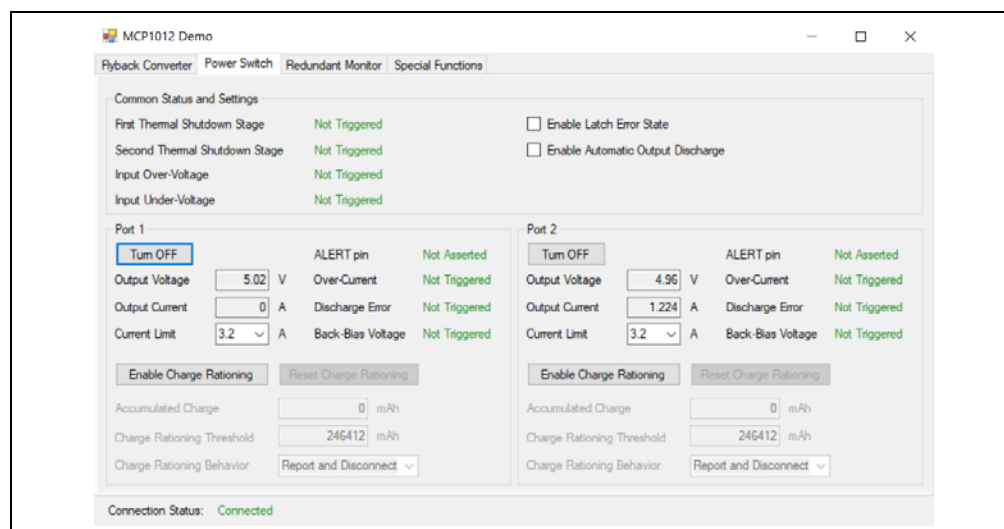


FIGURE 2-4: GUI Power Switch Tab.



FIGURE 2-5: GUI Special Functions Tab.

Figure 2-5, the GUI's "Special Functions" tab allows access to the following:

- Displays
 - Fault Status
 - Input UVLO
 - Output UVLO
 - Output OVLO
 - Output OC Status
 - Mode of Operation Status
- Selections
 - Lock-out Voltage Settings
 - Mode of Operation

When the board is in EXTERNAL mode, controlled by the GUI, the board can go in Standby mode by applying this condition in the Special Functions tab. In this mode the board enters in Sleep mode, which means the load is disconnected from the power supply and the MCP1012 receives the sleep command from the secondary side controller. In this mode the power consumption decreases to a minimum because the load and preload circuits from the board are disconnected during the specific interval of voltages range for MCP1012 VDD pin, which is necessary for the MCP1012 to receive commands even in this mode. When the MCP1012 reaches undervoltage, the secondary side controller initiates a wake-up command and MCP1012 starts up the 16 pulses sequence to increase the secondary side voltage into a normal interval so that if the standby mode is still active, then the secondary side controller issues another sleep command. This sequence will repeat until standby mode is deactivated by the GUI.

When the secondary side controller, SAMD20, is not detecting 5V provided through the USB connector it enters in the Standalone Mode, where it is checking to see if all voltage and currents are within defined parameters and after that it applies load using UCS2113.

After the board is supplied with a voltage in the range of 85 - 265 VAC the initial states of the two outputs are OFF. When one output is turned on, the corresponding green LED,(D4 or D10), on the board will signal that the output is on.

2.2.1 Fault Modes

There are three fault conditions that can cause the Secondary-Side Controller to enter FAULT MODE:

- Output Overvoltage (OV)
- Output Undervoltage (UV)
- Output Overcurrent (OC)

In all three cases, a fault will cause the Flyback Converter to 'hiccup'. 'Hiccup' is defined as returning to the MCP1012 start-up and attempting to re-enter normal run. Fault mode is defined as setting a 'flag' to indicate that a 'hiccup' has occurred. If the fault persists, the Flyback Converter will re-enter normal run and the fault will again cause a 'hiccup' and the 'flag' will remain. If the fault clears, then the Flyback Converter will re-enter and remain in normal run (closed loop) and after a period, the 'flag' is reset. The secondary side controller shall be able to identify if it is OV, UV, or OC that is causing the fault. The Fault conditions are identified by the GUI for each output port in the Power Switch tab and for whole power supply in the Special Functions tab.

MCP1012 15W Reference Design

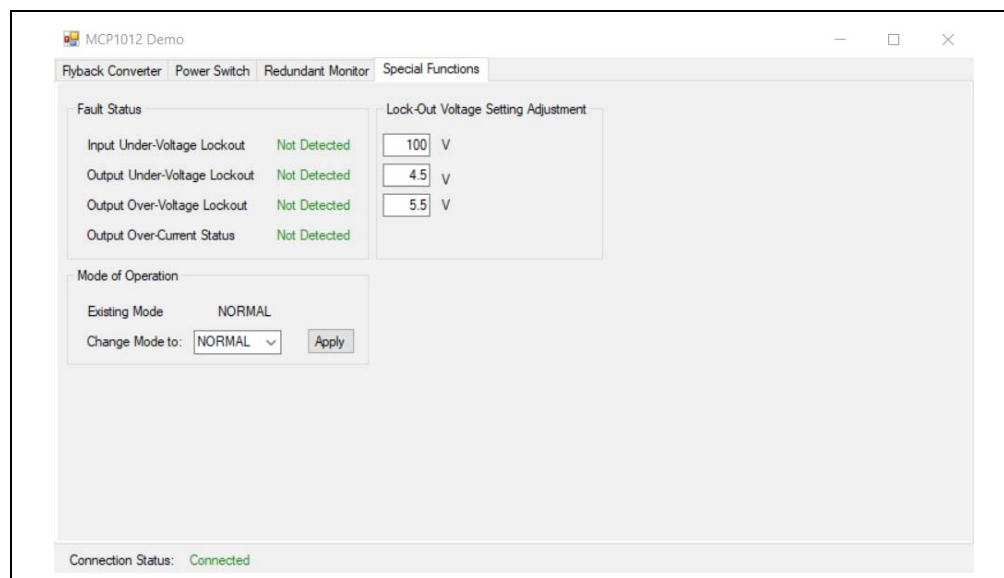


FIGURE 2-6: GUI Redundant Monitor Tab.

The GUI's "Redundant Monitor" tab is shown in Figure 2-6. Key voltage and current measurements are made using the ADC of the MCP2221A and provide redundancy to similar measurements made by the secondary-side controller. The GUI provides a "10% mismatch Alert" when comparing the two measurements of a similar key parameter.

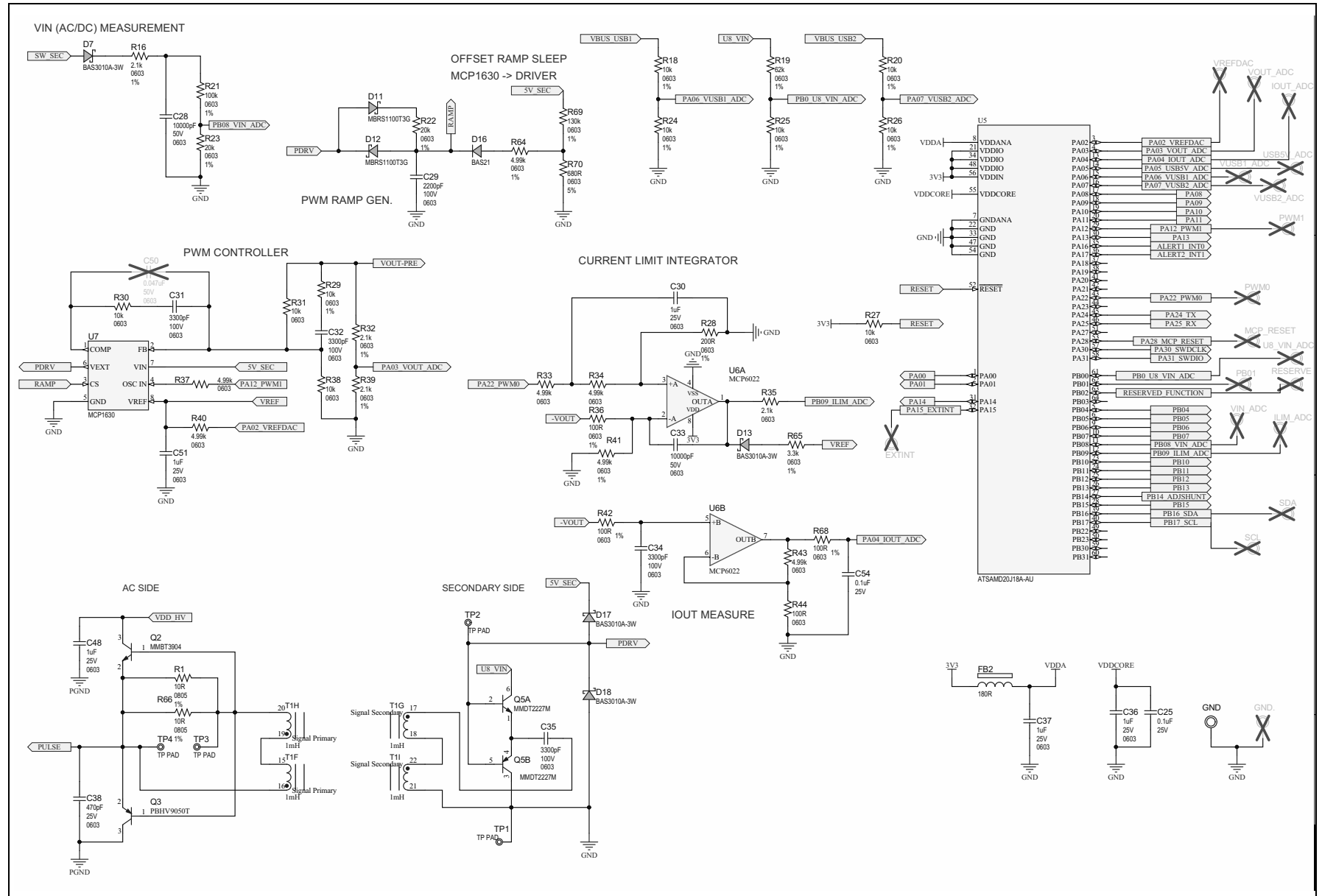
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

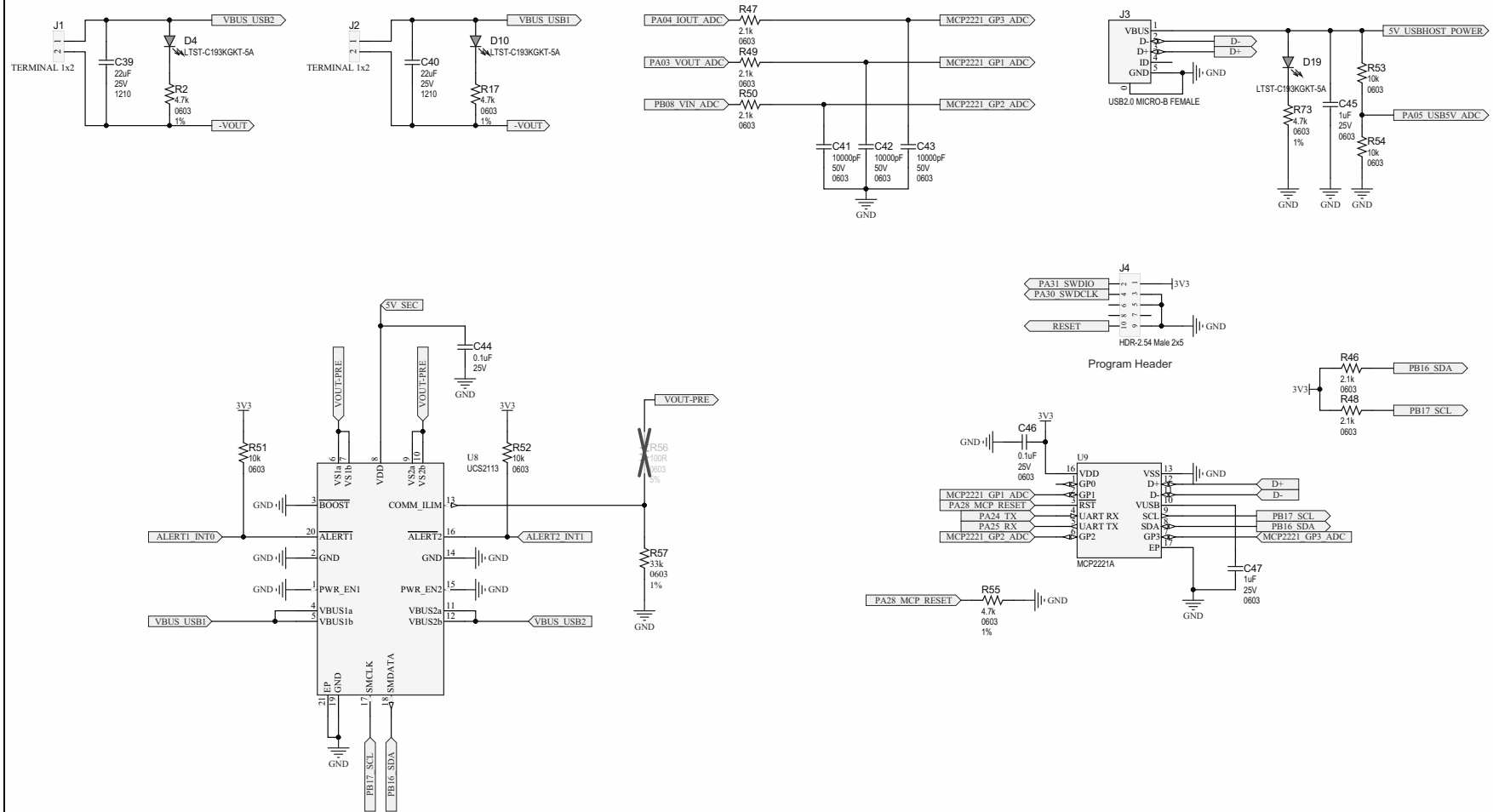
This appendix contains the following schematic and layouts for the MCP1012:

- [EV37F82A Board – Schematic Page 1](#)
- [EV37F82A Board – Schematic Page 2](#)
- [EV37F82A Board – Schematic Page 3](#)
- [EV37F82A Board – Top Silk](#)
- [EV37F82A Board – Top Copper and Silk](#)
- [EV37F82A Board – Top Copper](#)
- [EV37F82A Board – Bottom Silk](#)
- [EV37F82A Board – Bottom Copper and Silk](#)
- [EV37F82A Board - Bottom Copper](#)

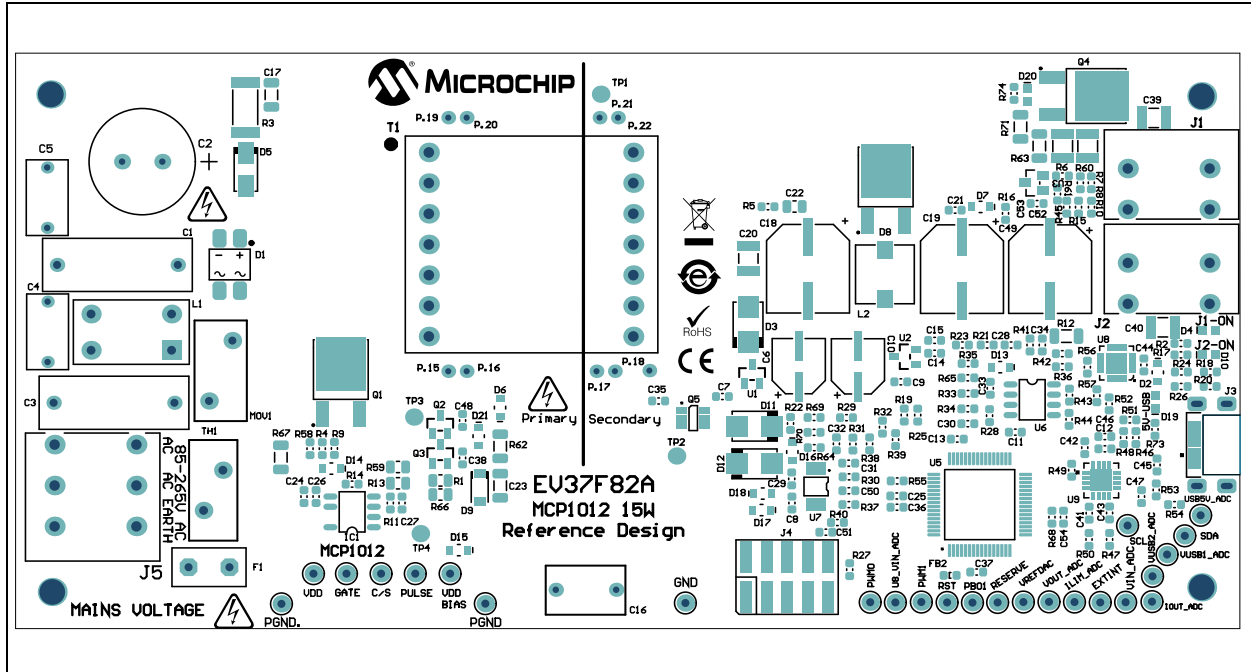
A.3 EV37F82A BOARD – SCHEMATIC PAGE 2



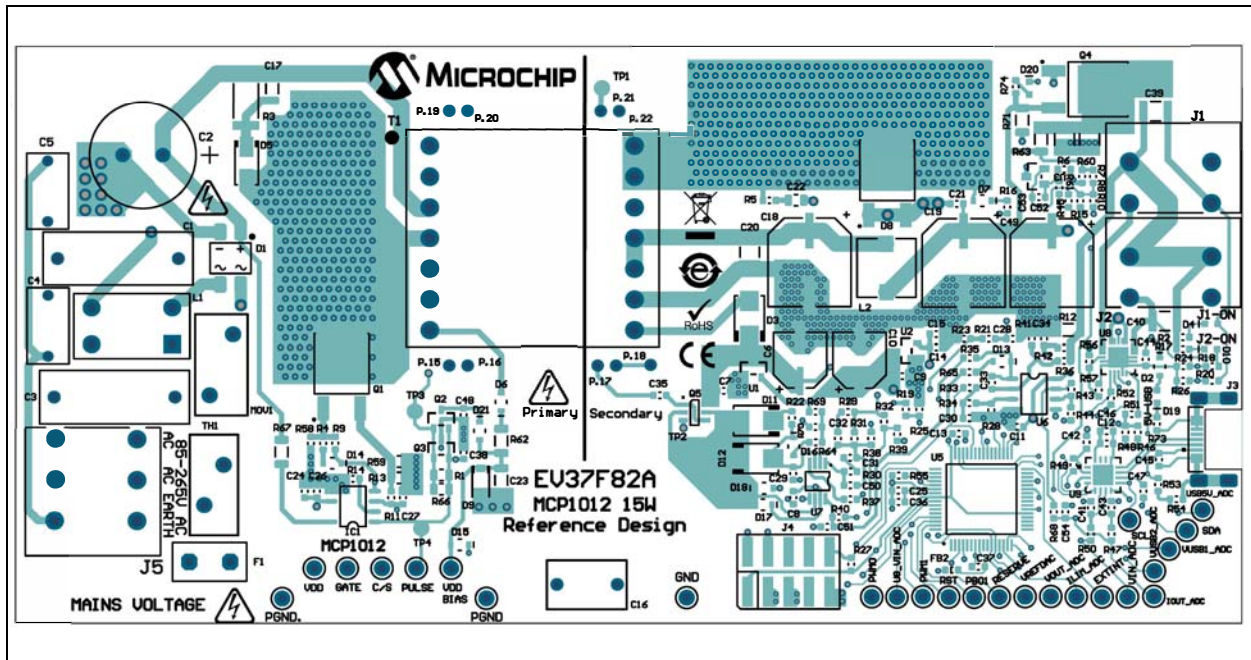
A.4 EV37F82A BOARD – SCHEMATIC PAGE 3



A.5 EV37F82A BOARD – TOP SILK

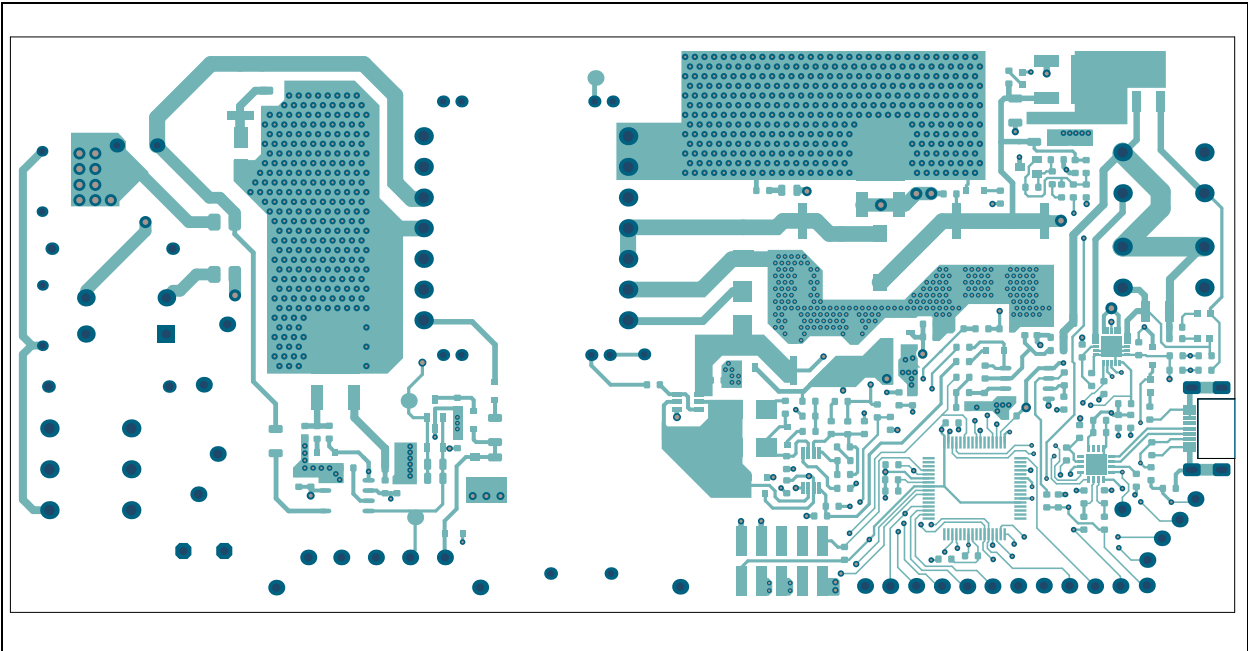


A.6 EV37F82A BOARD – TOP COPPER AND SILK

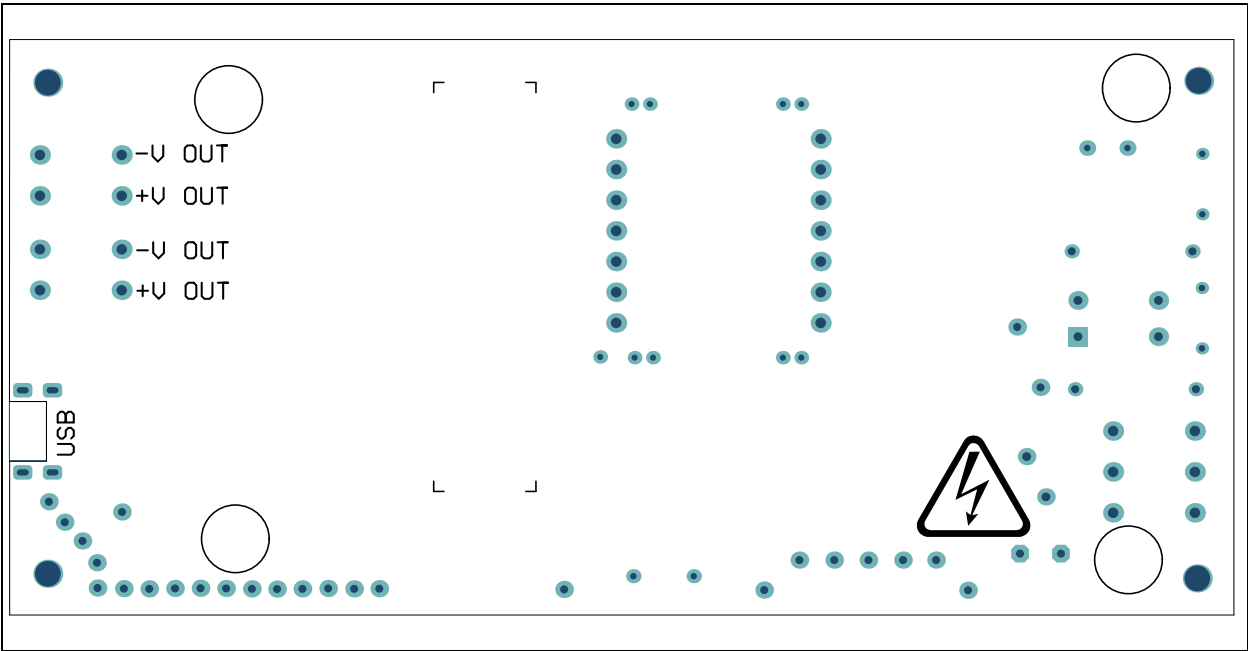


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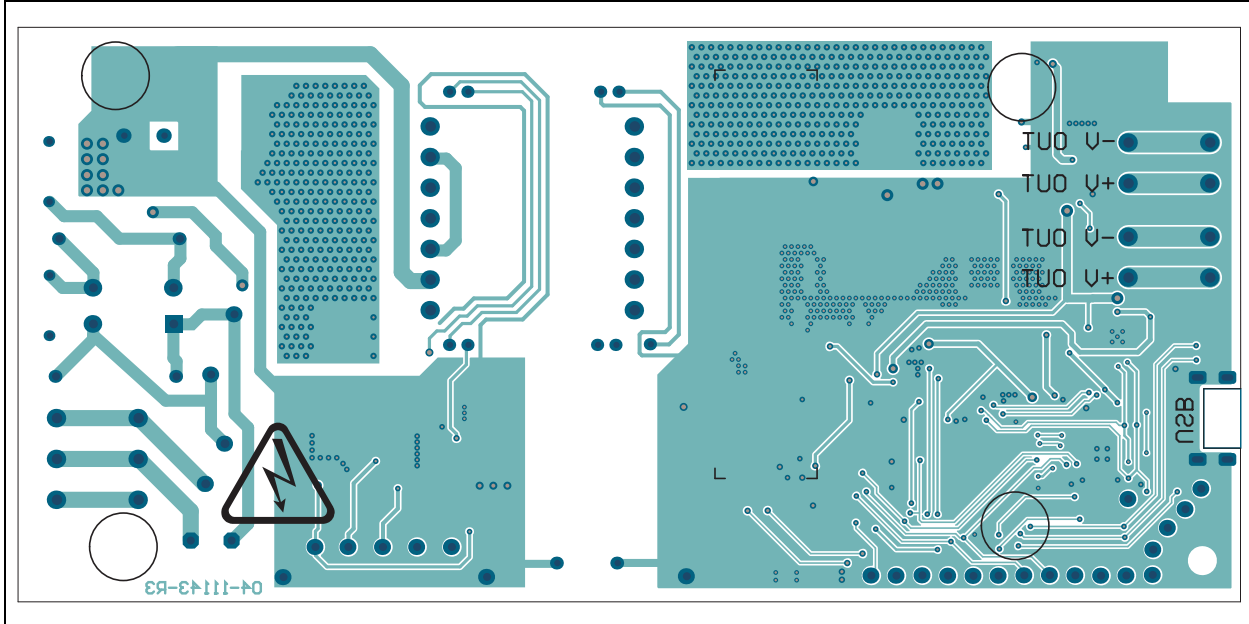
A.7 EV37F82A BOARD – TOP COPPER



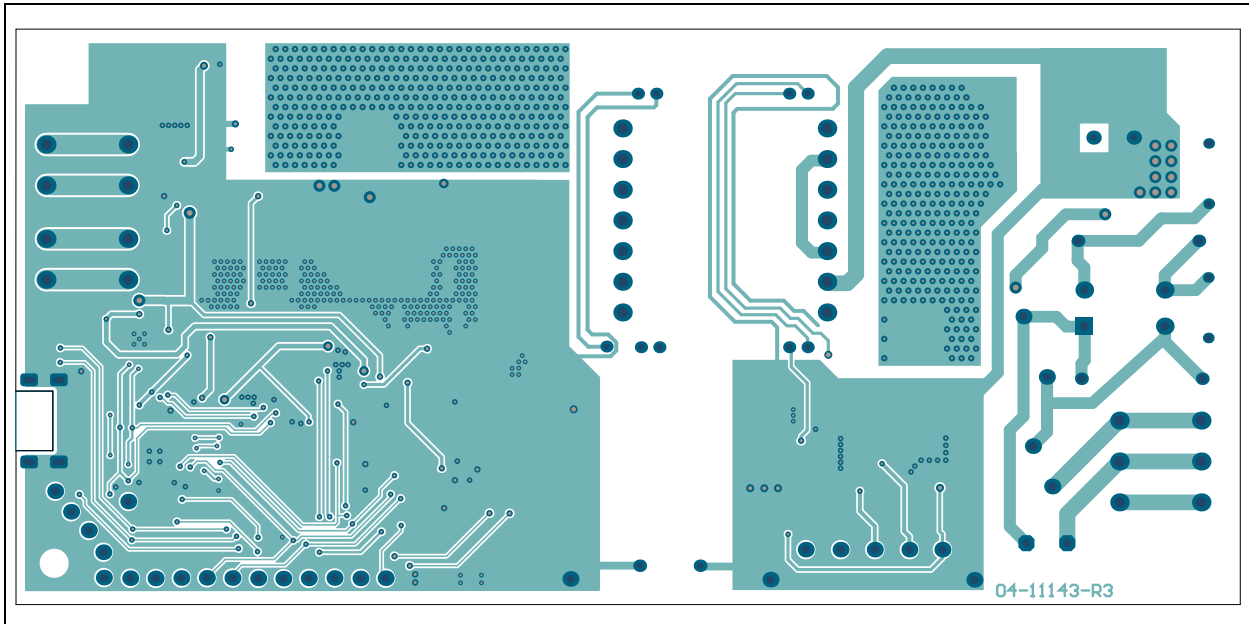
A.8 EV37F82A BOARD – BOTTOM SILK



A.9 EV37F82A BOARD – BOTTOM COPPER AND SILK



A.10 EV37F82A BOARD - BOTTOM COPPER



MCP1012 15W Reference Design

NOTES:

Appendix B. Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)⁽¹⁾

Qty.	Reference	Description	Manufacturer	Part Number
2	C1, C3	Capacitor, film, 0.1 μ F, 310 VAC, 20%, RAD, P15L18W6H12	Wurth Elektronik	890334025017CS
1	C2	Capacitor, aluminum, 22 μ F, 400V, 20%, RAD, P5D13H20	Wurth Elektronik	860241378003
2	C4, C5	Capacitor, ceramic, 2200 pF, 300V, 20%, RAD, P7.5D8H11	Murata	DE2E3KY222MN3AU02F
2	C6, C10	Capacitor, aluminum 150 μ F, 16V, 20%, SMD, D8	Panasonic®	EEE-FPC151XAP
15	C7, C8, C9, C11, C12, C13, C14, C15, C30, C36, C37, C45, C47, C48, C51	Capacitor, ceramic, 1 μ F, 25V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206076
1	C16	Capacitor, film, 2200 pF, 20%, 440 VAC, RADIAL DISC	Vishay Beyschlag	VY2222M35Y5US63V7
1	C17	Capacitor, ceramic, 1000 pF, 250V, 5%, NPO, SMD, 1206	KEMET	C1206C102KAGECAUTO
3	C18, C19, C49	Capacitor, aluminum 1000 μ F, 10V, 20%, SMD, G	Wurth Elektronik	865080257014
3	C20, C39, C40	Capacitor, ceramic, 22 μ F, 25V, 10%, X5R, SMD, 1210	Wurth Elektronik	885012109014
6	C21, C24, C25, C44, C46, C54	Capacitor, ceramic, 0.1 μ F, 25V, 10%, X7R, SMD, 0603	TDK	C1608X7R1E104K
1	C22	Capacitor, ceramic, 1000 pF, 50V, 10%, NPO, SMD, 0805	Wurth Elektronik	885012007063
1	C23	Capacitor, ceramic, 10 μ F, 25V, 20%, X7R, SMD, 1206	Wurth Elektronik	885012208069
1	C26	Capacitor, ceramic, 1 μ F, 25V, 10%, X7R, SMD, 0603	TDK	CGA3E1X7R1E105K080AC
1	C27	Capacitor, ceramic, 100 pF, 100V, 5%, SMD, 0603	Wurth Elektronik	885012006079
5	C28, C33, C41, C42, C43	Capacitor, ceramic, 10000 pF, 50V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206089
1	C29	Capacitor, ceramic, 2200 pF, 100V, 10%, X7R, SMD, 0603	TDK	C1608X7R2A222K080AA
4	C31, C32, C34, C35	Capacitor, ceramic, 3300 μ F, 100V, 10%, X7R, SMD, 0603	Wurth Elektronik	885012206111
1	C38	Capacitor, ceramic, 470 pF, 25V, 5%, NPO, SMD, 0603	Wurth Elektronik	885012006042

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.

MCP1012 15W Reference Design

TABLE B-1: BILL OF MATERIALS (BOM)⁽¹⁾ (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
9	C/S, GATE, GND, PGND, PGND., PULSE, VDD, VDD BIAS	Miscellaneous, Test Point, Multipurpose, Mini, Black	Keystone® Electronics Corp.	5001
1	D1	Diode, rectifier, BRG, MB6S, 1V, 0.5A, 600V, SMD, SOIC-4	ON Semiconductor/ Fairchild	MB6S
6	D2, D6, D14, D15, D16, D21	Diode, rectifier BAS21, 1.25V, 250 mA, 200V, SOD-323	Infineon Technologies AG	BAS21-03WE6327
1	D3	Diode, Schottky, 10BQ100, 780 mV, 1A, 100V, DO-214AA_SMB	Vishay Semiconductor Diodes Division	10BQ100TRPBF
4	D4, D10, D19, D20	Diode, LED, Green, 2V, 5 mA, Clear, SMD, 0603	Vishay/Lite-On	LTST-C193KGKT-5A
1	D5	Diode, rectifier, ES1J, 1.7V, 1A, 600V, SMD, DO-214AC_SMA	ON Semiconductor/ Fairchild	ES1J
4	D7, D13, D17, D18	Diode, Schottky, BAS3010A-3W, 470 mV, 1A, 30V, SOD-323	Infineon Technologies AG	BAS3010A-03WE6327
1	D8	Diode, Schottky, Array, MBRD20150CT-13, 0.9V, 2x10A, 150V, SMD, TO-252-3	Diodes Incorporated®	MBRD20150CT-13
1	D9	Diode, Zener, SZMMSZ16T1G, 16V, 500 mW, AEC-Q101, SMD, SOD-123	ON Semiconductor	SZMMSZ16T1G
2	D11, D12	Diode, Schottky, 100V, 1A, SMB	ON Semiconductor	MBRS1100T3G
1	F1	Mechanical, HW, FUSE, 3.15A, 250V, Slow, RST, Radial, P5.08L8.35W4H7.	Bel Fuse Inc.	RST 3.15-BULK
1	FB2	Ferrite, 180R, 1.5A, SMD, 0603	Würth Elektronik	742792624
1	J1, J2	Connector, terminal, 5.08mm 1x2, Female, 16-22AWG, 12A, TH R/A	On-Shore Technology, Inc.	OSTHD020080
1	J3	Connector, USB2.0, Micro-B, Female, SMD, R/A, Mid-mount	Amphenol ICC (FCI)	10103593-0001LF
6	J4	Connector, HDR-2.54, Male 2x5, Tin 6.10 MH, TH, vertical	Samtec, Inc.	TSM-105-01-T-DV
	J5	Connector, Terminal, 5.08mm, 1x3 Female, 16-22AWG, 10A, TH, R/A	Würth Elektronik	691415520003
1	L1	Inductor, Dual, 4 mH, 1.5A, 30%, TH L15.8W7.8H18	Würth Elektronik	744821240
1	L2	Inductor, 15 µH, 2.2A, 15%, SMD, 7.3x7.3x4.5	Würth Elektronik	7447779115
1	MOV1	Resistor, Varistor, MO, 420V, 45J Disc, 10mm	TDK Electronics	B72210S0421K101
1	Q1	Transistor, FET, N-Channel, FCD900N60Z, 600V, 4.5A, 0.9R, 52W, TO-252-3	ON Semiconductor/ Fairchild	FCD900N60Z
1	Q2	Transistor, BJT, NPN, MMBT3904, 40V, 200 mA, 310 mW, SOT-23-3	Micro Commercial Components (MCC)	MMBT3904-TP

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.

Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)⁽¹⁾ (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
1	Q3	Transistor, BJT, PNP, PBHV9050T,215, -500V, -150 mA, 300 mW, SOT-23-3	Nexperia USA Inc	PBHV9050T,215
1	Q5	Transistor, BJT Dual, NPN+PNP MMDT2227M, 40V, -60V, 0.6A -0.6A, 0.3W, SOT-23-6	Diodes Incorporated	MMDT2227M-7
2	R1, R66	Resistor, TKF, 10R, 1%, 1/8W, SMD, 0805	Vishay Dale	CRCW080510R0FKEAC
5	R2, R17, R55, R73, R74	Resistor, TKF, 4.7k, 1%, 1/16W, SMD, 0603	Multicomp Inc.	MC0063W060314K7
1	R3	Resistor, TKF, 47K, 5%, 1W, SMD, 2512	Panasonic	ERJ-1TYJ473U
1	R4	Resistor, TKF, 1R, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3RQF1R0V
1	R5	Resistor, TKF, 10R, 5%, 1/10W, SMD, 0603	KOA Speer Electronics, Inc.	RK73B1JTDD100J
2	R6, R60	Resistor, TF, 43R, 5%, 1/2W, 1210	Panasonic	ERJ-14YJ430U
1	R9	Resistor, TKF, 3.3R, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3RQF3R3V
1	R11	Resistor, TKF, 100R, 5%, 1/10W, SMD, 0603	Vishay Dale	CRCW0603100RJNEA
1	R12	Resistor, SHUNT, MF, 0.01R, 1%, 1W, SMD, 1206	Bourns®, Inc.	CRF1206-FX-R010ELF
2	R13, R59	Resistor, TF, 0.5R, 1%, 1/3W, SMD, 0805	Susumu Co., LTD.	RL1220S-R50-F
1	R14	Resistor, TKF, 270k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-07270KL
9	R16, R32, R35, R39, R46, R47, R48, R49, R50	Resistor, TKF, 2.1k, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3EKF2101V
16	R18, R20, R24, R25, R26, R27, R29, R30, R31, R38, R51, R52, R53, R54, R58, R61	Resistor, TF, 10k, 1%, 1/8W, SMD, 0603	Vishay Beyschlag	MCT06030C1002FP500
1	R19	Resistor, TKF, 62k, 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT62K0
1	R21	Resistor, TF, 100k, 1%, 1/8W, SMD, 0603	Vishay Beyschlag	MCT06030C1003FP500
2	R22, R23	Resistor, TKF, 20k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0720KL
1	R28	Resistor, TKF, 200R, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3EKF2000V
7	R33, R34, R37, R40, R41, R43, R64	Resistor, TKF, 4.99k, 1%, 1/10W, SMD, 0603	NIC Components Corp.	NRC06F4991TRF
4	R36, R42, R44, R68	Resistor, TKF, 100R, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-07100RL

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.

MCP1012 15W Reference Design

TABLE B-1: BILL OF MATERIALS (BOM)⁽¹⁾ (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
1	R57	Resistor, TKF, 33k, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3EKF3302V
1	R62	Resistor, TKF, 62R, 1%, 1/4W, SMD, 1206, AEC-Q200	Panasonic	ERJ-8ENF62R0V
1	R63	Resistor, TKF, 0R, SMD, 1206, AEC-Q200	Panasonic	ERJ-8GEY0R00V
1	R65	Resistor, TKF, 3.3k 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT3K30
1	R67	Resistor, TKF, 10k, 5%, 1/3W, SMD, 1206	Riedon®	PCR1206-10KJ1
1	R69	Resistor, TKF, 130k, 1%, 1/10W, SMD, 0603, AEC-Q200	Panasonic	ERJ-3EKF1303V
1	R70	Resistor, TKF, 680R, 5%, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603JT680R
1	R71	Resistor, TKF, 200R, 1%, 1/4W, SMD, 1206	Vishay Dale	CRCW1206200RFKEA
1	T1	Transformer, SMPS, Custom, Flyback	Würth Elektronik	750318659
1	TH1	Resistor, Thermistor, NTC, 4.7 Ohms, 3A, Radial	TDK Electronics	B57153S479M
Microchip Parts				
1	IC1	IC, MCP1012, SOIC-8	Microchip Technology Inc.	MCP1012-V/EKA
1	U1	Microchip, Analog, LDO, 5V, MCP1703T-5002E/CB, SOT-23-3	Microchip Technology Inc.	MCP1703T-5002E/CB
1	U2	Microchip, Analog, LDO, 3.3V, MCP1703T-5002E/CB, SOT-23-3	Microchip Technology Inc.	MCP1703AT-3302E/CB
1	U5	Microchip, MCU, 32-BIT, 48 MHz, 256kB, 32kB, ATSAMD20J18A-AU, TQFP-64	Microchip Technology Inc.	ATSAMD20J18A-AU
1	U6	Microchip, Analog, op amp, 2-Channel, 10 MHz, MCP6022-E/SN SOIC-8	Microchip Technology Inc.	MCP6022-E/SN
1	U7	Microchip, Analog, PWM Controller, 1 MHz, MCP1630V-E/MS, MSOP-8	Microchip Technology Inc.	MCP1630VT-E/MS
1	U8	Microchip, Interface, USB Power Controller, UCS2113-1-V/G4, QFN-20	Microchip Technology Inc.	UCS2113-1-V/G4
1	U9	Microchip, Interface, USB, I2C/UART, MCP2221A-I/ML, QFN-16	Microchip Technology Inc.	MCP2221A-I/ML
Mechanical Parts (to be added in the package)				
4	PAD1, PAD2, PAD3, PAD4	Mechanical, HW, Rubber Pad, Cylindrical Flat Top, D8H2.8, Black	3M	SJ5076BLACK
PCB				
1	PCB1	Printed Circuit Board	Microchip Technology Inc.	04-11143-R3
Do Not Populate				
0	C50	Capacitor, ceramic, 0.047 µF, 50V, 10%, X7R, SMD, 0603	TDK Multilayer Ceramic Capacitors MLCC	C1608X7R1H473K080AA

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.

Bill of Materials (BOM)

TABLE B-1: BILL OF MATERIALS (BOM)⁽¹⁾ (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
0	C52	Capacitor, ceramic, 330 pF, 50V, 5%, C0G, SMD, 0603	KEMET	C0603C331J5GACTU
0	C53	Capacitor, ceramic, 1000 pF, 50V, 20%, X7R, SMD, 0603	TDK Multilayer Ceramic Capacitors MLCC	C1608X7R2A102K080AA
0	EXTINT, GND., ILIM_ADC, IOUT_ADC, MCP_RESET, PB01, PWM0, PWM1, RESERVE, SCL, SDA, U8_VIN_ADC, USB5V_ADC, VIN_ADC, VOUT_ADC, VREFDAC, VUSB1_ADC, VUSB2_ADC	Miscellaneous, Test Point, Multipurpose, Mini, Black	Keystone Electronics Corp.	5001
0	Q4	Transistor, BJT, PNP, MJD45H11TM, -80V, 8A, 20W TO-252-3	ON Semiconductor/ Fairchild	MJD45H11TM
0	R7	Resistor, TKF, 2.32k, 1%, 1/10W, SMD, 0603	Panasonic	ERJ-3EKF2321V
0	R8	Resistor, TKF, 1k, 1%, 1/16W, SMD, 0603	Multicomp Inc.	MC0063W060311K
0	R10	Resistor, TKF, 2.55k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-072K55L
0	R15	Resistor, TKF, 12k, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0712KL
0	R45	Resistor, TKF, 1k, 1%, 1/10W, AEC-Q200, SMD, 0603	Panasonic	ERJ3EKF1001V
0	R56, R61	Resistor, TKF, 100R, 5%, 1/10W, SMD, 0603	Vishay Dale	CRCW0603100RJNEA
0	U3	IC Power, ZTL431AFFTA, Shunt Voltage Reference, SOT-23F	Diodes Incorporated/ Zetex	ZTL431AFFTA

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.

MCP1012 15W Reference Design

NOTES:

Appendix C. Board Performance Curves and Waveforms

C.1 REFERENCE DESIGN PERFORMANCE

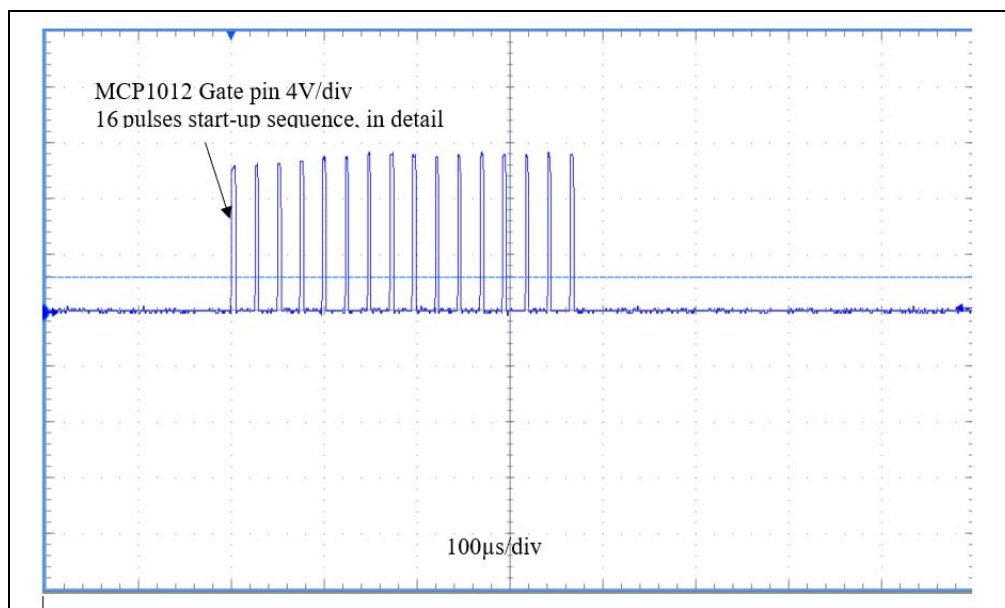


FIGURE C-1: 230VAC MCP1012 16 Pulses Start-up Sequence in Open Loop No LOAD Condition.

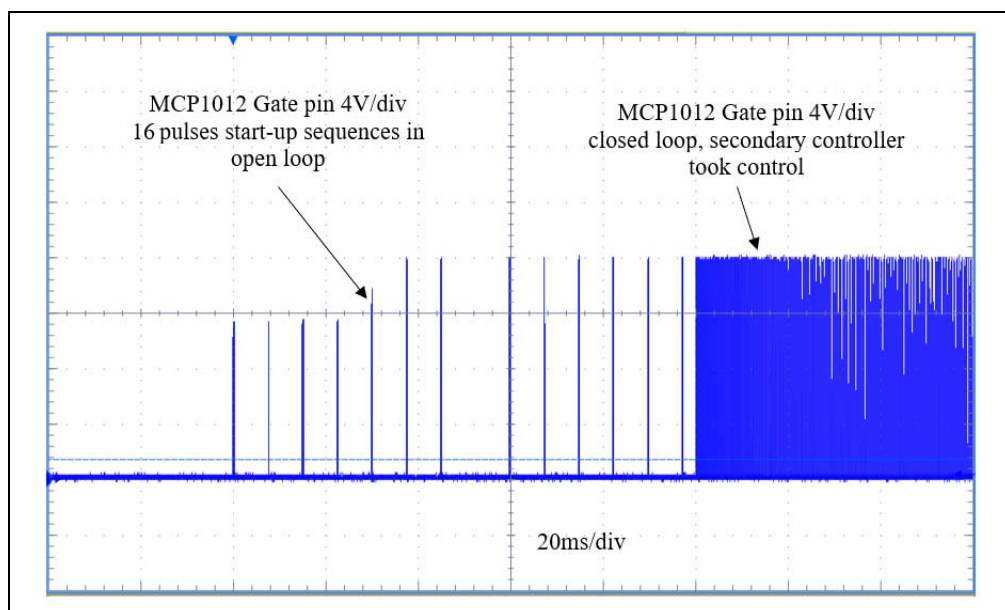


FIGURE C-2: 230VAC MCP1012 Total Start-up Sequence in Open Loop No LOAD Condition.

MCP1012 15W Reference Design

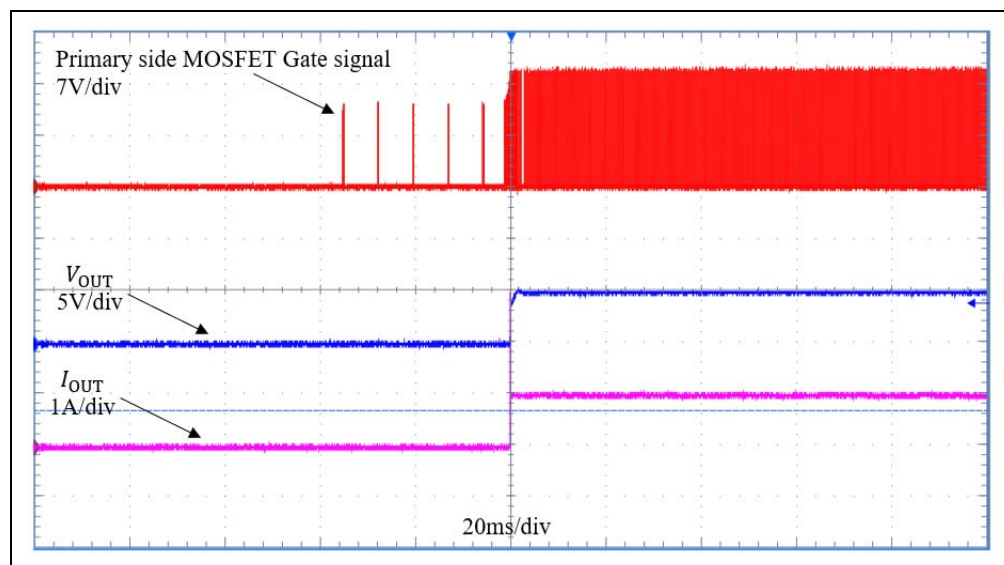


FIGURE C-3: Startup at 230VAC with 1A Load.

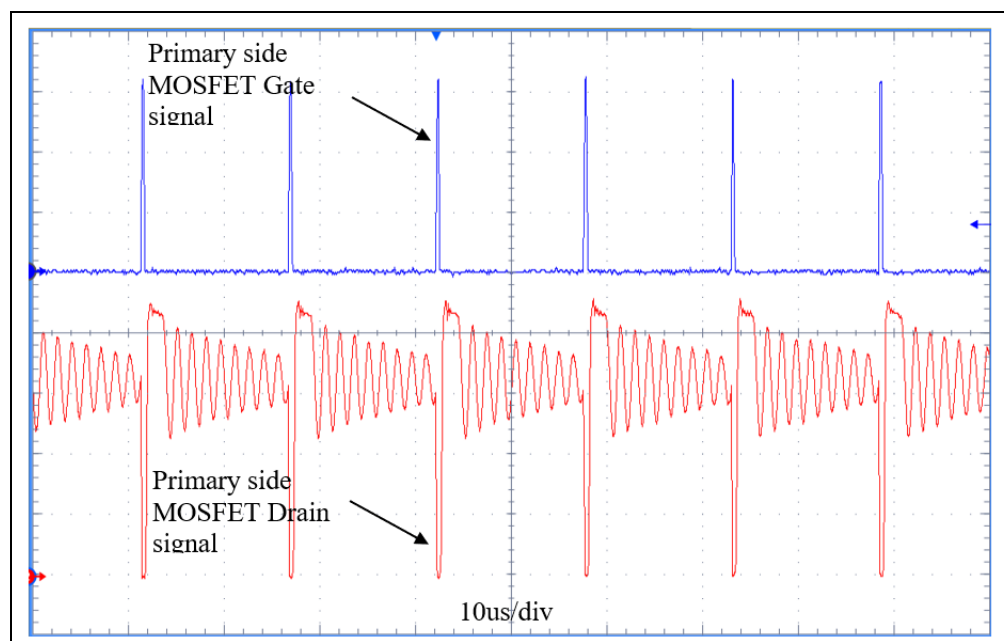


FIGURE C-4: Primary Side MOSFET Signals without Load.

Board Performance Curves and Waveforms

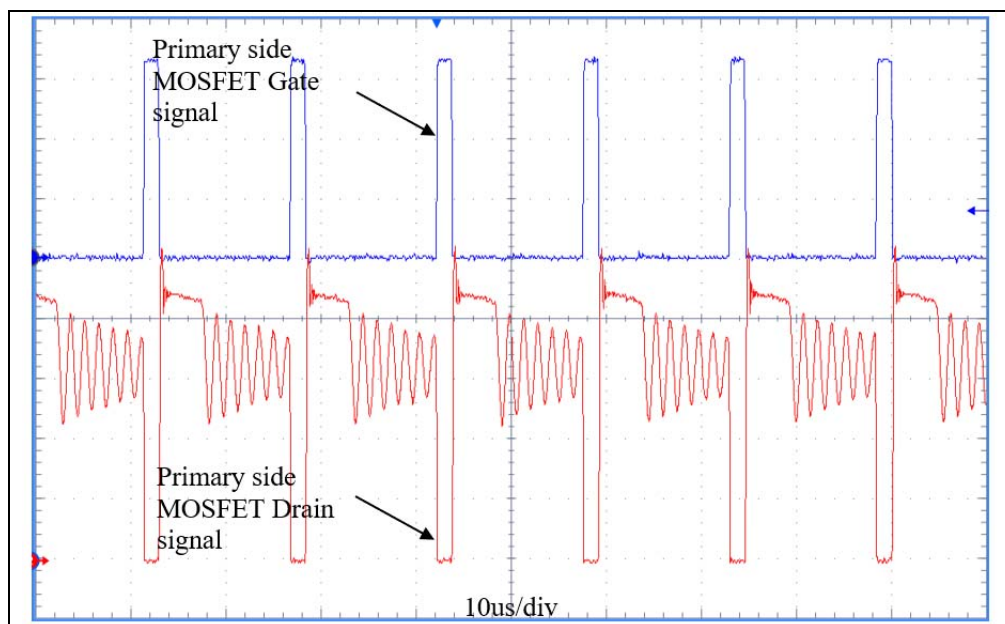


FIGURE C-5: Primary Side MOSFET Signals with Load.

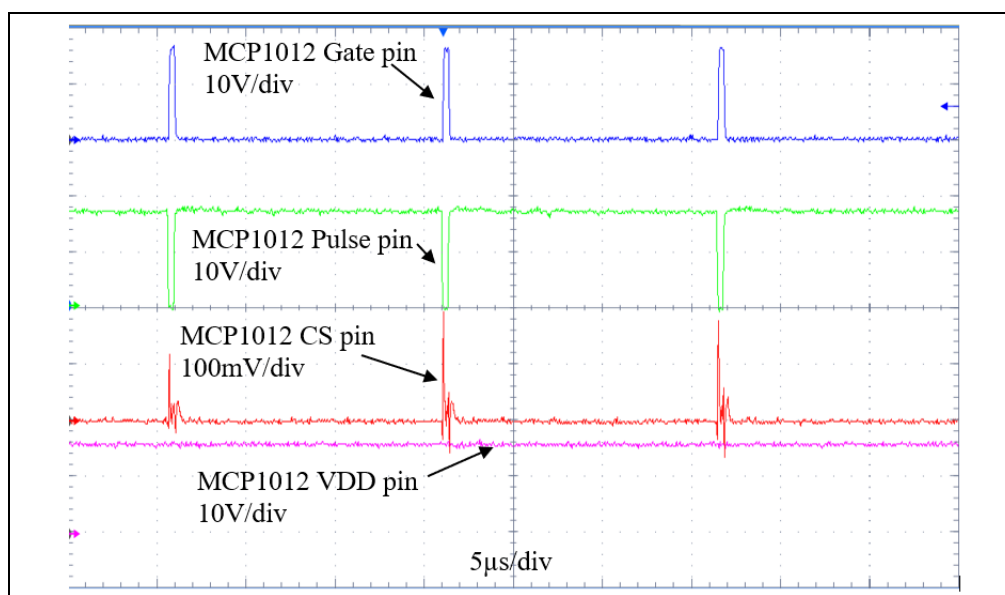


FIGURE C-6: 230VAC MCP1012 Waveforms Without Load.

MCP1012 15W Reference Design

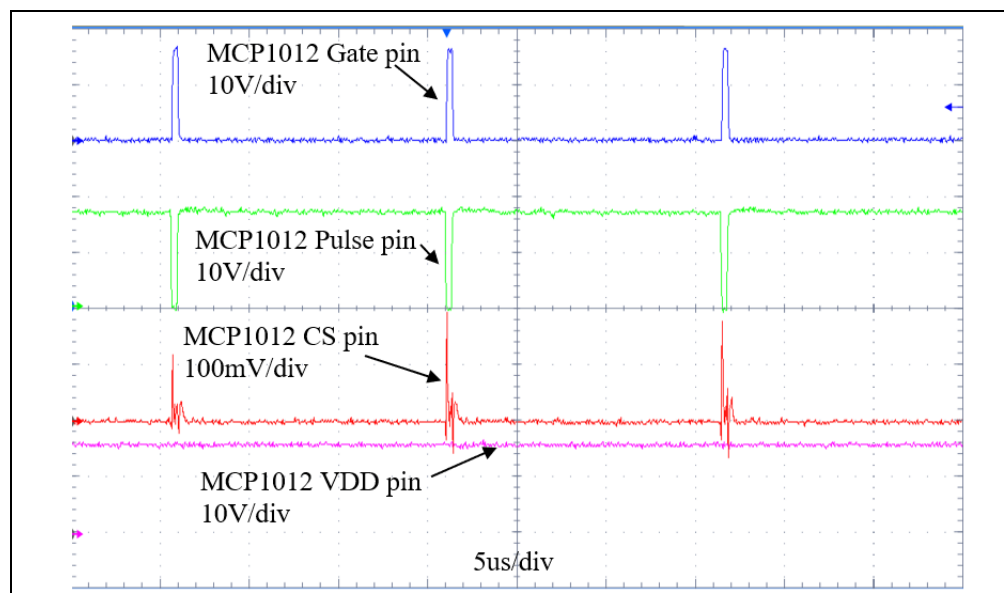


FIGURE C-7: 230VAC MCP1012 Waveforms With 3A Load.

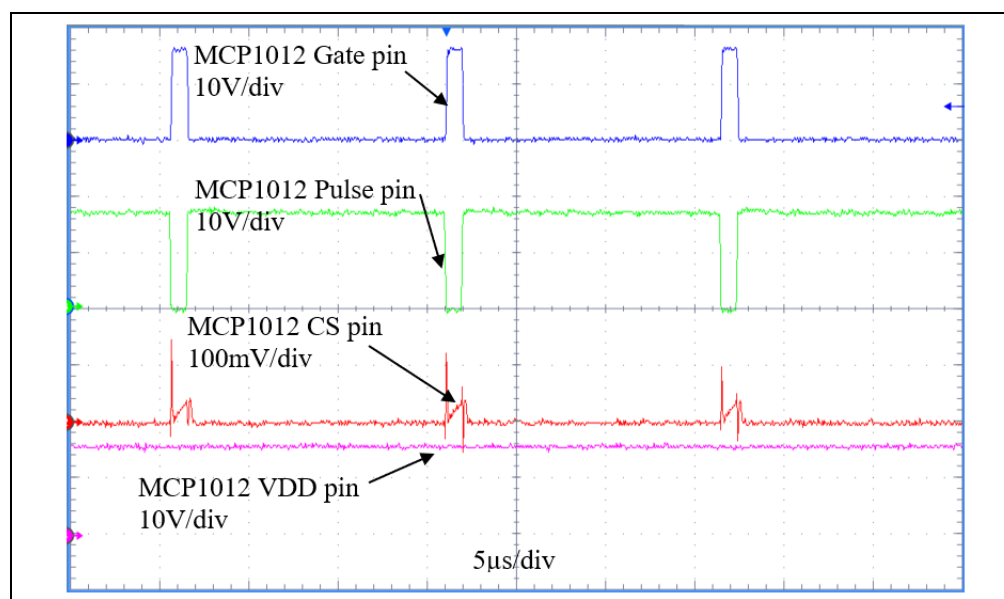


FIGURE C-8: 120VAC MCP1012 Waveforms Without Load.

Board Performance Curves and Waveforms

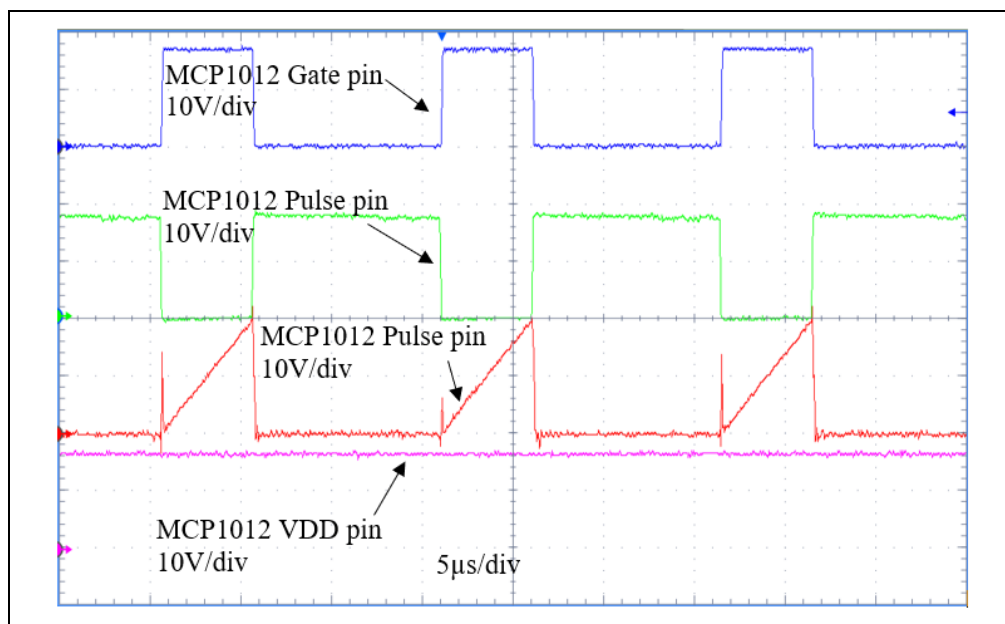


FIGURE C-9: 120VAC MCP1012 Waveforms With 3A Load.

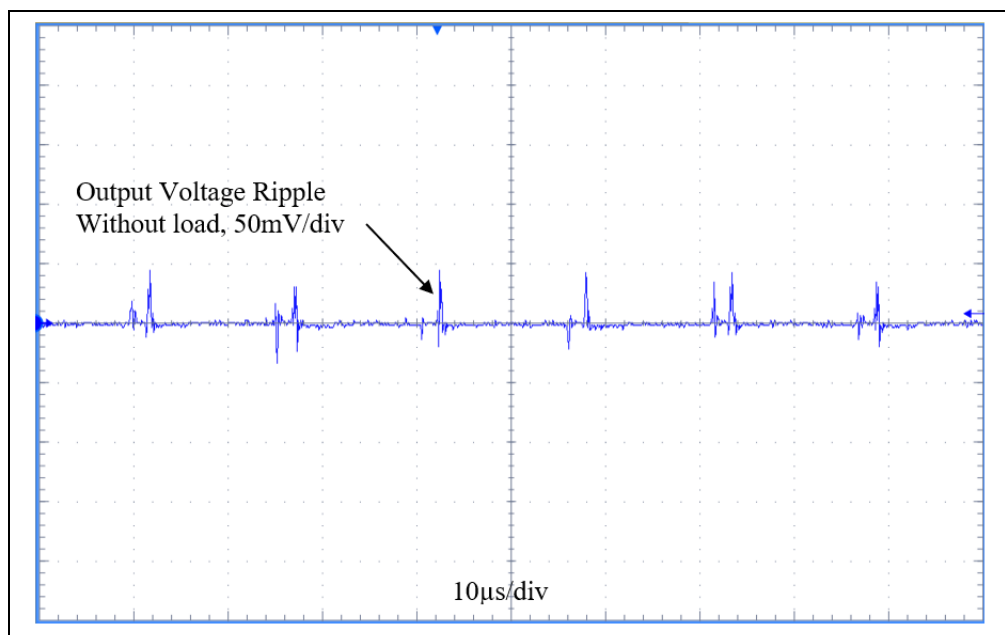


FIGURE C-10: Output Voltage Ripple, No Load.

MCP1012 15W Reference Design

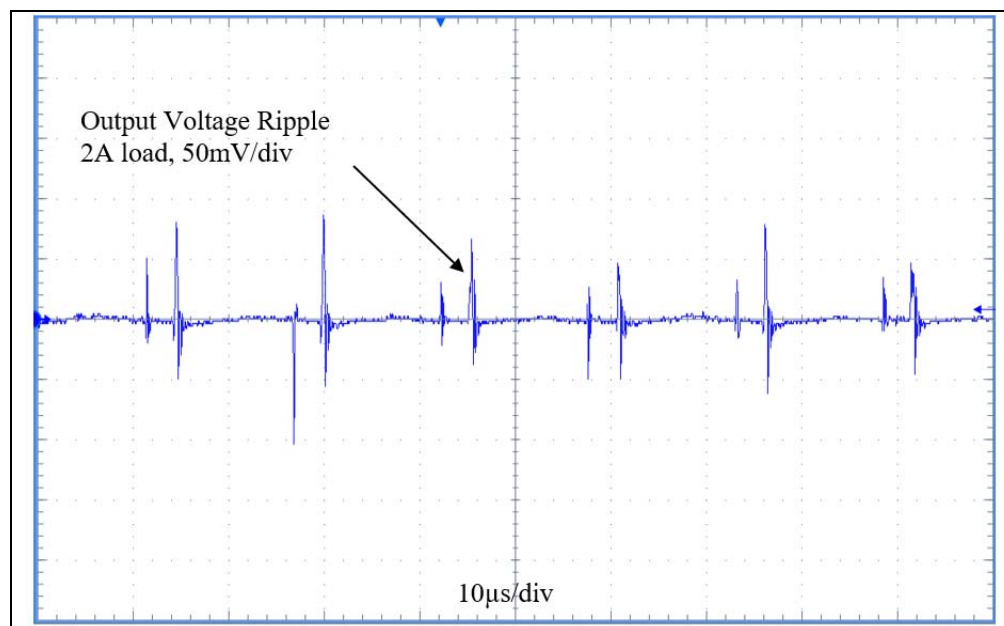


FIGURE C-11: Output Voltage Ripple, 2A Load.

C.2 PERFORMANCE CURVES

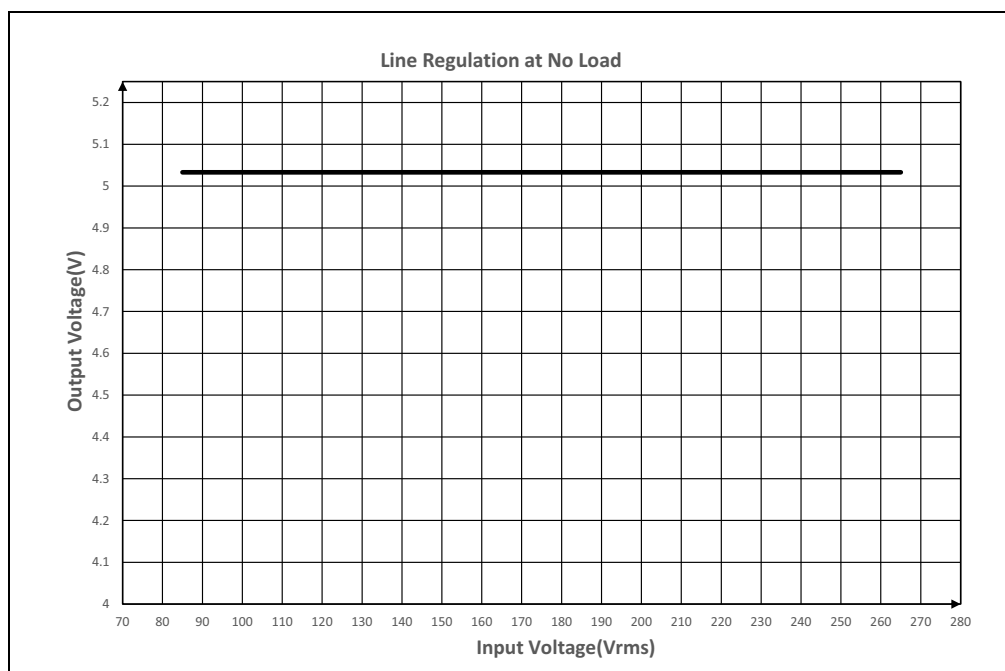


FIGURE C-12: *Input Voltage vs Output Voltage with no Load.*

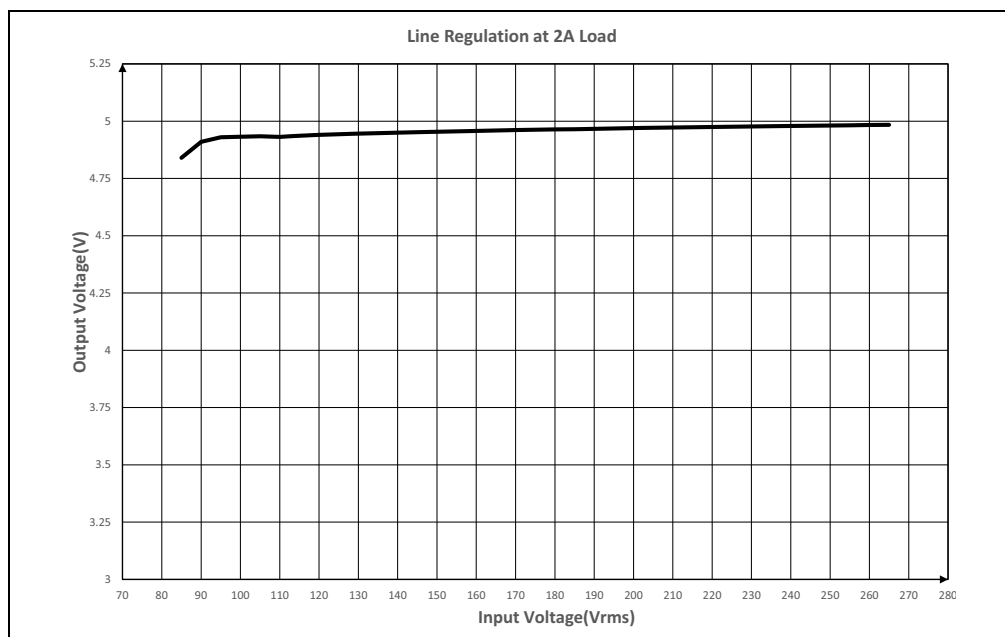


FIGURE C-13: *Input Voltage vs Output Voltage with 2A Load.*

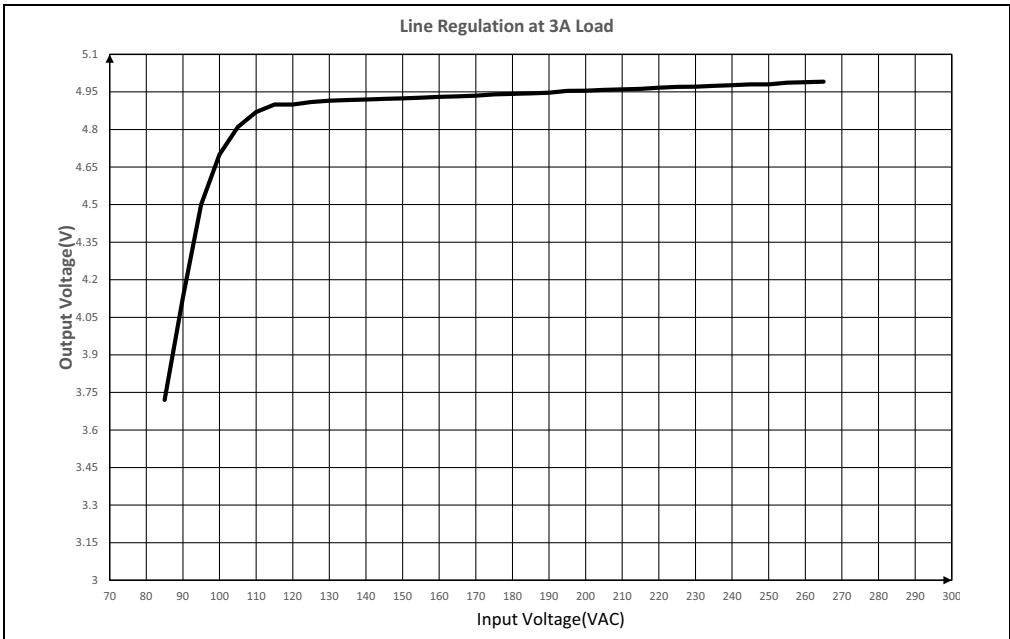


FIGURE C-14: Input Voltage vs Output Voltage with 3A Load.

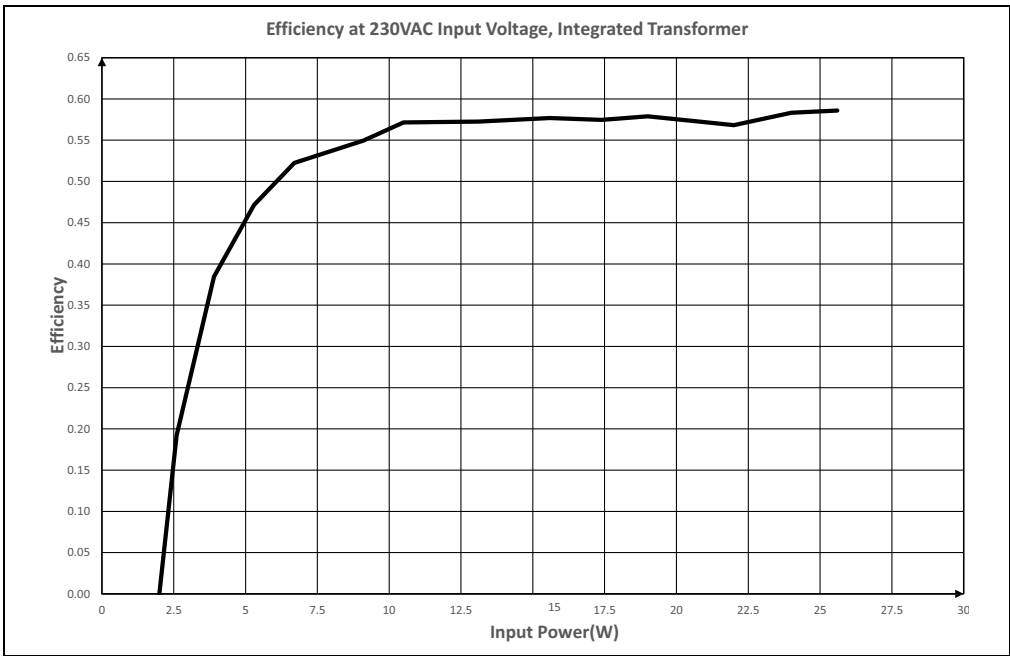


FIGURE C-15: Input Power vs Efficiency.

Board Performance Curves and Waveforms

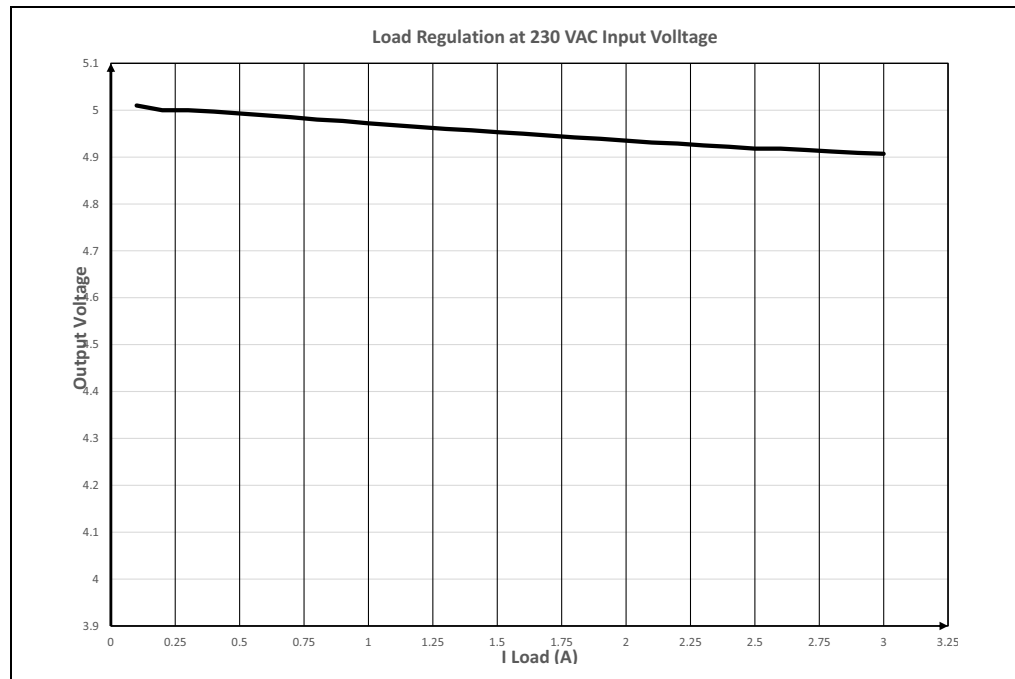


FIGURE C-16: Output Voltage vs Output Current.

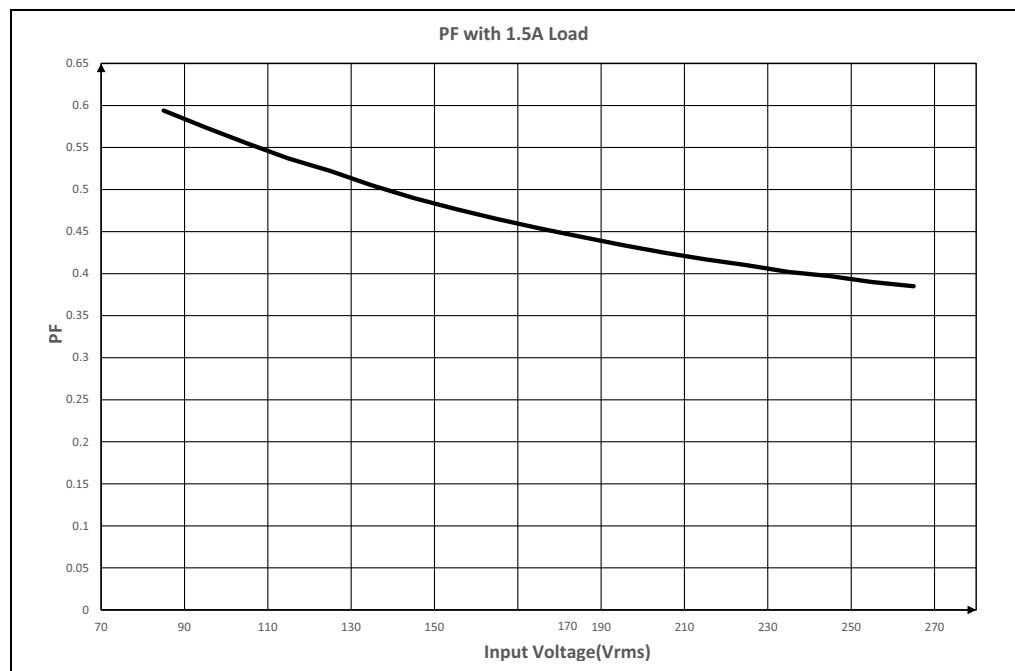


FIGURE C-17: Power Factor vs Input Voltage.

MCP1012 15W Reference Design

NOTES:



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Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
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Fax: 44-118-921-5820