

100-W, 5-V Output Hard-Switched Full-Bridge Converter Reference Design for 100-kRad Applications



Description

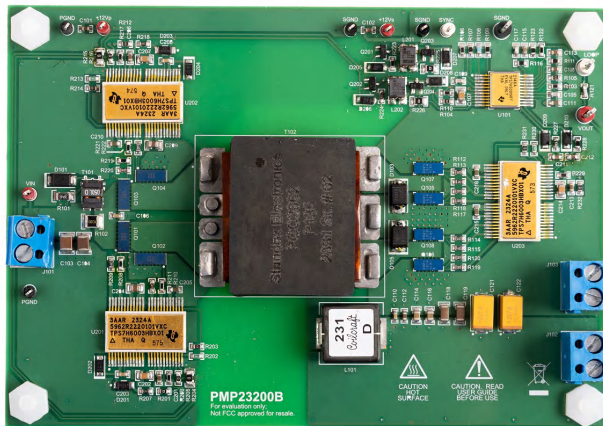
This reference design uses the TPS7H5001-SP PWM controller and three TPS7H6003-SP half-bridge drivers to construct a hard-switched full-bridge converter that takes an input ranging from 22 V to 36 V and generates an isolated 5-V output capable of 100-W loading. The controller, driver, and power field-effect transistors (FETs) are selected to meet Geosynchronous Earth Orbit (GEO) class radiation performance. Synchronous rectifiers on the secondary side increase efficiency and improve thermal performance compared to conventional diode rectifiers.

Features

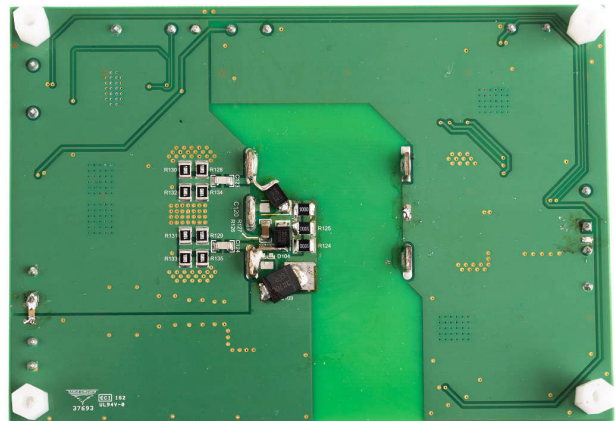
- GEO class radiation performance
- GaN FETs on primary and secondary side to increase efficiency
- Secondary-side controller for faster control loop
- < 1% voltage ripple on output
- Two-layer, 3.5 in × 5 in PCB

Applications

- [Communications payload](#)



Top of Board



Bottom of Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage	22 V to 36 V
Output voltage	5 V
Maximum output current	20 A
Switching frequency	500 kHz, primary side, nominal

1.2 Considerations

- Unless noted, all tests were conducted with 20-A loading on the output
- Local airflow used
- External 12-V bias applied to primary and secondary sides

1.3 Dimensions

Board size: 3.5 in × 5 in, tallest component = 0.44 in (bridge transformer).

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

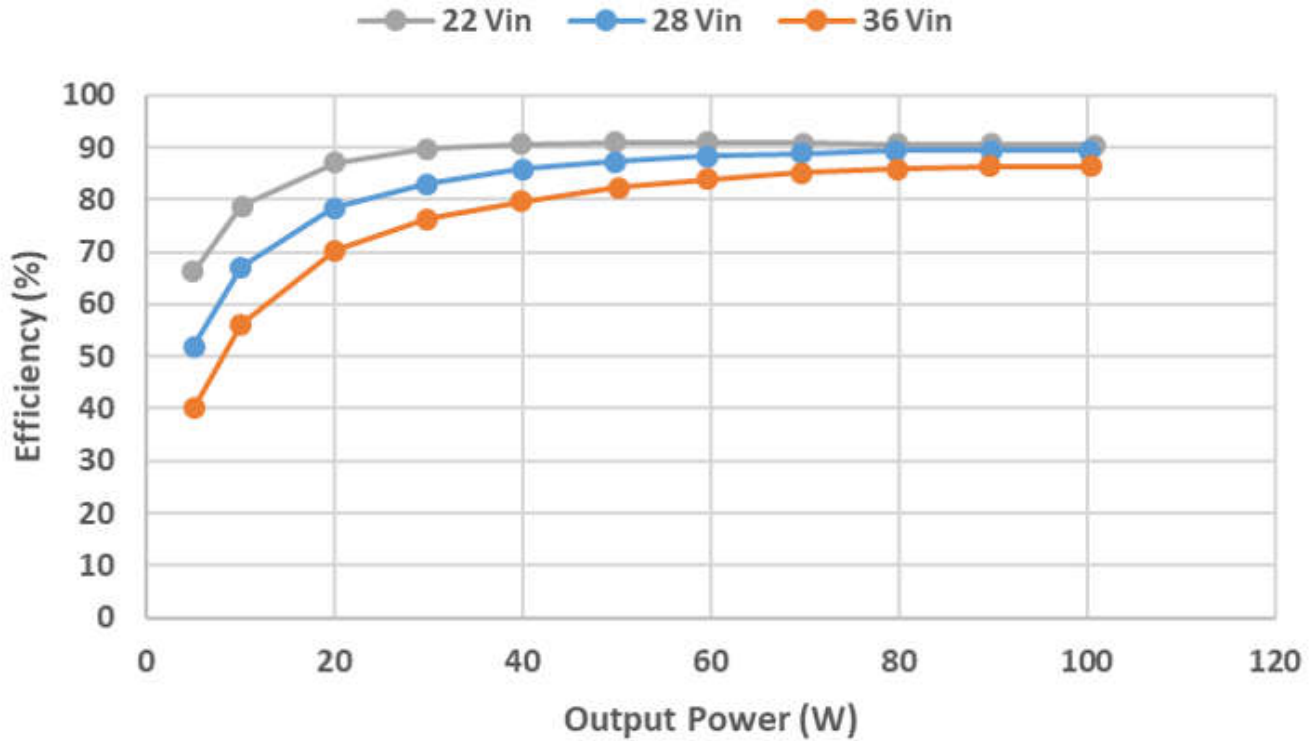


Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Table 2-1 shows the efficiency data with a 22-V input

Table 2-1. Efficiency Data, 22-V Input

Input			Output			Total	
Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Efficiency (%)	Loss (W)
22.048	0.110	2.428	4.985	0.001	0.005	0.205	2.423
22.049	0.344	7.585	4.985	1.009	5.029	66.308	2.555
22.049	0.589	12.985	4.984	2.053	10.231	78.796	2.753
22.050	1.046	23.058	4.982	4.029	20.072	87.050	2.986
22.050	1.511	33.307	4.980	6.001	29.885	89.727	3.422
22.050	1.992	43.917	4.978	8.000	39.826	90.684	4.091
22.051	2.483	54.748	4.976	10.008	49.803	90.967	4.945
22.051	2.978	65.674	4.975	12.010	59.744	90.969	5.931
22.052	3.488	76.911	4.973	14.051	69.869	90.844	7.042
22.052	3.998	88.153	4.971	16.085	79.952	90.697	8.201
22.053	4.504	99.327	4.969	18.100	89.933	90.543	9.393
22.053	5.057	111.522	4.967	20.295	100.797	90.383	10.725

Table 2-2 shows the efficiency data with a 28-V input.

Table 2-2. Efficiency Data, 28-V Input

Input			Output			Total	
Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Efficiency (%)	Loss (W)
27.951	0.161	4.500	4.985	0.001	0.005	0.111	4.495
27.951	0.350	9.780	4.985	1.018	5.074	51.884	4.706
27.951	0.538	15.024	4.984	2.023	10.082	67.108	4.942
27.951	0.912	25.483	4.982	4.013	19.992	78.454	5.491
27.952	1.288	36.005	4.980	6.007	29.915	83.087	6.090
27.951	1.667	46.580	4.978	8.028	39.966	85.800	6.615
27.952	2.039	57.000	4.976	10.004	49.784	87.341	7.216
27.952	2.421	67.666	4.975	12.011	59.750	88.301	7.916
27.953	2.801	78.285	4.973	14.000	69.619	88.930	8.666
27.953	3.193	89.254	4.971	16.035	79.708	89.305	9.546
27.953	3.598	100.569	4.969	18.103	89.954	89.445	10.615
27.954	4.018	112.308	4.967	20.197	100.316	89.323	11.992

Table 2-3 shows the efficiency data with a 36-V input.

Table 2-3. Efficiency Data, 36-V Input

Input			Output			Total	
Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Efficiency (%)	Loss (W)
35.998	0.205	7.387	4.986	0.001	0.005	0.067	7.382
35.999	0.352	12.668	4.985	1.017	5.070	40.018	7.599
35.999	0.498	17.910	4.984	2.017	10.053	56.130	7.857
35.998	0.793	28.539	4.982	4.026	20.057	70.279	8.482
35.998	1.089	39.191	4.980	6.008	29.920	76.345	9.271
35.999	1.392	50.121	4.978	8.019	39.920	79.647	10.201
35.999	1.696	61.036	4.976	10.092	50.221	82.280	10.815
36.000	1.975	71.111	4.975	12.003	59.709	83.966	11.402
36.000	2.272	81.806	4.973	14.001	69.623	85.107	12.184
36.000	2.585	93.053	4.971	16.076	79.911	85.877	13.142
36.000	2.886	103.907	4.969	18.048	89.677	86.305	14.230
36.000	3.229	116.251	4.967	20.239	100.521	86.469	15.730

2.3 Thermal Images

The following thermal images were captured after operating at full load for 20-minutes.

Measurements

Bx1	Max	63.6 °C
Bx2	Max	67.5 °C

Parameters

Emissivity	0.95
Refl. temp.	20 °C

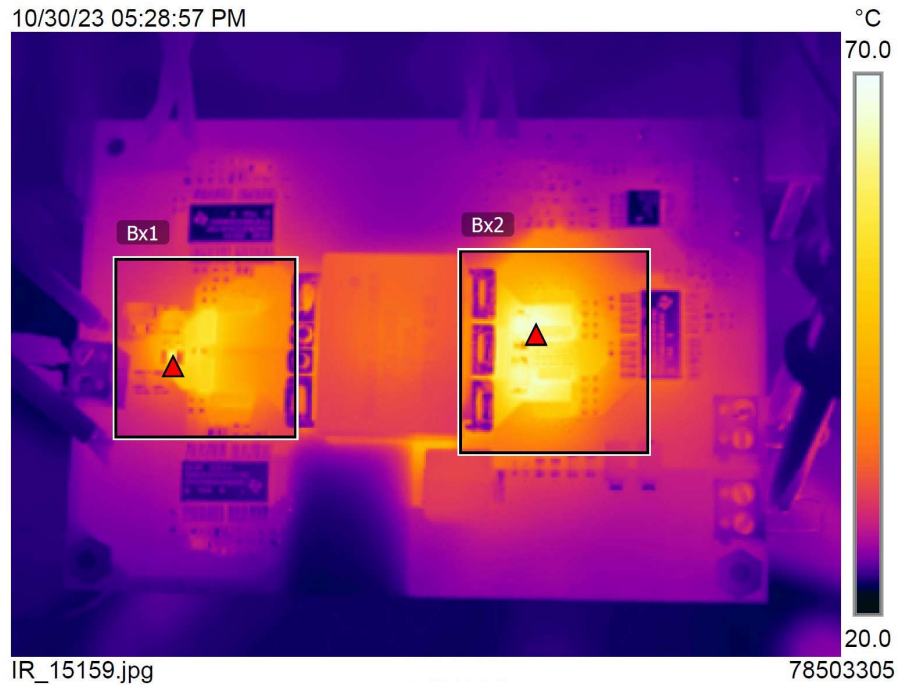


Figure 2-2. Thermal Images, 28-V Input, Top of Board

Measurements

Bx1	Max	62.4 °C
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Parameters

Emissivity	0.95
Refl. temp.	20 °C

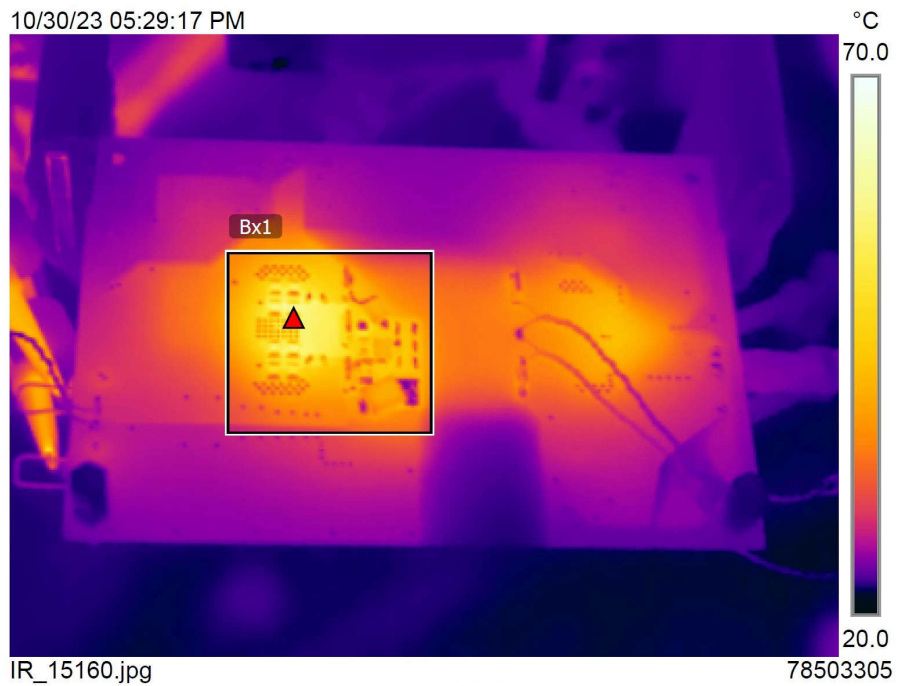


Figure 2-3. Thermal Images, 28-V Input, Bottom of Board

Measurements

Bx1	Max	74.5 °C
Bx2	Max	76.7 °C

Parameters

Emissivity	0.95
Refl. temp.	20 °C

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Figure 2-4. Thermal Images, 36-V Input, Top of Board

Measurements

Bx1	Max	72.5 °C
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Parameters

Emissivity	0.95
Refl. temp.	20 °C

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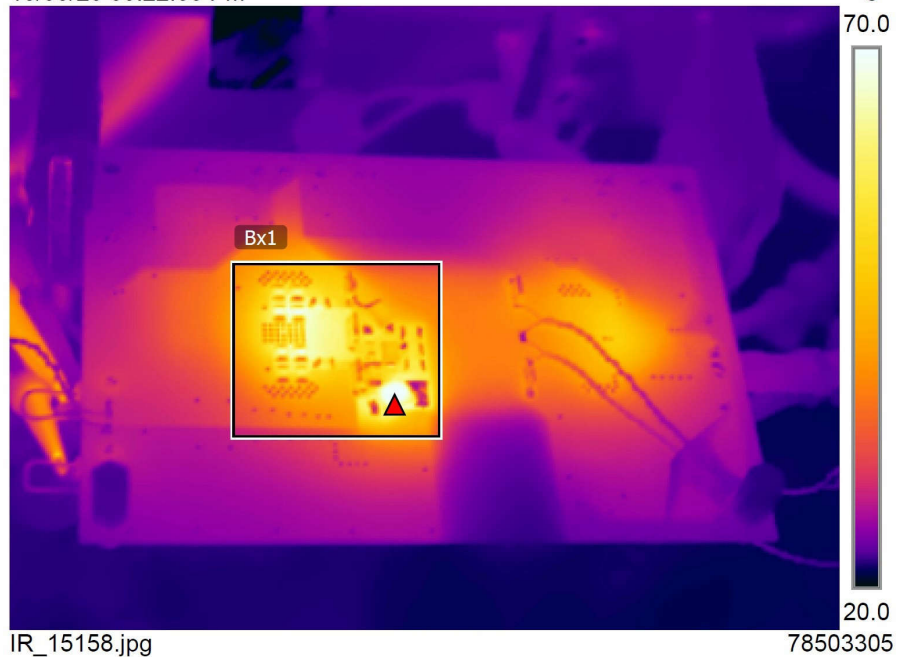


Figure 2-5. Thermal Images, 36-V Input, Bottom of Board

2.4 Bode Plots

Bode plot was measured with a 28-V input.

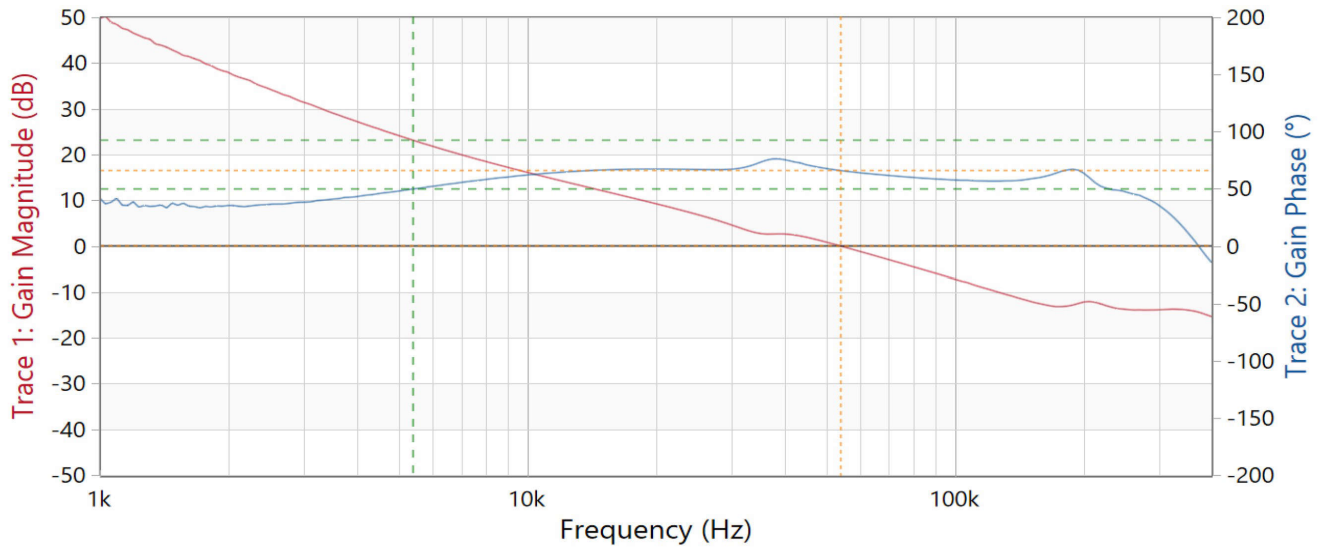


Figure 2-6. Bode Plot

3 Waveforms

3.1 Switching

Switching behavior with 36-V input is shown in the following figures.

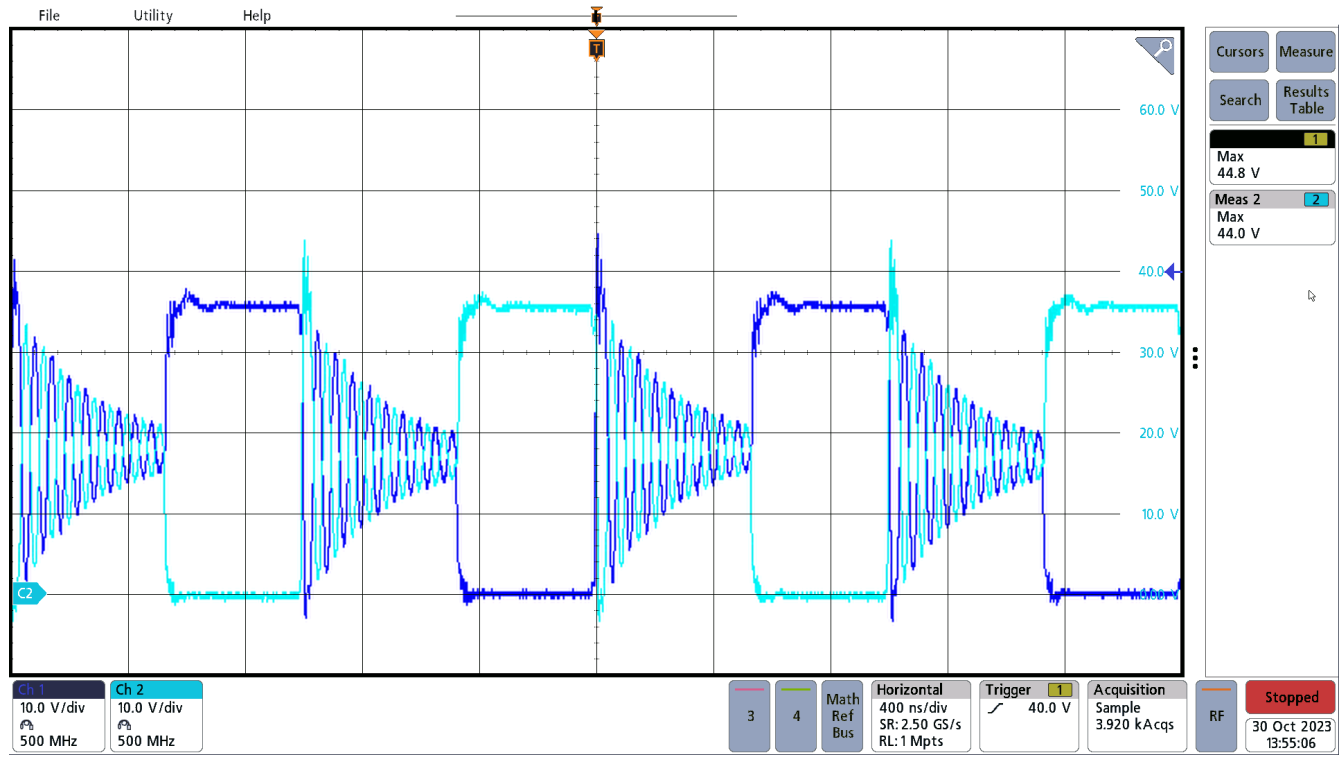


Figure 3-1. Drain-to-Source Voltage of Primary-Side FETs

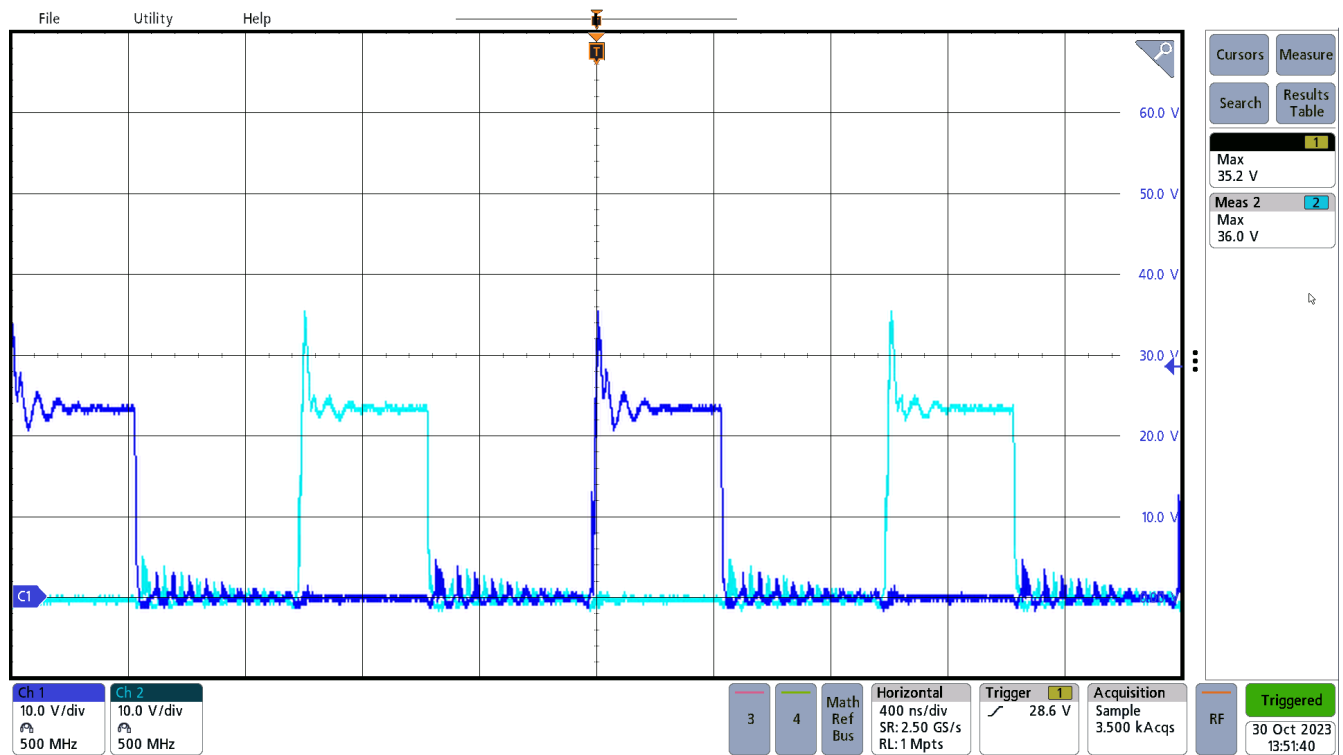


Figure 3-2. Drain-to-Source Voltage of Secondary-Side FETs

3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.

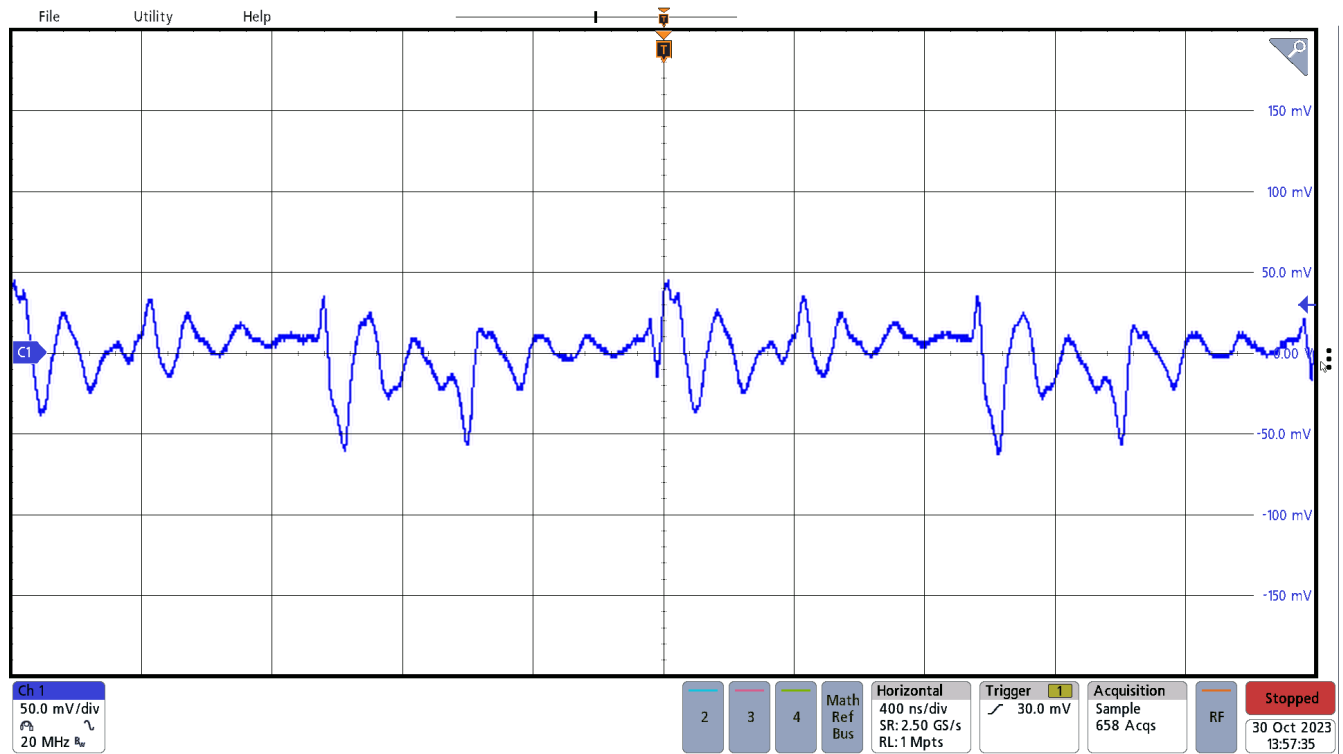


Figure 3-3. Output Voltage Ripple

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