

TPSM365R6EVM User's Guide

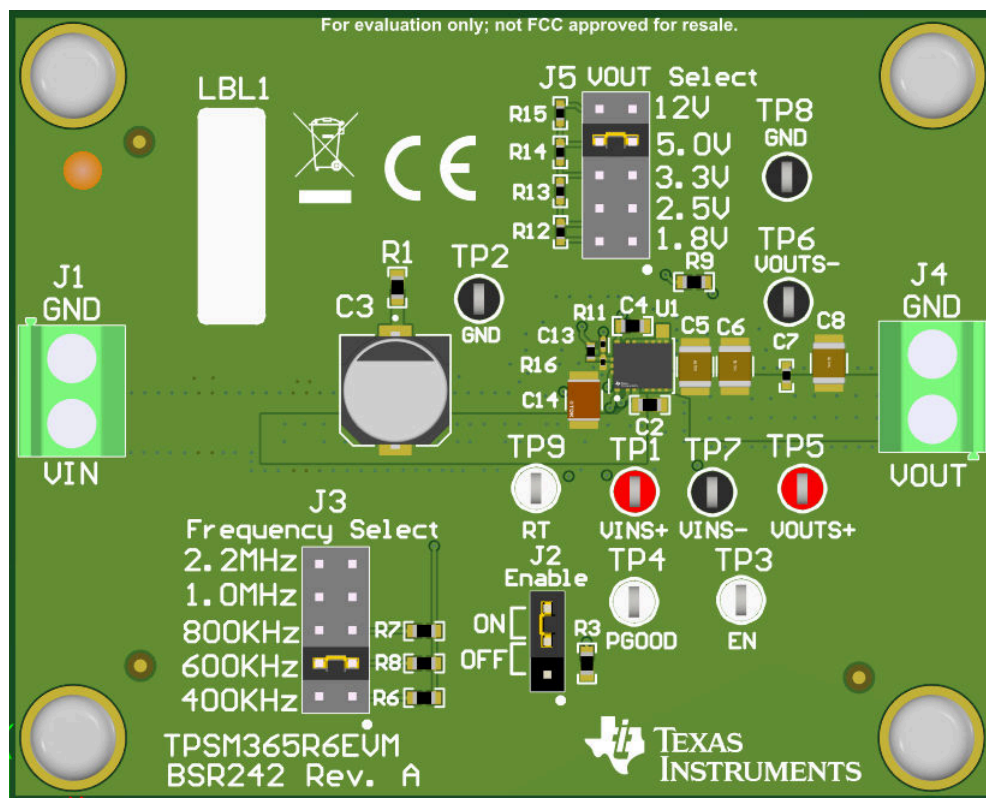


ABSTRACT

The Texas Instruments TPSM365R6EVM evaluation module helps designers evaluate the operation and performance of the TPSM365R6 wide-input voltage buck modules. The TPSM365R6 is an easy-to-use synchronous step-down DC/DC module capable of driving up to 0.6 A of load current from an input voltage of up to 65 V. The TPSM365R6EVM features a wide array of selectable output voltages from 1.8 V to 12 V and a selectable switching frequencies of 400 kHz to 2.2 MHz. This feature allows engineers to exercise the full capabilities of the TPSM365R6 in pulse frequency modulation (PFM) mode. See the [TPSM365R6, 3-V to 65-V Input, 600-mA, 4-μA No-Load IQ Synchronous Buck Converter Power Module in a HotRod™ QFN Package](#) data sheet for additional features, detailed descriptions, and available options.

Table 1-1. Device and Package Configurations

EVM	U1	FREQUENCY	SPREAD SPECTRUM	CURRENT	PIN 11 TRIM
TPSM365R6EVM	TPSM365R6RDNR	200 kHz – 2.2 MHz	Disabled	0.6 A	RT with PFM



TPSM365R6EVM Board

Table of Contents

1 Setup	3
1.1 Test Points.....	3
1.2 Jumpers.....	5
2 Operation	6
2.1 Quick Start.....	6
3 Schematic	7
4 Board Layout	8
5 Bill of Materials	11
6 Typical Characteristics	12
7 Application Curves	14

List of Figures

Figure 1-1. EVM Board Connections.....	4
Figure 1-2. Jumper Locations.....	5
Figure 3-1. TPSM365R6EVM Schematic.....	7
Figure 4-1. Top View of EVM.....	8
Figure 4-2. EVM Top Copper Layer.....	8
Figure 4-3. EVM Mid Layer One.....	9
Figure 4-4. EVM Mid Layer Two.....	9
Figure 4-5. EVM Bottom Copper Layer.....	10
Figure 6-1. Efficiency 3.3-V Output, $F_{SW} = 1$ MHz, Auto Mode.....	12
Figure 6-2. Efficiency 3.3-V Output, $F_{SW} = 1$ MHz, FPWM.....	12
Figure 6-3. Efficiency 5-V Output, $F_{SW} = 1$ MHz, Auto Mode.....	12
Figure 6-4. Efficiency 5-V Output, $F_{SW} = 1$ MHz, FPWM.....	12
Figure 6-5. Typical CISPR 11 Class B Conducted EMI 150 kHz - 30 MHz with EMI Filter (Standard EVM Layout and BOM).....	12
Figure 6-6. Typical CISPR 11 Class B Conducted EMI 150 kHz - 30 MHz without EMI Filter (Standard EVM Layout and BOM).....	12
Figure 6-7. Typical CISPR 11 Class B Radiated EMI 30 kHz - 1000 MHz (Standard EVM Layout and BOM, Input Filter Removed).....	13
Figure 7-1. Start-Up Waveforms.....	14
Figure 7-2. Shutdown Waveforms.....	14
Figure 7-3. Load Transient, 0 A to 0.6 A, 1 A/ μ s.....	14
Figure 7-4. Load Transient, 0.3 A to 0.6 A, 1 A/ μ s.....	14
Figure 7-5. Load Transient, 0 A to 0.6 A, 1 A/ μ s.....	14
Figure 7-6. Load Transient, 0.3 A to 0.6 A, 1 A/ μ s.....	14

List of Tables

Table 1-1. Device and Package Configurations.....	1
Table 1-1. Test Point Descriptions.....	3
Table 5-1. Bill Of Materials.....	11

Trademarks

HotRod™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

1 Setup

Figure 1-1 shows a typical setup with the EVM. The VIN power terminal block (J1) is used for connection to the host input supply and the VOUT power terminal block (J4) is used for connection to the load.

1.1 Test Points

The test points on the top of the board can be used for connecting to the input and output of the EVM. Table 1-1 describes each test point.

Table 1-1. Test Point Descriptions

Test Point ⁽¹⁾	Description
VINS+	Sense line for measuring the input voltage. Not meant to be used to power the device.
VINS-	Ground test point located near the ground terminal of the high frequency bypass capacitor. Meant to be connected to the ground sense line for VIN, but can be used in place of a general ground test point.
VOUTS+	Sense line test point for the output voltage. Do not connect to an output load.
VOUTS-	Ground test point located near the ground terminal of the output capacitors. Meant to be connected to the ground sense line for VOUT, but can be used in place of a general ground test point.
GND	Test points for ground connection. Not meant to be used as a ground connection for the input power supply.
EN	Input voltage scope monitor. Connect an oscilloscope probe to this set of points to measure input ripple voltage.
PGOOD	This test point is connected to the PGOOD pin from the IC. This test point is an open-drain output of the PGOOD pin. In this EVM configuration, the pin is pulled up to VOUT by R4.
EN	This test point is connected to the EN pin. By default, there is a pullup resistor R2 (RENT) to VIN to enable the IC.
RT	This test point is connected to the RT pin of the IC when the R4 (RMODE) is installed. In a MODE/SYNC trim part, this test point is connected to the SYNC pin of the IC. This can be connected to an external clock to synchronize the IC. In a MODE/SYNC configuration, make sure J3 is left open.
VCC	This test point is connected to the VCC pin.

(1) Refer to the product data sheet for absolute maximum ratings associated with the features in this table.

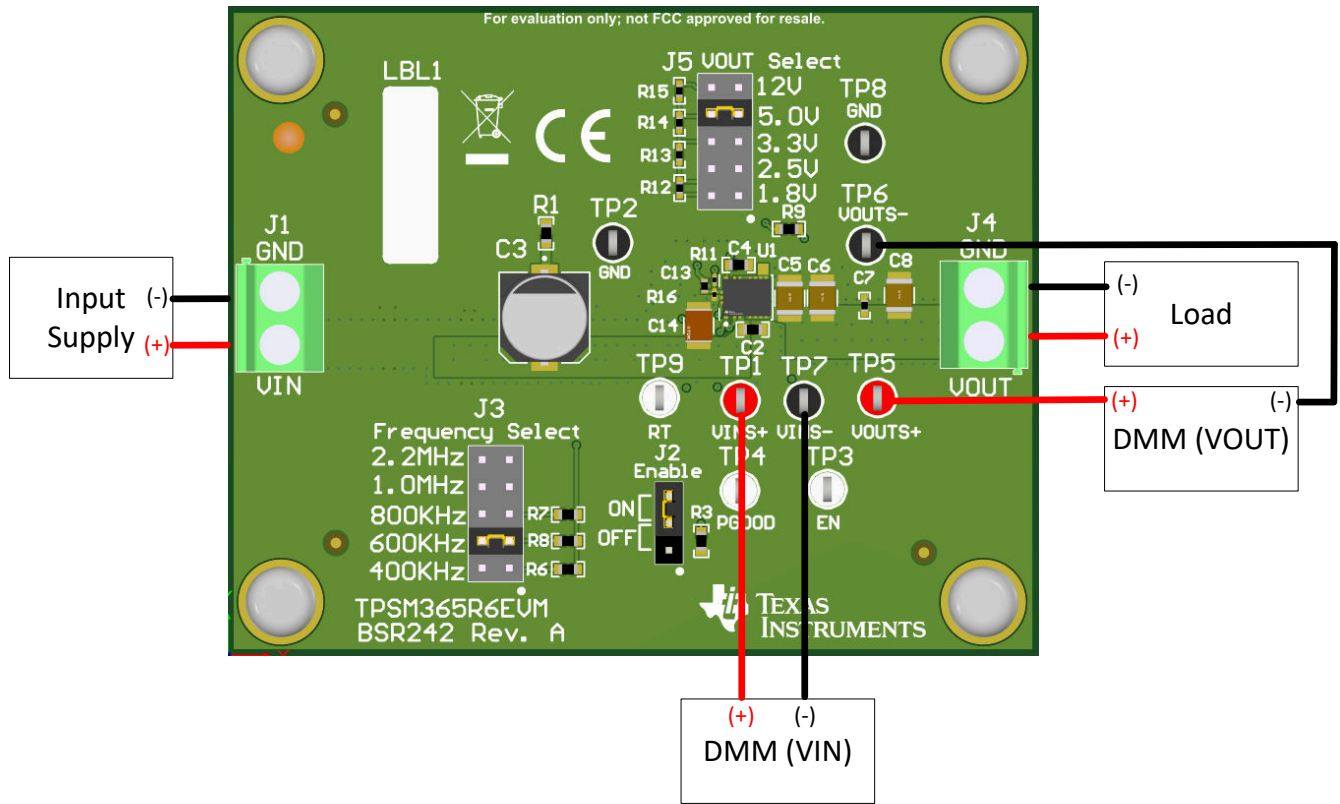


Figure 1-1. EVM Board Connections

1.2 Jumpers

See [Figure 1-2](#) for jumper locations.

- **J2 EN-** This jumper allows the ENABLE input to be connected to GND to disable the IC. The "ON" position is the same as an unconnected jumper as EN is pulled up by R2. The "OFF" position shorts EN to ground which disables TPSM365R6RDNR.
- **J3 Frequency Select-** This EVM is supplied with an **RT** trimmed version of TPSM365R6 to allow for an adjustable switching frequency. The selectable frequencies are 400 kHz, 600 kHz, 800 kHz, 1.0 MHz, and 2.2 MHz. Make sure a jumper is connected to a desired switching frequency before powering the device. If a **Mode/Sync** trim of TPSM365R6 is installed, then leave this jumper unpopulated.
- **J5 VOUT Select -** This header allows selection of the desired output voltage: 1.8 V, 2.5 V, 3.3 V, 5.0 V, 12.0 V. Before powering the EVM make sure the jumper is properly positioned for the intended output voltage. If no jumper is present, the output voltage defaults to 12 V.

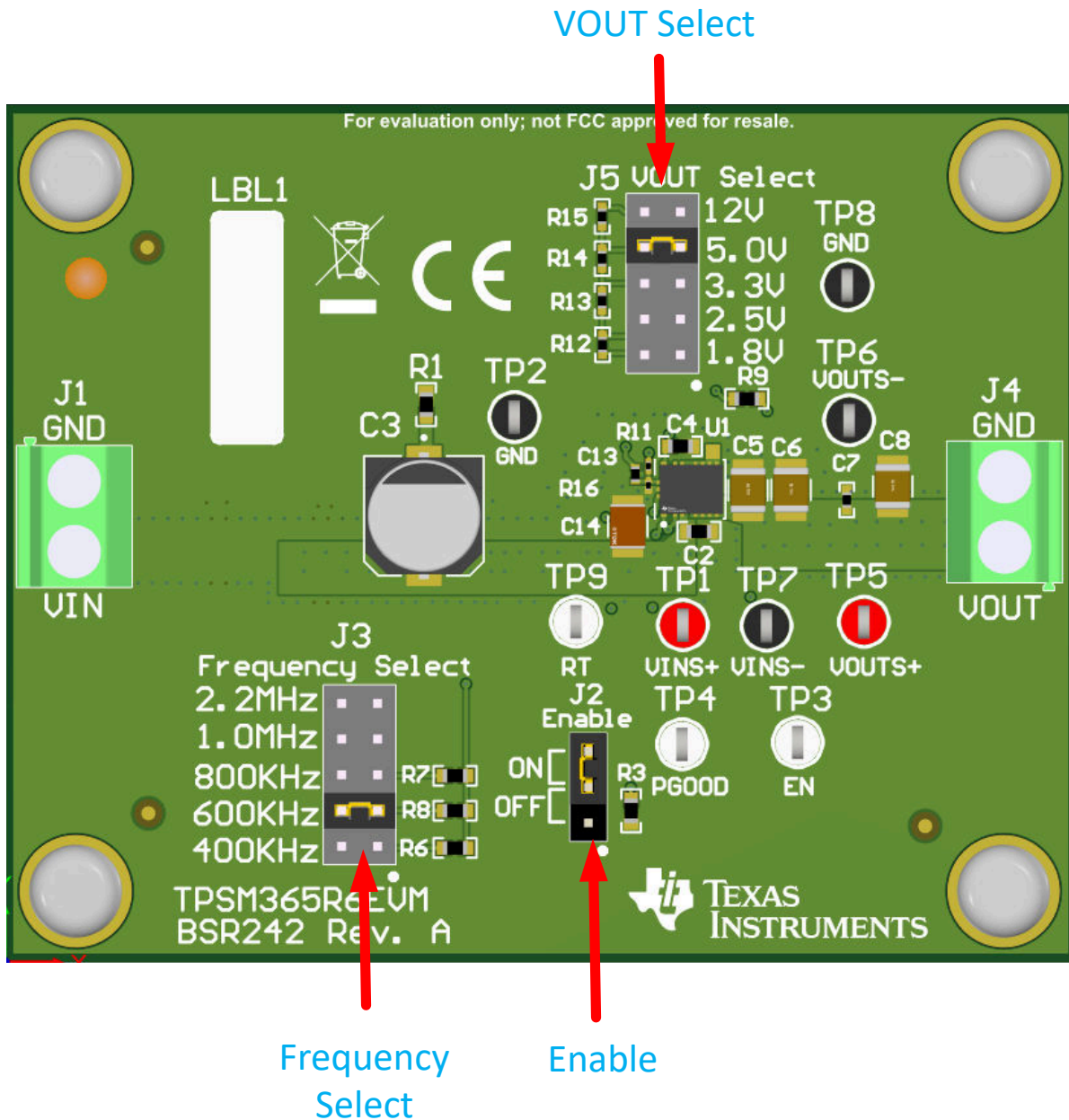


Figure 1-2. Jumper Locations

2 Operation

2.1 Quick Start

1. Make sure that a jumper is connected to one of the frequencies on the frequency select header. The device does not function properly if this is not connected.
2. Connect the load between the VOUT and GND points on J4. Make sure GND is connected on the top terminal, and VOUT is located on the bottom terminal.
3. Set the supply voltage at an appropriate level between 3.0 V to 65 V. Set the current limit of the supply to an appropriate level.
4. Turn on the power supply. With the default configuration, the EVM powers up and provides $V_{OUT} = 5.0$ V.
5. Monitor the output voltage. The maximum load current is limited to 0.6 A with the TPSM36506 device.
6. Connect the voltage supply between the VIN and GND points on J1.

3 Schematic

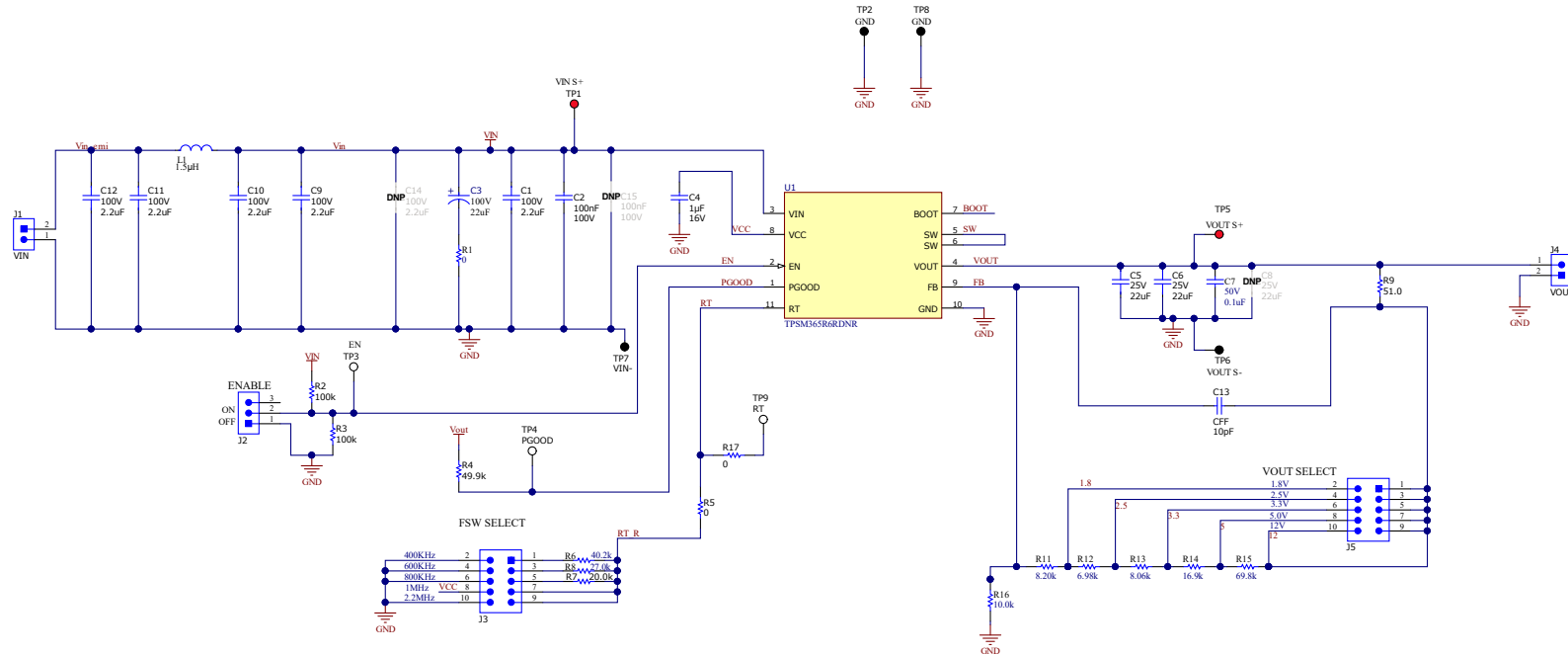


Figure 3-1. TPSM365R6EVM Schematic

4 Board Layout

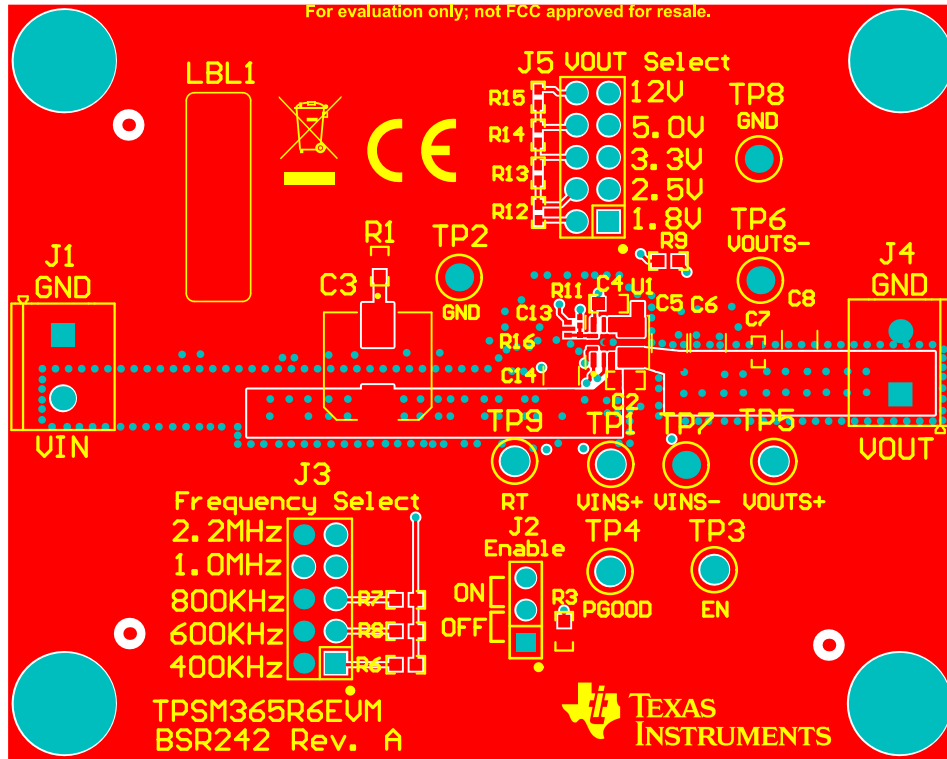


Figure 4-1. Top View of EVM

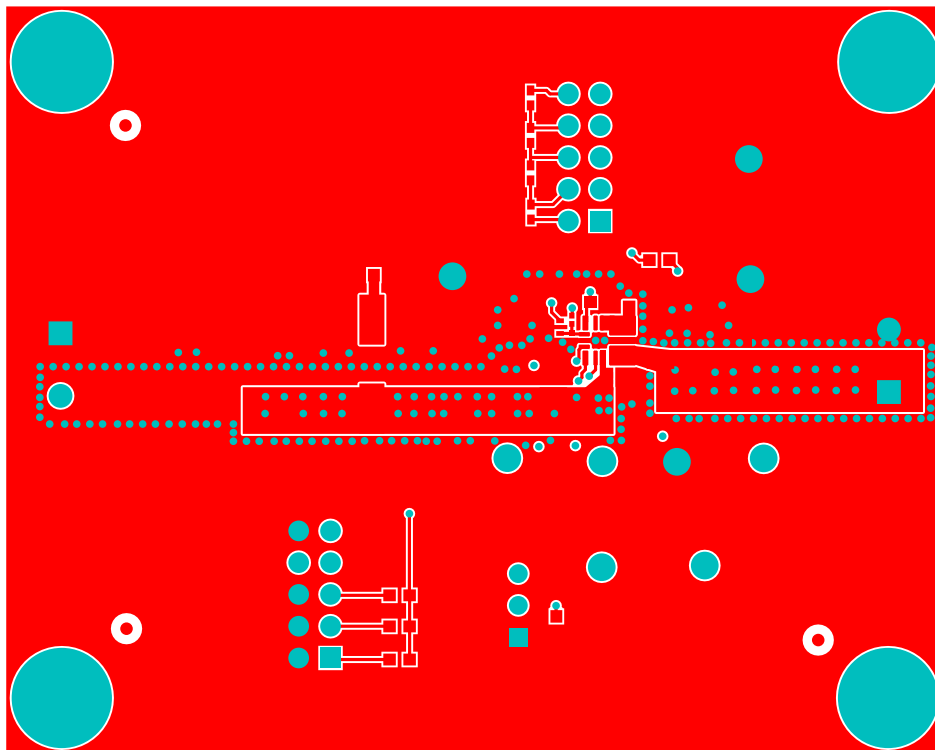


Figure 4-2. EVM Top Copper Layer

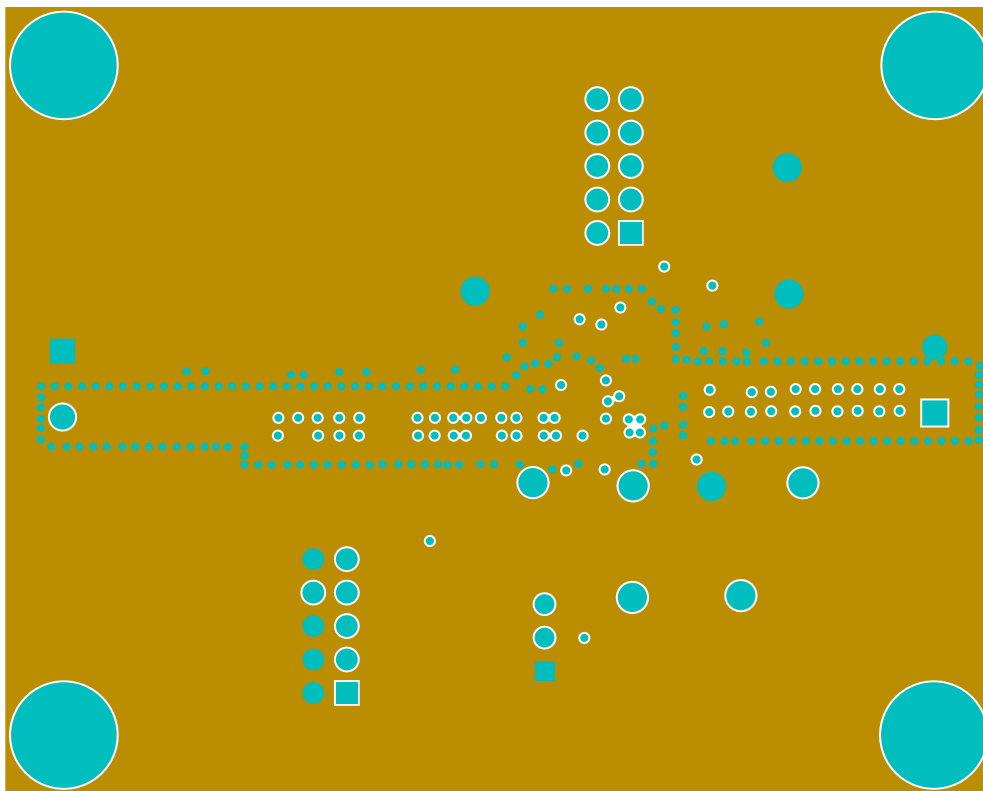


Figure 4-3. EVM Mid Layer One

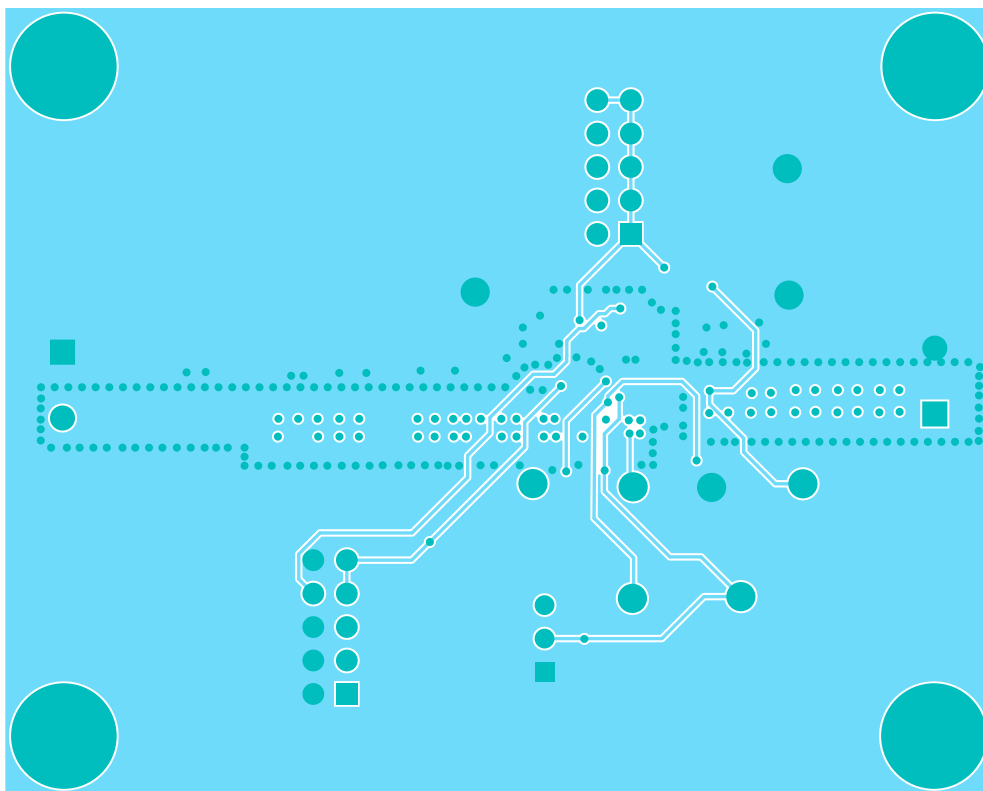


Figure 4-4. EVM Mid Layer Two

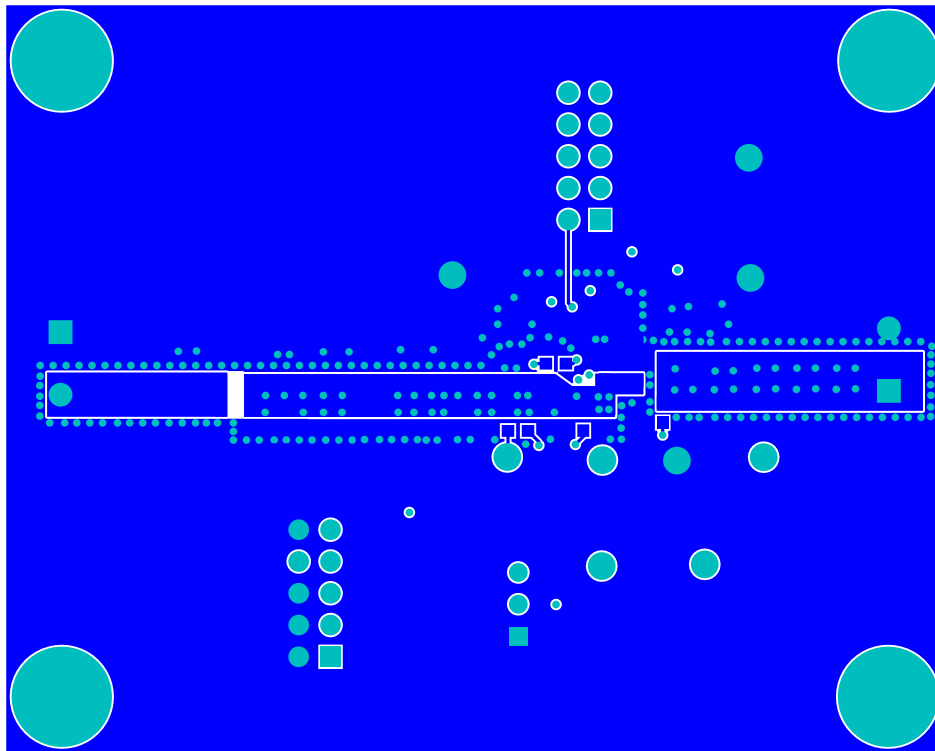


Figure 4-5. EVM Bottom Copper Layer

5 Bill of Materials

Table 5-1. Bill Of Materials

DESIGNATOR	PART NUMBER	DESCRIPTION	MANUFACTURER	QUANTITY
C1, C9, C10, C11, C12	C3225X7R2A225K230AB	Multilayer Ceramic Capacitors 2.2 uF ±10% 100 V X7R SMD 1210	TDK	5
C2	GRM188R72A104KA35J	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	MuRata	1
C3	EEE-TG2A220UP	Cap Aluminum 22 uF 100 V 20% (8 X 10.2 mm) SMD 1.3 Ohm 70 mA 2000h 125 C T/R	Panasonic Electronic Components	1
C4	C1608X7R1C105K080AC	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0603	TDK	1
C5, C6	C3225X7R1E226M250AB	Cap Ceramic 22 uF 25 V X7R 20% Pad SMD 1210 125C T/R	TDK	2
C7	C1005X7R1H104K050BE	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0402	TDK	1
C8	C3225X7R1E226M250AB	Cap Ceramic 22 uF 25 V X7R 20% Pad SMD 1210 125C T/R	TDK	0
C13	CGA2B2C0G1H100D050BA	CAP, CERM, 10 pF, 50 V, +/- 5%, COG/NPO, AEC-Q200 Grade 1, 0402	TDK	1
C14	C3225X7R2A225K230AB	Multilayer Ceramic Capacitors 2.2 uF ±10% 100 V X7R SMD 1210	TDK	0
C15	GRM188R72A104KA35J	CAP, CERM, 0.1 uF, 100 V, +/- 10%, X7R, 0603	MuRata	0
J1, J4	1729018	TERM BLOCK 2POS 5 mm, TH	Phoenix Contact	2
J2	PEC03SAAN	Header, 100mil, 3x1, Tin, TH	Sullins Connector Solutions	1
J3, J5	PEC05DAAN	Header, 100mil, 5x2, Tin, TH	Sullins Connector Solutions	2
L1	XGL4020-152MEC	Shielded Power Inductors	Coilcraft	1
R1, R5, R17	RC0603JR-070RL	RES, 0, 5%, 0.1 W, 0603	Yageo	3
R2, R3	CRCW0603100KJNEAC	RES, 100 k, 5%, 0.1 W, 0603	Vishay-Dale	2
R4	RC0603FR-0749K9L	RES, 49.9 k, 1%, 0.1 W, 0603	Yageo	1
R6	RC0603FR-0740K2L	RES, 40.2 k, 1%, 0.1 W, 0603	Yageo	1
R7	RC0603FR-0720KL	RES, 20.0 k, 1%, 0.1 W, 0603	Yageo	2
R8	RC0603FR-0727KL	RES, 27.0 k, 1%, 0.1 W, 0603	Yageo	1
R9	RC0603FR-0751RL	RES, 51.0, 1%, 0.1 W, 0603	Yageo	1
R11	RC0201FR-078K2L	RES, 8.20 k, 1%, 0.05 W, 0201	Yageo America	1
R12	CRCW04026K98FKED	RES, 6.98 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	1
R13	CRCW04028K06FKED	RES, 8.06 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	1
R14	CRCW040216K9FKED	RES, 16.9 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	1
R15	CRCW040269K8FKED	RES, 69.8 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	Vishay-Dale	1
R16	RC0201FR-7D10KL	RES, 10.0 k, 1%, 0.05 W, 0201	Yageo America	1
SH-J1, SH-J2, SH-J3	SNT-100-BK-G	Shunt, 100mil, Gold plated, Black	Samtec	3
TP1, TP5	5010	Test Point, Multipurpose, Red, TH	Keystone	2
TP2, TP6, TP7, TP8	5011	Test Point, Multipurpose, Black, TH	Keystone	4
TP3, TP4, TP9	5012	Test Point, Multipurpose, White, TH	Keystone	3
U1	TPSM365R6RDNR	3-V to 65-V Input, 1-V to 13-V Output, 600-mA Synchronous Buck Converter Power Module in a HotRod™ QFN Package	Texas Instruments	1

6 Typical Characteristics

Unless otherwise specified, the following conditions apply: $T_A = 25^\circ\text{C}$, $V_{IN} = 24\text{ V}$

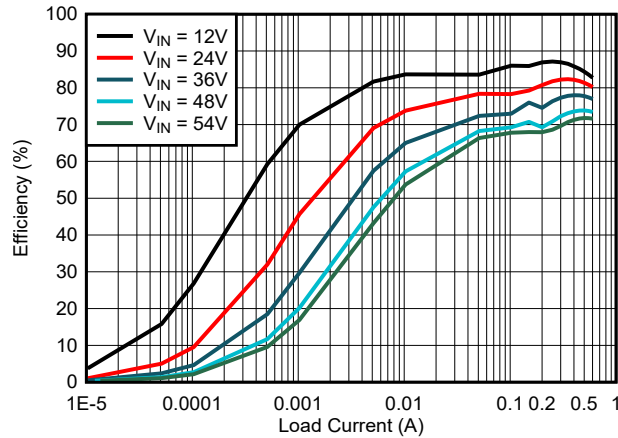


Figure 6-1. Efficiency 3.3-V Output, $F_{SW} = 1\text{ MHz}$, Auto Mode

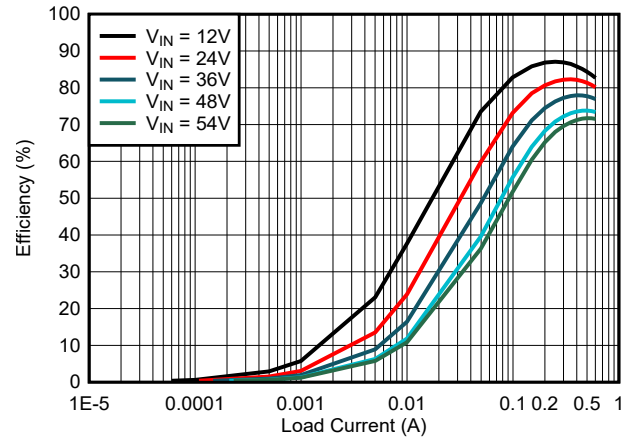


Figure 6-2. Efficiency 3.3-V Output, $F_{SW} = 1\text{ MHz}$, FPWM

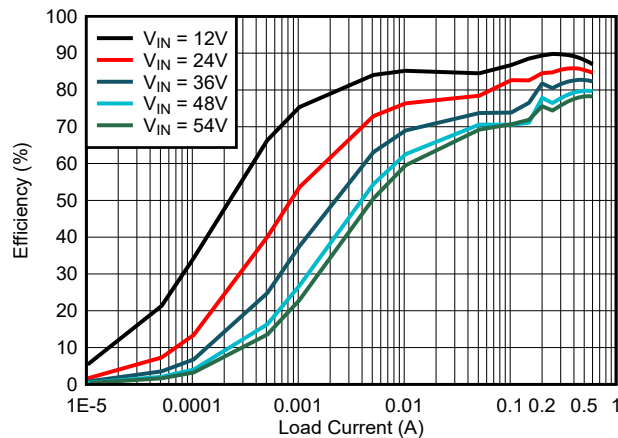


Figure 6-3. Efficiency 5-V Output, $F_{SW} = 1\text{ MHz}$, Auto Mode

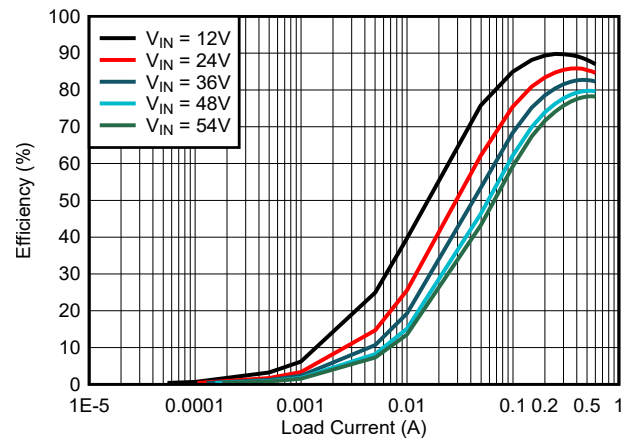


Figure 6-4. Efficiency 5-V Output, $F_{SW} = 1\text{ MHz}$, FPWM

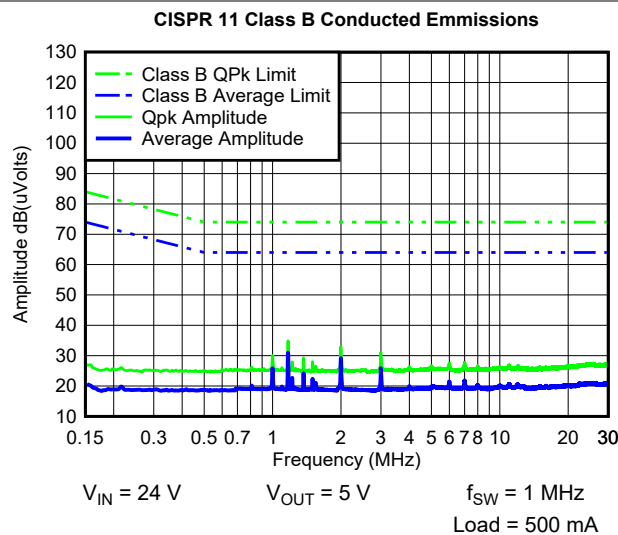


Figure 6-5. Typical CISPR 11 Class B Conducted EMI 150 kHz - 30 MHz with EMI Filter (Standard EVM Layout and BOM)

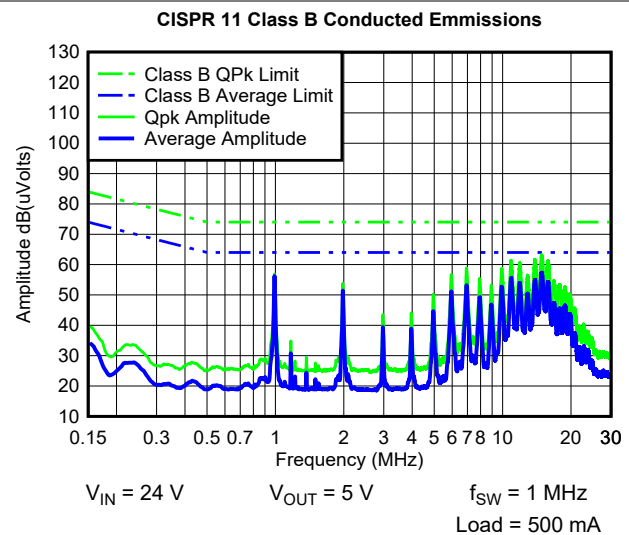
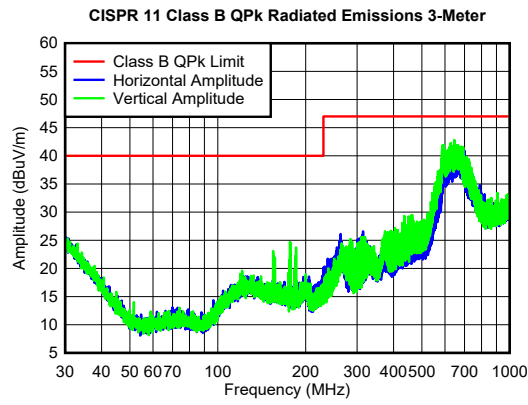


Figure 6-6. Typical CISPR 11 Class B Conducted EMI 150 kHz - 30 MHz without EMI Filter (Standard EVM Layout and BOM)



$V_{IN} = 24\text{ V}$

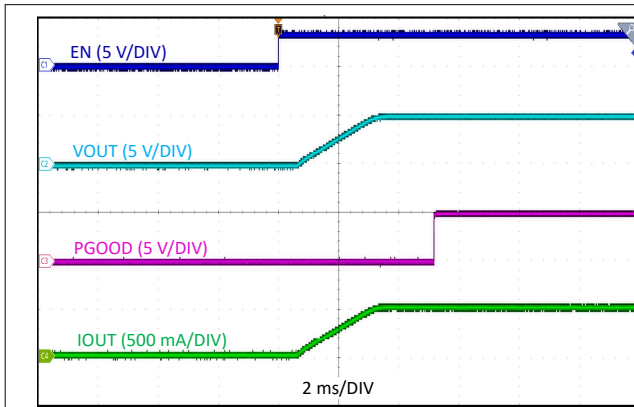
$V_{OUT} = 5\text{ V}$

$f_{SW} = 1\text{ MHz}$
 Load = 500 mA

Figure 6-7. Typical CISPR 11 Class B Radiated EMI 30 kHz - 1000 MHz (Standard EVM Layout and BOM, Input Filter Removed)

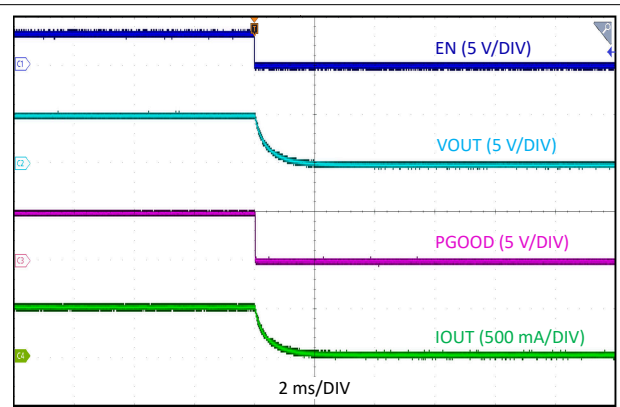
7 Application Curves

Unless otherwise indicated, $V_{IN} = 24\text{ V}$, $V_{OUT} = 5\text{ V}$, $I_{OUT} = 0.5\text{ A}$, and $F_{SW} = 1\text{ MHz}$



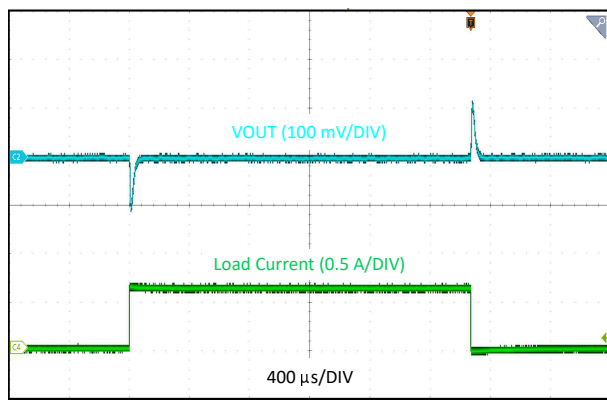
$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$

Figure 7-1. Start-Up Waveforms



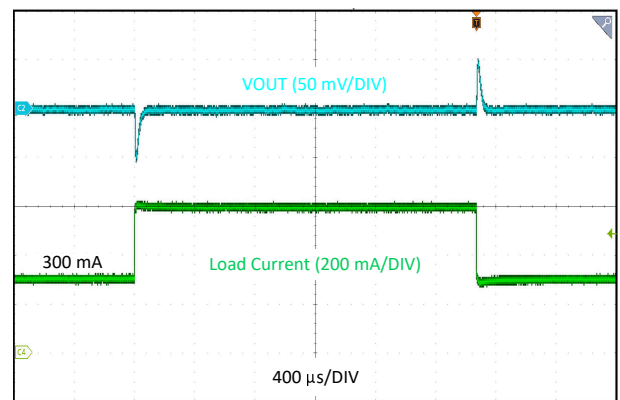
$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$

Figure 7-2. Shutdown Waveforms



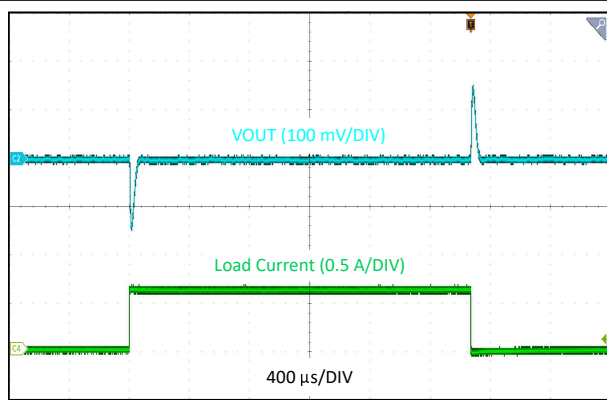
$V_{IN} = 24\text{ V}$ $V_{OUT} = 3.3\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-3. Load Transient, 0 A to 0.6 A, 1 A/μs



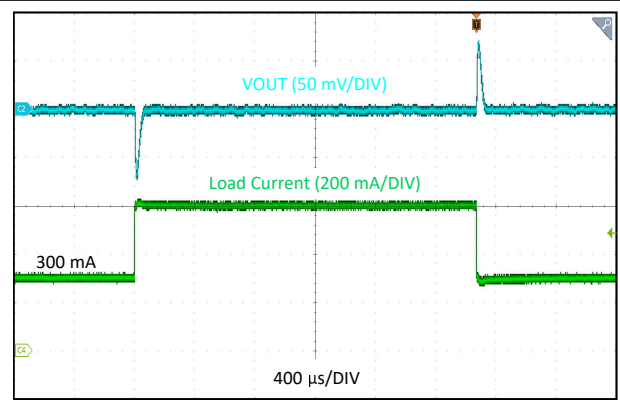
$V_{IN} = 24\text{ V}$ $V_{OUT} = 3.3\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-4. Load Transient, 0.3 A to 0.6 A, 1 A/μs



$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-5. Load Transient, 0 A to 0.6 A, 1 A/μs



$V_{IN} = 24\text{ V}$ $V_{OUT} = 5\text{ V}$ $F_{SW} = 1\text{ MHz}$
 $C_{OUT} = 2 \times 22\text{ }\mu\text{F}$

Figure 7-6. Load Transient, 0.3 A to 0.6 A, 1 A/μs

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2022, Texas Instruments Incorporated