Test Report: PMP22405

320W, Dual-Phase, Multicell Battery Charger Reference Design With Hybrid Switching FETs

Description

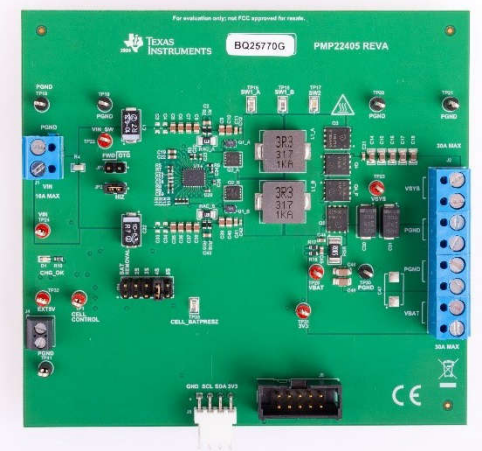
This battery charger is designed for a 40V, 320W notebook PC, featuring the BQ25770G quasi-dual-phase buck-boost battery charge controller. This reference design delivers 320W with 98% peak efficiency, and spreads out the heat across two parallel half bridges and inductors. Gallium nitride (GaN) field effect transistors (FETs) are chosen as the high-side FETs for high efficiency, and silicon FETs are chosen as the low-side FETs for low cost. This hybrid-FET reference design is cost-effective and highly-efficient for high-power multicell battery chargers.

Features

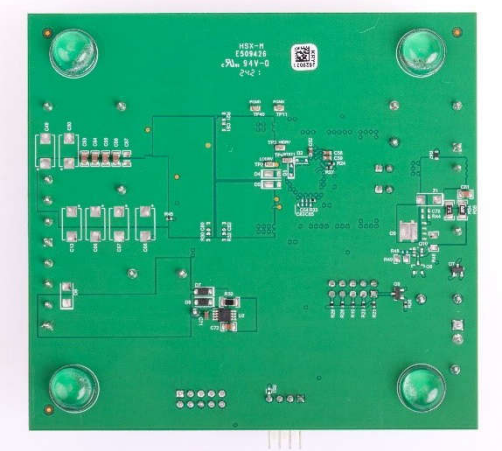
- High-power 40V input and 320W
- High efficiency of 98%
- Cost-effective hybrid GaN and Silicon FETs
- Excellent thermal performance
- Supports 2 to 5-cell battery
- Extended Power Range (EPR) USB Type-C® Power Delivery (PD) compliance

Applications

- Standard notebook PC
- Ventilators



PMP22405 Board (Front)



PMP22405 Board (Back)

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input voltage, V_{IN}	3.5 to 40V, 320W
Output voltage, V_{OUT}	9.5 to 23V, 320W
Input current	8.2A maximum
Output current	16A maximum

1.2 Required Equipment

- Main power supply: 0V to 40V, 0A to 12A
- Bipolar power supply: 36V, ±12A
- EV2400 or USB2ANY interface device

Note

This design does not include the EV2400 or USB2ANY interface device; the EV2400 or USB2ANY must be ordered separately.

1.3 Dimensions

Solution size: 1.1in × 1.9in (27.9mm × 48.3mm).

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in Figure 2-1 and Figure 2-2.

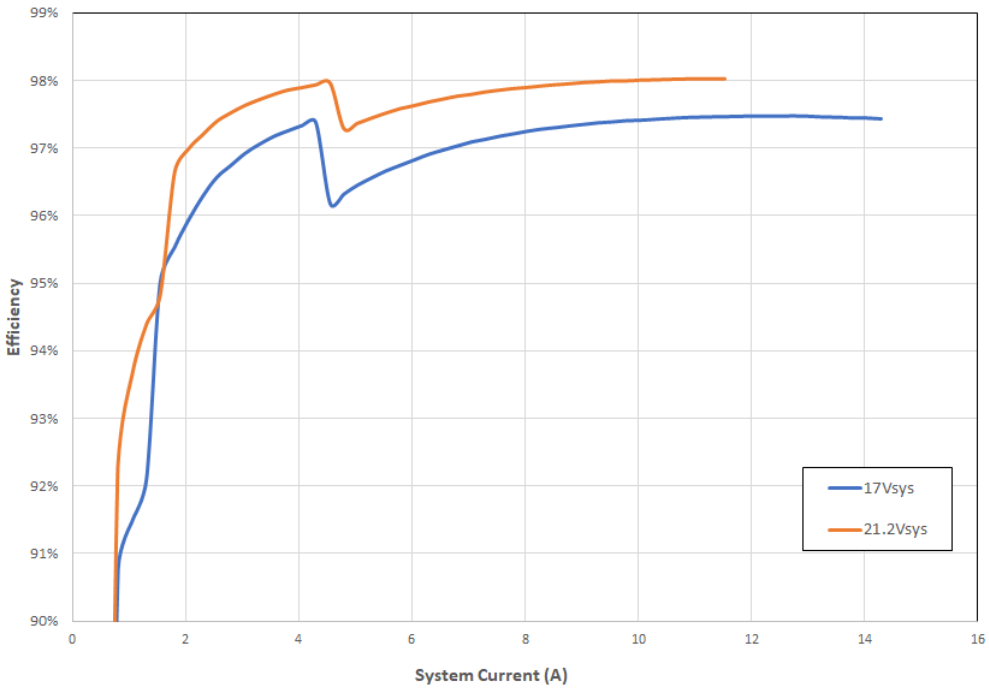


Figure 2-1. 28V_{IN}, 600kHz, 4S System Efficiency

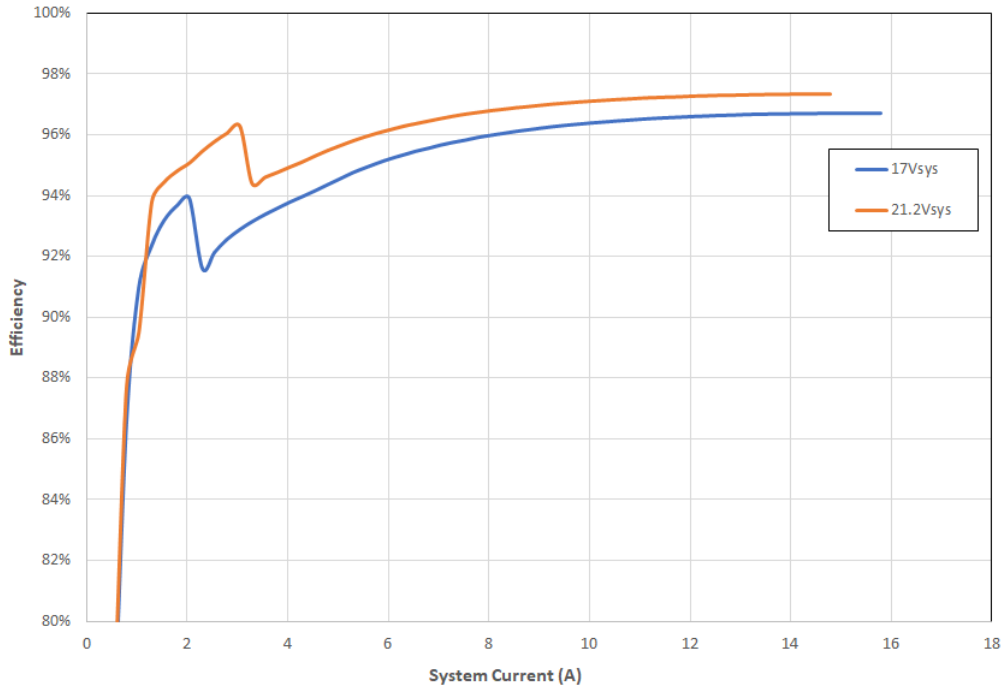


Figure 2-2. 36V_{IN}, 600kHz, 4S System Efficiency

2.2 Efficiency Data

Efficiency data is shown in Table 2-1.

Table 2-1. PMP22405 Efficiency Data

V_{BUS} (V)	I_{BUS} (A)	V_{SYS} (V)	I_{SYS} (A)	V_{BAT} (V)	P_{LOSS} (W)	Efficiency (%)
28.014	0.244	16.996	0.294	16.826	1.839	73.1
28.013	0.854	16.994	1.296	16.826	1.89	92.1
28.013	1.141	16.993	1.797	16.826	1.426	95.5
28.012	1.447	16.993	2.298	16.826	1.501	96.3
28.012	1.745	16.992	2.783	16.826	1.592	96.7
28.012	2.054	16.993	3.286	16.826	1.694	97.1
28.011	2.363	16.992	3.788	16.826	1.816	97.3
28.011	2.671	16.992	4.287	16.826	1.954	97.4
28.011	3.016	16.993	4.789	16.826	3.106	96.3
28.01	3.323	16.993	5.29	16.826	3.195	96.6
28.01	3.631	16.993	5.79	16.826	3.305	96.8
28.01	3.937	16.993	6.29	16.826	3.405	96.9
28.01	4.246	16.993	6.791	16.826	3.526	97.0
28.009	4.545	16.993	7.276	16.826	3.651	97.1
28.009	4.854	16.993	7.778	16.826	3.788	97.2
28.009	5.162	16.993	8.278	16.826	3.927	97.3
28.009	5.473	16.994	8.779	16.826	4.09	97.3
28.008	5.783	16.994	9.281	16.826	4.248	97.4
28.008	6.093	16.993	9.782	16.826	4.422	97.4
28.008	6.403	16.993	10.282	16.826	4.609	97.4
28.008	6.714	16.993	10.784	16.826	4.788	97.5
28.007	7.028	16.994	11.289	16.826	4.989	97.5
28.007	7.339	16.993	11.79	16.826	5.194	97.5

Table 2-1. PMP22405 Efficiency Data (continued)

V_{BUS} (V)	I_{BUS} (A)	V_{SYS} (V)	I_{SYS} (A)	V_{BAT} (V)	P_{LOSS} (W)	Efficiency (%)
28.007	7.64	16.994	12.274	16.826	5.401	97.5
28.007	7.952	16.994	12.775	16.826	5.616	97.5
28.007	8.266	16.994	13.277	16.826	5.873	97.5
28.006	8.579	16.994	13.777	16.826	6.131	97.4
28.006	8.893	16.994	14.279	16.826	6.384	97.4
28.015	0.304	21.195	0.294	21.03	2.287	73.2
28.014	0.653	21.192	0.797	21.03	1.415	92.3
28.014	1.04	21.191	1.298	21.03	1.635	94.4
28.014	1.408	21.19	1.799	21.03	1.321	96.7
28.013	1.79	21.19	2.3	21.03	1.404	97.2
28.013	2.16	21.189	2.785	21.03	1.503	97.5
28.013	2.546	21.189	3.289	21.03	1.631	97.7
28.012	2.93	21.189	3.79	21.03	1.761	97.9
28.012	3.313	21.189	4.289	21.03	1.919	97.9
28.012	3.725	21.19	4.79	21.03	2.832	97.3
28.011	4.108	21.19	5.291	21.03	2.94	97.4
28.011	4.49	21.191	5.792	21.03	3.042	97.6
28.011	4.872	21.191	6.291	21.03	3.166	97.7
28.01	5.256	21.191	6.792	21.03	3.291	97.8
28.01	5.628	21.191	7.278	21.03	3.427	97.8
28.009	6.013	21.191	7.779	21.03	3.575	97.9
28.009	6.396	21.191	8.278	21.03	3.732	97.9
28.009	6.782	21.191	8.78	21.03	3.895	97.9
28.009	7.168	21.191	9.282	21.03	4.059	98.0
28.008	7.554	21.191	9.783	21.031	4.249	98.0
28.008	7.938	21.191	10.283	21.031	4.429	98.0
28.008	8.325	21.191	10.785	21.031	4.62	98.0
28.007	8.715	21.192	11.289	21.03	4.831	98.0
28.007	8.902	21.192	11.532	21.031	4.929	98.0
36.02	0.539	16.993	1.039	16.826	1.746	91
36.02	0.906	16.993	1.8	16.826	2.062	93.7
36.02	1.302	16.994	2.543	16.826	3.684	92.1
36.019	1.666	16.995	3.289	16.826	4.11	93.2
36.019	2.036	16.994	4.047	16.826	4.545	93.8
36.019	2.395	16.994	4.791	16.826	4.858	94.4
36.018	2.75	16.994	5.533	16.826	5.029	94.9
36.018	3.113	16.994	6.292	16.826	5.221	95.3
36.017	3.47	16.994	7.036	16.826	5.41	95.7
36.017	3.827	16.994	7.779	16.826	5.617	95.9
36.017	4.191	16.994	8.537	16.826	5.856	96.1
36.017	4.549	16.994	9.282	16.826	6.098	96.3
36.016	4.908	16.994	10.026	16.826	6.369	96.4
36.016	5.274	16.994	10.785	16.826	6.667	96.5
36.016	5.635	16.994	11.532	16.826	6.964	96.6
36.015	5.995	16.995	12.275	16.826	7.291	96.6
36.015	6.363	16.995	13.035	16.826	7.633	96.7
36.015	6.724	16.995	13.778	16.826	8.007	96.7

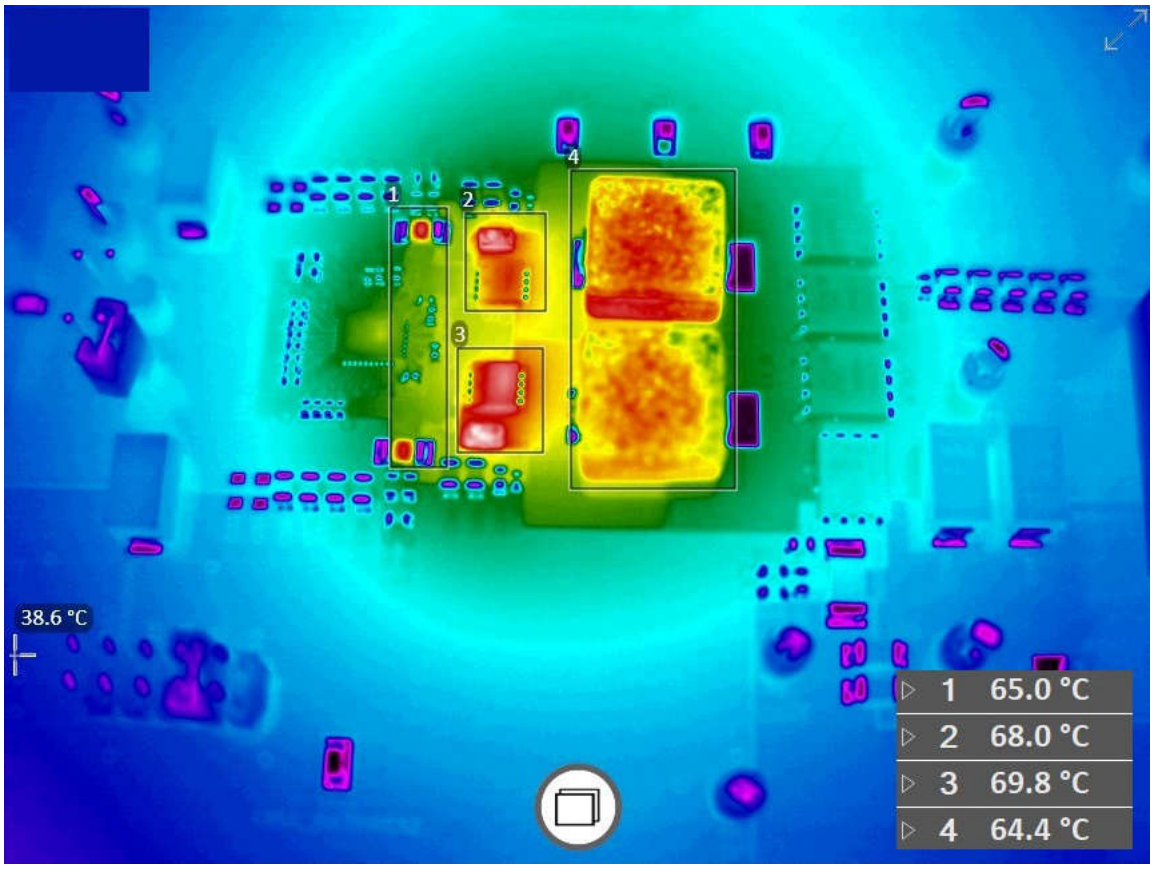
Table 2-1. PMP22405 Efficiency Data (continued)

V_{BUS} (V)	I_{BUS} (A)	V_{SYS} (V)	I_{SYS} (A)	V_{BAT} (V)	P_{LOSS} (W)	Efficiency (%)
36.014	7.086	16.995	14.521	16.826	8.401	96.7
36.014	7.457	16.995	15.282	16.826	8.827	96.7
36.014	7.701	16.995	15.782	16.827	9.111	96.7
36.02	0.535	21.196	0.797	21.03	2.364	87.7
36.02	0.815	21.193	1.299	21.03	1.817	93.8
36.02	1.117	21.192	1.8	21.03	2.091	94.8
36.02	1.418	21.191	2.301	21.03	2.321	95.5
36.019	1.707	21.191	2.786	21.03	2.434	96
36.019	2.05	21.192	3.29	21.03	4.142	94.4
36.019	2.354	21.193	3.791	21.03	4.445	94.8
36.018	2.654	21.192	4.29	21.03	4.679	95.1
36.018	2.953	21.192	4.792	21.03	4.808	95.5
36.018	3.251	21.193	5.292	21.03	4.923	95.8
36.018	3.548	21.193	5.793	21.03	5.038	96.1
36.017	3.845	21.192	6.292	21.031	5.159	96.3
36.017	4.144	21.193	6.793	21.03	5.302	96.4
36.017	4.434	21.193	7.279	21.031	5.42	96.6
36.017	4.733	21.193	7.78	21.031	5.57	96.7
36.016	5.031	21.193	8.279	21.031	5.732	96.8
36.016	5.331	21.194	8.781	21.03	5.903	96.9
36.015	5.631	21.194	9.283	21.031	6.067	97
36.015	5.931	21.194	9.784	21.03	6.248	97.1
36.015	6.231	21.194	10.284	21.03	6.436	97.1
36.014	6.532	21.194	10.785	21.03	6.64	97.2
36.014	6.834	21.194	11.29	21.031	6.841	97.2
36.014	7.136	21.195	11.791	21.031	7.073	97.2
36.014	7.426	21.195	12.275	21.031	7.279	97.3
36.013	7.728	21.196	12.776	21.031	7.516	97.3
36.013	8.03	21.196	13.277	21.031	7.759	97.3
36.013	8.332	21.196	13.778	21.031	8.024	97.3
36.013	8.635	21.196	14.28	21.031	8.292	97.3
36.012	8.937	21.196	14.78	21.031	8.577	97.3

2.3 Thermal Images

The PMP22405 design was tested with a 4S battery at room temperature and natural convection as shown in Figure 2-3 and Figure 2-4.

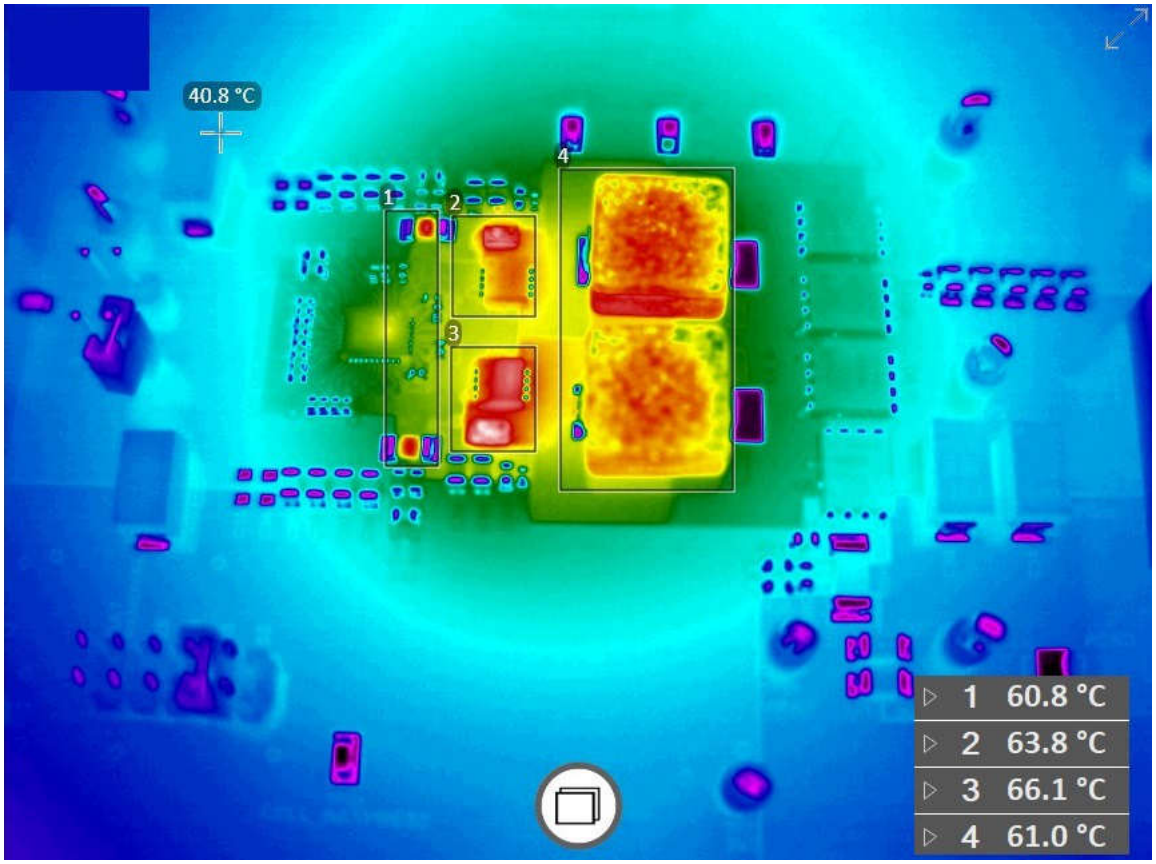
Figure 2-3 shows test results at $36V_{IN}$, $14.8V_{BAT}$, 180W, 600kHz.



1. R_{AC} temperature = 65.0°C
2. Phase A FETs = 68.0°C
3. Phase B FETs = 69.8°C
4. IND temperature = 64.4°C

Figure 2-3. Thermal Image ($36V_{IN}$, $14.8V_{BAT}$, 180W)

Figure 2-4 shows test results at $36V_{IN}$, $17.8V_{BAT}$, 180W, 600kHz.



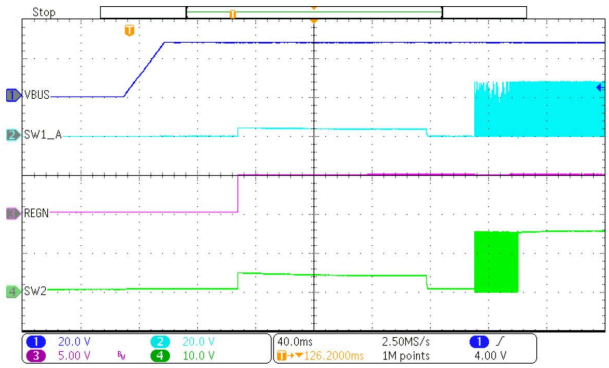
1. R_{AC} temperature = 60.8°C
2. Phase A FETs = 63.8°C
3. Phase B FETs = 66.1°C
4. IND temperature = 61.0°C

Figure 2-4. Thermal Image ($36V_{IN}$, $17.8V_{BAT}$, 180W)

3 Waveforms

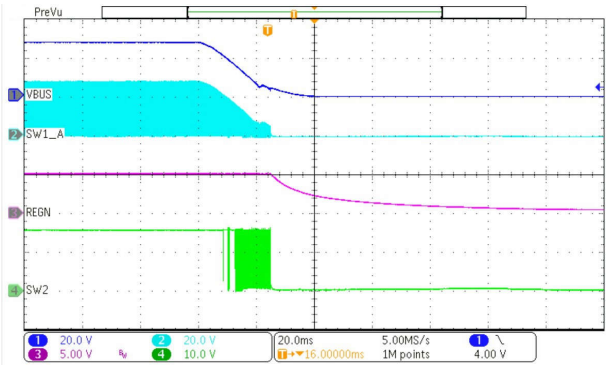
3.1 Start-Up and Shutdown

Start-up and shutdown waveforms are shown in Figure 3-1 and Figure 3-2.



V_{IN} = 28V, V_{BAT} = 15V, I_{CHG} = 3A

Figure 3-1. Start-Up

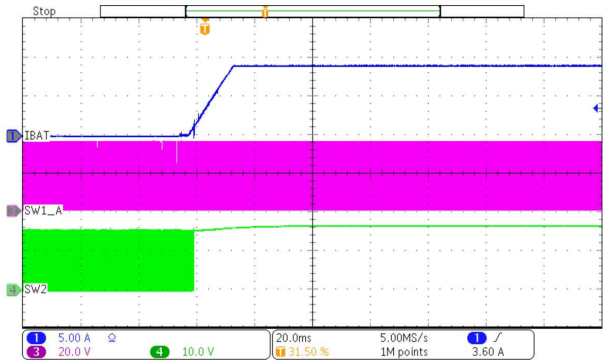


V_{IN} = 28V, V_{BAT} = 15V, I_{CHG} = 3A

Figure 3-2. Shutdown

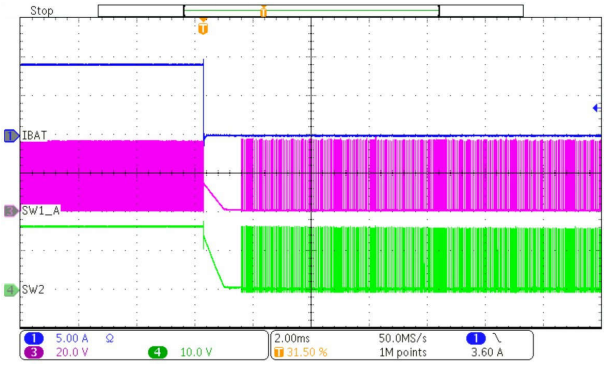
3.2 Charge Enable and Disable

Charge enable and disable waveforms are shown in Figure 3-3 and Figure 3-4.



V_{IN} = 36V, V_{BAT} = 14.8V, I_{CHG} = 9A

Figure 3-3. Charge Enable

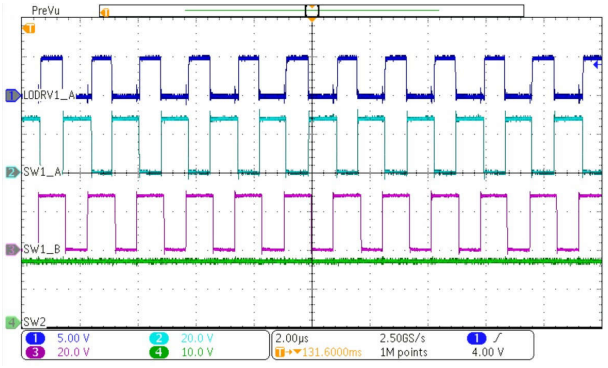


V_{IN} = 36V, V_{BAT} = 14.8V, I_{CHG} = 9A

Figure 3-4. Charge Disable

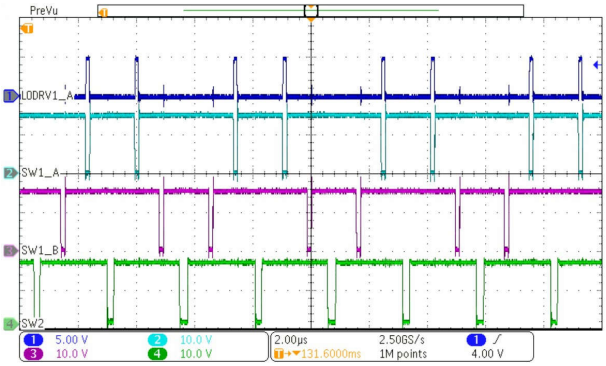
3.3 Typical Charge Waveforms

Typical charge waveforms are shown in Figure 3-5 and Figure 3-6.



V_{IN} = 28V, V_{BAT} = 15V, I_{CHG} = 3A

Figure 3-5. Typical PWM Charge Waveform in Buck Mode

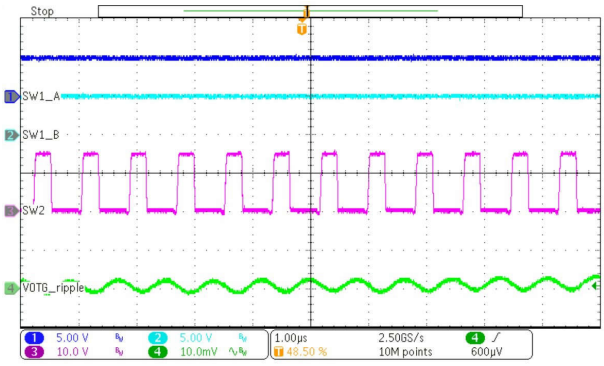


V_{IN} = 15V, V_{BAT} = 15V, I_{CHG} = 3A

Figure 3-6. Typical PWM Charge Waveform in Buck-Boost Mode

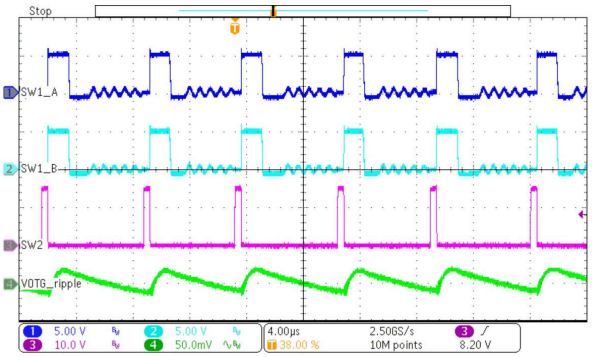
3.4 Typical OTG Waveforms

Typical OTG waveforms are shown in Figure 3-7 and Figure 3-8.



V_{BAT} = 14.8V, V_{OTG} = 5V, I_{OTG} = 3A

Figure 3-7. Typical PWM OTG Waveform

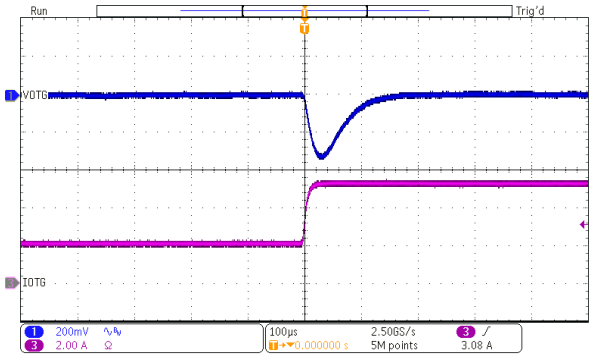


V_{BAT} = 14.8V, V_{OTG} = 5V, I_{OTG} = 200mA

Figure 3-8. Typical PFM OTG Waveform

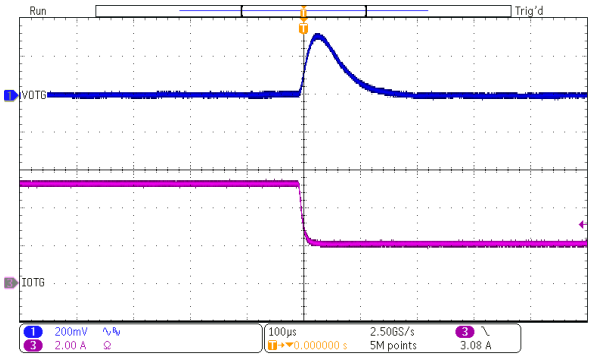
3.5 OTG Transient

OTG transient waveforms are shown in Figure 3-9 and Figure 3-10.



V_{BAT} = 17.8V, V_{OTG} = 5V, I_{OTG} = 2A to 5A,
C_{OTG} = 4.7µF × 12 + 10µF × 2 + 100µF,
EN_OTG_BIG_CAP = 1

Figure 3-9. OTG Transient (Rising Edge)



V_{BAT} = 17.8V, V_{OTG} = 5V, I_{OTG} = 5A to 2A,
C_{OTG} = 4.7µF × 12 + 10µF × 2 + 100µF,
EN_OTG_BIG_CAP = 1

Figure 3-10. OTG Transient (Falling Edge)

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