EVM User's Guide: TPS1686-87EVM

TPS1686-87 Evaluation Module for eFuse

Description

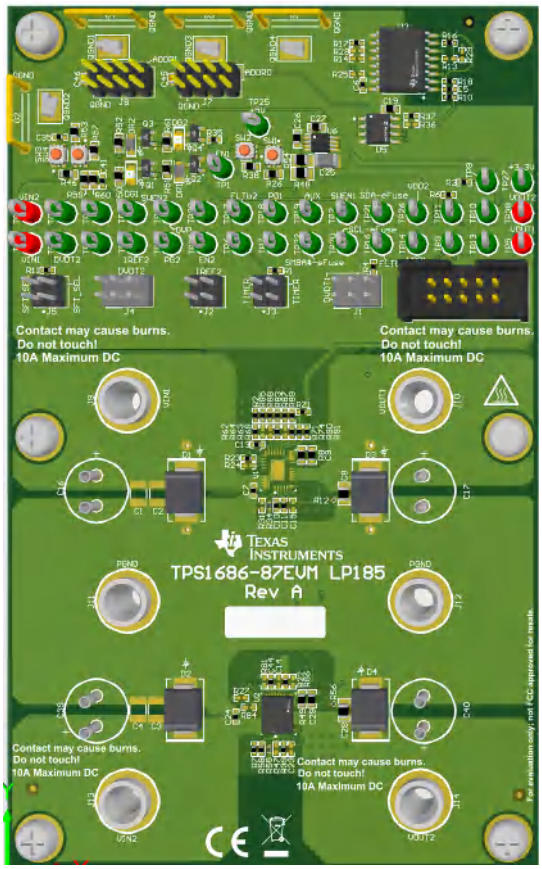
The TPS1686-87EVM is used to evaluate the performance of the TPS1686 eFuse device. The TPS1686-87EVM comes with TPS16861 eFuse to evaluate a 54V (typical) and 10A (steady state) designs.

Features

- 40V to 60V (typical) operation
- 10A programmable circuit breaker threshold
- Adjustable reference voltage for over-current protection
- Undervoltage and overvoltage protections
- Adjustable output voltage slew rate control using onboard jumpers
- Adjustable transient current blanking timer using onboard jumpers
- Adjustable scalable fast-trip threshold using onboard jumpers
- TVS diode for input and Schottky diode for output transient protections
- LED status for power good and fault indications
- Options to engage the enable power cycle and the quick output discharge (QOD)

Applications

- Input hotswap and hotplug
- Server and high performance computing
- Network interface cards
- Graphics and hardware accelerator cards
- Data center switches and routers
- Fan trays
- Switches and routers



TPS1686-87EVM

1 Evaluation Module Overview

1.1 Introduction

The TPS1686-87EVM eFuse evaluation board allows for reference circuit evaluation of the Texas Instruments TPS1686 eFuse. The TPS1686 device is a 9V to 80V and 10A (RMS) eFuse with accurate and fast current monitoring capabilities. Features of the TPS1686 eFuse include:

- Integrated FET
- Ultra-low ON resistance: 16mΩ
- Adjustable and robust over-current and short-circuit protections
- Precise load current monitoring
- Fast and adjustable undervoltage and overvoltage protections
- Adjustable output slew rate control for inrush current protection
- Built-in over-temperature protection to verity the FET safe operating area (SOA)
- Adjustable over-current transient blanking timer that supports load transients
- Integrated FET health monitoring and reporting
- Analog die temperature monitor output
- Dedicated fault and power-good indication pins

This EVM user's guide describes the evaluation module (EVM) for the TPS1686 eFuse.

CAUTION
Hot surface. Contact can cause burns. Do not touch.

1.2 Kit Contents

Table 1-1. TPS1686-87EVM: Kit Contents

Item	Description	Quantity
TPS1686-87EVM	Evaluation module for TPS1686 eFuse	1

1.3 Specification

TPS1686-87EVM specifications are summarized in Table 1-2.

Table 1-2. TPS1686-87EVM Design Specifications

PARAMETER	VALUE
Input voltage range (V_{IN})	40V to 60V
Maximum RMS load current ($I_{OUT(max)}$)	< 10A
Over-current protection threshold (I_{TRIP})	10A
Maximum output capacitance (C_{LOAD})	1mF
Maximum ambient temperature	70°C
Transient overload blanking timer	3ms
Output voltage slew rate	1V/ms
Fault response	Latch-off

1.4 Device Information

The TPS1686-87EVM enables the evaluation of TPS16861 and TPS16860 eFuses from TPS1686 family. TPS16861 is populated on the EVM by default. The input power is applied across the connectors J13 and J11. Connectors J14 and J12 provide the output connection for the EVM as shown in Figure 4-1 and the EVM test setup in Figure 3-1. TVS diodes D2 provide the input protection from transient overvoltages. Schottky diodes in D4 protect the output by clamping the negative voltage excursion at the OUT pin of TPS1686 eFuse within the maximum absolute rating.

SW1 allows completion of the input power cycle and SW2 enables the quick output discharge (QOD). Power Good (PG2) indicators are provided by LED DG2 and fault (FLTb2) indicators are provided by DR2.

Table 1-3. TPS1686-87EVM eFuse Evaluation Board Options and Setting

EVM Function	Vin UVLO Threshold	Vin OVLO Threshold	ITIMER	Output Slew Rate (dv/dt)	IMON	VREF
Performance evaluation of TPS1686, 9V to 80V, 10A eFuse	40V	60V	Selectable - 3ms and 17ms	Selectable - 1V/ms, 0.5V/ms, and 0.1V/ms	10A with V_{REF} of 1V	Selectable - 1V and 0.8V

Additional TPS1686-87EVM device information includes:

- Loads are off until the PG is asserted
- Survives a *hot-short* on output condition
- Survives a *power up into short* condition
- A board can be hot-plugged in
- A board can be power cycled
- Current load monitoring

2 Hardware

2.1 General Configurations

2.1.1 Physical Access

The TPS1686-87EVM eFuse Evaluation Board input and output connectors functions are listed in Table 2-1. The availability of test points and the functions of the jumpers are described in Table 2-2 and Table 2-3. The function of the signal LED indicators is detailed in Table 2-4.

Table 2-1. Input and Output Connector Functionality

Connector	Label	Description
J13	VIN2 (+)	Positive terminal for the input power to the TPS1686
J14	VOUT2 (+)	Positive terminal for the output power from the TPS1686
J11, J12	PGND (–)	Negative terminal for the EVM (Common for both input and output)

Table 2-2. Test Points Description

Test Points	Label	Description
TP37	VIN2	TPS1686 input voltage
TP38	VOUT2	TPS1686 output voltage
TP30	EN2	Active-high enable input for TPS1686
TP31	SWEN2	Open-drain signal to indicate and control TPS1686 ON and OFF status
TP3	OVP	Voltage at the OVP pin of the TPS1686
TP6	TIMER	Overcurrent blanking timer of TPS1686
TP26	VDD2	TPS1686 controller input power
TP32	TEMP2	TPS1686 die temperature monitor analog voltage output
TP33	DVDT2	Start-up output slew rate control
TP34	IREF2	Reference voltage for overcurrent and amp, short-circuit protections, and active current-sharing blocks
TP12	ILIM2	TPS1686 current monitor
TP36	IMON2	An external resistor from this pin to GND sets the overcurrent protection threshold and fast-trip threshold during steady-state. This pin also acts as a fast and accurate analog output load current monitor signal during steady-state.
TP15	SFT_SEL	Scalable fast trip threshold multiplier during steady state
TP17	FLTb2	Open-drain active low fault indication: secondary device
TP35	PG2	TPS1686 open-drain active high power good indication
TP25	VDD Pullup	5V pullup power supply generated using a LDO from VIN
QGND1, QGND2, QGND3, and QGND4	QGND	Device ground
G1, G2, G3, and G4	QGND	Device ground

Table 2-3. Jumper Descriptions and Default Positions

Jumper	Label	Description	Default Jumper Position
J4	DVDT2	1-2 position sets the output slew rate to 1V/ms	3-4
		3-4 position sets the output slew rate to 0.5V/ms	
		5-6 position sets the output slew rate to 0.1V/ms	
J3	TIMER	1-2 position sets the overcurrent blanking timer to 3ms	3-4
		3-4 position sets the overcurrent blanking timer to 17ms	
J2	IREF2	1-2 position sets the reference voltage for over-current, short-circuit protection, and active current sharing blocks to 0.8V	3-4
		3-4 position sets the reference voltage for over-current, short-circuit protection, and active current sharing blocks to 1V	
J5	SFT_SEL	1-2 position sets the scalable fast-trip threshold at 2.5 times over-current threshold	1-2
		3-4 position sets the scalable fast-trip threshold at 2 times over-current threshold	

Table 2-4. LED Descriptions

LED	Description
DG2	When ON, indicates that PG2 is asserted
DR2	When ON, indicates that FLTb2 is asserted

2.1.2 Test Equipment and Setup

Power supplies: One adjustable power supply with a 0V to 80V output and a 0A to 15A output current limit.

Meters: Two digital multimeters (DMM).

Oscilloscope: A DPO2024 or equivalent, three 10× voltage probes, and a DC current probe rated to 30A.

Loads: One resistive load or equivalent which can tolerate up to 10A DC load at 80V.

3 Implementation Results

3.1 Test Setup and Procedures

This EVM user's guide describes test procedure for the TPS1686 eFuse. Verify that the evaluation board has the default jumper settings as shown in Table 3-1.

Table 3-1. Default Jumper Setting for TPS1686-87EVM eFuse Evaluation Board

J4	J5	J2	J3
3-4	1-2	-4	3-4

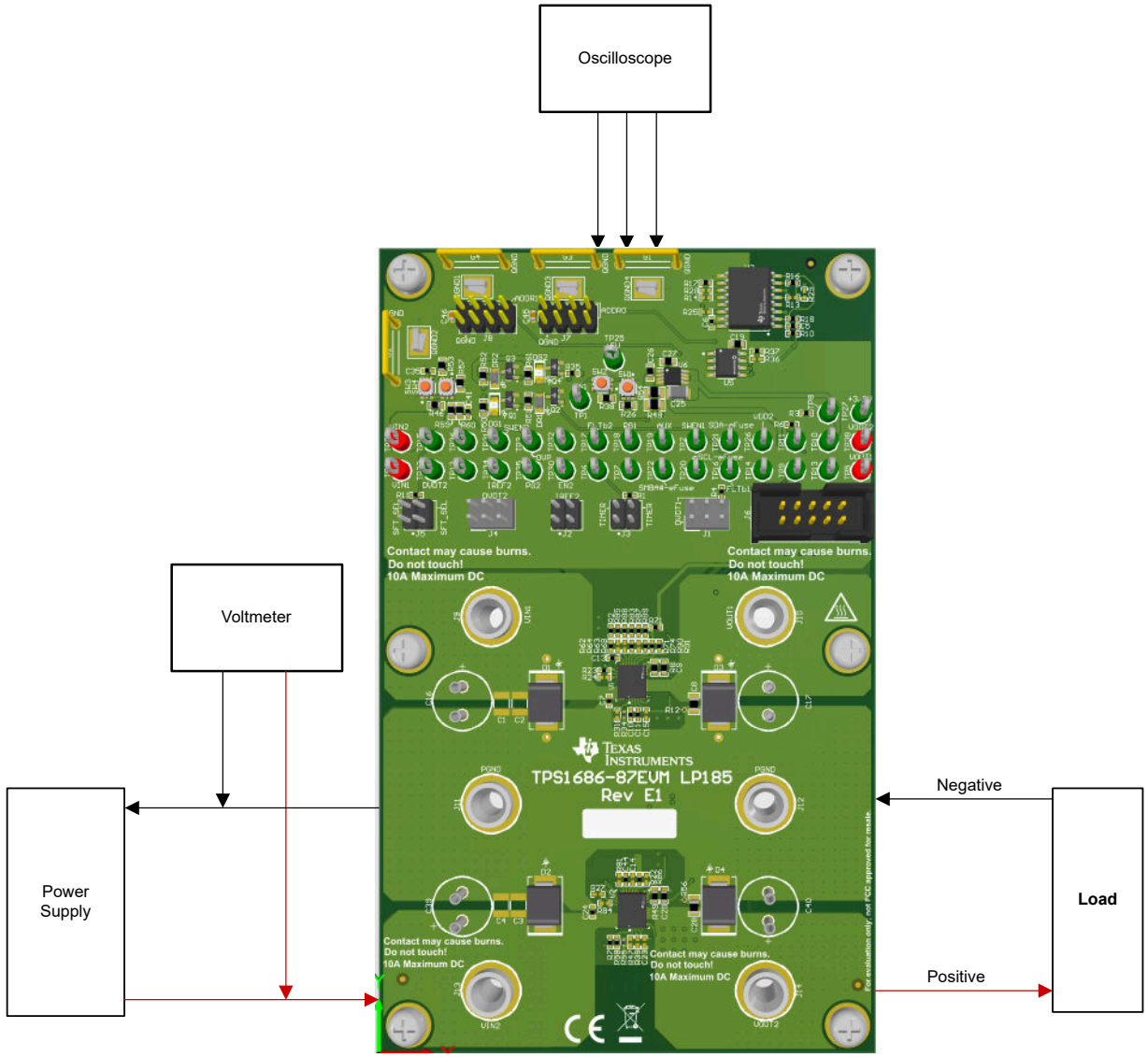


Figure 3-1. TPS1686-87EVM Setup with Test Equipment

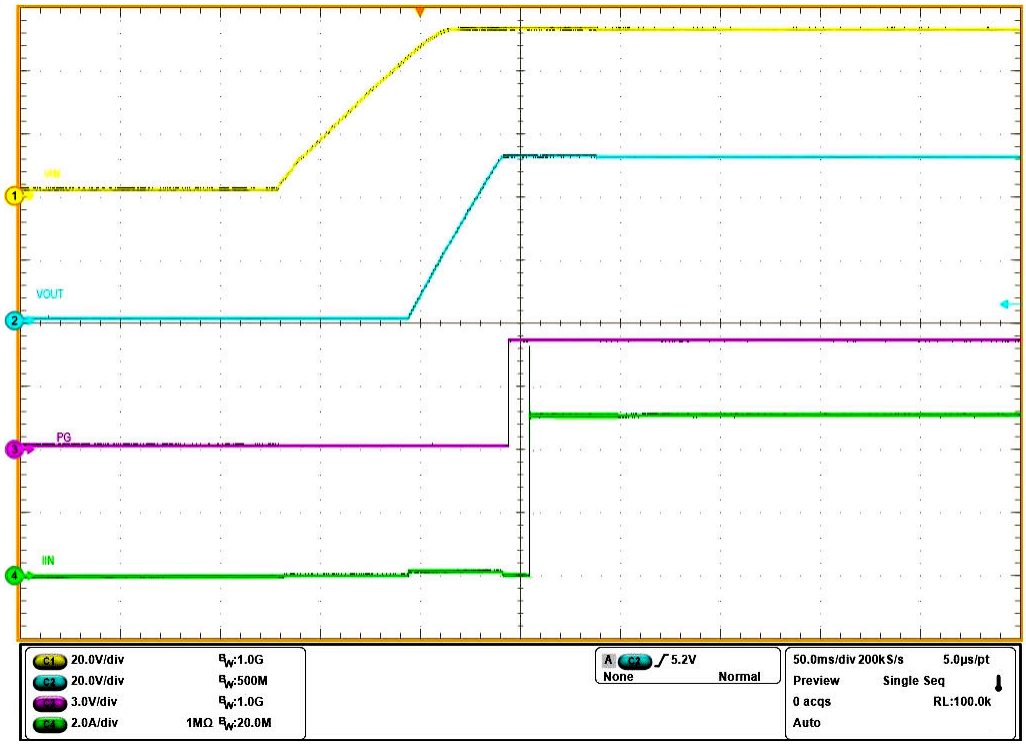
Adhere to the following instructions before starting any test and repeat again before moving to the next test:

1. Set the power supply output (VIN) to zero volts.
2. Turn off the power supply.
3. Adjust the jumper positions on the EVM to the default configuration as shown in Table 3-1.
4. Turn the power supply on and set the power supply output (VIN) to 54V and 10A. Verify that the power supply output is disabled.
5. Enable the power supply output so that the EVM receives the input power supply.

3.1.1 Supply Ramped From 0V to 54V — Start-up

Comply with the following instructions to measure the inrush current during a hot plug event:

1. Configure the jumper J4 position to the desired start-up slew rate as detailed in Table 2-3.
2. Connect the positive terminal of the power supply to connector J13.
3. Connect the negative terminal of the power supply to connector J11.
4. Set the input supply voltage VIN to 54V and current limit to 10A. Enable the power supply.
5. Observe the waveforms at VOUT2(TP38) and input current using an oscilloscope to measure the slew rate and rise time of the VOUT2 with a given input voltage of 54V.



V_{IN} step up from 0V to 54V and C_{DVDT} = 47nF

Figure 3-2. TPS1686 eFuse Power-Up Profile

3.1.2 Power Up Into Short

Follow the instructions to perform the power-up into short test:

1. Set the input supply voltage VIN to 54V and current limit to 5A. Keep the power supply OFF.
2. Connect the supply between VIN2 (connector J13) and PGND (connector J11).
3. Short the output of the EVM to ground. For example, short VOU2 (connector J14) to PGND (connector J12) through a cable.
4. Turn ON the power supply.

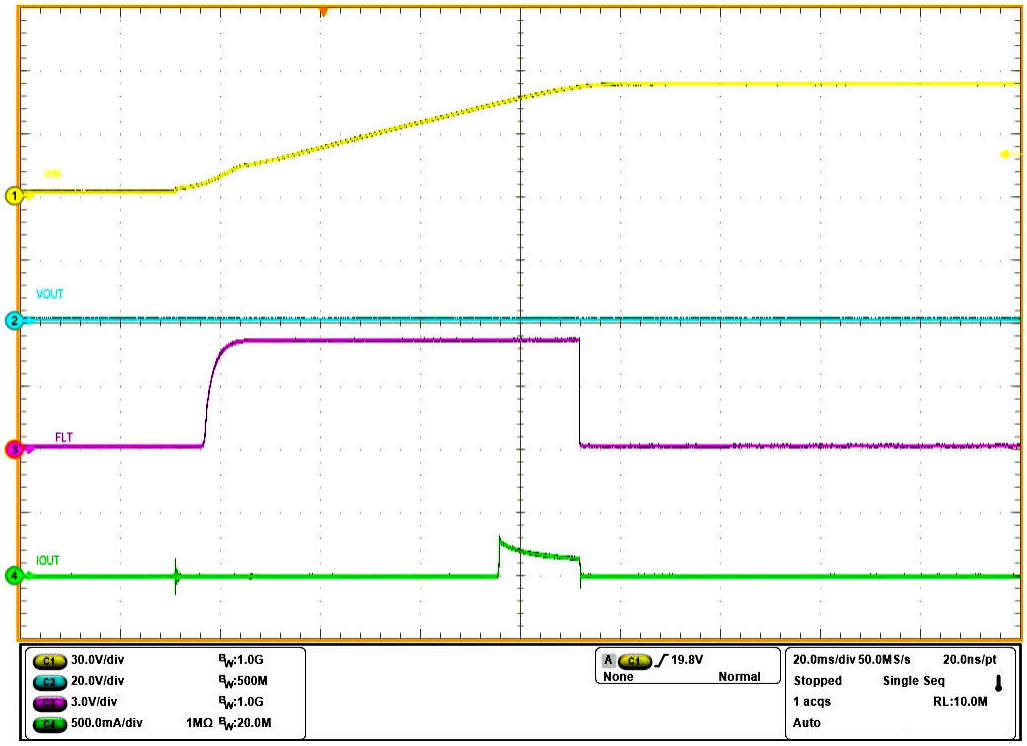
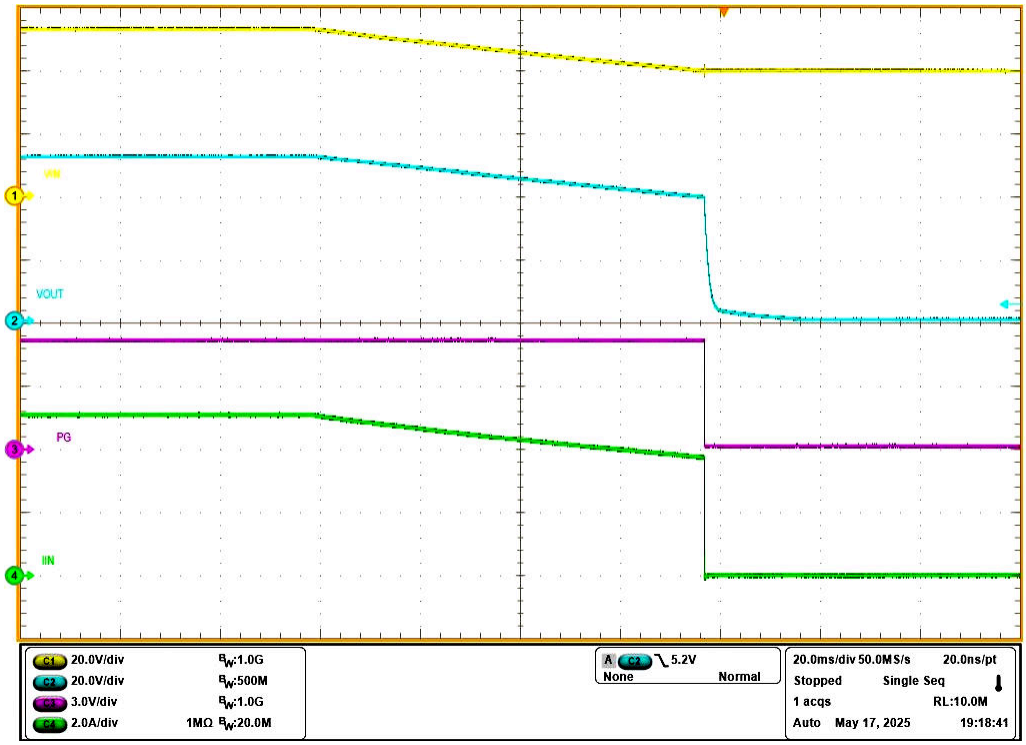


Figure 3-3. Power Up Into Output Short Response of TPS1686

3.1.3 Undervoltage Lockout

Follow the instructions to perform the undervoltage protection test:

1. Set the input supply voltage VIN2 to 54V and current limit to 10A.
2. Apply the supply between VIN2 (Connector J13) and PGND (Connector J11) and enable the power supply.
3. Apply a load of 5A between VOUT2 (connector J14) and PGND (connector J12).
4. Turn off the supply. Observe the waveforms using an oscilloscope.



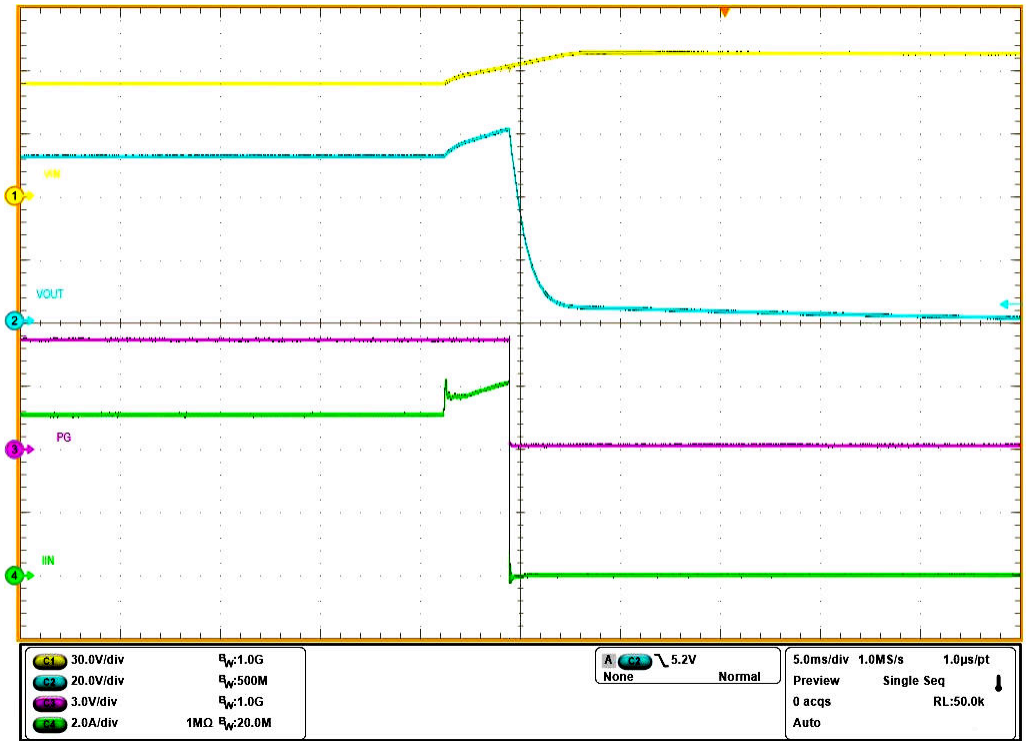
Supply turned off, $V_{IN(UVP)}$ = 40V, C_{OUT} = 100uF, and I_{LOAD} = 5A

Figure 3-4. Undervoltage Lockout Response of TPS1686 eFuse

3.1.4 Overvoltage Lockout

Use the following instructions to perform the overvoltage protection test:

1. Set the input supply voltage VIN to 54V and current limit to 10A. Apply the supply between VIN2 (connector J13) and PGND (connector J11) and enable the power supply.
2. Apply a load of 5A between VOUT2 (connector J14) and PGND (connector J12).
3. Increase the input supply VIN2 from 54V to 65V. Observe the waveforms using an oscilloscope.



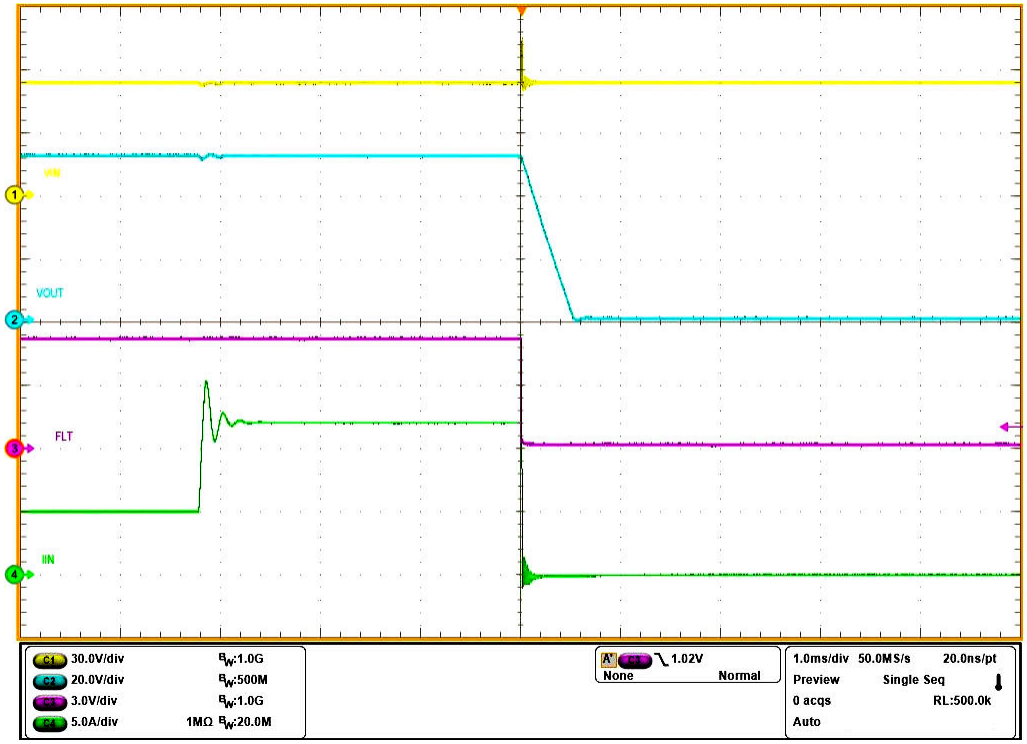
V_{IN} ramped up from 54V to 65V, $V_{IN(OVP)}$ = 60V, C_{OUT} = 100uF, and I_{LOAD} = 5A

Figure 3-5. Overvoltage Lockout Response of TPS1686 eFuse

3.1.5 Overcurrent Event

Use the following instructions to perform the persistent over-current test on the TPS1686 eFuse:

1. Configure the jumper J2 position to the desired reference voltage for overcurrent protection as mentioned in Table 2-3.
2. Configure the Jumper J5 position to set the required scalable fast-trip threshold (I_{SFT}) as per Table 2-3.
3. Set the input supply voltage VIN to 54V and the current limit of 15A.
4. Connect the power supply between VIN2 (connector J13) and PGND (connector J11) and enable the power supply.
5. Apply an overload in the range of I_{OCP} <I_{LOAD} <I_{SFT} between VOUT2 (connector J14) and PGND (connector J12) for a time duration more than t_{TIMER} decided by using jumper J3.
6. Observe the waveforms using an oscilloscope.



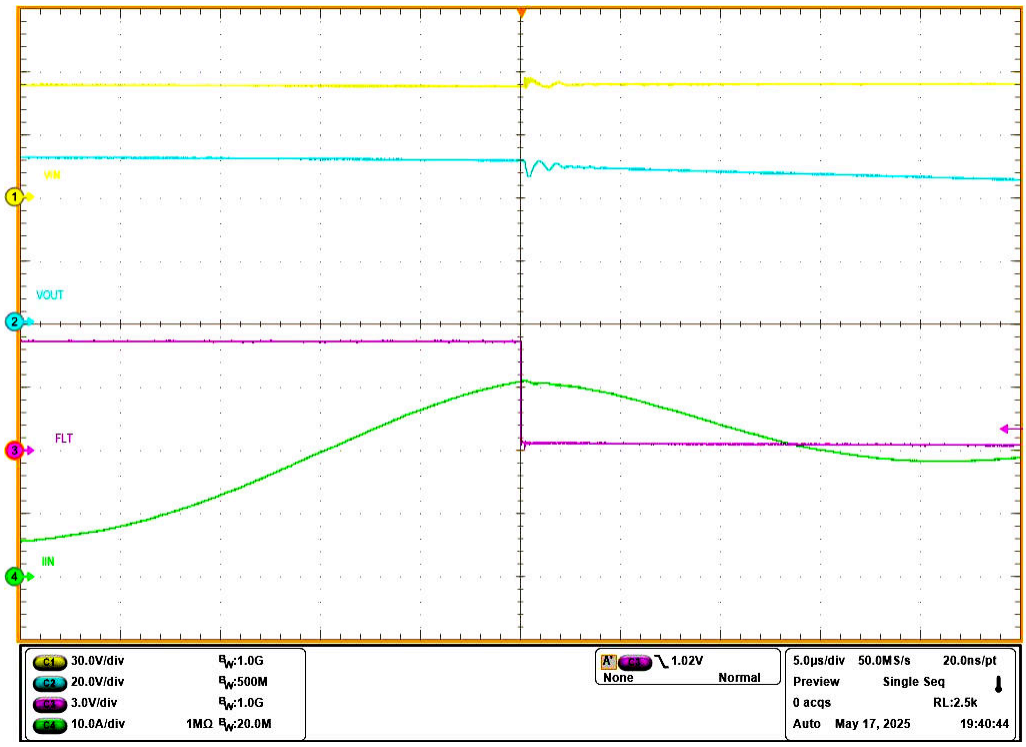
V_{IN} = 54V, C_{ITIMER} = 4.7nF, C_{OUT} = 100uF, R_{IMON} = 5.6kΩ (I_{OCP} = 10A), R_{IREF} = 40.2kΩ (V_{REF} = 1V), and I_{OUT} ramped from 5A to 12A

Figure 3-6. Persistent Overload Performance of TPS1686 eFuse

3.1.6 Output Hot Short

Use the following instructions to perform the output hot short test:

1. Set the input supply voltage VIN2 to 54V and connect the power supply between VIN2 (connector J13) and PGND (Connector J11).
2. Configure the Jumper J5 to set the required scalable fast-trip threshold (I_{SFT}) as per Table 2-3.
3. Turn ON the power supply to power up the EVM.
4. Short the output of the device for example, VOUT2 (connector J14) to PGND (connector J12) through a short cable.
5. Observe the waveforms using an oscilloscope.



V_{IN} = 54V, R_{IMON} = 5.6kΩ, R_{IREF} = 40.2kΩ, R_{SFT} = 150kΩ, and C_{OUT} = 100uF

Figure 3-7. Output Hot Short Response for TPS1686

Note

Verify that there is sufficient input capacitor to eliminate voltage dips at the input. A combination of electrolytic and ceramic capacitors are preferred. With these capacitors, a large current can be provided for a short period of time during short-circuit.

Obtaining repeatable and similar short-circuit testing results can be difficult. The following factors contributes to the variation in results:

- Source bypassing
- Input leads
- Board layout
- Component selection
- Output shorting method
- Relative location of the short
- Instrumentation

The actual short exhibits a certain degree of randomness because the short microscopically bounces and arcs. Verify that the configuration and methods are used to obtain realistic results. Hence, do not expect to see waveforms exactly like the waveforms in this user's guide because every setup is different.

4 Hardware Design Files

4.1 Schematics

Figure 4-1 and Figure 4-2 show the EVM schematic.

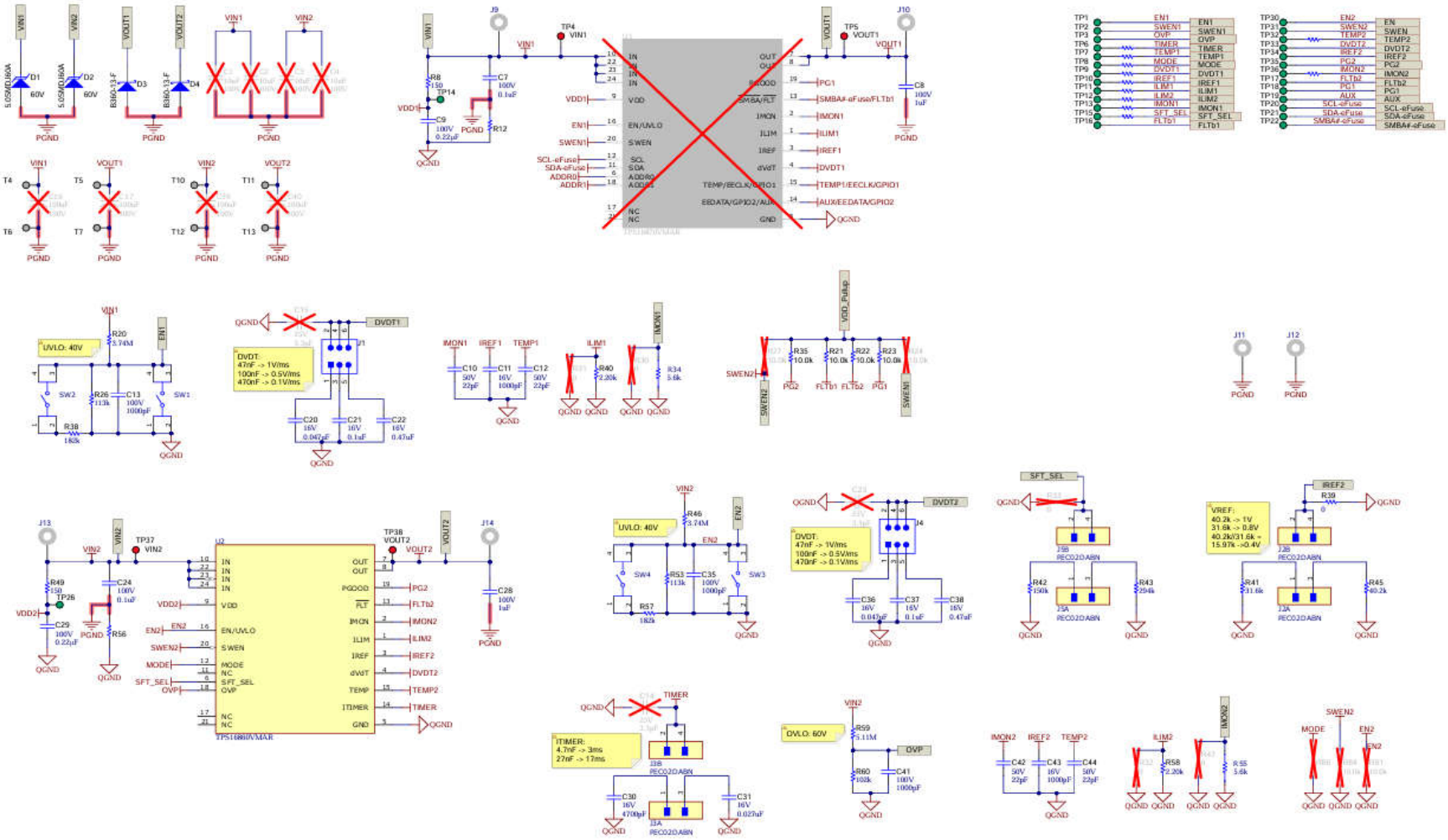


Figure 4-1. TPS1686-87EVM Evaluation Board Schematic (Image 1)

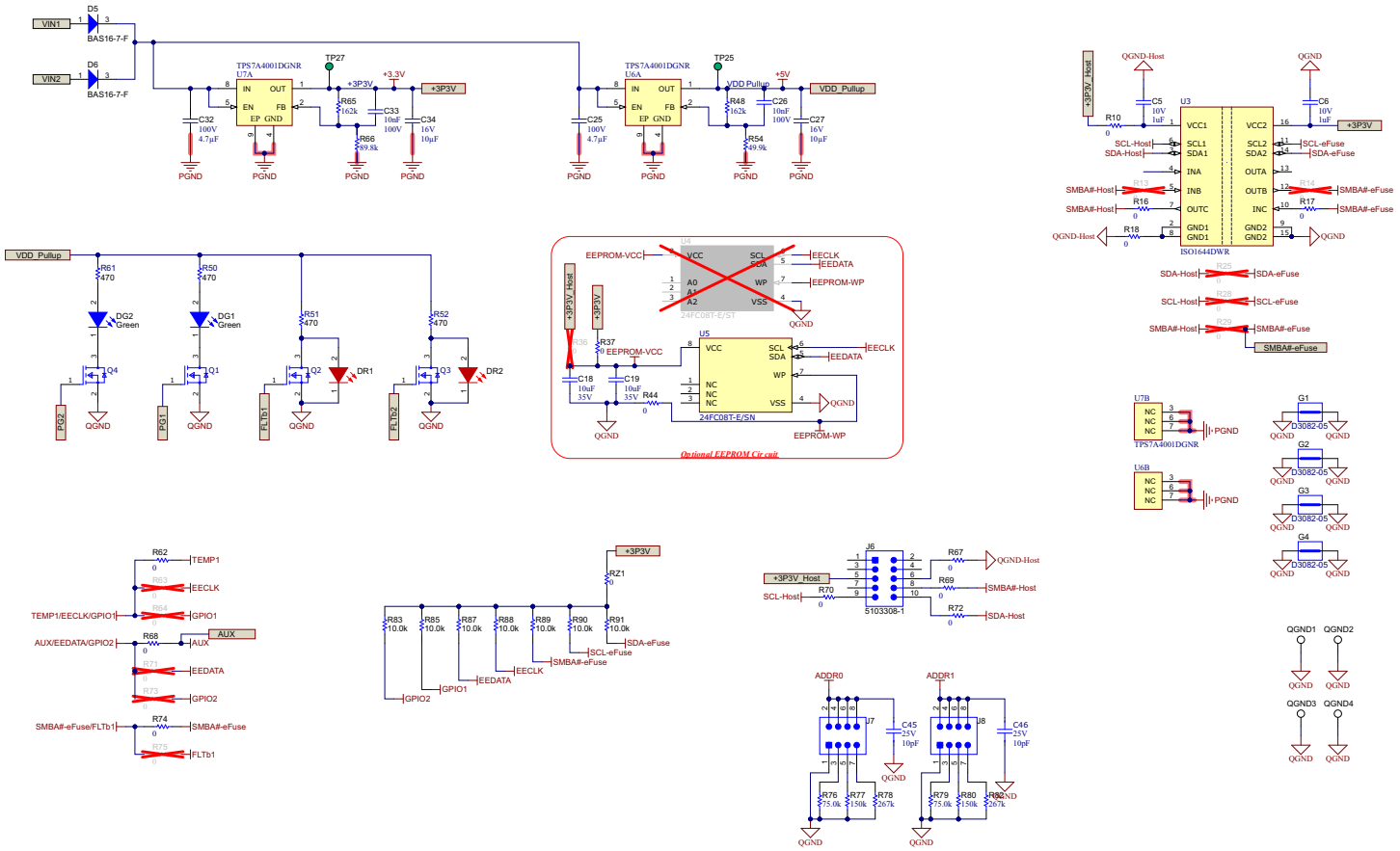


Figure 4-2. TPS1686-87EVM Evaluation Board Schematic (Image 2)

4.2 PCB Drawings

Figure 4-3 and Figure 4-4 show the component placement of the EVM.

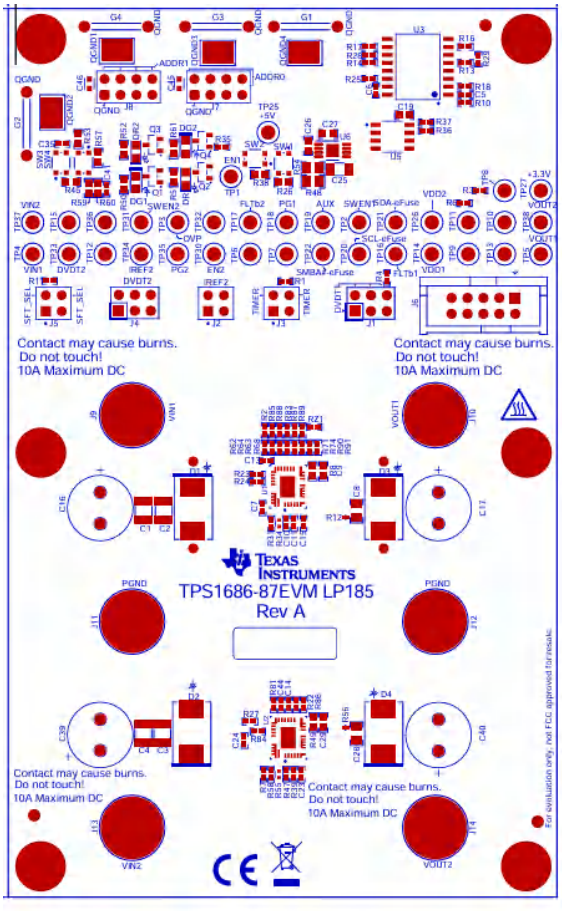


Figure 4-3. TPS1686-87EVM Board: Top Assembly

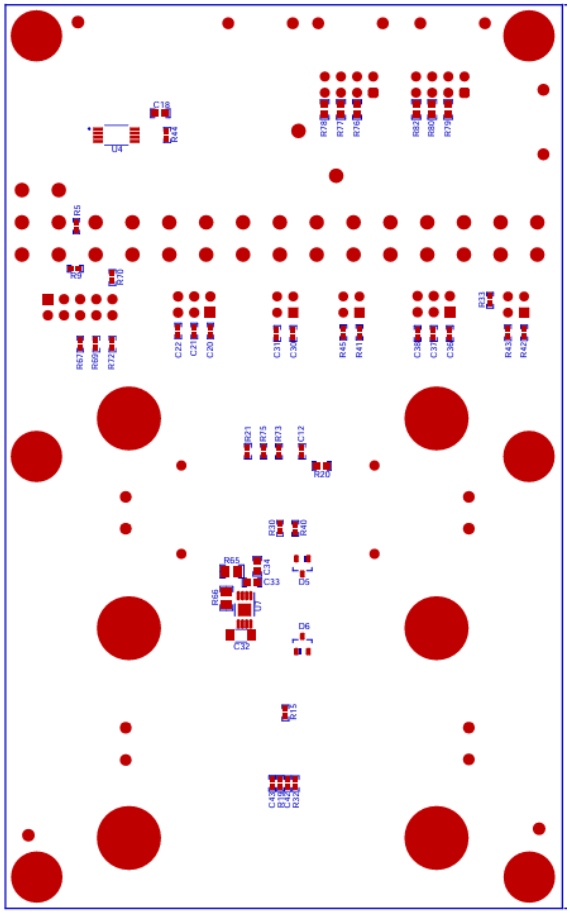


Figure 4-4. TPS1686-87EVM Board: Bottom Assembly

Note

Analog signal nets, such as IREF, IMON, and TEMP must be routed away as much as possible from power nets, such as VIN, VOUT, and PGND.

4.3 Bill of Materials (BOM)

Table 4-1 lists the EVM BOM.

Table 4-1. TPS1686-87EVM Bill of Materials

Designator	Quantity	Value	Part Number	Manufacturer
!PCB1	1		LP185	Any
C5, C6	2	1uF	GRM155R61A105KE15D	MuRata
C7, C24	2	0.1uF	GRM155R62A104KE14D	MuRata
C8, C28	2	1uF	C2012X7S2A105K125AB	TDK
C9, C29	2	0.22uF	HMK107C7224KAHTE	Taiyo Yuden
C10, C12, C42, C44	4	22pF	GRM1555C1H220FA01D	MuRata
C11, C43	2	1000pF	GRM155R61C102KA01D	MuRata
C13, C35, C41	3	1000pF	GRM155R72A102KA01D	MuRata
C18, C19	2	10uF	GRM188R6YA106MA73D	Murata
C20, C36	2	0.047uF	GRM155R61C473KA01D	MuRata
C21, C37	2	0.1uF	GRM155R71C104KA88D	MuRata
C22, C38	2	0.47uF	GRM155R61C474KE01	MuRata
C25, C32	2	4.7uF	12061Z475MAT2A	AVX
C26, C33	2	0.01uF	GRM188R72A103KA01D	MuRata
C27, C34	2	10uF	GRM188R61C106KAALD	MuRata
C30	1	4700pF	GRM155R71C472KA01D	MuRata
C31	1	0.027uF	GRM155R71C273KA01D	MuRata
C45, C46	2	10pF	06033A100JAT2A	AVX
D1, D2	2	60V	5.0SMDJ60A	Littelfuse
D3, D4	2	60V	B360-13-F	Diodes Inc.
D5, D6	2	75V	BAS16-7-F	Diodes Inc.
DG1, DG2	2	Green	LG R971-KN-1	OSRAM
DR1, DR2	2	Red	LS R976-NR-1	OSRAM
FID1, FID2, FID3, FID4, FID5, FID6	6		N/A	N/A
G1, G2, G3, G4	4		D3082-05	Harwin
H1, H2, H3, H4, H11, H12	6		1902C	Keystone

Table 4-1. TPS1686-87EVM Bill of Materials (continued)

Designator	Quantity	Value	Part Number	Manufacturer
H5, H6, H7, H8, H9, H10	6		NY PMS 440 0025 PH	B&F Fastener Supply
J1, J4	2		PEC03DAAN	Sullins Connector Solutions
J2, J3, J5	3		PEC02DABN	Sullins Connector Solutions
J6	1		5103308-1	TE Connectivity
J7, J8	2		PRPC004DAAN-RC	Sullins Connector Solutions
J9, J10, J11, J12, J13, J14	6		575-8	Keystone
Q1, Q2, Q3, Q4	4		SI2306BDS-T1-GE3	Vishay Siliconix
QGND1, QGND2, QGND3, QGND4	4		5016	Keystone
R1, R2, R3, R4, R5, R6, R7, R9, R11, R15, R19	11	1.00k	ERA-2APB102X	Panasonic
R8, R49	2	150	CRCW0603150RJNEA	Vishay-Dale
R10, R16, R17, R18, R37, R44, R62, R67, R68, R69, R70, R72, R74, RZ1	14	0	CRCW04020000Z0ED	Vishay-Dale
R12, R56	2		RC0201JR-070RL	Yageo
R20, R46	2	3.74Meg	CRCW06033M74FKEA	Vishay-Dale
R21, R22, R23, R35, R83, R85, R87, R88, R89, R90, R91	11	10.0k	RC0402FR-0710KL	Yageo America
R26, R53	2	113k	RC0603FR-07113KL	Yageo
R34, R55	2	5.6k	ERA-2AEB562X	Panasonic Electronic Components
R38, R57	2	182k	CRCW0603182KFKEA	Vishay-Dale
R40, R58	2	2.20k	ERA2AEB222X	Panasonic
R41	1	31.6k	CRCW040231K6FKED	Vishay-Dale
R42	1	150k	ERJ-2RKF1503X	Panasonic
R43	1	294k	ERJ-2RKF2943X	Panasonic
R45	1	40.2k	ERJ-2RKF4022X	Panasonic
R48, R65	2	162k	RT0805BRD07162KL	Yageo America
R50, R51, R52, R61	4	470	RC0603JR-07470RL	Yageo
R54	1	49.9k	RT0805BRD0749K9L	Yageo America
R59	1	5.11Meg	CRCW06035M11FKEA	Vishay-Dale

Table 4-1. TPS1686-87EVM Bill of Materials (continued)

Designator	Quantity	Value	Part Number	Manufacturer
R60	1	102k	CRCW0603102KFKEA	Vishay-Dale
R66	1	89.8k	RT0805BRD0789K8L	Yageo America
R76, R79	2	75.0k	RT0603BRD0775KL	Yageo America
R77, R80	2	150k	RT0603BRD07150KL	Yageo America
R78, R82	2	267k	RT0603BRD07267KL	Yageo America
SH1, SH2, SH3, SH4, SH5, SH6, SH7, SH8, SH9, SH10, SH11, SH12	12		60900213621	Wurth Elektronik
SW1, SW2, SW3, SW4	4		PTS830GM140SMTRLFS	C&K Components
T4, T5, T6, T7, T10, T11, T12, T13	8		0300-2-15-01-47-01-10-0	Mill-Max
TP1, TP2, TP3, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP25, TP26, TP27, TP30, TP31, TP32, TP33, TP34, TP35, TP36	30		5126	Keystone
TP4, TP5, TP37, TP38	4		5010	Keystone
U2	1		TPS16860NLMR	Texas Instruments
U3	1		ISO1644DWR	Texas Instruments
U5	1		24FC08T-E/SN	Microchip
U6, U7	2		TPS7A4001DGNR	Texas Instruments
C1, C2, C3, C4	0		GRM32EC72A106KE05L	Murata
C14, C15, C23	0	3.3pF	GRM1555C1E3R3CA01D	MuRata
C16, C17, C39, C40	0	100µF	ECA2AM101	Panasonic
R13, R14, R25, R28, R29, R30, R31, R32, R33, R36, R39, R47, R63, R64, R71, R73, R75, R86	0	0	CRCW04020000Z0ED	Vishay-Dale
R24, R27	0	10.0k	RC0402FR-0710KL	Yageo America
R81, R84	0	10.0k	ERJPA2F1002X	Panasonic
U1	0		TPS16870NLMR	Texas Instruments
U4	0		24FC08T-E/ST	Microchip

5 Additional Information

5.1 Trademarks

All trademarks are the property of their respective owners.

6 Revision History

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

Changes from Revision * (June 2025) to Revision A (November 2025)	Page
• Updated board image	1
• Updated images in Section 4.1	14
• Updated Section 4.2	16
• Updated Section 4.3	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。

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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

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