Test Report: PMP22089

Half-Bridge Point-of-Load Converter Reference Design With GaN Technology

Description
The board is a redesign of the LMG5200POLEVM-10 EVM. It modifies the inboard transformer turns ratio from 5:1 to 3:1 to reduce input the range. The original EVM was designed to evaluate the LMG5200 GaN half-bridge power stage and the TPS53632G half-bridge point-of-load (PoL) controller. This board implements the converter as a single-stage hard-switched half-bridge with a current-doubler rectifier. The board supports input voltages from 24 V to 32 V and output voltages between 0.5 V to 1.0 V with continuous output currents up to 40 A. This topology efficiently supports the high step-down ratio while providing significant output current and controllability.

Figure 1 Top of Board
1 Test Prerequisites

1.1 Voltage and Current Requirement

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage Range (J1)</td>
<td>24 Vdc – 32Vdc</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>0.5 – 1.0 Vdc</td>
</tr>
<tr>
<td>Output Current</td>
<td>40A</td>
</tr>
<tr>
<td>TPS53632G Switching Frequency</td>
<td>600kHz</td>
</tr>
</tbody>
</table>

Table 1 System Specifications
1.2 Turning on the Board and Operation

1. Connect the input and output supplies as shown in Figure 4, but do not power them on yet.
2. Connect kelvin voltage sense (from multimeters) to test points TP3, TP4, TP12 and TP14.
3. Ensure the enable (EN) switch is set to off.
4. Connect and power the bias supply between 6 V and 9 V. An on-board LDO provides 5 V and 3.3 V to the power and control circuitry.
5. Power up the input supply and set to the desired input voltage. Set the current limit to 2 A.
6. Slide the EN switch to the on position to start the converter. The output voltage will ramp up and the PGOOD LED should light to indicate the output voltage is in regulation.
7. Enable the electronic load and set to the desired load current
8. To use the onboard dynamic load, slide the DynLoad switch to the on position to enable the 120mOhm dynamic Load. This adds 120mOhms in parallel to the load. It can be used isolated or with another load as a base current.

1.3 Turning off the Board

1. Slide the EN switch to the off position.
2. Disable the input voltage supply.
3. Disable the electronic load.
4. Disable the bias supply.

1.4 Notes

- If the converter shuts off due to UVP or over-current protection (OCP), the controller IC must be restarted to re-enable the converter. Shut down the converter by following the steps in Section 1.3, then restart the converter according to the steps in Section 1.2.

- To vary the output voltage, the I2C bus must be used to communicate with the TPS53632G. Consult the user guide for the TPS53632G for the necessary VID protocol. The EVM uses the TPS53632G’s default I2C address. Device Address: 40h. Program Register 00h with 28h for 0.65V, and 3C for 0.85V.
1.5 I2C Programming

1.5.1 Software Download


2. Run the downloaded installation application. Follow the installation instructions. This will install the driver and Texas Instruments Fusion Digital Power Design tool.

3. The I2C GUI that is needed for communicating to the EVM can be accessed from the Windows Programs menu under Texas Instruments.

4. Select the SMBus & I2C & SAA Debug Tool. The tool can be launched directly from here or for easier access going forward, it is recommended that the user right-click on the SMBus & I2C & SAA Debug Tool and choose “Pin to Taskbar” or “Pin to Start Menu”.

1.5.2 USB-I2C Adapter Setup

1. Connect the host computer to the USB-TO-GPIO adaptor with the USB-to-Mini-USB cable.

2. Connect the USB-TO-GPIO adaptor at the I2C jumper of the EVM (J3) as indicated by the “SDA”, “SCL”, and “GND” labels. It may be necessary to use jumpers to connect the supplied GPIO cable to the pins on the board.

![GPIO Cable Pinout](image)

*Figure 3 GPIO Cable Pinout (6: GND, 9: SCL, 10: SCA)*

3. Provide the bias supply to the EVM. The I2C communication is active when the 6V – 9V bias supply is on, providing 5V to the TPS53632G.
1.5.3 Read and Write Procedure

1. Enter the correct address (Default I2C device address is 40h) of TPS53632G in either box (decimal or hexadecimal).

2. To read data from a specific register address, select the I2C Read panel and enter the address of the register you want to read in the Cmd box.

3. Click “Send”.

4. Ensure you see an ACK (NACK will indicate incorrect I2C communications).

5. Data will be displayed in 2-digit Hexadecimal.

6. To write data to a specific register address, select the I2C Write panel and enter the address in the box.

7. Enter the data to be written in hexadecimal.

8. Click “Send” in that same panel.

9. Ensure you see an ACK (NACK will indicate incorrect I2C communications).

Figure 4 I2C GUI
2 Testing and Results

2.1 Efficiency Graphs

Figure 4 Efficiency graph for 0.65 Vout

Figure 5 Efficiency graph for 0.85 Vout
## 2.2 Efficiency Data

<table>
<thead>
<tr>
<th>Target Vin</th>
<th>Target Vout</th>
<th>Input Voltage (V)</th>
<th>Input Current (A)</th>
<th>Input Power (W)</th>
<th>Output Voltage (V)</th>
<th>Output Current (A)</th>
<th>Output Power (W)</th>
<th>Efficiency (%)</th>
<th>Power Loss (W)</th>
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</thead>
<tbody>
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<td>24V</td>
<td>0.65V</td>
<td>24.000 0.156 3.732 0.646 5.000 3.230 86.535% 0.503</td>
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<td>24V</td>
<td>0.85V</td>
<td>28.000 0.138 3.858 0.646 5.000 4.230 87.599% 0.599</td>
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<tr>
<td>28V</td>
<td>0.65V</td>
<td>32.000 0.124 3.962 0.646 5.000 4.230 85.544% 0.715</td>
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<tr>
<td>32V</td>
<td>0.65V</td>
<td>32.000 0.124 3.962 0.646 5.000 4.230 81.533% 0.732</td>
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<td>32V</td>
<td>0.85V</td>
<td>32.000 0.230 7.360 0.643 10.000 8.420 90.305% 0.904</td>
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<td>0.85V</td>
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<tr>
<td>32V</td>
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<td>32.000 0.493 13.804 0.839 15.000 12.585 91.169% 1.219</td>
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### Table 2 Efficiency Table
2.3 Thermal Image

All thermal images are taken after a 10 minute soak with no airflow.

Figure 3 Top of board. Conditions were as follows: Vin = 28 V, Vout = 0.85 V, Load = 14 A
Figure 4 Bottom of Board. Conditions were as follows: Vin = 28 V, Vout = 0.85 V, Load = 14 A
Figure 5 Conditions were as follows: Vin = 32 V, Vout = 0.65 V, Load = 40 A
Figure 6 Conditions were as follows: Vin = 32 V, Vout = 0.65 V, Load = 40 A
3 Waveforms

3.1 Output Voltage Ripple

Measurements were taken using the SMA connector with a 50Ohm termination.

Figure 7 Vin = 28 V, Vout = 0.85 V, ILoad = 14 A.
Figure 8 Vin = 28 V, Vout = 0.65 V, ILoad = 40 A
3.2 Load Transients

![Graph showing load transients](image)

**Figure 9** Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 5.41 A. Vin = 28 V and Vout = 0.65 V.

![Graph showing load transients](image)

**Figure 10** Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 5.41 A. Vin = 28 V and Vout = 0.65 V.
Figure 11 Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 7.08 A. Vin = 28 V and Vout = 0.85 V.

Figure 12 Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 7.08 A. Vin = 28 V and Vout = 0.85 V.
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