Test Report: PMP23580

Bidirectional Flyback for Active Cell Balancing Reference Design

Description

This bidirectional flyback reference design can handle bus voltages of 18V to 36V and single cell battery of 3V to 4.2V. The charge current is limited to 5A. While in the charging state, the bus voltage can input 18V to 36V and output up to 4.2A at 5A charge current. There are external constant current and constant voltage (CC/CV) loops on the battery side to maintain that the battery gets properly charged to the battery voltage. In discharge mode, the single cell battery (3V to 4.2V) becomes the input and outputs 27.5V on the Vbus. The input current from the battery is limited to 5A using a separate external CC loop. The bus voltage output side also has a CV loop that verifies that the bus voltage is regulated to 27.5Vout.

Features

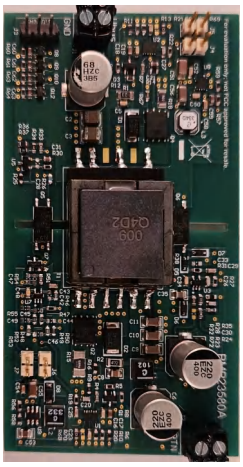
- Bidirectional isolated supply
- Small size
- Low cost
- CC, CV loop for battery charger

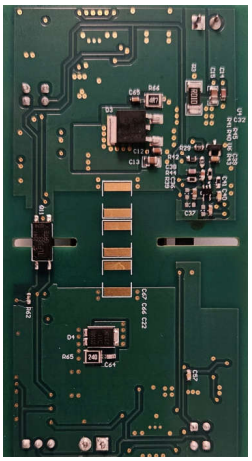
Applications

- Battery cell and pack monitoring unit

Resources

PMP23580	Design Folder
LM51561DSSR	Product Folder
TLV9101IDCKR	Product Folder
TLV61048DBVR	Product Folder
LMR36500P5RPER	Product Folder





Copyright © 2025 Texas Instruments Incorporated

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Charge mode: Voltage and Current Requirements

Parameter	Specifications
Input voltage range	18V to 36V
Output voltage and current	3Vto 4.2V at 5A
Switching frequency	250kHz
Isolation	Yes

Table 1-2. Discharge mode: Voltage and Current Requirements

Parameter	Specifications
Input voltage range	3V to 4.2V
Output voltage and current	26.5V at 5A (input current limited)
Switching frequency	250kHz
Isolation	Yes

1.2 Required Equipment

- E-load
- Power supply, adjustable, 0V to 50V and 6A minimum
- 2 Aux supplies (10V at 0.2A each)
- Oscilloscope and HV probes
- Digital Multimeters

1.3 Dimensions

94mm × 50mm

Copyright © 2025 Texas Instruments Incorporated

2 Testing and Results

2.1 Efficiency Graphs

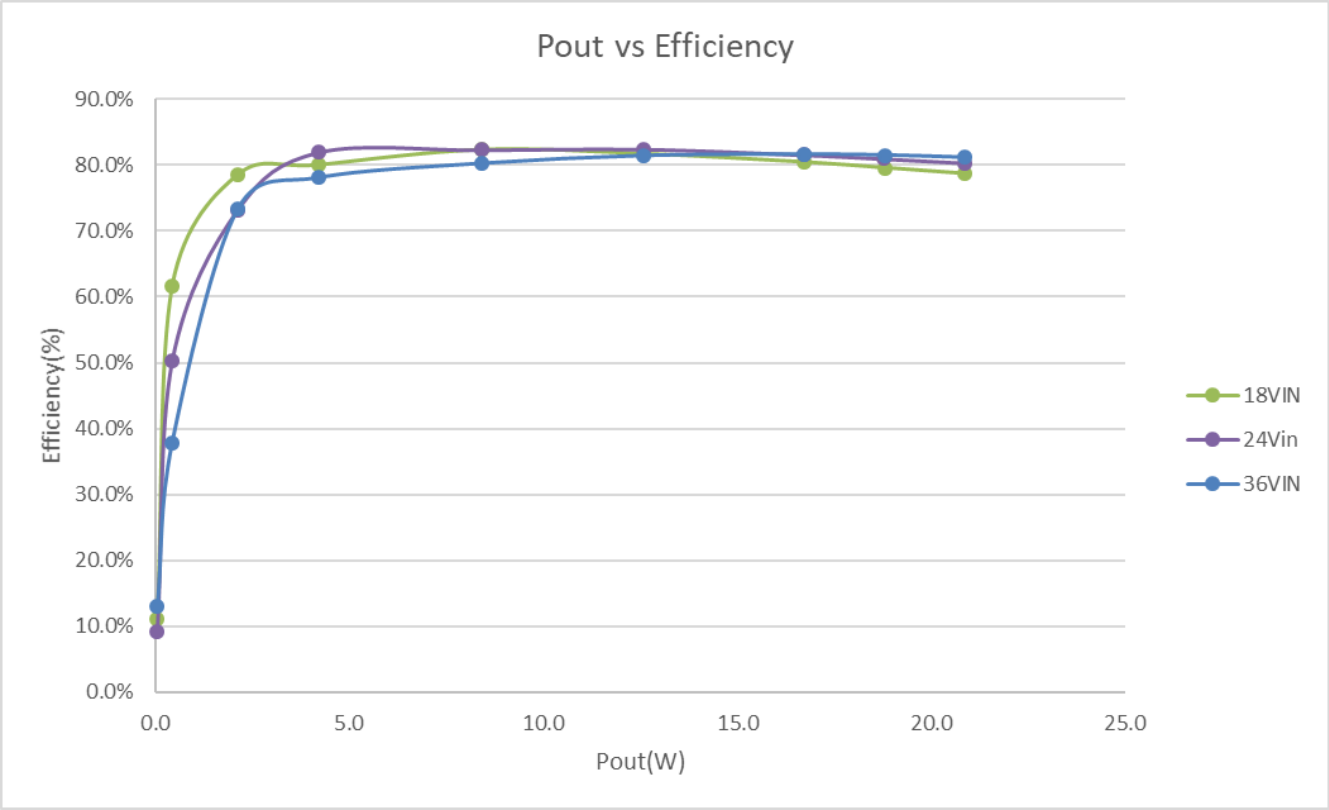


Figure 2-1. Pout versus Efficiency-Charging

Figure 2-2. Pout versus Power Loss-Charging

Copyright © 2025 Texas Instruments Incorporated

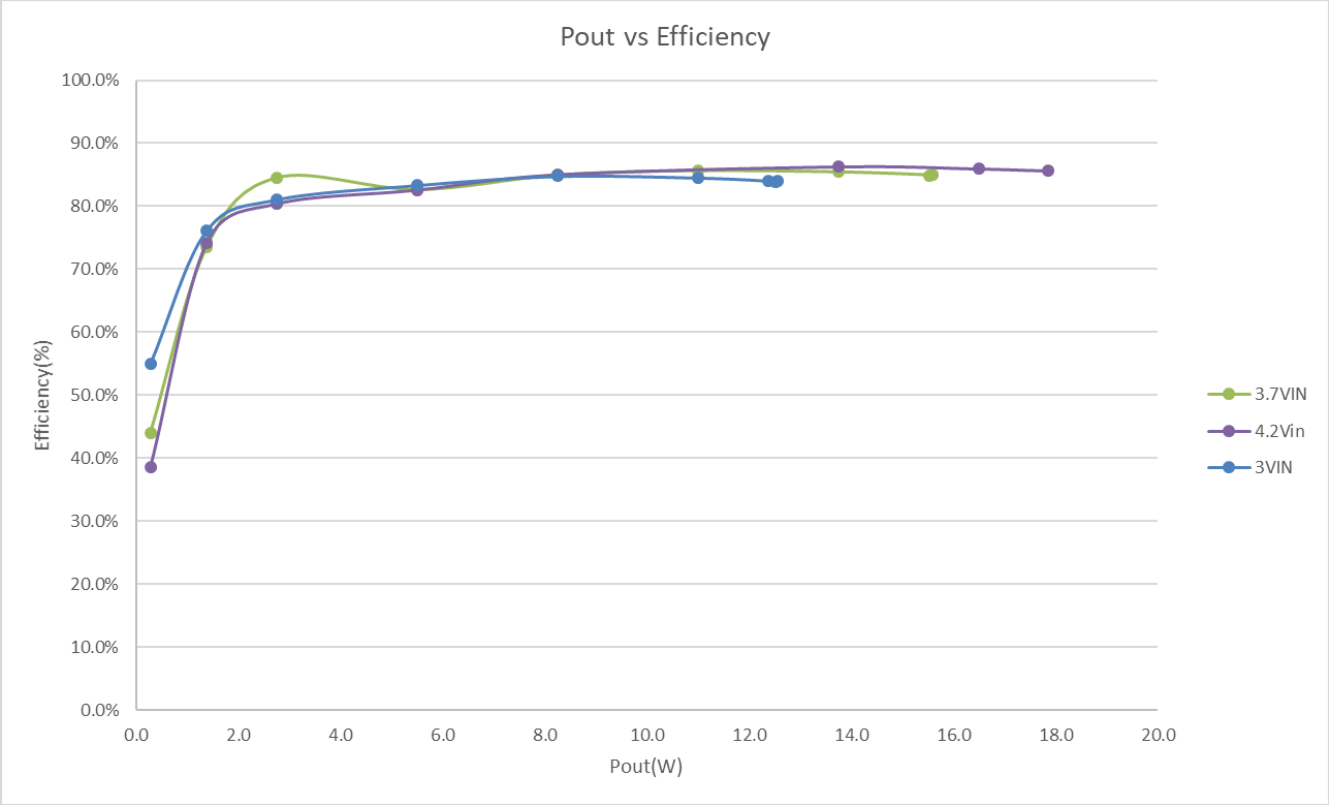


Figure 2-3. Pout versus Efficiency-Discharging

Figure 2-4. Pout versus Power Loss-Discharging

Copyright © 2025 Texas Instruments Incorporated

2.2 Efficiency Data

Table 2-1 and Table 2-2 show the PMP23580 efficiency data.

Table 2-1. Charging Data

V_{IN} (VDC)	I_{IN} (A)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Efficiency (%)	P_{LOSS} (W)
18.059	0.018	0.3251	4.231	0.000	0.000	0.00%	0.325
18.059	0.021	0.379	4.231	0.010	0.042	11.16%	0.337
18.059	0.038	0.686	4.231	0.100	0.423	61.65%	0.263
18.059	0.149	2.691	4.225	0.500	2.113	78.51%	0.578
18.06	0.292	5.274	4.219	1.000	4.219	80.00%	1.055
18.06	0.566	10.222	4.207	2.000	8.414	82.31%	1.808
18.06	0.853	15.405	4.195	3.000	12.585	81.69%	2.820
18.06	1.152	20.805	4.183	4.000	16.732	80.42%	4.073
18.06	1.308	23.622	4.177	4.500	18.797	79.57%	4.826
18.06	1.467	26.494	4.170	5.000	20.850	78.70%	5.644
24.052	0.008	0.1924	4.231	0.000	0.000	0.00%	0.192
24.052	0.019	0.457	4.232	0.010	0.042	9.26%	0.415
24.052	0.035	0.842	4.231	0.100	0.423	50.26%	0.419
24.052	0.12	2.886	4.226	0.500	2.113	73.21%	0.773
24.052	0.214	5.147	4.220	1.000	4.220	81.99%	0.927
24.052	0.425	10.222	4.207	2.000	8.414	82.31%	1.808
24.052	0.635	15.273	4.196	3.000	12.588	82.42%	2.685
24.052	0.853	20.516	4.183	4.000	16.732	81.55%	3.784
24.052	0.965	23.210	4.176	4.500	18.792	80.96%	4.418
24.052	1.079	25.952	4.170	5.000	20.850	80.34%	5.102
36.044	0.004	0.1442	4.231	0.000	0.000	0.00%	0.144
36.044	0.009	0.324	4.232	0.010	0.042	13.05%	0.282
36.044	0.031	1.117	4.231	0.100	0.423	37.87%	0.694
36.044	0.08	2.884	4.226	0.500	2.113	73.28%	0.771
36.044	0.15	5.407	4.220	1.000	4.220	78.05%	1.187
36.044	0.291	10.489	4.207	2.000	8.414	80.22%	2.075
36.044	0.429	15.463	4.195	3.000	12.585	81.39%	2.878
36.044	0.569	20.509	4.183	4.000	16.732	81.58%	3.777
36.044	0.64	23.068	4.177	4.500	18.797	81.48%	4.272
36.044	0.713	25.699	4.170	5.000	20.850	81.13%	4.849

Table 2-2. Discharging Data

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
4.264	0.0993	27.520	0.000	0.4234	0.000	0.423	0.00%
4.264	0.1676	27.510	0.010	0.715	0.275	0.440	38.49%
4.264	0.4351	27.510	0.050	1.855	1.376	0.480	74.14%
4.264	0.8026	27.510	0.100	3.422	2.751	0.671	80.38%
4.264	1.5627	27.510	0.200	6.663	5.502	1.161	82.57%
4.264	2.277	27.510	0.300	9.709	8.253	1.456	85.00%
4.264	3.74	27.510	0.500	15.947	13.755	2.192	86.25%
4.264	4.504	27.500	0.600	19.205	16.500	2.705	85.91%
4.264	4.889	27.370	0.652	20.847	17.845	3.001	85.60%
4.264	4.879	24.910	0.713	20.804	17.766	3.038	85.40%
3.719	0.097	27.520	0.000	0.3607	0.000	0.361	0.00%
3.719	0.168	27.510	0.010	0.625	0.275	0.350	44.03%
3.719	0.503	27.510	0.050	1.871	1.376	0.495	73.53%
3.719	0.875	27.510	0.100	3.254	2.751	0.503	84.54%

Copyright © 2025 Texas Instruments Incorporated

Table 2-2. Discharging Data (continued)

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
3.719	1.79	27.510	0.200	6.657	5.502	1.155	82.65%
3.719	2.611	27.510	0.300	9.710	8.253	1.457	84.99%
3.719	3.455	27.510	0.400	12.849	11.004	1.845	85.64%
3.719	4.328	27.510	0.500	16.096	13.755	2.341	85.46%
3.719	4.936	27.310	0.571	18.357	15.594	2.763	84.95%
3.719	4.921	24.910	0.623	18.301	15.519	2.782	84.80%
3.038	0.09	27.520	0.000	0.2734	0.000	0.273	0.00%
3.038	0.165	27.510	0.010	0.501	0.275	0.226	54.88%
3.038	0.595	27.510	0.050	1.808	1.376	0.432	76.09%
3.038	1.117	27.510	0.100	3.393	2.751	0.642	81.07%
3.038	2.173	27.510	0.200	6.602	5.502	1.100	83.34%
3.038	3.204	27.510	0.300	9.734	8.253	1.481	84.79%
3.038	4.285	27.510	0.400	13.018	11.004	2.014	84.53%
3.038	4.848	27.510	0.450	14.728	12.380	2.349	84.05%
3.038	4.925	27.300	0.460	14.962	12.558	2.404	83.93%
3.038	4.915	24.880	0.503	14.932	12.515	2.417	83.81%

Copyright © 2025 Texas Instruments Incorporated

2.3 Thermal Images

The thermal image below shows the operating temperature of the top side of the board with 18Vdc input and 4.2Vout at 5A at room temperature and no air flow. The soak time was 20 minutes.

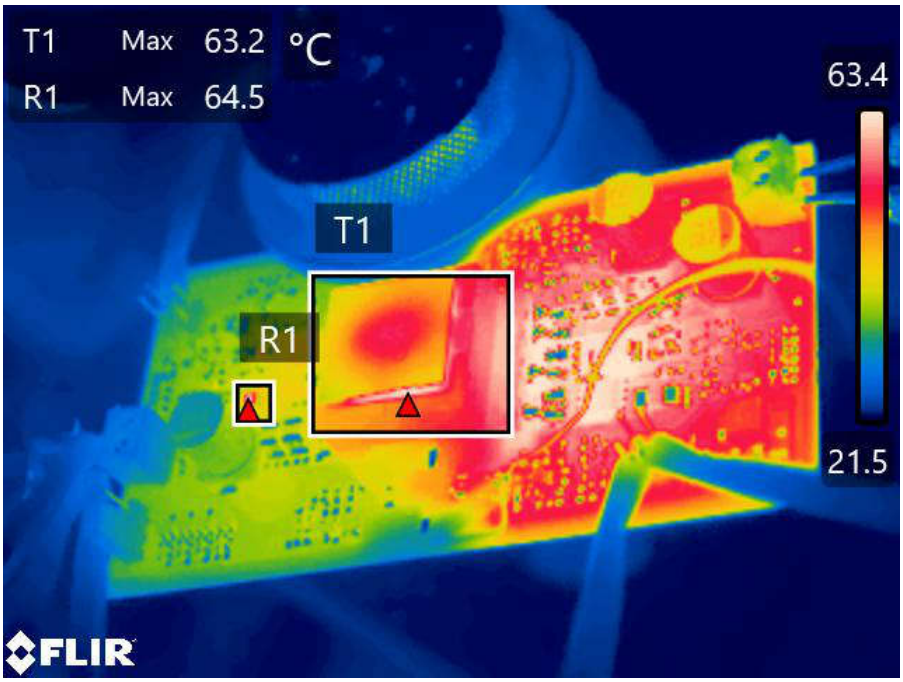


Figure 2-5. Top Side of the Board

The thermal image below shows the operating temperature of the bottom side of the board with 18Vdc input and 4.2Vout at 5A at room temperature and no air flow. The soak time was 20 minutes.

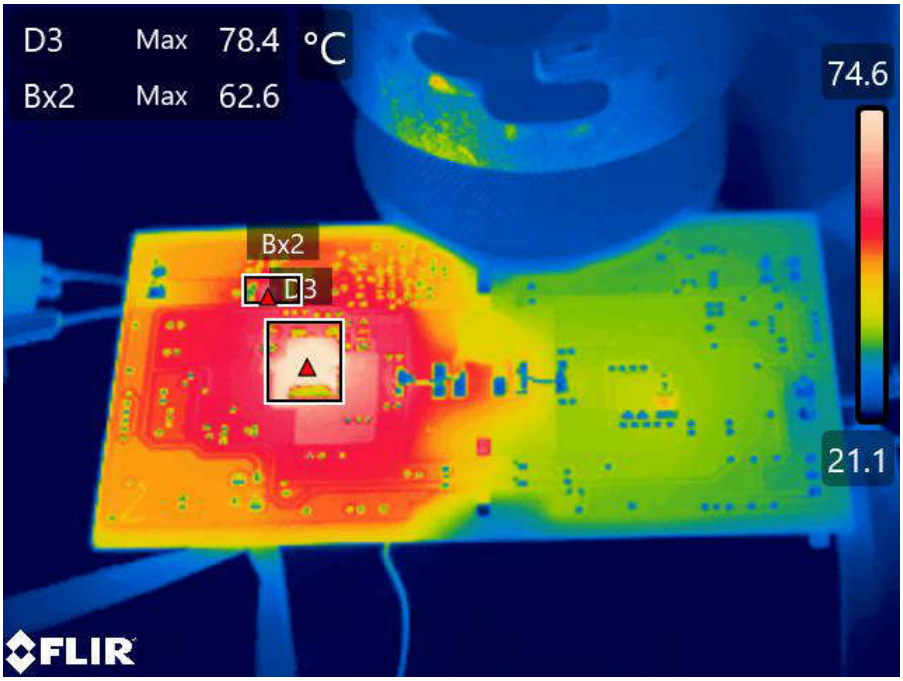


Figure 2-6. Bottom Side of the Board

The thermal image below shows the operating temperature of the top side of the board with 4.2Vdc input and 26.5Vout at 5A(input current limited) at room temperature and no air flow. The soak time was 20 minutes.

Copyright © 2025 Texas Instruments Incorporated

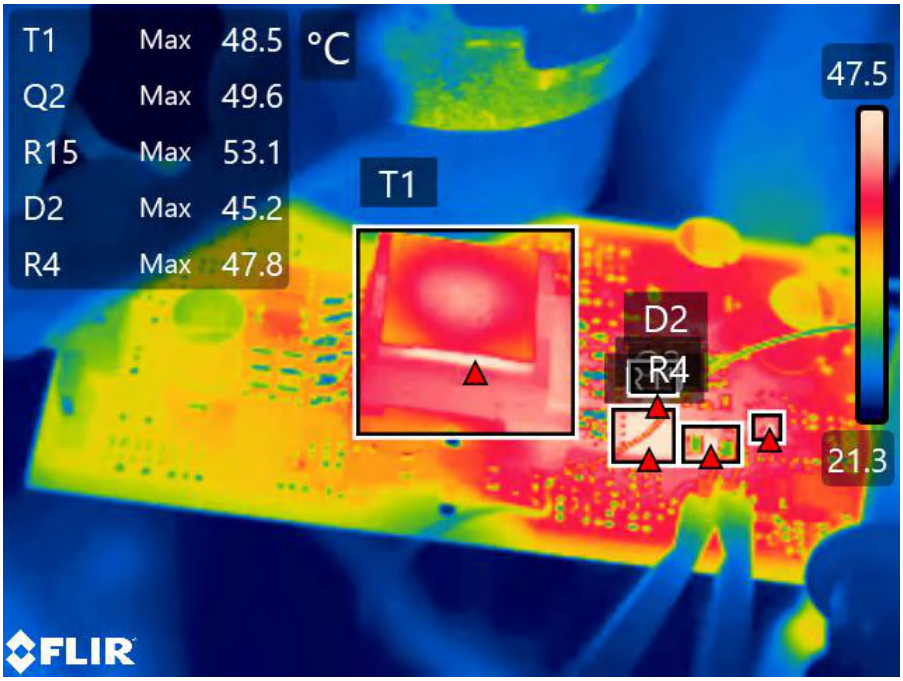


Figure 2-7. Top side of the board

The thermal image below shows the operating temperature of the bottom side of the board with 4.2Vdc input and 26.5Vout at 5A(input current limited) at room temperature and no air flow. The soak time was 20 minutes.

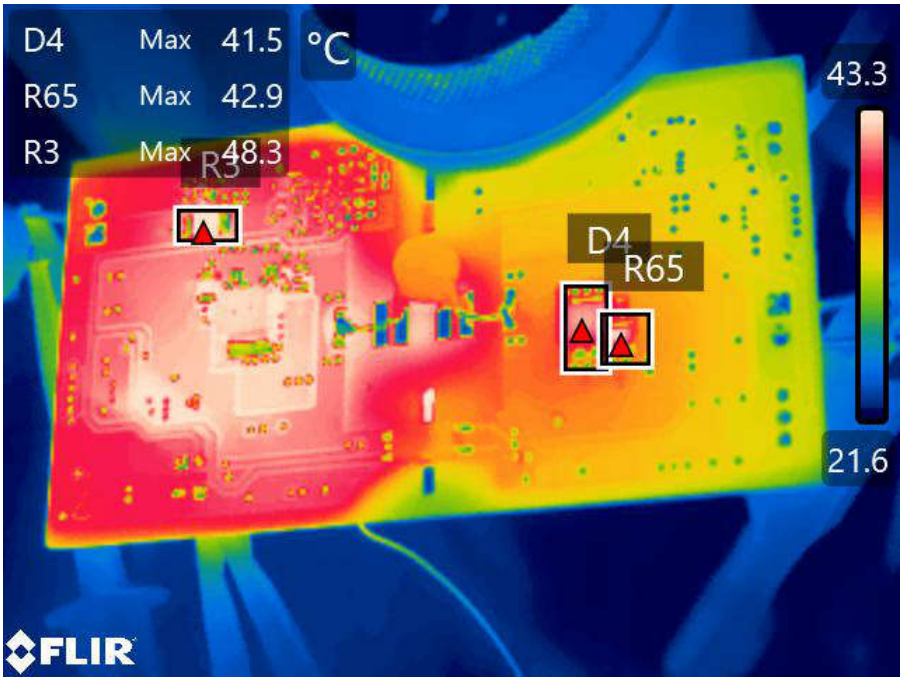


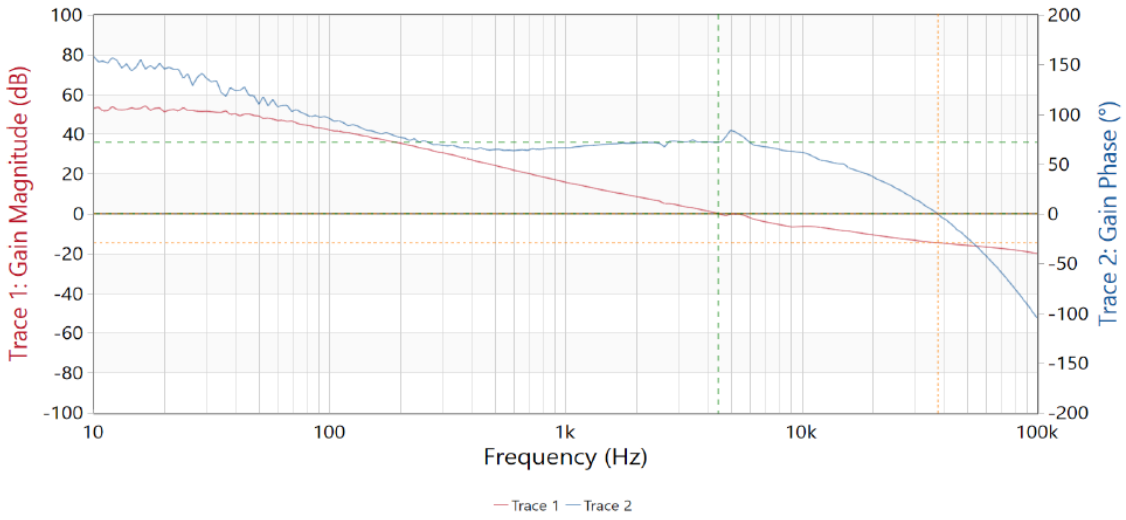
Figure 2-8. Bottom Side of the Board

Copyright © 2025 Texas Instruments Incorporated

2.4 Bode Plots

Charging Mode

This loop was measured with the charging in CV mode. The input was 24vin with 4.2Vout and Iout = 5A.

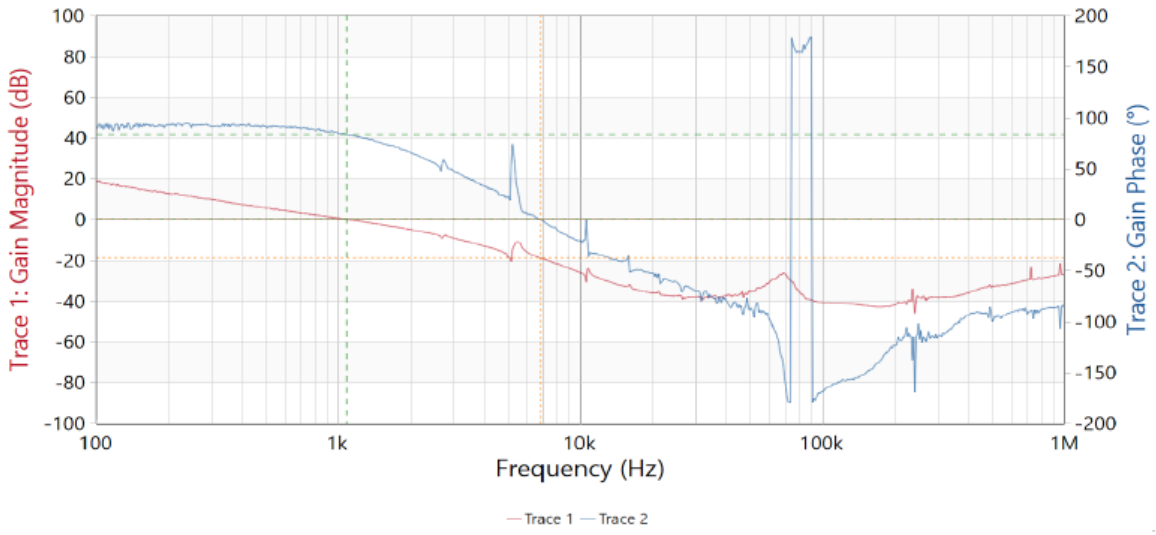


	Cursor 1	Cursor 2	Delta C2-C1
Frequency	4.432 kHz	37.654 kHz	33.222 kHz
Trace 1	**Magnitude (dB)**	**Magnitude (dB)**	**Magnitude (dB)**
Measurement	0 dB	-14.645 dB	-14.645 dB
Trace 2	**Phase (°)**	**Phase (°)**	**Phase (°)**
Measurement	71.731 °	0 °	-71.731 °

Figure 2-9. CV Loop

This loop was taken at 18vin; 3.9Vout; 4.5A out, in CC mode.

Copyright © 2025 Texas Instruments Incorporated



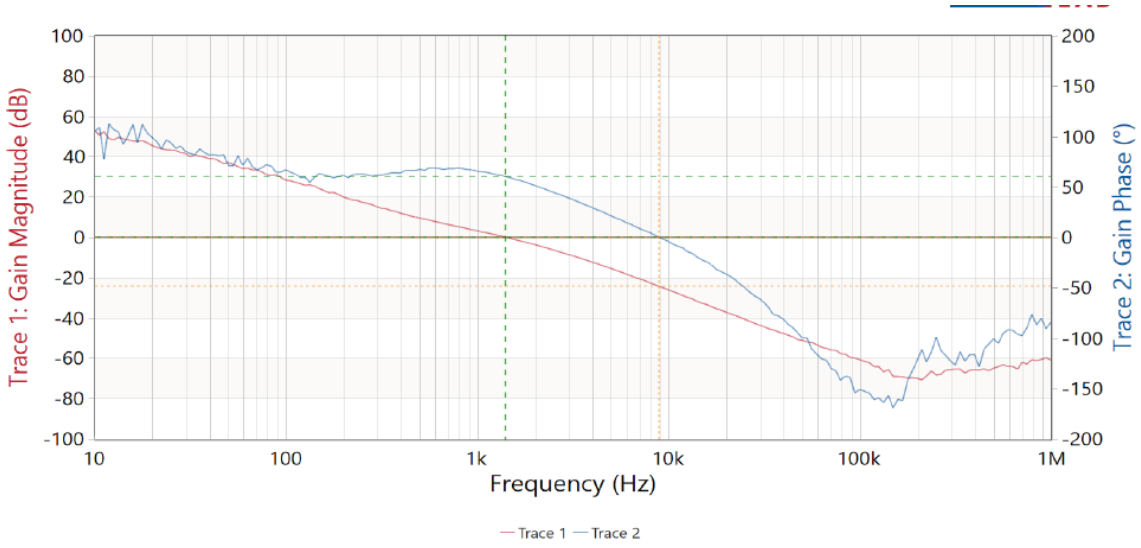
	Cursor 1	Cursor 2	Delta C2-C1
Frequency	1.087 kHz	6.865 kHz	5.777 kHz
Trace 1	**Magnitude (dB)**	**Magnitude (dB)**	**Magnitude (dB)**
Measurement	0 dB	-18.834 dB	-18.834 dB
Trace 2	**Phase (°)**	**Phase (°)**	**Phase (°)**
Measurement	83.487 °	0 °	-83.487 °

Figure 2-10. CC Loop

Copyright © 2025 Texas Instruments Incorporated

Discharging Mode

This loop was measured with the charging in CV mode. The input was 4.2vin with 27.5Vout and Iout=5A.

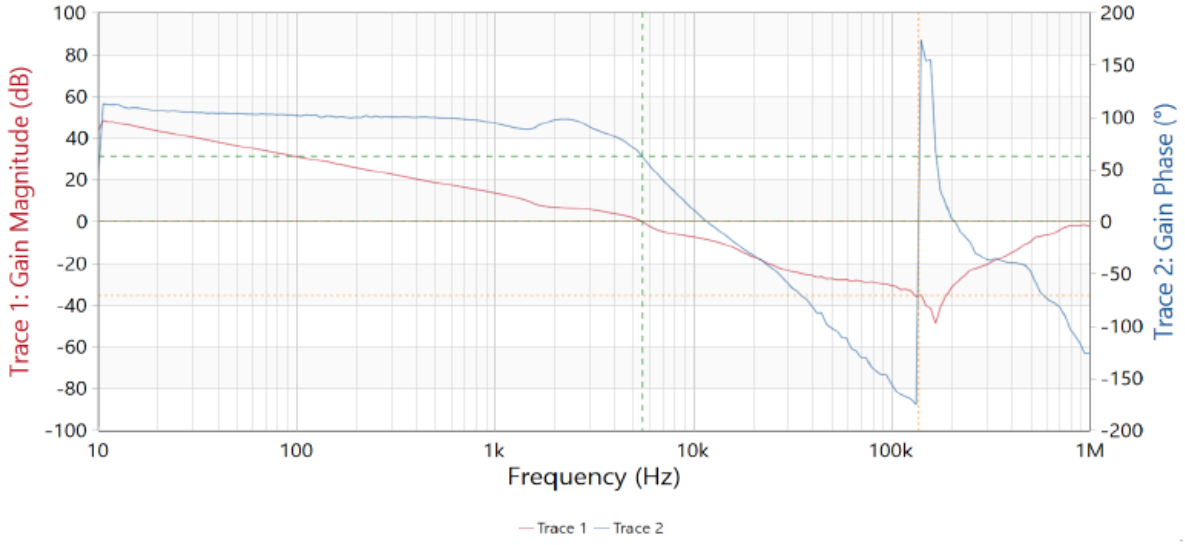


	Cursor 1	Cursor 2	Delta C2-C1
Frequency	1.408 kHz	8.88 kHz	7.472 kHz
Trace 1	**Magnitude (dB)**	**Magnitude (dB)**	**Magnitude (dB)**
Measurement	0 dB	-24.214 dB	-24.214 dB
Trace 2	**Phase (°)**	**Phase (°)**	**Phase (°)**
Measurement	60.208 °	0 °	-60.208 °

Figure 2-11. CV Loop

Copyright © 2025 Texas Instruments Incorporated

This loop was taken at 4.2vin; 26.5Vout; 5A out, in CC mode on the input side.



	Cursor 1	Cursor 2	Delta C2-C1
Frequency	5.508 kHz	137.262 kHz	131.754 kHz
Trace 1	**Magnitude (dB)**	**Magnitude (dB)**	**Magnitude (dB)**
Measurement	0 dB	-35.552 dB	-35.552 dB
Trace 2	**Phase (°)**	**Phase (°)**	**Phase (°)**
Measurement	62.654 °	0 °	-62.654 °

Figure 2-12. CC Loop

Copyright © 2025 Texas Instruments Incorporated

3 Waveforms

3.1 Switch Node Waveforms

The photo below shows the switch node waveform for both primary and secondary switch node in charging mode. The input voltage was 36Vin with the output at 4.2V and Iout at 5A; this was taken in CV mode.

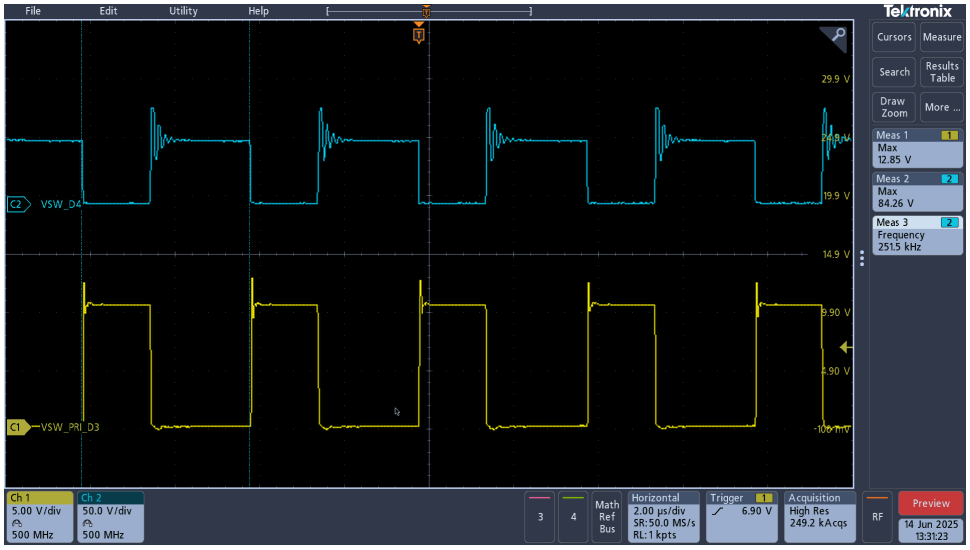


Figure 3-1. Charge Mode

The photo below shows the switch node waveform for both primary and secondary switch node in discharging mode. The input voltage was 4.2Vin with the output at 26.5V. the load was limited by the 5A input current limit; this was taken in CC mode.

Figure 3-2. Discharge Mode

Trademarks

All trademarks are the property of their respective owners.

Copyright © 2025 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale, TI’s General Quality Guidelines, or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2025, Texas Instruments Incorporated

Last updated 10/2025