Test Report: PMP22419

140-W, High-Density Battery Charger Reference Design

Description

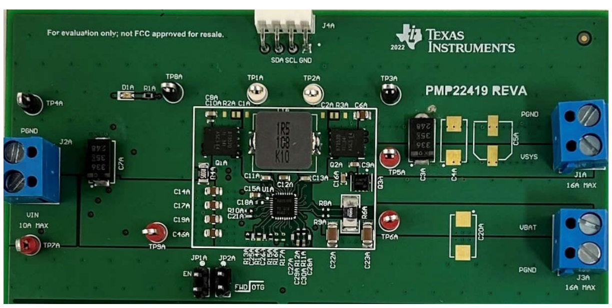
This battery charger is designed for a 20-V_{IN}, 140-W notebook personal computer (PC), featuring the BQ25720 1-to-4 cell narrow voltage DC (NVDC) buck-boost battery charge controller. This battery charger delivers 140-W with 97.2% efficiency and fits in a compact 1-in × 1.3-in (25.4-mm × 33.0-mm) form factor. The high-density design utilizes TI dual field-effect transistor (FET) - CSD87352 and reduces the design size by 40% compared to a discrete FET design. Due to the low thermal resistance of TI dual FETs, the device temperature is kept low, even with a smaller design size. This reference design is an excellent choice for notebook PCs where high power, high efficiency, and high density are top priorities. The design supports a 1-to-4S battery and accepts a wide input range such as USB Type-C® Power Delivery (PD) sources and traditional adapters.

Features

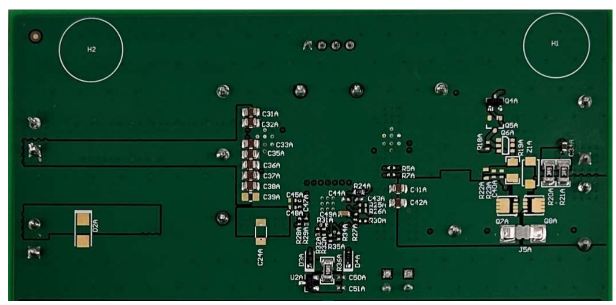
- 16-A maximum charge current
- 97.2% efficiency at 16.8 V, 140 W
- Compact size: 1 in × 1.3 in (25.4 mm × 33.0 mm)
- Low thermal resistance dual FET package
- Excellent thermal performance

Applications

- Standard notebook PC
- Tablet (multimedia)
- Ventilators



PMP22419 Board (Front)



PMP22419 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 V – 26 V
Output voltage, V_{OUT}	12 V – 19.36 V
Input current	10-A maximum
Output current	16-A maximum

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.)

1.3 Dimensions

1 in × 1.3 in (25.4 mm × 33.0 mm)

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

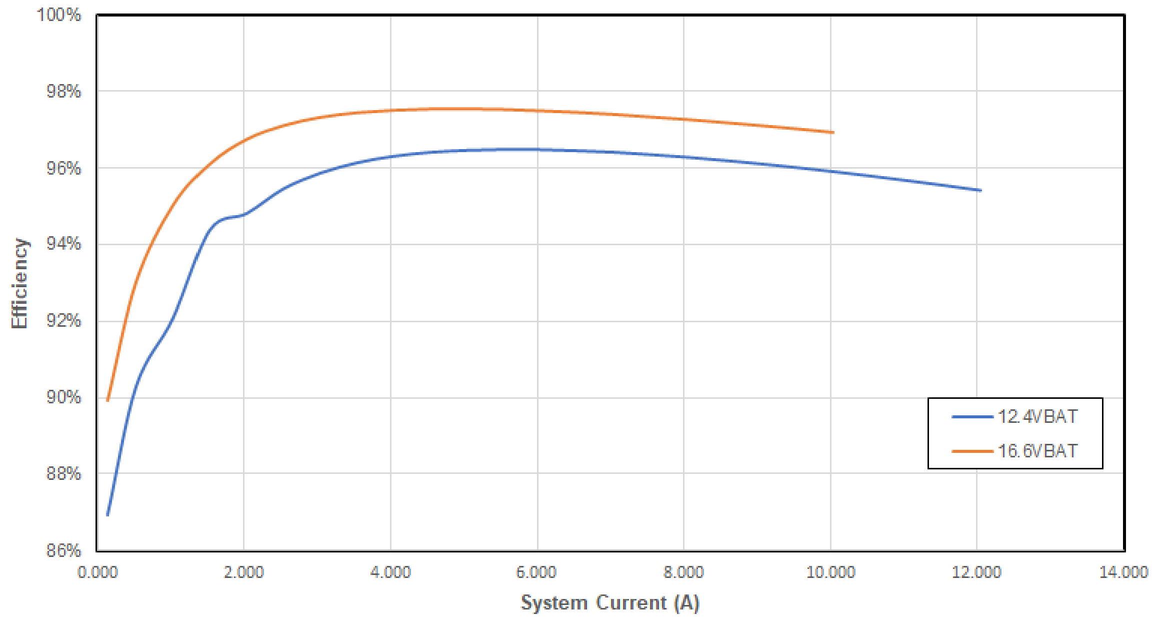


Figure 2-1. 20 V_{IN}, 800-kHz, 3S and 4S System Efficiency

2.2 Efficiency Data

Efficiency data is shown in the following table.

Table 2-1. PMP22419 Efficiency Data

V_{IN} (V)	I_{IN} (A)	V_{SYS} (V)	I_{SYS} (A)	V_{BAT} (V)	P_{LOSS} (W)	Efficiency (%)
20.006	0.108	12.586	0.150	12.421	0.283	86.93
20.005	0.374	12.586	0.537	12.421	0.727	90.29
20.005	0.710	12.586	1.039	12.421	1.125	92.07
20.004	1.027	12.586	1.541	12.421	1.152	94.39
20.003	1.355	12.585	2.042	12.421	1.404	94.82
20.003	1.676	12.585	2.544	12.421	1.520	95.47
20.003	2.000	12.585	3.048	12.421	1.650	95.88
20.002	2.323	12.585	3.550	12.421	1.789	96.15
20.001	2.646	12.585	4.051	12.421	1.949	96.32
20.001	2.971	12.585	4.552	12.421	2.126	96.42
20.000	3.286	12.585	5.038	12.421	2.318	96.47
20.000	3.612	12.585	5.539	12.421	2.530	96.50
19.999	3.939	12.585	6.041	12.421	2.765	96.49
19.999	4.267	12.584	6.540	12.421	3.019	96.46
19.998	4.596	12.584	7.042	12.421	3.289	96.42
19.997	4.926	12.584	7.544	12.421	3.584	96.36
19.997	5.258	12.584	8.045	12.421	3.898	96.29

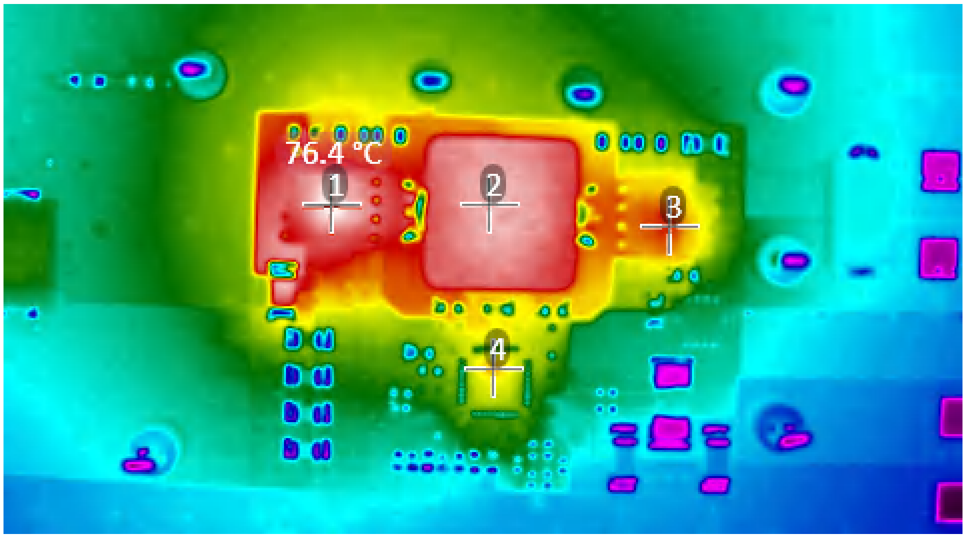
Table 2-1. PMP22419 Efficiency Data (continued)

V_{IN} (V)	I_{IN} (A)	V_{SYS} (V)	I_{SYS} (A)	V_{BAT} (V)	P_{LOSS} (W)	Efficiency (%)
19.996	5.589	12.584	8.544	12.421	4.237	96.21
19.996	5.923	12.584	9.046	12.421	4.597	96.12
19.995	6.247	12.584	9.531	12.421	4.968	96.02
19.994	6.582	12.583	10.031	12.421	5.374	95.92
19.994	6.917	12.583	10.530	12.421	5.805	95.80
19.993	7.256	12.582	11.031	12.421	6.263	95.68
19.992	7.596	12.582	11.534	12.421	6.748	95.56
19.992	7.937	12.582	12.034	12.421	7.260	95.42
20.006	0.138	16.780	0.148	16.627	0.278	89.93
20.005	0.484	16.779	0.536	16.627	0.674	93.03
20.004	0.916	16.779	1.038	16.627	0.910	95.04
20.004	1.344	16.779	1.540	16.627	1.041	96.13
20.003	1.770	16.779	2.042	16.627	1.142	96.77
20.002	2.197	16.779	2.544	16.627	1.259	97.13
20.001	2.627	16.779	3.049	16.627	1.393	97.35
20.000	3.056	16.779	3.551	16.627	1.547	97.47
20.000	3.484	16.779	4.051	16.627	1.717	97.54
19.999	3.915	16.779	4.553	16.627	1.906	97.57
19.998	4.332	16.779	5.038	16.627	2.104	97.57
19.998	4.764	16.779	5.539	16.627	2.329	97.55
19.997	5.197	16.779	6.041	16.627	2.577	97.52
19.996	5.630	16.779	6.540	16.627	2.839	97.48
19.995	6.066	16.778	7.043	16.627	3.124	97.42
19.995	6.502	16.778	7.544	16.627	3.435	97.36
19.994	6.939	16.778	8.045	16.627	3.760	97.29
19.993	7.376	16.778	8.544	16.627	4.112	97.21
19.992	7.815	16.778	9.045	16.627	4.482	97.13
19.991	8.242	16.777	9.531	16.627	4.866	97.05
19.991	8.683	16.777	10.031	16.627	5.288	96.95

2.3 Thermal Images

The PMP22419 design was tested with a 4S battery at room temperature and natural convection as shown in the following figures.

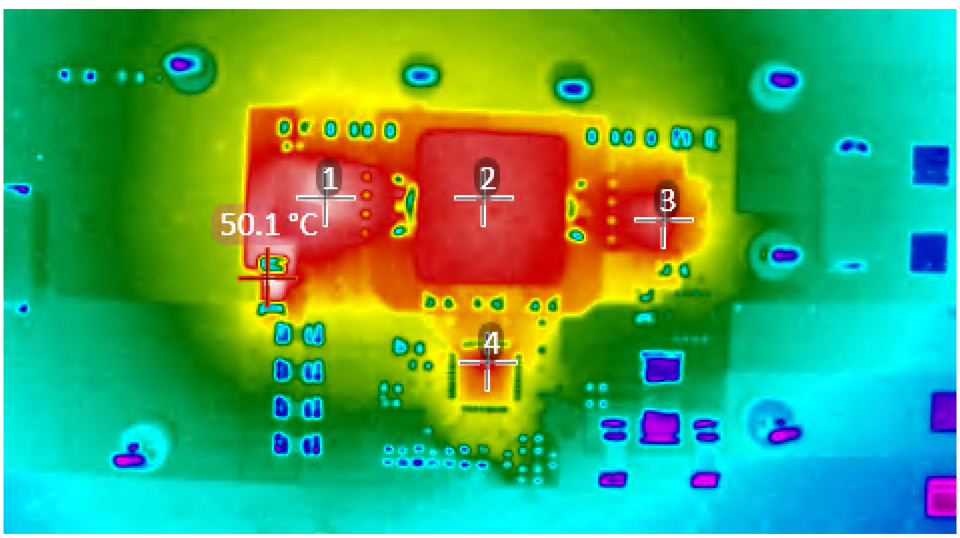
Figure 2-2 shows test results at 20 V_{IN}, 12 V_{BAT}, 130 W, 800 kHz.



Q1 FET temperature = 76.4°C, IND temperature = 74.3°C
Q4 FET temperature = 66.8°C, IC temperature = 63.4°C

Figure 2-2. Thermal Image (20 V_{IN}, 12 V_{BAT}, 130 W)

Figure 2-3 shows test results at 20 V_{IN}, 18 V_{BAT}, 130 W, 800 kHz.



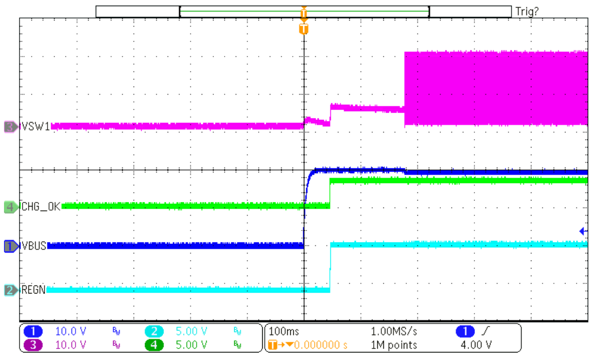
Q1 FET temperature = 48.6°C, IND temperature = 46.8°C
Q4 FET temperature = 46.3°C, IC temperature = 45.8°C

Figure 2-3. Thermal Image (20 V_{IN}, 18 V_{BAT}, 130 W)

3 Waveforms

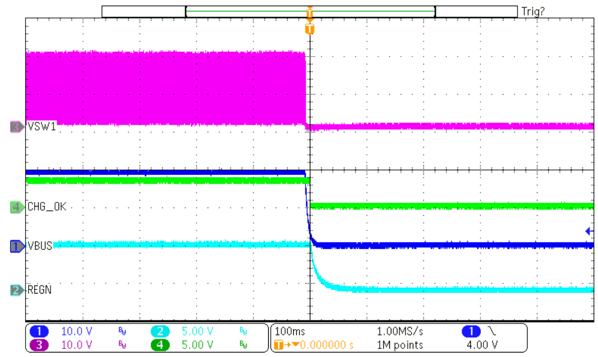
3.1 Start-Up and Shutdown

Start-up and shutdown waveforms are shown in the following figures.



V_{IN} = 20 V, V_{BAT} = 16 V, I_{SYS} = 8 A

Figure 3-1. Start-Up

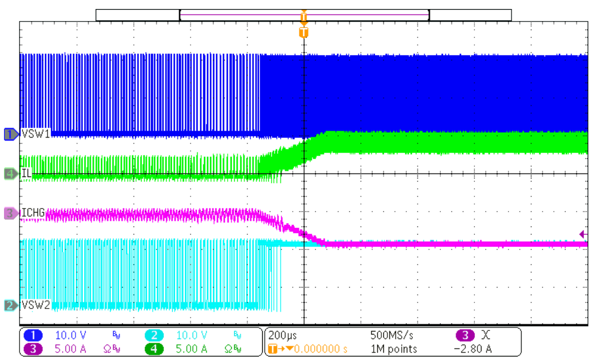


V_{IN} = 20 V, V_{BAT} = 16 V, I_{SYS} = 8 A

Figure 3-2. Shutdown

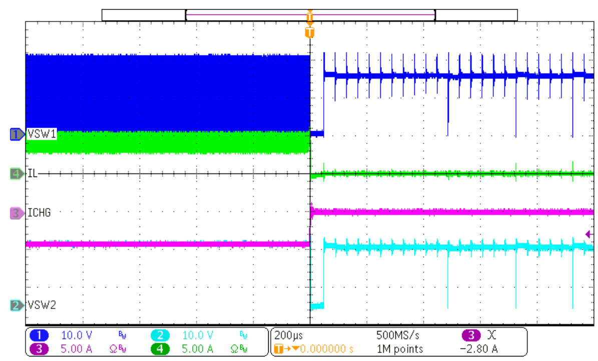
3.2 Charge Enable and Disable

Charge enable and disable waveforms are shown in the following figures.



V_{IN} = 20 V, V_{BAT} = 16 V, V_{SYS} = 16.3 V, I_{CHG} = 4 A

Figure 3-3. Charge Enable

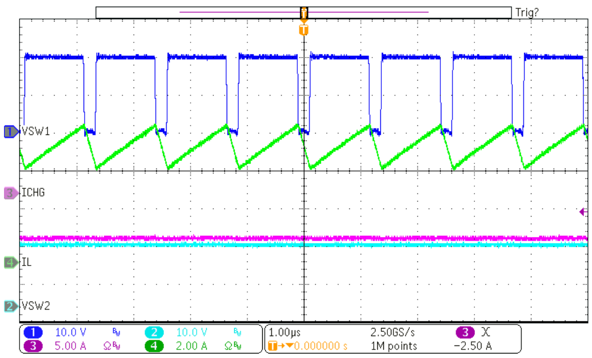


V_{IN} = 20 V, V_{BAT} = 16 V, V_{SYS} = 16.3 V, I_{CHG} = 4 A

Figure 3-4. Charge Disable

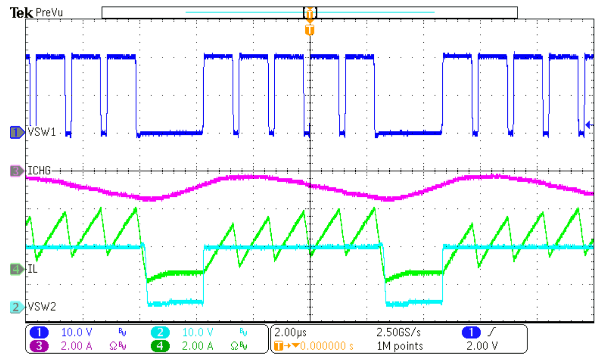
3.3 Typical Charge Waveforms

Typical charge waveforms are shown in the following figures.



V_{IN} = 20 V, V_{BAT} = 16 V, I_{CHG} = 6 A

Figure 3-5. Typical PWM Charge Waveform

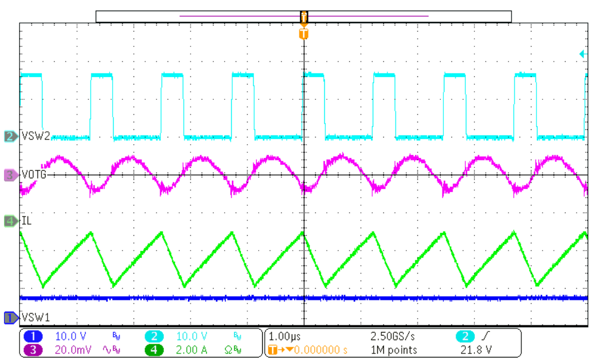


V_{IN} = 20 V, V_{BAT} = 16 V, I_{CHG} = 1 A

Figure 3-6. Typical PFM Charge Waveform

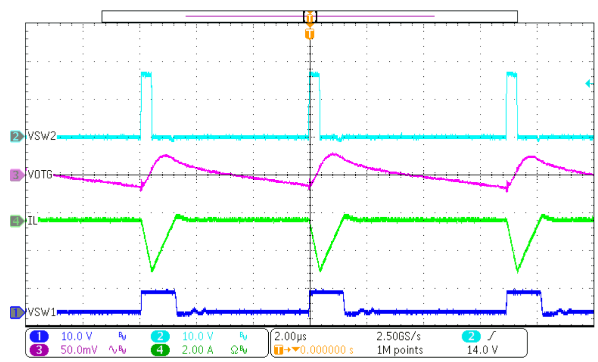
3.4 Typical OTG Waveforms

Typical OTG waveforms are shown in the following figures.



V_{BAT} = 16 V, V_{OTG} = 5 V, I_{OTG} = 2 A

Figure 3-7. Typical PWM OTG Waveform

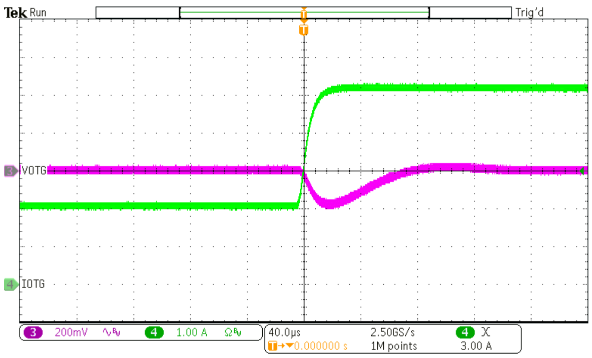


V_{BAT} = 16 V, V_{OTG} = 5 V, I_{OTG} = 200 mA

Figure 3-8. Typical PFM OTG Waveform

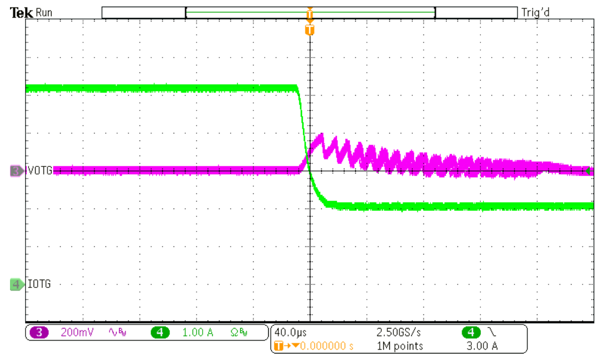
3.5 OTG Transient

OTG transient waveforms are shown in the following figures.



V_{BAT} = 10 V, V_{OTG} = 5 V,
I_{OTG} = 2 A to 5 A, C_{OTG}= 10 µF × 6 + 33 µF + 100 µF

Figure 3-9. OTG Transient (Rising Edge)



V_{BAT} = 10 V, V_{OTG} = 5 V,
I_{OTG} = 5 A to 2 A, C_{OTG}= 10 µF × 6 + 33 µF + 100 µF

Figure 3-10. OTG Transient (Falling Edge)

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