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1 High Density EVM Description

The LM5175RHFEVM-HD demonstrates a compact buck-boost design using the LM5175 high performance 4-switch buck-boost controller. This evaluation module is designed to operate with input voltage from 5 V to 42 V and provide a regulated 12 V output with load current up to 6 A. The transition region control method of the LM5175 maintains high efficiency over the entire operating input voltage in contrast with a conventional four-switch buck-boost converter which has a drop in efficiency at $V_{IN}$ close to $V_{OUT}$. The switching frequency is set at 400 kHz and can be synchronized to an external clock signal. The board specifications are listed in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage ($V_{IN}$)</td>
<td>5.5V to 42V (45V transient)</td>
</tr>
<tr>
<td>Output Voltage ($V_{OUT}$)</td>
<td>12V</td>
</tr>
<tr>
<td>Maximum Output Current ($I_{OUT}$)</td>
<td>6A</td>
</tr>
<tr>
<td>Default Switching Frequency ($f_{sw}$)</td>
<td>400 kHz</td>
</tr>
<tr>
<td>Synchronizable Frequency Range</td>
<td>Up to 600 kHz</td>
</tr>
<tr>
<td>Efficiency ($I_{OUT} = 5A, V_{IN} = 6V$ to 36V)</td>
<td>95.1% to 98.4%</td>
</tr>
<tr>
<td>Board Size (6 layers)</td>
<td>50 mm x 43 mm (1.98 in x 1.7 in)</td>
</tr>
</tbody>
</table>

1.1 Additional Features

- Smooth Buck-Boost Operation
- Ultra-high (>98%) peak power conversion efficiency
- High power density compact design
- Adjustable output voltage using TRIM
- Resistor programmable switching frequency (adjustable) with optional external synchronization (SYNC) up to 600 kHz
- Cycle-by-cycle overcurrent protection via shunt resistor current sensing
- Optional hiccup mode overload protection (off by default)
- Default forced PWM (CCM) fixed switching operation with option to set diode emulation mode (DCM)
- Programmable $V_{IN}$ UVLO threshold and hysteresis
- Spread spectrum dither option for reduced EMI
- Power Good indicator
- Input circuit damping and energy storage provided by bulk electrolytic capacitor
- Easy access to PGOOD, ENABLE, TRIM and SYNC using conveniently located test points
2 EVM Photos

Figure 1. EVM Top Side

Figure 2. EVM Bottom Side
3 Signal Connections and Test Point Descriptions

3.1 Test Point Descriptions

Table 2. Test Point Descriptions

<table>
<thead>
<tr>
<th>LABEL</th>
<th>DESCRIPTION</th>
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</thead>
<tbody>
<tr>
<td>VIN</td>
<td>Input voltage positive power and sense connection</td>
</tr>
<tr>
<td>GND</td>
<td>Input voltage negative power and sense connection</td>
</tr>
<tr>
<td>VOUT</td>
<td>Output voltage positive power and sense connection</td>
</tr>
<tr>
<td>GND</td>
<td>Output voltage negative power and sense connection</td>
</tr>
<tr>
<td>AGND</td>
<td>Analog GND</td>
</tr>
<tr>
<td>SYNC</td>
<td>External frequency synchronization input (SYNC). This terminal is connected to the RT/SYNC pin of the LM5175 controller through a 100 pF capacitor on the board.</td>
</tr>
<tr>
<td>EN</td>
<td>ENABLE input; tie to GND to disable converter</td>
</tr>
<tr>
<td>PGOOD</td>
<td>Power Good output</td>
</tr>
</tbody>
</table>

3.2 Optional Configurations

Table 3. Optional Configurations

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>R8</td>
<td>R8 can be used to select DCM or CCM mode and for enabling hiccup mode current limit. See LM5175 device datasheet for R8 values. Default EVM configuration is CCM/No hiccup.</td>
</tr>
<tr>
<td>Rcd</td>
<td>Dither is disabled by default. Replace with an appropriate capacitor to enable dither. See LM5175 datasheet on how to set the dither frequency.</td>
</tr>
</tbody>
</table>

3.3 Signal Connections

3.3.1 Input Voltage Monitoring

The LM5175RHFEVM-HD provides two solder lug test points for measuring input voltage at the input banana connections. This allows the user to measure the actual input voltage without losses from input cables and connectors. All input voltage measurements should be made between VIN and GND test points.

3.3.2 Output Voltage Monitoring

The LM5175RHFEVM-HD provides two solder lug test points for measuring output voltage at the output banana connections. This facilitates measurement of the output voltage without losses related to output cables and connectors.

3.3.3 Power Good Voltage Output

The LM5175RHFEVM-HD provides a test point for measuring the PGOOD flag voltage. A 20-kΩ pullup resistor, Rpg, to VCC is included. For true open-drain operation with no pullup, remove Rpg. One possible scenario where a PGOOD pullup is not required involves PGOOD of an upstream converter connected to the EN input of a downstream converter to provide sequential startup of multiple regulators.

3.3.4 Enable Voltage Input

The LM5175RHFEVM-HD provides a test point for measuring the EN voltage. Shorting this test point to GND disables the converter. The EN/UVLO voltage should not exceed the input voltage.
3.3.5  SYNC Input

The LM5175RHFEVM-HD provides a test point for applying a synchronization (SYNC) input signal. The free-running switching frequency is set at 400 kHz by resistor RT1. However, the converter aligns in frequency and phase with that of the applied SYNC signal up to 600 kHz. If required, apply an external SYNC signal with a frequency higher than the internal free-running frequency as per the LM5175 device datasheet.

4 Test Setup and Procedure

Figure 3 shows the recommended test setup to evaluate the LM5175RHFEVM-HD. Working at an ESD workstation, make sure that any wrist straps, boot straps or mats are connected referencing the user to earth ground before power is applied to the EVM.

![Test Setup Connection Diagram](image)
4.1 Test Equipment

**Voltage Source:** The input voltage source VIN should be a 0–50-V dc source capable of supplying 15 A.

**Multimeters:**
- **Voltmeter 1:** Input voltage at VIN to GND
- **Voltmeter 2:** Output voltage at VOUT to GND
- **Ammeter:** Input current (or use the power supply readout if its accuracy is deemed acceptable)

**Electronic Load:** The output load should be an electronic constant-resistance or constant-current mode load capable of 0-10 A at 12 V.

**Oscilloscope (optional):** A digital or analog oscilloscope can be used to measure pertinent converter waveforms. With the scope set to 20-MHz bandwidth and AC coupling, the output voltage ripple can be measured directly across an output capacitor with a short ground lead normally provided with the scope probe. Place the oscilloscope probe tip on the positive terminal of the output capacitor, holding the probe's ground barrel through the ground lead to the capacitor's negative terminal. It is not recommended to use a long leded ground connection because this may induce additional noise given a large ground loop. To measure other waveforms, adjust the oscilloscope as needed.

**Fan:** Depending on the EVM's operating conditions, the temperature rise of certain powertrain components can approach 50°C. Although not mandatory, use a small fan capable of 200–400 LFM to reduce component temperatures while the EVM is operating. Exercise care when touching the EVM while the fan is not running. Always use caution when touching any circuits that may be live or energized.

4.2 Recommended Test Setup

4.2.1 Input Connections

- Prior to connecting the DC input source, it is advisable to limit the source current to 10 A maximum. Make sure the input source is initially set to 0 V and connected to VIN and GND banana connections as shown in Figure 3. While the on-board hybrid electrolytic capacitor provides input circuit damping, an additional high-ESR input capacitor may be required if long input lines are used.
- Connect voltmeter 1 at VIN and GND test points to measure the input voltage.
- Connect ammeter to measure the input current.

4.2.2 Output Connections

- Connect an electronic load to VOUT and GND connections. Set the load to constant-resistance mode or constant-current mode at 0 Adc before applying input voltage. Use short load lines to minimize voltage drop to the load.
- Connect voltmeter 2 at VOUT and GND solder lugs to measure the output voltage.
- The output current level can be taken from the electronic load readout (if its accuracy is deemed acceptable).
4.3 Test Procedure

4.3.1 Line, Load Regulation and Efficiency
- Set up the EVM as described above.
- Set target load in the electronic load using either constant resistance or constant current mode.
- Increase input source from 0 V to 42 V, using voltmeter 1 to measure input voltage.
- Use voltmeter 2 to measure output voltage, $V_{\text{OUT}}$.
- Vary load from 0 to 6 A, $V_{\text{OUT}}$ should remain within load regulation specification.
- Vary input source voltage from 5.5 V to 42 V, $V_{\text{OUT}}$ should remain within line regulation specification.
- Decrease load to 0 A. Decrease input source voltage to 0 V to power down.

4.3.2 Control Loop Gain and Phase
The resistor R16 on the LM5175RHFEVM-HD is a convenient injection point for loop response analysis.
- Set up EVM as described previously.
- Connect isolation transformer secondary across R16.
- Connect output signal amplitude measurement probe (TEST) to VOUT and input signal amplitude measurement (REF) probe to opposite side of R16.
- Connect ground leads to the AGND test point as required.
- Apply 10 mV or less AC signal to the isolation transformer primary. Adjust amplitude as necessary.
- Sweep the frequency over the frequency range of interest (e.g. 100 Hz to 100 kHz) with 10 Hz or lower post filter.
- Measure the control loop gain and phase characteristic. Record the crossover frequency and phase margin.
- Disconnect isolation transformer before making other measurements (signal injection into the loop may interfere with the integrity of other measurements).

5 Test Data and Performance Curves

5.1 Efficiency

![Figure 4. Efficiency vs. Output Current](image-url)
Figure 5. Efficiency vs Input Voltage

Figure 6. Efficiency vs Output Current for $V_{IN} = 24$ V
Figure 7. Efficiency vs Output Current for $V_{IN} = 6\, \text{V}$

Figure 8. Efficiency vs Output Current for $V_{IN} = 12\, \text{V}$

Table 4. No Load Input Current (IQ) vs Input Voltage

<table>
<thead>
<tr>
<th>$V_{IN}$</th>
<th>IQ (CCM)</th>
<th>IQ (DCM)</th>
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</thead>
<tbody>
<tr>
<td>24V</td>
<td>35 mA</td>
<td>2.6 mA</td>
</tr>
<tr>
<td>12V</td>
<td>22 mA</td>
<td>12 mA</td>
</tr>
<tr>
<td>6V</td>
<td>58 mA</td>
<td>41 mA</td>
</tr>
</tbody>
</table>
5.2 Line and Load Regulation

![Graph of Line and Load Regulation](image)

**Figure 9. Line and Load Regulation**

5.3 Bode Plots

![Graph of Bode Plot](image)

**Figure 10. Bode Plot for $V_{IN} = 6V$, $I_{OUT} = 3A$**
Figure 11. Bode Plot for $V_{IN} = 12\,V$, $I_{OUT} = 3\,A$

Figure 12. Bode Plot for $V_{IN} = 24\,V$, $I_{OUT} = 3\,A$
5.4 Operating Waveforms

5.4.1 Switch Node Voltages and Inductor Current

Figure 13. SW1, SW2, I_L Waveforms: V_in = 6 V, V_out = 12 V, I_out = 0 A

Figure 14. SW1, SW2, I_L Waveforms: V_in = 6 V, V_out = 12 V, I_out = 5 A

Figure 15. SW1, SW2, I_L Waveforms: V_in = 12 V, V_out = 12 V, I_out = 0 A

Figure 16. SW1, SW2, I_L Waveforms: V_in = 12 V, V_out = 12 V, I_out = 5 A

Figure 17. SW1, SW2, I_L Waveforms: V_in = 16 V, V_out = 12 V, I_out = 0 A

Figure 18. SW1, SW2, I_L Waveforms: V_in = 16 V, V_out = 12 V, I_out = 5 A
Test Data and Performance Curves

Figure 19. SW1, SW2, I_L Waveforms: \( V_{IN} = 18 \, V \), \( V_{OUT} = 12 \) A, \( I_{OUT} = 0 \) A

Figure 20. SW1, SW2, I_L Waveforms: \( V_{IN} = 18 \, V \), \( V_{OUT} = 12 \) V, \( I_{OUT} = 5 \) A

Figure 21. SW1, SW2, I_L Waveforms: \( V_{IN} = 24 \, V \), \( V_{OUT} = 12 \) V, \( I_{OUT} = 0 \) A

Figure 22. SW1, SW2, I_L Waveforms: \( V_{IN} = 24 \, V \), \( V_{OUT} = 12 \) V, \( I_{OUT} = 5 \) A

Figure 23. SW1, SW2, I_L Waveforms: \( V_{IN} = 42 \, V \), \( V_{OUT} = 12 \) V, \( I_{OUT} = 0 \) A

Figure 24. SW1, SW2, I_L Waveforms: \( V_{IN} = 42 \, V \), \( V_{OUT} = 12 \) V, \( I_{OUT} = 5 \) A
5.4.2 Output Voltage Ripple, 20-MHz Bandwidth

![Graphs showing output voltage ripple for different input voltages and output currents.](image)

5.4.3 Startup Waveform

![Graphs showing startup waveforms for different input voltages and output currents.](image)
Figure 31. Startup at $V_{IN} = 24$ V, $I_{OUT} = 0$A

Figure 32. Startup at $V_{IN} = 24$ V, $I_{OUT} = 4$A
6 EVM Documentation

6.1 Schematic

Figure 33. EVM Schematic
6.2 PCB Layout

Figure 34 through Figure 41 show the design of the LM5175 6-layer PCB with 2-oz copper thickness. The EVM is a two-sided design, and it includes positions for input and output bulk capacitors.

Figure 34. Top Copper (Top View)

Figure 35. Layer 2 (Top View)
Figure 36. Layer 3 (Top View)

Figure 37. Layer 4 (Top View)
Figure 38. Layer 5 (Top View)

Figure 39. Bottom Copper (Bottom View)
Figure 40. Top Layer Silkscreen (Top View)

Figure 41. Bottom Layer Silkscreen (Bottom View)
# Bill of Materials

## Table 5. Bill of Materials

<table>
<thead>
<tr>
<th>Count</th>
<th>Ref Des</th>
<th>Description</th>
<th>Part Number</th>
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<td>4</td>
<td>C1, C4, C11, CT1</td>
<td>Capacitor, Ceramic, 100pF, 50V, C0G, 5%, 0603</td>
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<td>1</td>
<td>Cc1</td>
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<td>Cb1, Cb2</td>
<td>Capacitor, Ceramic, 0.1μF, 25V, X7R, 10%, 0603</td>
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<td>Std</td>
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<td>Capacitor, Ceramic, 0.22μF, 50V, X7R, 10%, 0603</td>
<td>GRM32EC71H106KA03L</td>
<td>Murata</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>CGA6P3X7S1H106K250AE</td>
<td>TDK</td>
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<tr>
<td>12</td>
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<td>C1210C106K5RACTU</td>
<td>Kemet</td>
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<td>GRM32ER71H106KA12L</td>
<td>Murata</td>
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<td>UMK325AB7106KM-T</td>
<td>Taiyo Yuden</td>
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<td>2</td>
<td>Cin7, Co7</td>
<td>Capacitor, AL, 68μF, 50V, 20%, 30mΩ, 4000hr</td>
<td>EEHZC1H680P</td>
<td>Panasonic</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>NSPE-Z680M50V8X10</td>
<td>NIC Components</td>
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<td>1</td>
<td>Cvcc</td>
<td>Capacitor, Ceramic, 1μF, 25V, X7R, 10%, 0603</td>
<td>GRM188R71C105KA12D</td>
<td>Murata</td>
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<tr>
<td>2</td>
<td>D1</td>
<td>Diode Schottky, 30V, 200mA, SOD-323</td>
<td>BAT54HT1G</td>
<td>On Semi</td>
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<td>D2, D3</td>
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<td>NXP</td>
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<td>Inductor, 3.3μH, 7.7mΩ DCR, 15A Irms, 32A Isat</td>
<td>PIMC135T-3R3MF</td>
<td>Delta</td>
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<tr>
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<td></td>
<td></td>
<td>7443969303</td>
<td>Wurth</td>
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<tr>
<td>2</td>
<td>OH1, QL1</td>
<td>MOSFET, N-Channel, 60V, 40A, PG-TSDSON-8</td>
<td>BSZ042N06NS</td>
<td>Infineon</td>
</tr>
<tr>
<td>2</td>
<td>OH2, QL2</td>
<td>MOSFET, N-Channel, 30V, 40A, PG-TSDSON-8</td>
<td>BSZ0902NS</td>
<td>Infineon</td>
</tr>
<tr>
<td>2</td>
<td>R1, R8</td>
<td>Resistor, Chip, 200kΩ, 1/10W, 1%, 0603</td>
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<td>Std</td>
</tr>
<tr>
<td>1</td>
<td>R2</td>
<td>Resistor, Chip, 52.3kΩ, 1/10W, 1%, 0603</td>
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<td>Std</td>
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<td>5</td>
<td>R3, R4, R5, R6, R16</td>
<td>Resistor, Chip, 10Ω, 1/10W, 1%, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
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<td>R10</td>
<td>Resistor, Chip, 7.15kΩ, 1/10W, 1%, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>1</td>
<td>R12</td>
<td>Resistor, Chip, 100kΩ, 1/10W, 1%, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>2</td>
<td>R13, R14</td>
<td>Resistor, Chip, 100Ω, 1/10W, 1%, 0603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>1</td>
<td>R15</td>
<td>Resistor, Chip, 6.65kΩ, 1/10W, 1%, 0603</td>
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<td>1</td>
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<td>Resistor, Chip, 20kΩ, 1/10W, 1%, 0603</td>
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<td>1</td>
<td>Rc</td>
<td>Resistor, Chip, 3.01kΩ, 1/10W, 1%, 0603</td>
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<td>3</td>
<td>Rh1, Rl1</td>
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<td>Resistor, 7mΩ, 3W, 1%, 2512 WIDE</td>
<td>KRL6432E-M-R007</td>
<td>Susumu</td>
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<tr>
<td></td>
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<td>CSR1225FK07L0</td>
<td>Stackpole</td>
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<td>LRF3WLF-01-R007</td>
<td>TT Electronics</td>
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<td>RT1</td>
<td>Resistor, Chip, 60.4kΩ, 1/10W, 1%, 0603</td>
<td>Std</td>
<td>Std</td>
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<td>U1</td>
<td>IC, Synchronous Buck-Boost Controller, TSSOP-28</td>
<td>LM5175PWP</td>
<td>TI</td>
</tr>
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<td>1</td>
<td>PCB1</td>
<td>PCB, FR4, 6 layer, 2 oz, 50 mm x 43 mm</td>
<td>PCB</td>
<td>Any</td>
</tr>
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<td>4</td>
<td>VIN, VOUT, GND, GND</td>
<td>Banana Jack Power Terminal with Solder Lug</td>
<td>108-0740-001</td>
<td>Emerson</td>
</tr>
<tr>
<td>4</td>
<td>H3, H4, H7, H8</td>
<td>Screw, Round, #4-40 x 1/4, Nylon, Philips panhead</td>
<td>NY PMS 440 0025 PH</td>
<td>B&amp;F</td>
</tr>
<tr>
<td>4</td>
<td>H1, H2, H5, H6</td>
<td>Standoff, Hex, 0.5&quot;L #4-40 Nylon</td>
<td>1902C</td>
<td>Keystone</td>
</tr>
<tr>
<td>5</td>
<td>AGND, EN, TRIM, PGGOOD, SYNC</td>
<td>Test Point, SMT</td>
<td>5016</td>
<td>Keystone</td>
</tr>
<tr>
<td>DATE</td>
<td>REVISION</td>
<td>NOTES</td>
<td></td>
<td></td>
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<tr>
<td>April 2016</td>
<td>*</td>
<td>Initial release.</td>
<td></td>
<td></td>
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STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. Delivery: TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software.

1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 Limited Warranty and Related Remedies/Disclaimers:

2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.
FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 Notice for EVMs delivered in Japan: Please see http://www.tij.co.jp/lads/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/lads/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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2. 実験局の免許を取得後ご使用いただく。
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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。
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4. EVM Use Restrictions and Warnings:

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 Safety-Related Warnings and Restrictions:

4.3.1 User shall operate the EVM within TI’s recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User’s handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. Accuracy of Information: To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.
6. **Disclaimers:**

6.1 **EXCEPT AS SET FORTH ABOVE,** EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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8. **Limitations on Damages and Liability:**

8.1 **General Limitations.** IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

8.2 **Specific Limitations.** IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. **Return Policy.** Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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