

Automotive USB Power Delivery Reference Design with Two Ports 180W Maximum Each, 24V to 60V Input



Description

This reference design offers power for automotive advanced driver assistance systems (ADAS), infotainment, and cluster applications. Operation is over the 24V to 60VDC input range with focus on 48VDC power. Two USB PD outputs are provided, to allow charging of various high-power devices. The design exhibits conversion efficiency of 98.1% for the maximum 180W 36V 5A output off 48V_{in}. The test report includes operational data spanning over the full input range and includes output transitions between 5V_{out} and 36V_{out} to show the worst-case scenarios. Thermal images at 180W out and voltage ripple are also showcased in this test report. This reference design is the extended power range version of the PMP23501 board.

Resources

[PMP23618](#)

Design Folder

[TPS26744E-Q1](#)

Product Folder

[LM72880-Q1](#)

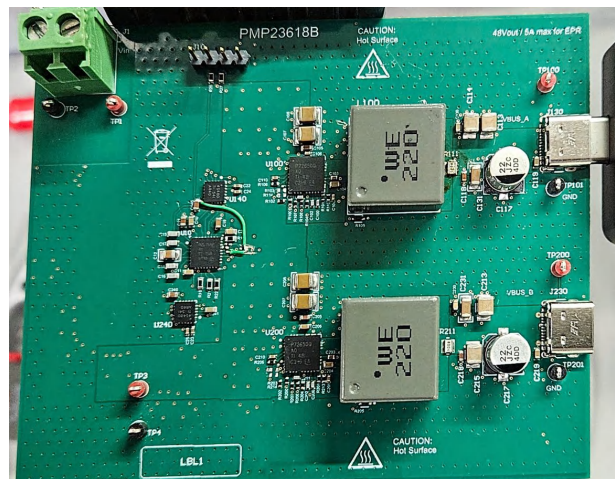
Product Folder

Features

- TPS26744E-Q1 provides USB-PD control for two ports
- Fully integrated LM72880-Q1 power converter for each port
- USB-PD: 180W max per port and 36V_{out} max
- Allows charging of both personal computer and phone from the car at same time
- Thermal foldback and cable drop compensation programmable if needed

Applications

- [Automotive USB charging](#)
- [Automotive media hub](#)



Top of Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage range	24V to 60V
Output voltage and current	5V/9V/12V/15V at 3A or 20V/28V/36V at 5A
Switching frequency	200kHz
Isolation	no

1.2 Required Equipment

- E-load
- Power supply, adjustable, 0V to 60V and 8A minimum
- USB dongle and USB breakout board
- Oscilloscope and HV probes
- Digital multimeters
- Programming header connectors for USB-PD controller

1.3 Dimensions

- The dimensions of the board are 3.76in × 3.15in
- Four Layer board, 1 ounce each

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in [Figure 2-1](#). The graph does not include losses in input EMI filter; FPWM (Forced Pulse width modulation) mode selected. Only port A was loaded.



Figure 2-1. Efficiency Graph

2.2 Efficiency Data

Efficiency data is shown in [Table 2-1](#).

Table 2-1. Efficiency Data

V _{IN} (V)	I _{IN} (A)	V _{OUT} (V)	I _{OUT} (A)	P _{IN} (W)	P _{OUT} (W)	P _{Loss} (W)	Efficiency (%)
48.07	0.012	5	0	0.57684	0	0.57684	0.000%
48.07	0.025	5	0.101	1.20175	0.505	0.69675	42.022%
48.07	0.035	5	0.203	1.68245	1.015	0.66745	60.329%
48.07	0.067	5	0.503	3.22069	2.515	0.70569	78.089%
48.07	0.121	4.99	1.003	5.81647	5.00497	0.8115	86.048%
48.07	0.176	4.99	1.502	8.46032	7.49498	0.96534	88.590%
48.07	0.23	4.99	2.003	11.0561	9.99497	1.06113	90.402%
48.07	0.284	4.99	2.503	13.65188	12.48997	1.16191	91.489%
48.07	0.34	4.98	3.003	16.3438	14.95494	1.38886	91.502%
48.07	0.0353	19.97	0	1.696871	0	1.696871	0.000%
48.07	0.0777	19.97	0.101	3.735039	2.01697	1.718069	54.001%
48.07	0.1206	19.97	0.203	5.797242	4.05391	1.743332	69.928%
48.07	0.246	19.97	0.503	11.82522	10.04491	1.78031	84.945%
48.07	0.4557	19.96	1.003	21.9055	20.01988	1.885619	91.392%
48.07	0.8758	19.96	2.003	42.09971	39.97988	2.119826	94.965%
48.07	1.2967	19.95	3.003	62.33237	59.90985	2.422519	96.114%
48.07	1.7207	19.95	4.005	82.71405	79.89975	2.814299	96.598%
48.07	2.145	19.94	5	103.1102	99.7	3.41015	96.693%
48.065	0.0385	27.93		1.850503	0	1.850503	0.000%
48.067	0.0975	27.92	0.101	4.686533	2.81992	1.866613	60.171%
48.067	0.1576	27.92	0.203	7.575359	5.66776	1.907599	74.818%
48.067	0.3324	27.92	0.503	15.97747	14.04376	1.933711	87.897%
48.068	0.625	27.92	1.003	30.0425	28.00376	2.03874	93.214%
48.068	1.2107	27.92	2.003	58.19593	55.92376	2.272168	96.096%
48.068	1.7966	27.91	3.003	86.35897	83.81373	2.545239	97.053%
48.069	2.386	27.91	4.005	114.6926	111.7796	2.913084	97.460%
48.069	2.976	27.9	5	143.0533	139.5	3.553344	97.516%
48.065	0.0331	35.89	0	1.590952	0	1.590952	0.000%
48.067	0.1096	35.89	0.101	5.268143	3.62489	1.643253	68.808%
48.069	0.1862	35.89	0.203	8.950448	7.28567	1.664778	81.400%
48.07	0.4105	35.88	0.503	19.73274	18.04764	1.685095	91.460%
48.07	0.786	35.88	1.003	37.78302	35.98764	1.79538	95.248%
48.07	1.5392	35.88	2.003	73.98934	71.86764	2.121704	97.132%
48.07	2.29	35.87	3.003	110.0803	107.7176	2.36269	97.854%
48.07	3.045	35.87	4.005	146.3732	143.6594	2.7138	98.146%
48.069	3.8	35.86	5	182.6622	179.3	3.3622	98.159%

2.3 Thermal Images

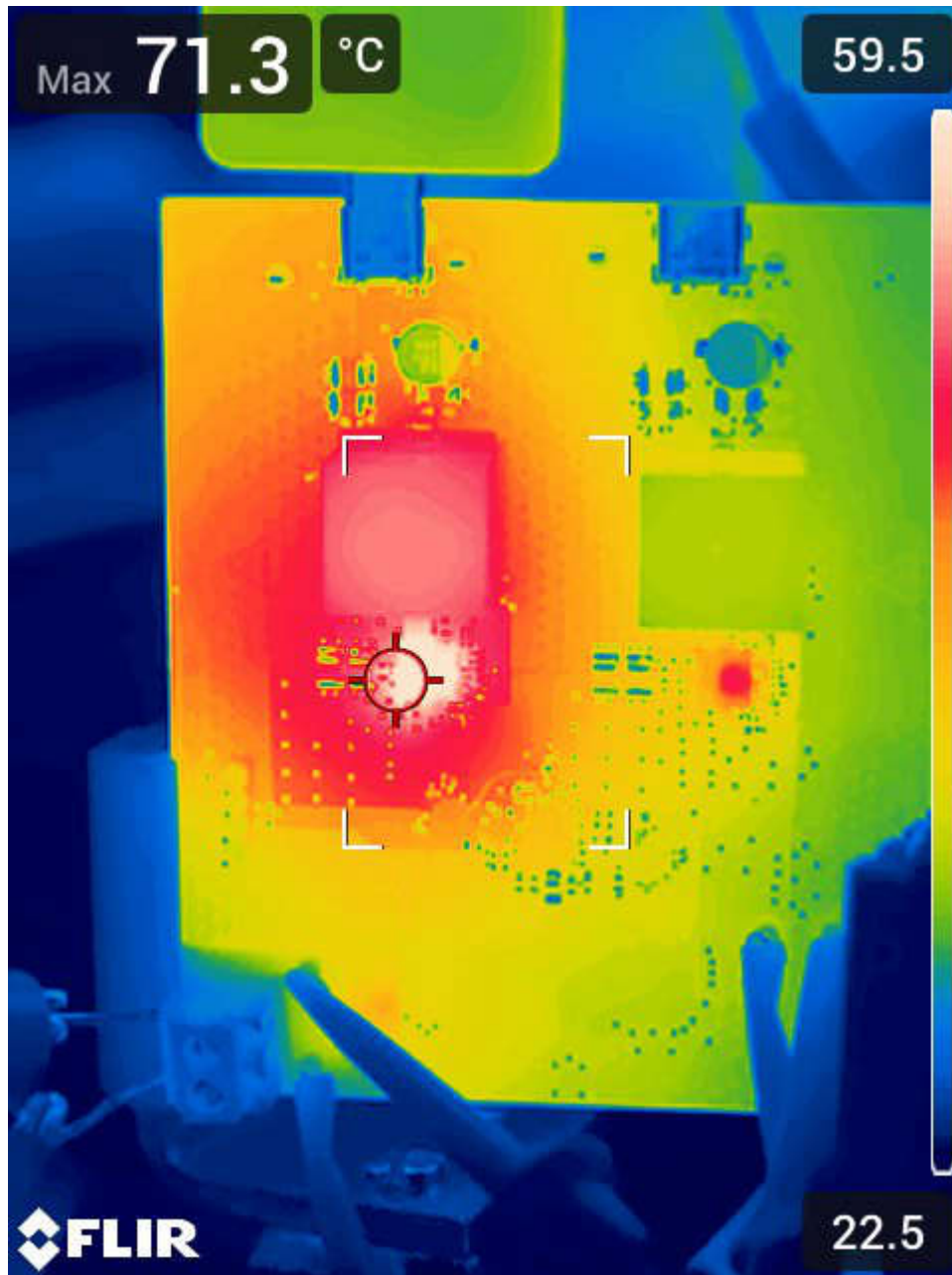


Figure 2-2. Top of Board Showing 36V_{out} at 5A. 48V_{in}. 10 Minutes Soak. No Fan. Ambient : 25°C

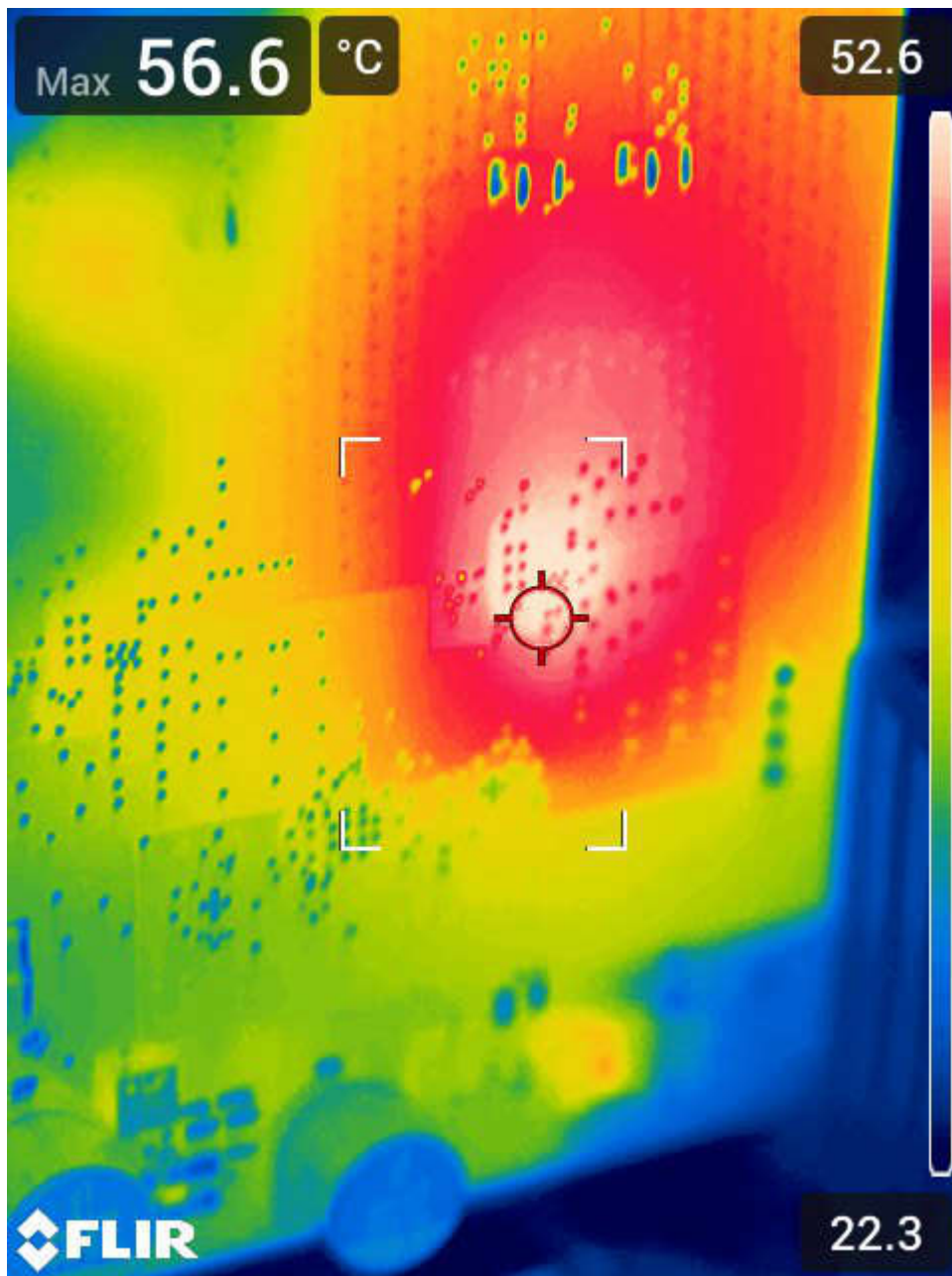


Figure 2-3. Bottom of the Board - Port A

3 Waveforms

3.1 Output Transitions

Output transitions between the lowest and highest V_{out} in USB-PD EPR voltage levels of 5V and 36V are shown in [Figure 3-1](#); V_{in} is 48V.

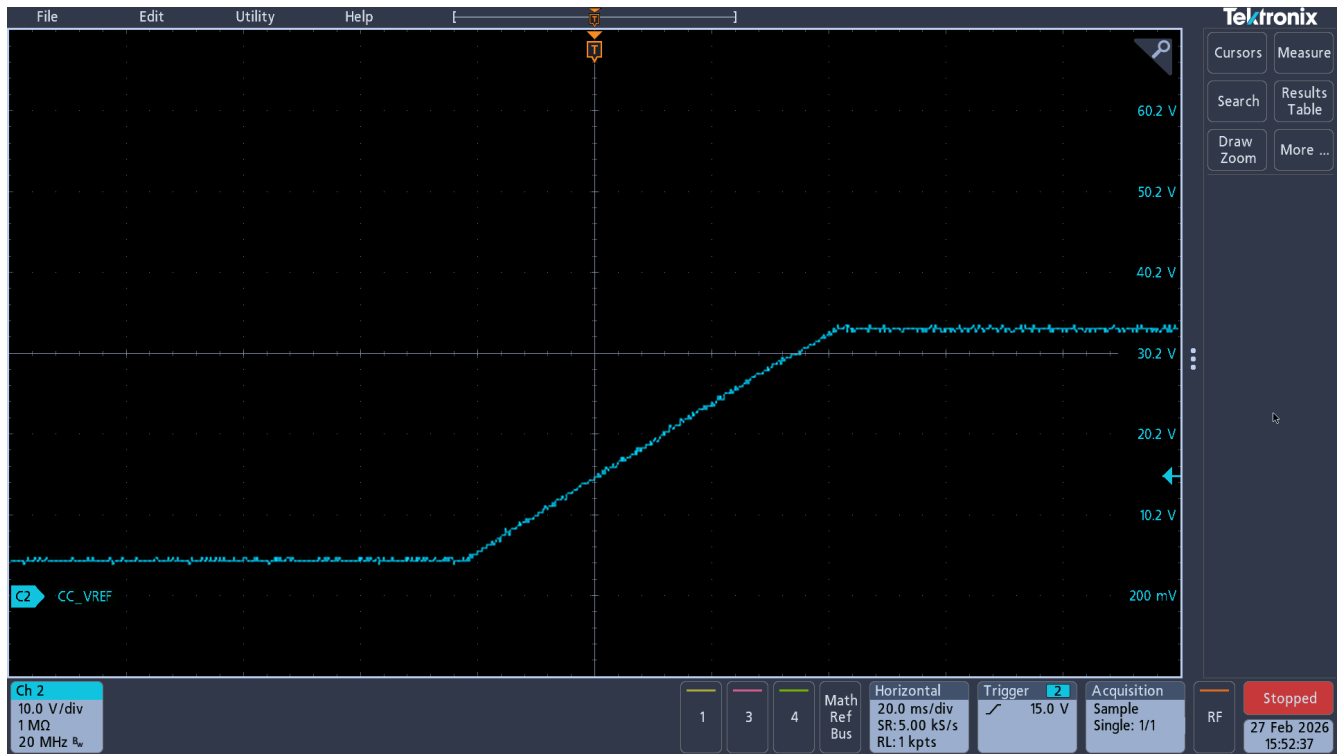


Figure 3-1. From 5V_{out} to 36V_{out} - No load

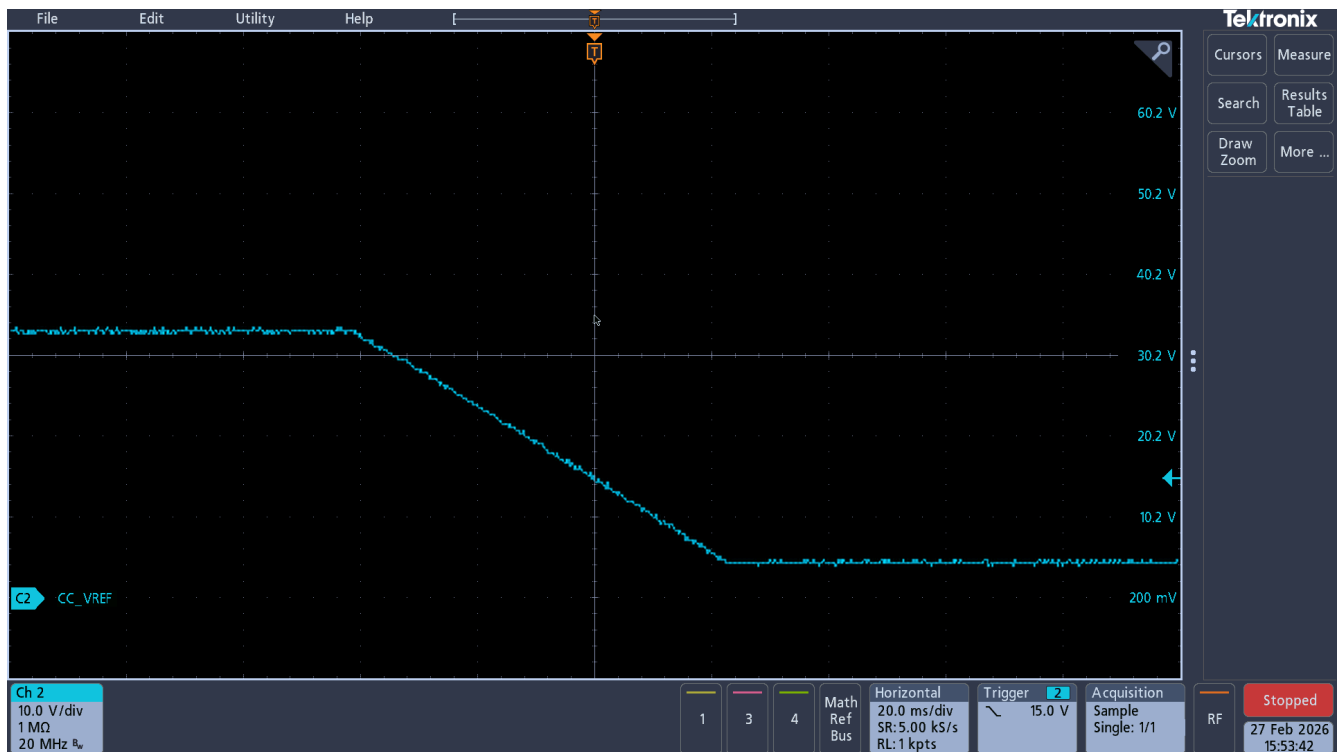


Figure 3-2. From 36V_{out} to 5V_{out} - No load

3.2 Output Voltage Ripple

Output voltage ripple is shown in [Figure 3-3](#) through [Figure 3-8](#).

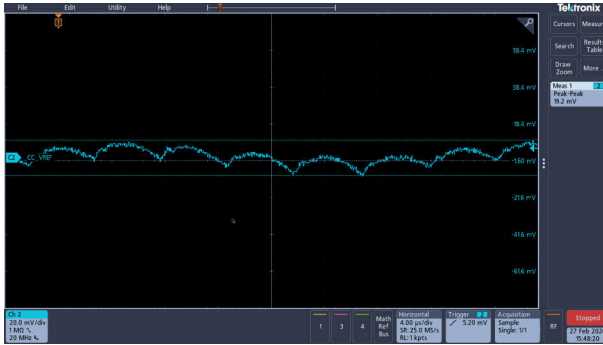


Figure 3-3. V_{out} No Load - 19.2mV pk-pk

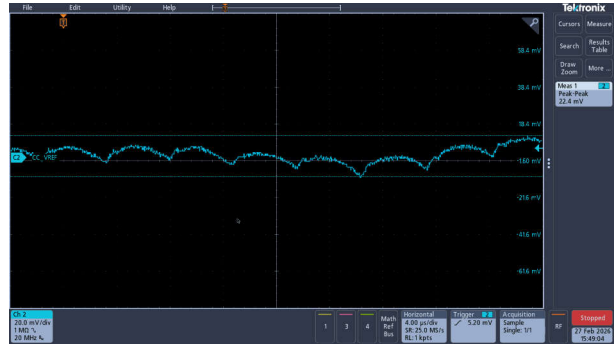


Figure 3-4. 5V_{out} 3A Load - 22.4mV pk-pk

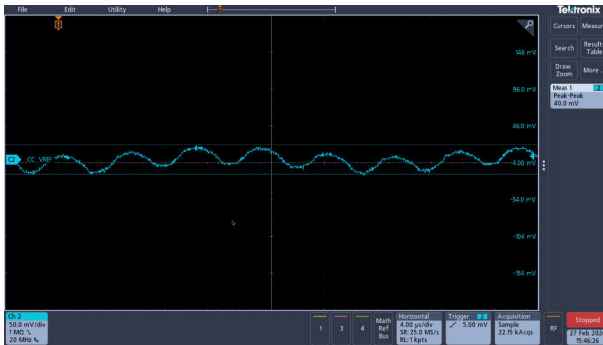


Figure 3-5. 20V_{out} No Load - 40mV pk-pk

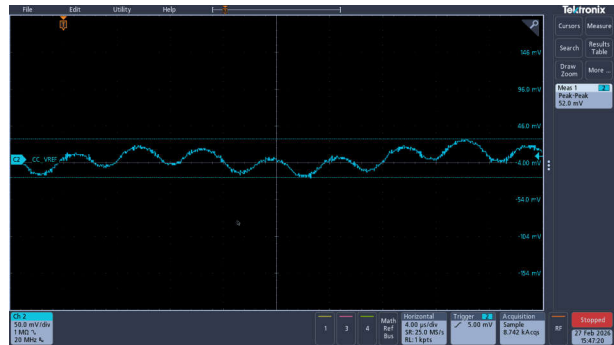


Figure 3-6. V_{out} 5A Load - 52mV pk-pk

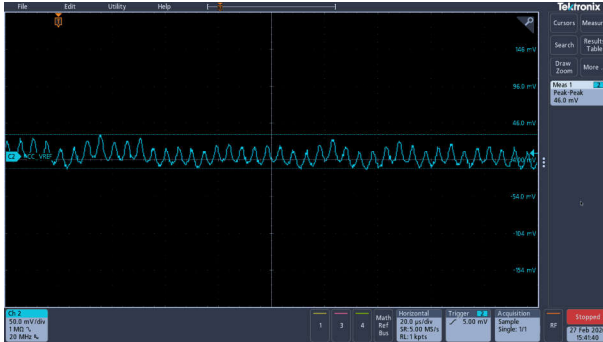


Figure 3-7. 36V_{out} 0A Load - 46mV pk-pk

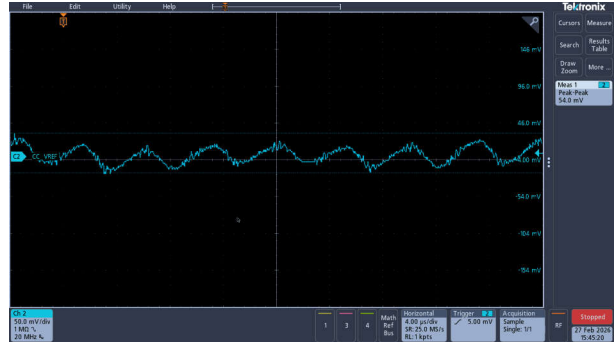


Figure 3-8. 36V_{out} 0A Load - 54mV pk-pk

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