

# LM5056 Evaluation Board

## User's Guide



Literature Number: SNVU201  
November 2012

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## **LM5056 Evaluation Board**

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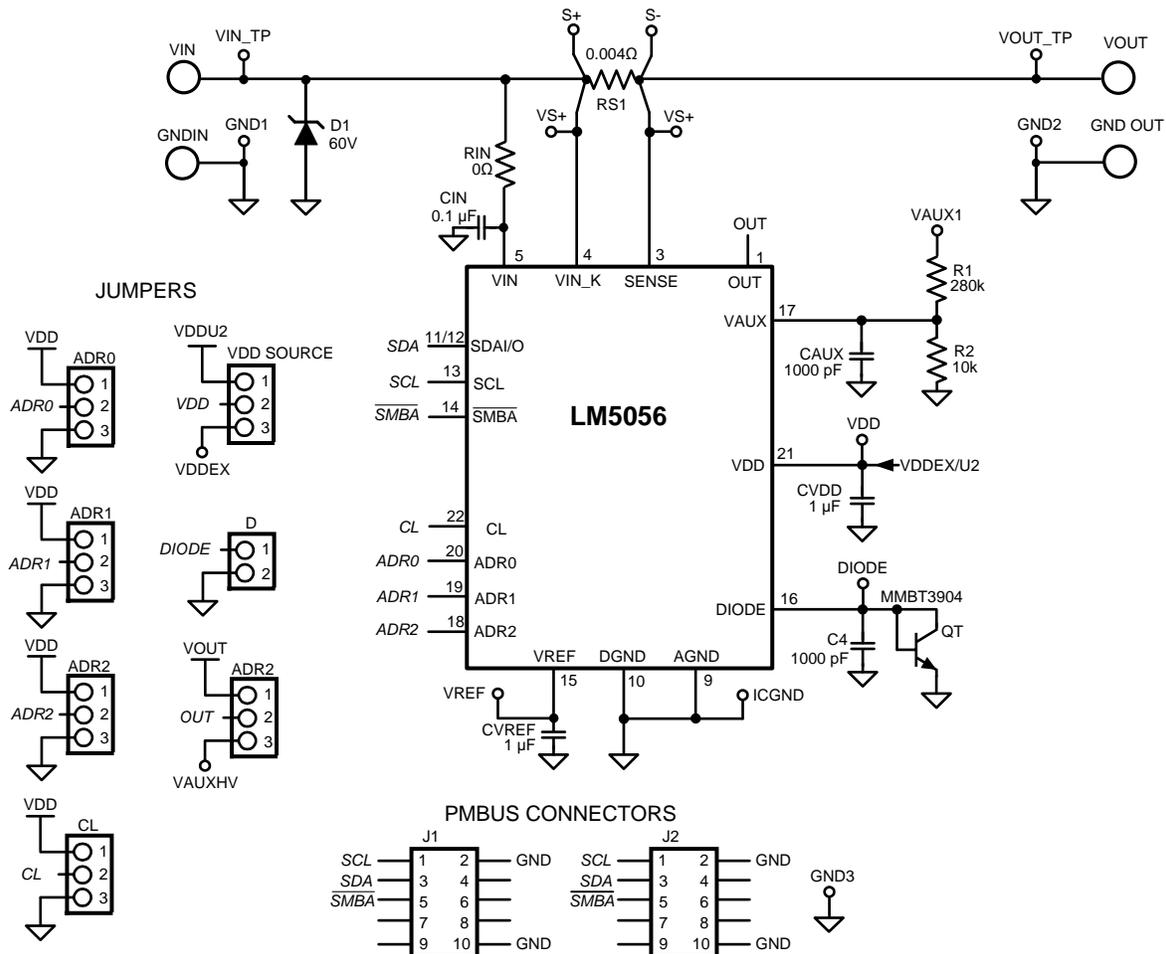
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The LM5056EVK evaluation kit provides the design engineer with a telemetry measurement IC board with a PMBus™ compliant SMBus/I2C interface. This application note describes the various functions of the board, how to test and evaluate it, and how to use the companion System Protection and Management graphical user interface (GUI). The GUI is used to collect telemetry, configure warning and fault thresholds, and assist the designer with selection of external components for a specific application. Use of the advanced telemetry and monitoring capabilities of this device requires the installation of the Texas Instruments System Protection and Management (SPM) graphical user interface. Check the LM5056 webpage for the latest software and datasheet information.

### **1 PCB Features**

- Input voltage range: 10V to 60V (limited by 60V input clamp D1)
- Programmable current measurement range: 6.75A or 13.6A
- 27 user settable addresses
- On board regulated 5.0V bias rail
- Computer connection to communications dongle, through USB cable
- PCB Size: 3.5" × 3.5"

## 2 Simplified Schematic



Simplified Schematic (Unpopulated Components Omitted)

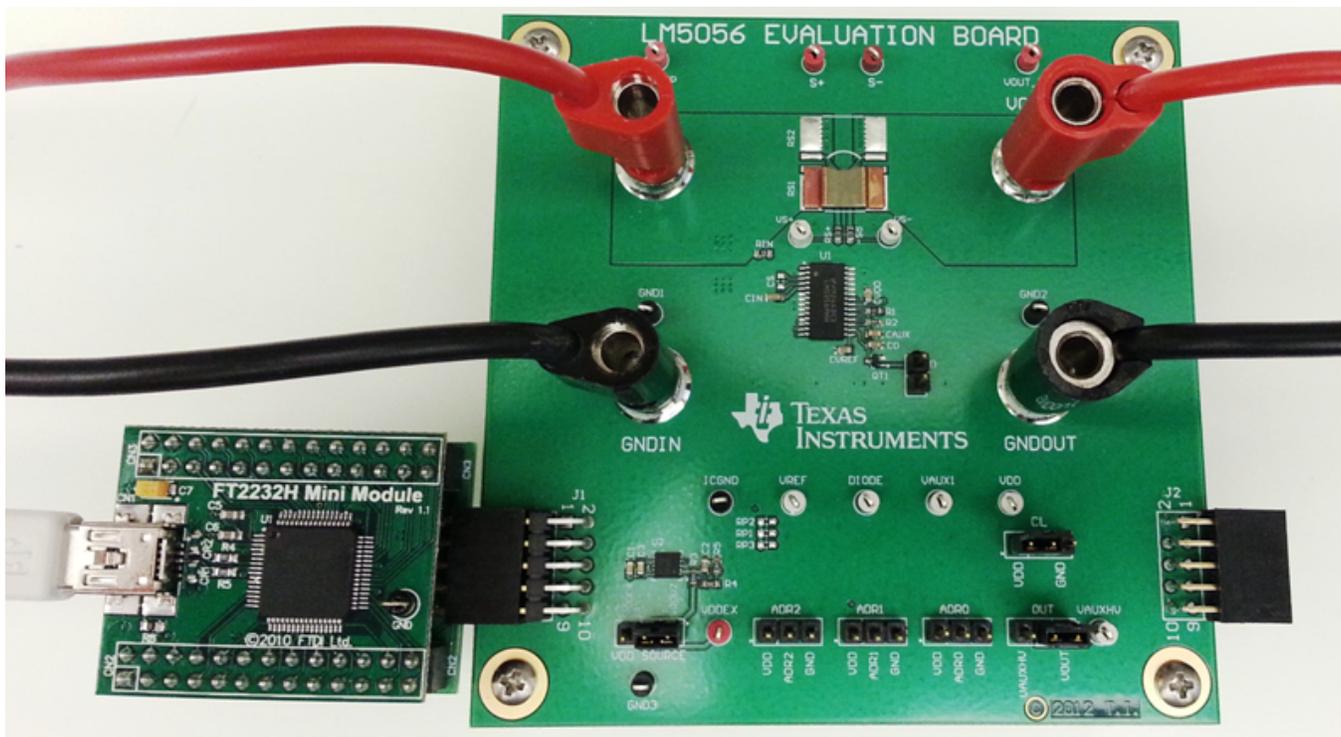
Figure 1. Simplified Evaluation Board Schematic

The simplified schematic for the LM5056 evaluation board is shown in [Figure 1](#). Connections to the PMBus interface are provided by J1. Banana terminals are soldered to the PCB to provide input power and load connections. Jumpers ADR0, ADR1, and ADR2 set the PMBus address of the LM5056 to one of 27 unique addresses. Jumpers also connect to a voltage divider to VAUX for high voltage measurements. Other jumpers exist such as "D" to bypass and disable the temperature measurement, "CL" to change the current range, "OUT" to switch between a VOUT measurement and the VAUXHV test point and "VDD SOURCE" to switch between an on board 5.0V source and an external 5V source (VDDEX). Test points are provided to measure the input voltage (VIN\_TP), output voltage (VOUT\_TP), VDD, VREF, the sense resistor voltage (through S+ to S-), and DIODE, the temperature diode voltage.

### 3 Getting Started

The LM5056 evaluation kit hardware is shown in [Figure 2](#). The board offers two banana connections for the system input voltage and output load. In the board's current form, the system voltage and load can be plugged directly into the female banana receptacles. To measure higher currents, the sense resistor can be paralleled (RS2) or replaced with another sense resistor to maintain the full-scale measurement voltage of the LM5056. A footprint for RS2 is not populated and is provided to accommodate evaluation of designs for measuring currents greater than 13.6A or if two resistors are needed. For currents higher than 13.6A, it is recommended to solder directly to the banana connections rather than using the banana plugs to reduce heat created by the banana connection resistance.

The LM5056EVM is supplied with the PMBus address set to 40h as dictated by the jumper configuration of the ADR0, ADR1, and ADR2 jumper connections (not populated).



**Figure 2. Connection Illustration**

The first step to evaluate the telemetry features of LM5056 is to install the SPM GUI software. The software is included on a CD in the evaluation kit and is titled PMBManager-x.x.x-xxxxxxx.exe, where the x characters indicate the software version and build date. This file should be executed on a PC running Windows XP or later. Once the SPM GUI software is installed the USB hardware should be configured as shown in [Figure 2](#).

## 4 Hardware Setup Steps

1. Connect the positive (+) and negative (-) terminals of the input supply to the VIN and GNDIN banana plugs respectively.
2. Connect the positive (+) and negative (-) terminals of the load to the VOUT and GNDOUT banana plugs respectively.
3. Connect the supplied FTDI F2232H Mini Module USB dongle to the 10 pin connector (J1) on the left side of the board.
4. Connect the supplied mini USB cable from the USB dongle to an available USB port on a PC.

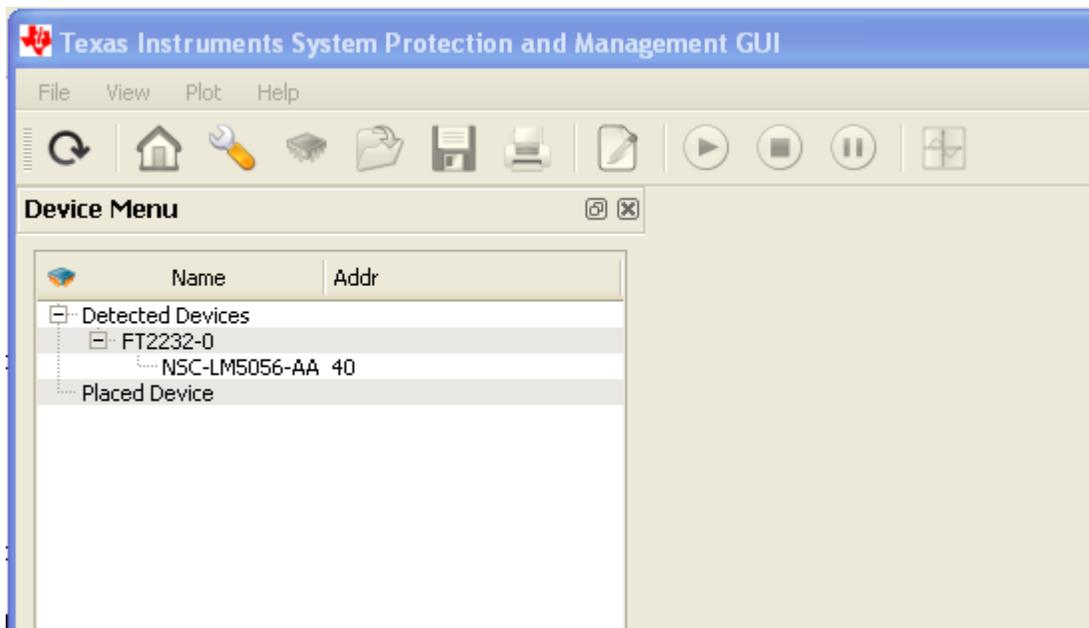
When the USB dongle is connected for the first time the user will be prompted to install the device drivers. For the most current driver installation procedure refer to the README.TXT file in the installation directory.

For testing the EVM functionality, a low inductance connection to the input supply is recommended. The purpose of this is to minimize voltage transients that occur when the load current changes or is shut-off. If not careful, wiring inductance in the supply lines will generate a voltage transient at shut-off that can exceed the absolute maximum voltage ratings of the LM5056 resulting in its destruction. To protect against such voltage transients, a transient voltage suppression (TVS) diode, D1, is provided to clamp the voltage at the input to within safe operating limits. The passive TVS begins to conduct current at about 60V. If a voltage greater than 60V is required, the TVS must be removed and the LM5056EVM should be handled with care as to not over-voltage any of the pins connected directly to the input rail (VIN, VIN\_K, SENSE\_K, OUT).

## 5 Device Evaluation

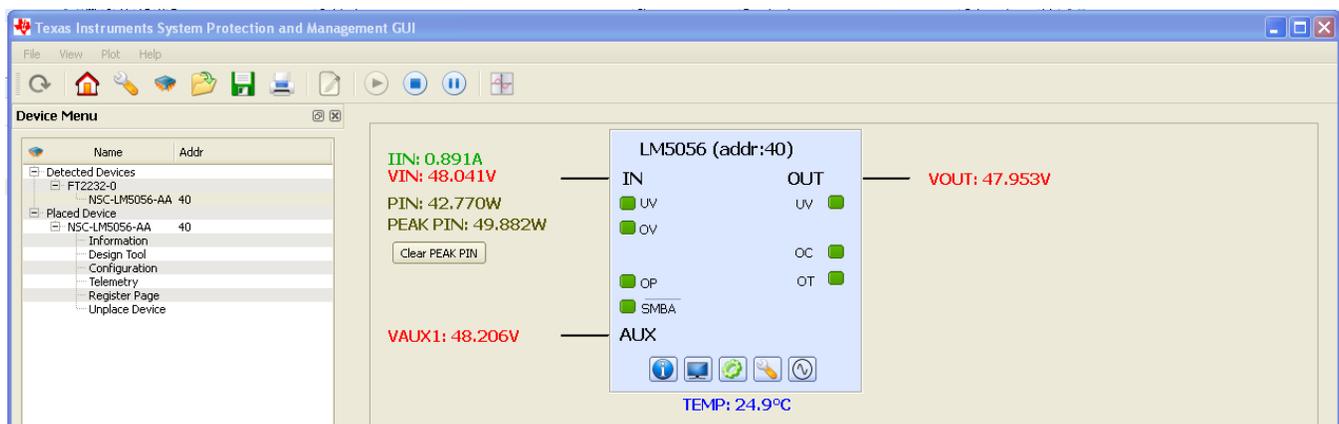
After configuring the hardware connections, apply an input voltage of 48V to the EVM. The current hardware configuration allows the LM5056 device to work with 10V to 60V system rails; however, this getting started guide will assume an input voltage of 48V. Launch the GUI by going to the Windows Start menu -> All Programs -> Texas Instruments SPM\_GUI-x.x.xxxx> SPM\_GUI. The device should be detected on the PMBus and the initial load screen should appear as shown in [Figure 3](#).

If a device is not detected, an option is provided to re-scan, ignore, or exit the GUI. If the hardware is intended to be connected, check the USB connection to the PCB, FTDI connection to the evaluation module, and verify that power is present on the evaluation PCB by measuring the voltage between the VIN\_TP to GND1 testpoints. Ignoring the detection message allows use of the integrated design tool without the hardware connected.



**Figure 3. Initial GUI Screen**

Click on the detected device ID (NSC-LM5056-AA) to display a block level representation of the device as shown in [Figure 4](#). The block level view of the device provides a display of all the telemetry data as well as the faults and warnings supported by the device. The faults and warnings supported are generally associated with an invalid input or output condition.



**Figure 4. LM5056 Block Level Representation**

The warnings shown on the left side of the block representation are generally associated with the input. These include input under-voltage (UV), input over-voltage (OV), and input over-power (OP). The warning indicators are green until the user programmed threshold has been surpassed by the warnings respective signal at which point the indicator will turn red. The SMBus alert status (SMBA) is also shown on the left side and will turn red during any warning or fault event. To facilitate the evaluation of the device, SMBus alerts are automatically cleared by the GUI.

The warnings or faults shown on the right side of the block representation include input over-current (OC), over-temperature (OT), and output under-voltage (UV).

To show a repetitive update of the device telemetry and status, click on the play icon at the top of the screen. The play button starts an active telemetry log of the gathered data. Clicking the stop icon stops the telemetry collection and allows for the log file to be viewed and saved. The pause button pauses both the displaying and logging of telemetry information.

To disable displaying undesired telemetry click the display icon on the block representation. This will open the window shown in [Figure 5](#) that will allow the user to disable the undesired telemetry, fault, and warning information from appearing on the block level device representation.

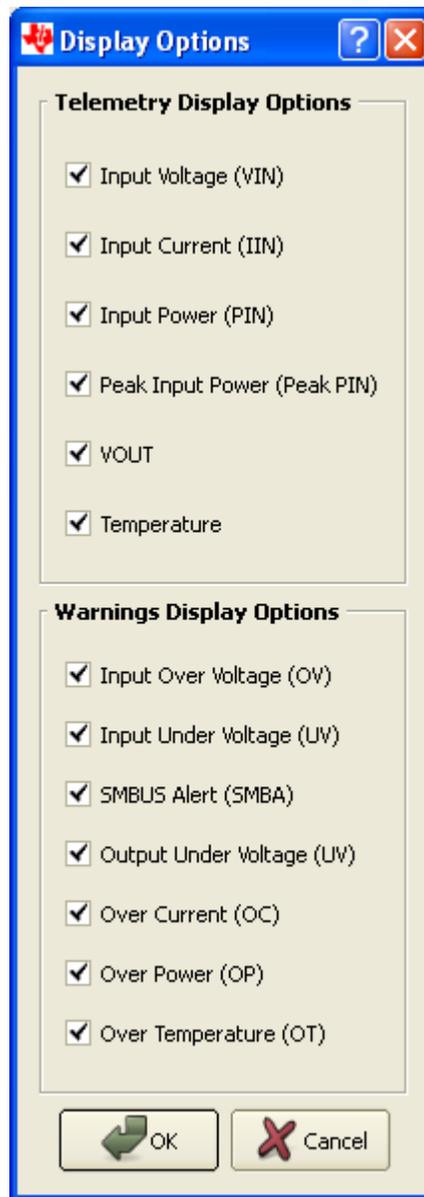


Figure 5. LM5056 Telemetry Display Options

Note that turning off the various warning display options will not mask the faults from issuing an SMBus alert, it just does not display them if they occur. The LM5056 is capable of masking various faults and this functionality can be setup in the device configuration panel.

## 6 GUI Event Log

A GUI event log is provided to keep track of GUI configuration changes and device fault events. To display the event log select View>>Event Log from the main menu bar. The event log will appear in the left of the main GUI window. The event log can be detached and expanded if desired by double left clicking on the event log window and dragging the window with the mouse to the desired location.

## 7 Plotting Telemetry

To enable telemetry data plots, click on the sine wave icon located on the LM5056 block representation. After enabling the telemetry, a prompt will appear requesting entry of the GUI sample rate, plot rate, and plot depth. For most cases the default rates and depths will be acceptable. The plotting tool allows the user to select the desired data to be plotted. Up to two different parameters may be plotted at the same time as shown in Figure 6.



Figure 6. LM5056 GUI with Telemetry Plotting Tool Enabled

Device telemetry data is plotted as a black line that continually updates as the device is queried. In addition to the device data, the relevant warning and fault thresholds are also plotted. Warning thresholds are shown as orange lines while fault thresholds are shown in red.

By going to the plot menu option the user can disable the plotting grid as well as the warning and fault lines.

## 8 Configuring the LM5056

Warning thresholds, temperature fault threshold, protection ranges, fault masking, and averaging can be configured in the Device Configuration panel. To view the device configuration panel go to View >> Device Configuration. The Device Configuration panel, shown in Figure 7, can also be enabled by clicking the gear icon shown on the LM5056 block representation.

The Warning and Fault Threshold tab is the first tab in the Device Configuration panel. It allows customization of the input under-voltage, input over-voltage, output under-voltage, input over-current, input power, and over-temperature warnings. This tab also allows adjustment of the over-temperature fault threshold. Decimal values for the thresholds are shown in the text box located to the right of the slide bar. Above the decimal values setting is the value of the setting in hexadecimal; which can be useful when developing software for this device. Anytime a warning or fault threshold is changed, the GUI will send the displayed hexadecimal value to the LM5056 as the new fault or threshold value.

The Fault Behavior tab shown in Figure 8 allows the user to set the device fault and warning configuration and masking. By selecting Fault Masking, it allows individual faults and warnings to be masked and not be shown as an SMBus alert. Faults and warnings that only issue an SMBus alert allow masking of the alert.

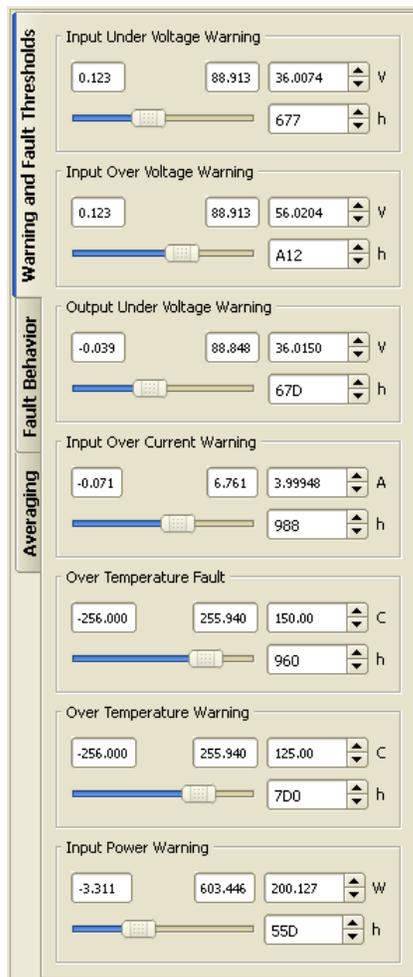


Figure 7. Device Configuration Panel – Warning and Fault Thresholds Tab

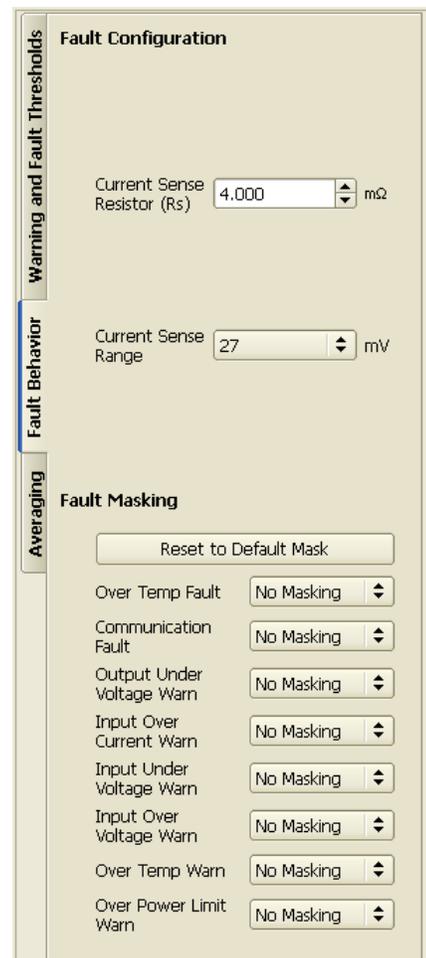
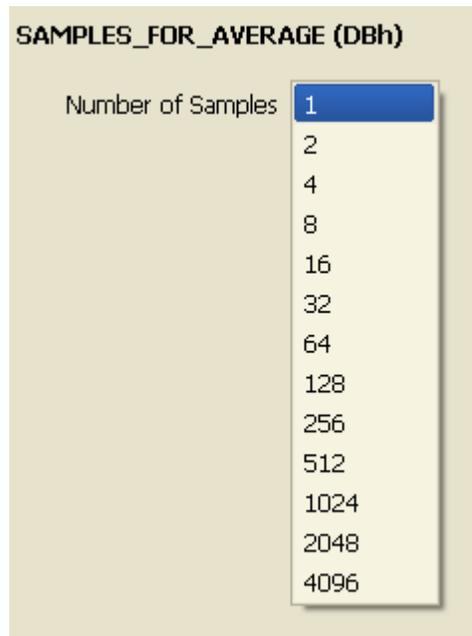


Figure 8. Device Configuration Panel – Fault Behavior Tab

The Averaging tab allows the user to set the value of the MFR\_SAMPLES\_FOR\_AVG register of the LM5056. This sets the number of samples averaged for telemetry of VIN, IIN, PIN and VOUT. This is selectable from 1 to 4096 in powers of 2. Detail of the Averaging tab is shown in [Figure 9](#).



**Figure 9. Device Configuration Panel – Averaging Tab**

For convenience, the Device Configuration Panel can be undocked by holding down the left mouse button while the cursor is at the top of the panel and dragging it to where you would like it to be placed.

## 9 GUI Design Page

The GUI assumes the hardware configuration is set to default evaluation board configuration. If any of the components are changed, the device hardware configuration needs to be updated in the design tool section. To open the design tool click the wrench icon located on the LM5056 block representation which will open the window displayed in Figure 10.

The screenshot displays the LM5056 GUI Design Tool interface. On the left, there are three main configuration sections: 'General Inputs', 'Current Sense Resistor', and 'Communications'. The 'General Inputs' section includes fields for 'Input Voltage' (48.00 V), 'Maximum VAUX1' (88.00 V), and 'Maximum Load Current' (6.75 A). The 'Current Sense Resistor' section includes 'Current Sense Range' (27 mV) and 'Current Sense Resistor (Rs)' (4.000 mΩ). The 'Communications' section includes 'PMBus Slave Address' (0x40). The central area shows a schematic diagram of the LM5056 device with various pins labeled: VIN, VIN\_K, SENSE, OUT, DIODE, ADR0, ADR1, ADR2, SMBA, SCL, SDAI, SDAO, GND, GNDA, VAUX, CL, and VDD. A PCL Regulator is connected to the VAUX pin. The 'Component Results' section at the bottom left shows 'Std. 1% Resistors' checked, with R1 = 280.00 kΩ, R2 = 10.00 kΩ, and Rs = 4.000 mΩ. The 'Parametric Results' section shows 'Rs Power Dissipation' as 0.18 W.

Figure 10. LM5056 GUI Design Tool

Activating the design page displays several adjustable inputs and a typical application schematic. Design inputs are keyed in on the left side of the window.

The input voltage for the LM5056 runs from 10V to 80V (10V to 60V for the EVM). In this tool, the range is displayed only for informational purposes and is not used for calculation in the remainder of the window.

The "Maximum VAUX1" window is used to calculate the resistor divider for R1 and R2. The calculator assumes that the maximum measured value of the VAUX pin is 2.966V. In operation, the maximum measured value is near 2.97V and the difference allows for a buffer to the full scale. The tool also assumes that R2 is 10.0 kΩ and calculates the required R1 value. Once the Maximum VAUX1 value is entered, values for R1 and R2 appear in the Component Results section. The Std. 1% Resistors checkbox will implement the closest standard 1% values that are available to the resistors.

The Maximum Load Current window is used to determine the size of the sense resistor needed based on the current sense range. The LM5056 has two current sense ranges. The current sense range is set with the pull down window on the left side of the design tool.

Once the Maximum Load Current and the Current Sense Range windows are set, the current sense resistor is set in the Current Sense Resistor and Component Results sections. As a default, a setting of 7.5A as the maximum load current at the current sense range of 27.0mV will set the current sense resistor RS to 4 mΩ. Entering these values will also show the power dissipation of RS in the Parametric Results section at the bottom of the design tool.

The PMBus Slave Address pulldown window shows the possible PMBus addresses that the LM5056 can be set to respond to. By selecting the one of the 27 possible addresses, the necessary connection to the ADR0, ADR1, and ADR2 pins is shown on the circuit diagram. As an example, if 0x17 is selected, the ADR0 will be floating, ADR1 will be connected to VDD, and ADR2 will be grounded. This set of connections will be shown on the circuit diagram, and can be tested on the demo board with the included jumpers.

Once a design is complete, it can be saved by selecting the File menu, and then Save. Once the hardware is modified to match the design the GUI should be restarted and the hardware configuration file loaded right after the device is detected and placed. If the values in the design tool are different than the values on the board, erroneous telemetry and fault data will be reported by the GUI. To return to the block view of the device press the home icon located at the far left in the menu bar.

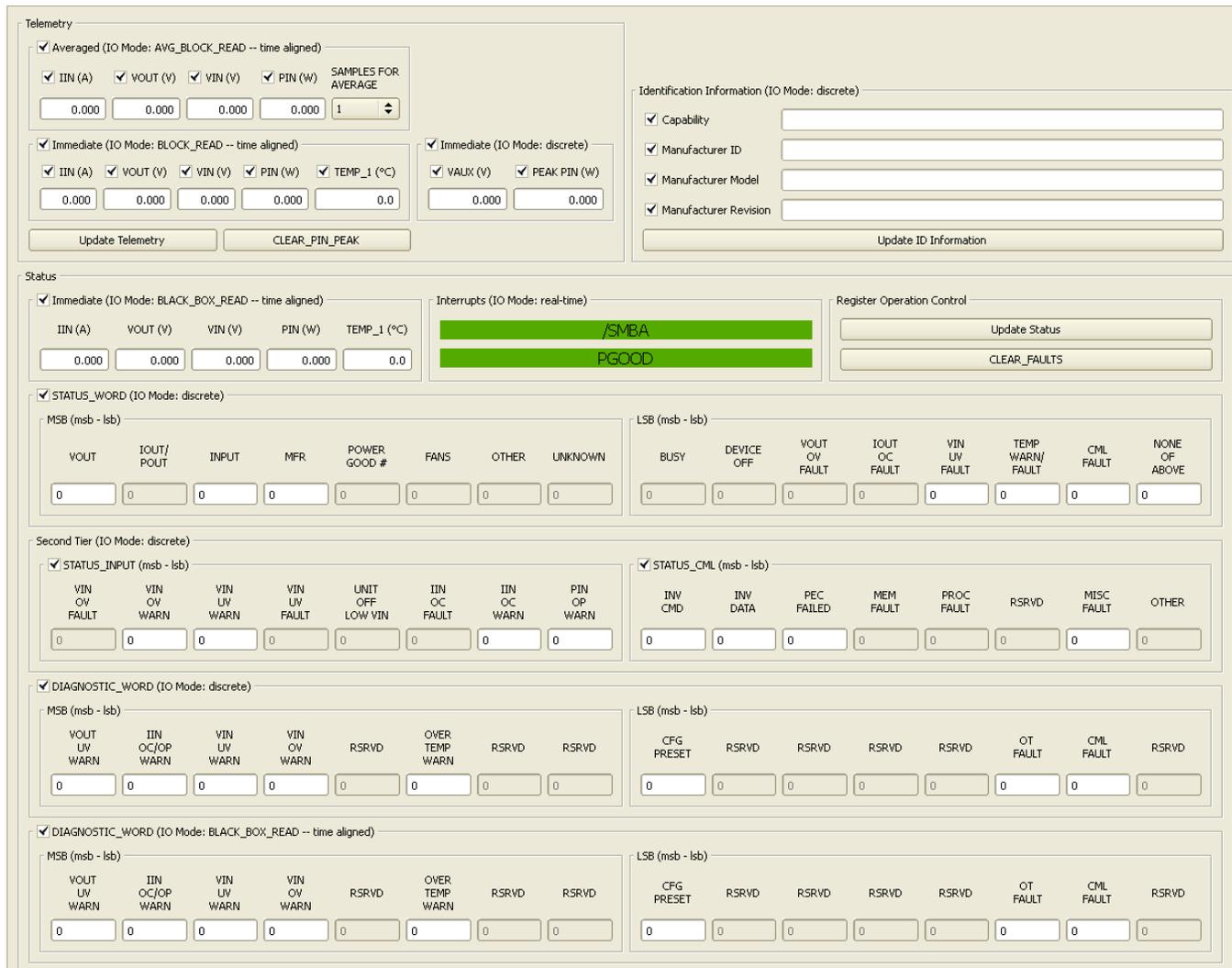
The design tool is also useful to calculate the PMBus coefficients. With the correct value for current sense resistor (RS1) the tool will calculate the correct coefficients to scale the raw telemetry data. The coefficients can be viewed by selecting View from the main menu bar, and then selecting the PMBus Coefficient Editor. When the PMBus Coefficient Editor is opened, press the Get All button to show the currently used coefficients.

If desired, the parameters in the design tool can be calculated by hand using the equations provided in the datasheet.

However, note the design tool calculates parameters factoring in worst case tolerances, while the equations in the datasheet are based on typical thresholds.

## 10 GUI Register Page

The GUI Register Page, as shown in [Figure 11](#), provides the user with several features to help better understand the functionality of the LM5056. These features include the ability to read telemetry, device identification and status registers, as well monitoring the SMBus Alert interrupt.



The screenshot displays the LM5056 GUI Register Page, organized into several functional sections:

- Telemetry:**
  - Averaged (IO Mode: AVG\_BLOCK\_READ -- time aligned):** Includes checkboxes for IIN (A), VOUT (V), VIN (V), and PIN (W). A 'SAMPLES FOR AVERAGE' dropdown is set to 1. Values for each parameter are 0.000.
  - Immediate (IO Mode: BLOCK\_READ -- time aligned):** Includes checkboxes for IIN (A), VOUT (V), VIN (V), PIN (W), and TEMP\_1 (°C). Values are 0.000, 0.000, 0.000, 0.000, and 0.0.
  - Immediate (IO Mode: discrete):** Includes checkboxes for VALX (V) and PEAK PIN (W). Values are 0.000 and 0.000.
  - Buttons: 'Update Telemetry' and 'CLEAR\_PIN\_PEAK'.
- Identification Information (IO Mode: discrete):**
  - Checkboxes for Capability, Manufacturer ID, Manufacturer Model, and Manufacturer Revision.
  - Input fields for each parameter.
  - Button: 'Update ID Information'.
- Status:**
  - Immediate (IO Mode: BLOCK\_BOX\_READ -- time aligned):** Values for IIN (A), VOUT (V), VIN (V), PIN (W), and TEMP\_1 (°C) are 0.000, 0.000, 0.000, 0.000, and 0.0.
  - Interrupts (IO Mode: real-time):** Shows 'SMBA' and 'PGOOD' status bars.
  - Register Operation Control:** Buttons for 'Update Status' and 'CLEAR\_FAULTS'.
- STATUS\_WORD (IO Mode: discrete):**
  - MSB (msb - lsb):** VOLT, IOUT/POUT, INPUT, MFR, POWER GOOD #, FANS, OTHER, UNKNOWN.
  - LSB (msb - lsb):** BUSY, DEVICE OFF, VOLT OV FAULT, IOUT OC FAULT, VIN UV FAULT, TEMP WARN/FAULT, CML FAULT, NONE OF ABOVE.
- Second Tier (IO Mode: discrete):**
  - STATUS\_INPUT (msb - lsb):** VIN OV FAULT, VIN OV WARN, VIN UV WARN, VIN UV FAULT, UNIT OFF LOW VIN, IIN OC FAULT, IIN OC WARN, PIN OP WARN.
  - STATUS\_CML (msb - lsb):** INV CMD, INV DATA, PEC FAILED, MEM FAULT, PROC FAULT, RSRVD, MISC FAULT, OTHER.
- DIAGNOSTIC\_WORD (IO Mode: discrete):**
  - MSB (msb - lsb):** VOLT UV WARN, IIN OC/OP WARN, VIN UV WARN, VIN OV WARN, RSRVD, OVER TEMP WARN, RSRVD, RSRVD.
  - LSB (msb - lsb):** CFG PRESET, RSRVD, RSRVD, RSRVD, RSRVD, OT FAULT, CML FAULT, RSRVD.
- DIAGNOSTIC\_WORD (IO Mode: BLOCK\_BOX\_READ -- time aligned):**
  - MSB (msb - lsb):** VOLT UV WARN, IIN OC/OP WARN, VIN UV WARN, VIN OV WARN, RSRVD, OVER TEMP WARN, RSRVD, RSRVD.
  - LSB (msb - lsb):** CFG PRESET, RSRVD, RSRVD, RSRVD, RSRVD, OT FAULT, CML FAULT, RSRVD.

**Figure 11. LM5056 GUI Register Page**

Telemetry is updated by clicking the Update Telemetry button. This action will update the fields under the Averaged heading and under the Immediate heading along with PEAK PIN. Select which parameters to update by clicking in the box next to each parameter. If all parameter boxes under a given heading are checked, the Update Telemetry button will use the block read PMBus commands (AVG\_BLOCK\_READ and BLOCK\_READ) to update the fields, ensuring that the readings are time aligned. If one or more of the boxes under the headings is not checked, the Update Telemetry button will use the respective individual read PMBus commands to make the telemetry readings and the measurements will not be time aligned. PEAK PIN is always read with discrete PMBus commands and, therefore, are never time aligned. The CLEAR\_PIN\_PEAK button is provided to clear the PEAK PIN reading, which is often much higher than one would expect under steady state conditions. This is related to the large inrush current during power-on that is sampled by the internal power measurement circuitry and used to calculate PEAK PIN.

The Identification Information can be obtained by clicking the Update ID Information button.

The rest of this page is used to monitor and diagnose warning and fault conditions. The  $\overline{\text{SMBA}}$  interrupt will indicate if a warning or fault has occurred and if the output voltage is within specifications. It is always active and there is no need to click an Update button to change its state. The LM5056 does not have a POWER GOOD indicator and is not used in this GUI. Clicking the Update Status button under the Register Operation Control heading will update the bits in all of the registers under the Status section as well as the telemetry in the BLACK\_BOX\_READ. Clicking the CLEAR\_FAULTS will reset all warning and fault bits and issue an Update Status. If the warning and/or fault condition has been remedied, the bits will reset. If the warning and/or fault condition still exists, the registers will be updated within a millisecond and thus will appear to never have been cleared. The STATUS\_WORD, STATUS\_INPUT, STATUS\_CML and DIAGNOSTIC\_WORD registers operate in a cumulative way. That is, these registers display any and all warnings and errors that have occurred since the last CLEAR\_FAULTS command was issued.

The telemetry and DIAGNOSTIC\_WORD that are part of the BLACK\_BOX\_READ are also updated by clicking the Update Status button. These telemetry parameters and bits are latched at the moment the  $\overline{\text{SMBA}}$  signal was asserted. They are not reset or cleared by the CLEAR\_FAULTS command but rather they are rearmed, or readied, to be over-written with new values at the onset of the next  $\overline{\text{SMBA}}$  signal assertion. Note that these telemetry fields and this register are not cumulative. That is, they can only be updated once after the CLEAR\_FAULTS command is issued, and it will be at the first occurrence of the  $\overline{\text{SMBA}}$  assertion following the CLEAR\_FAULTS. This allows the user to determine device conditions at the first occurrence of the  $\overline{\text{SMBA}}$  assertion.

## 11 Shutdown

With the circuit in normal operation, the LM5056EVM must be shutdown by disabling the input supply.

## 12 External VDD

On the evaluation board, a connection of VDDEX to 5V can be used to power the VDD line. Be sure to set the VDD SOURCE jumper to allow an external 5V source to power the LM5056 VDD pin.

## 13 Board Layout and Probing Cautions

Refer to the product datasheet for detailed layout guidelines. For most applications the layout of this evaluation module as detailed in the PC Board Layout section of this document should be sufficient to provide a working solution with accurate telemetry. The following should be kept in mind when the board is powered:

1. Use caution when probing the circuit to prevent injury as well as possible damage to the circuit.
2. At larger load current (>13.5A), the wire size and length used to connect the power source and the load may become very important. The wires connecting this evaluation board to the power source should be twisted together to minimize inductance in those leads. The same applies for the wires connecting this board to the load. This recommendation is made in order to minimize high voltage transients from occurring when the load current is quickly shut-off.
3. A 60V TVS diode located as close as possible to the LM5056 VIN and GND pins provides the critical function of clamping inevitable input voltage overshoots.
4. An analog signal ground plane is used local to the LM5056 and is connected to the PCB power ground planes at a single point. To compare telemetry voltage measurements to real world values, use the ICGND testpoint as the ground voltage reference. All voltage measurements by the LM5056 are in reference to the AGND pin in which the ICGND testpoint is kelvin connected.

13.1 Schematic

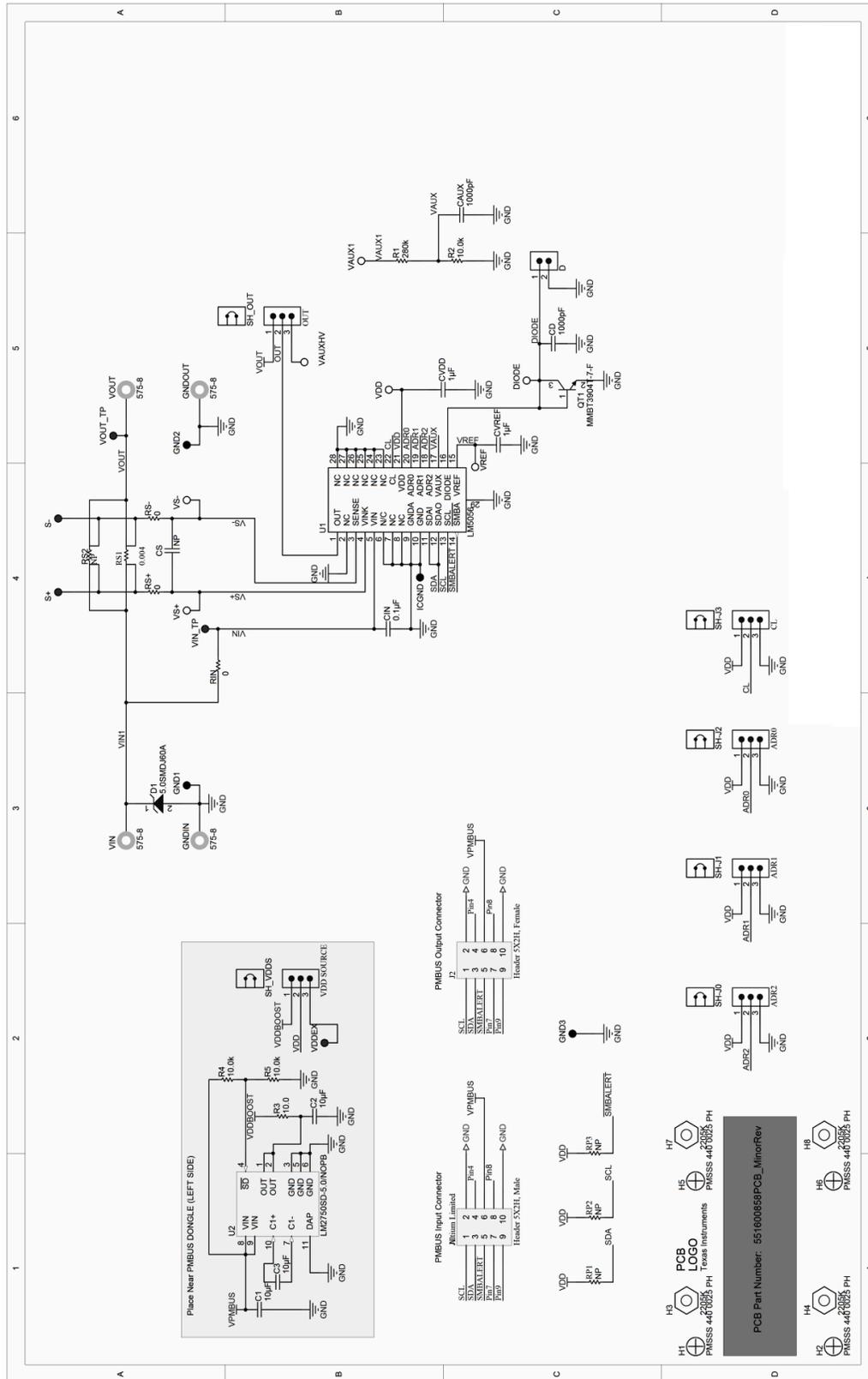


Figure 12. Evaluation Board Schematic

### 13.2 Bill of Materials

Designator	Value	Description	Manufacturer	Part Number	Qty.
ADR0, ADR1, ADR2, CL, OUT, VDD SOURCE	1x3	Header, TH, 100mil, 1x3, Gold plated, 230 mil above insulator	Samtec Inc.	TSW-103-07-G-S	6
C1, C2,C3	10uF	CAP, CERM, 10uF, 6.3V, +/-20%, X5R, 0603	MuRata	GRM188R60J106ME47D	3
CAUX, CD	1000pF	CAP, CERM, 1000pF, 25V, +/-10%, X7R, 0603	MuRata	GRM188R71E102KA01D2	2
CIN	0.1uF	CAP, CERM, 0.1uF, 100V, +/-10%, X7R, 0603	MuRata	GRM188R72A104KA35D	1
CVDD, CVREF	1uF	CAP, CERM, 1uF, 6.3V, +/-10%, X5R, 0603	MuRata	GRM185R60J105KE26D	2
D	1x2	Header, TH, 100mil, 2x1, Gold plated, 230 mil above	Samtec Inc.	TSW-102-07-G-S	1
D1	60V, 5000W	Diode, TVS, 60V, 5000W, 5%, SMD	Littelfuse	5.0SMDJ60A	1
DIODE, VAUX1, VAUXHV, VDD, VREF, VS+, VS-		Test Point, TH, Miniature, White	Keystone Electronics	5002	7
GND1, GND2, GND3, ICGND		Test Point, TH, Miniature, Black	Keystone Electronics	5001	4
GNDIN, GNDOUT, VIN, VOUT		Standard Banana Jack, Uninsulated, 8.9mm	Keystone	575-8	4
H1, H2, H5, H6		Screw Machine, PHIL 4-40x1/4 SS	B&F Fastener Supply	PMSSS 440 0025 PH	4
H3, H4, H7, H8		Standoff, Hex, 1"L #4-40 Aluminum	Keystone	2205K	4
J1		Header, 5-Pin, Dual row, Right Angle, Male	Samtec, Inc.	TSW-105-08-L-D-RA	1
J2		Header, 5-Pin, Dual row, Right Angle, Female	Sullins	PPPC052LJBN-RC	1
QT1		NPN, 0.2A, 40V	Central Semiconductor	MMBT3904T-7-F	1
R1	280kΩ	RES, 280k ohm, 1%, 0.1W, 0603	Central Semiconductor	CRCW0603280KFKEA	1
R2, R4, R5	10.0kΩ	RES, 10.0k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW060310K0FKEA	3
R3	10.0Ω	RES, 10.0 ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW060310R0FKEA	1
RIN, RS+, RS-	0Ω	RES, 0 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06030000Z0EA	3
RS1	4mΩ	RES, .004 ohm, 1%, 3W, 3921 SMD	Vishay-Dale	WSL39214L000FEA	1
S+, S-, VDDEX, VIN_TP, VOUT_TP		Test Point, TH, Miniature, Red	Keystone Electronics	5000	5
U1	LM5056	Power Management IC with PMBus	Texas Instruments	LM5056PMH	1
U2	LM2750-5.0 (5.0V)	Low Noise Regulator Switched Capacitor Boost Regulator, 10-pin LLP, Pb-Free	Texas Instruments	LM2750SD-5.0/NOPB	1



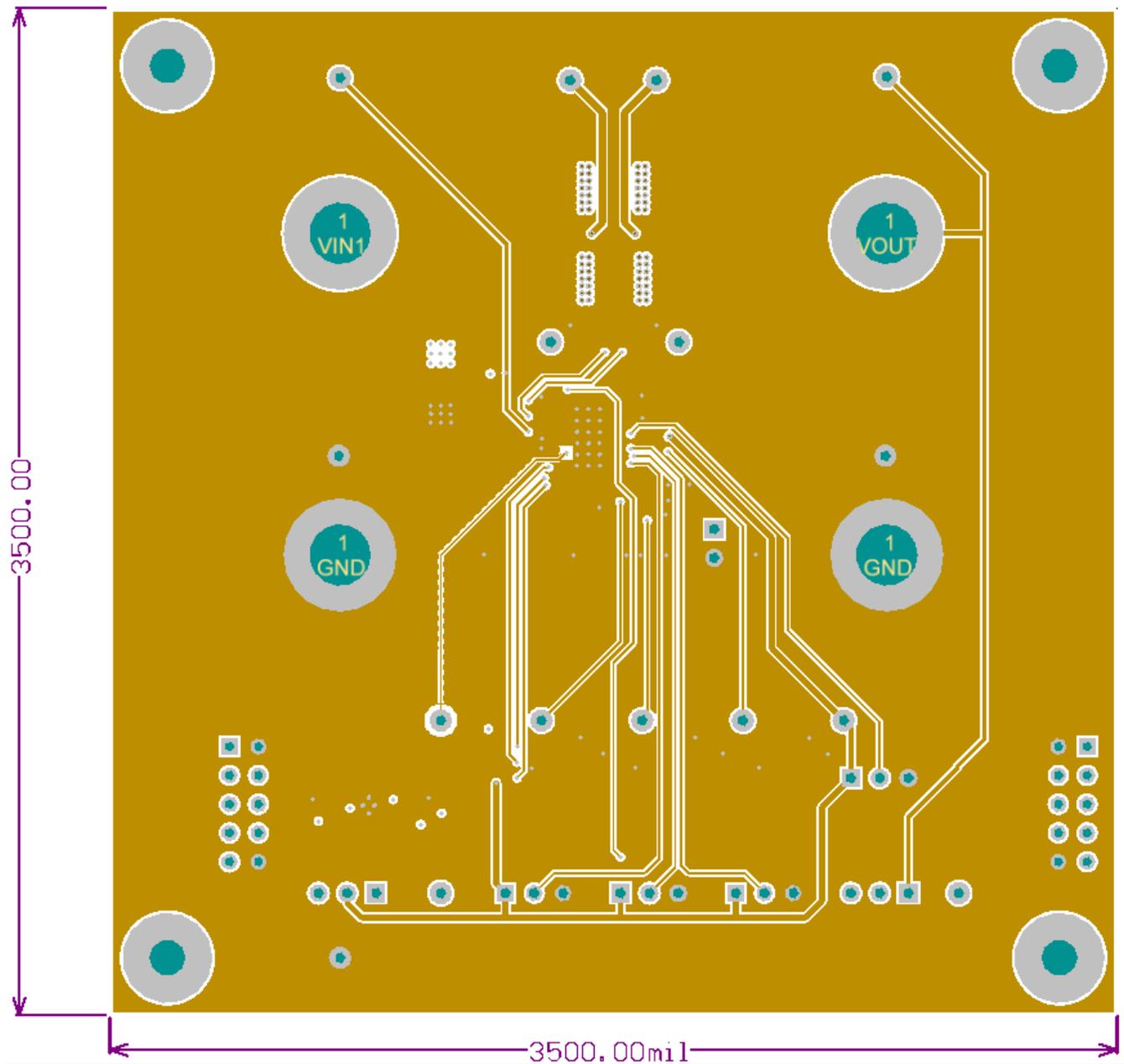


Figure 14. Board Mid Layer 1

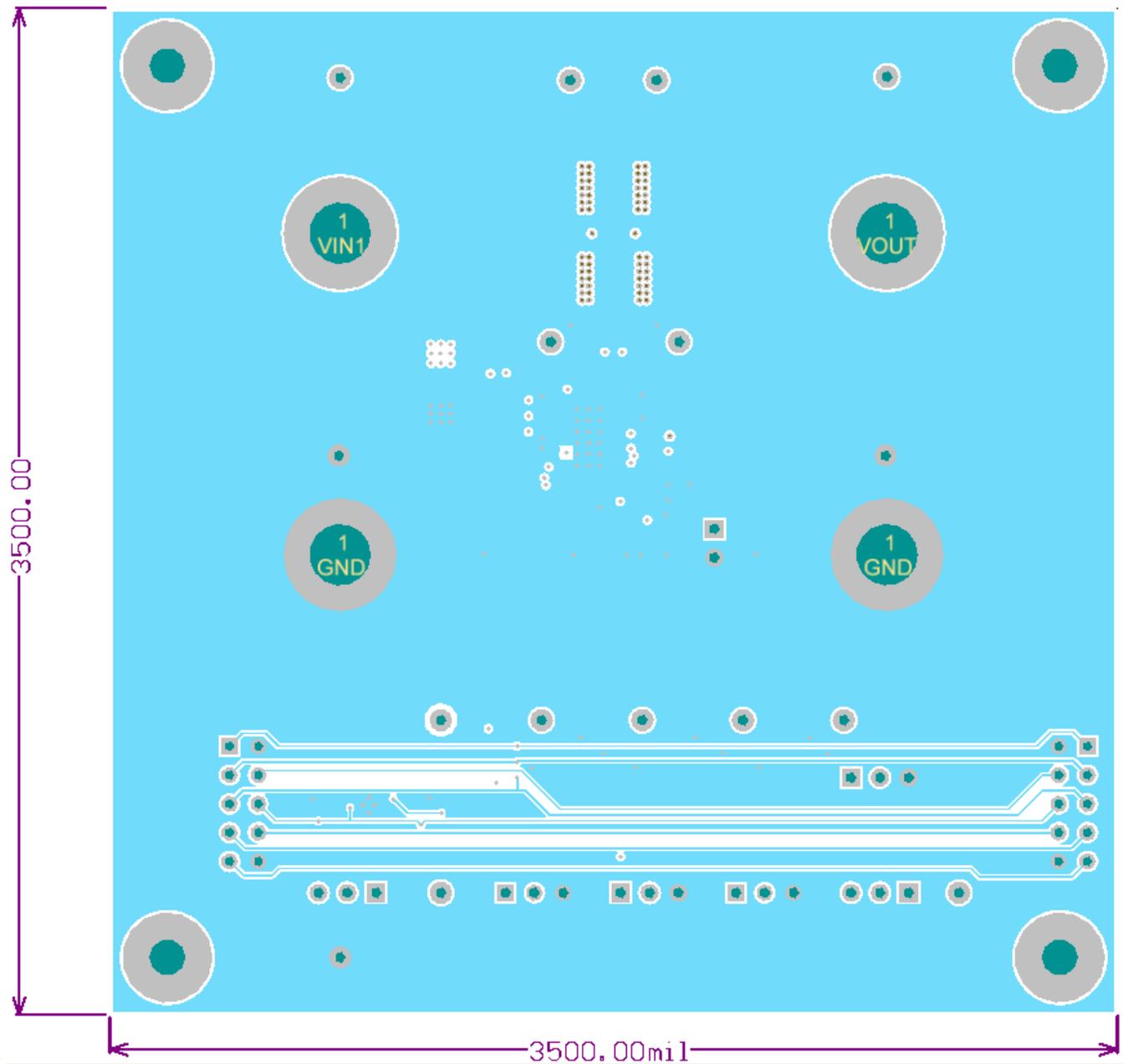


Figure 15. Board Mid Layer 2

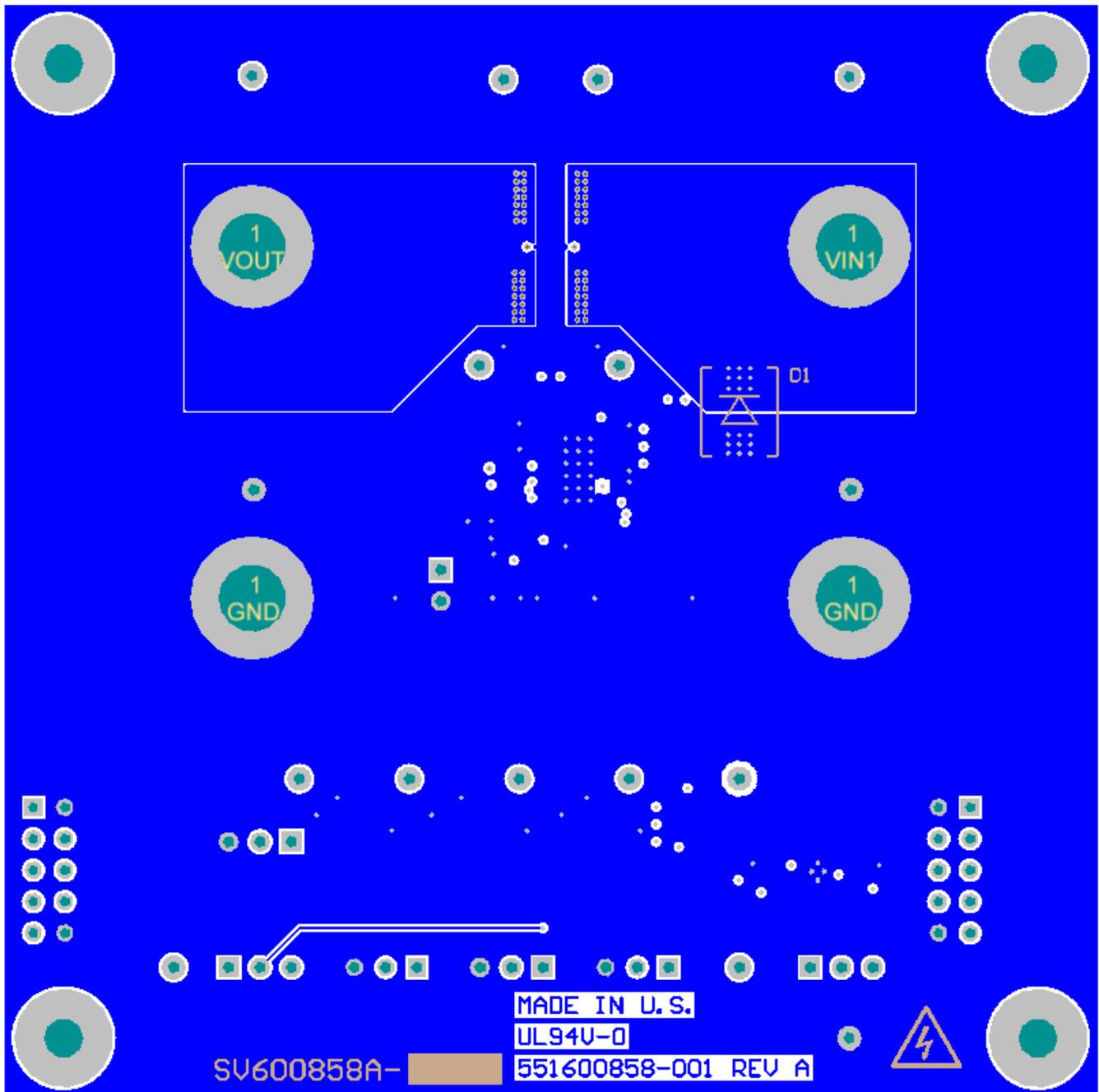


Figure 16. Board Bottom Layer (viewed from bottom)

## EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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## REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

### General Statement for EVMs including a radio

*User Power/Frequency Use Obligations:* This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

### 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

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**

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.

### **For EVMs annotated as IC – INDUSTRY CANADA Compliant**

This Class A or B digital apparatus complies with Canadian ICES-003.

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

### **Concerning EVMs including radio transmitters**

This device complies with Industry Canada licence-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.

### **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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

### **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.

### **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.

## **【Important Notice for Users of this Product in Japan】**

### **This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan**

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

**Texas Instruments Japan Limited**  
**(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan**

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## EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

**For Feasibility Evaluation Only, in Laboratory/Development Environments.** Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

**Certain Instructions.** It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

**Agreement to Defend, Indemnify and Hold Harmless.** You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

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