

LM53625xQEVM and LM53635xQEVM

User's Guide



Literature Number: SNVU526
May 2016

1	Introduction	3
2	Technical Specification EVM Board	4
3	Schematics	5
4	Board Layout	7
5	Operation and Test Setup	11
	5.1 Efficiency Measurement	11
	5.2 Measure Load Transient.....	12
	5.3 Measure EMI	12
6	Posts, Probes, and Jumpers	13
	6.1 VIN1 and GND1 Posts	13
	6.2 VOUT and GND Posts	13
	6.3 IN+ and IN- Posts.....	13
	6.4 EN and GND2 Probe	13
	6.5 VINs, VOUTs, and GNDs Probe.....	13
	6.6 BIAS and GNDS Probe	13
	6.7 RESET and GND3 Probe.....	14
	6.8 SYNC and GND3 Probe	14
	6.9 Jumper J1.....	14
	6.10 Jumper J2.....	14
	6.11 Jumper J3.....	14
7	Bill of Materials	14
8	Efficiency and Line- and Load-Regulation	16
	8.1 Load Transients	17
	8.2 Conducted EMI.....	17

LM53625xQEVM and LM53635xQEVM User's Guide

1 Introduction

The LM53635xEVM is specifically designed for automotive applications, providing a fixed output voltage of 5 V, 3.3 V, or an adjustable output voltage at 3.5-A continuous load. The LM53625xEVM is implemented using the same board and components but with or an IC with current limit set for 2.5 A maximum continuous load.

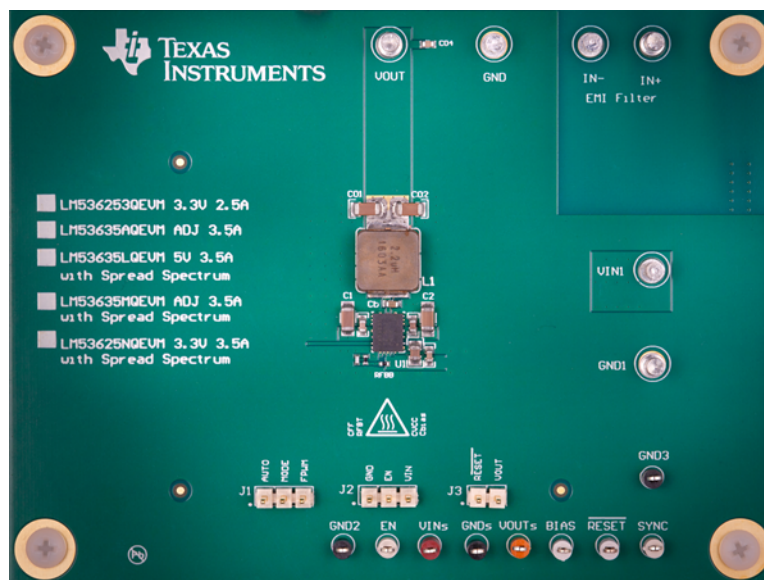


Figure 1. LM53625xQEVM and LM53635xQEVM Evaluation Board – Top View

All aspects of the LM53625xQEVM and LM53635xQEVM are optimized for the automotive market. An input voltage range to 36 V eases input surge protection design. Exceptional dropout performance allows the elimination of a boost stage in many designs for start/stop applications. An open drain RESET output, with filtering and Power-GOOD delay, provides a true indication of system status. This feature negates the requirement for additional supervisory circuitry, saving cost, and board space. Seamless transition between PWM and PFM operation AUTO MODE, along with a low quiescent current, ensures high efficiency at all loads. The Texas Instruments LM53625QEVM and LM53635QEVM helps to evaluate the operation and performance of the LM53625x and LM53635x and is available for order in five variants. See [Table 1](#) of orderable EVM variants and configuration.

Table 1. Orderable EVM Variants and Configuration for LM53625 and LM53635

EVM VARIANT	EVM ORDERABLE NAME	IC U1	CONTINUOUS LOAD	OUTPUT VOLTAGE	SPREAD SPECTRUM
001	LM536253QEVM	LM536253QRNLRQ1	2.5 A	3.3 V Fixed	—
002	LM53635AQEVM	LM53635AQRNLRQ1	3.5 A	5 V Adjusted	—
003	LM53635LQEVM	LM53635LQRNLRQ1	3.5 A	5 V Fixed	Yes
004	LM53635MQEVM	LM53635MQRNLRQ1	3.5 A	5 V Adjusted	Yes
005	LM53635NQEVM	LM53635NQRNLRQ1	3.5 A	3.3 V Fixed	Yes

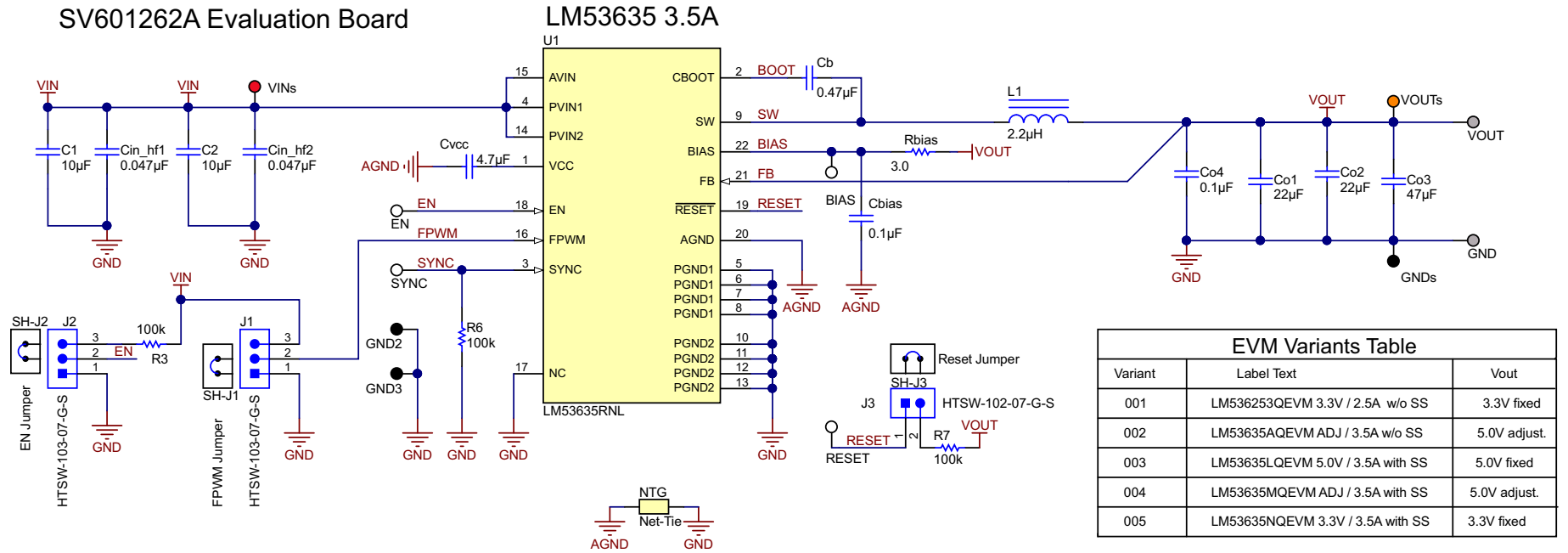
2 Technical Specification EVM Board

Table 2 shows specifications for the LM53625xQEVM and LM53635xQEVM board.

Table 2. Technical Specification

BOARD SIZE		
4000 x 3000 mil	101 mm x 76 mm	76 cm ²
BOARD LAYER		
4-Layer FR4 PCB	Top Layer1 and Bottom Layer2 Mid Layer2 and Mid Layer3	2.8 mil 2 oz. Cu 1.4 mil 1 oz. Cu
SOLUTION SIZE		
860 mil x 490 mil	22 mm x 12.5 mm	2.75 cm ²
POWER INPUT		
VIN1 and GND1 IN+ / IN-	Power Supply Input Power Input for EMI Test	typical 13.5 V (range 3.5 to 36 V) transient typical 13.5 V
Power Output:		
VOUT and GND	Power Output to Load	typical 3.3 V or 5 V
JUMPERS		
J1 FPWM pin J2 ENABLE pin J3 RESET pin	Auto Mode or Forced PWM Enable LM536325x and LM536335x Open drain output	Set – Default [AUTO-MODE] Set – Default [EN-VIN] Optional - [RESET-VOUT]
TEST POINTS		
GNDs, GND2 and GND3 EN VINs VOUTs BIAS RESET SYNC	Sense GND Points Enable Pin Voltage Input Voltage Sense Output Voltage Sense BIAS Voltage Sense RESET output Switch node SYNC input	If J2[EN-VIN] then VIN1 3.5 - 36 V Sense VIN1 3.5 to 36 V Sense VOUT typical 3.3 V or 5 V Sense BIAS typical 3.3 V or 5 V If J3 [RESET-VOUT] then VOUTs external sync frequency source

3 Schematics

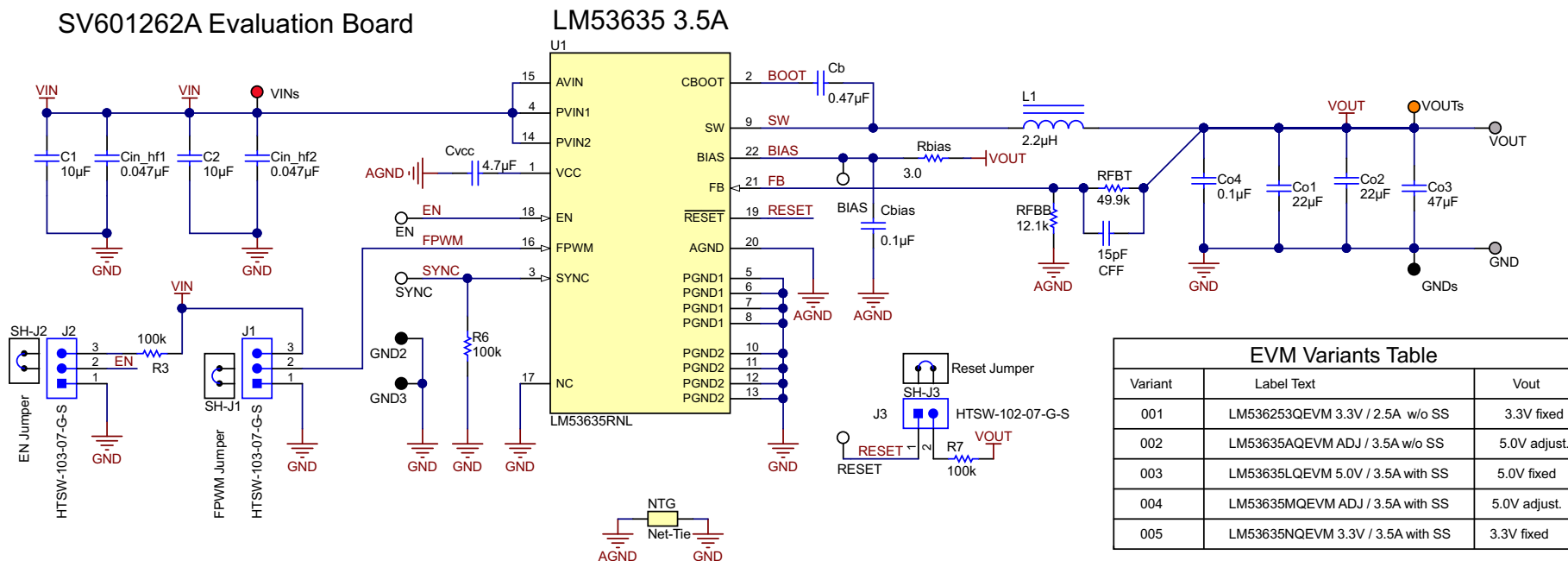


Copyright © 2016, Texas Instruments Incorporated

Figure 2. Fixed - Output Voltage Option Schematic

The fixed voltage option has an internal resistor divider and FB pin that connects directly to Cout capacitor.

NOTE: Cvcc and Cbias must connect directly to pin 20 AGND.



Copyright © 2016, Texas Instruments Incorporated

Figure 3. Adjustable - Output Voltage Option Schematic

Adjustable option uses external resistor divider to define output voltage. The CFF capacitor can be adjusted to make the feedback loop response faster for load transient. By lowering the total resistance of the feedback divider the noise immunity can be increased.

NOTE: To minimize noise coupling into the feedback pin, the maximum resistance recommended in the feedback resistors RFBB and RFBT is 50 kΩ. The feedback resistors RFBB and RFBT must be placed as close to the FB pin as possible, and RFBB must be grounded to AGND pin.

4 Board Layout

The LM53635xQEVN uses a four-layer PCB stack-up design. Top Layer 1 and Bottom Layer 4 are implemented using 2 oz. copper for optimized heat transfer and dissipation. Mid Layer 2 and Mid Layer 3 utilize 1 oz. copper. Total PCB thickness is 61 mil (1.55 mm).

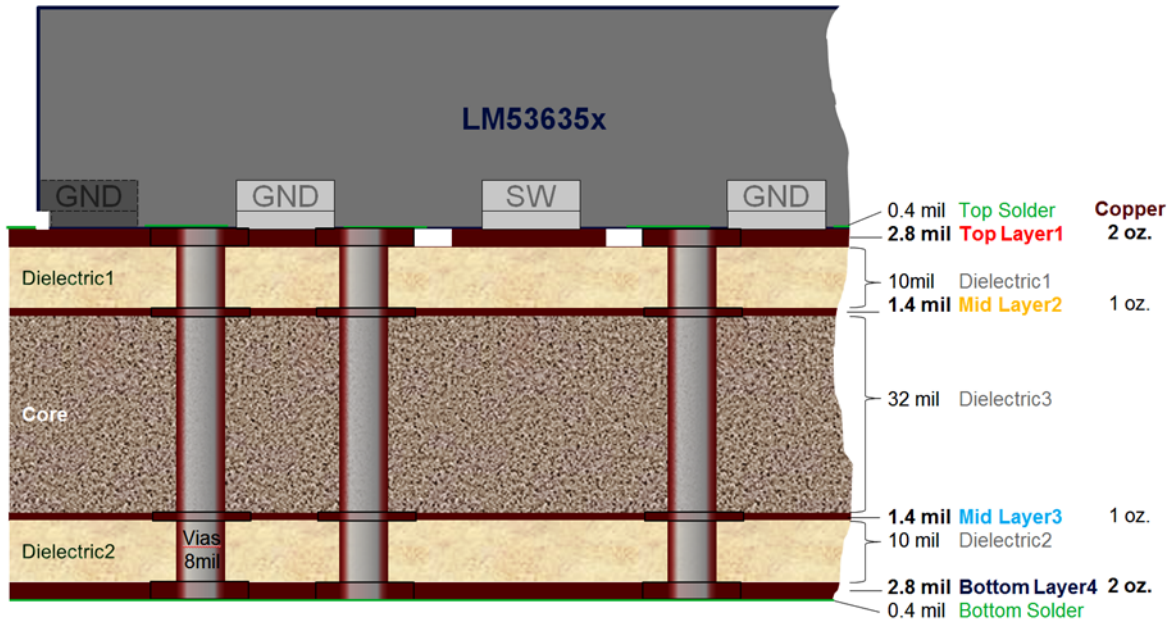


Figure 4. Four-Layer PCB Stack-Up

The overall EVM PCB board size dimension is 4000 mil x 3000 mil (101 mm x 76 mm) with a top surface area of 76 cm². All vias on the PCB are constructed using 8-mil drill thru-hole with 16-mil pad size.

Figure 5 to Figure 8 shows the PCB Layout for each Cu Layer. Top Layer1 and Bottom Layer4 are constructed using large filled Cu areas connected to GND. This is done to improve thermal performance as well as improve overall EMI performance. Mid Layer 2 is constructed using a large GND plane as well. The intention here is to minimize loop inductance by placing metal right under the Top Layer 1 traces minimizing the cross section of current loops. Mid Layer 3 is mainly used to route non-critical signal traces to the IC.

NOTE: The PCB board layout is not fully optimized to use for final applications, but gives a good starting point. The layout can be simplified and optimized by eliminating features included for evaluation purposes such as measurement sense lines, jumper connections and features unused in a particular application such as the feedback resistor divider for fixed voltage options.

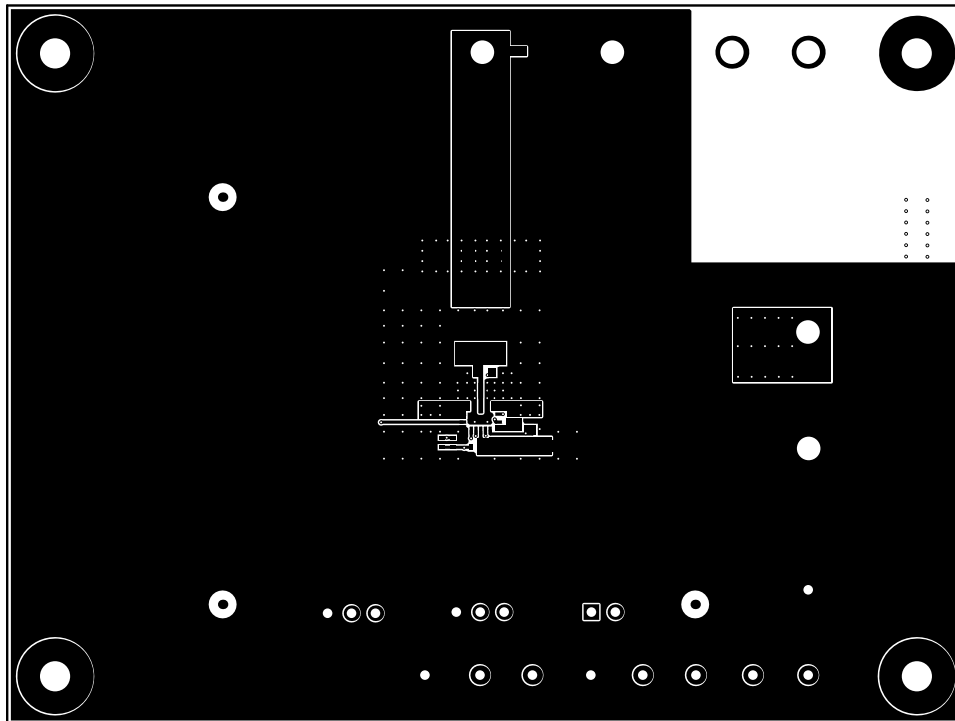


Figure 5. PCB Layout Top Layer 1 – Top View

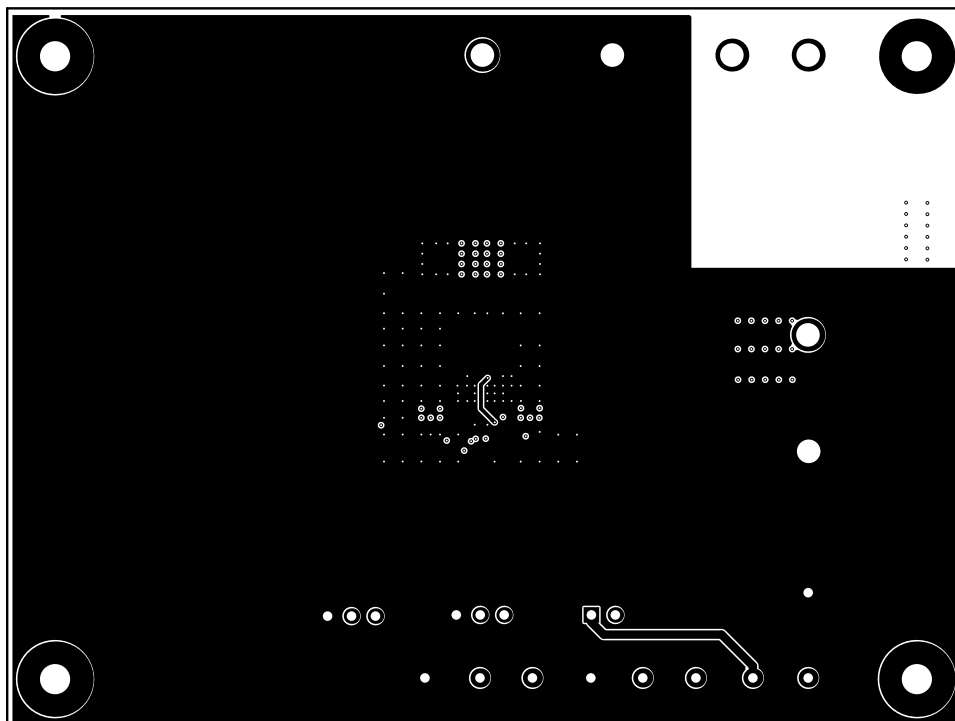


Figure 6. PCB Layout Mid Layer 2 GND Plane – Top View

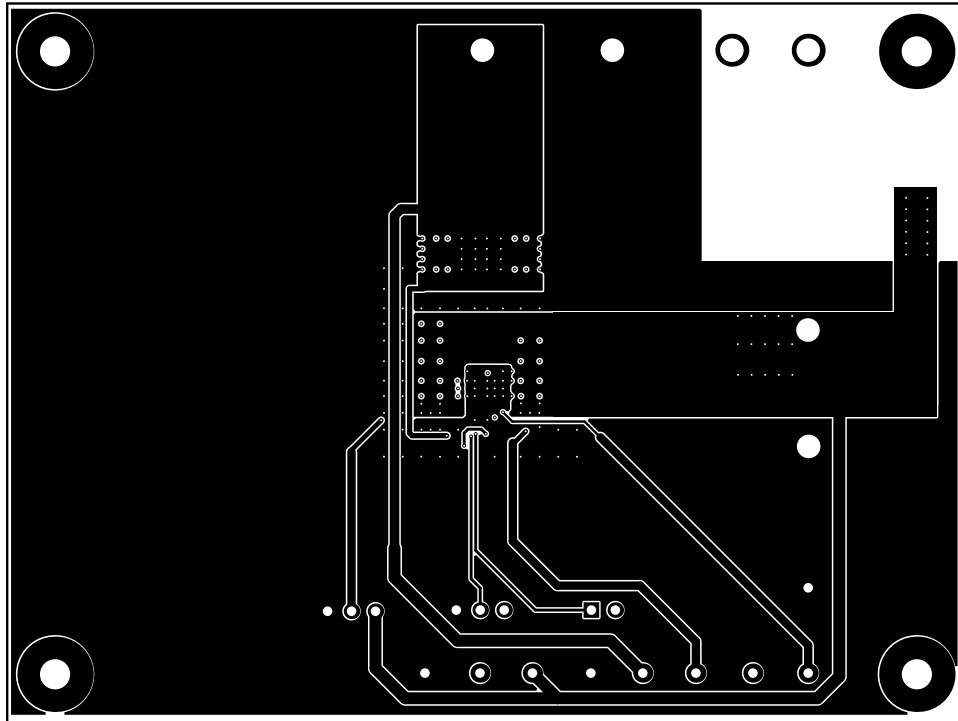


Figure 7. PCB Layer Mid Layer 3 – Top View

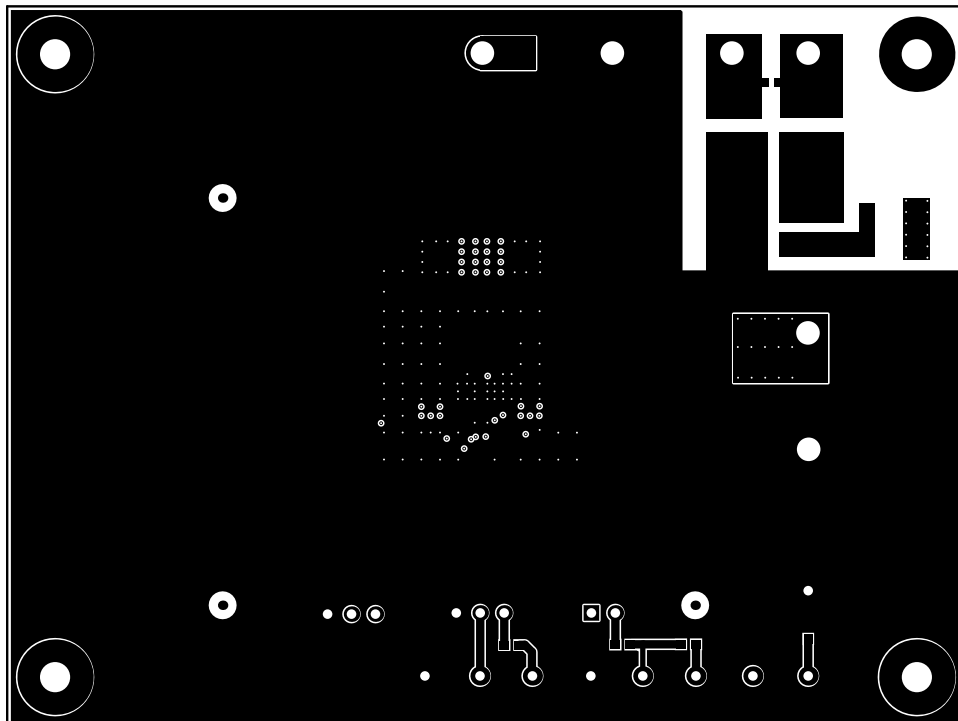


Figure 8. PCB Layer Bottom Layer 4 – Flipped View (as Seen From Bottom of Board)

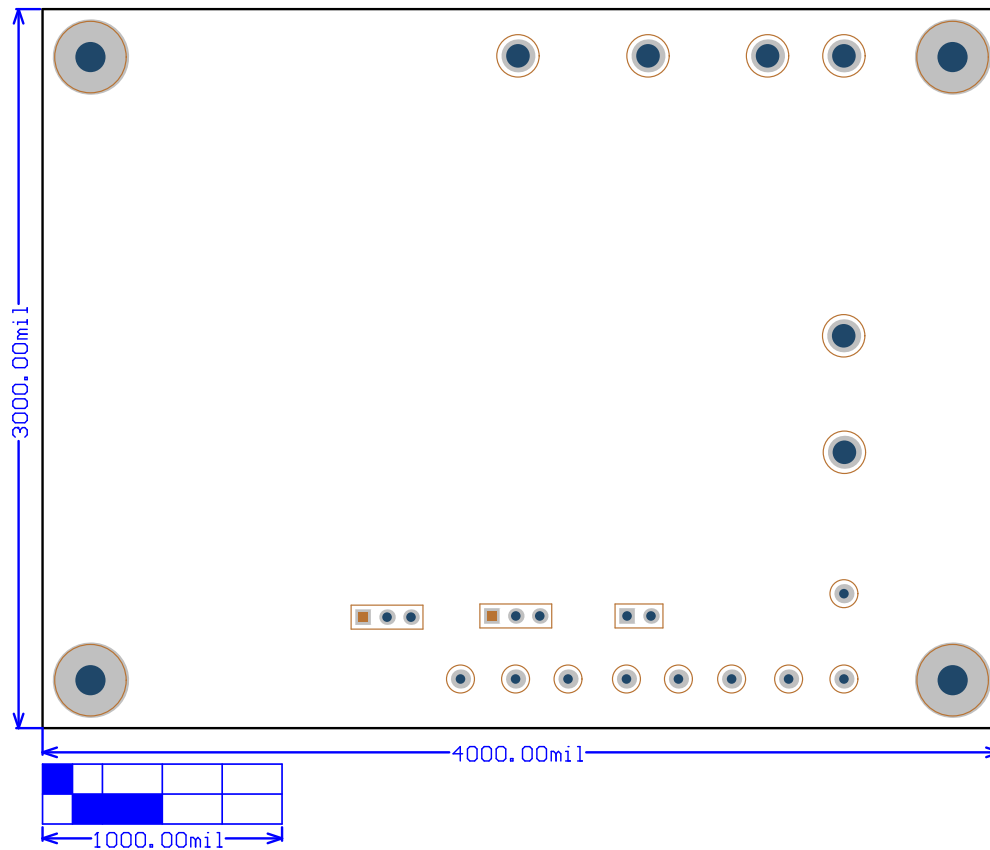


Figure 9. PCB Layer 5 – Dimensions

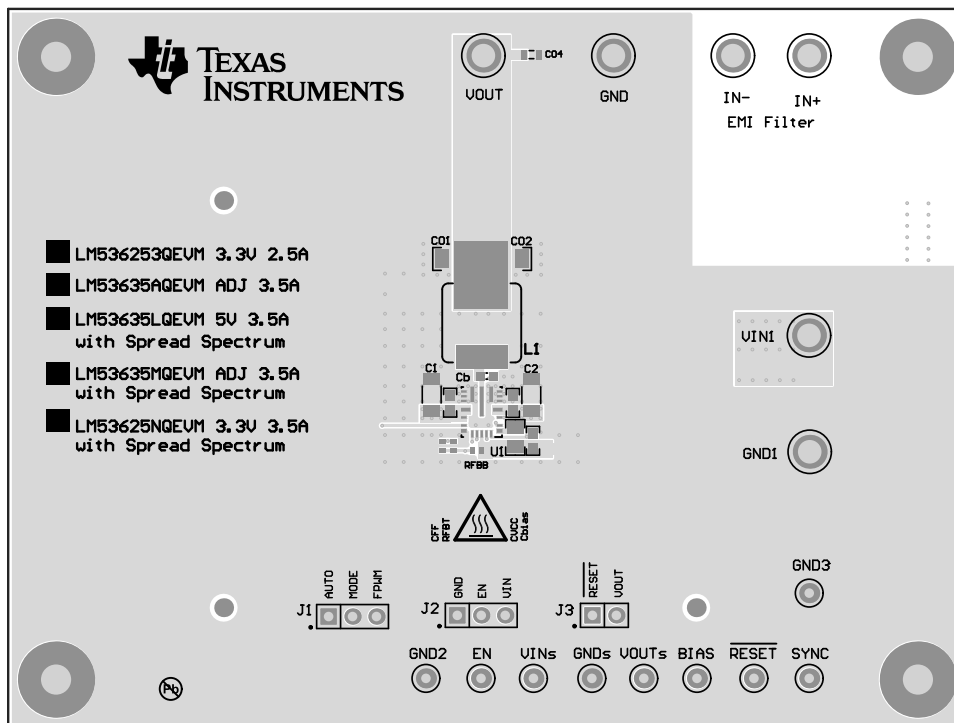


Figure 10. PCB Layer 7 Composite Top

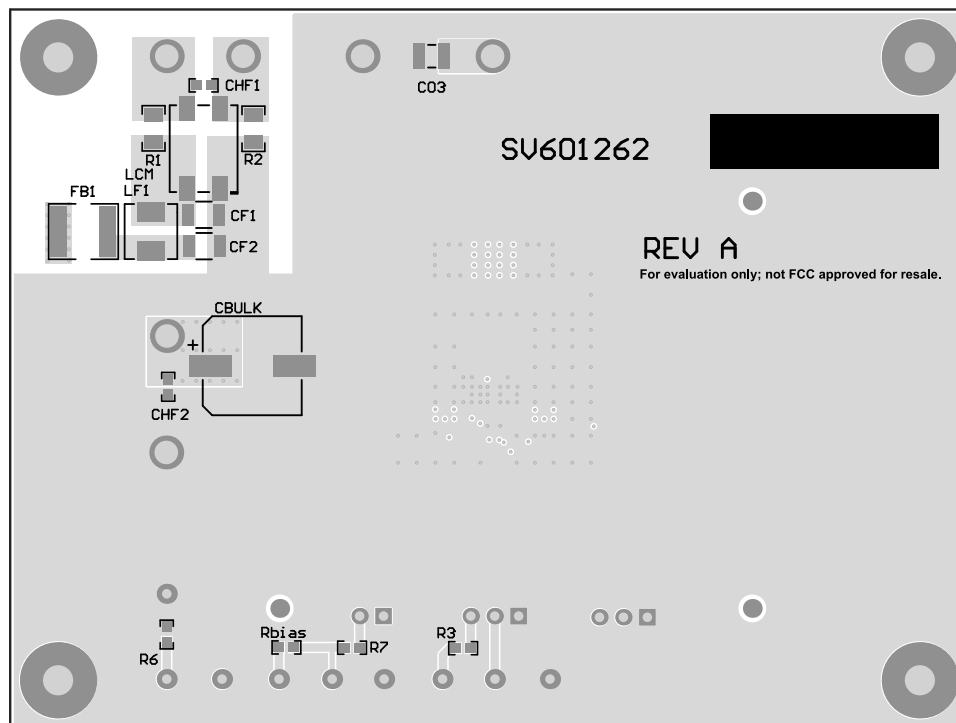


Figure 11. PCB Layer 6 Composite Bottom

5 Operation and Test Setup

5.1 Efficiency Measurement

1. Connect power supply to posts VIN1 and GND1 and make sure the power supply provides sufficient current.

NOTE: There is no reverse polarity protection or fuse on the evaluation board.

2. Connect electronic load to posts VOUT and GND. For all power wires use preferable twisted lab wires. If the power supply wires are very long > 50 cm please solder additional 470 μ F, 50 V bulk capacitor to posts VIN1 and GND1. Always use sufficient power wires and separate measurement sense wires.

NOTE: These sense lines are not designed to carry power.

3. To accurately sense input and output voltage use the test points VINs, VOUTs, and GNDs. Alternatively sense wires can be soldered directly over input capacitors C1 or C2 and the output capacitors C01 or C02.
4. Make sure the IC is enabled by having jumper J2 set to [EN-VIN] and check test point EN is driven high. While measuring I_q (unloaded input current) remove all the input and output voltage probes that are most likely causing additional current draw.

NOTE: If the jumper J1 is set to [MODE-FPWM] the part will have a lower efficiency at light loads by maintaining the 2.1-MHz switch frequency. To measure the highest light load efficiency place the Jumper J1 in [AUTO-MODE].

5.2 Measure Load Transient

1. Connect power supply to posts VIN1 and GND1 and make sure the power supply can provide sufficient peak current.

NOTE: There is no reverse polarity protection or fuse on the evaluation board.

2. Connect transient load to posts VOUT and GND. For all power wires use preferable twisted lab wires. If the power supply wires are very long > 50 cm; solder additional 470 μF , 50 V bulk capacitor to posts VIN1 and GND1. Use sufficient power wires to avoid voltage drops and use short sense probe connection for the measurement.
3. To accurately sense the output voltage, the scope probe should be placed directly over the output capacitors C01 or C02. Make sure to connect scope probe GND ring directly to the output capacitor GND pad for minimal ground loop. Ground loops can introduce ringing in observed waveforms which is an artifact; not present on the PCB. Alternatively use differential probe over output capacitors C01 or C02. Do not use wires to differential probe and always probe directly with shortest possible pins.
 Make sure the IC is enabled by having jumper J2 set to [EN-VIN] and check test point EN is driven high and not drooping during the load transient.

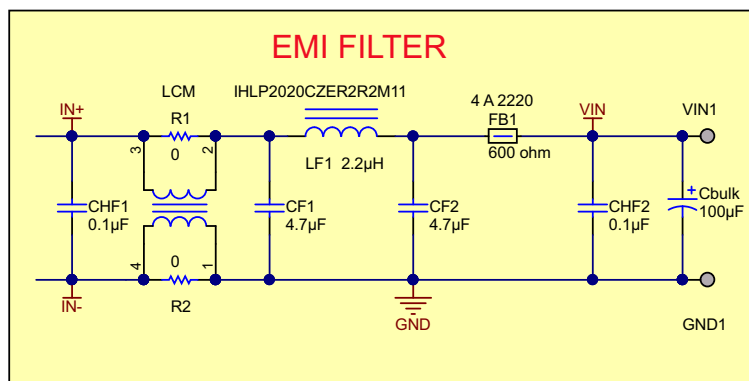
5.3 Measure EMI

1. Connect power supply cable from LISN to posts IN+ and IN- and make sure the board is placed 5 cm above the table.

NOTE: The length of the LISN cable to VIN+/VIN- should be between 20 cm to 40 cm for conducted EMI CISPR 25.

2. Connect resistive load directly to posts VOUT and GND. Use extremely short leads.

NOTE: To accurately measure EMI make sure the table has good ground connection to the chamber, connect the battery GND cable to ground table, and do not touch the board and setup or close the switch node. The board has a very effective 3-stage EMI filter where the common mode choke is not assembled by default. If the common mode choke is added, remove the bypass resistors R1 and R2.



Copyright © 2016, Texas Instruments Incorporated

Figure 12. 3-Stage EMI Filter Schematic

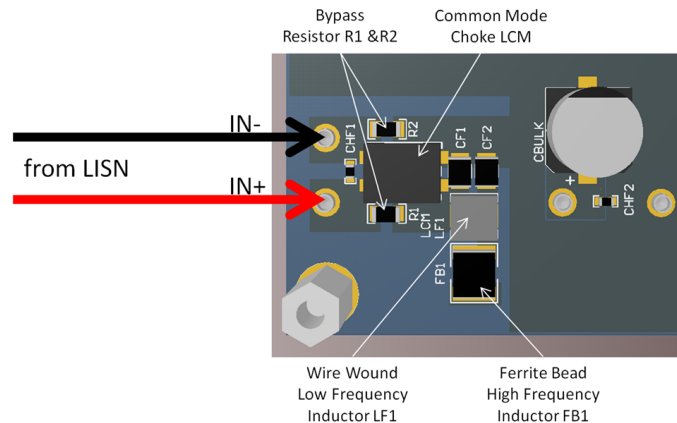


Figure 13. Position of the EMI Filter Components on PCB – Bottom Layer

6 Posts, Probes, and Jumpers

6.1 VIN1 and GND1 Posts

Standard input posts from power supply to operate EVM. The maximum input voltage is 36 V with 42 V absolute maximum transient.

6.2 VOUT and GND Posts

Standard output posts to load. Use sufficient lab cables and preferable twist them to reduce inductive parasitic of lab cables. The typical output voltage is 5 V or 3.3 V.

6.3 IN+ and IN- Posts

Standard Input posts for EMI Measurements so the IC is operated with EMI input Filter. By default there is a 2-stage filter assembled with a wire wound Inductor PI-Filter for low frequency filtering followed by stage utilizing a ferrite bead for high frequency filtering. If one wishes to measure a setup with a common mode choke; add the choke and remove bypass resistors R1 and R2.

6.4 EN and GND2 Probe

EN and GND2 probe can be used to measure the enable voltage or drive it from external source. If an external source is used make sure to remove jumper J2. By default J2 jumper is set EN to VIN.

6.5 VINs, VOUTs, and GNDs Probe

VINs and VOUTs are sense points for input and output voltage.

NOTE: Do not use for power supply or load.

These probe points are intended for use as kelvin sense point for static measurements like efficiency or line- or load regulation. For dynamic measurements please measure directly over the input capacitors C1 and C2 or directly over the output capacitor CO1 and CO2.

6.6 BIAS and GNDS Probe

BIAS probe senses the bias voltage to the IC. Bias voltage is provided from the output voltage of the IC over $R_{bias} = 3 \Omega$ resistor. An external Bias supply voltage can be provided by removing R_{bias} located on bottom side of PCB to disconnect IC output voltage as source for bias.

6.7 **RESET and GND3 Probe**

RESET provides an accurate power good signal with release delay. By default jumper J3 is set to VOUT and pulls the RESET pin to VOUT through a 100-kΩ resistor. RESET is an open drain output so it can be pulled to other external voltage levels by removing jumper J3.

6.8 **SYNC and GND3 Probe**

By default the IC is running with internal oscillator at 2.1 MHz. There are IC options available with and without internal spread spectrum modulation. Over the SYNC pin, an external function generator can be connected to take control of the LM53625 and LM53635's clock, changing switching frequency. SYNC function is responsive enough to be used for custom frequency modulation techniques.

6.9 **Jumper J1**

Jumper J1 sets light load operation mode of the IC. If set to [AUTO-MODE] when lightly loaded the IC goes automatically into PFM mode operation with fewer switching pulses and higher efficiency. The IC can be set into forced PWM mode (jumper position is marked *FPWM*) to operate with a constant switching frequency over the entire load range. This forced FPWM mode of operation will have best load transient behavior as well because there is no operation mode change during load transient steps.

6.10 **Jumper J2**

Jumper J2 enables the IC. By default it is set to [EN-VIN] and pulls the enable pin through a 100-kΩ resistor to Vin. If an external source drives the EN pin then remove jumper J2 and use probe points EN and GND2 or use a 3-pin wire connector directly plugged over J2.

6.11 **Jumper J3**

Jumper J3 pulls the open drain RESET output to VOUT through a 100-kΩ resistor. If another RESET output level is needed use probe point RESET and pullup resistor to external reference voltage and remove jumper J3.

7 **Bill of Materials**

Table 3. Bill of Materials

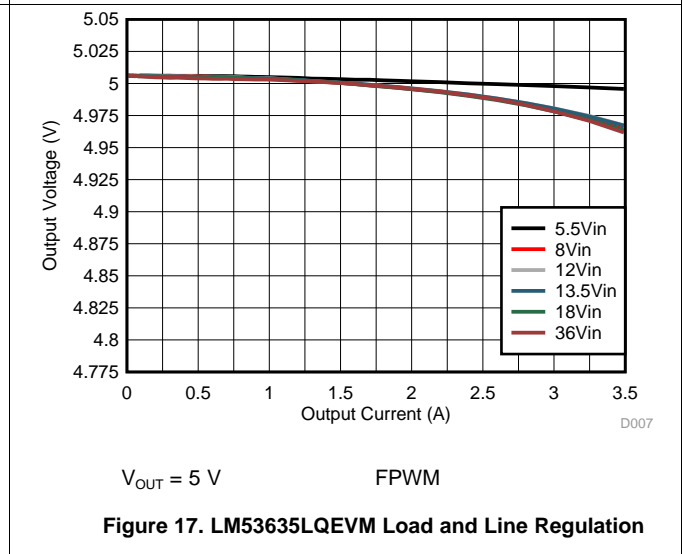
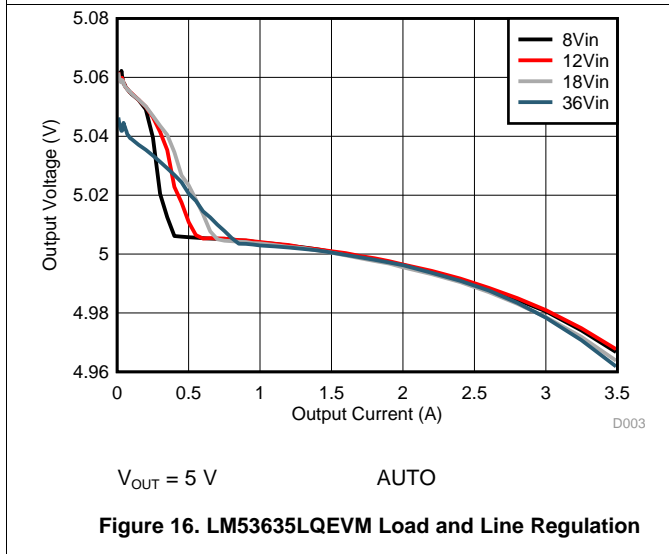
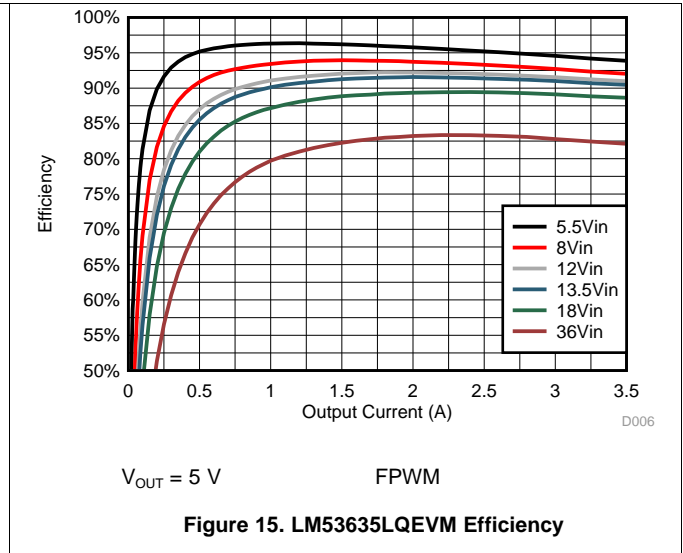
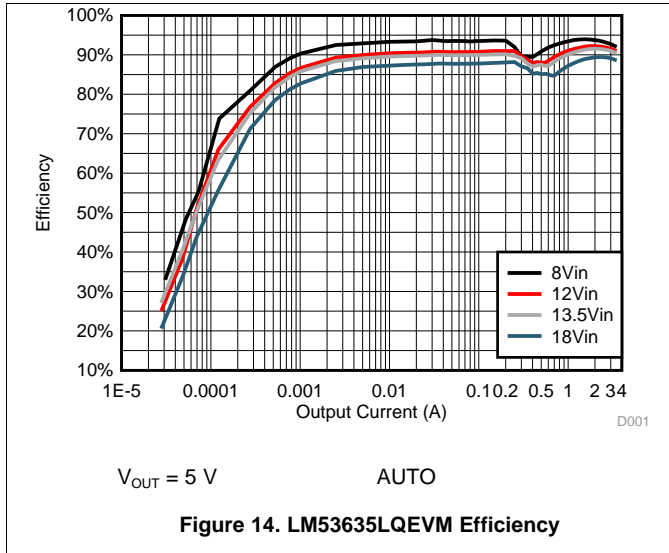
DESIGNATOR	QTY	VALUE	DESCRIPTION	PART NUMBER
BIAS, EN, RESET, SYNC	4		Test Point, Miniature, White, TH	5002
C1, C2	2	10 μF	CAP, CERM, 10 μF, 50 V, ±10%, X5R, 1206_109	GRM31CR61H106KA12L
Cb	1	0.47 μF	CAP, CERM, 0.47 μF, 25 V, ±10%, X5R, 0603	GRM188R61E474KA12D
Cbias, Co4	2	0.1 μF	CAP, CERM, 0.1 μF, 16 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	GCM188R71C104KA37J
Cbulk	1	100 μF	CAP, Aluminum Polymer, 100 μF, 50 V, ±20%, 0.025 Ω, AEC-Q200 Grade-2	HHXB500ARA101MJA0G
CF1, CF2	2	4.7 μF	CAP, CERM, 4.7 μF, 50 V, ±20%, X7R, AEC-Q200 Grade 1, 1210	CGA6P3X7R1H475M250AB
CHF1, CHF2	2	0.1 μF	CAP, CERM, 0.1 μF, 16 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	CGJ3E2X7R1C104K080AA
Cin_hf1, Cin_hf2	2	0.047 μF	CAP, CERM, 0.047 μF, 50 V, +/- 10%, X7R, 0603	GRM188R71H473KA61D
Co1, Co2	2	22 μF	CAP, CERM, 22 μF, 10 V, ±10, X7R, 1206	GRM31CR71A226KE15L
Co3	1	47 μF	CAP, CERM, 47 μF, 10 V, ±10, X7R, 1210	GRM32ER71A476KE15L
Cvcc	1	4.7 μF	CAP, CERM, 4.7 μF, 16 V, ±10%, X7R, AEC-Q200 Grade 1, 0805	GCM21BR71C475KA73L
FB1	1	600 Ω	Ferrite Bead, 600 Ω at 100 MHz, 4 A, 2220	HI2220P601R-10
GND, GND1, IN+, IN-, VIN1, VOUT	6	Double	Terminal, Turret, TH, Double	1502-2
GND2, GND3, GNDs	3	Black	Test Point, Miniature, Black, TH	5001
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 × 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH

Table 3. Bill of Materials (continued)

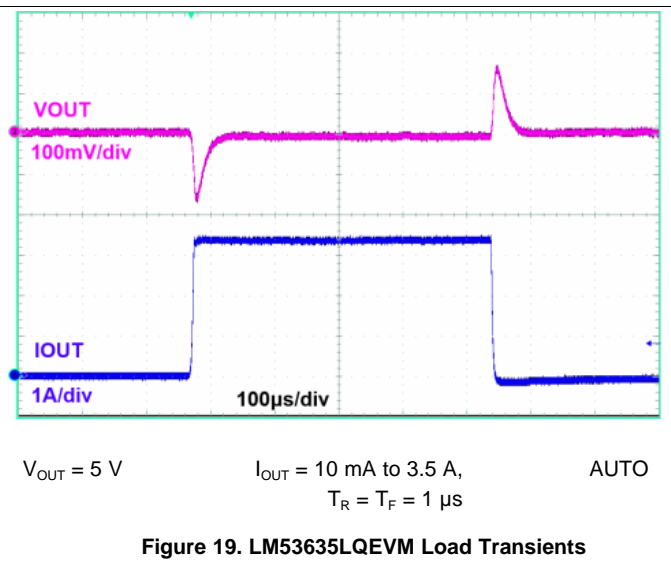
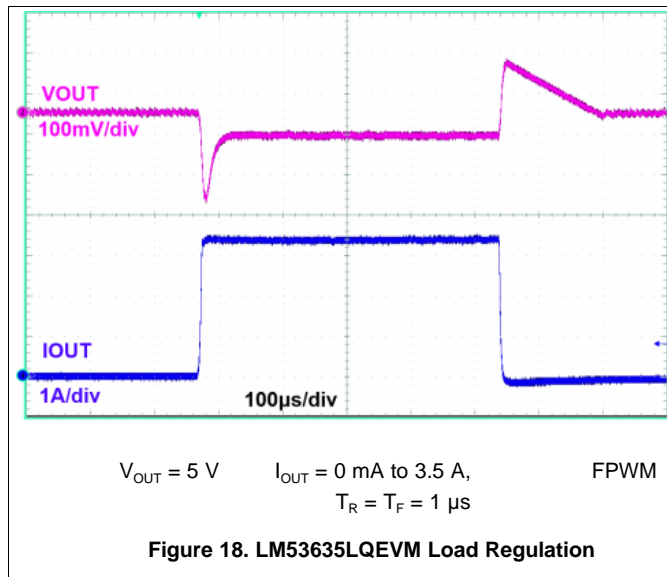
DESIGNATOR	QTY	VALUE	DESCRIPTION	PART NUMBER
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	1902C
J1, J2	2		Header, 100 mil, 3x1, Gold, TH	HTSW-103-07-G-S
J3	1		Header, 100 mil, 2x1, Gold, TH	HTSW-102-07-G-S
L1	1	2.2 μ H	Inductor, Shielded, Powdered Iron, 2.2 μ H, 10.2 A, 0.00941 Ω , SMD	IHLP3232DZER2R2M11
LCM	0		Coupled inductor, 5 A, 0.01 Ω , SMD	ACM9070-701-2PL-TL01
LF1	1	2.2 μ H	Inductor, Shielded Drum Core, Powdered Iron, 2.2 μ H, 5.5 A, 0.025 Ω , SMD	IHLP2020CZER2R2M11
R1, R2	2	0 Ω	RES, 0 Ω , 5% 0.25 W, 1206	CRCW12060000Z0EA
R3, R6, R7	3	100 k	RES, 100 K, 5%, 0.1 W, 0603	CRCW0603100KJNEA
Rbias	1	3 Ω	RES, 3 Ω , 5%, 0.1 W, 0603	CRCW06033R00JNEA
SH-J1, SH-J2, SH-J3	3	1x2	Shunt, 100 mil, Gold plated, Black	969102-0000-DA
VINs	1		Test Point, Miniature, Red, TH	5000
VOUTs	1		Test Point, Miniature, Orange, TH	5003
Variant 001	LM536253QEVM Fixed 3.3 V, 2.5 A Without Spread Spectrum			
U1	1		2.5/3.5 A Synchronous Buck Regulator for Automotive Applications, RNL0022A	LM536253QRNLRQ1
RFBB	0	DNP		
RFBT	1	0 Ω	2.5/3.5 A Synchronous Buck Regulator for Automotive Applications, RNL0022A	CRCW04020000Z0ED
CFF	0	DNP		
Variant 002	LM53635AQEVM Adjustable 5 V, 3.5 A Without Spread Spectrum			
U1	1		2.5/3.5 A Synchronous Buck Regulator for Automotive Applications, RNL0022A	LM53635AQRNLRQ1
RFBB	1	12.1 k	RES, 12.1 k, 1%, 0.063 W, 0402	CRCW040212K1FKED
RFBT	1	49.9 k	RES, 49.9 k, 1%, 0.063 W, 0402	CRCW040249K9FKED
CFF	1	15 pF	CAP, CERM, 15 pF, 50 V, \pm 5%, COG/NP0, 0402	GRM1555C1H150JA01D
Variant 003	LM53635LQEVM Fixed 5 V, 3.5 A With Spread Spectrum			
U1	1		2.5/3.5A Synchronous Buck Regulator for Automotive Applications, RNL0022A	LM53635LQRNLRQ1
RFBB	0	DNP		
RFBT	1	0 Ω	RES, 0 Ω , 5%, 0.063 W, 0402	CRCW04020000Z0ED
CFF	0	DNP		
Variant 004	LM53635MQEVM Adjustable 5 V, 3.5 A With Spread Spectrum			
U1	1		2.5/3.5A Synchronous Buck Regulator for Automotive Applications, RNL0022A	LM53635MQRNLRQ1
RFBB	1	12.1 k	RES, 12.1 k, 1%, 0.063 W, 0402	CRCW040212K1FKED
RFBT	1	49.9 k	RES, 49.9 k, 1%, 0.063 W, 0402	CRCW040249K9FKED
CFF	1	15 pF	CAP, CERM, 15 pF, 50 V, \pm 5%, COG/NP0, 0402	GRM1555C1H150JA01D
Variant 005	LM53635NQEVM Fixed 3.3 V, 3.5 A With Spread Spectrum			
U1	1		2.5/3.5A Synchronous Buck Regulator for Automotive Applications, RNL0022A	LM53635NQRNLRQ1
RFBB	0	DNP		
RFBT	1	0 Ω	RES, 0 Ω , 5%, 0.063 W, 0402	CRCW04020000Z0ED
CFF	0	DNP		

8 Efficiency and Line- and Load-Regulation

The variant of the board LM53635LQEVm is used for all measurements and curves in [Figure 14](#) to [Figure 23](#).



8.1 Load Transients



8.2 Conducted EMI

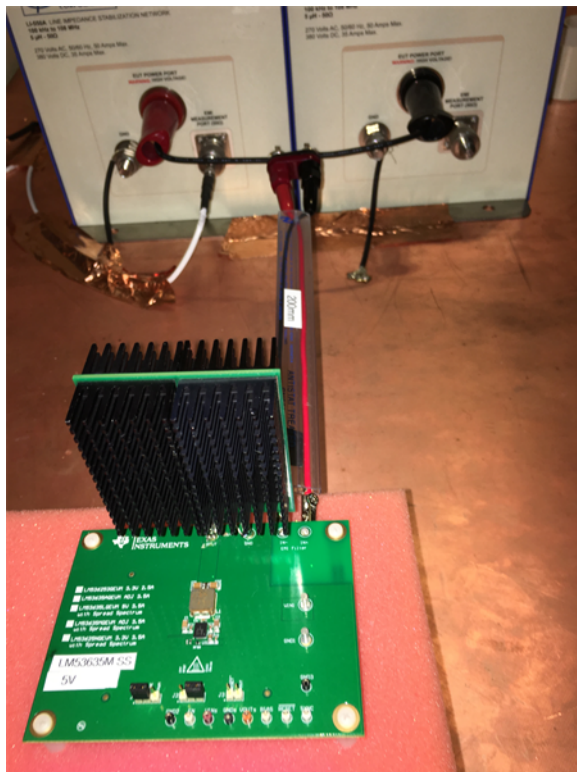


Figure 20. Conducted EMI Setup - Front View

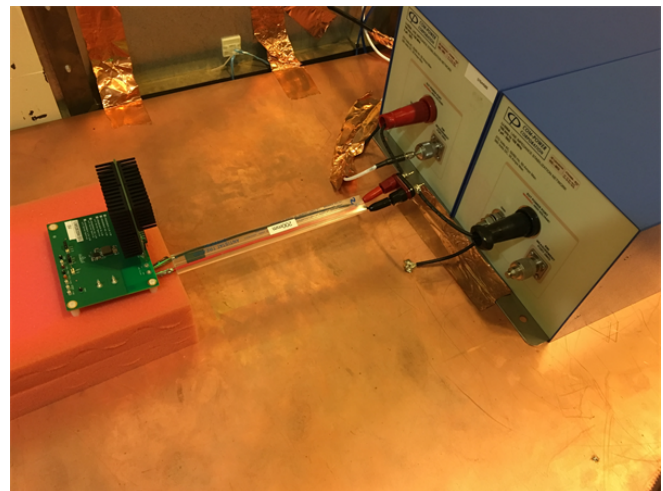


Figure 21. Conducted EMI Setup - Side View

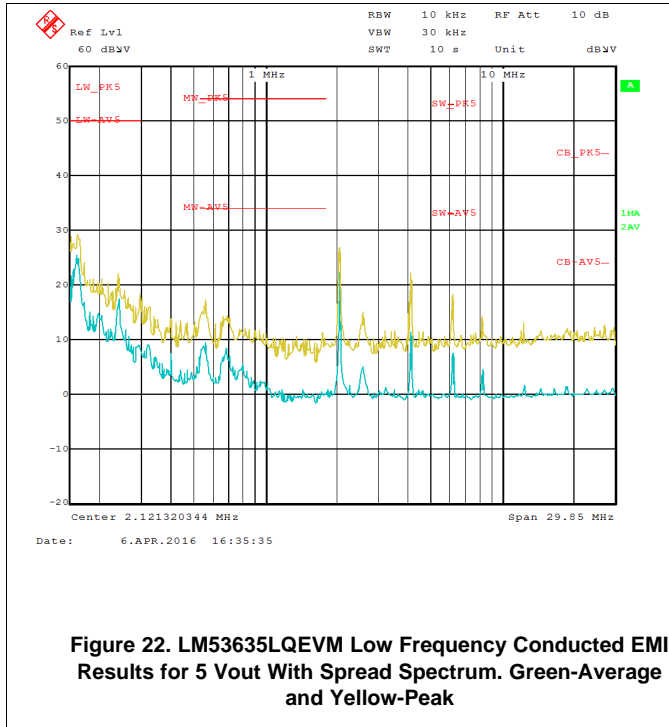


Figure 22. LM53635LQEVM Low Frequency Conducted EMI Results for 5 Vout With Spread Spectrum. Green-Average and Yellow-Peak

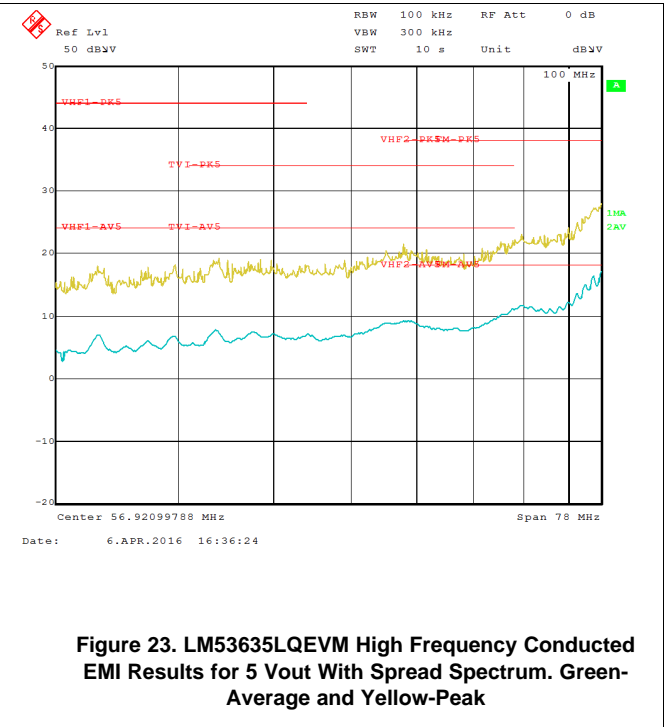


Figure 23. LM53635LQEVM High Frequency Conducted EMI Results for 5 Vout With Spread Spectrum. Green-Average and Yellow-Peak

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
 - 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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
 - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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.
3. *Regulatory Notices:*
 - 3.1 *United States*
 - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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/lstds/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。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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/llds/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。http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page

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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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 AND CONDITIONS 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 MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.
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 AND CONDITIONS. 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 AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, 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 ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.
- 8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS 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
Copyright © 2015, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com