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**Class 4, Wide Input Range, 15-W Power over Ethernet (PoE) Converter Reference Design**

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**Design Resources**

- PMP6659 Tool Folder Containing Design Files
- TPS23756 Product Folder
- TL431 Product Folder

**Design Features**

- Input voltage range: 10.8 to 57 VDC, 18 to 32VAC, or Power over Ethernet (PoE)
- 12-V at 1.25-A output
- Isolated flyback with synchronous rectifier for high efficiency
- Uses the TPS23765 high-power PoE interface and DC-DC controller
- Supports hardware Class 4 from the IEEE 802.3at standard

**Featured Applications**

- PoE Security Cameras
- Wireless LAN—Wireless Access Points

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**Class 4, Wide Input Range, 15-W Power over Ethernet (PoE) Converter Reference Design**

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# System Description

The Class 4—Wide Input Range, 15-W Power over Ethernet (PoE) Converter reference design is intended for users to develop end-products for various internet protocol (IP) industrial applications. The reference design provides a complete guide for the hardware design of a flyback converter with synchronous rectification used for Class 4 PoE applications where a wide input range is required. The design files include schematics, Bill of Materials (BOMs), layer plots, Altium files, Gerber Files, and Fabrication Files.

This reference design has an optimized wide input voltage range. The output power is 12-V at 1.25-A (15-W) from either an adapter input (10.8 to 57 VDC or 18 to 32 VAC) or PoE. The synchronous rectifier provides excellent efficiency with the wide input voltage range. The wide input voltage range and high efficiency makes this design compatible with legacy applications where 12-VDC, 24-VDC, or 24-VAC auxiliary power is used. This design gives customers a ready-to-use high efficiency, wide input power design for building automation applications. The input and output combination of the design is typically required for PoE security cameras.

The core of this reference design is the PoE interface and DC-DC controller from TI, the TPS23756 device, that interfaces with the AC or DC-adapter input or the PoE input. The TPS23756 device is compliant with the IEEE 802.3at Power over Ethernet standard.

## 1.1 TPS23756

The TPS23756 device has a combined power-over-ethernet (PoE) powered-device (PD) interface and current-mode DC-DC controller optimized specifically for isolated converters. The PoE interface supports the IEEE 802.3at standard.

The TPS23756 device supports a number of input voltage ORing options including highest voltage, external adapter preference, and PoE preference. These features allow the designer to determine which power source will carry the load under all conditions.

The PoE interface features the new extended hardware classification necessary for compatibility with high-power midspan power sourcing equipment (PSE) per IEEE 802.3at. The detection signature pin can also be used to force power from the PoE source off. Classification can be programmed to any of the defined types with a single resistor.

The DC-DC controller features two complementary gate drivers with programmable dead time. This simplifies the design of active-clamp forward converters or optimized gate drive for highly-efficient flyback topologies. The second gate driver may be disabled if desired for single MOSFET topologies. The controller also features internal softstart, bootstrap startup source, current-mode compensation, and a 78% maximum duty cycle. A programmable and synchronizable oscillator allows design optimization for efficiency and eases use of the controller to upgrade existing power supply designs. Accurate programmable blanking, with a default period, simplifies the usual current-sense filter design trade-offs.

## 1.2 TL431

The TL431 is a three-terminal adjustable shunt regulator with specified thermal stability over applicable automotive, commercial, and military temperature ranges. The output voltage can be set to any value between $V_{\text{ref}}$ (approximately 2.5 V) and 36 V, with two external resistors. These devices have a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turn-on characteristic, making these devices excellent replacements for Zener diodes in many applications, such as onboard regulation, adjustable power supplies, and switching power supplies.
2 Design Features

- Input voltage range of 10.8 to 57 VDC, 18 to 32 VAC, or Power over Ethernet (PoE)
- 12-V at 1.25-A output
- Isolated flyback with synchronous rectifier for high efficiency
- Uses the TPS23756 high-power PoE interface and DC-DC controller
- Supports hardware Class 4 from the IEEE 802.3at standard

3 Block Diagram

![Block Diagram](image-url)

Figure 1. Block Diagram
4 Highlighted Products

The wide input range PoE converter reference design features the following devices:

- TPS23756
  - This device is a high-power and high-efficiency PoE interface and DC-DC controller.
- TL431
  - This device is an adjustable precision shunt-regulator.

For more information on each of these devices, see the respective product folders at www.TI.com.

4.1 TPS23756

- Powers up to 30-W (Input) PDs
- DC-DC control optimized for isolated converters
- Supports high-efficiency topologies
- Complete PoE interface
- Enhanced classification per IEEE 802.3at with status flag
- Adapter ORing support
- Programmable frequency with synchronization
- Robust 100-V, 0.5-Ω hotswap mOSFET
- –40°C to 125°C junction temperature range
- Industry standard PowerPAD™ TSSOP-20

4.2 TL431

- Equivalent full-range temperature coefficient, 30 ppm/°C
- 0.2-Ω typical output impedance
- Sink-current capability, 1 mA to 100 mA
- Low output noise
- Adjustable Output Voltage, $V_{\text{ref}}$ to 36 V
- Available in a wide range of high-density packages
5 System Design Theory

5.1 PoE Hardware Classification

The reference design powered device (PD) supports hardware Class 4 from the IEEE 802.3at standard. This hardware classification allows PSE to determine the power requirements of a PDF before powering. This classification also helps with power management once power is applied. A Type 2 hardware classification permits high-power PSEs and PDs to determine whether the connected device can support high-power operation. A Type 2 PD presents Class 4 in hardware to indicate that the PD is a high-power device. A Type 1 PSE recognizes a Class 4 device as a Class 0 device which allows for 13 W if the PSE chooses to power the PD.

The maximum power entries in Table 1 determine the class classified by the PD. A Type 1 PD is not classified as Class 4. The PSE can disconnect a PD if the PD draws more than the power of the stated class, which is either the hardware class or a lower DLL-derived power level. The standard dictates that the PD draws limited-current peaks that increase the instantaneous power above the limited-current peaks listed in Table 1. However, the average power requirement always applies to the PD.

Table 1. Power

<table>
<thead>
<tr>
<th>CLASS</th>
<th>CLASS REQUIREMENT</th>
<th>POWER AT PD</th>
<th>USAGE</th>
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<tr>
<td></td>
<td>MIN (mA)</td>
<td>MAX (mA)</td>
<td>MIN (W)</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0.44</td>
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<tr>
<td>1</td>
<td>9</td>
<td>12</td>
<td>0.44</td>
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<td>2</td>
<td>17</td>
<td>20</td>
<td>3.84</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>30</td>
<td>6.49</td>
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<tr>
<td>4</td>
<td>36</td>
<td>44</td>
<td>12.95</td>
</tr>
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</table>

(1) For a more detailed PoE overview with the TPS23756 device, please refer to the PoE Overview Section in the TPS23756 datasheet (SLVS885).

(2) The yellow row indicates the PD classification for the PMP6659.

(3) The IEEE 802.3at standard is an update to IEEE 802.3-2008 clause 33 (PoE), adding high-power options and enhanced classification. Standards change and should always be referenced when making design decisions.

5.2 Wide Input Range

This reference design supports a wide input range of 10.8 to 57 VDC, 18 to 32 VAC, or Power over Ethernet. The wide input voltage range makes this design compatible with legacy applications where 12-VDC, 24-VDC, or 24-VAC auxiliary power is used. When operating from an adaptor the TPS23756 device has a lower internal PoE undervoltage-lockout (UVLO) circuit allowing it to work with wider inputs. The IEEE 802.3at standard states that the nominal operating conditions from the PSE is 48-VDC but may vary between 42.5 to 57 VDC with a maximum-generated current rating typically at 600-mA per mode to protect the Ethernet cable from overheating. The DC-DC converter, after the PoE interface, converts the input to the applications operating voltage defined for this reference design as 12 V with a 1.25-mA load.
5.3 Other Recommended Devices

This reference design addresses legacy applications where 12-VDC, 24-VDC, or 24-VAC auxiliary power is used. Applications requiring an optimized PD and DC-DC Controller solution with high efficiency and does not require a wide input range should use the TPS23751 device or the TPS23752 device. Both devices have an evaluation module, TPS23751EVM-104 and TPS23752EVM-145, which is used to evaluate the performance of the TPS23751/2 IEEE 802.3at PoE Interface and Green-mode DC-DC Controller. See Figure 2 for the TPS23751 and TPS23752 device light load efficiency versus mode.

![Figure 2. TPS23751 and TPS23752 Light Load Efficiency Versus Mode](image)

5.4 Additional Application Notes

<table>
<thead>
<tr>
<th>Description</th>
<th>TI Literature Number</th>
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<tr>
<td>Practical Guidelines to Designing an EMI Compliant PoE Powered Device with Isolated Flyback</td>
<td>SLUA469</td>
</tr>
<tr>
<td>Practical Guidelines to Designing an EMI Compliant PoE Powered Device with Non-Isolated DC/DC</td>
<td>SLUA454</td>
</tr>
<tr>
<td>PoE Powered Device for 24 VAC Building Power Applications</td>
<td>SLUA477</td>
</tr>
<tr>
<td>Using the TPS2398/99 Hot Swap Controller With Power Trends PT4485</td>
<td>SLUA306</td>
</tr>
</tbody>
</table>
6 Getting Started

6.1 Hardware

The reference design comprises of one board, shown in Figure 3, which has several input capabilities.

![Figure 3. The PMP6659 Board (Revision B)](image-url)
Getting Started

Figure 4 shows the partition of the PMP6659 board.

Figure 4. PMP6659 Partition

Figure 5 shows the adapter inputs, PoE input, data port, and the output.

Figure 5. PMP6659 Inputs and Outputs
6.1.1 Hardware Setup

This section lists the different ways to apply power to the PMP6659 board.

6.1.1.1 Connect a DC Adapter Input

As shown in Figure 6 and Figure 7, connect an adapter input or bench supply of 10.8 to 57 VDC to J3 (see Section 8 for the PMP6659 schematic). The output power is transmitted from the J5 connector.

Figure 6. PMP6659 DC-Adaptor Input Schematic

Figure 7. PMP6659 DC-Adaptor Input Setup
6.1.1.2 Connect an AC adapter input

As shown in Figure 8 and Figure 9, connect an adapter input of 18 to 32 VAC to J4 (see Section 8 for the PMP6659 schematic). The output power is transmitted from the J5 connector.

Figure 8. PMP6659 AC-Adaptor Input Schematic

Figure 9. PMP6659 AC-Adapter Input Setup
### 6.1.1.3 Connect Power over Ethernet

As shown in Figure 10 and Figure 11, connect a Power over Ethernet input or a bench supply to J2 (see Section 8 for the PMP6659 schematic). The output power is transmitted from the J5 connector.

![Figure 10. PMP6659 PoE Input Schematic](image1)

![Figure 11. PMP6659 PoE Input Setup](image2)
7 Test Data

7.1 Efficiency versus Input Voltage

Figure 12 shows the efficiency of the converter with various inputs. The efficiency data is taken from three points:

1. 48-VDC input at J2 (see Figure 10 and Figure 11)
2. 12-VDC input at J3 (see Figure 6 and Figure 7)
3. 24-VAC input at J4 (see Figure 8 and Figure 9)

Figure 12. Efficiency of the PMP6659 Across a Wide Input Range
7.2 Input Ripple Voltage (Ripple and Noise Measurements)

Figure 13 and Figure 14 show the ripple voltage (J5 connector). The input ripple shown in Figure 13 and Figure 14 was measured with an input voltage of 48 VDC at J2, an output load at 1.25 A, and 20 MHz BWL.

NOTE: A short ground lead was required for the ripple measurement. The oscilloscope was set to 20 MHz bandwidth limited.

![Figure 13. 12-V Ripple (C38), 20 mV/div, 1 µs/div](image)

Figure 14. Input Ripple (D1), 10 mV/div, 1 µs/div

The input ripple shown in Figure 15 and Figure 16 was taken with an input voltage of 12 VDC at J3, the output loaded to 1.25 A, and 20 MHz BWL.

![Figure 15. 12-V Ripple (C38), 20 mV/div, 1 µs/div](image)

Figure 16. Input Ripple (C37), 10 mV/div, 1 µs/div
The input ripple shown in Figure 17 was taken with an input voltage of 24 VAC across C27.

Figure 17. Input Ripple Across C27 with a 24-V AC Input, 2 V/div, 5 ms/div
7.3  **Load Transients (Dynamic Loading)**

*Figure 18* shows the 12-V output voltage (at J5) when the load current pulses between 0.5 A and 1.25 A. The input voltage ($V_i$) is 48 VDC at J2.

![Figure 18. Load Step, 48 V, at J2 100 mV/div, 500 µs/div](image)

*Figure 19* shows the 12-V output voltage (at J5) when the load current pulses between 0.5 A and 1.25 A. $V_i$ is 12-VDC at J3.

![Figure 19. Load Step, 12 V, at J3 200 mV/div, 1 ms/div](image)
7.4  **Turn-on Response**

Figure 20 and Figure 21 show the 12-V output voltage start-up waveform after the application of 48 VDC at J2 (PoE). The output was loaded to 0 A (see Figure 20) and 1.25 A (see Figure 21).

Figure 20. 48 V, 0-A Load, 2 ms/div  
Figure 21. 48 V, 1.25-A Load, 2 ms/div

Figure 22 and Figure 23 show the 12-V output voltage start-up waveform after the application of 12 VDC at J3. The output was loaded to 0 A (see Figure 22) and 1.25 A (see Figure 23).

Figure 22. 12 V, 0-A Load, 2 ms/div  
Figure 23. 12 V, 1.25-A Load, 2 ms/div
7.5 Control Loop Gain / Stability

Table 2 lists the loop gain and phase margin (see Figure 24). The output was loaded to 1.25 A.

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<thead>
<tr>
<th>Input Voltage</th>
<th>48-V</th>
<th></th>
</tr>
</thead>
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<td></td>
<td>Gain/Phase</td>
<td>Crossover</td>
</tr>
<tr>
<td>PMP6659</td>
<td>6.4 kHz</td>
<td>58.3°</td>
</tr>
</tbody>
</table>

Figure 24. Loop Gain and Phase Margin at 48 V

Table 3 lists the loop gain and phase margin (see Figure 25). The output was loaded to 1.25 A.

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<thead>
<tr>
<th>Input Voltage</th>
<th>12-V</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gain/Phase</td>
<td>Crossover</td>
</tr>
<tr>
<td>PMP6659</td>
<td>3.3 kHz</td>
<td>36°</td>
</tr>
</tbody>
</table>

Figure 25. Loop Gain and Phase Margin at 12 V
7.6 Thermal Performance of the Design

A simple test confirmed the thermal performance of the design. Thermal measurements were taken at two data points: 48-V input with a 1.25-A load and 12-V input with a 1.25-A load.

Thermal-imaging camera hot spots were analyzed at 30 minutes after launching the application. The results of this test confirm that the design can effectively dissipate heat without localized heating.

As shown in Figure 26 and Figure 27, there is no localized heating observed in the system after the 30 minute period.

![Figure 26. 48-V Input and 1.25-A Load](image1)

![Figure 27. 12-V Input and 1.25-A Load](image2)
Figure 28. The DC-DC Converter
Figure 29. The Adapter Inputs, PoE Input, and Data Port
To download the bill of materials (BOM) for each board, see the design files at www.ti.com/tool/PMP6659. Table 4 lists the BOM for the PMP6659.

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<thead>
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<th>Designator</th>
<th>Quantity</th>
<th>Value</th>
<th>Description</th>
<th>Package Reference</th>
<th>Part Number</th>
<th>Manufacturer</th>
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</thead>
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<td>IPCB</td>
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<td>Printed Circuit Board</td>
<td></td>
<td>PMP6659</td>
<td>Any</td>
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<td>C1, C2, C3, C4</td>
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<td>0.01 µF</td>
<td>Capacitor, Ceramic, 100 V, X7R, 10%</td>
<td>603</td>
<td>STD</td>
<td>STD</td>
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<tr>
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<td>1</td>
<td>22 µF</td>
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<td>STD</td>
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<td>C10, C11, C19</td>
<td>3</td>
<td>2.2 µF</td>
<td>Capacitor, Ceramic, 100 V, X7R, 10%</td>
<td>805</td>
<td>STD</td>
<td>STD</td>
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<td>C13</td>
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<td>470 pF</td>
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<td>C16</td>
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<td>39 µF</td>
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<td>vsVPxxyyM</td>
<td>Sanyo</td>
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<td></td>
<td>Fiducial mark. There is nothing to buy or mount.</td>
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<td>2</td>
<td>520252</td>
<td>Connector, Jack, Modular, 8 POS</td>
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<td>N/A</td>
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<td>J3, J4, J5</td>
<td>3</td>
<td></td>
<td>Terminal Block, 6 A, 3.5-mm Pitch, 2-Pos, TH</td>
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<td>On-Shore Technology</td>
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<td>J6</td>
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<td>PTC36SAAN</td>
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<td>Coilcraft</td>
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Table 4. BOM
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<td>R20, R25</td>
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<td>2K</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R21, R23, R26</td>
<td>3</td>
<td>10K</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R22</td>
<td>1</td>
<td>301</td>
<td>Resistor, Chip, 1/16W, 1%</td>
<td>603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R28</td>
<td>1</td>
<td>2.61K</td>
<td>Resistors, Chip, 1/16W, 1%</td>
<td>603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R29</td>
<td>1</td>
<td>422K</td>
<td>Resistors, Chip, 1/16W, 1%</td>
<td>603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R32</td>
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<td>237K</td>
<td>Resistors, Chip, 1/16W, 1%</td>
<td>603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>R33</td>
<td>1</td>
<td>37.4K</td>
<td>Resistors, Chip, 1/16W, 1%</td>
<td>603</td>
<td>Std</td>
<td>Std</td>
</tr>
<tr>
<td>T1</td>
<td>1</td>
<td>ETH1-230LD</td>
<td>Transformer, High Power PoE</td>
<td>S0 14 Wide</td>
<td>ETH1-230LD</td>
<td>Coilcraft</td>
</tr>
<tr>
<td>T2</td>
<td>1</td>
<td>MAS281-BL</td>
<td>Transformer, Flyback, 45uH</td>
<td>0.810 x 1.181 inch</td>
<td>MAS281-AL</td>
<td>Coilcraft</td>
</tr>
<tr>
<td>T1</td>
<td>1</td>
<td>5012</td>
<td>Test Point, White, Thru Hole</td>
<td>0.125 x 0.125 inch</td>
<td>5012</td>
<td>Keystone</td>
</tr>
<tr>
<td>U2</td>
<td>1</td>
<td>TPS23756PWP</td>
<td>IC, IEEE 802.3at PoE Interface/Isolated Converter Controller</td>
<td>PWP20</td>
<td>TPS23756PWP</td>
<td>Ti</td>
</tr>
<tr>
<td>U3</td>
<td>1</td>
<td>TCMT1107</td>
<td>IC, Photocoupler, 80-160% CTR</td>
<td>MF4</td>
<td>TCMT110x</td>
<td>Vishay</td>
</tr>
<tr>
<td>U4</td>
<td>1</td>
<td>TL431ACDBVR</td>
<td>IC, Precision Adjustable Shunt Regulator</td>
<td>SOT23-5</td>
<td>TL431DBVR</td>
<td>Ti</td>
</tr>
<tr>
<td>U5</td>
<td>1</td>
<td>TCMT1109</td>
<td>IC, Photocoupler, 200-400% CTR</td>
<td>MF4</td>
<td>TCMT110x</td>
<td>Vishay</td>
</tr>
</tbody>
</table>
10  Layer Plots

To download the layer plots for each board, see the design files at www.ti.com/tool/PMP6659. Figure 30 shows the layer plots.

Figure 30. PMP6659 Layer Plot
11 Assembly Drawings

To download the assembly drawings, see the design files at [www.ti.com/tool/PMP6659](http://www.ti.com/tool/PMP6659). Figure 31 shows the assembly drawing for the PMP6659 board.

**Figure 31. PMP6659 Assembly Drawing**
To download the Altium project files, see the design files at [www.ti.com/tool/PMP6659](http://www.ti.com/tool/PMP6659). Figure 32 shows the layout for the PMP6659.

Figure 32. PMP6659 Layout
To download the Gerber files for each board, see the design files at www.ti.com/tool/PMP6659
About the Author

David Strasser is a Senior Applications Engineer and Member Group Technical Staff at Texas Instruments where he is responsible for developing power reference designs across a wide array of markets. David brings to this role over 30 years of experience in power conversion design. David earned his Bachelor of Science in Electrical Engineering from Western Michigan University in Kalamazoo, Michigan and his Master of Science in Electrical Engineering from the Illinois Institute of Technology in Chicago, Illinois.
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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.

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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.
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- 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.

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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.
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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:

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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.

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3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. 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.

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