EVM User's Guide: LMG5126EVM

LMG5126 Evaluation Module

Description

The LMG5126EVM evaluation module showcases the features and performance of the LMG5126 wide input voltage synchronous GaN boost converter. This EVM is designed for ease of configuration, enabling the user to evaluate many different applications on the same module. The standard configuration is designed to provide a regulated output voltage of 24V and switching at 400kHz. The output voltage can be dynamically adjusted using the ATRK, DTRK pin.

Get Started

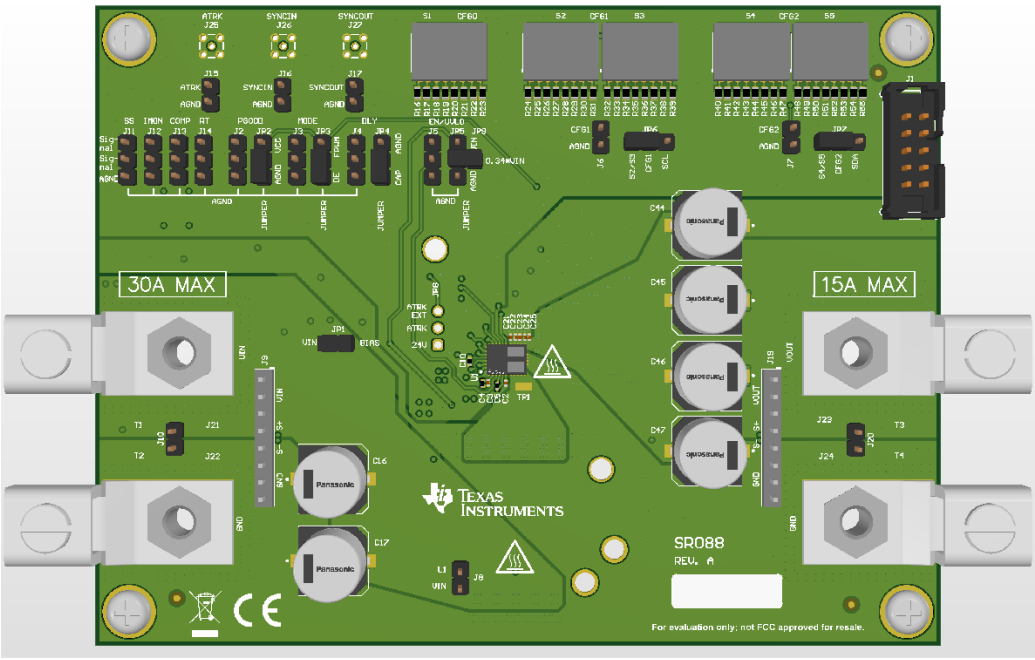
1. Connect EVM to power supply and load

Features

- Stackable
- Output voltage tracking
- Wide input voltage range
- Inductor current monitoring and average current limit
- Bypass mode, PGOOD indicator, and Dual Random Spread Spectrum (DRSS)
- Soft-start and peak current limit
- Optional synchronization (SYNC)
- Programmable line undervoltage lockout (UVLO) and hysteresis

Applications

- Automotive Class H audio power amplifier
- Automotive LED headlight



1 Evaluation Module Overview

1.1 Introduction

The LMG5126EVM evaluation module provides the design engineer with a fully functional synchronous boost converter to evaluate the LMG5126 synchronous GaN boost converter. The EVM operates over an input voltage range of 8V to 18V and can handle input transients up to 42V. The EVM provides an output voltage of 24V with 240W maximum power. Using a heat sink can increase the maximum power up to 400W. The output voltage can also be adjusted up to 60V using the ATRK/DTRK pin. Figure 1-1 shows the standard application circuit for the LMG5126EVM evaluation module.

1.2 Kit Contents

- One LMG5126EVM PCB assembly
- EVM Disclaimer Read Me

1.3 Specification

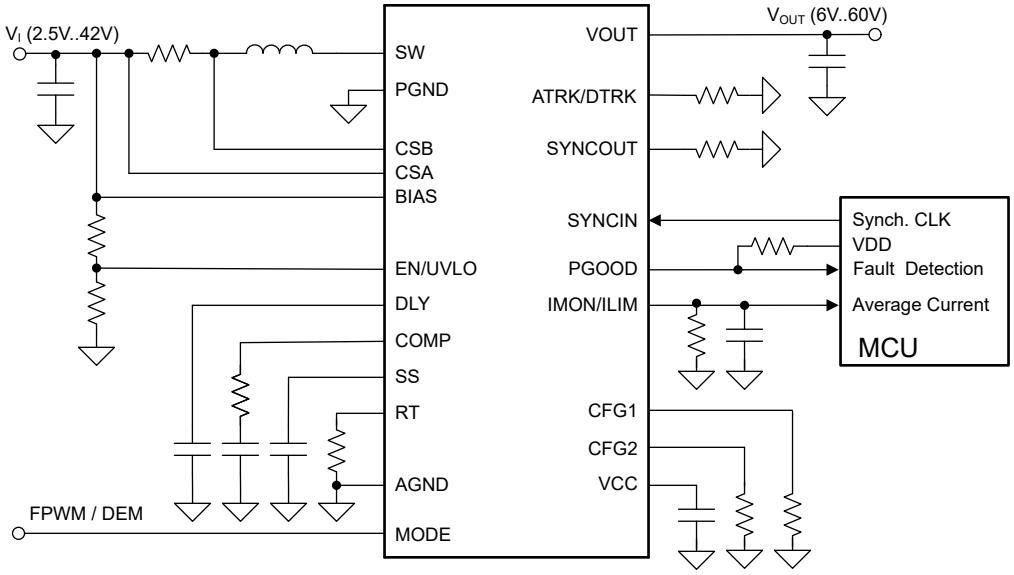


Figure 1-1. Typical Application Circuit

1.4 Device Information

The LMG5126 is a synchronous GaN boost converter. The device enters bypass mode when input voltage is higher than the desired output voltage.

- Wide input voltage range: 2.5V to 42V
- Output voltage: 6V to 60V
- Peak current regulation scheme
- Dynamic output voltage tracking
  - Analog and digital PWM tracking input
- Minimum quiescent current
  - Low shut down Iq of 50µA

2 Hardware

2.1 EVM Characteristics, Test Point, and Connector Description

This section describes the operating conditions for the EVM, as well as the configuration points of the evaluation module.

2.1.1 EVM Characteristics

Table 2-1 details the EVM characteristics.

Table 2-1. EVM Characteristics

Parameter	Test Condition		MIN	TYP	MAX	UNIT
INPUT VOLTAGE CHARACTERISITCS						
Input voltage range	Operation		8	14	18	V
	UVLO voltage levels	Turn-on		4.2		V
		Turn-off		3.2		V
Input current	No load operation V_{in} = 12V, V_{out} = 24V			1.7		mA
OUTPUT CHARACTERISITICS						
Output voltage	R_{ATRK} = 40.2kΩ			24		V
	R_{ATRK} = 75kΩ			45		V
Output power	Vin=16V, JP4 Pin1-2 shorted (average current limit feature deactivated)			240	400 (with heat sink)	W
SYSTEM CHARACTERISITCS						
Switching frequency				400		kHz
Full load efficiency	V_{IN} = 12V, V_{OUT} = 24V			95.6		%

2.1.2 EVM Connectors and Test Points

Section 2.1.2 describes the connection points of the evaluation module. Table 2-2 to Table 2-4 describe these connections. Table 2-2 lists the power connections of the evaluation module. These connections are intended to handle relatively large currents.

Table 2-2. Power Connections

Connector	Pin	Description
T1	VIN+	Positive input voltage power for the evaluation module
T2	VIN-	Negative input voltage power for the evaluation module
T3	VOUT+	Positive output voltage power for the evaluation module
T4	VOUT-	Negative output voltage power for the evaluation module
J9	VIN	Positive input voltage pin 1 - pin 3, negative input pin 6 - pin 8 (Pin 4 and 5 are only for sensing the input voltage)
J19	VOUT	Positive output voltage pin 1 - pin 3, negative output pin 6 - pin 8 (Pin 4 and 5 are only for sensing the output voltage)

Table 2-3 lists the EVM jumpers and test points that configure the LMG5126 and LMG51261 as desired. These jumpers can set different modes of operation or provide signals to different pins of the LMG5126 and LMG51261.

Table 2-3. Programmable Jumper Connections

Connector	Pins	Description	Default Connection
JP1	BIAS to VIN	Connecting BIAS pin of LMG5126 to the VIN	X
JP2	Pin1 to pin 2	Connecting PGOOD pin to the VCC enabling the power good indicator	X
	OPEN	If power good indicator is not used this pin can be left floating	

Table 2-3. Programmable Jumper Connections (continued)

Connector	Pins	Description	Default Connection
JP3	Pin 1 to pin 2	Connecting MODE pin to VCC to enable FPWM mode	
	Pin 2 to Pin 3	Connecting MODE pin to AGND to enable DEM	X
JP4	Pin1 to pin 2	Connecting DLY pin to a resistor to disable delay function and average current limit feature	
	Pin 2 to Pin 3	Connecting DLY pin to a capacitor to enable delay function	X
	Pin 2 to JP8	Connecting DLY pin to GND to disable delay function and average current limit feature	
JP5	Pin 1 to pin 2	UVLO/EN Connected to VIN as VIN ramps up the UVLO/EN pin also ramps up and LMG5126 is enabled once the UVLO threshold is surpassed.	
	Pin 2 to pin 3	Connects EN2 to AGND disabling LMG5126	
	Pin 2 to JP9	EN UVLO pin tied to resistor divider network consisting of R14, R15 and C51, where this resistor divider network sets the UVLO threshold for enabling LMG5126.	X
JP6	Pin 1 to Pin 2	Uses DIP switches S2 and S3 for CFG1 settings	X
	Pin 2 to Pin 3	Sets CFG1 as I2C pin for I2C version	
JP7	Pin 1 to pin 2	Uses DIP switches S4 and S5 for CFG2 settings	X
	Pin 2 to pin 3	Sets CFG2 as I2C pin for I2C version	
JP8	Pin 1 to pin 2	Connecting ATRK to 40.2k resistor to set Vout to 24V	X
	Pin 2 to pin 3	Connecting ATRK to J15 to supply from external	
J25	MMCX jack	Digital PWM signal input to the ATRK/DTRK Pin	
J26	MMCX jack	External syncing	
J27	MMCX jack	External SYNCOUT	

Table 2-4 indicates the dedicated voltage probe points of the EVM. These points are used to make measurements on the EVM.

Table 2-4. Probe Points

Sense Point	Name	Description
TP1	SW	Sense point for switch node of the Boost converter
J1	I2C	I2C measuring header with analog ground
J2	PGOOD	Power Good measuring header with analog ground
J3	MODE	MODE pin measuring header with analog ground
J4	DLY	DLY pin measuring header with analog ground
J5	UVLO	UVLO pin measuring header with analog ground
J6	CFG1	CFG1 pin measuring header with analog ground
J7	CFG2	CFG2 pin header with analog ground
J8	CS	Terminals of the current sense resistors
J10	Vin sense	Sense pins for the input voltage
J11	SS	SS pin measuring header with analog ground
J12	ILIM/IMON	ILIM/IMON pin header with analog ground
J13	COMP	COMP pin header with analog ground
J14	RT	RT pin header wit analog ground
J15	ATRK	ATRK pin header with analog ground
J16	SYNCIN	SYNCIN pin header with analog ground
J17	SYNCOUT	SYNCOUT pin header with analog ground
J18	PGND	Connection to PGND
J20	Vout sense	Sense pins for the output voltage

3 EVM Configurations

Section 3 shows modifications outside of the default configuration that are used to further evaluate the LMG5126.

3.1 Output Voltage Tracking

Section 3.1 describes how to setup the evaluation module for dynamic output voltage tracking.

The LMG5126EVM is typically configured to have fixed output voltage of 24V. Figure 3-1 shows the resistor from the ATRK, DTRK pin to the analog ground sets the output voltage to 24V. R_{ATRK} is R11 referring to the schematic.

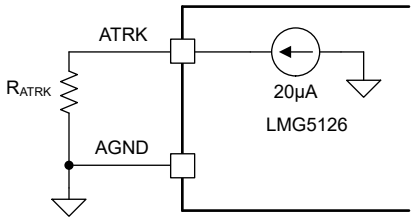


Figure 3-1. Fixed Output Voltage Configuration

To dynamically change the output voltage by analog signal, R_{ATRK} is removed and the ATRK, DTRK pin voltage is driven directly to change the output voltage. See the LMG5126 Wide-Input, 2.5MHz, Boost Converter data sheet for selecting the voltage range and setting the ATRK pin voltage to produce the desired output voltage. Figure 3-2 shows the configuration to change the output voltage dynamically by applying voltage or supplying analog signal.

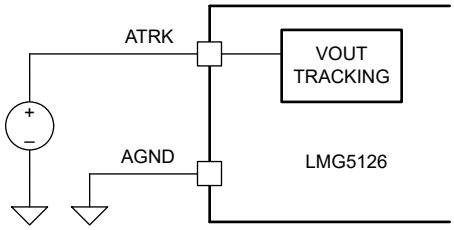


Figure 3-2. Variable Output Voltage Configuration via analog signal

Applying an analog voltage of around 0.8V and 1.5V to the ATRK, DTRK pin sets the output voltage of 24V and 45V respectively.

To dynamically change the output voltage digitally, R_{ATRK} is removed and the ATRK/DTRK pin is fed a PWM signal directly to change the output voltage. See the LMG5126 Wide-Input, 2.5MHz, Boost Converter data sheet for setting the PWM duty cycle of DTRK pin voltage to produce the desired output voltage. Figure 3-3 shows the configuration to change the output voltage dynamically by applying a digital signal.

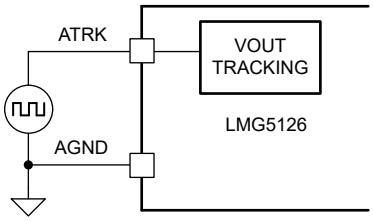


Figure 3-3. Variable Output Voltage Configuration via digital signal

Applying a PWM signal on the ATRK/DTRK pin with duty cycle of 32% and 60%, sets the output voltage to 24V and 45V, respectively.

3.2 Device Configuration

The LMG5126 can be configured using three pins SYNCOUT, CFG1 and CFG2. In the LMG5126EVM, these pins can be configured through the five DIP switches by selecting one of the 16 levels presented for each of the two configuration pins when the jumpers on connectors JP6 and JP7 are connecting CFG1 to DIP1 and CFG2 to DIP2, respectively. Each DIP switch has eight toggling switches that either connects or disconnects a fixed valued resistor from the configuration pins. At one time, there can be only one of the 16 levels, for each configuration pin, selected to configure the LMG5126 as seen below and according to the information given on the LMG5126 Wide-Input, 2.5MHz, Boost Converter data sheet.

The SYNCOUT-pin defines the overvoltage protection level and the ATRK, DTRK-pin 20uA current used for output voltage programming by resistor.

Table 3-1. SYNCOUT-Pin Settings

Level	OVP level	20µA ATRK current
1	25V	ON
2	25V	OFF
3	35V	ON
4	35V	OFF
5	50V	ON
6	50V	OFF
7	65V	ON
8	65V	OFF

The CFG1-pin setting defines the clock dithering, the peak current limit (ICL_latch) operation, current sense voltage level and the gate driver strength.

Table 3-2. CFG1-Pin Settings

Level	Spread Spectrum	Sense Voltage	ICL_{latch}	Gate Drive Strength
1	DRSS ON	30mV	Enabled	Weak
2	DRSS ON	60mV	Enabled	Weak
3	DRSS ON	30mV	Enabled	Strong
4	DRSS ON	60mV	Enabled	Strong
5	DRSS ON	30mV	Disabled	Weak
6	DRSS ON	60mV	Disabled	Weak
7	DRSS ON	30mV	Disabled	Strong
8	DRSS ON	60mV	Disabled	Strong
9	DRSS OFF	30mV	Enabled	Weak
10	DRSS OFF	60mV	Enabled	Weak
11	DRSS OFF	30mV	Enabled	Strong
12	DRSS OFF	60mV	Enabled	Strong
13	DRSS OFF	30mV	Disabled	Weak
14	DRSS OFF	60mV	Disabled	Weak
15	DRSS OFF	30mV	Disabled	Strong
16	DRSS OFF	60mV	Disabled	Strong

The CFG2-pin defines if the device is configured for a single-or multichip setup, which then defines the operation mode of SYNCIN and SYNCOUT pin. PGOOD OVP can also be set.

Table 3-3. CFG2-Pin Settings

Level	Single or Multichip	SYNCOUT	SYNCIN	PGOOD OVP Enable
1	Single	OFF	OFF	ON
2	Single	OFF	ON	ON
3	Primary	90°	ON	ON
4	Primary	120°	ON	ON
5	Primary	180°	ON	ON
6	Secondary	OFF	ON	ON
7	Secondary	90°	ON	ON
8	Secondary	120°	ON	ON
9	Single	OFF	OFF	OFF
10	Single	OFF	ON	OFF
11	Primary	90°	ON	OFF
12	Primary	120°	ON	OFF
13	Primary	180°	ON	OFF
14	Secondary	OFF	ON	OFF
15	Secondary	90°	ON	OFF
16	Secondary	120°	ON	OFF

S1 through S5 are 8-bit DIP switches.

- S1 is for SYNCOUT
  - S1-position 1 selects level 1,..., S1-position 8 selects Level 8
- S2 and S3 are for CFG1
  - S2-position 1 selects level 1,..., S2-position 8 selects Level 8
  - S3-position 1 selects level 9,..., S3-position 8 selects Level 16
- S4 and S5 are for CFG2
  - S4-position 1 selects level 1,..., S4-position 8 selects Level 8
  - S5-position 1 selects level 9,..., S5-position 8 selects Level 16

Select position 7 for S1 by default to set level 7 for SYNCOUT:

- OVP level 65V
- 20uA ATRK current source ON

Select position 2 for S3 by default to set level 10 for CFG1:

- DRSS OFF
- Sense voltage = 60mV
- ICL_latch enabled
- Gate driver strength: weak

Select position 1 for S4 by default to set level 1 for CFG2:

- Single chip operation
- SYNCOUT OFF
- SYNCIN OFF
- PGOOD OVP Enable ON

4 Implementation Results

4.1 Test Setup and Procedure

4.1.1 Test Setup

Figure 4-1 shows the required test setup to evaluate the LMG5126EVM

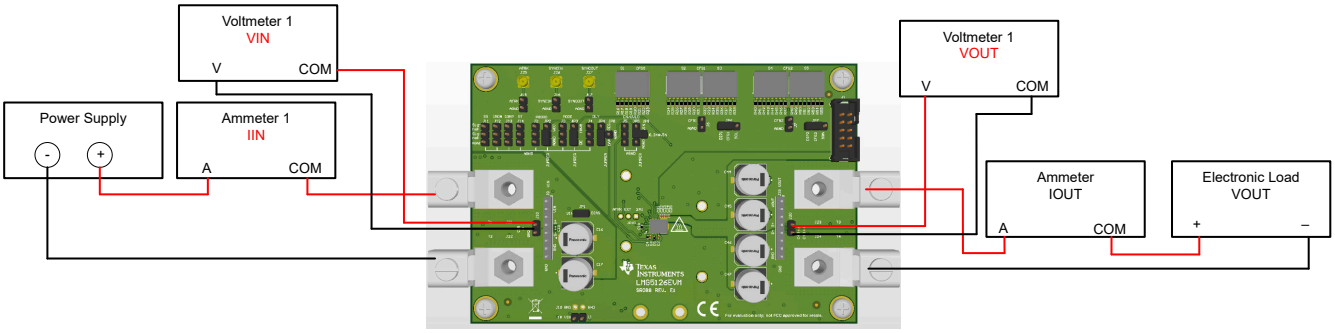


Figure 4-1. EVM Test Setup

4.1.2 Test Procedure and Equipment

The following test equipment is needed to test the LMG5126EVM:

- Power supply: the input voltage source (V_{IN}) is a variable supply. The power supply needs to be at least 20V and be able to supply more than 30A of current. Turn off the power supply. Connect the positive output of the power supply to T1 and the negative output to T2.
- Electronic load: connect the load to T3 for the positive connection and T4 for the negative connection. The electronic load needs to be able to dissipate 350W at 60V.

Multimeters: for DC measurements, connected as shown in Figure 6-1.

- – Voltmeter 1 (V_{IN}): Capable of measuring the input voltage range up to at least 20V
  – Voltmeter 2 (V_{OUT}): Capable of measuring output voltage of 60V
  – Ammeter 1 (I_{IN}): Capable of 30A DC measurement. A shunt resistor can also be used to measure the input current
  – Ammeter 2 (I_{OUT}): Capable of at least 15A DC measurement
- Oscilloscope: minimum of 20MHz bandwidth and 10x probes.
- Set the power supply voltage to 12V and the electronic load to 0.1A. The electronic load voltage must be in regulation with a nominal 24V output.
- Slowly increase the load while monitoring the output voltage between J23-VOUT and J24-GND. The voltage must remain in regulation with a nominal 24V output as the load is increased up to 7A.
- Slowly sweep the input voltage from 8V to 18V. The output voltage must remain in regulation with a nominal 24V output.
- Slowly sweep the input voltage from 18V to 8V. The output voltage must remain in regulation with a nominal 24V output.

4.1.3 Precautions

WARNING

Board surface and heat sink is hot. Do not touch Contact can cause burns.

5 Application Curves

5.1 Efficiency

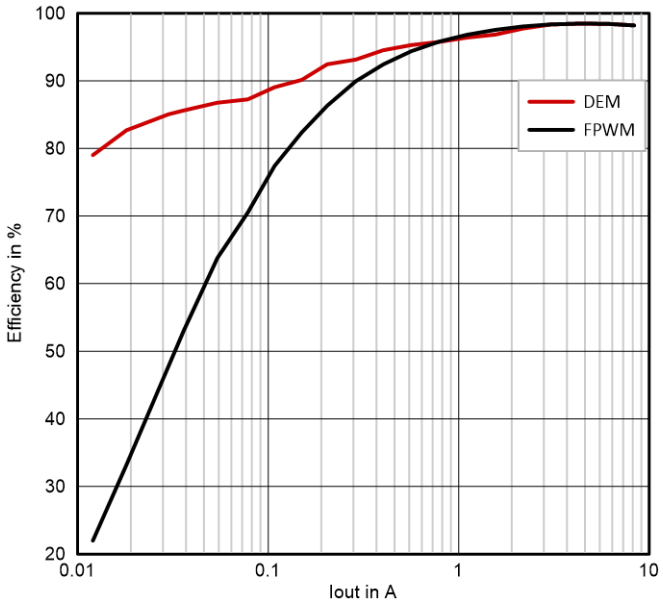


Figure 5-1. Efficiency vs. Output Current, Vin=14.4V, Vout=24V

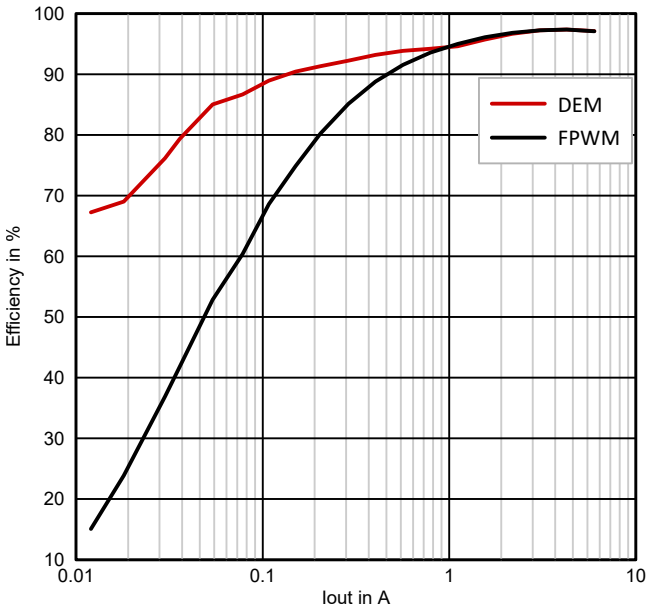


Figure 5-2. Efficiency vs. Output Current, Vin=14.4V, Vout=45V

5.2 Steady State Waveforms

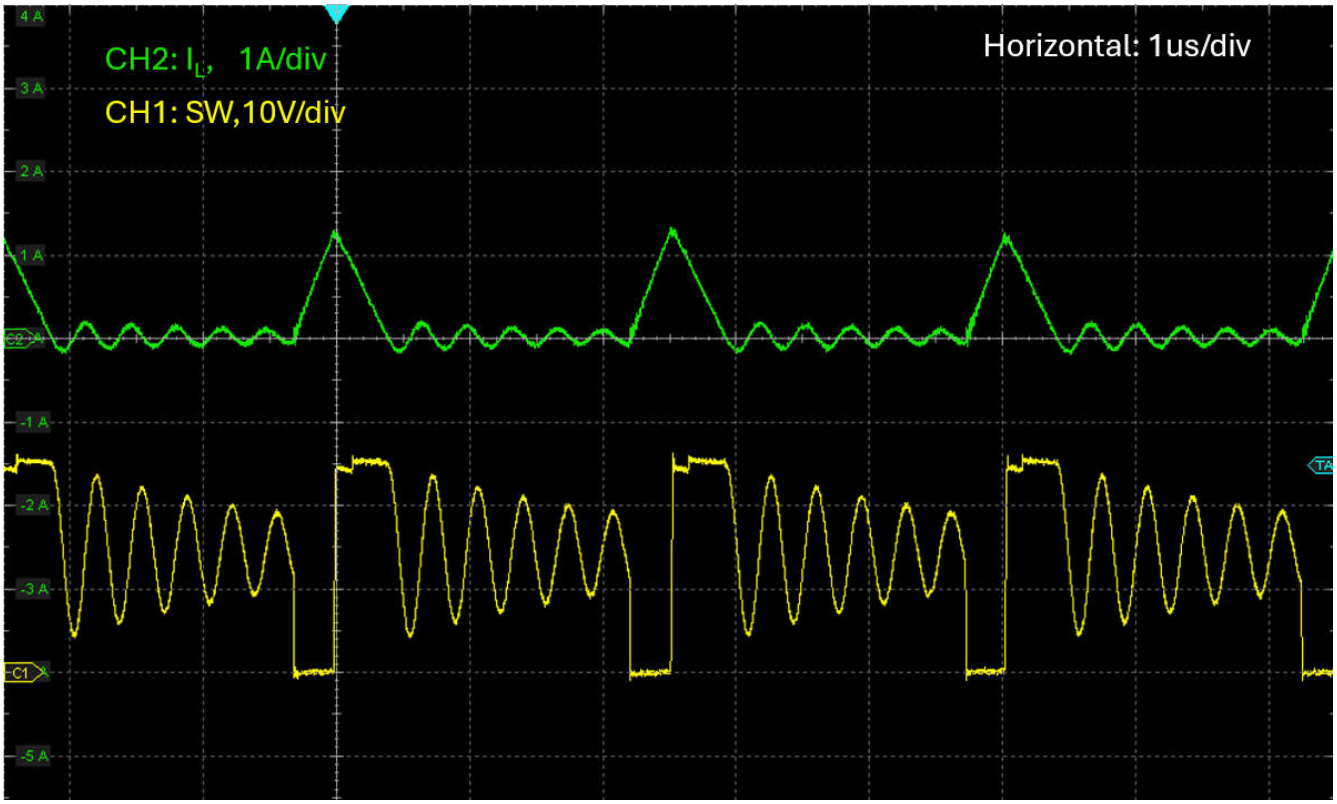


Figure 5-3. V_{in} = 14.4V, V_{out} = 24V, DEM, I_{load}= 0.1A

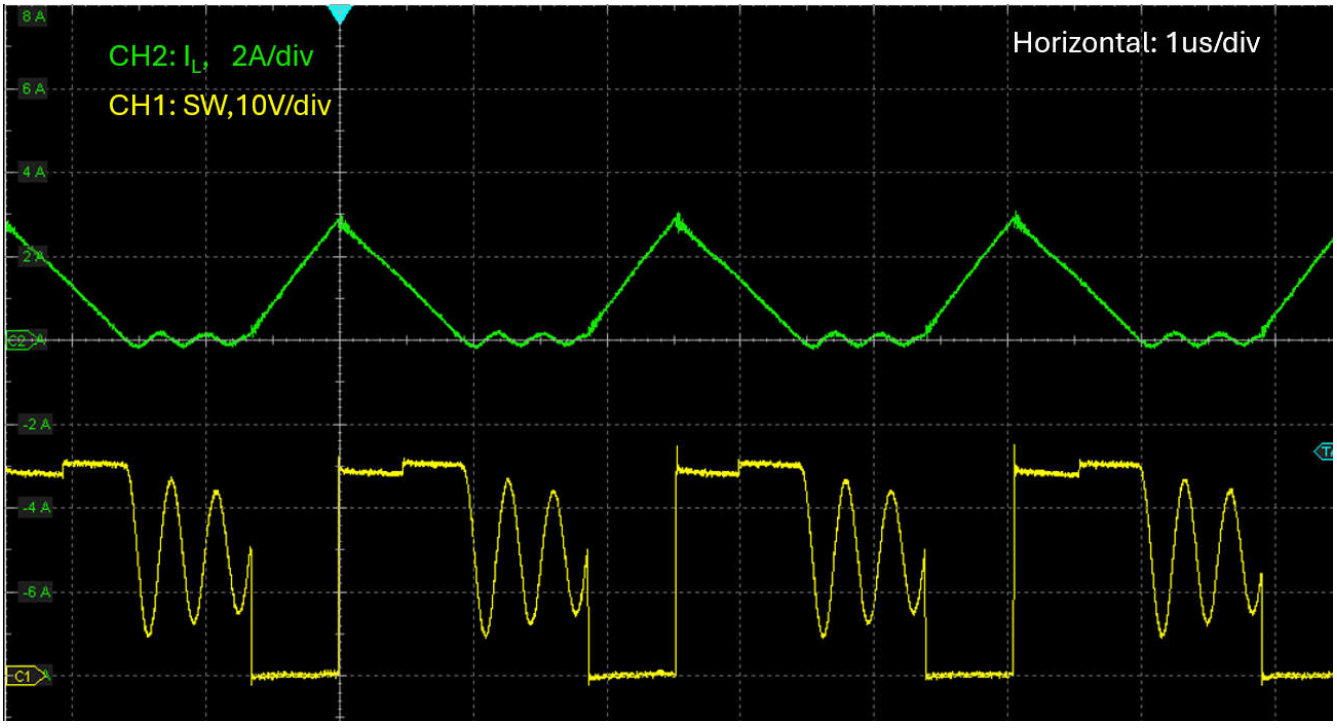


Figure 5-4. V_{in} = 14.4V, V_{out} = 24V, DEM, I_{load}= 0.5A

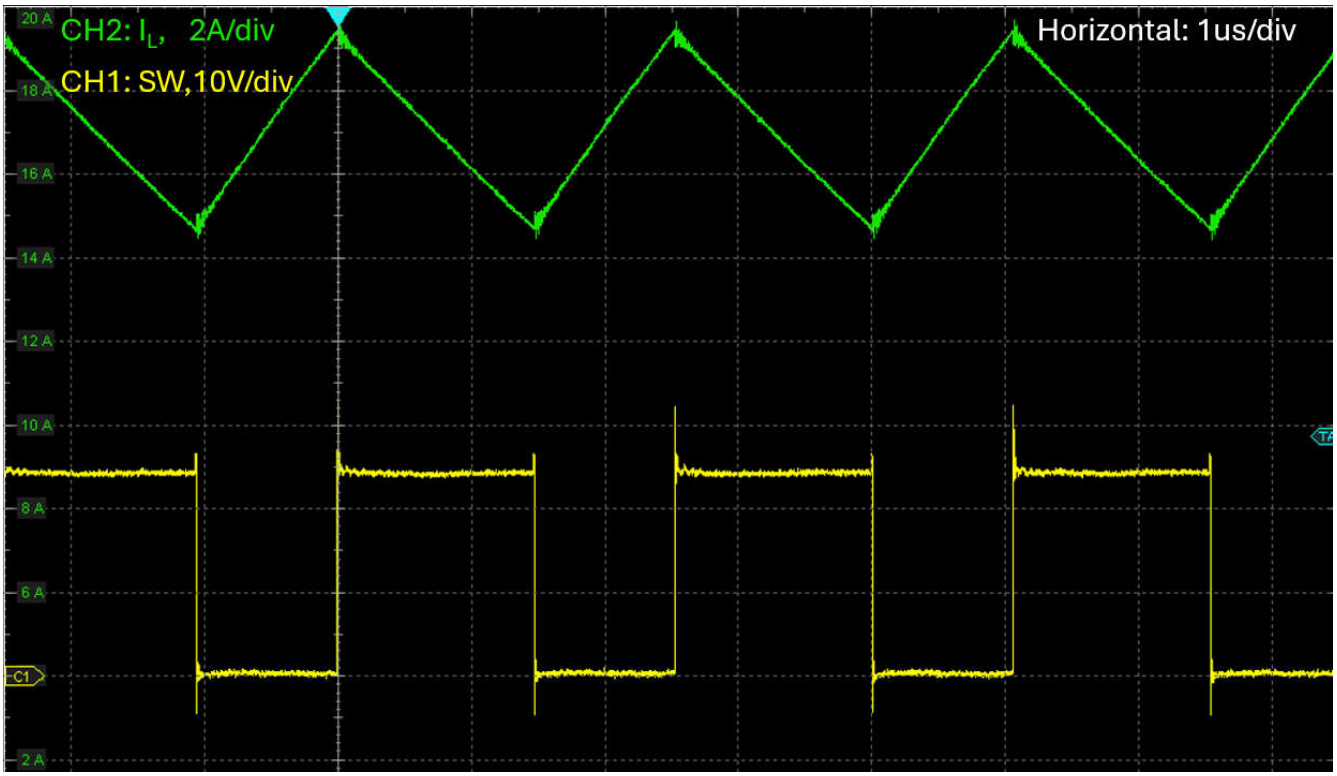


Figure 5-5. V_{in} = 14.4V, V_{out} = 24V, DEM, I_{load}= 10A

6 Hardware Design Files

6.1 Schematic

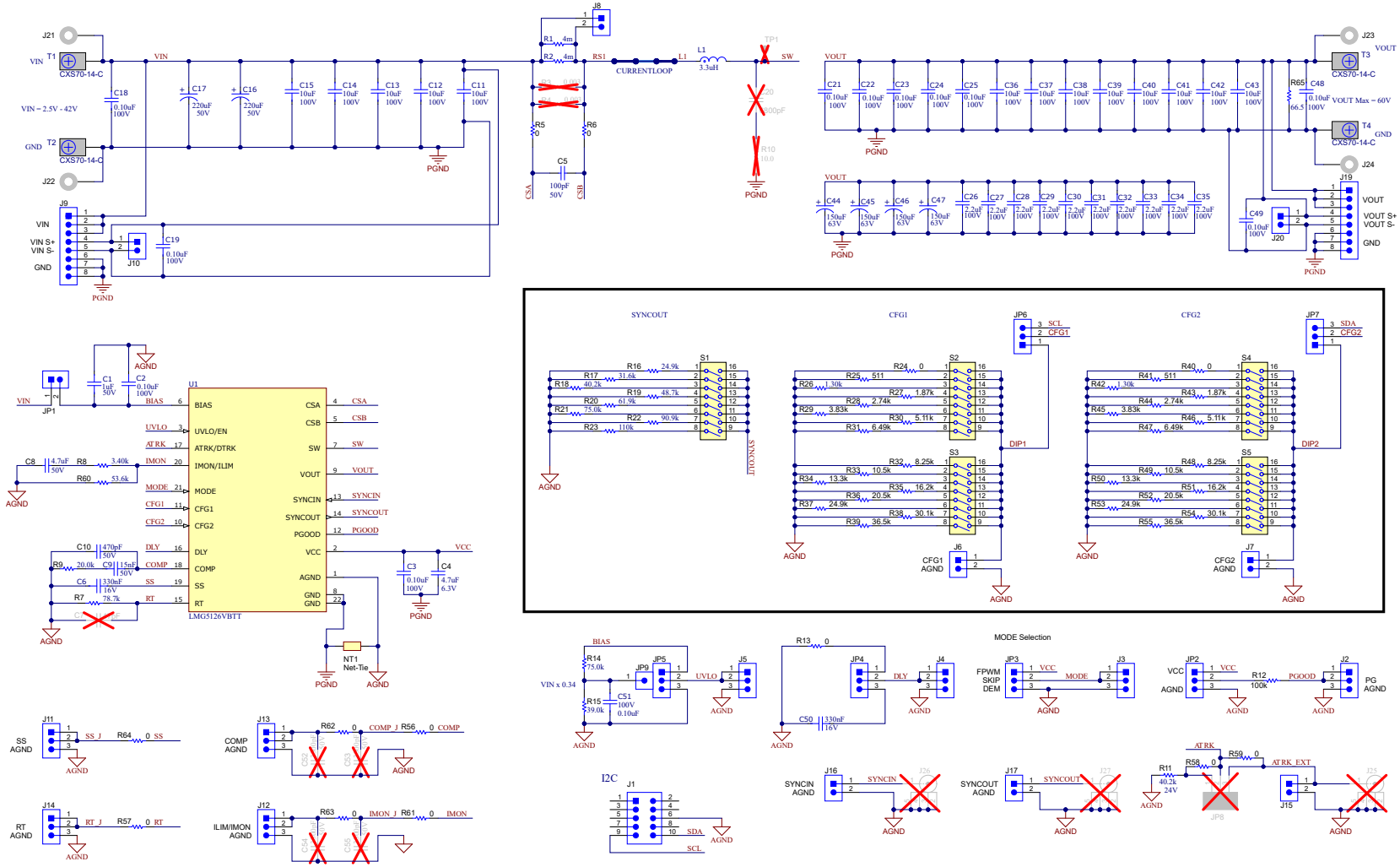


Figure 6-1. Schematic

6.2 PCB Layers

Figure 6-2 through Figure 6-3 illustrate the EVM PCB layout.

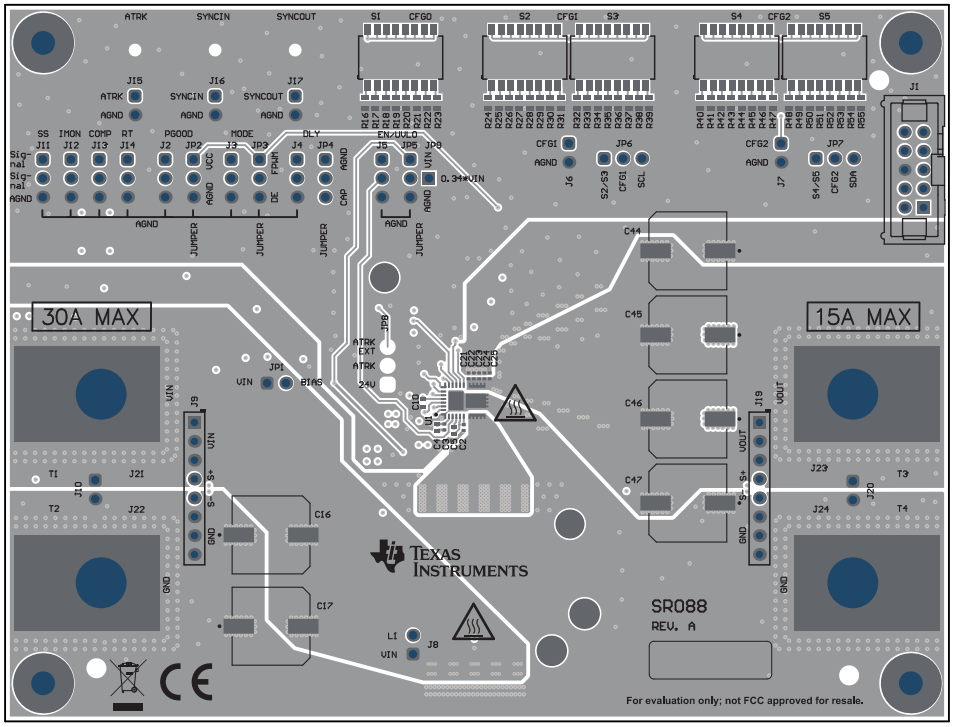


Figure 6-2. Top Silk Screen

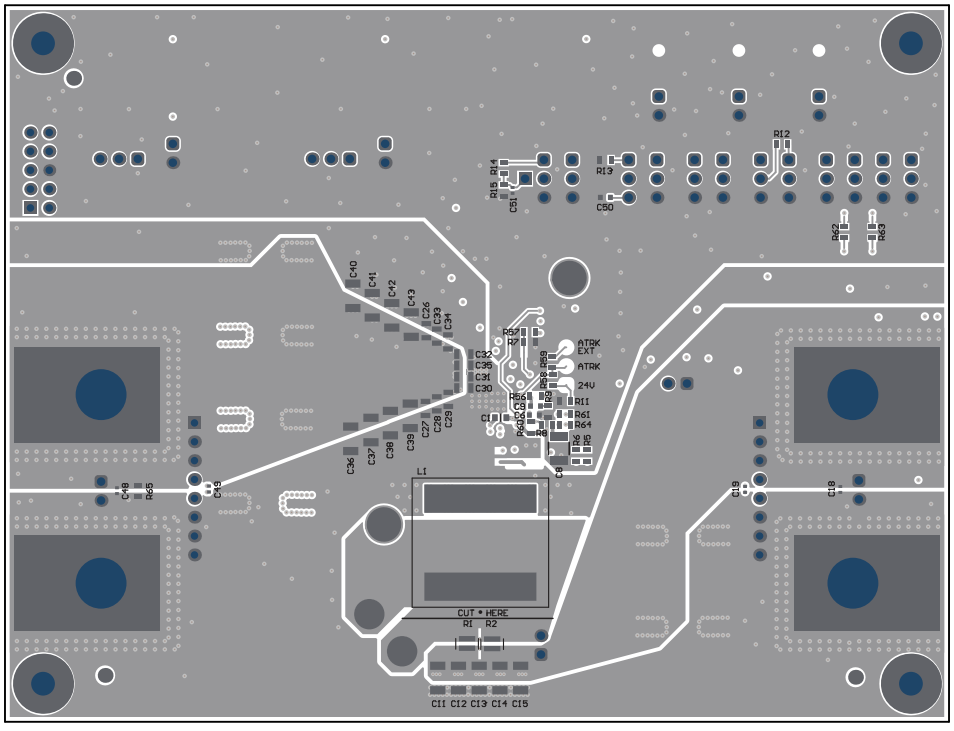


Figure 6-3. Bottom Silk Screen

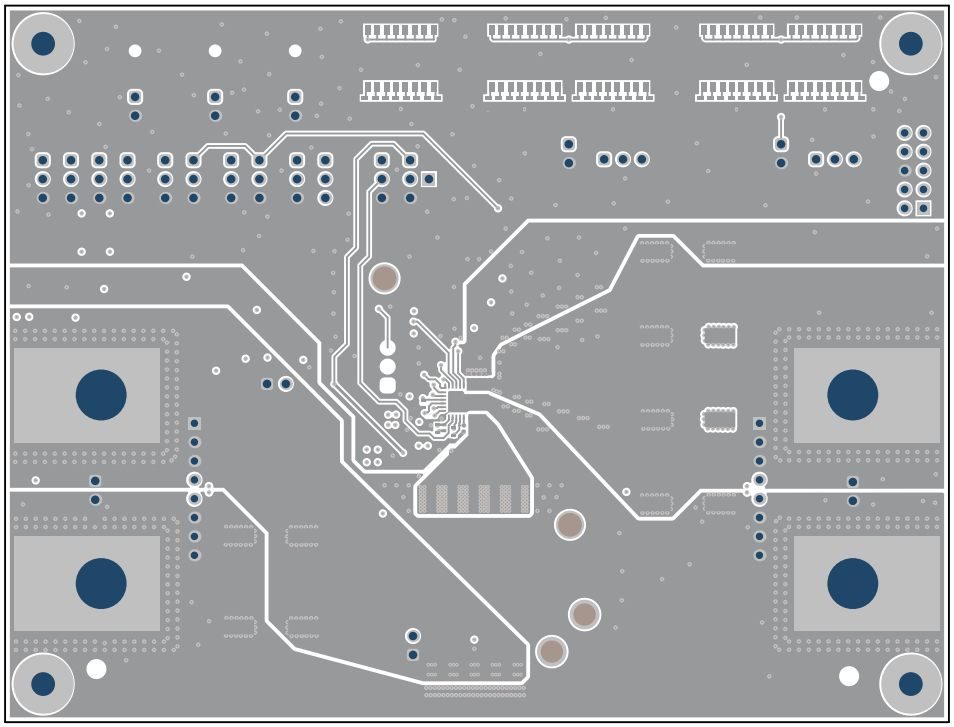


Figure 6-4. Top Layer

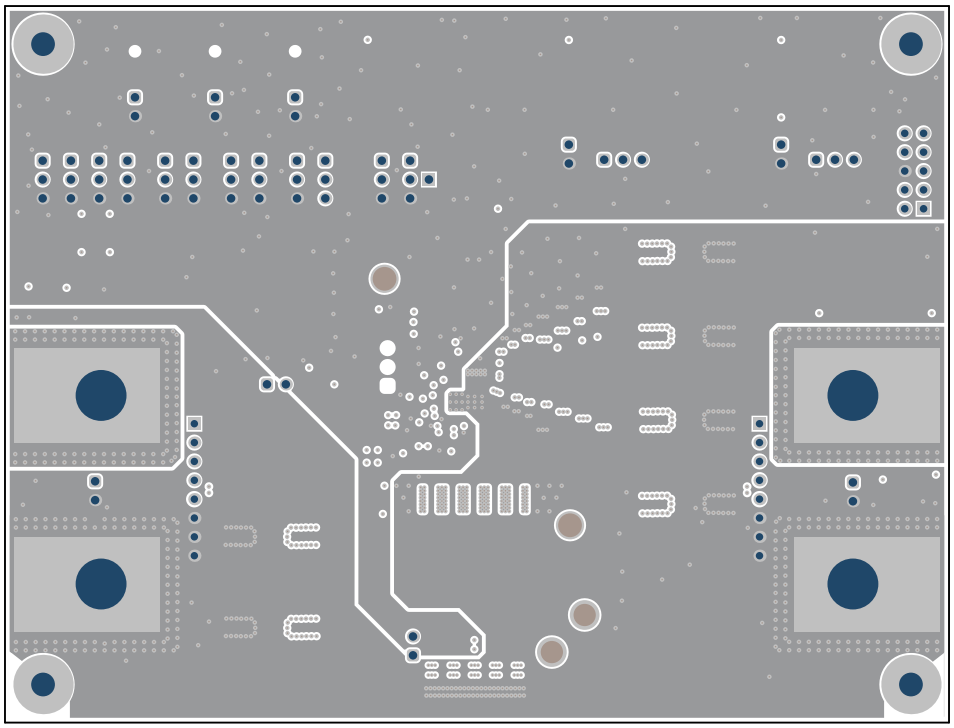


Figure 6-5. Signal Layer 1

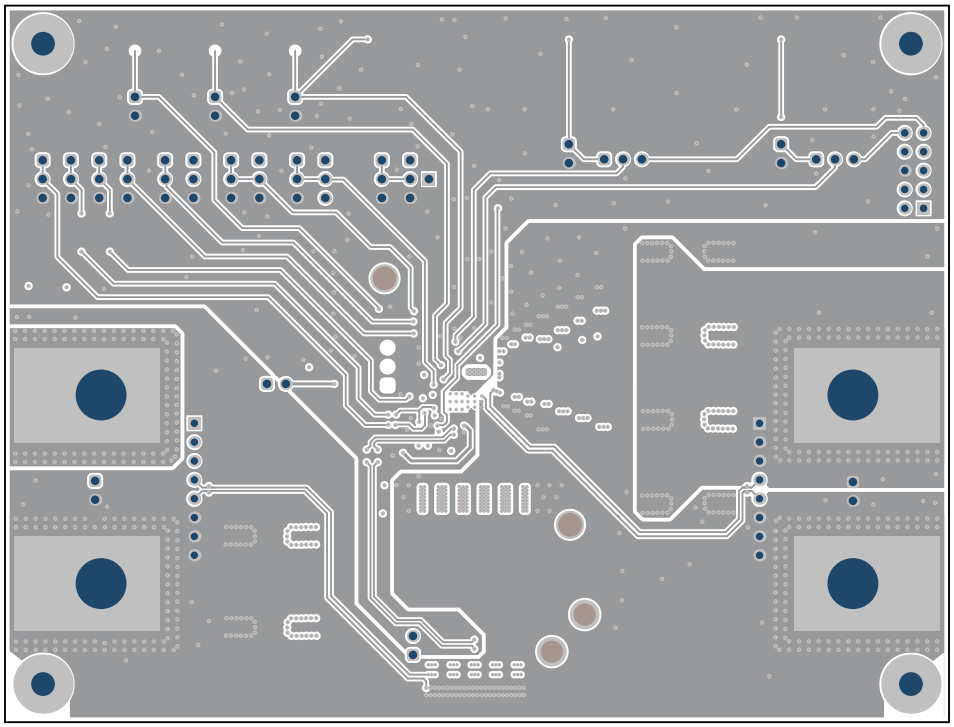


Figure 6-6. Signal Layer 2

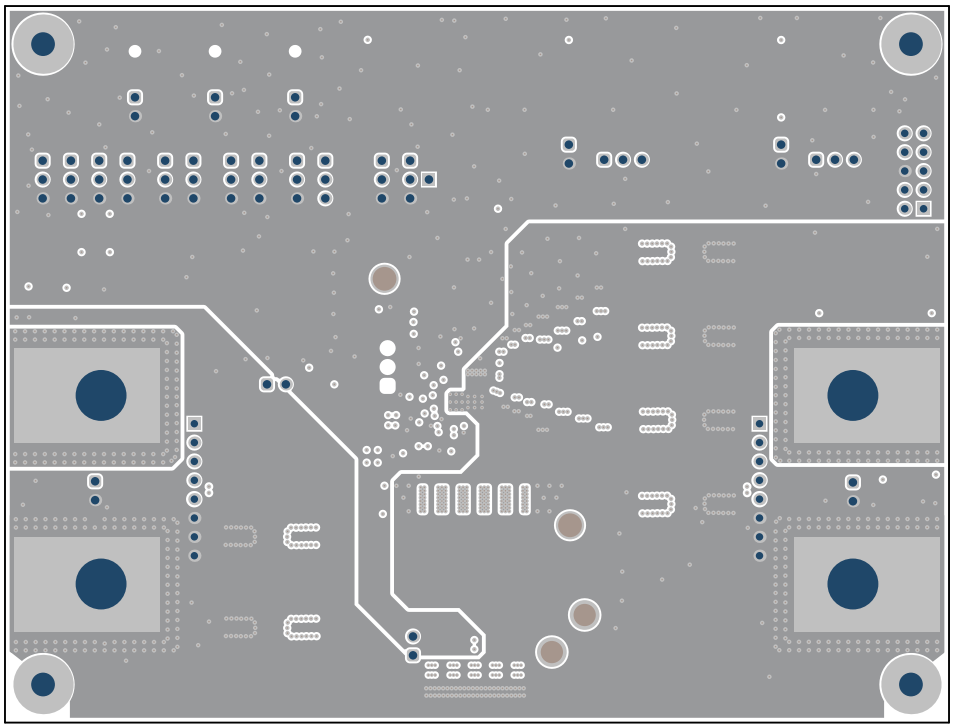


Figure 6-7. Signal Layer 3

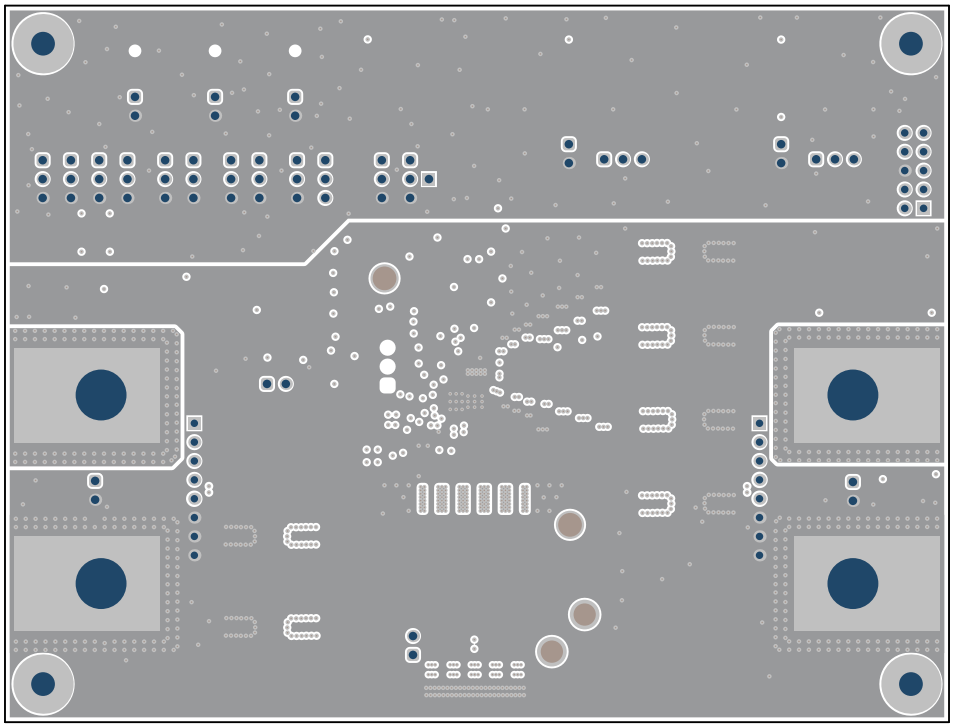


Figure 6-8. Signal Layer 4

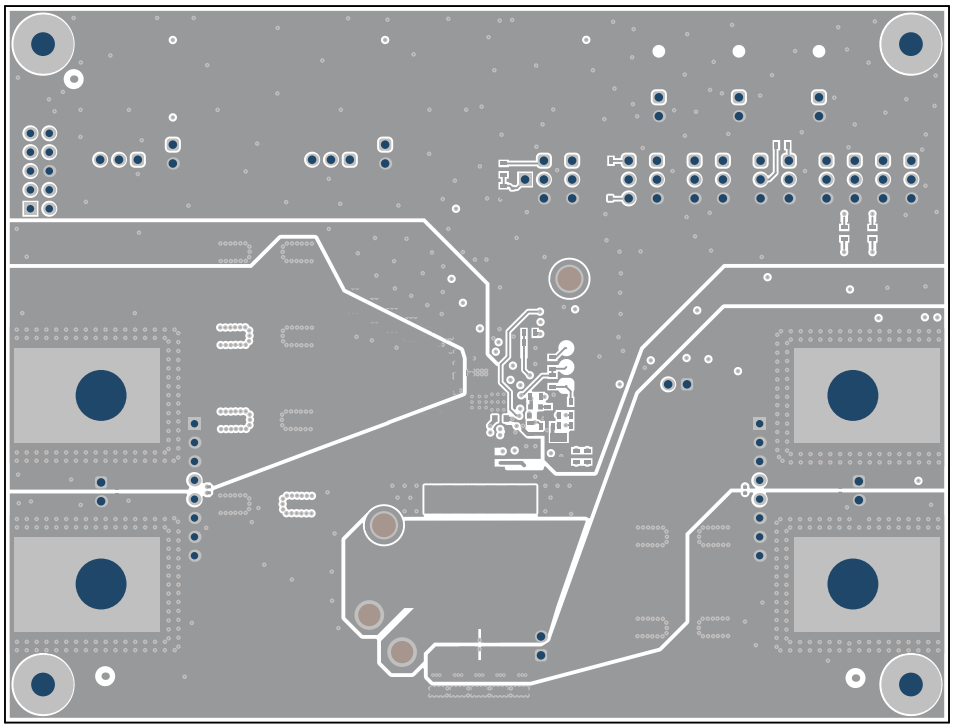


Figure 6-9. Bottom Layer

6.3 Bill of Materials

Section 6.3 details the EVM bill of materials.

Table 6-1. Bill of Materials

Designator	Quantity	Value	PartNumber	Manufacturer	Description
C1	1	1µF	GCM188D71H105KE36J	Murata	1 µF ±10% 50V Ceramic Capacitor X7T 0603 (1608 Metric)
C2, C3, C18, C19, C21, C22, C23, C24, C25, C48, C49, C51	12	100nF	GRM155R62A104ME14D	Murata	Chip Multilayer Ceramic Capacitors for General Purpose, 0402, 0.10uF, X5R, 15%, 20%, 100V
C4	1	4.7uF	GRM155R60J475ME87D	MuRata	CAP, CERM, 4.7uF, 6.3V, +/- 20%, X5R, 0402
C5	1	100pF	CGA2B2C0G1H101J050BA	TDK	CAP, CERM, 100pF, 50V, +/- 5%, C0G/NP0, AEC-Q200 Grade 1, 0402
C6, C50	2	330nF	GRT188R71C334KE01D	Murata	Multi-Layer Ceramic Capacitor 330nF 16V X7R ±10% 0603 Paper T/R
C8	1	4.7uF	CGA6P3X7R1H475K250AB	TDK	CAP, CERM, 4.7uF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210
C9	1	15nF	GCD188R71H153KA01D	Murata	Chip Multilayer Ceramic Capacitors for Automotive, 0603, 15000pF, X7R, 15%, 10%, 50V, Grade 1
C10	1	470pF	GRM1555C1H471JA01D	MuRata	CAP, CERM, 470pF, 50V, +/- 5%, C0G/NP0, 0402
C11, C12, C13, C14, C15, C36, C37, C38, C39, C40, C41, C42, C43	13		GRM32EC72A106KE05L	Murata	10µF ±10% 100V Ceramic Capacitor X7S 1210 (3225 Metric)
C16, C17	2	220µF	EEHZU1H221P	Panasonic	Aluminum Hybrid Polymer Capacitors 220uF 20% 50V Life 4000Hours AEC-Q200 RADIAL SMT

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	PartNumber	Manufacturer	Description
C26, C27, C28, C29, C30, C31, C32, C33, C34, C35	10	2.2µF	GRM21BD72A225ME01K	Murata	Chip Multilayer Ceramic Capacitor for General Purpose 2.2uF ±20% 100V X7T SMD 0805
C44, C45, C46, C47	4	150µF	EEHZU1J151P	Panasonic	Aluminum Hybrid Polymer Capacitors 150uF 20% 63V Life 4000Hours AEC-Q200 RADIAL SMT
FID4, FID5, FID6	3		N/A	N/A	Fiducial mark. There is nothing to buy or mount.
H1, H2, H3, H4	4		NY PMS 440 0025 PH	B&F Fastener Supply	Machine Screw, Round, #4-40x 1/4, Nylon, Philips panhead
J1	1		N2510-6002-RB	3M	Header (shrouded), 100mil, 5x2, High-Temperature, Gold, TH
J21, J22, J23, J24	4		108-0740-001	Cinch Connectivity	Standard Banana Jack, Uninsulated, 15A
JP9	1		61300111121	Wurth Elektronik	Header, 2.54mm, 1x1, Gold, TH
L1	1	3.3uH	XGL1712-332MED	Coilcraft	Shielded Power Inductors 3.3µH ±20% 41.7A 1.9mOhms
R1, R2	2	4m	KRL2012E-M-R004F-T5	Susumu	4 mOhms ±1% 1W Chip Resistor Wide 0805 (2012 Metric), 0508 Automotive AEC-Q200, Current Sense Metal Foil
R5, R6, R62, R63	4	0	ERJ-3GEY0R00V	Panasonic	RES, 0, 5%, 0.1W, AEC-Q200 Grade 0, 0603
R7	1	78.7k	CRCW060378K7FKEA	Vishay-Dale	RES, 78.7k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R8	1	3.40k	CRCW06033K40FKEA	Vishay-Dale	RES, 3.40k, 1%, 0.1W, AEC-Q200 Grade 0, 0603

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	PartNumber	Manufacturer	Description
R9	1	20.0k	CRCW060320K0FKEA	Vishay-Dale	RES, 20.0k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R11, R18	2	40.2k	CRCW060340K2FKEA	Vishay-Dale	RES, 40.2k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R12	1	100k	CRCW0603100KFKEA	Vishay-Dale	RES, 100k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R13, R24, R40, R56, R57, R58, R59, R61, R64	9	0	RMCF0603ZT0R00	Stackpole Electronics Inc	RES, 0, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R14, R21	2	75.0k	CRCW060375K0FKEA	Vishay-Dale	RES, 75.0k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R15	1	39.0k	RC0603FR-0739KL	Yageo	RES, 39.0k, 1%, 0.1W, 0603
R16, R37, R53	3	24.9k	CRCW060324K9FKEA	Vishay-Dale	RES, 24.9k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R17	1	31.6k	CRCW060331K6FKEA	Vishay-Dale	RES, 31.6k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R19	1	48.7k	CRCW060348K7FKEA	Vishay-Dale	RES, 48.7k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R20	1	61.9k	CRCW060361K9FKEA	Vishay-Dale	RES, 61.9k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R22	1	90.9k	CRCW060390K9FKEA	Vishay-Dale	RES, 90.9k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R23	1	110k	CRCW0603110KFKEA	Vishay-Dale	RES, 110k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R25, R41	2	511	CRCW0603511RFKEA	Vishay-Dale	RES, 511, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R26, R42	2	1.30k	CRCW06031K30FKEA	Vishay-Dale	RES, 1.30k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R27, R43	2	1.87k	CRCW06031K87FKEA	Vishay-Dale	RES, 1.87k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R28, R44	2	2.74k	CRCW06032K74FKEA	Vishay-Dale	RES, 2.74k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R29, R45	2	3.83k	CRCW06033K83FKEA	Vishay-Dale	RES, 3.83k, 1%, 0.1W, AEC-Q200 Grade 0, 0603

Table 6-1. Bill of Materials (continued)

Designator	Quantity	Value	PartNumber	Manufacturer	Description
R30, R46	2	5.11k	CRCW06035K11FKEA	Vishay-Dale	RES, 5.11k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R31, R47	2	6.49k	CRCW06036K49FKEA	Vishay-Dale	RES, 6.49k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R32, R48	2	8.25k	CRCW06038K25FKEA	Vishay-Dale	RES, 8.25k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R33, R49	2	10.5k	CRCW060310K5FKEA	Vishay-Dale	RES, 10.5k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R34, R50	2	13.3k	CRCW060313K3FKEA	Vishay-Dale	RES, 13.3k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R35, R51	2	16.2k	CRCW060316K2FKEA	Vishay-Dale	RES, 16.2k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R36, R52	2	20.5k	CRCW060320K5FKEA	Vishay-Dale	RES, 20.5k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R38, R54	2	30.1k	CRCW060330K1FKEA	Vishay-Dale	RES, 30.1k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R39, R55	2	36.5k	CRCW060336K5FKEA	Vishay-Dale	RES, 36.5k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R60	1	53.6k	CRCW060353K6FKEA	Vishay-Dale	RES, 53.6k, 1%, 0.1W, AEC-Q200 Grade 0, 0603
R65	1	66.5k	CRCW060366K5FKEA	Vishay-Dale	RES, 66.5k, 1%, 0.1W, AEC-Q200 Grade 0, 0603

7 Additional Information

7.1 Trademarks

All trademarks are the property of their respective owners.

8 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (July 2025) to Revision B (December 2025)	Page
• Updated switching from: 420kHz to: 400kHz	1
• Deleted disconnection of jumper JP10 and JP2 instructions	5
• Updated table name from: CHG0-Pin Settings to: SYNCOUT-Pin Settings	6
• Added pin setting position information	6
• Added Application Curves section	9
• Updated Bill of Materials	17

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), 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 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, TI’s General Quality Guidelines, 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. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

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

Last updated 10/2025