Test Report: PMP22805

24-V_{IN}, 240-W, 98% Efficient, Compact 5S Battery Charger With USB On-The-Go Reference Design

Description

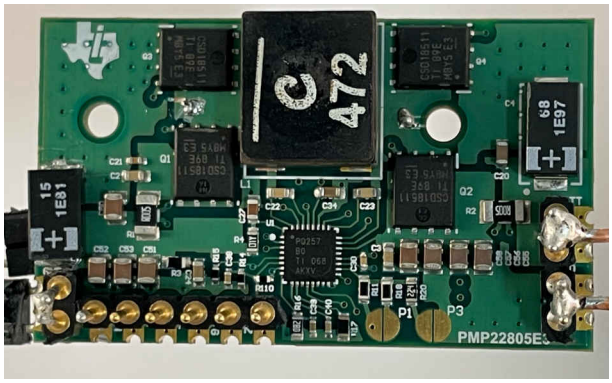
This battery charger reference design is designed for a 5- to 24-V_{IN}, 240-W power tool, featuring the BQ25731—1-5 cell NVDC buck-boost battery charge controller. This controller enables a high-power, high-efficiency, and high-density design. PMP22805 delivers 240 W, with 98% efficiency, and fits in a compact 1.08 in × 1.68 in (27.4 mm × 42.7 mm) form factor. The USB On-The-Go (OTG) capability makes it a power bank. This design is ideal for power tools where high-power, high-efficiency, and high-density are top priorities. The design also supports 1-5S battery and accepts a wide input range such as USB-Type C® power delivery (PD) interface.

Features

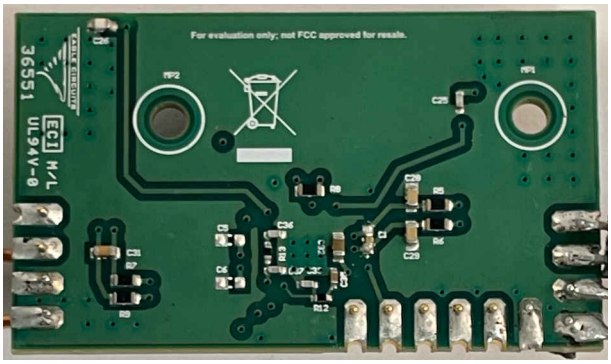
- High power 5 to 24 V_{IN}, 240 W
- High efficiency 98%
- Compact size 1.08 in × 1.68 in
- USB On-the-Go (OTG) power bank
- Supports 1-5S battery
- Wide input range USB-Type C PD compliance

Applications

- Cordless power tool
- Power bank
- Appliances: battery charger



Top Board Photo



Bottom Board Photo

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage, V_{IN}	5 V–24 V
Output Voltage, V_{OUT}	15 V–21 V, 10 A

1.2 Required Equipment

- Main Power Supply: 0 V–35 V, 0 A–12 A
- Bipolar Power Supply: 36 V, ±12 A
- EV2400 or USB2ANY interface device (This design does not include the EV2400 or USB2ANY interface device; the EV2400 or USB2ANY must be ordered separately.)

2 Testing and Results

2.1 Charge Efficiency

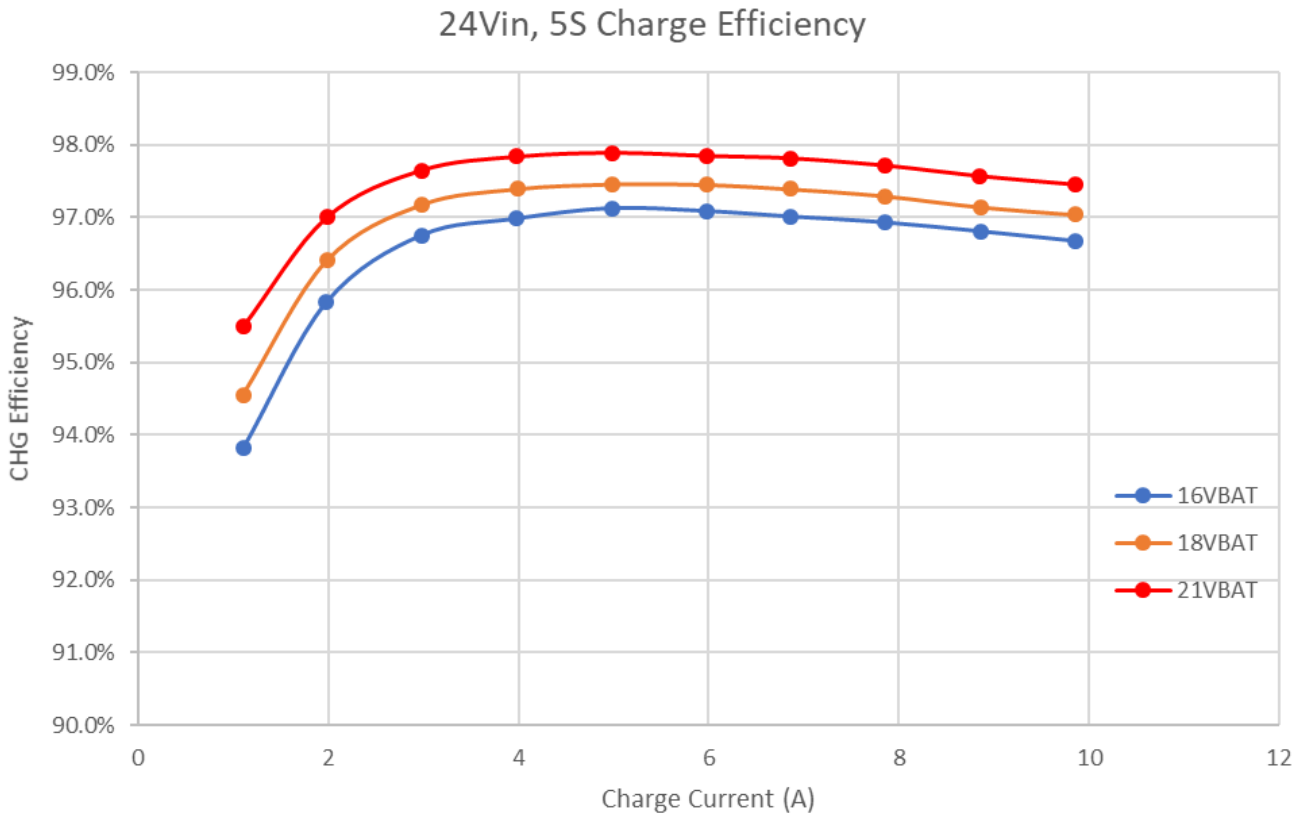


Figure 2-1. Charge Efficiency Graph

Table 2-1. Test Conditions: 24 VBUS, 5S VBAT, 400 kHz

VBUS (V)	VBAT (V)	IBUS (A)	IBAT (A)	Efficiency	PLOSS (W)
24.017	16.028	0.785	1.103	93.81%	1.167
24.016	16.029	1.379	1.980	95.83%	1.381
24.016	16.031	2.055	2.979	96.75%	1.603
24.015	16.032	2.740	3.981	96.98%	1.986
24.015	16.033	3.422	4.979	97.13%	2.362
24.014	16.035	4.115	5.984	97.09%	2.880
24.014	16.036	4.720	6.857	97.01%	3.387
24.013	16.037	5.414	7.857	96.93%	3.991
24.013	16.039	6.110	8.856	96.81%	4.684
24.012	16.040	6.807	9.852	96.68%	5.435
24.017	18.030	0.877	1.105	94.55%	1.148
24.016	18.031	1.545	1.984	96.40%	1.335
24.016	18.033	2.304	2.982	97.17%	1.564
24.015	18.034	3.072	3.985	97.39%	1.926
24.015	18.035	3.837	4.979	97.46%	2.343
24.014	18.036	4.611	5.982	97.45%	2.824

Table 2-1. Test Conditions: 24 VBUS, 5S VBAT, 400 kHz (continued)

VBUS (V)	VBAT (V)	IBUS (A)	IBAT (A)	Efficiency	PLOSS (W)
24.013	18.038	5.292	6.861	97.39%	3.318
24.013	18.039	6.069	7.860	97.29%	3.946
24.012	18.040	6.850	8.856	97.14%	4.705
24.012	18.042	7.631	9.855	97.04%	5.433
24.016	21.033	1.013	1.105	95.50%	1.096
24.016	21.034	1.790	1.983	97.00%	1.291
24.015	21.035	2.675	2.982	97.65%	1.511
24.015	21.037	3.566	3.983	97.84%	1.854
24.014	21.038	4.458	4.981	97.89%	2.261
24.014	21.040	5.358	5.983	97.85%	2.769
24.013	21.041	6.146	6.861	97.81%	3.227
24.012	21.042	7.046	7.857	97.72%	3.865
24.012	21.043	7.952	8.853	97.57%	4.641
24.011	21.045	8.863	9.854	97.45%	5.418

2.2 OTG Efficiency

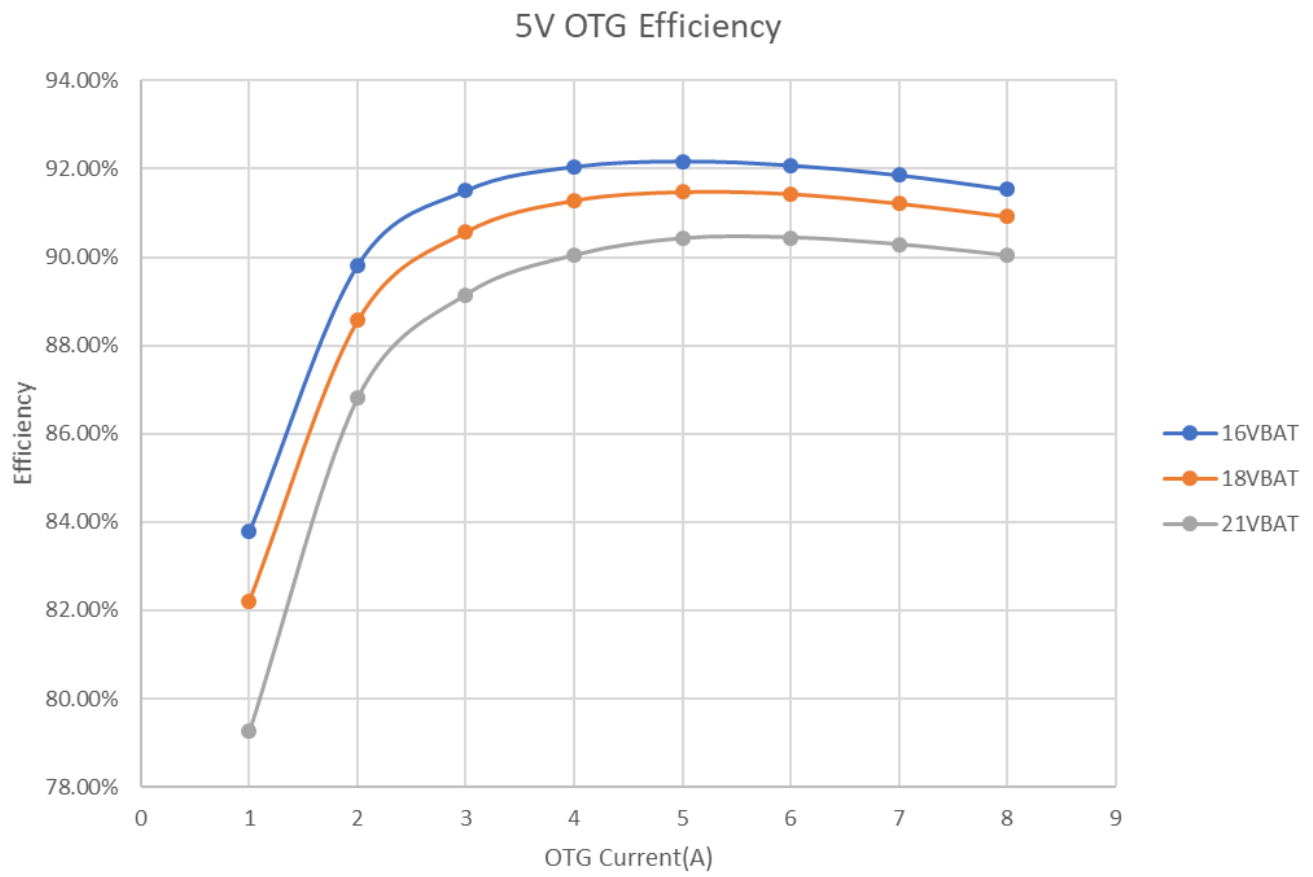


Table 2-2. Test Conditions: 5S VBAT, 5 VOTG, 400 kHz

VOTG (V)	VBAT (V)	IOTG (A)	IBAT (A)	Efficiency	PLOSS (W)
4.985	16.026	1.041	0.386	83.79%	1.004
4.981	16.026	2.047	0.708	89.82%	1.156
4.978	16.026	3.057	1.038	91.51%	1.412
4.975	16.026	4.062	1.370	92.05%	1.746
4.972	16.026	5.052	1.701	92.17%	2.134
4.969	16.026	6.058	2.040	92.08%	2.590
4.965	16.026	7.063	2.382	91.85%	3.110
4.962	16.026	8.069	2.730	91.53%	3.706
4.980	18.028	1.039	0.349	82.21%	1.120
4.978	18.028	2.046	0.638	88.56%	1.315
4.975	18.028	3.056	0.931	90.57%	1.583
4.972	18.028	4.062	1.227	91.28%	1.928
4.969	18.028	5.052	1.522	91.48%	2.338
4.966	18.028	6.058	1.825	91.43%	2.820
4.963	18.028	7.063	2.132	91.22%	3.376
4.960	18.028	8.069	2.442	90.92%	3.999
4.977	21.031	1.039	0.310	79.26%	1.354
4.975	21.031	2.046	0.558	86.81%	1.547
4.972	21.031	3.056	0.811	89.15%	1.850
4.969	21.031	4.062	1.066	90.04%	2.233
4.966	21.031	5.052	1.319	90.42%	2.658
4.963	21.031	6.058	1.581	90.44%	3.178
4.960	21.031	7.063	1.845	90.28%	3.770
4.957	21.031	8.069	2.113	90.03%	4.428

2.3 Thermal Images

The PMP22085 can deliver 240 W with a small heat sink and approximately 200-LFM airflow. When air flow is not available, but with a small heat sink, the output capability is derated to 150 W. If a heat sink is not available, the output capability is further derated to 90 W.

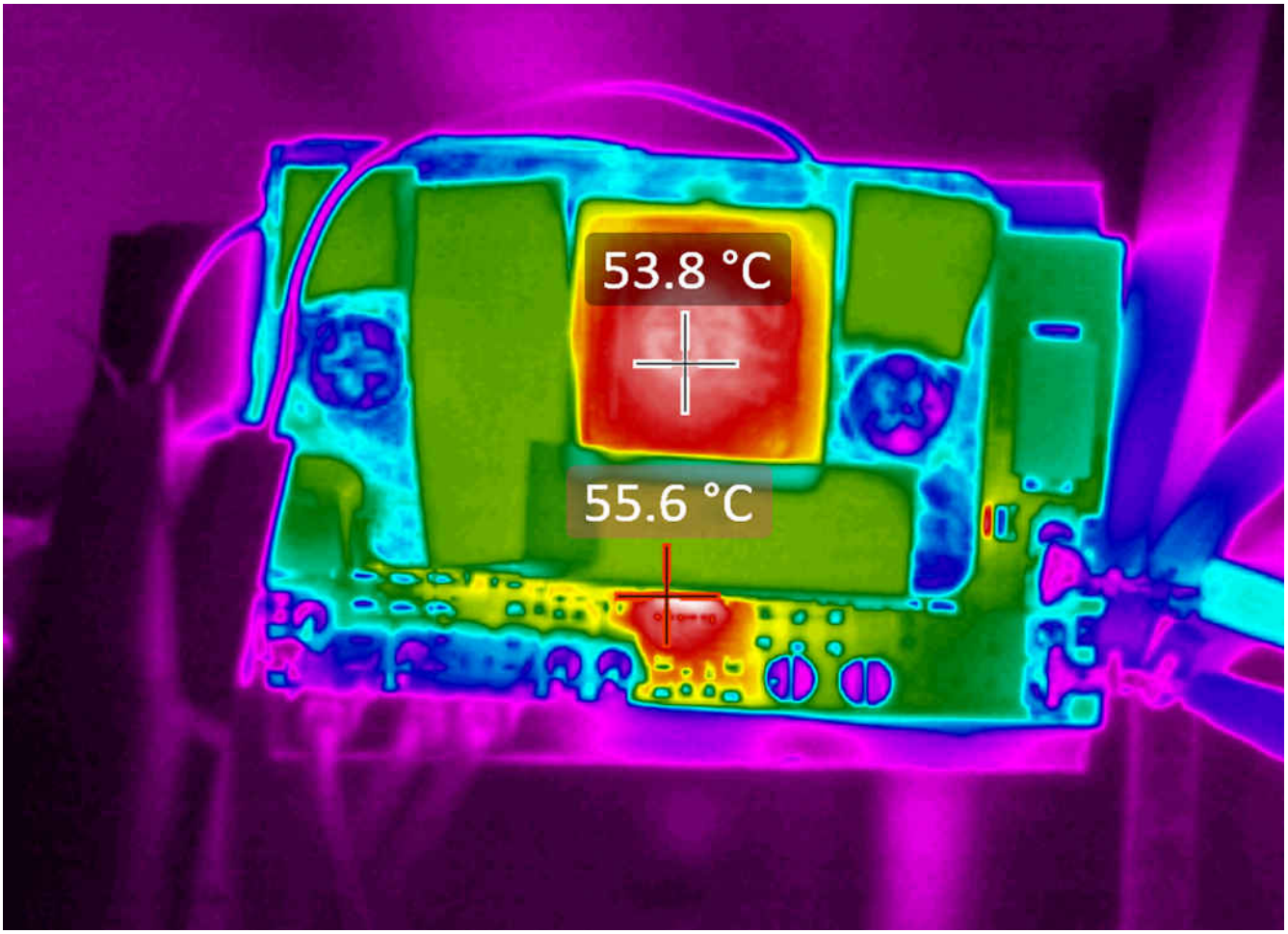


Figure 2-2. VBUS = 24 V, VBAT = 21 V, IBAT = 9.6 A, About 200 W, IC Temp = 55.6°C, Q1 FET = 53.6°C, IND Temp = 53.8°C (With Heat Sink, About 200 LFM Airflow)

3 Waveforms

3.1 Start-up

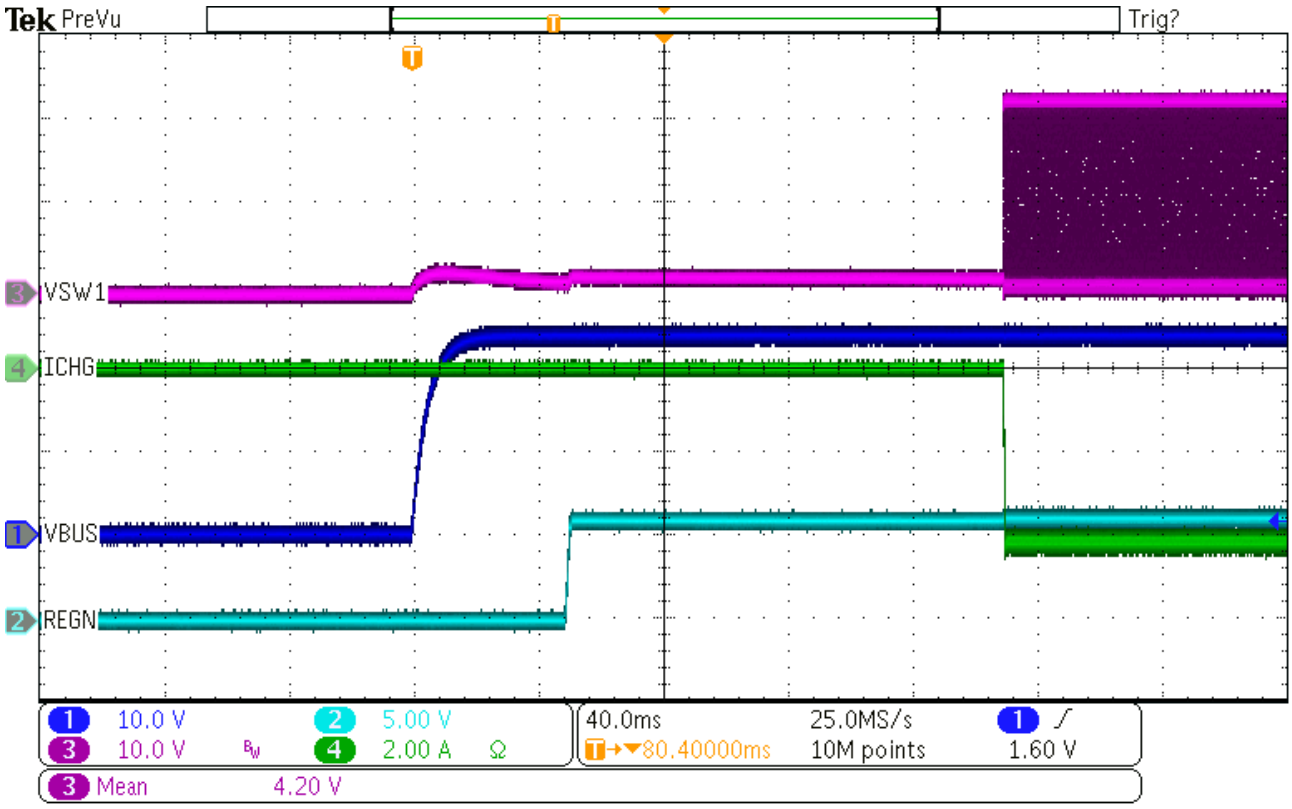


Figure 3-1. VBUS = 24 V, VBAT = 15 V, ICHG = 4096 mA

3.2 Shutdown

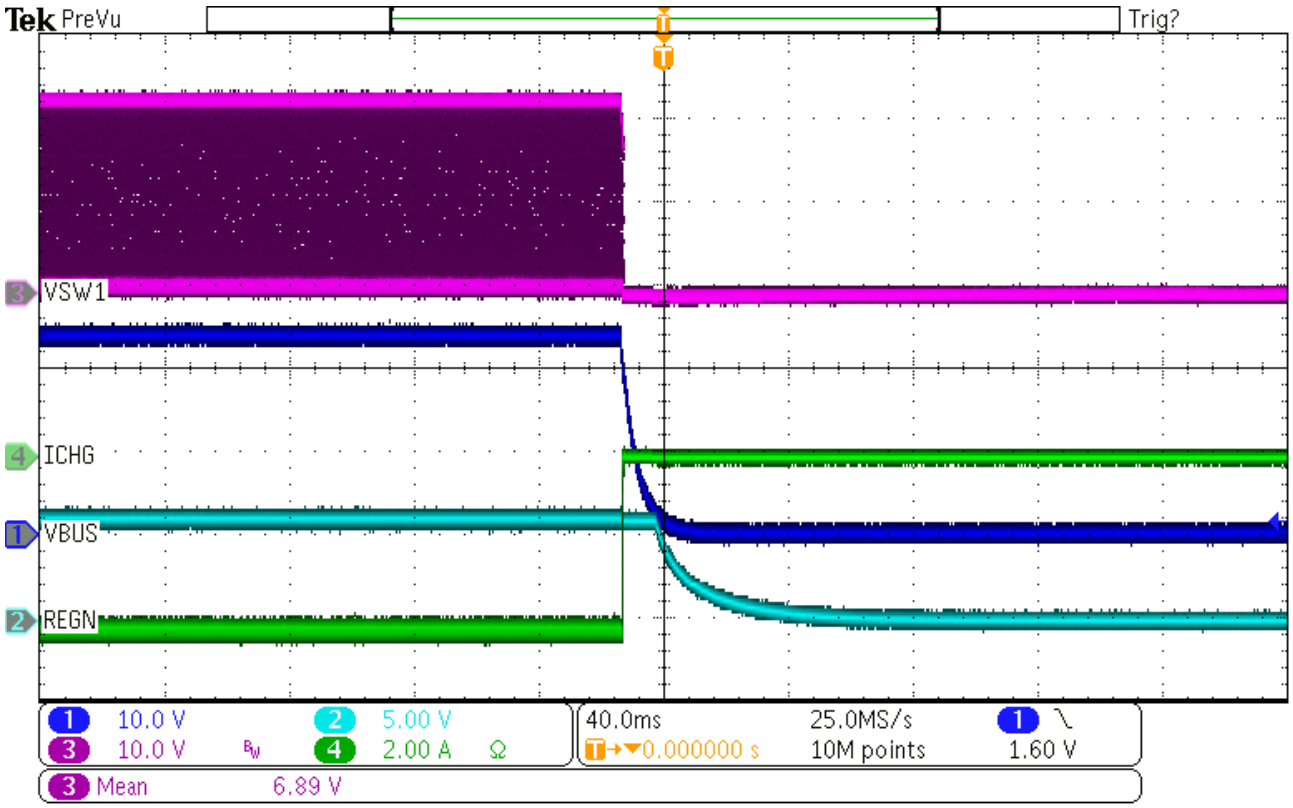


Figure 3-2. VBUS = 24 V, VBAT = 15 V, ICHG = 4096 mA

3.3 Charge Enable

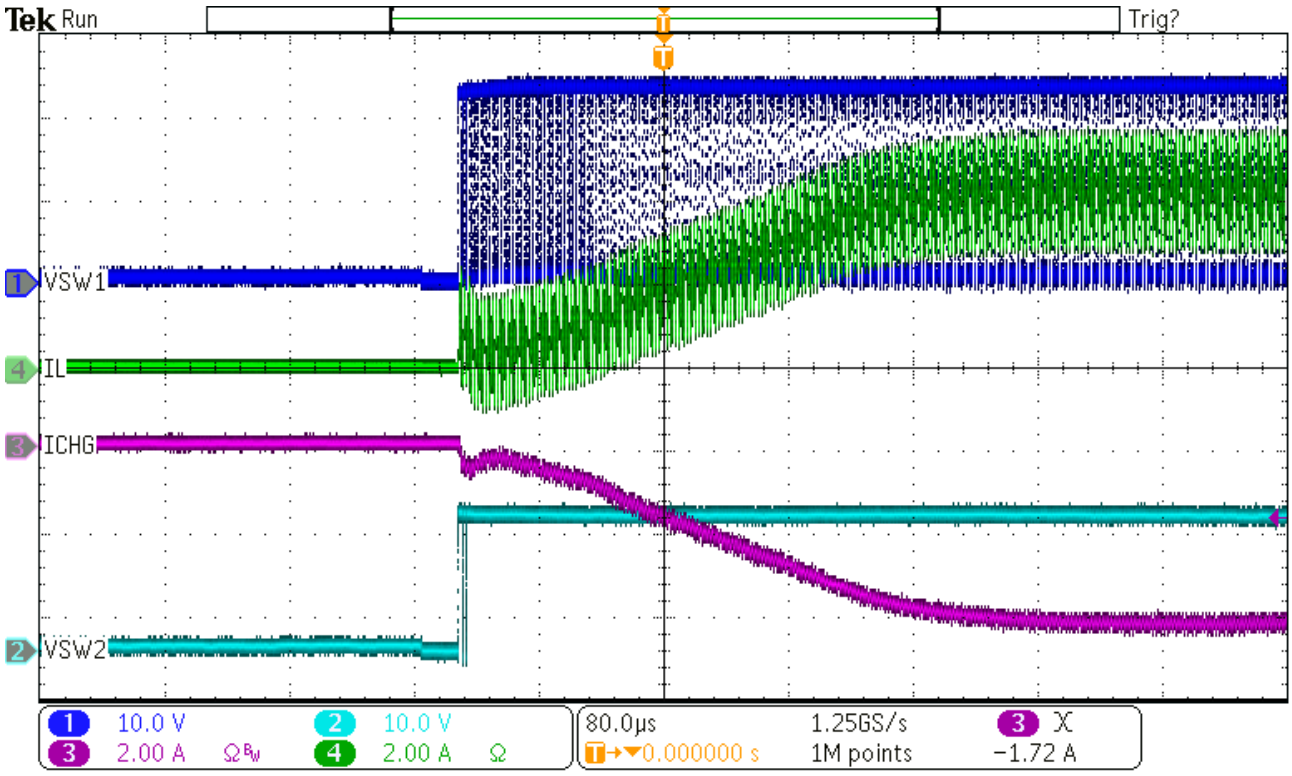


Figure 3-3. VBUS = 24 V, VBAT = 16 V, ICHG = 4096 mA

3.4 Charge Disable

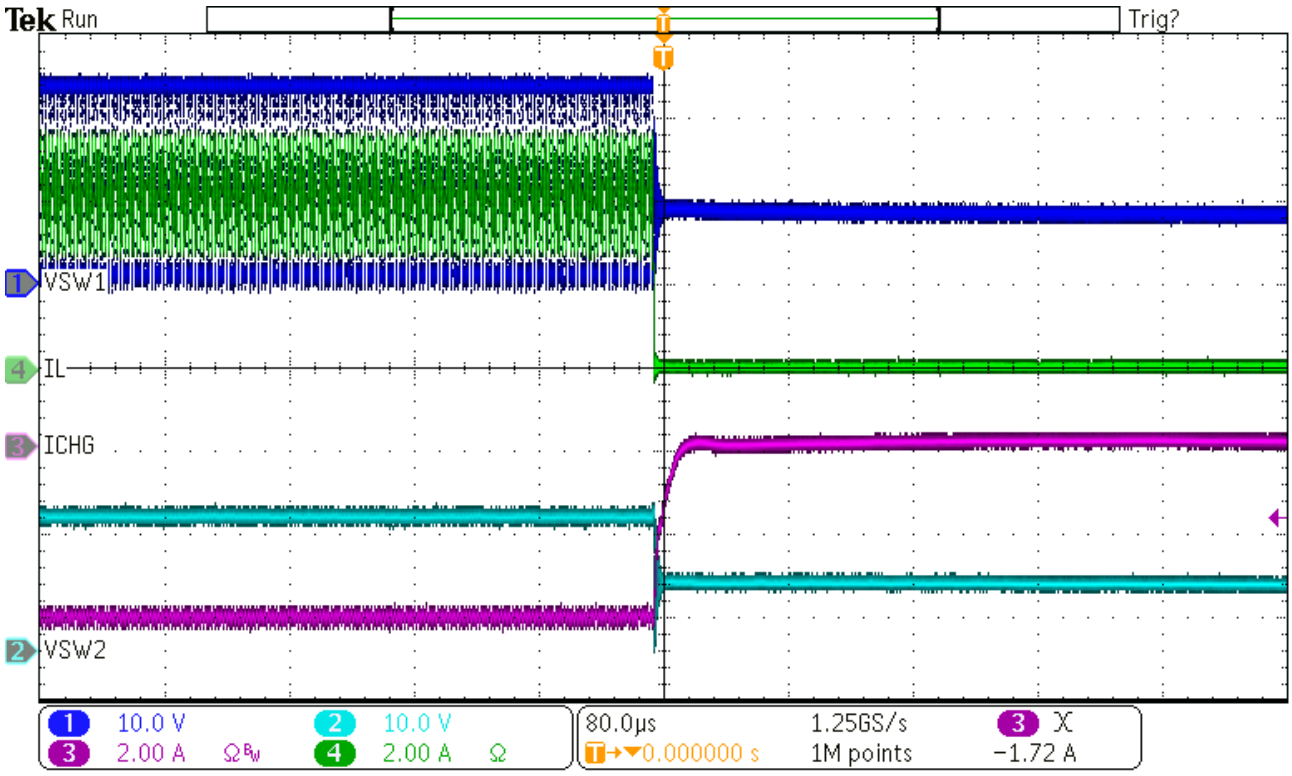


Figure 3-4. VBUS = 24 V, VBAT = 16 V, ICHG = 4096 mA

3.5 Typical Charge

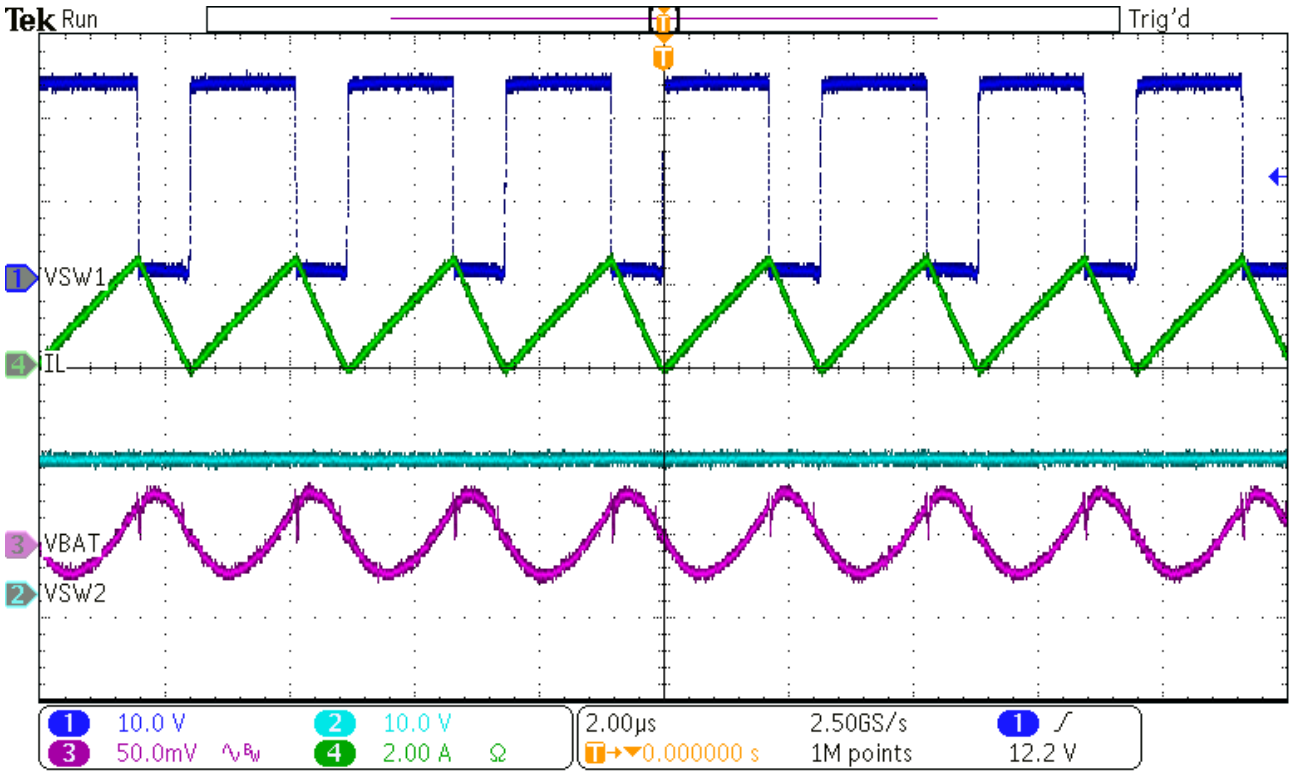


Figure 3-5. VBUS = 24 V, VBAT = 16 V, ICHG = 1024 mA

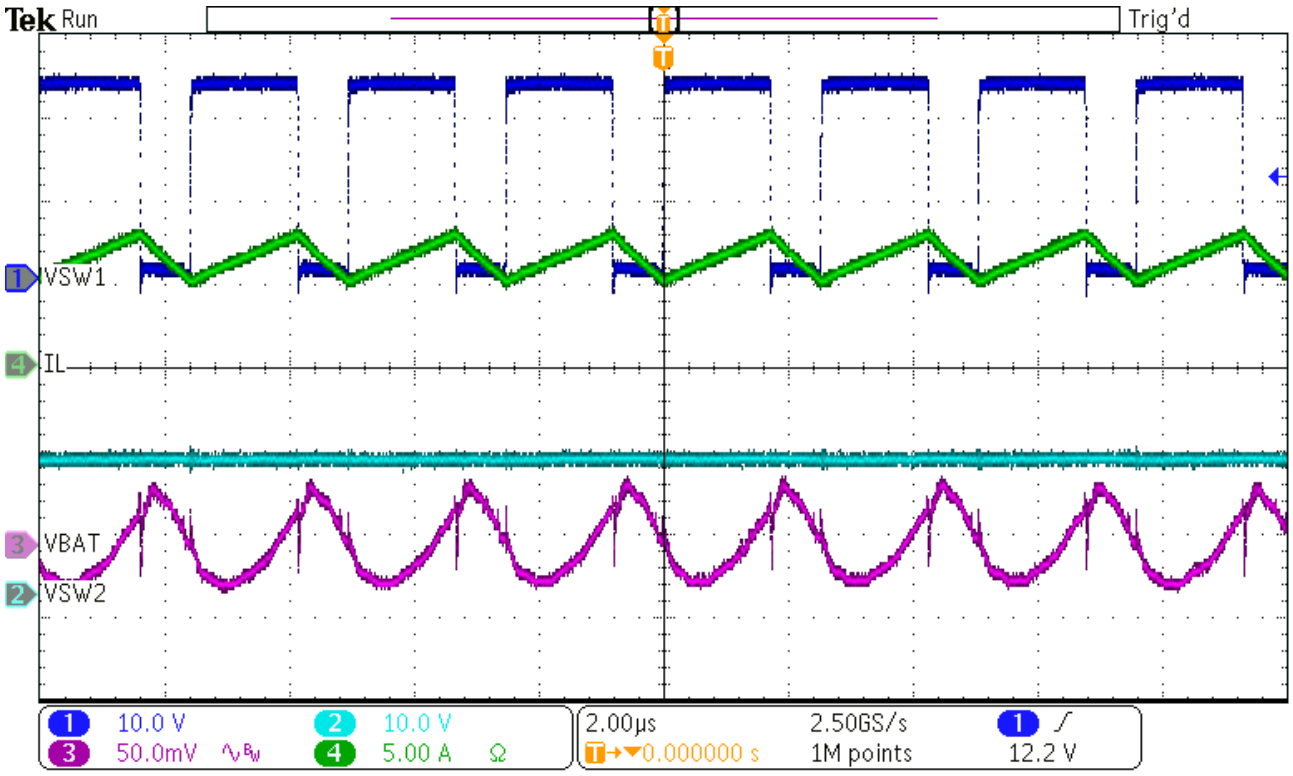


Figure 3-6. VBUS = 24 V, VBAT = 16 V, ICHG = 6400 mA

3.6 Typical OTG

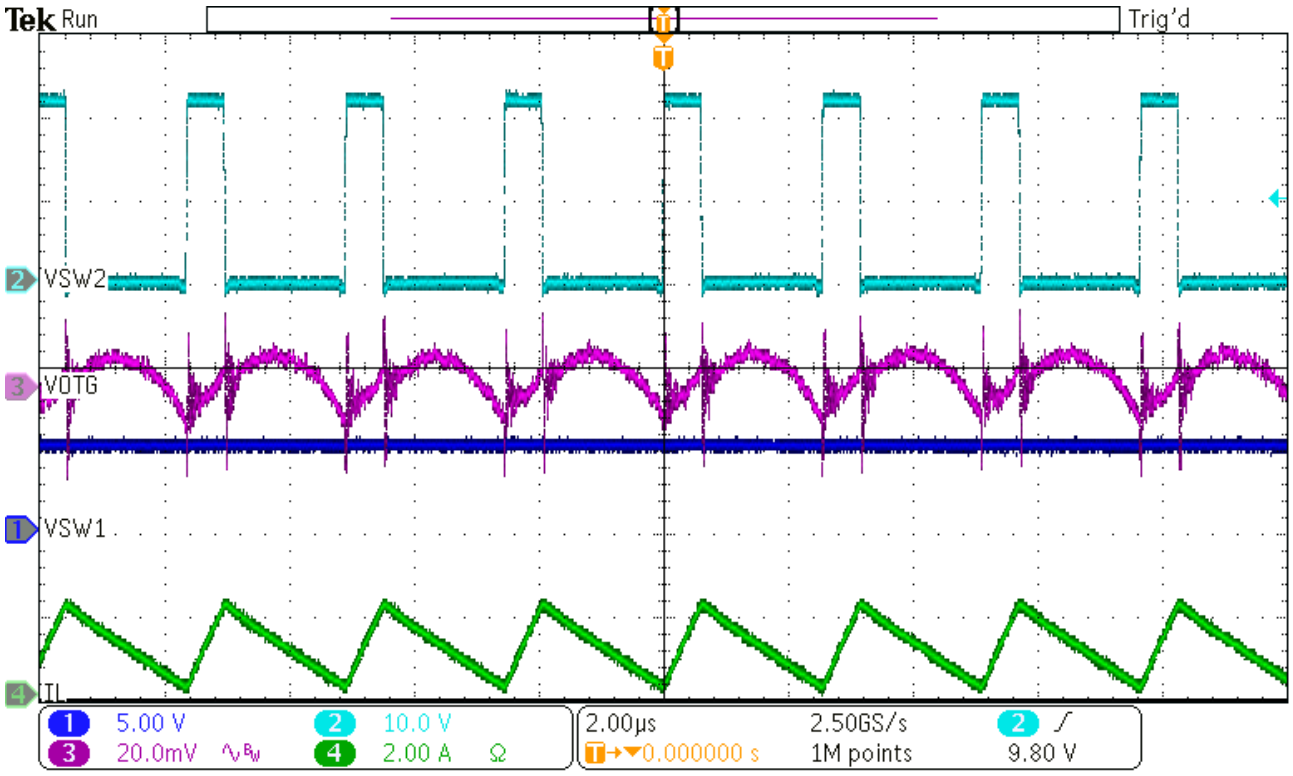


Figure 3-7. VBAT = 21 V, VOTG = 5 V, IOTG = 1 A

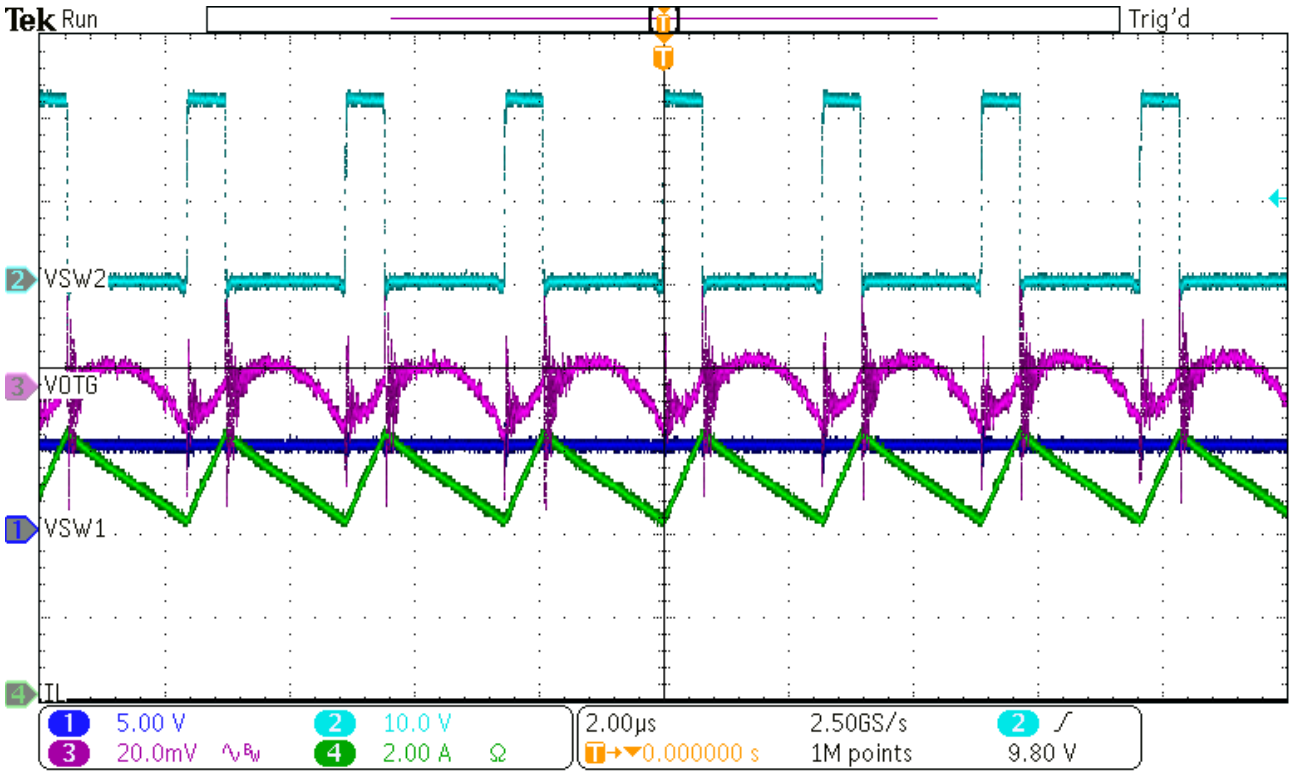


Figure 3-8. VBAT = 21 V, VOTG = 5 V, IOTG = 5 A

3.7 OTG Transient

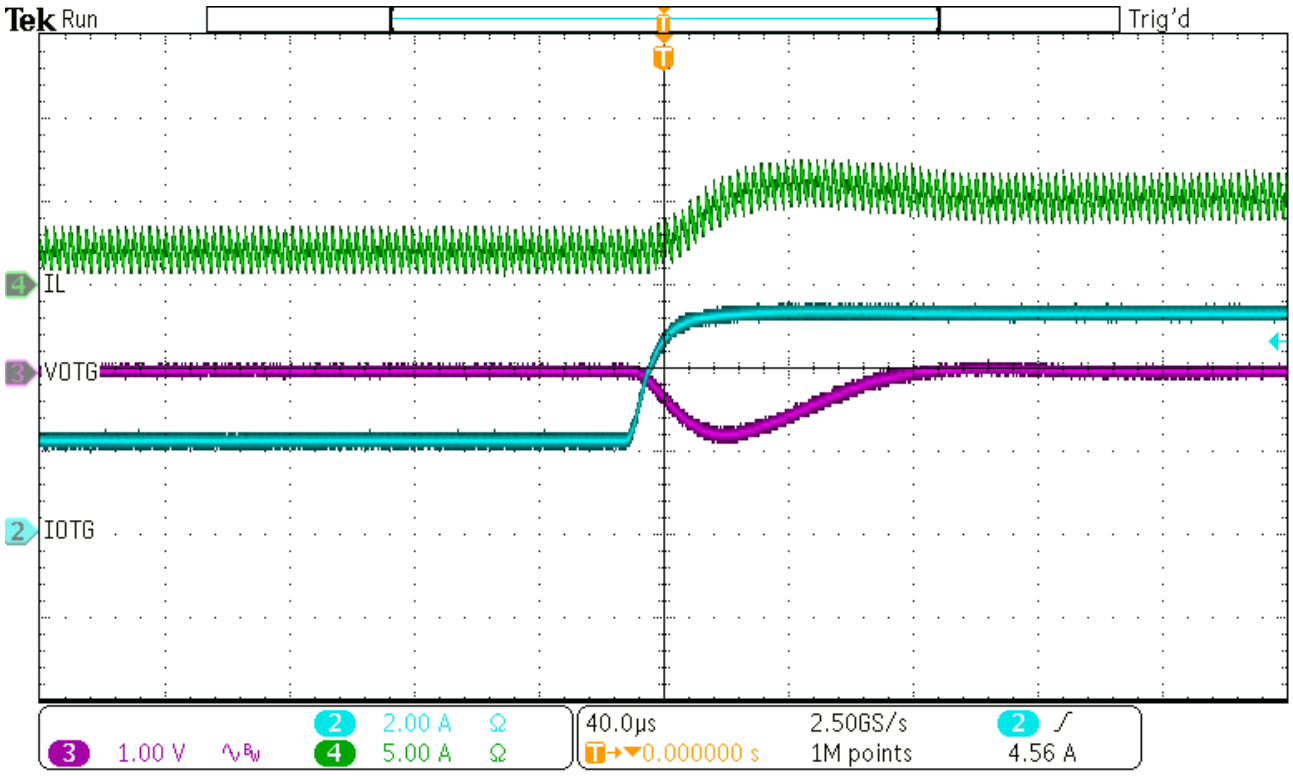


Figure 3-9. VBAT = 21 V, VOTG = 5 V, ICHG = 2 A to 5 A

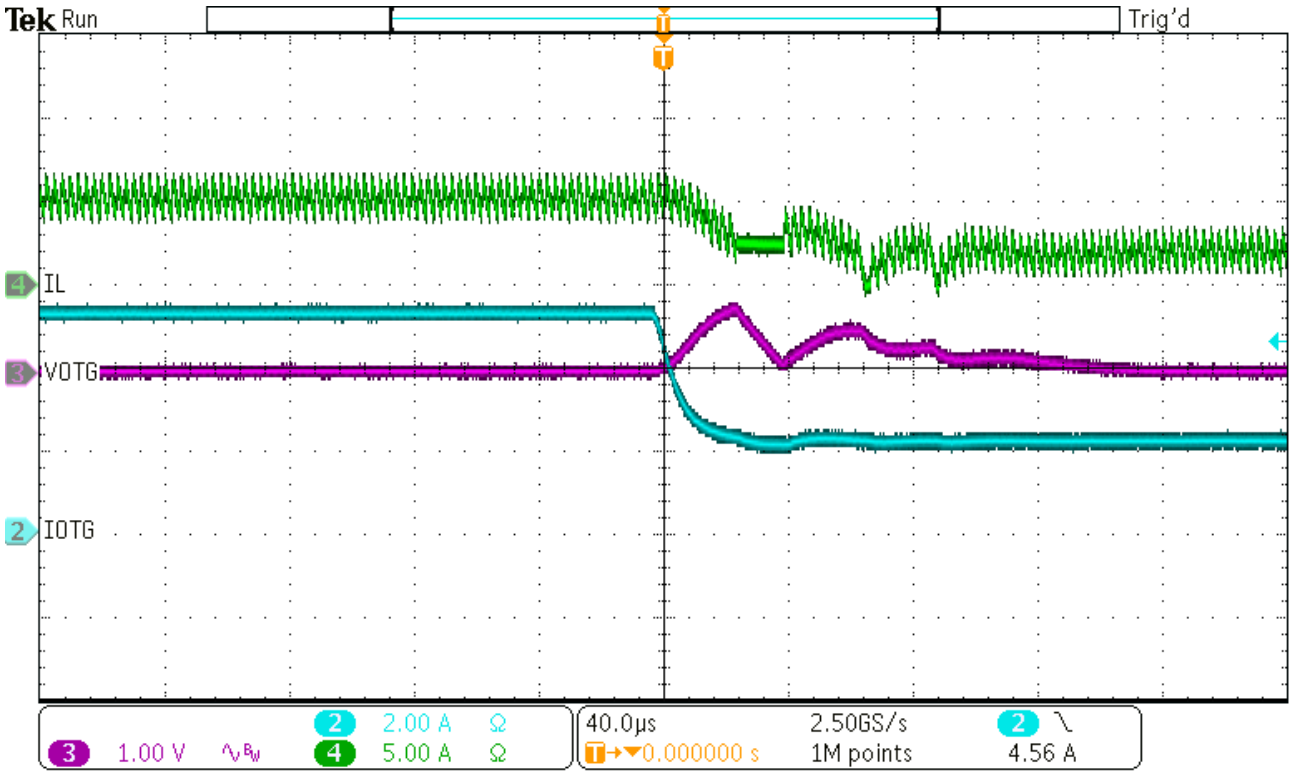


Figure 3-10. VBAT = 21 V, VOTG = 5 V, ICHG = 5 A to 2 A

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