Design Overview
The TIDA-00745 is a 14-W, system-optimized (CISPR25 class 4) SMPS design specified for automotive body control modules.

Design Resources
- TIDA-00745
- LM53601-Q1
- LM53602-Q1
- LM26420-Q1
- TPS40210-Q1
- TPS7B4250-Q1
- TPS7B4253-Q1

Design Features
- 15-W Pre-Boost Solution
- 5 V at 2 A, 6 V at 0.65 A, 3.3 V at 1 A, and 1.32 V at 1-A Outputs From 2.1-MHz Switching Converter
- Input: 3.5 V to 32 V With Start-up at 4.7 V
- 86.5% System Efficiency at Full Load at 12 V
- Switching Frequency: 2.1 MHz for Buck and 450 KHz for Boost
- Lossless Bypass Operation: Avoids Loss in Boost Diode
- Wide VIN Integrated Front-End DC-DC Converters: LM53603Q1 and LM53601
- Passes CISPR 25 Class 4 FM Radio Band
- All ICs AEC-Q100 Qualified Versions
- 3.5 V to 30 V (20 V Overvoltage Protection) Wide VIN Range: Supports Cold Cranking Conditions

Featured Applications
- SMPS for Automotive Body Control Module

An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.
1 Key System Specifications

Table 1. Key System Specifications

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{\text{IN}} ) minimum</td>
<td>3.5 V (start-up at 4.7 V)</td>
</tr>
<tr>
<td>( V_{\text{IN}} ) maximum</td>
<td>36 V</td>
</tr>
<tr>
<td>( V_{\text{IN}} ) nominal</td>
<td>12 V (automotive design)</td>
</tr>
<tr>
<td>( V_{\text{OUT} 1} ) (pre-boost)</td>
<td>7.5 V at 2 A (supply to buck converters and LDOs)</td>
</tr>
<tr>
<td>( I_{\text{OUT} 1} )</td>
<td>2 A</td>
</tr>
<tr>
<td>Switching frequency (pre-boost)</td>
<td>450 KHz</td>
</tr>
<tr>
<td>( V_{\text{OUT} 2} )</td>
<td>5 V (supply to LM26420 for 3.3 V and 1.32 V)</td>
</tr>
<tr>
<td>( I_{\text{OUT} 2} )</td>
<td>2 A</td>
</tr>
<tr>
<td>( V_{\text{OUT} 3} )</td>
<td>3.3 V</td>
</tr>
<tr>
<td>( I_{\text{OUT} 3} )</td>
<td>1 A</td>
</tr>
<tr>
<td>( V_{\text{OUT} 4} )</td>
<td>1.32 V</td>
</tr>
<tr>
<td>( I_{\text{OUT} 4} )</td>
<td>1 A</td>
</tr>
<tr>
<td>( V_{\text{OUT} 5} )</td>
<td>6 V (supply to 5-V LDOs downstream)</td>
</tr>
<tr>
<td>( I_{\text{OUT} 5} )</td>
<td>0.65 A</td>
</tr>
<tr>
<td>Switching frequency</td>
<td>2.1 MHz for all switching buck regulators</td>
</tr>
</tbody>
</table>

2 System Description

The TIDA-00745 is a 14-W, system-optimized (CISPR25 class 4) switched-mode power supply (SMPS) design for automotive body control modules. The TIDA-00745 uses buck converters that switch at 2.1 MHz. The design is divided into four major blocks:

1. EMI filter: The electromagnetic interference (EMI) filter is a common mode and differential filter for conducted EMI suppression.

2. Pre-boost (TPS40210): The TPS40210 pre-boost controller is an efficient, low-cost, non-synchronous pre-boost design for 15-W applications. The output is maintained at 7.5 V and when the \( V_{\text{IN}} \) surpasses the \( V_{\text{OUT}} \) (programmed boost out) the output follows the input and the losses in the boost diode are avoided by the bypass operation through a conducting p-channel field-effect transistor (FET).

3. Buck converters (LM53603, LM53601, and LM26420): Each buck converter in this design switches at 2.1 MHz to avoid the AM frequency and provide a small size solution. The LM53603 and LM53601 devices have been placed at the front end and both are synchronous, wide-input automotive buck converters with a high level of integration.

4. Downstream LDOs: The design uses low-dropout regulators (LDOs) that have been placed downstream at the output of the buck converter and have a trackable output voltage.
3 Block Diagram

Figure 1. TIDA-00745 Block Diagram

Figure 2. Example of Automotive Body Control Module Highlighting TIDA-00745
3.1 Highlighted Products

The TIDA-00745 design uses the following products from TI:

- **LM53601-Q1**
  - Synchronous buck converter
  - Qualified for automotive applications (AEC-Q100 qualified)
  - Wide operating input voltage: 3.55 V to 36 V (with transient to 42 V)
  - Spread spectrum option available—helps with EMI compliance
  - 2.1-MHz fixed switching frequency—avoids AM band
  - Low quiescent current: 23 µA
  - Shutdown current: 1.8 µA
  - Adjustable, 3.3-V, or 5-V output
  - Maximum current load: 650 mA for LM53600-Q1, 1000 mA for LM53601-Q1
  - 10-lead, 3-mm × 3-mm SON package with wettable flanks

- **LM53602-Q1**
  - Synchronous buck converter
  - Qualified for automotive applications
  - 3- or 2-A maximum load current specifically designed for automotive applications
  - Input voltage range from 3.5 V to 36 V (transients to 42-V option)
  - 2.1-MHz fixed switching frequency
  - 1.7-µA shutdown current (typical)
  - 24-µA input supply current at no load (typical)
  - Thermally enhanced 16-lead package: 5 mm × 4.4 mm × 1 mm

- **LM26420-Q1**
  - Dual synchronous buck converter
  - LM26420-Q0: AEC-Q100 grade 0 (Q0) qualified ($T_J = -40°C$ to $150°C$)
  - LM26420-Q1: AEC-Q100 grade 1 (Q1) qualified ($T_J = -40°C$ to $125°C$)
  - Input voltage range of 3 V to 5.5 V
  - Output voltage range of 0.8 V to 4.5 V
  - 2-A output current per regulator
  - High switching frequency: 2.2 MHz
  - Current mode, PWM operation
  - Compliant with CISPR25 Class 5 conducted emissions

- **TPS40210-Q1**
  - For boost, flyback, SEPIC, light-emitting diode (LED) drive applications (non synchronous)
  - Wide input operating voltage: 4.5 V to 52 V
  - Adjustable oscillator frequency
  - Internal slope compensation
  - Programmable closed-loop soft-start
  - Overcurrent protection
  - Low current disable function

- **TPS7B4250-Q1**
  - Low-dropout voltage-tracking LDO
  - Qualified for automotive applications (AEC-Q100 qualified)
  - –20- to 45-V wide, maximum input voltage
  - Output current, 50 mA
  - 40-µA low quiescent current at light load
  - Over 150-mV low dropout voltage when $I_{OUT} = 10$ mA
  - Output short-circuit proof to ground and supply
4 System Design Theory

The switched-mode power supply (SMPS) is designed to support a low \( V_{\text{IN}} \) during start and stop conditions or cold crank conditions, which is why the design requires a pre-boost solution. During normal operation, when the \( V_{\text{IN}} \) is high enough (7.5 V), avoiding any loss across the boost rectifier diode is desirable. Avoid this loss by enabling a bypass operation using a PFET.

As the schematic in Figure 3 shows, the PFET SQJ461 only turns on when the \( V_{\text{IN}} > 7.5 \) V and achieves a true bypass operation.

![Figure 3. TIDA-00745 Schematic](image)

The normal operating frequency for all the synchronous buck converters that the design uses (LM53601,LM53602, and LM26420) is 2.1 MHz, which allows the use of small passive components. At 2.1 MHz, the frequency is above the AM band, which allows a significant saving in input filtering. These parts have low, unloaded current consumption and do not require an external back-up LDO. The low shutdown current and high maximum operating voltage of the LM53601-Q1 and LM53602-Q1 devices also eliminate the requirement of an external load switch.

Refer to the datasheets of the devices used for design calculations and layout examples:

- [LM53601-Q1 datasheet](http://www.ti.com/product/lm53601-Q1)
- [LM53602-Q1 datasheet](http://www.ti.com/product/lm53602-q1)
- [LM26420-Q1 datasheet](http://www.ti.com/product/LM26420-q1)
- [TPS40120-Q1 datasheet](http://www.ti.com/product/tps40210-q1)
- [TPS7B4250-Q1 datasheet](http://www.ti.com/product/TPS7B4250-q1)
5 Test Results

5.1 Thermal Data

Figure 4. Setup: IR Thermal Image at Steady State With 12 V\textsubscript{IN} and 5 V at 2 A and 6 V at 0.65 A (Boost Bypassed)

Figure 5. Setup: IR Thermal Image Taken at Steady State With 5.6 V\textsubscript{IN} and 5 V at 2 A and 6 V at 0.65 A (Boost Operational)
5.2 Efficiency Data

5.2.1 Boost Efficiency—TPS40210 Only

Table 2. Efficiency Data—Boost Efficiency Only

<table>
<thead>
<tr>
<th>$V_{IN}$ (V)</th>
<th>$I_{IN}$ (A)</th>
<th>$V_{OUT}$ (V)</th>
<th>$I_{OUT}$ (A)</th>
<th>EFFICIENCY (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.5</td>
<td>1.82</td>
<td>14.32</td>
<td>1.82</td>
<td>98.759%</td>
</tr>
<tr>
<td>12</td>
<td>1.82</td>
<td>11.82</td>
<td>1.82</td>
<td>98.500%</td>
</tr>
<tr>
<td>10.8</td>
<td>1.82</td>
<td>10.6</td>
<td>1.82</td>
<td>98.148%</td>
</tr>
<tr>
<td>6.98</td>
<td>2.1412</td>
<td>7.5</td>
<td>1.82</td>
<td>91.331%</td>
</tr>
<tr>
<td>5.95</td>
<td>3.1652</td>
<td>7.5</td>
<td>1.82</td>
<td>86.078%</td>
</tr>
<tr>
<td>4.5</td>
<td>3.635</td>
<td>7.5</td>
<td>1.82</td>
<td>83.448%</td>
</tr>
<tr>
<td>3.94</td>
<td>4.29</td>
<td>7.5</td>
<td>1.82</td>
<td>80.757%</td>
</tr>
</tbody>
</table>

Figure 6. Boost Efficiency vs Input Voltage at Full Load (Boost and Smart Diode Only)

5.2.2 System Efficiency (Pre-Boost and Two Bucks)

Table 3. Efficiency Data—Complete Efficiency Data of System

<table>
<thead>
<tr>
<th>$V_{IN}$ (V)</th>
<th>$I_{IN}$ (A)</th>
<th>$V_{OUT1}$ (V)</th>
<th>$I_{OUT1}$ (A)</th>
<th>$V_{OUT2}$ (V)</th>
<th>$I_{OUT2}$ (A)</th>
<th>EFFICIENCY (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.09</td>
<td>0.9397</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>81.828%</td>
</tr>
<tr>
<td>16.07</td>
<td>1.0362</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>83.535%</td>
</tr>
<tr>
<td>14.4</td>
<td>1.1444</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>84.409%</td>
</tr>
<tr>
<td>12</td>
<td>1.3438</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>86.260%</td>
</tr>
<tr>
<td>10.72</td>
<td>1.4994</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>86.540%</td>
</tr>
<tr>
<td>9.41</td>
<td>1.7122</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>86.334%</td>
</tr>
<tr>
<td>7.57</td>
<td>2.2373</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>82.131%</td>
</tr>
<tr>
<td>6.13</td>
<td>2.8509</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>79.595%</td>
</tr>
<tr>
<td>5.09</td>
<td>3.563</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>76.700%</td>
</tr>
<tr>
<td>4.45</td>
<td>4.248</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>73.584%</td>
</tr>
</tbody>
</table>
Figure 7. Efficiency vs Input Voltage at Full Load—Pre-Boost (7.5 V) and Dual Buck (5 V and 6 V)

Table 4. Efficiency Data at Fixed Input Voltage and Varying Output Current

<table>
<thead>
<tr>
<th>$V_{\text{IN}}$ (V)</th>
<th>$I_{\text{IN}}$ (A)</th>
<th>$V_{\text{OUT1}}$ (V)</th>
<th>$I_{\text{OUT1}}$ (A)</th>
<th>$V_{\text{OUT2}}$ (V)</th>
<th>$I_{\text{OUT2}}$ (A)</th>
<th>EFFICIENCY (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0.076</td>
<td>6</td>
<td>0.05</td>
<td>5.005</td>
<td>0.05</td>
<td>60.334%</td>
</tr>
<tr>
<td>12</td>
<td>0.2535</td>
<td>6</td>
<td>0.15</td>
<td>5.005</td>
<td>0.25</td>
<td>70.718%</td>
</tr>
<tr>
<td>12</td>
<td>0.4632</td>
<td>6</td>
<td>0.25</td>
<td>5.005</td>
<td>0.6</td>
<td>81.013%</td>
</tr>
<tr>
<td>12</td>
<td>0.6792</td>
<td>6</td>
<td>0.35</td>
<td>5.005</td>
<td>0.95</td>
<td>84.103%</td>
</tr>
<tr>
<td>12</td>
<td>0.8977</td>
<td>6</td>
<td>0.45</td>
<td>5.005</td>
<td>1.3</td>
<td>85.464%</td>
</tr>
<tr>
<td>12</td>
<td>1.1192</td>
<td>6</td>
<td>0.55</td>
<td>5.005</td>
<td>1.65</td>
<td>86.060%</td>
</tr>
<tr>
<td>12</td>
<td>1.3438</td>
<td>6</td>
<td>0.65</td>
<td>5.005</td>
<td>2</td>
<td>86.260%</td>
</tr>
</tbody>
</table>

Figure 8. Efficiency vs Load Current—Pre-Boost (7.5 V) and Dual Buck (5 V and 6 V)
6 Waveforms

6.1 Output Ripple Performance

6.1.1 Pre-Boost

Figure 9. Ch1: Switch Node 7.5-V Boost  
Ch2: Pre-Boost 7.5-V Ripple at 3.5-V$_{\text{IN}}$ and 2-A Load

Figure 10. Ch1: Switch Node 7.5-V Boost  
Ch2: Pre-Boost 7.5-V Ripple at 5-V$_{\text{IN}}$ and 2-A Load
Figure 11. Ch1: Switch Node 7.5-V Boost
Ch2: Pre-Boost 7.5-V Ripple at 6.3-V\(\text{IN}\) and 2-A Load

Figure 12. Ch1: Switch Node 7.5-V Boost
Ch2: Pre-Boost 7.5-V Ripple at 8-V\(\text{IN}\) (No Ripple—Boost Bypassed at 8 V) and 2-A Load
6.1.2 Dual Bucks

Figure 13. Ch1: 5-V Ripple at 12-V<sub>IN</sub> and 2-A Load
Ch2: Switch Node 5-V Buck

Figure 14. Ch1: 5-V Ripple at 4.5-V<sub>IN</sub> and 2-A Load
Ch2: Switch Node 5-V Buck

Figure 15. Ch1: 5-V Ripple at 15-V<sub>IN</sub> and 2-A Load
Ch2: Switch Node 5-V Buck
Figure 16. Ch1: 6.5-V Ripple at 15-V<sub>IN</sub> and 0.65-A Load  
Ch2: Switch Node 6.5-V Buck

Figure 17. Ch1: 6.5-V Ripple at 12-V<sub>IN</sub> and 0.65-A Load  
Ch2: Switch Node 6.5-V Buck

Figure 18. Ch1: 6.5-V Ripple at 4-V<sub>IN</sub> and 0.65-A Load  
Ch2: Switch Node 6.5-V Buck
6.2 System Start-up Waveforms

**Figure 19. Start-up—No Load at 7.5-V\textsubscript{IN}**
Ch1: \(V_{\text{IN}}\), Ch2: Boost \(V_{\text{OUT}}\), Ch3: 5-V Buck\(_{\text{OUT}}\), Ch4: 6.5-V Buck\(_{\text{OUT}}\)

**Figure 20. Start-up—No Load at 10.8-V\textsuperscript{IN}**
Ch1: \(V_{\text{IN}}\), Ch2: Boost \(V_{\text{OUT}}\), Ch3: 5-V Buck\(_{\text{OUT}}\), Ch4: 6.5-V Buck\(_{\text{OUT}}\)

**Figure 21. Start-up—No Load at 4.5-V\textsubscript{IN}**
Ch1: \(V_{\text{IN}}\), Ch2: Boost \(V_{\text{OUT}}\), Ch3: 5-V Buck\(_{\text{OUT}}\), Ch4: 6.5-V Buck\(_{\text{OUT}}\)
Figure 22. Start-up—No Load at 12-V\textsubscript{IN}
Ch1: V\textsubscript{IN}, Ch2: Boost V\textsubscript{OUT}, Ch3: 5-V Buck\textsubscript{OUT}, Ch4: 6.5-V Buck\textsubscript{OUT}

Figure 23. Start-up—No Load at 18-V\textsubscript{IN}
Ch1: V\textsubscript{IN}, Ch2: Boost V\textsubscript{OUT}, Ch3: 5-V Buck\textsubscript{OUT}, Ch4: 6.5-V Buck\textsubscript{OUT}

Figure 24. Start-up—Full Load at 18-V\textsubscript{IN}
Ch1: V\textsubscript{IN}, Ch2: Boost V\textsubscript{OUT}, Ch3: 5-V Buck\textsubscript{OUT}, Ch4: 6.5-V Buck\textsubscript{OUT}
Figure 25. Start-up—Full Load at 14.4-V$_{IN}$
Ch1: $V_{IN}$, Ch2: Boost $V_{OUT}$, Ch3: 5-V Buck$_{OUT}$, Ch4: 6.5-V Buck$_{OUT}$

Figure 26. Start-up—Full Load at 12-V$_{IN}$
Ch1: $V_{IN}$, Ch2: Boost $V_{OUT}$, Ch3: 5-V Buck$_{OUT}$, Ch4: 6.5-V Buck$_{OUT}$

Figure 27. Start-up—Full Load at 9-V$_{IN}$
Ch1: $V_{IN}$, Ch2: Boost $V_{OUT}$, Ch3: 5-V Buck$_{OUT}$, Ch4: 6.5-V Buck$_{OUT}$
Figure 28. Start-up—Full Load at 7-V<sub>IN</sub>
Ch1: V<sub>IN</sub>, Ch2: Boost V<sub>OUT</sub>, Ch3: 5-V Buck<sub>OUT</sub>, Ch4: 6.5-V Buck<sub>OUT</sub>

Figure 29. Start-up—Full Load at 5-V<sub>IN</sub>
Ch1: V<sub>IN</sub>, Ch2: Boost V<sub>OUT</sub>, Ch3: 5-V Buck<sub>OUT</sub>, Ch4: 6.5-V Buck<sub>OUT</sub>
6.3 System Transient Performance

Figure 30. Transient Performance of 5-V Buck at 12-V\textsubscript{IN} and 1- to 2-A Current Transient
Ch2: 5-V AC Coupled, Ch4: 5-V Load

Figure 31. Transient Performance of 5-V Buck at 4.5-V\textsubscript{IN} and 1- to 2-A Current Transient
Ch2: 5-V AC Coupled, Ch4: 5-V Load

Figure 32. Transient Performance of 5-V Buck at 14.4-V\textsubscript{IN} and 1- to 2-A Current Transient
Ch2: 5-V AC Coupled, Ch4: 5-V Load
7 Conducted Emissions

The conducted emissions have been tested following the CISPR 25 standards. The examined frequency band spans from 150 kHz to 108 MHz and covers the AM, FM, VHF, and TV bands as specified in the CISPR 25.

Figure 33 and Figure 34 show the test results. Figure 33 shows the test result using a peak detector and average detector measurement, respectively, up to 30 MHz. Figure 34 shows the test result using an average detector and peak detector measurement from 30 MHz to 108 MHz. The red limit lines are the Class 5 limits (up to 30 MHz) and Class 4 limits (30 MHz to 108 MHz) for conducted disturbances specified in the CISPR 25. The yellow traces (peak detector measurement) and blue traces (average detector measurement) are the test results. The user can observe that the power supply operates quietly and the noise is below the Class 4 limit.

Figure 33. Test Result—up to 30-MHz Conducted Emission: Peak and Average Detection (Both Front-End Buck Switching With Full Load)
Figure 34. Test Result—30 MHz to 108 MHz Conducted Emission: Peak and Average Detection
8 Design Files

8.1 Schematics
To download the schematics, see the design files at TIDA-00745.

8.2 Bill of Materials
To download the bill of materials (BOM), see the design files at TIDA-00745.

8.3 Layout Prints
To download the layer plots, see the design files at TIDA-00745.

8.4 Altium Project
To download the Altium project files, see the design files at TIDA-00745.

8.5 Gerber Files
To download the Gerber files, see the design files at TIDA-00745.

8.6 Assembly Drawings
To download the assembly drawings, see the design files at TIDA-00745.

9 Software Files
To download the software files, see the design files at TIDA-00745.

10 References

1. Texas Instruments, *LM53600/01-Q1, 0.65A/1A, 36V Synchronous, 2.1MHz, Automotive Step Down DC-DC Converter*, LM53600-Q1 and LM53601-Q1 Datasheet (SNAS660)

2. Texas Instruments, *LM53603-Q1 (3 A), LM53602-Q1 (2 A) 3.5 V to 36 V Wide-V<sub>In</sub> Synchronous 2.1 MHz Step-Down Converters for Automotive Applications*, LM53602-Q1 and LM53603-Q1 Datasheet (SNVSA42)


4. Texas Instruments, *TPS4021x-Q1 4.5-V to 52-V Input, Current-Mode Boost Controllers*, TPS40210-Q1 and TPS40211-Q1 Datasheet (SLVS861)

5. Texas Instruments, *TPS7B4250-Q1 Low-Dropout Voltage-Tracking LDO*, TPS7B4250-Q1 Datasheet (SLVSCA0)
IMPORTANT NOTICE FOR TI REFERENCE DESIGNS

Texas Instruments Incorporated (“TI”) reference designs are solely intended to assist designers (“Buyers”) who are developing systems that incorporate TI semiconductor products (also referred to herein as “components”). Buyer understands and agrees that Buyer remains responsible for using its independent analysis, evaluation and judgment in designing Buyer’s systems and products. TI reference designs have been created using standard laboratory conditions and engineering practices. **TI has not conducted any testing other than that specifically described in the published documentation for a particular reference design.** TI may make corrections, enhancements, improvements and other changes to its reference designs.

Buyers are authorized to use TI reference designs with the TI component(s) identified in each particular reference design and to modify the reference design in the development of their end products. **However, no other license, express or implied, by estoppel or otherwise to any other TI intellectual property right, and no license to any third party technology or intellectual property right, is granted herein, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used.** Information published by TI regarding third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

TI reference designs are provided “AS IS”. TI makes no warranties or representations with regard to the reference designs or use of the reference designs, express, implied or statutory, including accuracy or completeness. TI disclaims any warranty of title and any implied warranties of merchantability, fitness for a particular purpose, quiet enjoyment, quiet possession, and non-infringement of any third party intellectual property rights with regard to TI reference designs or use thereof. **TI shall not be liable for and shall not defend or indemnify buyers against any third party infringement claim that relates to or is based on a combination of components provided in a TI reference design. In no event shall TI be liable for any actual, special, incidental, consequential or indirect damages, however caused, on any theory of liability and whether or not TI has been advised of the possibility of such damages, arising in any way out of TI reference designs or buyer’s use of TI reference designs.**

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

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

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

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

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

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed an agreement specifically governing such use. Only those TI components that have specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components that have not been so designated is solely at Buyer's risk, and Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2016, Texas Instruments Incorporated