

# LM53602xEVM and LM53603xEVM

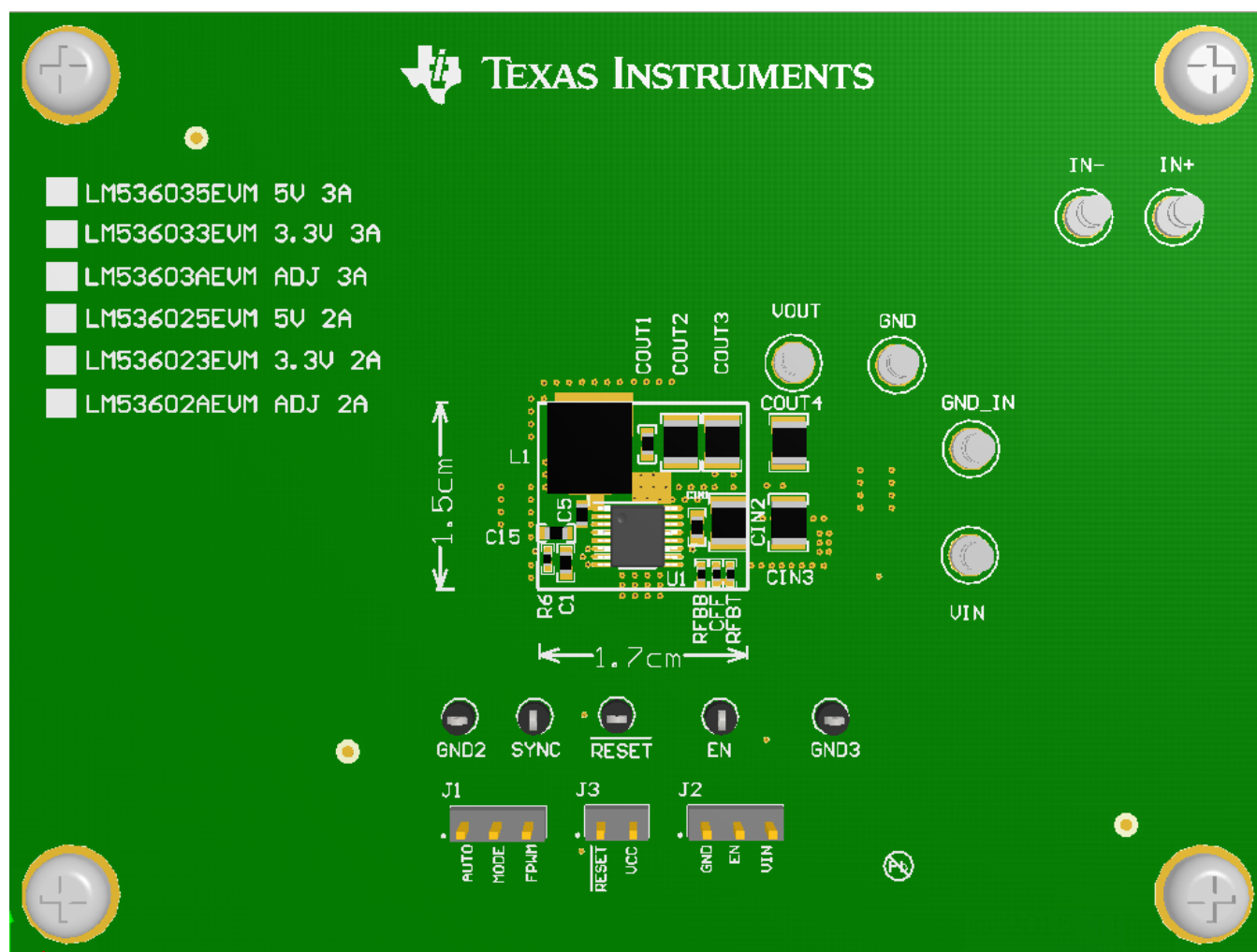
## User's Guide



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 an 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.

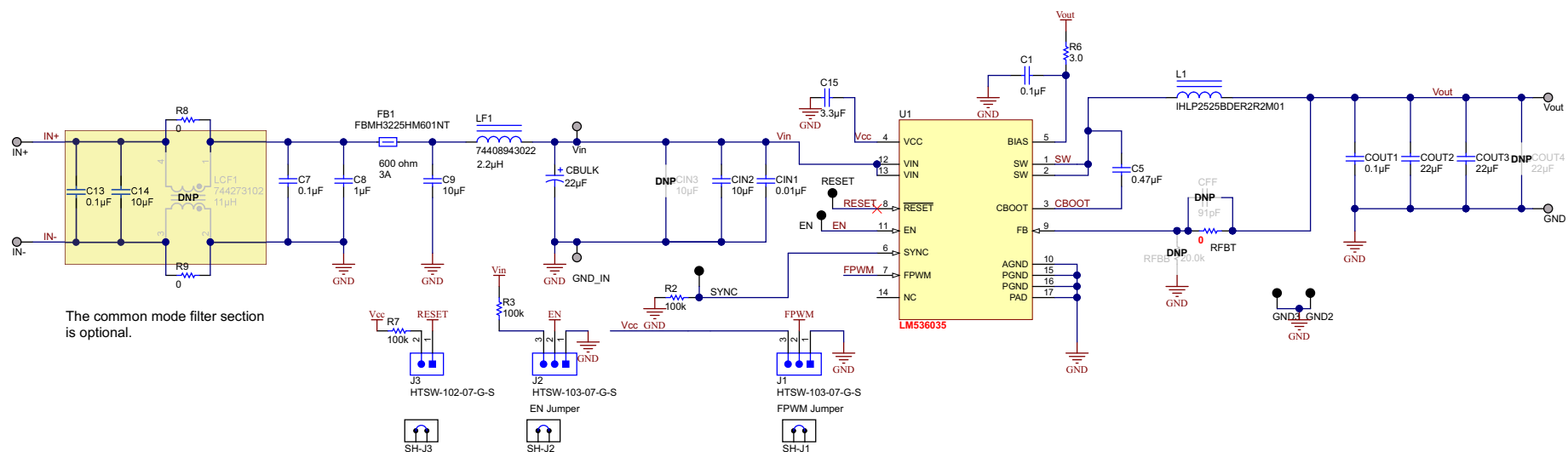
There are three jumper connectors that are used in order to interact with the LM53603. A jumper can be connected on each of these terminals. Refer to the schematic, [Figure 2-1](#) for details on the connection of these jumpers.

**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.

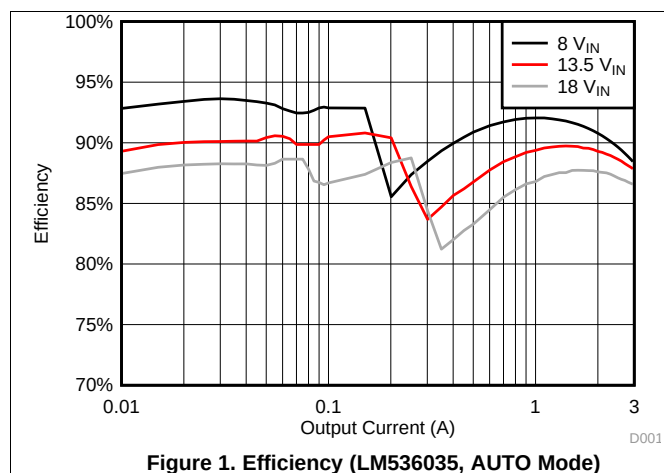


Figure 1. Efficiency (LM536035, AUTO Mode)

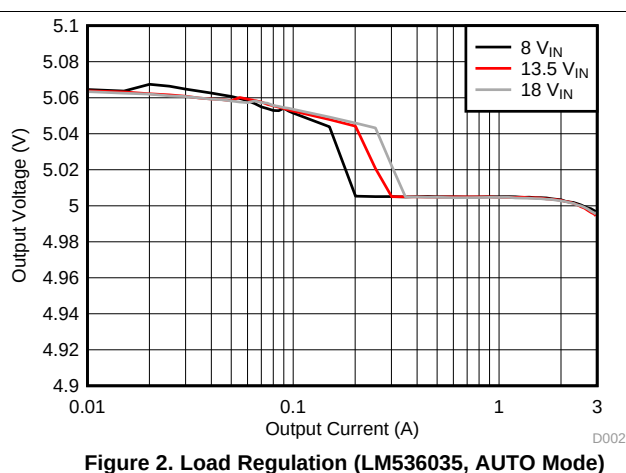


Figure 2. Load Regulation (LM536035, AUTO Mode)

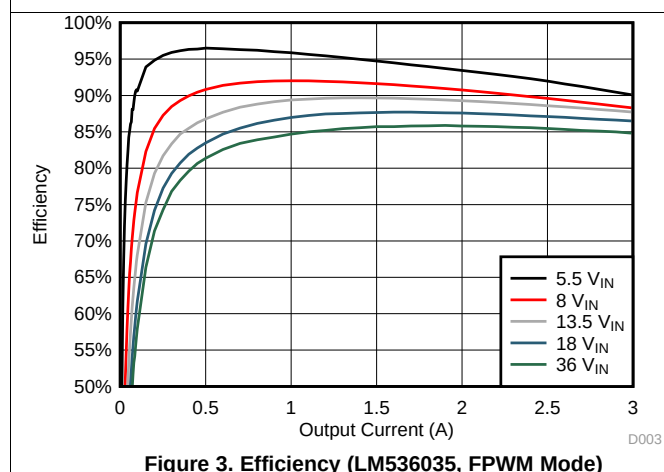


Figure 3. Efficiency (LM536035, FPWM Mode)

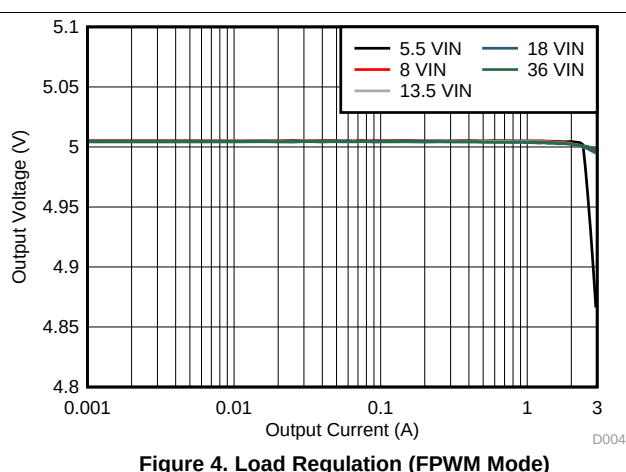


Figure 4. Load Regulation (FPWM Mode)

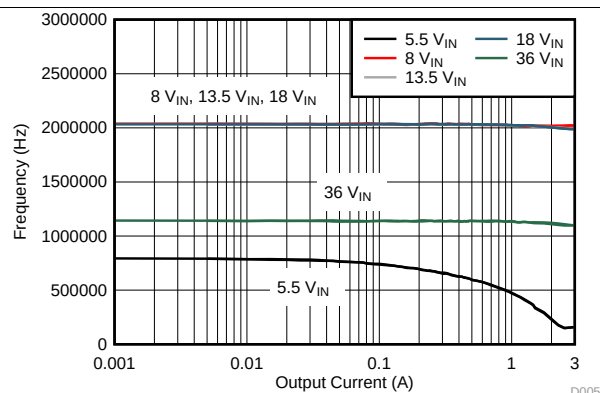


Figure 5. Frequency vs Output Current (LM536035, FPWM Mode)

### 3.2 LM536033EVM

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

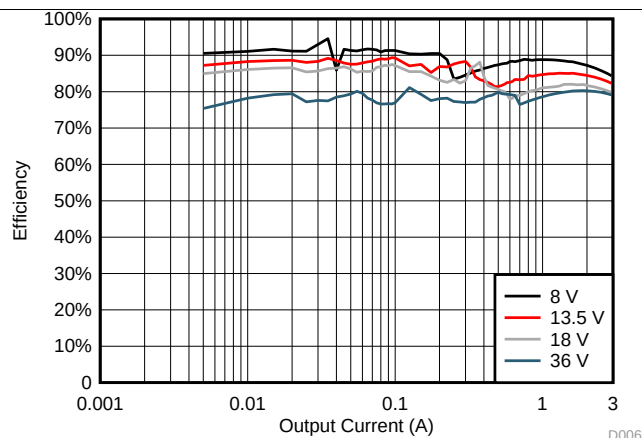


Figure 6. Efficiency (LM536033, AUTO Mode)

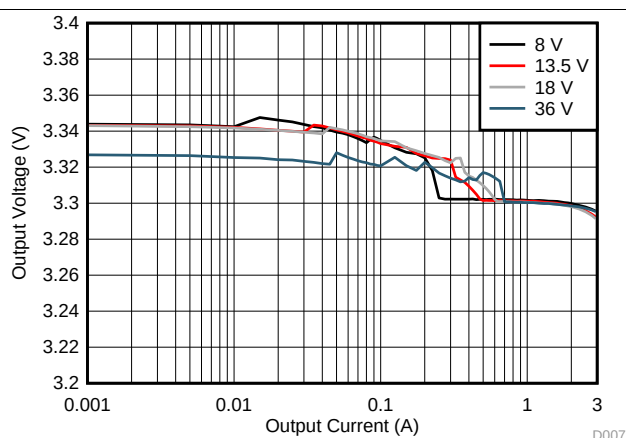


Figure 7. Load Regulation (LM536033, AUTO Mode)

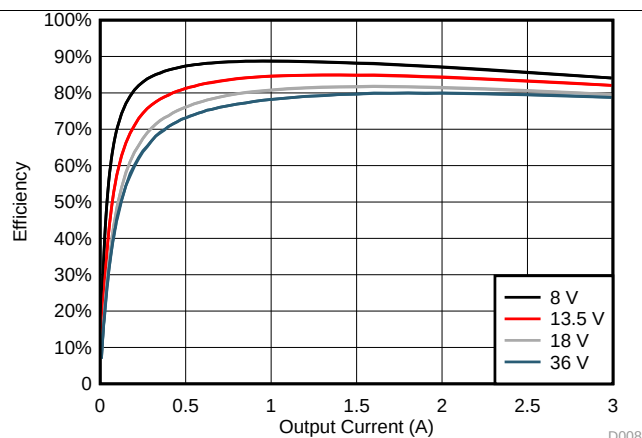


Figure 8. Efficiency (LM536033, FPWM Mode)

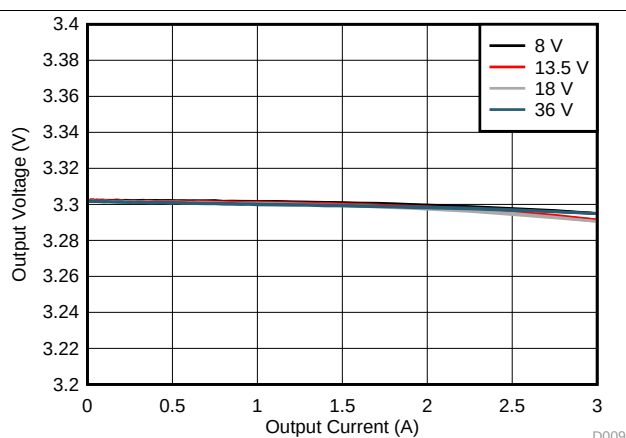


Figure 9. Load Regulation (LM536033, FPWM Mode)

## 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          | LM536035QPWPRQ1     |
| 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           |
| RFBF                             | 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

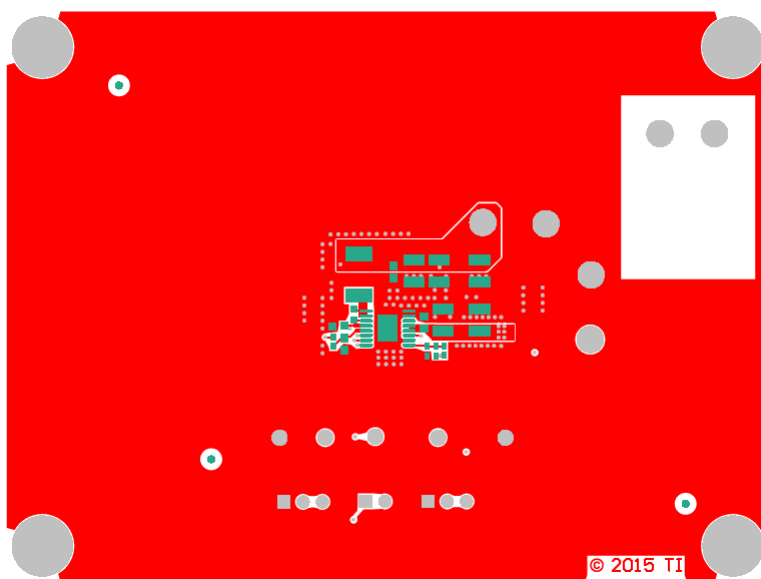


Figure 5-1. Top Layer

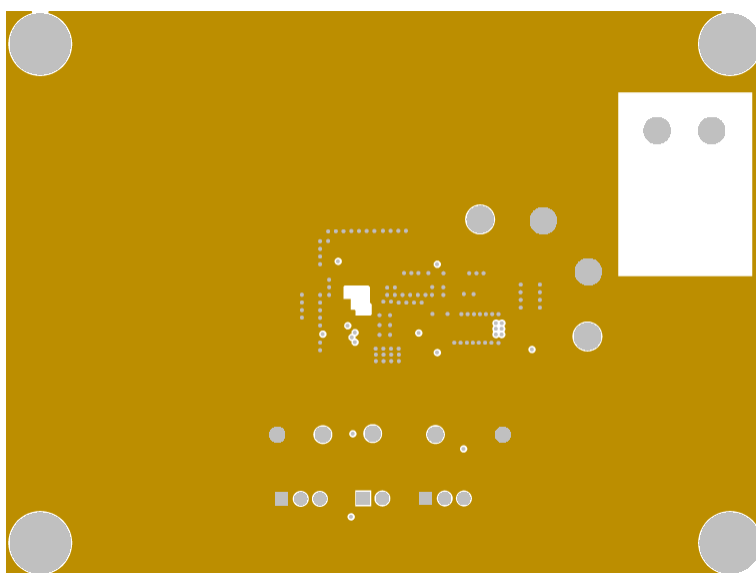
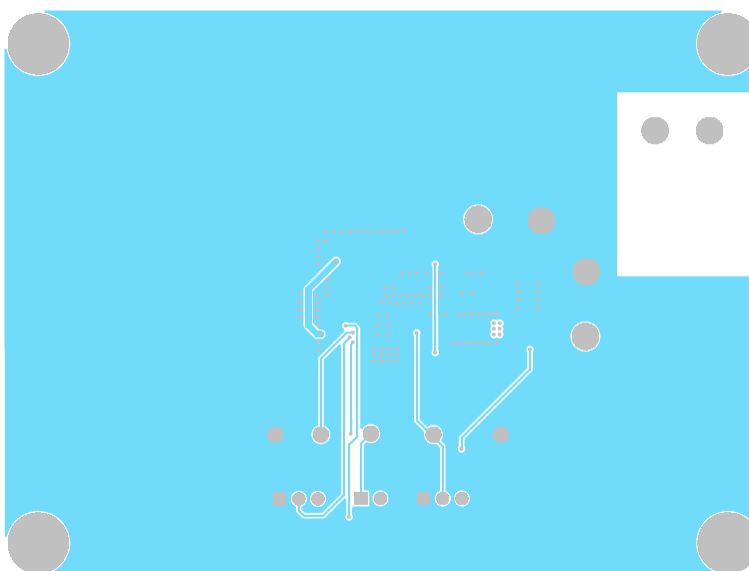
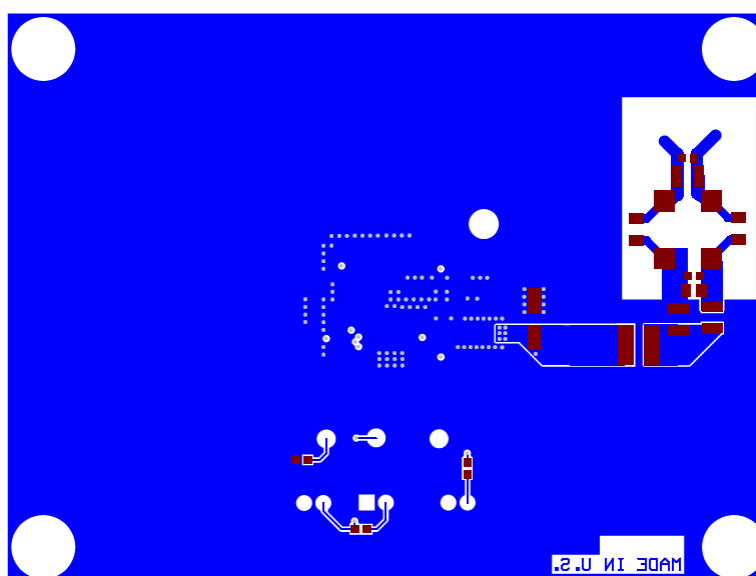


Figure 5-2. Mid Layer 1



**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 |
|-------------------------------------------------|------|
|-------------------------------------------------|------|

- |                                                         |                   |
|---------------------------------------------------------|-------------------|
| • Added new BOM information and reflowed document. .... | <a href="#">7</a> |
|---------------------------------------------------------|-------------------|

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- 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)

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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/lstds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page)  
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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.

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|                               |                                                                                          |
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