

# LM53602xEVM and LM53603xEVM

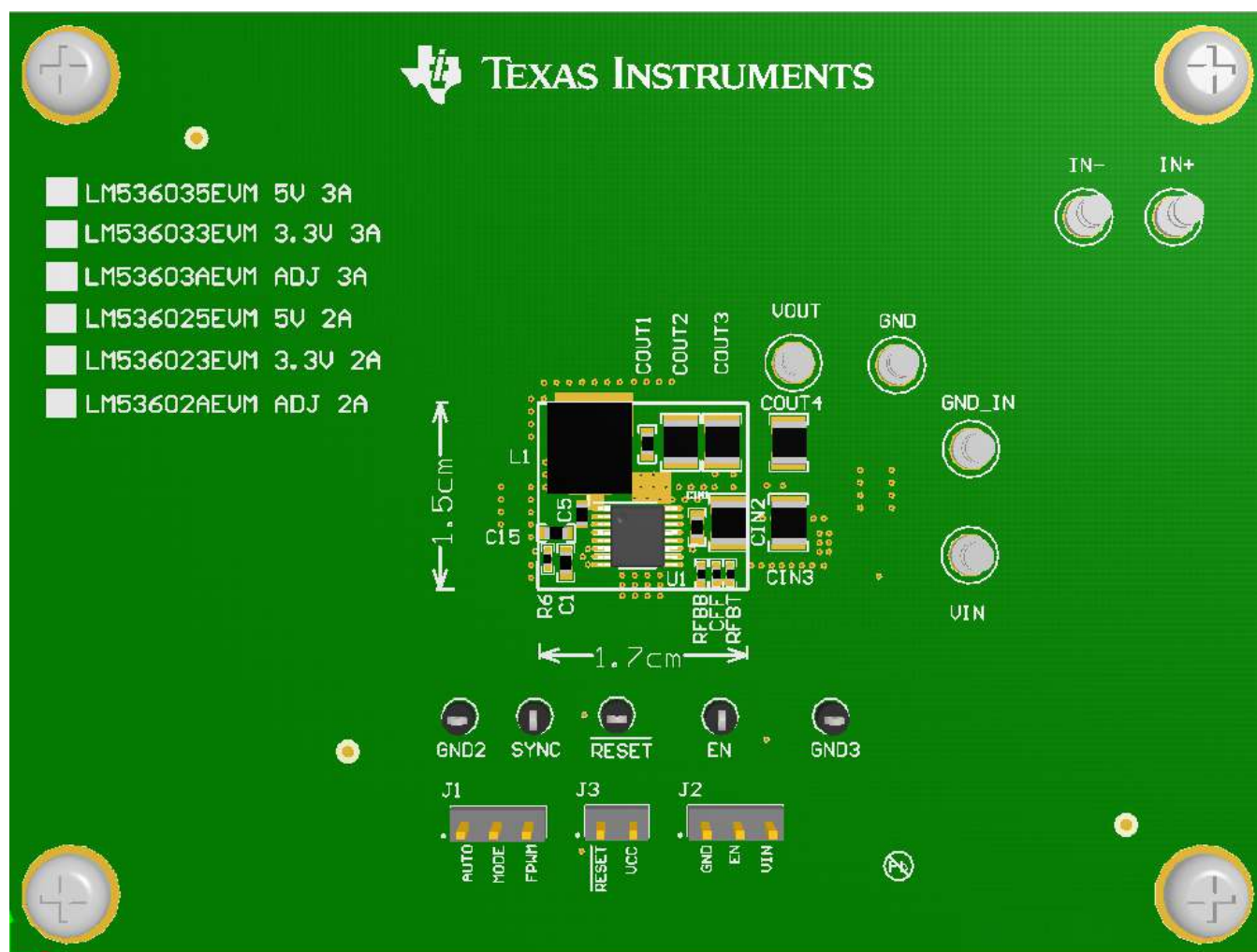
## User's Guide



Literature Number: SNVU470A  
June 2015–Revised May 2016

## Introduction

The LM53603 Evaluation Module helps designers evaluate the operation and performance of the LM53603 wide input voltage automotive buck regulator. The board enables the user to test external synchronization, RESET/Power Good output, precision enable and operation in both Auto mode (with high efficiency operation and light load) and Forced PWM mode (FPWM). The EN pin is rated up to  $V_{in}$  while the SYNC pin, RESET pin and the mode pin (FPWM) are rated up to 6 V. Please refer to the [LM53603 data sheet](#) for detailed information on the IC parameters and operating characteristics.



**Figure 1-1. Evaluation Board**

## **Setup**

The LM536035EVM is ready to operate. There are two sets of input terminals. The first one labeled IN+, IN- (positive, negative) connects the power supply to the LM53603 regulator through and EMI filter with optional common mode choke. The second set of terminals labeled VIN, GND\_IN (positive, negative) connects the supply directly to the LM53603, bypassing the EMI filter.

The output terminals are labeled VOUT and GND with posts located on top of the regulators. Additional pads are available for optional extra input and output capacitance: CIN3 and COUT4.

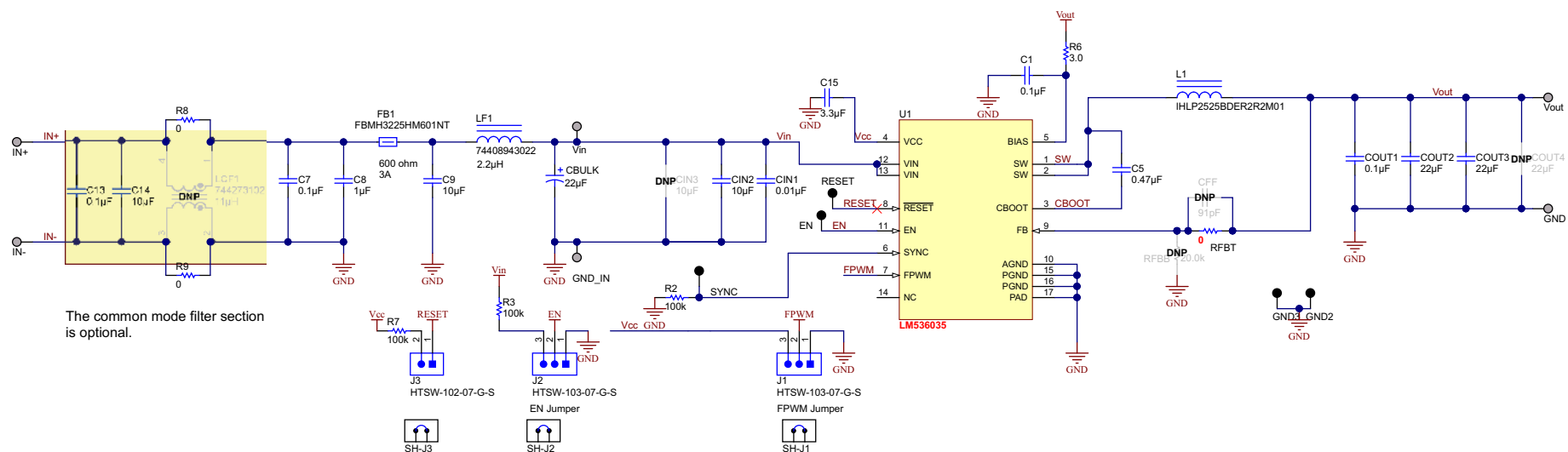
There are three jumper connectors that are used in order to interact with the LM53603. A jumper can be connected on each of these terminals. Refer to the schematic, [Figure 2-1](#) for details on the connection of these jumpers.

**Table 2-1. Jumper Options**

Designator	Attached Function	Jumper Position	Result
J1	Mode (FPWM)	1-2 (AUTO-MODE)	Auto mode. The part lowers frequency at light load to increase efficiency, diode emulation active
		3-2 (FPWM-MODE)	FPWM mode: The part operates does not reduce frequency at light load, no diode emulation
J2	Enable (EN)	1-2 (GND-EN)	The part is enabled (connection to Vin)
		3-2 (VIN-EN)	The part is disabled (connection to Gnd)
J3	PowerGood/Reset output (RESET)	1-2	RESET output is pulled up to VCC
		no jumper	RESET output pull-up disconnected. user can connect to pull-up source of her/his choice (<6V, ensure a pull-up resistance is connected to limit current when RESET pin goes low)

### **2.1 Quick Start**

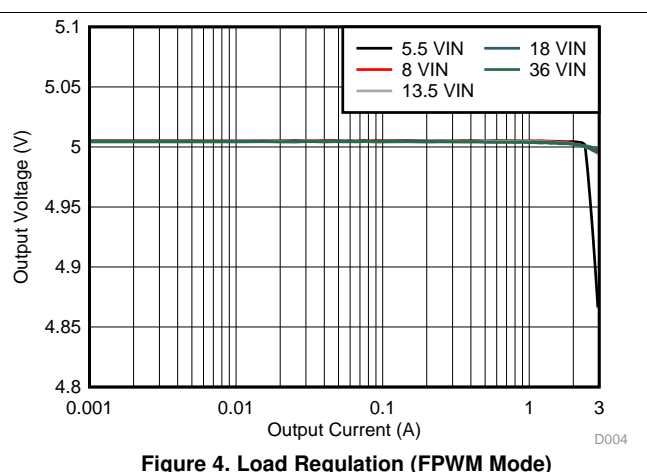
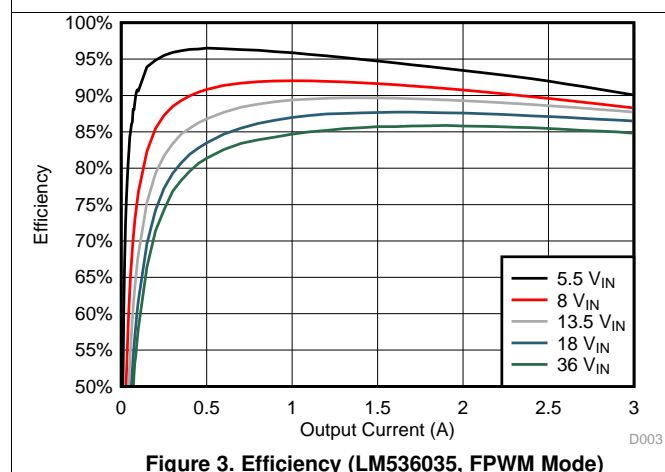
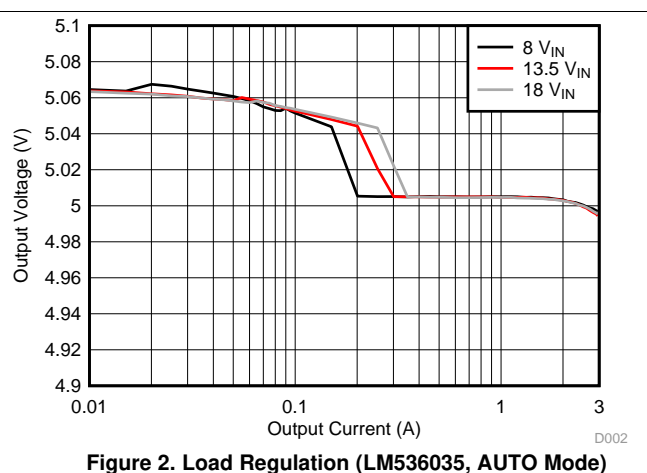
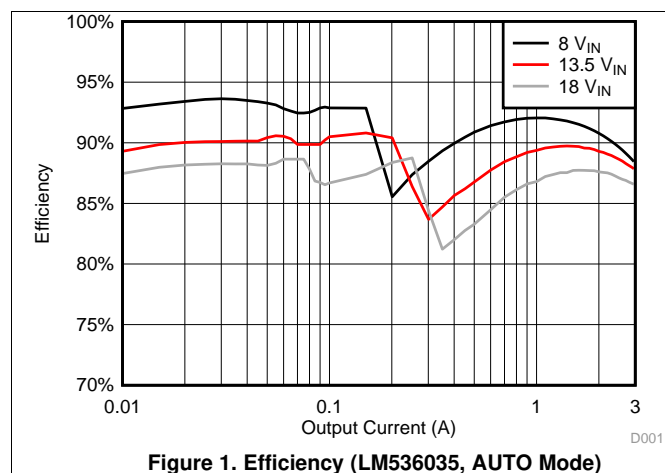
Connect the power supply to either the IN+, IN- terminal pair or the VIN, GND\_IN terminal pair. With the default jumper connection, the board should begin operating as soon as proper voltage is applied to the input. The default mode of operation is normal or "auto" mode (refer to the datasheet for more details on the operating mode). For the ADJ version, the default output voltage is 5V. To change the output voltage, modify RFBB and RFBT resistors as explained in the [LM53603 data sheet](#). Depending on the output voltage, a change in CFF may be required to achieve adequate transient response.



## Operating Curves

### 3.1 LM536035EVM

Figure 1 thru Figure 5 detail the operation of the EVM with the fixed 5 V version of the LM53603: the LM536035.



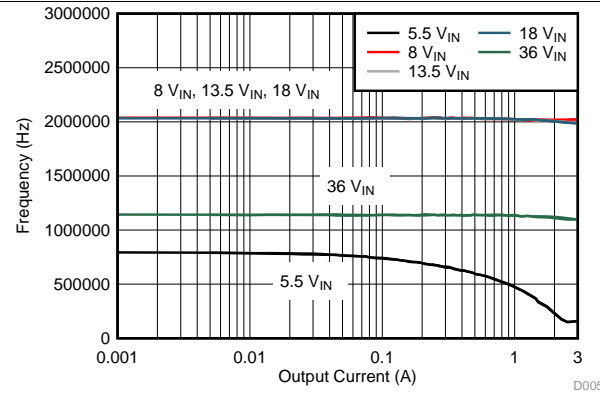


Figure 5. Frequency vs Output Current (LM536035, FPWM Mode)

### 3.2 LM536033EVM

Figure 6 thru Figure 9 detail the operation of the fixed 3.3 V version of the LM53603: the LM536033.

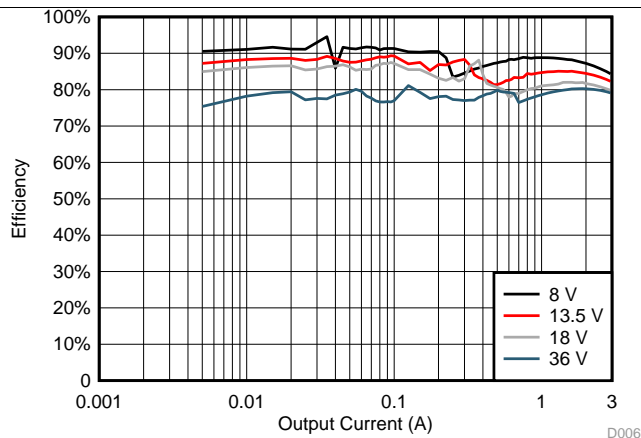


Figure 6. Efficiency (LM536033, AUTO Mode)

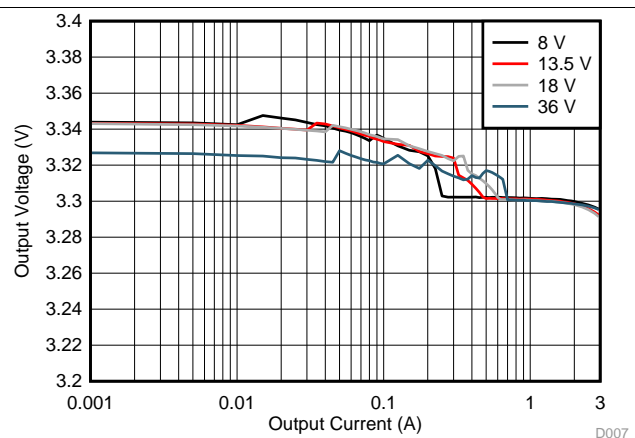


Figure 7. Load Regulation (LM536033, AUTO Mode)

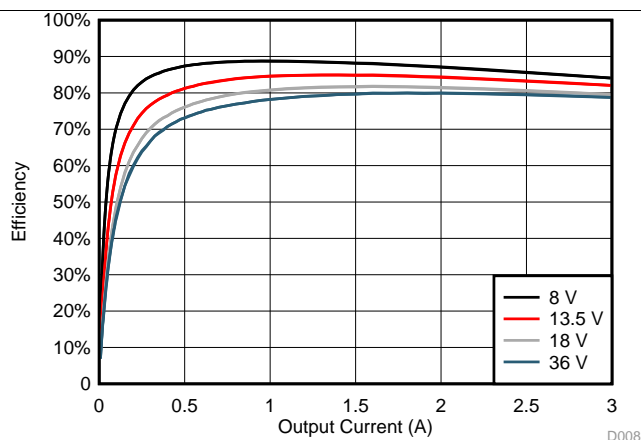


Figure 8. Efficiency (LM536033, FPWM Mode)

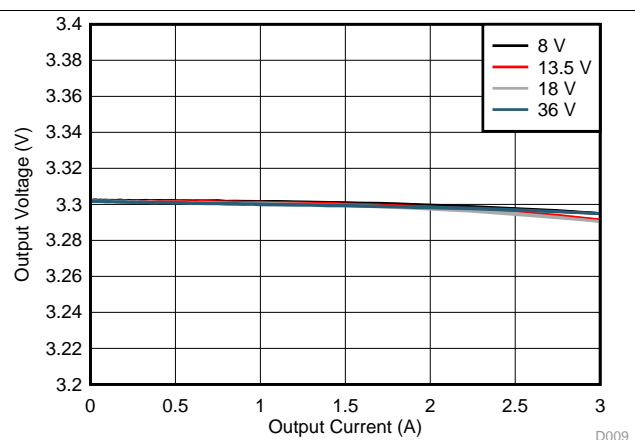


Figure 9. Load Regulation (LM536033, FPWM Mode)

## Bill of Materials

### 4.1 Fixed 5 V EVM (LM536035EVM)

Table 4-1 applies to the 5 V fixed EVM version (LM536035EVM).

**Table 4-1. Bill of Materials**

Designator	Qty	Value	Description	Part Number
C1	1	0.1uF	CAP, CERM, 0.1 $\mu$ F, 50 V, +/- 10%, X7R, 0603	06035C104KAT2A
C5	1	0.47uF	CAP, CERM, 0.47 $\mu$ F, 25 V, +/- 10%, X7R, 0603	GRM188R71E474KA12D
C7, C13, COUT1	3	0.1uF	CAP, CERM, 0.1 $\mu$ F, 50 V, +/- 10%, X7R, 0603	GRM188R71H104KA93D
C8	1	1uF	CAP, CERM, 1 $\mu$ F, 50 V, +/- 10%, X7R, 0805	GRM21BR71H105KA12L
C9, C14, CIN2	3	10uF	CAP, CERM, 10 $\mu$ F, 50 V, +/- 10%, X7R, 1210	GRM32ER71H106KA12L
C15	1	3.3uF	CAP, CERM, 3.3 $\mu$ F, 10 V, +/- 10%, X7S, 0603	C1608X7S1A335K080AC
CBULK	1	22uF	CAP, AL, 22 $\mu$ F, 50 V, +/- 20%, 0.88 ohm, SMD	EEE-FK1H220P
CIN1	1	0.01uF	CAP, CERM, 0.01 $\mu$ F, 50 V, +/- 10%, X7R, 0603	GRM188R71H103KA01D
COUT2, COUT3	2	22uF	CAP, CERM, 22 $\mu$ F, 16 V, +/- 10%, X7R, 1210	GRM32ER71C226KE18L
EN, GND2, GND3, RESET, SYNC	5	Black	Test Point, Miniature, Black, TH	5001
FB1	1	600 ohm	Ferrite Bead, 600 ohm @ 100 MHz, 3 A, 1210 (H=2.5mm)	FBMH3225HM601NT
GND, GND_IN, IN+, IN-, Vin, Vout	6	Double	Terminal, Turret, TH, Double	1502-2
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	1902C
J1, J2	2		Header, 100mil, 3x1, Gold, TH	HTSW-103-07-G-S
J3	1		Header, 100mil, 2x1, Gold, TH	HTSW-102-07-G-S
L1	1	2.2uH	Inductor, Shielded, Powdered Iron, 2.2 $\mu$ H, 6.5 A, 0.034 ohm, SMD	IHLP2525BDER2R2M01
LF1	1	2.2uH	Inductor, Shielded Drum Core, Ferrite, 2.2uH, 3A, 0.026 ohm, SMD	74408943022
R2, R3, R7	3	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL
R6	1	3.0	RES, 3.0, 5%, 0.063 W, 0402	CRCW04023R00JNED
R8, R9	2	0	RES, 0, 5%, 0.25 W, 1206	RC1206JR-070RL
RFBT	1	0	RES, 0, 5%, 0.063 W, 0402	RC0402JR-070RL
SH-J1, SH-J2, SH-J3	3	1x2	Shunt, 100mil, Gold plated, Black	969102-0000-DA
U1	1		5V, 3A, Buck Regulator For Automotive Applications, PWP0016H	LM536035QPWPQRQ1
COUT4	0	22uF	CAP, CERM, 22 $\mu$ F, 16 V, +/- 10%, X7R, 1210	GRM32ER71C226KE18L
CFF	0	91pF	CAP, CERM, 91 pF, 50 V, +/- 5%, C0G/NP0, 0402	GRM1555C1H910JA01D
CIN3	0	10uF	CAP, CERM, 10 $\mu$ F, 50 V, +/- 10%, X7R, 1210	GRM32ER71H106KA12L
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A
LCF1	0	11uH	Coupled inductor, 11 $\mu$ H, 2.5 A, 0.03 ohm, SMD	744273102
RFBB	0	20.0k	RES, 20.0 k, 1%, 0.063 W, 0402	CRCW040220K0FKED

## 4.2 Modification to LM536035EVM BOM for Other Variants of the LM53603 and LM53602

The other EVMs: LM536033EVM, LM53603AEVM, LM536025EVM, LM536023EVM and LM53602AEVM differ from the LM536035EVM by the components shown in [Table 4-2](#) thru [Table 4-6](#). Please refer to the Bill of Material for the LM536035EVM [Table 4-1](#) for the other components.

**Table 4-2. Modifications to BOM for LM536033EVM**

Designator	Qty	Value	Description	Part Number
U1	1		3.3V, 3A, Buck Regulator For Automotive Applications	LM536033QPWPRQ1
C15	1	4.7uF	CAP CER 4.7UF 10V X7S 0603	C1608X7S1A475K080AC

**Table 4-3. Modifications to BOM for LM53603AEVM**

Designator	Qty	Value	Description	Part Number
U1	1		3.3V, 3A, Buck Regulator For Automotive Applications	LM53603AQPWPRQ1
C15	1	4.7uF	CAP CER 4.7UF 10V X7S 0603	C1608X7S1A475K080AC
RFBB	1	20.0k	RES, 20.0 k, 1%, 0.063 W, 0402	CRCW040220K0FKED
RFBT	1	80.6k	RES, 80.6 k, 1%, 0.063 W, 0402	CRCW040280K6FKED
CFF	1	56pF	CAP, CERM, 56 pF, 50 V, +/- 5%, C0G/NP0, 0402	GRM1555C1H560JA01D

**Table 4-4. Modifications to BOM for LM536025EVM**

Designator	Qty	Value	Description	Part Number
U1	1		3.3V, 3A, Buck Regulator For Automotive Applications	LM536025QPWPRQ1
C15	1	4.7uF	CAP CER 4.7UF 10V X7S 0603	C1608X7S1A475K080AC

**Table 4-5. Modifications to BOM for LM536023EVM**

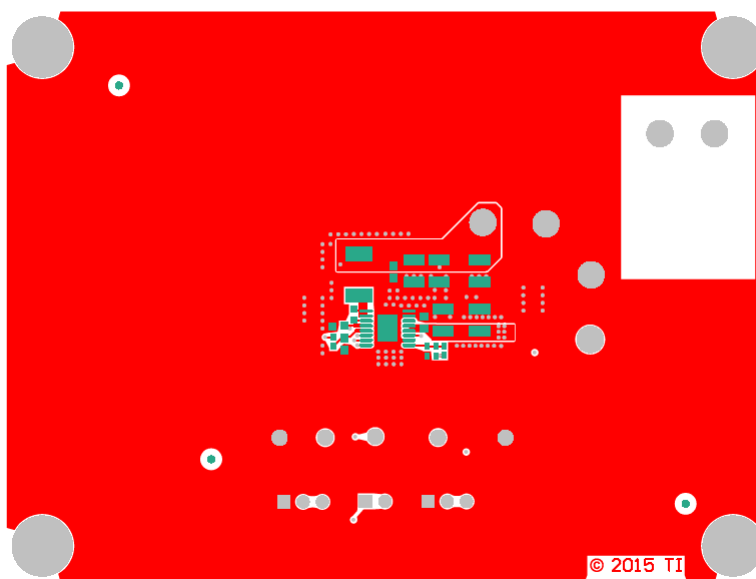
Designator	Qty	Value	Description	Part Number
U1	1		3.3V, 3A, Buck Regulator For Automotive Applications	LM536023QPWPRQ1
C15	1	4.7uF	CAP CER 4.7UF 10V X7S 0603	C1608X7S1A475K080AC

**Table 4-6. Modifications to BOM for LM53602AEVM**

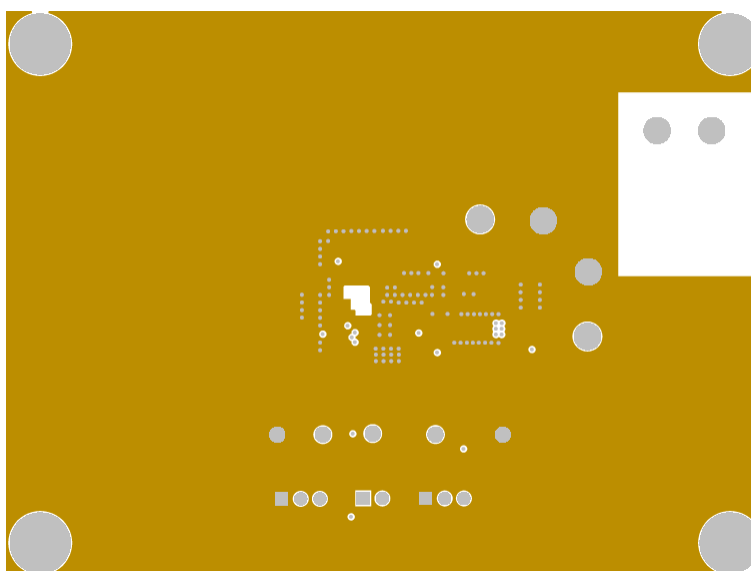
Designator	Qty	Value	Description	Part Number
U1	1		3.3V, 3A, Buck Regulator For Automotive Applications	LM53602AQPWPRQ1
C15	1	4.7uF	CAP CER 4.7UF 10V X7S 0603	C1608X7S1A475K080AC
RFBB	1	20.0k	RES, 20.0 k, 1%, 0.063 W, 0402	CRCW040220K0FKED
RFBT	1	80.6k	RES, 80.6 k, 1%, 0.063 W, 0402	CRCW040280K6FKED
CFF	1	56pF	CAP, CERM, 56 pF, 50 V, +/- 5%, C0G/NP0, 0402	GRM1555C1H560JA01D



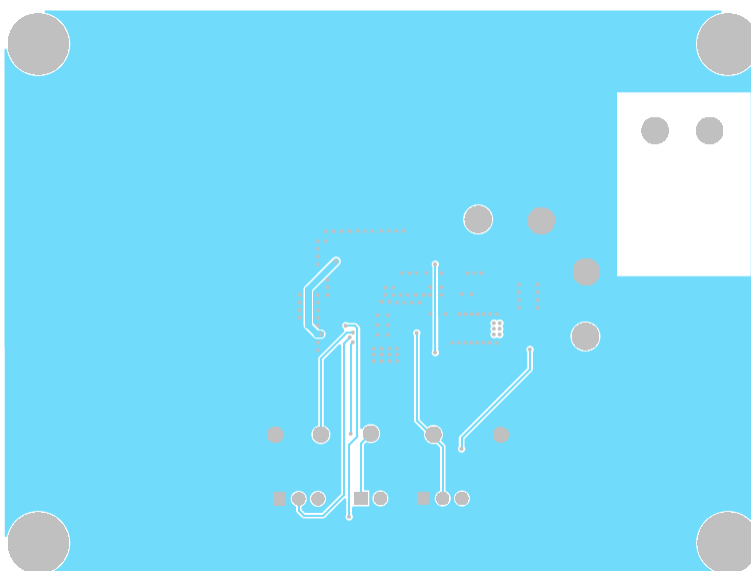
## PCB Layout



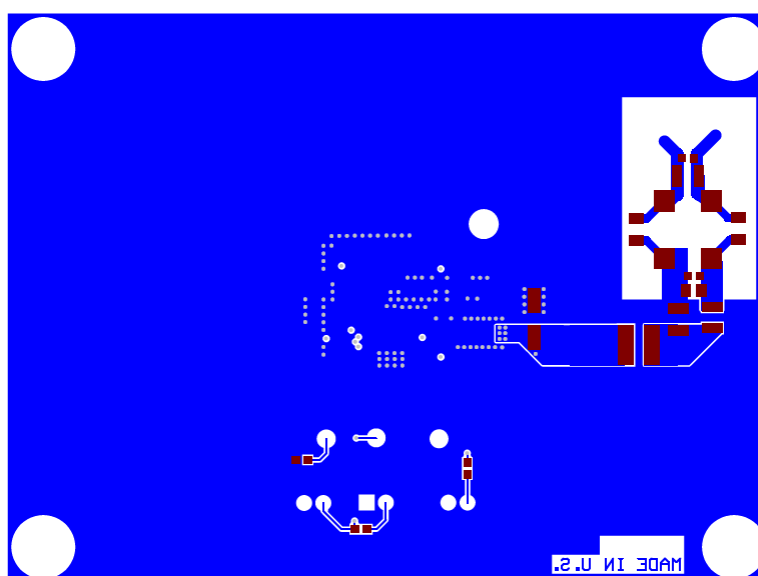
**Figure 5-1. Top Layer**



**Figure 5-2. Mid Layer 1**



**Figure 5-3. Mid Layer 2**



**Figure 5-4. Bottom Layer**

## Revision History

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

Changes from Original (June 2015) to A Revision	Page
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- |   |                   |
|---|-------------------|
| • Added new BOM information and reflowed document. .... | <a href="#">7</a> |
|---|-------------------|

## 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.

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- 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/llds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/llds/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/llds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/llds/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.

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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](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](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.
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