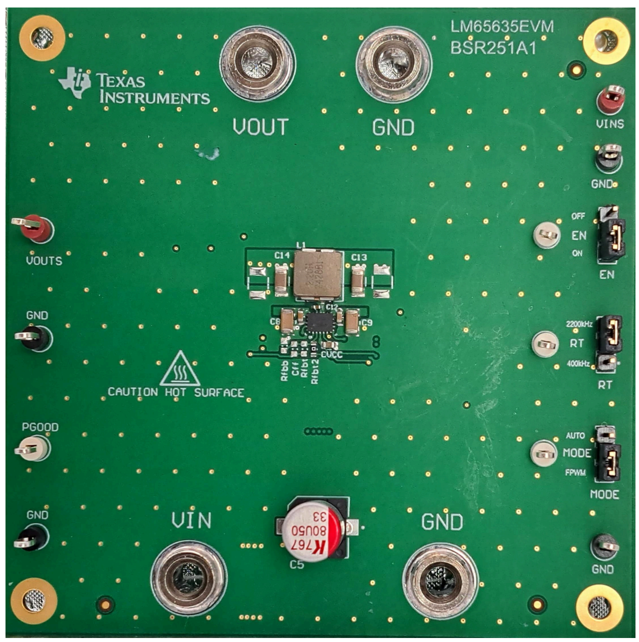
LM65635 Evaluation Module

Description

The LM65635EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LM656x5 family of wide input voltage buck converters. The LM65635EVM is configured to deliver a 5V output to a load requiring 3.5A or less.
The LM65635EVM can be used in many different configurations by substituting other versions of the LM656x5 and re-configuring the board components.

Features

- 3V to 65V wide input voltage range
- 5V, 3.3V, and ADJ voltage
- Up to 3.5A output current (LM65635)
- 300kHz to 2.2MHz switching frequency
- Minimized switch node ringing to reduce Electromagnetic Interference (EMI)
- Input transient capability up to 70V



LM65635EVM

1 Evaluation Module Overview

1.1 Introduction

The LM656x5 family of devices are easy-to-use synchronous step-down converters capable of supplying up to 2.5A, 3.5A, or 4.5A of load current from an input voltage as high as 65V. See Section 1.4 for more details. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the LM65635EVM.

This user's guide describes the operational use of the LM65635EVM evaluation module (EVM) as a reference for engineering demonstration and evaluation of the LM656x5 family of devices. Included in this user's guide are setup and operating instructions, thermal and layout guidelines, a printed-circuit board (PCB) layout, a schematic diagram, and a bill of materials (BOM).

1.2 Kit Contents

This kit includes one LM65635EVM.

1.3 Specification

Performance characteristics for the LM65635EVM, with LM65635, are found in Table 1-1

Unless otherwise stated: V_{IN} = 24V, V_{OUT} = 5V, T_A = 25ºC.

Table 1-1. LM65635EVM Electrical Performance Characteristics

Parameter	Test Conditions		MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS						
Input voltage range, V_{VIN}	EVM input voltage operating range		6	12	65	V
Input current, no load, $I_{IN(NL)}$	I_{OUT} = 0A	AUTO mode		5.5		μA
Input current, disabled, $I_{IN(OFF)}$	$V_{EN/UVLO}$ = 0V, no EN divider	V_{IN} = 24V		1		μA
OUTPUT CHARACTERISTICS						
Output voltage, V_O	I_{OUT} = 0A, AUTO mode			5.01		V
	I_{OUT} = 3.5A			5.005		V
Output voltage regulation, ΔV_{OUT}	Load regulation, AUTO mode	I_{OUT} = 0A to 3.5A		4		mV
Output voltage regulation, ΔV_{OUT}	Load regulation, FPWM mode	I_{OUT} = 0A to 3.5A		0.5		
Output voltage regulation, ΔV_{OUT}	Line regulation, V_{IN} = 12V to 48V	I_{OUT} = 3.5A		2		
Maximum output current	V_{IN} = 24V			4.5		A
SYSTEM CHARACTERISTICS						
Switching frequency	I_{OUT} = 3.5A			2200		kHz
Peak efficiency	I_{OUT} = 1.5A	V_{IN} = 24V		87%		
Full load efficiency	I_{OUT} = 3.5A	V_{IN} = 24V		86%		

1.4 Device Information

The default EVM incorporates the LM65635. Table 1-2 provides a list of additional devices that can be used with the LM65635EVM. Appropriate passive component changes must be made to use another device in the EVM.

Table 1-2. LM65635EVM Device Options

Device OPN	Output Current	Q-Grade ?
LM65645SRZTRQ1	4.5A	Y
LM65625SRZTRQ1	2.5A	Y
LM65645RZTR	4.5A	N
LM65625SRZTR	2.5A	N

2 Hardware

2.1 Additional Images

Figure 2-1 and Figure 2-2 show the front and back of the LM65635EVM, respectively.

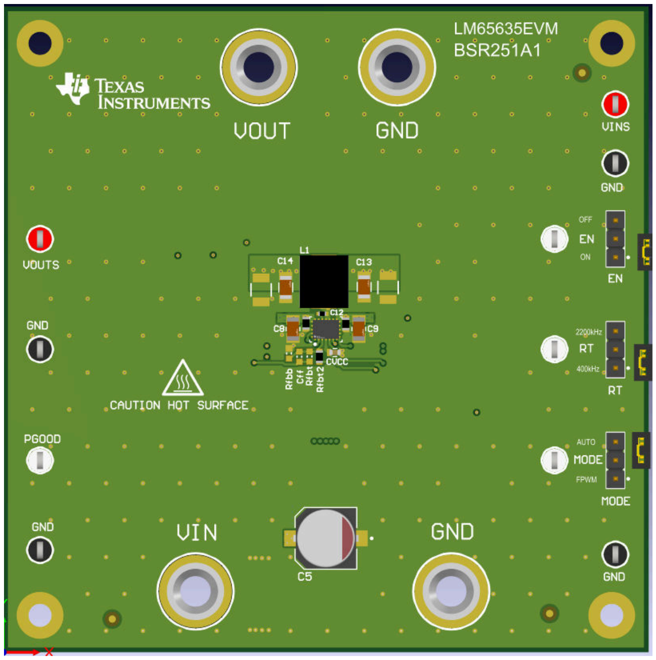


Figure 2-1. LM65635EVM (Top View)

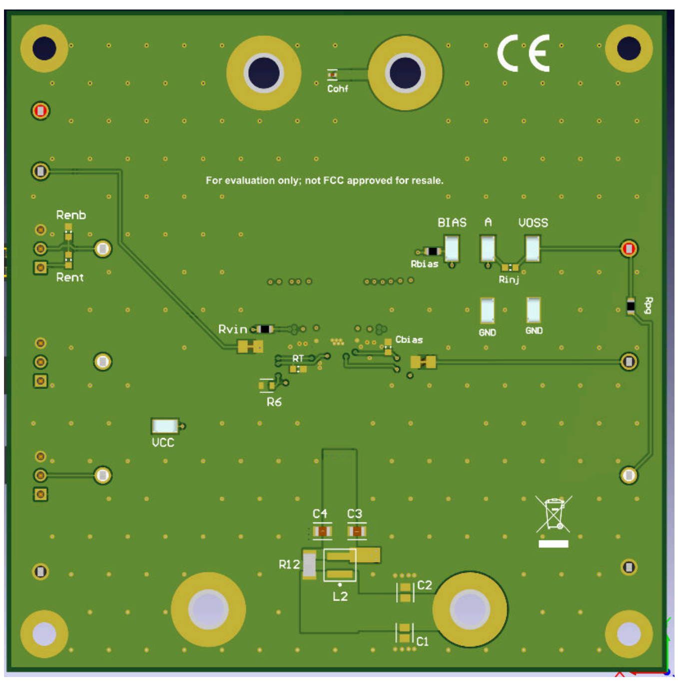


Figure 2-2. LM65635EVM (Bottom View)

2.2 Power Requirements

Any power source in the range of 6V to 65V, and capable of delivering 3.5A, can be used to evaluate the LM65635EVM.

2.3 Setup and Operation

This section describes the connectors, test points, and jumpers on the EVM and how to properly connect, set up, and use the LM65635EVM See Figure 2-3 for location of connectors and jumpers and typical setup.

VOUT Output voltage of the converter.
VOUT banana post. Apply load to this connector.

VOUTS The VOUTS test point is used to monitor output voltage.

GNDS Test point next to VOUTS test point.
This GNDS test point is use as the negative DMM connection for VOUT sensing.

VIN Input voltage to the converter.
VIN banana post. Apply input voltage to this connector.

VINS The VINS test point is used to monitor input voltage.

GNDS Test point next to VINS test point.
This GNDS test point is use as the negative DMM connection for VIN sensing.

GND Ground of the converter
GND banana posts. Apply load ground and input voltage ground to these connectors. The various GND test point are used as ground sense for input voltage and output voltage measurements.

EN The use of the EN jumper is self-explanatory.
To supply an external signal to the EN input of the device, remove the EN jumper shunt and apply the signal to the EN test point.
To use the external UVLO feature, populate Rent (R3) and Renb (R4) as desired and remove the EN jumper shunt. Note that for accurate shutdown current measurement, these resistors must be removed (if used) and the EN jumper shunt moved to "OFF".

RT The RT jumper is used to select the switching frequency and is self explanatory.
The default inductor on the EVM is designed for 2.2MHz operation. Other frequencies require a different value of inductance.
To adjust the switching frequency, remove the RT jumper shunt and populate RT (R5) with the desired value. See the LM656x5 data sheet for frequency vs. RT resistor value.

MODE MODE jumper is used to select the operating mode of the device. With MODE in the AUTO position, the device operates in automatic PFM/FPWM mode depending on load current. With the MODE in the FPWM position, the device operates at fixed frequency for all load currents.
The MODE pin is also the frequency synchronization input. To synchronize the device to an external clock, remove the MODE jumper shunt and apply the clock to the MODE test point.

Feed-back Connections The EVM is set for a fixed 5V output, with Rfbt2 (R7), 0Ω, populated. To set the output voltage to 3.3V, remove Rfbt2 (R7) and populate Rfbb (R10) with a 0Ω resistor.
To use the adjustable output voltage option, populate Rfbt (R9) and Rfbb (R10) with the appropriate value resistors. Rinj (R8) must also be populated with a 10Ω to 50Ω resistor. The reference voltage is 0.8V. See the LM656x5-Q1 High Performance Power Converter, 3V to 65V, Pin-Compatible, 2.5A/3.5A/4.5A, Automotive, Low EMI Synchronous Buck Converter data sheet for appropriate values of feed-back resistors.
When using the adjustable output voltage mode, a Bode plot can be taken using the Rinj (R8) resistor. This resistor becomes the injection point for the frequency response analyzer, allowing the loop frequency response to be taken in the usual way. In the fixed output voltage mode, a Bode plot can not be taken.

PGOOD The PGOOD test point is used to monitor the power-good indicator. This flag indicates whether the output voltage has reached the regulation level. PGOOD is an open-drain output that is tied to VOUT through a 100kΩ, resistor, Rpg (R1).

VCC VCC Test point

	The VCC pin is the output of the internal LDO. The VCC voltage is typically 3.3V. This point can be used for logic inputs and/or pull-up. Do not connect to external loads.
BIAS	Auxiliary input to LDO Connected to VOUT through 0Ω Rbias (R11) on EVM. To change the input supply of the LDO, remove Rbias (R11) and connect external supply to BIAS pin, or ground BIAS pin as required. Populate Cbias (C11) when using an external bias supply. See the LM656x5 data sheet for more information.
Bode Plot	When using the adjustable output voltage mode, a bode plot can be taken using the connection shown in Figure 2-4. Rinj (R8) must be populated.
EMI Filter	The EMI filter is not populated on the EVM. To test the EMI filter, components L2, C1 and C2 must be populated, while R12 must be removed. Typical values of these components are given in Section 4.3.

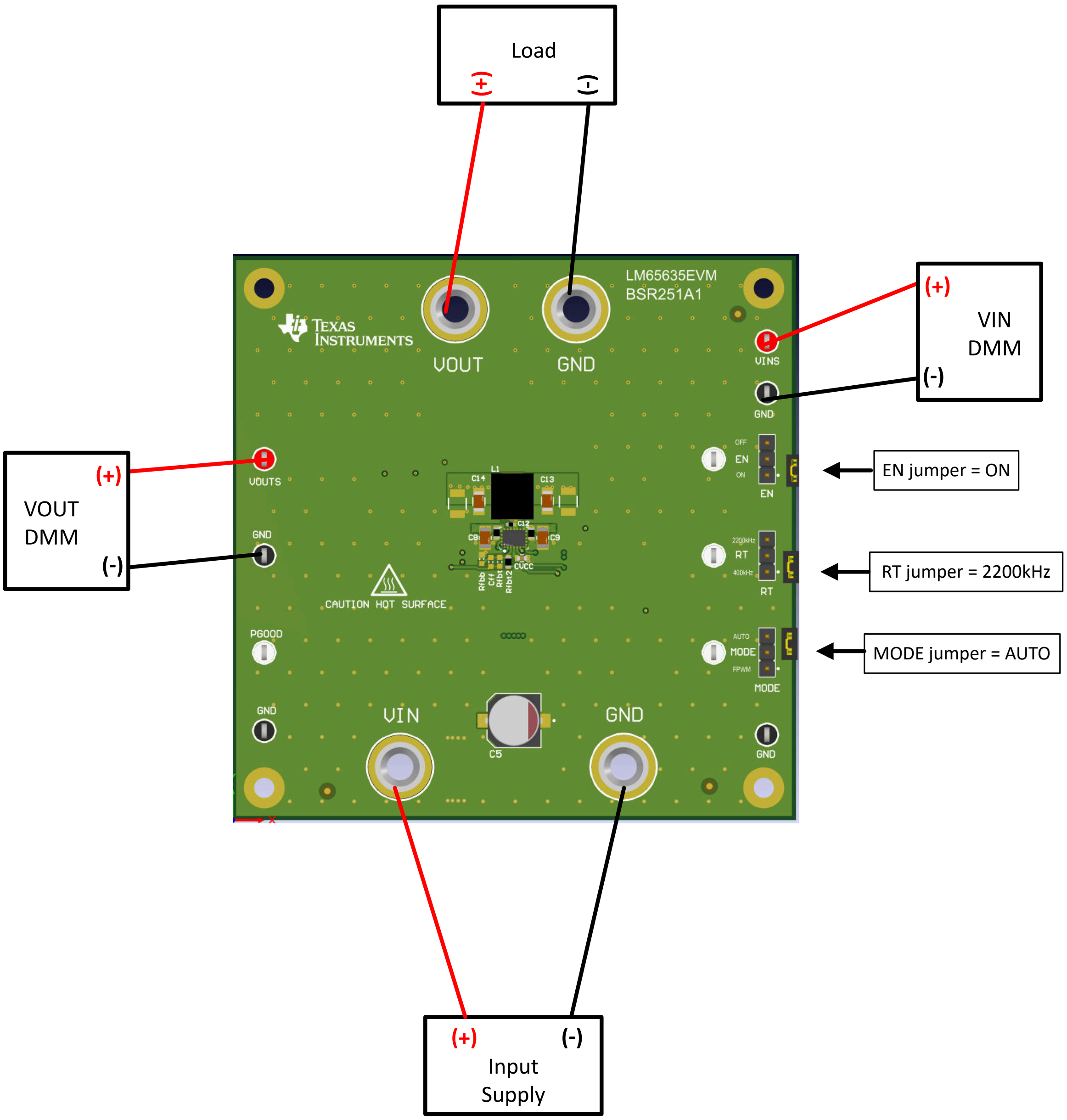


Figure 2-3. LM65635EVM Setup

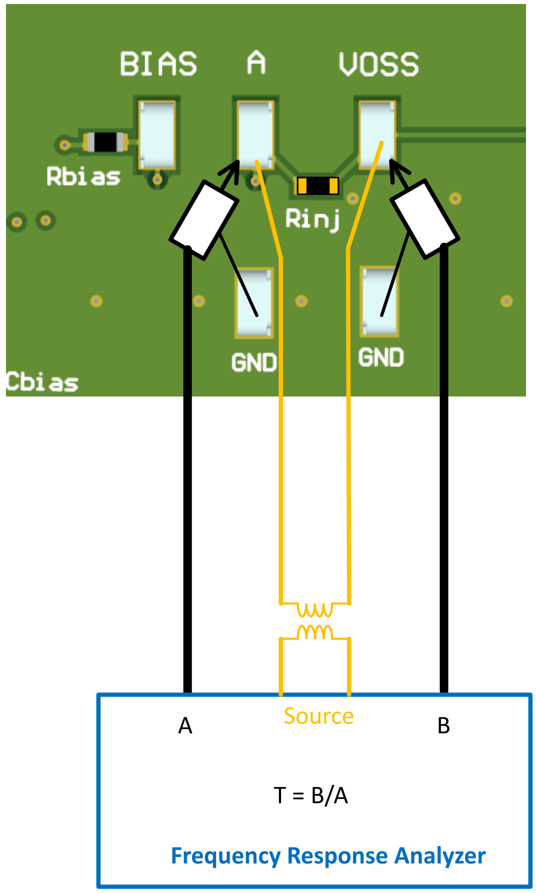


Figure 2-4. LM65635EVM Loop Response Connections

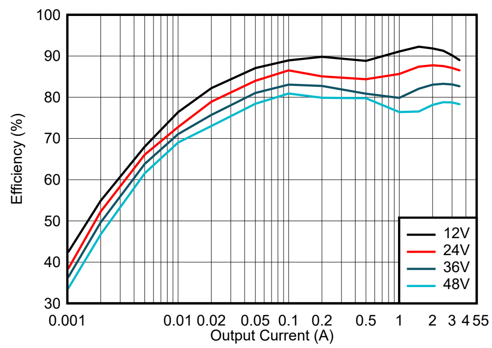
3 Implementation Results

3.1 Evaluation Setup

The LM65635VM was used to take the following data with the set-up shown in Figure 2-3.

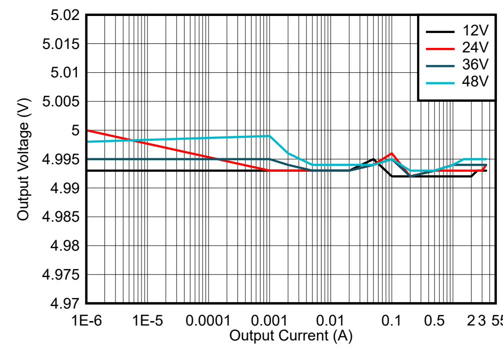
3.2 Performance Data and Results

Unless otherwise specified the following condition apply: T_A = 25ºC, V_{OUT} = 5V, V_{IN} = 24V, F_{SW} = 2200kHz.



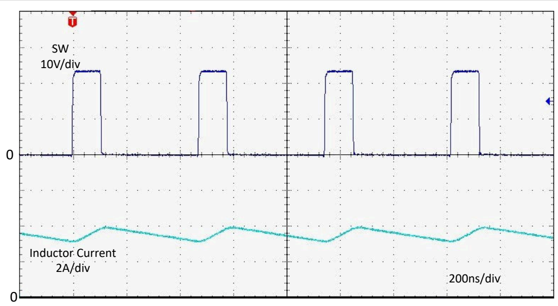
V_{OUT} = 5V 2200kHz, Auto Mode

Figure 3-1. Efficiency



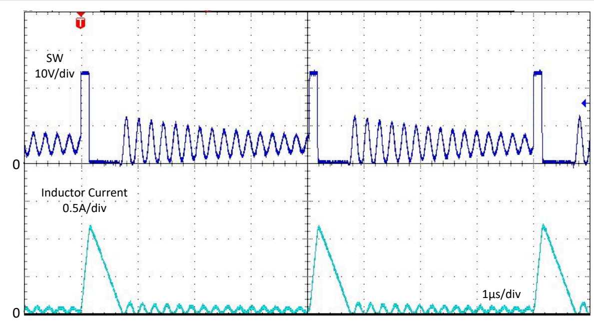
V_{OUT} = 5V 2200kHz, Auto Mode

Figure 3-2. Line and Load Regulation



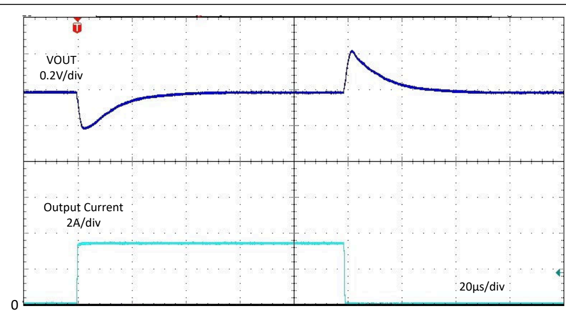
I_{OUT} = 3.5A V_{IN} = 24V V_{OUT} = 5V

Figure 3-3. Typical Switching Waveform in PWM



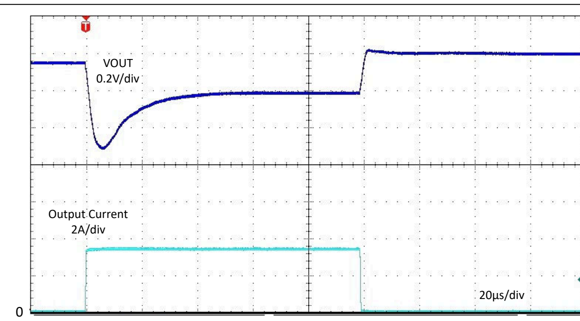
I_{OUT} = 100mA V_{IN} = 24V V_{OUT} = 5V

Figure 3-4. Typical Switching Waveform in PFM



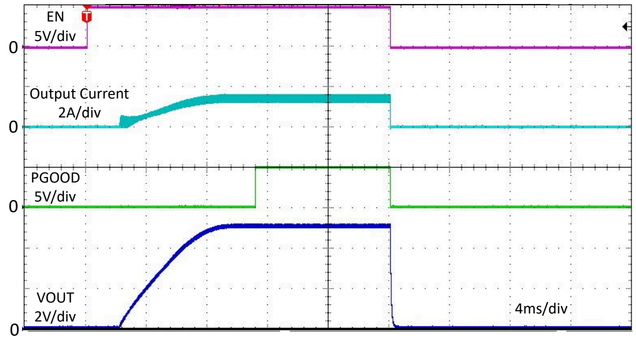
I_{OUT} = 0A to 3.5A V_{IN} = 24V FPWM Mode V_{OUT} = 5V

Figure 3-5. Load Transient



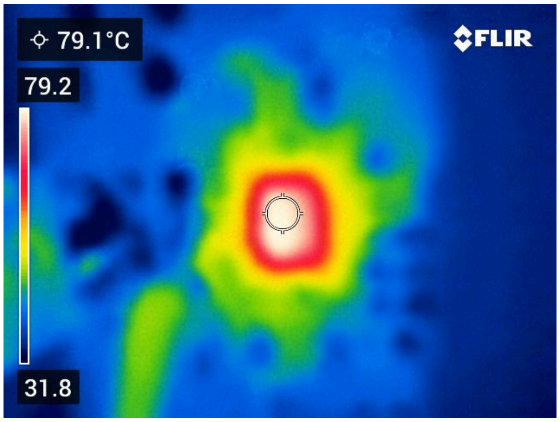
I_{OUT} = 0A to 3.5A V_{IN} = 24V AUTO Mode V_{OUT} = 5V

Figure 3-6. Load Transient



I_{OUT} = 3.5A V_{IN} = 24V AUTO Mode V_{OUT} = 5V

Figure 3-7. Start Up



V_{OUT} = 5V V_{IN} = 24V I_{OUT} = 3.5A

Figure 3-8. Thermal Image

4 Hardware Design Files

4.1 Schematics

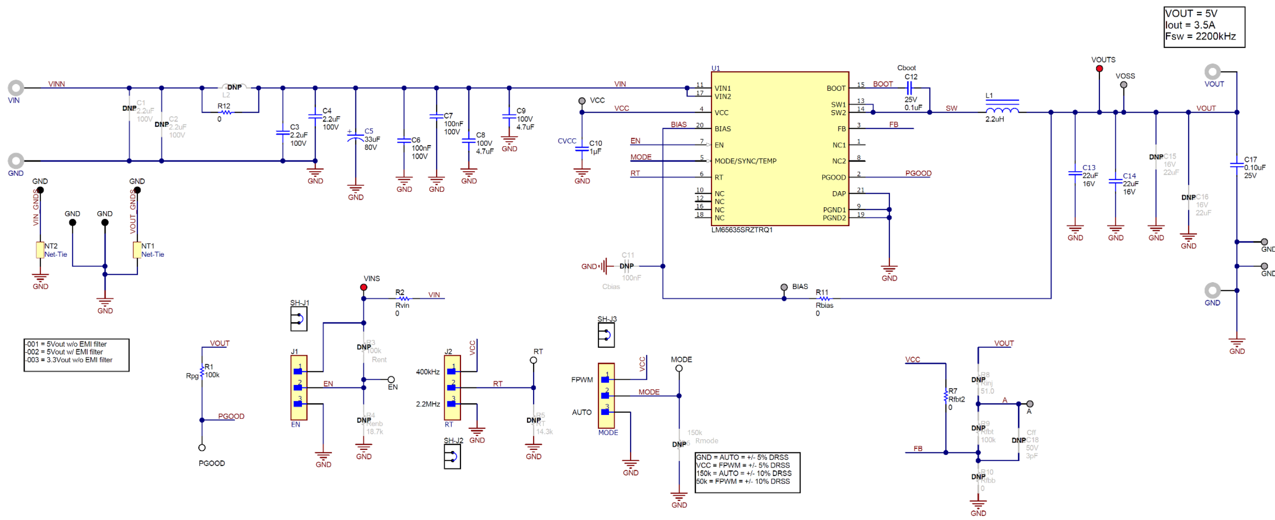


Figure 4-1. LM65635EVM Schematic

4.2 PCB Layouts

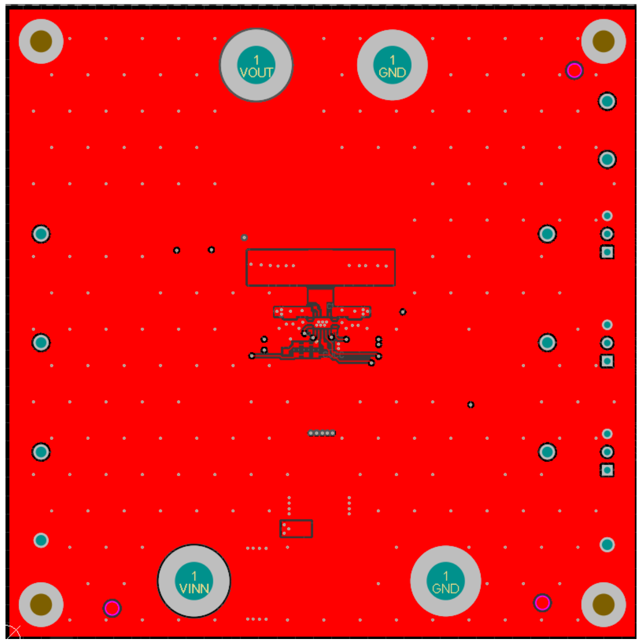


Figure 4-2. PCB Top Layer

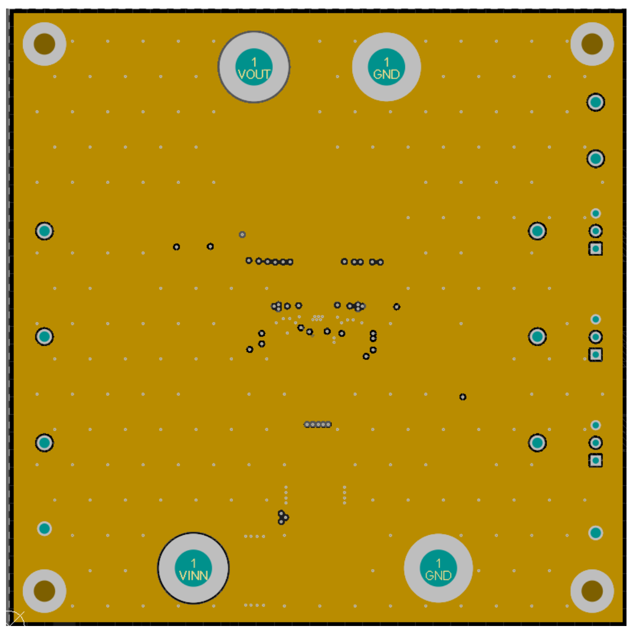


Figure 4-3. PCB Ground Layer (Directly Below Top Layer)

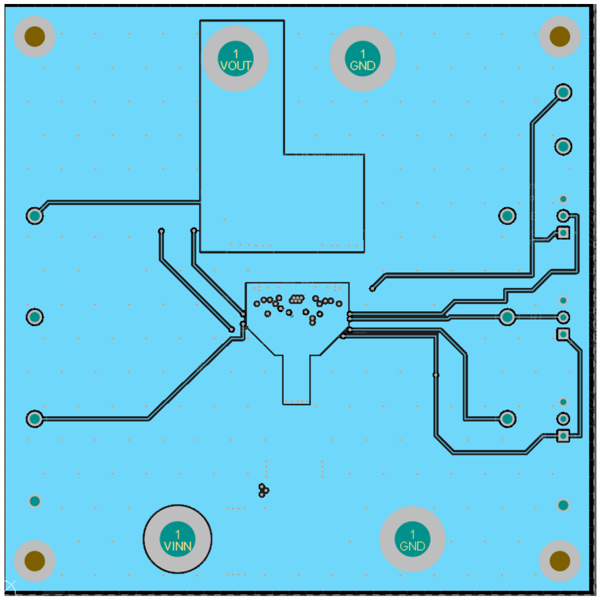


Figure 4-4. PCB Signal Layer

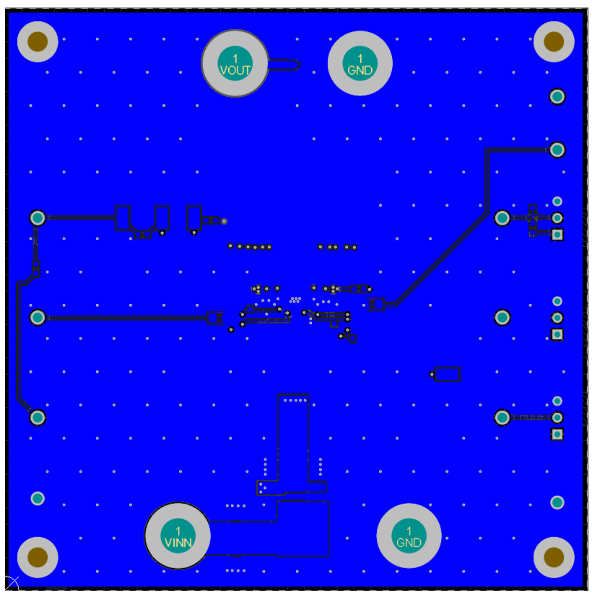


Figure 4-5. PCB Bottom Layer

4.3 Bill of Materials (BOM)

Table 4-1. LM65635EVM BOM (with options)

Designator	Alias	QTY	Value	Description	Part Number
C3, C4		2	2.2µF	Chip Multilayer Ceramic Capacitor for General Purpose 2.2uF ±20% 100V X7T SMD 0805	GRM21BD72A225ME01K
C5		1	33µF	33µF 80V Aluminum - Polymer Capacitors Radial, Can - SMD 45mOhm 2000 Hrs at 105°C	A767KS336M1KLAE045
C6, C7		2	0.1uF	CAP, CERM, 0.1µF, 100V,+/- 10%, X7R, AEC-Q200 Grade 1, 0603	HMK107B7104KAHT
C8, C9		2	4.7µF	4.7µF ±10% 100V Ceramic Capacitor X7S 1206 (3216 Metric)	GRM31CC72A475KE11L
C10	CVCC	1	1µF	Cap Ceramic 1uF 16V X7R 20% Pad SMD 0603 +125°C Automotive T/R	CGA3E1X7R1C105M080AC
C12	CBOOT	1	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 20%, X7R, 0402	C1005X7R1E104M050BB
C13, C14		2	22µF	Chip Multilayer Ceramic Capacitors for General Purpose, 1206, 22uF, X7R, 15%, 20%, 16V	GRM31CZ71C226ME15L
C17		1	100nF	Chip Multilayer Ceramic Capacitors for General Purpose, 0402, 0.10uF, X7R, 15%, 10%, 25V	GRM155R71E104KE14J
L1		1	2.2uH	Inductor, Shielded Drum Core, Powdered Iron, 2.2uH, 8A, 0.018 ohm, SMD	IHLP2525CZER2R2M01
R1	Rpg	1	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL
R2	Rvin	1	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00
R7	Rfbt2	1	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00
R11	Rbias	1	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00
R12		1	0	RES, 0, 1%, 0.5 W, 1206	5108
U1		1		Synchronous Step-Down Voltage Regulator, WQFN-FCRLF20	LM65635SRZTRQ1
C1, C2		0	2.2µF	Chip Multilayer Ceramic Capacitor for General Purpose 2.2uF ±20% 100V X7T SMD 0805	GRM21BD72A225ME01K
C11	Cbias	0	0.1uF	CAP, CERM, 0.1uF, 25V, +/- 10%, X7R, 0603	06033C104KAT2A
C15, C16		0	22uF	CAP, CERM, 22uF, 16V, +/- 20%, X7R, AEC-Q200 Grade 1, 1210	CGA6P1X7R1C226M250AC
C18	Cff	0	3pF	CAP, CERM, 3pF, 50V, +/- 8.3%, C0G/NP0, 0603	C0603C309C5GACTU
L2		0	1.5uH	Shielded Power Inductors 1.5µH 10.2A 10.5mOhm Max Nonstandard	XGL4030-152MEC
R3	Rent	0	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL
R9	Rfbt	0	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL
R4	Renb	0	18.7k	RES, 18.7 k, 1%, 0.1 W, 0603	RC0603FR-0718K7L
R5	RT	0	14.3k	RES, 14.3 k, 1%, 0.1 W, 0603	RC0603FR-0714K3L
R6	Rmode	0	150k	150kΩ ±1% 0.1W 0603 Thick Film Chip Resistor AEC-Q200 compliant	RMCF0603FT150K
R8	Rinj	0	51.0	RES, 51.0, 1%, 0.1 W, 0603	RC0603FR-0751RL
R10	Rfbb	0	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.