Test Report: PMP23342

4.5-V to 15-V Input, Dual 6-A Output Buck Module Reference Design

Description

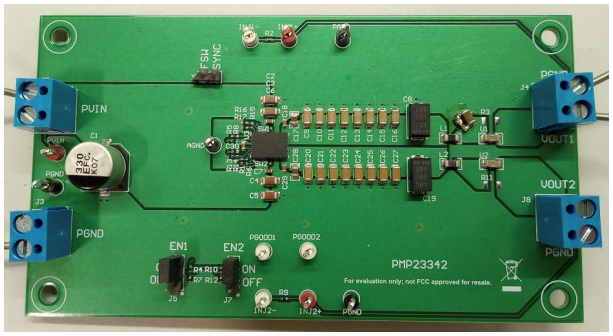
This reference design is a power module that converts 4.5 V to 15 V to dual 6-A outputs at 1.8 V and 1.2 V. The design uses a highly-integrated TPSM5D1806 buck power module with a second stage pi filter to minimize output voltage ripple to less than 5 mV. Three configurations for the 1.8-V output rail are evaluated in this test report. Configuration A is fully populated and produces the lowest output ripple. Configuration B has the minimum filtering components to achieve less than 5-mV output ripple. Configuration C has further had the second stage pi filter removed to demonstrate the impact on the output ripple.

Features

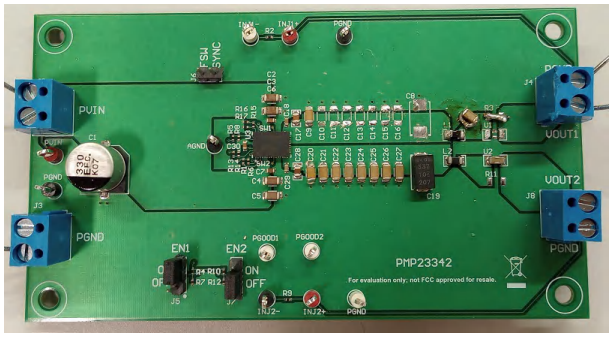
- Independent dual 6-A outputs
- Less than 5-mV output voltage ripple
- 1-MHz switching frequency
- Frequency synchronization with phase delay
- Independent enable and power good for each output

Applications

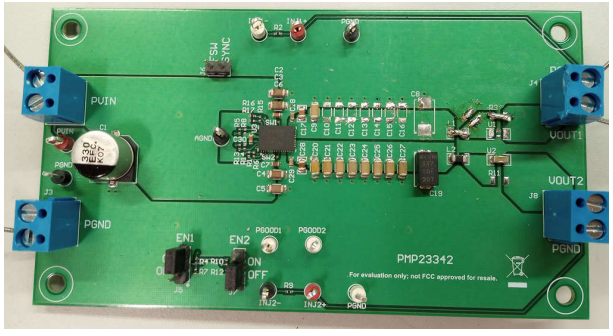
- Mobile robot CPU and compute module
- Seeker front end
- Endoscope
- Global positioning system receiver
- Battery cell formation and test equipment
- Data acquisition (DAQ)
- Digital multimeter (DMM)
- Oscilloscopes and digitizers



Board A Top



Board B Top



Board C Top

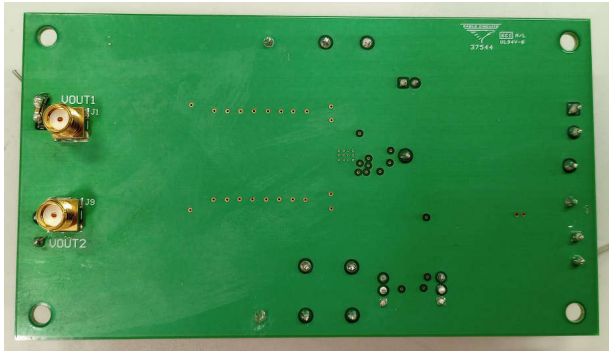


Figure 1-1. Board A, B, C Bottom

1 Test Prerequisites

1.1 Voltage and Current Requirements

Parameter	Specifications
Input Voltage	12 V
Output Voltage 1	1.8 V
Output Current 1	6 A
Output Voltage 2	1.2 V
Output Current 2	6 A
Switching Frequency	1 MHz

1.2 Considerations

Except for efficiency and load transient measurements, resistive load was used. Unless otherwise indicated the input voltage was set to 12 V.

Table 1-1. Board Setup Summary

Board Variant	C_{OUT} (Before FB)	Ferrite Bead	Feedthrough Capacitor	C_{OUT} (After FB)
A	8 × 100 µF	Yes	27 µF	2 × 100 µF
B	1 × 100 µF	Yes	No	2 × 100 µF
C	1 × 100 µF	Yes	No	1 × 100 µF

Table 1-2. Filtering Component Part Numbers

Component	Designator	Part Number	Manufacturer
Ferrite Bead	L1, L2	BLM31SN500SN1L	Murata
Feedthrough Capacitor	U1, U2	NFM31PC276B0J3L	Murata
Tantalum Capacitor	C8, C19	T520Y337M010ATE035	Kemet

2 Testing and Results

2.1 Efficiency Graphs

Efficiency measurements were taken with 12-V input and 1.8-V, single-channel output. The second output channel was disabled.

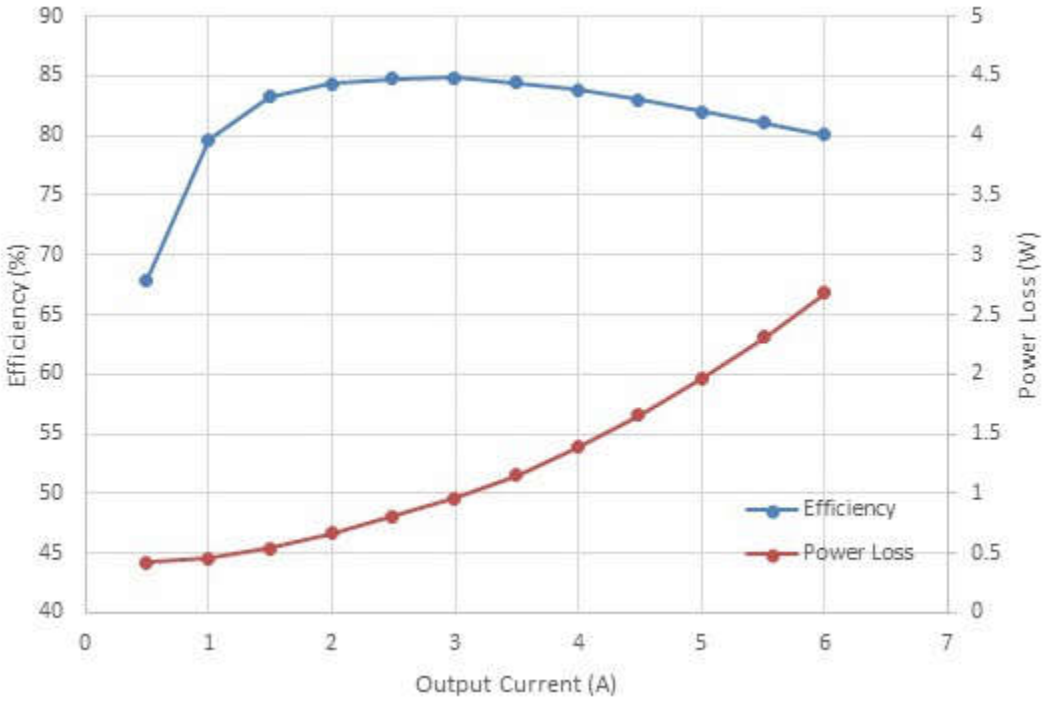


Figure 2-1. Board A Efficiency and Power Loss Across Load

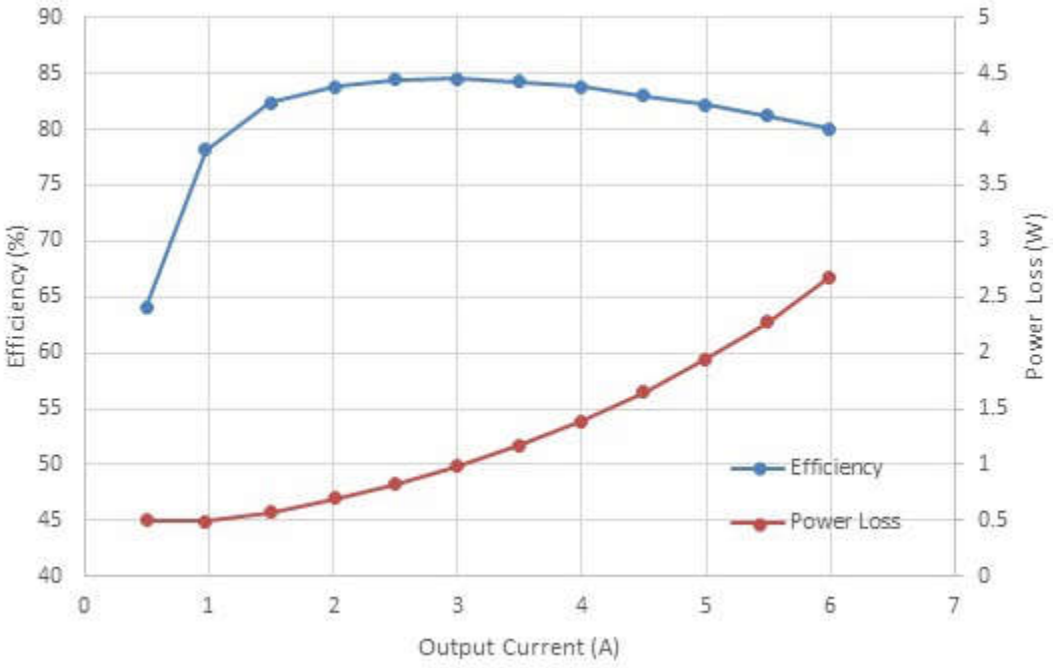


Figure 2-2. Board B Efficiency and Power Loss Across Load

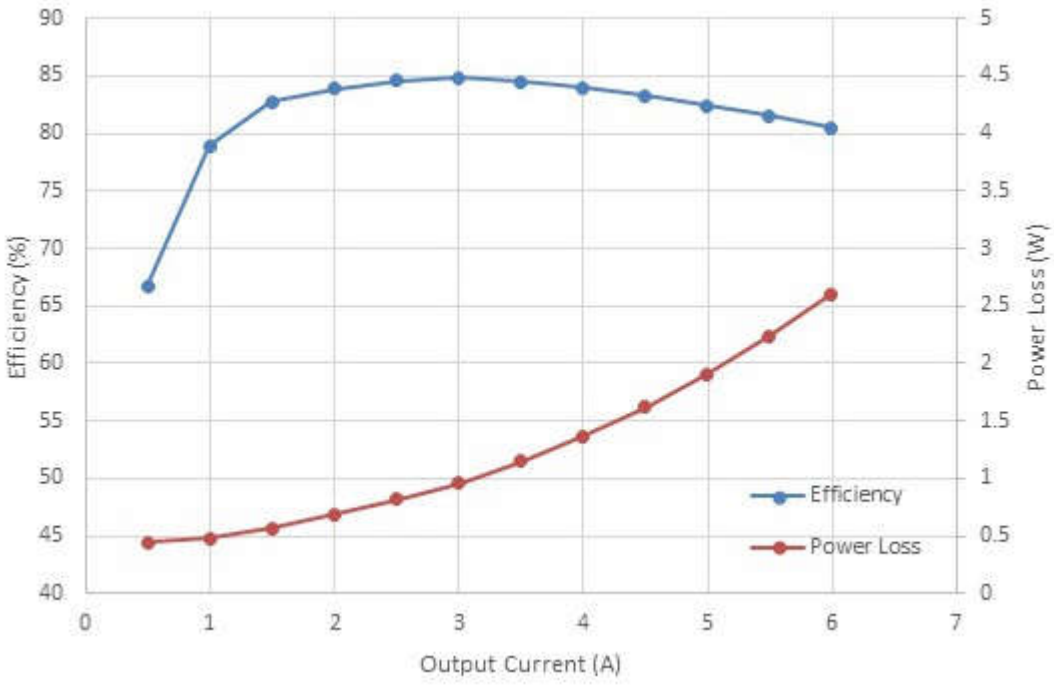


Figure 2-3. Board C Efficiency and Power Loss Across Load

2.2 Efficiency Data

Efficiency data is shown in the following tables.

Table 2-1. Board A Efficiency Data

Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Power Loss (W)	Efficiency (%)
11.980	0.110	1.803	0.496	0.424	67.86
11.970	0.188	1.802	0.995	0.457	79.68
11.970	0.270	1.801	1.495	0.539	83.31
11.960	0.356	1.801	1.995	0.665	84.39
11.960	0.443	1.800	2.495	0.807	84.76
11.960	0.531	1.799	2.995	0.963	84.84
11.960	0.622	1.798	3.495	1.155	84.47
11.960	0.716	1.797	3.995	1.384	83.83
11.960	0.813	1.797	4.490	1.655	82.98
11.960	0.917	1.796	5.010	1.969	82.04
11.960	1.020	1.795	5.510	2.309	81.07
11.950	1.125	1.794	6.000	2.680	80.07

Table 2-2. Board B Efficiency Data

Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Power Loss (W)	Efficiency (%)
12.030	0.116	1.801	0.497	0.500	64.14
12.029	0.187	1.800	0.977	0.491	78.18
12.029	0.272	1.800	1.497	0.577	82.36
12.028	0.360	1.799	2.017	0.701	83.80
12.028	0.442	1.798	2.497	0.827	84.45
12.027	0.530	1.798	2.996	0.988	84.51
12.027	0.620	1.797	3.495	1.176	84.23
12.026	0.712	1.796	3.995	1.387	83.80
12.026	0.808	1.795	4.495	1.648	83.04
12.025	0.907	1.795	4.995	1.941	82.21
12.025	1.009	1.794	5.494	2.277	81.23
12.025	1.117	1.794	5.994	2.679	80.06

Table 2-3. Board C Efficiency Data

Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Power Loss (W)	Efficiency (%)
11.944	0.113	1.801	0.500	0.449	66.72
11.944	0.191	1.800	1.000	0.481	78.90
11.944	0.273	1.800	1.499	0.563	82.75
11.943	0.359	1.799	1.999	0.691	83.88
11.942	0.445	1.798	2.500	0.819	84.58
11.942	0.532	1.798	2.999	0.961	84.87
11.942	0.623	1.797	3.498	1.154	84.49
11.942	0.716	1.796	3.997	1.372	83.96
11.942	0.812	1.796	4.497	1.620	83.29
11.942	0.911	1.795	4.997	1.910	82.45
11.941	1.013	1.794	5.496	2.236	81.51
11.942	1.119	1.794	5.996	2.606	80.50

2.3 Thermal Images

The thermal images were taken after 30 minutes of loading the 1.8-V output to 6 A with no airflow.

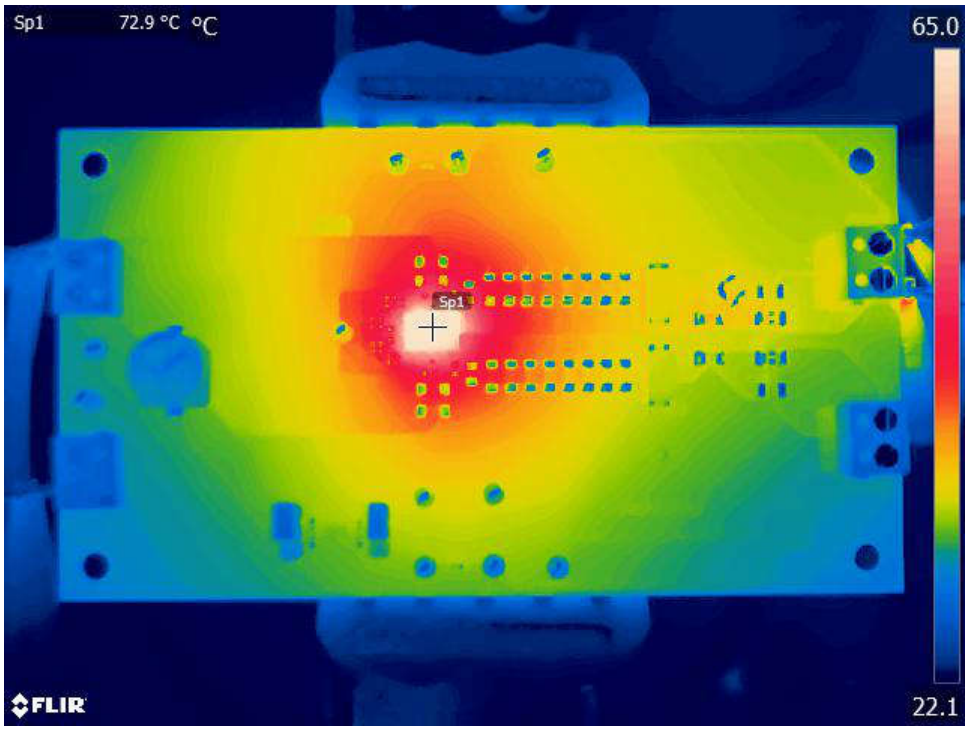


Figure 2-4. Board A Top

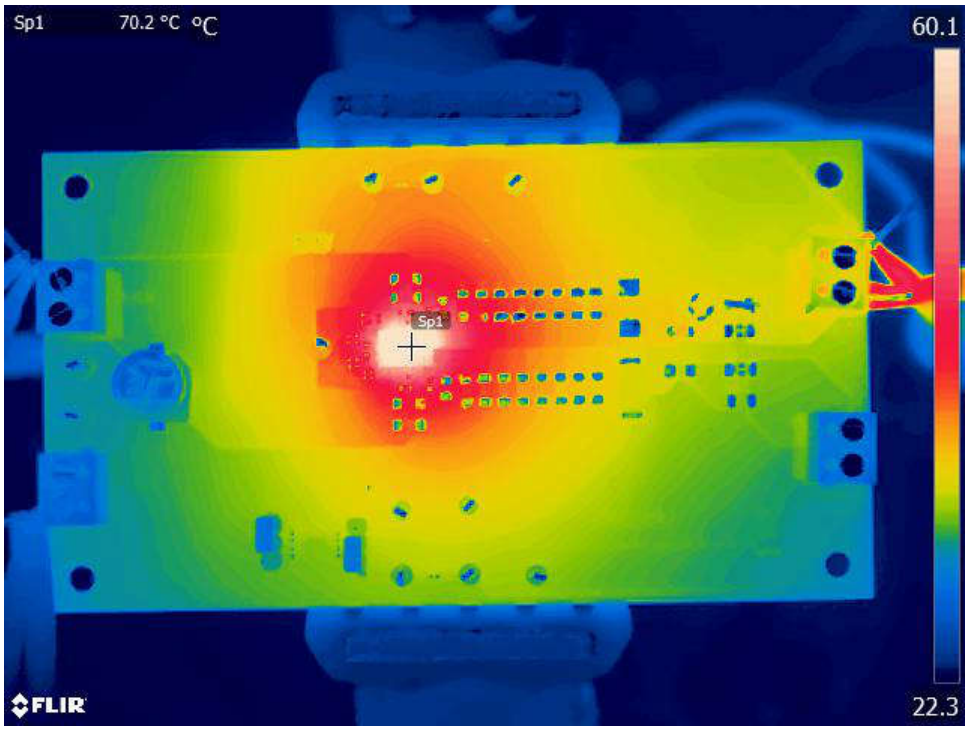


Figure 2-5. Board B Top

3 Waveforms

3.1 Start-Up

Start-up behavior is shown in the following figures.

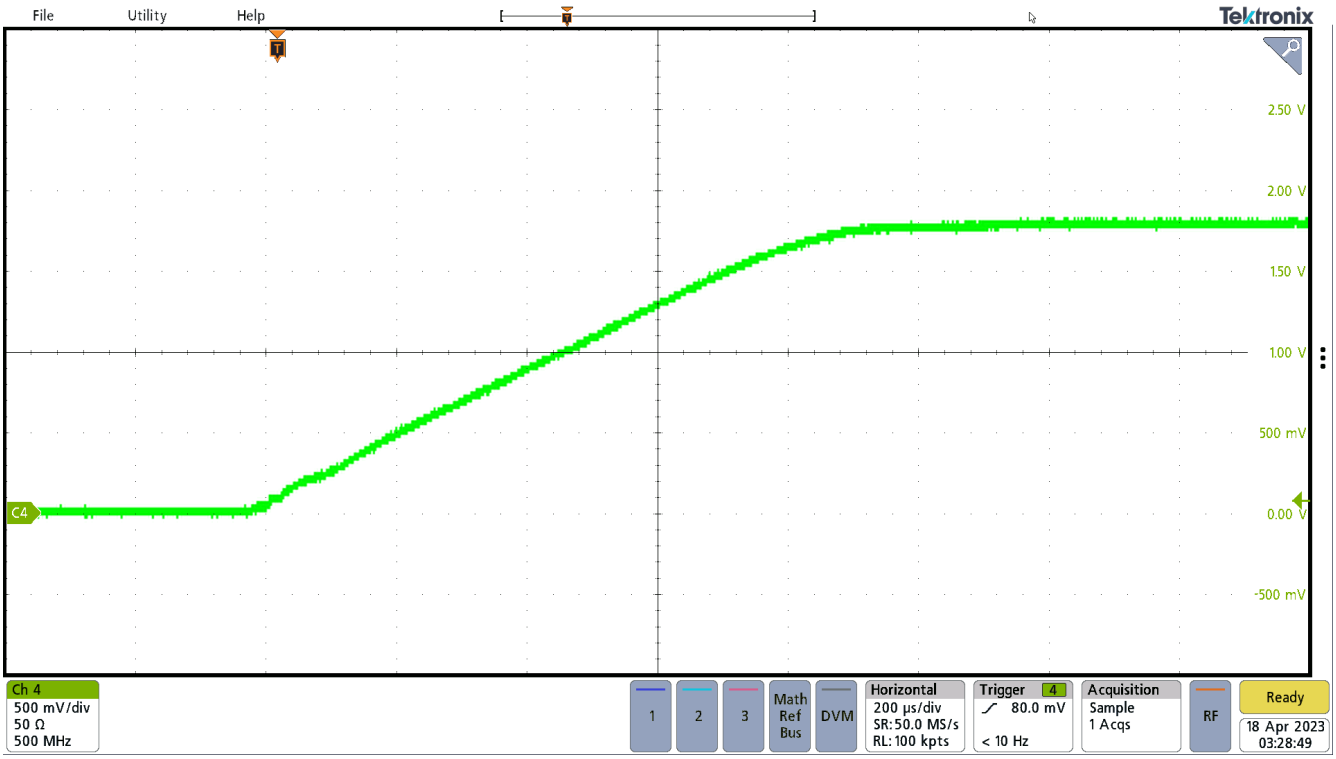


Figure 3-1. Board A Start-Up Sequence

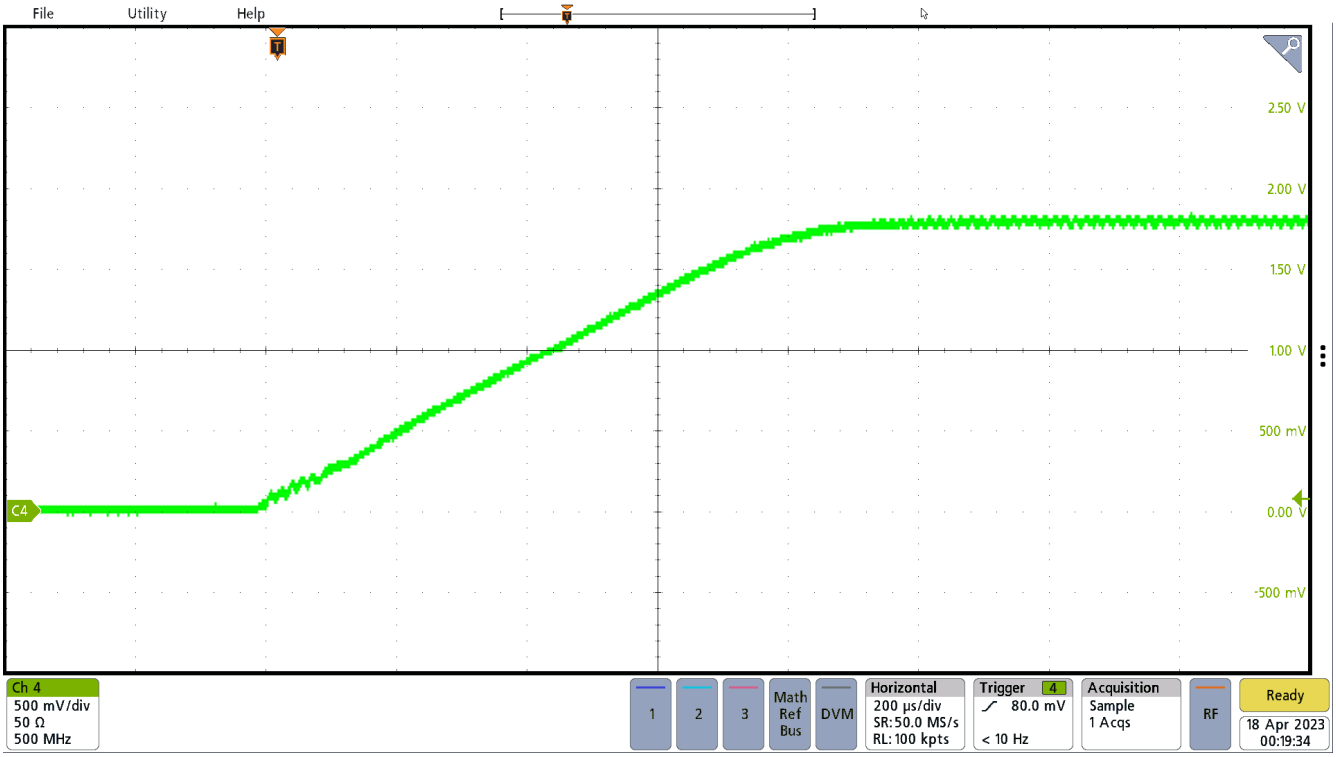


Figure 3-2. Board B Start-Up Sequence

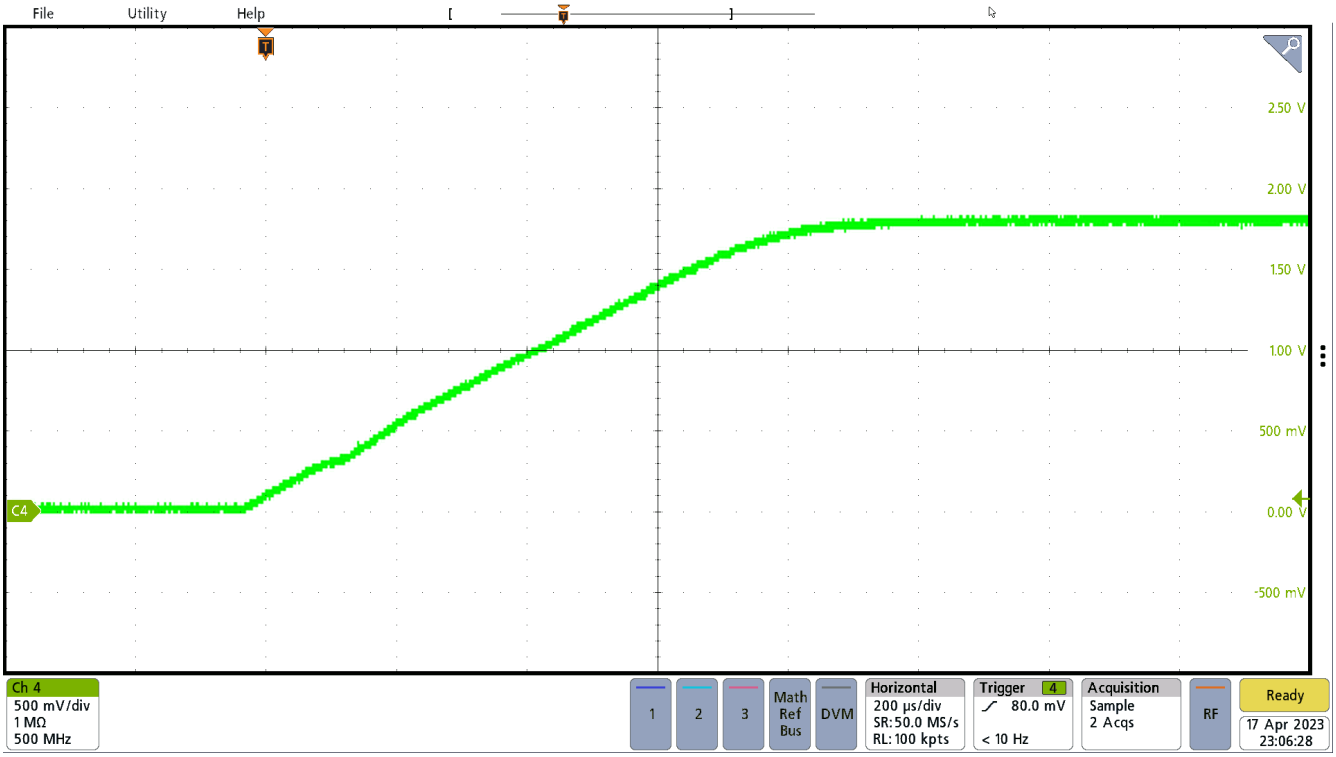


Figure 3-3. Board C Start-Up Sequence

3.2 Output Voltage Ripple

Output voltage ripple waveforms are shown in the following figures.

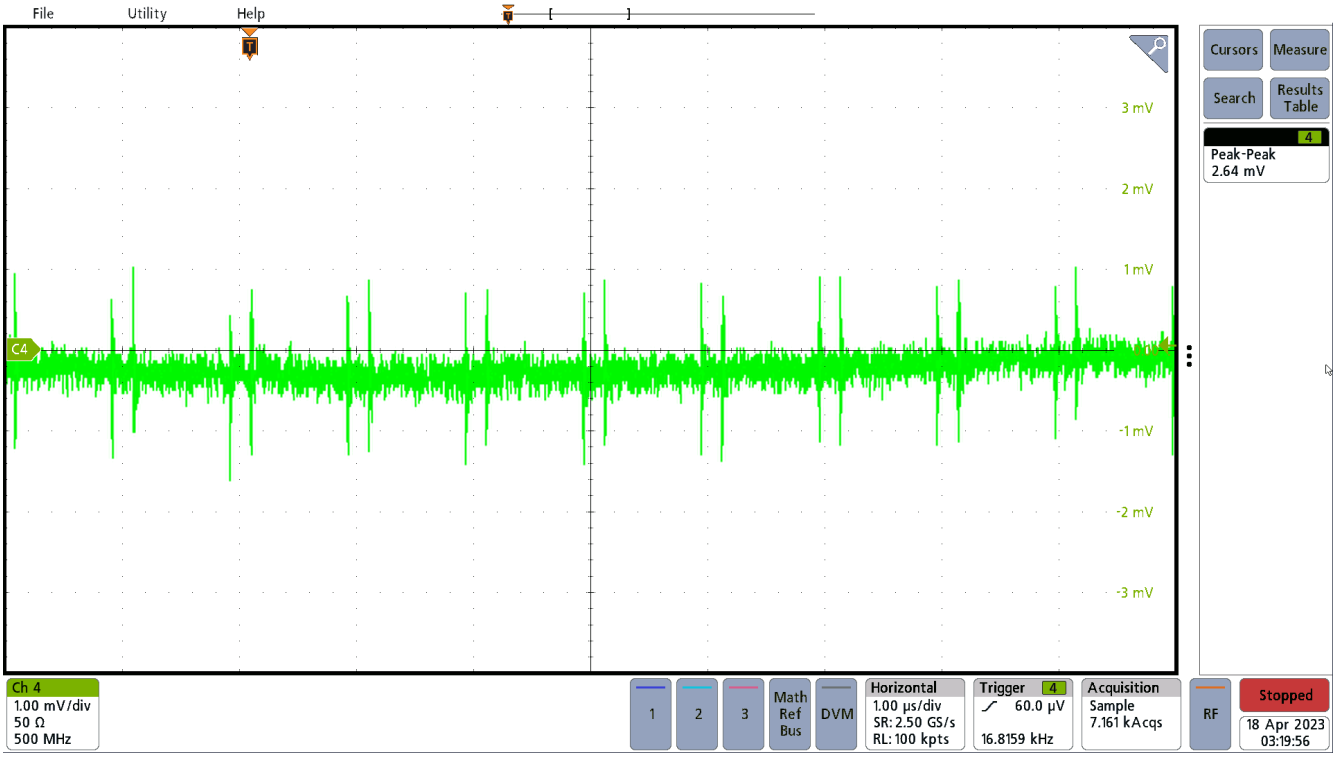


Figure 3-4. Board A Output Voltage Ripple

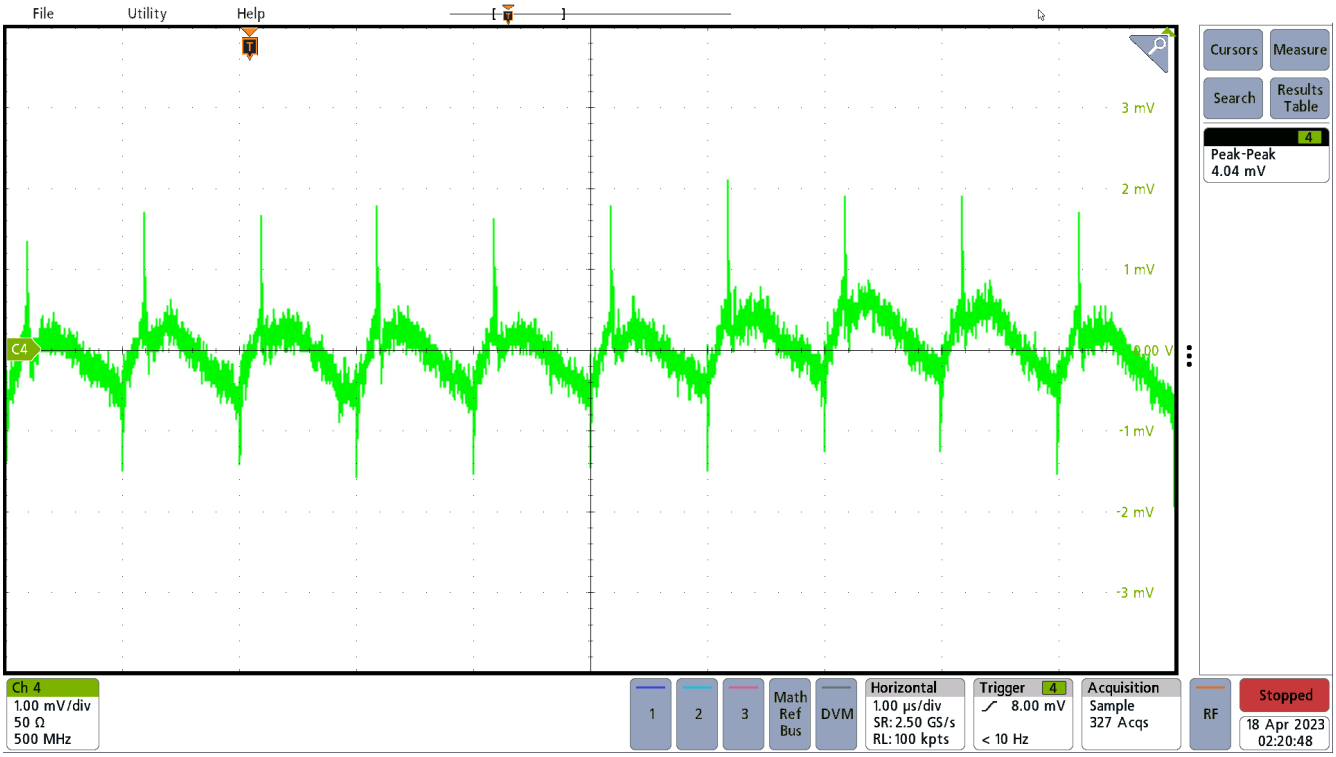


Figure 3-5. Board B Output Voltage Ripple

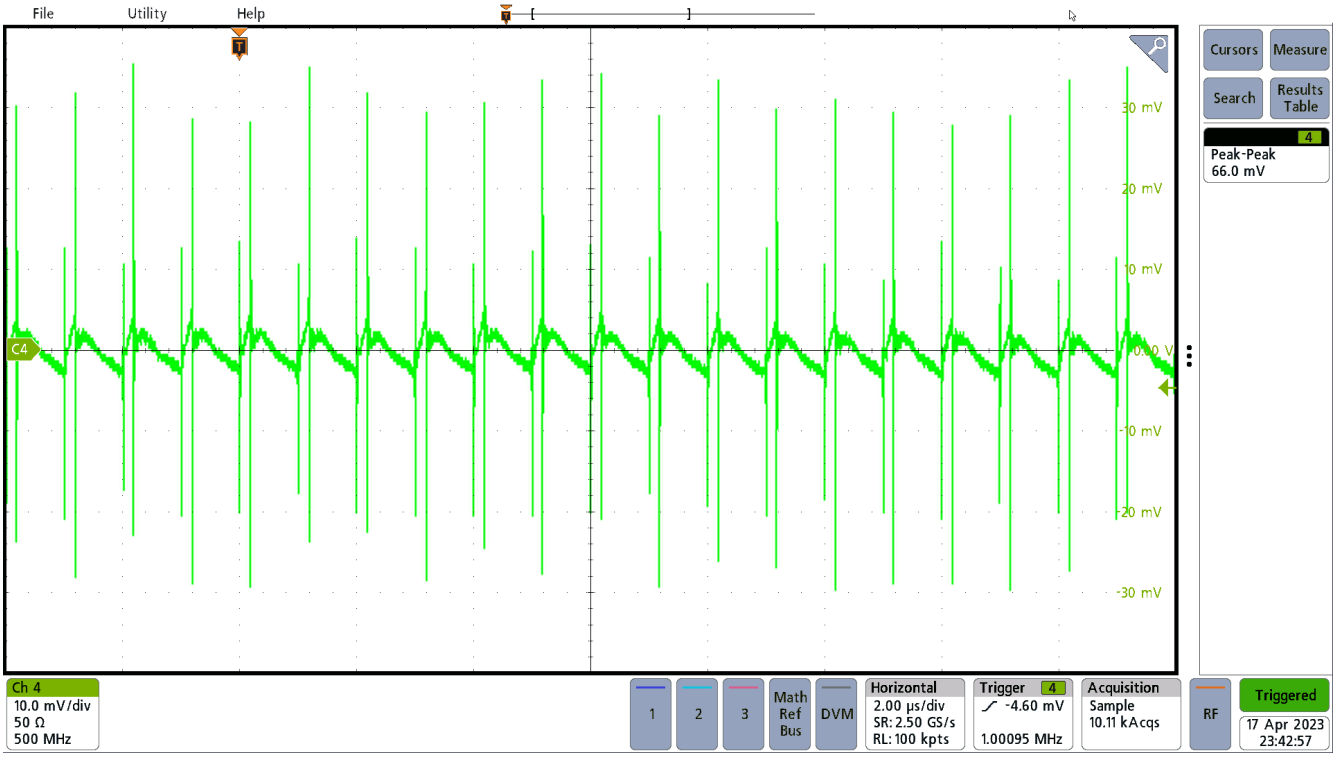


Figure 3-6. Board C Output Voltage Ripple

3.3 Load Transients

Load transient response is shown in the following figures.

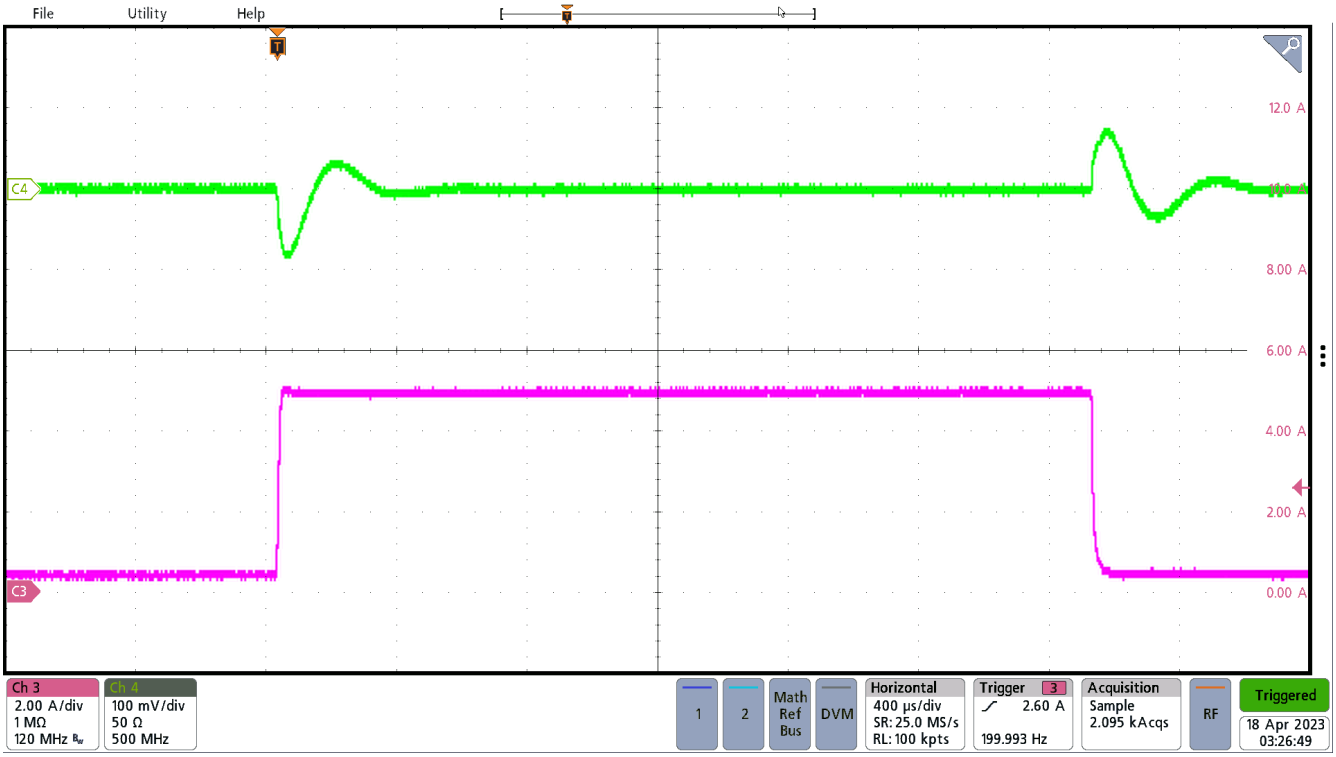


Figure 3-7. Board A Load Transient Response

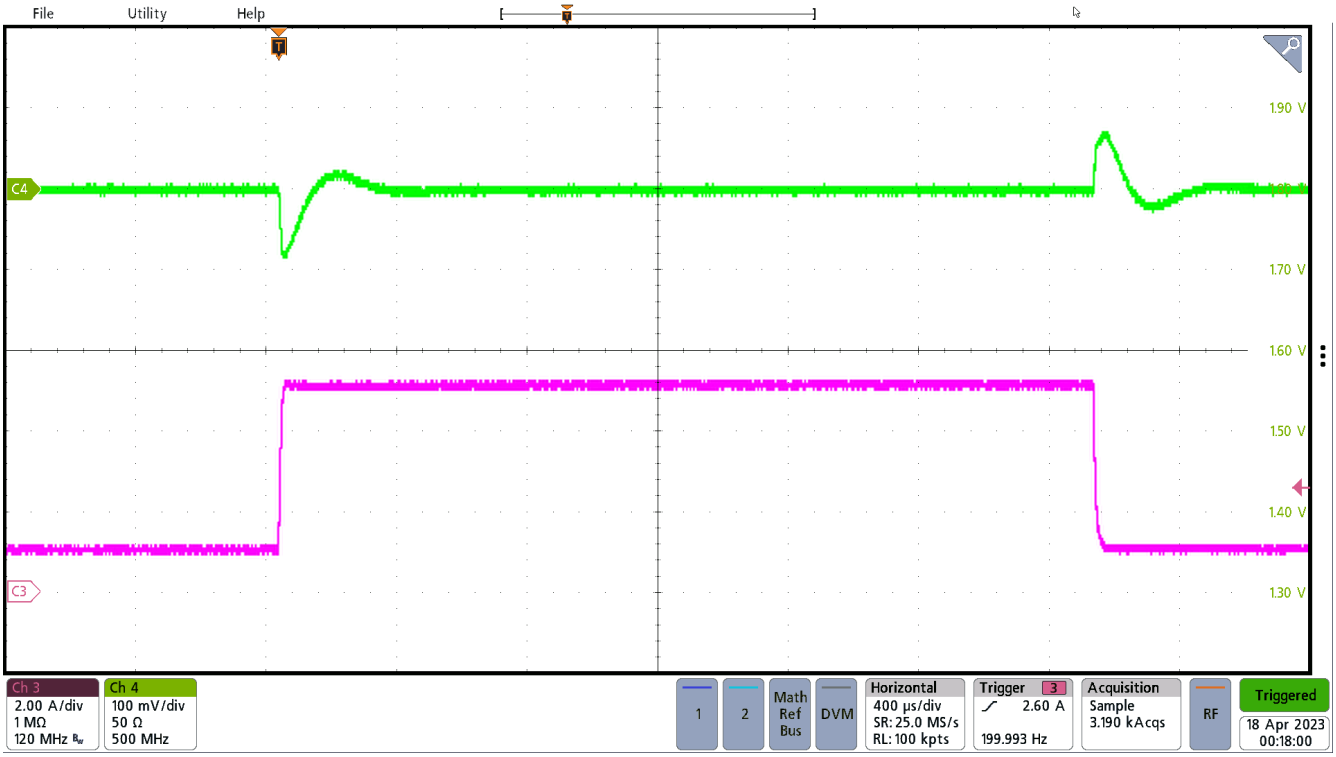


Figure 3-8. Board B Load Transient Response

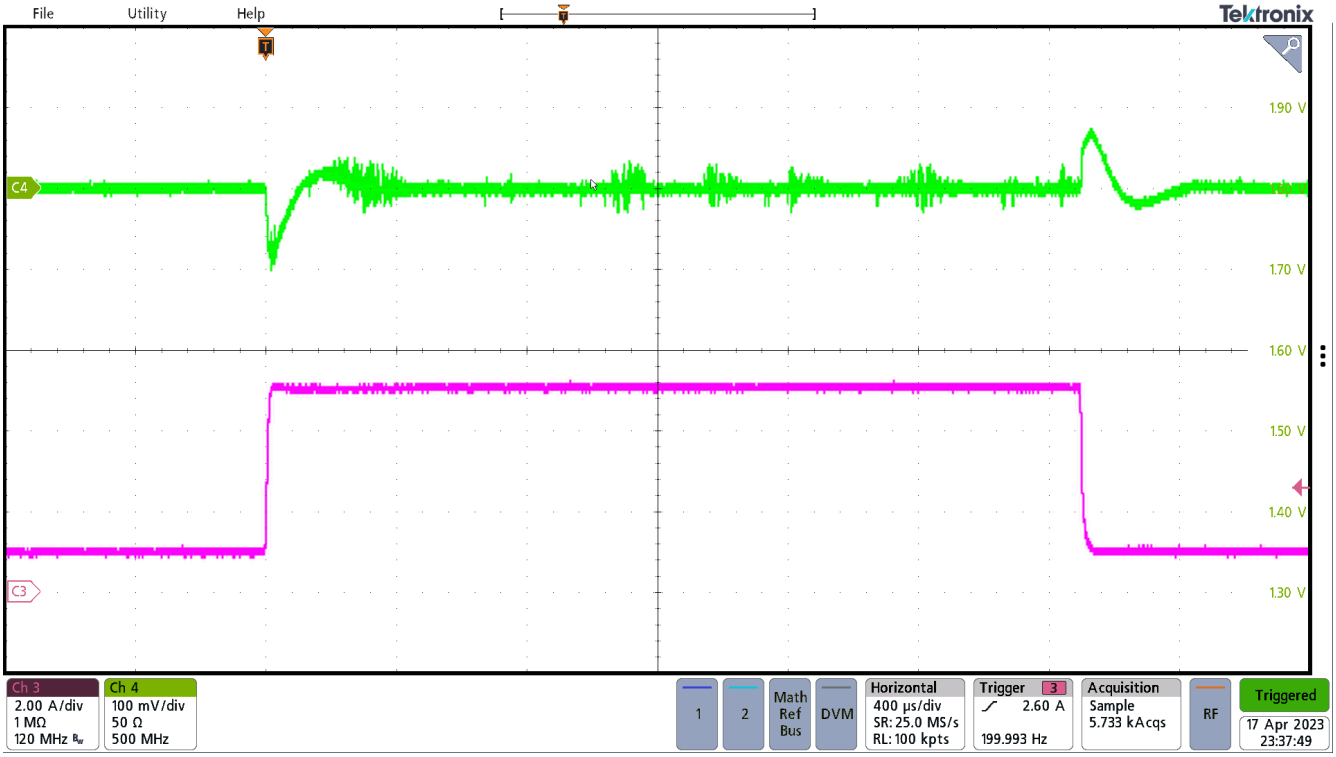


Figure 3-9. Board C Load Transient Response

3.4 Control Loop Stability

The following images illustrate the control loop stability.

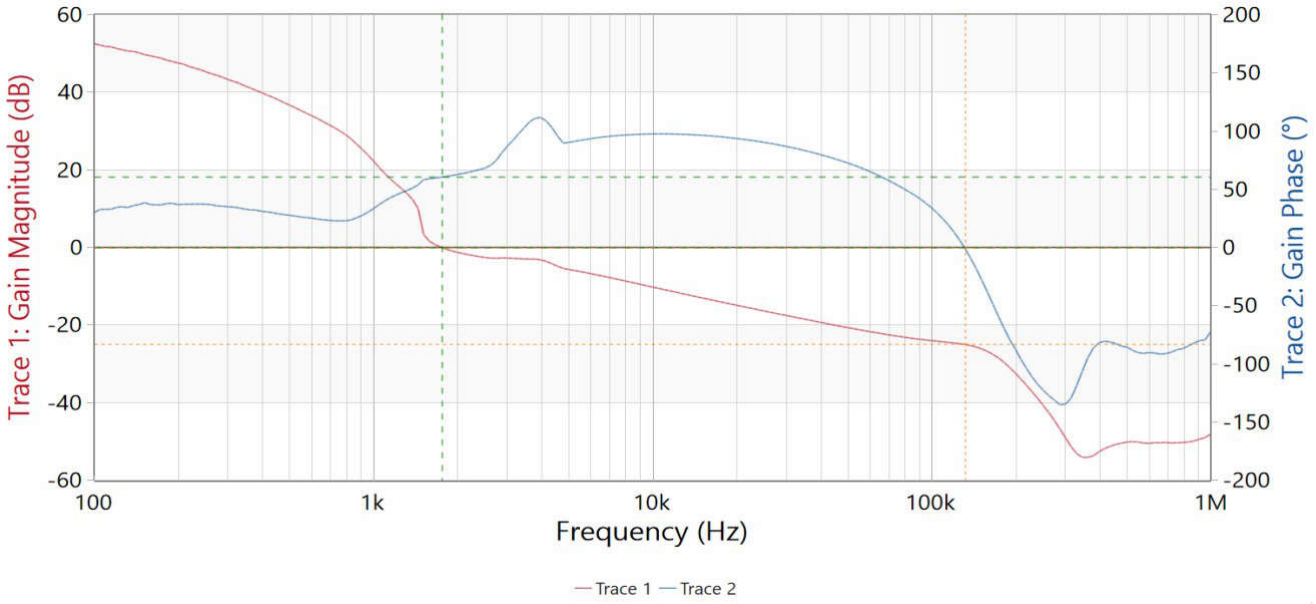


Figure 3-10. Board A Loop Response

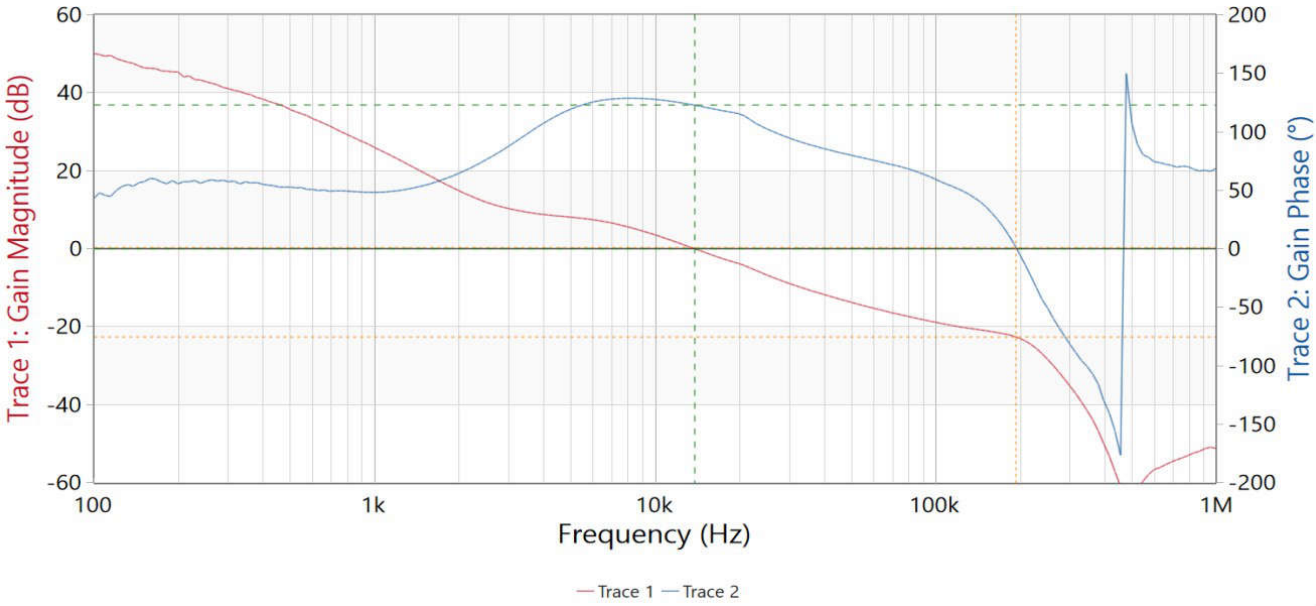


Figure 3-11. Board B Loop Response

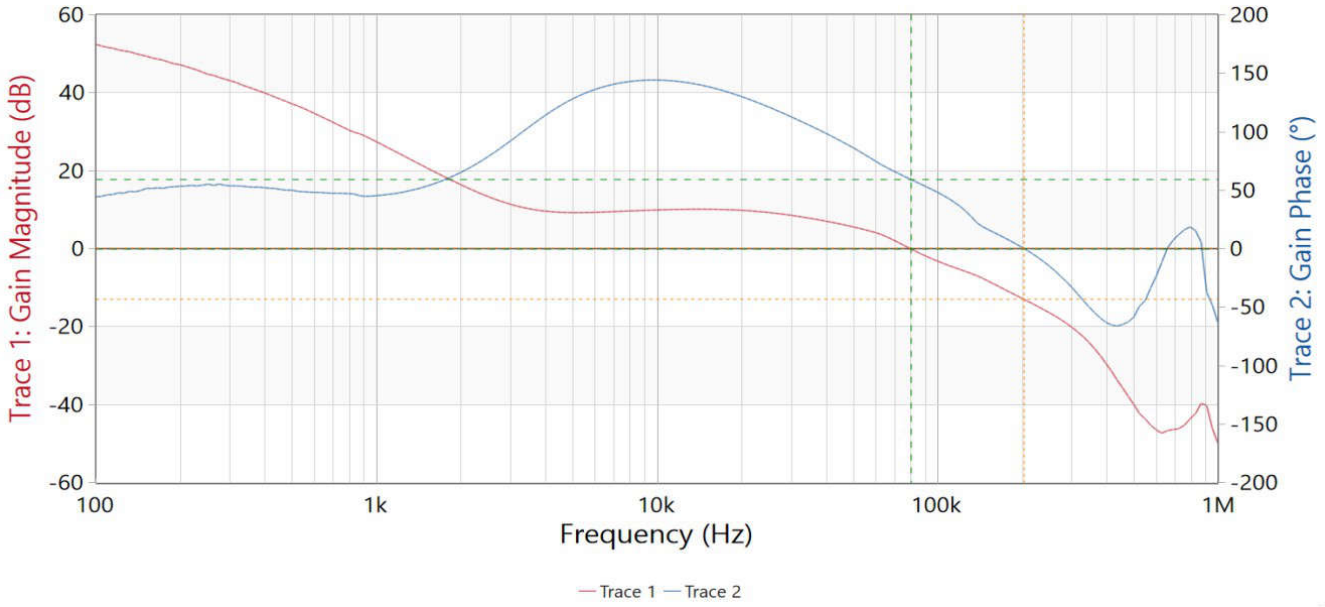


Figure 3-12. Board C Loop Response

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