

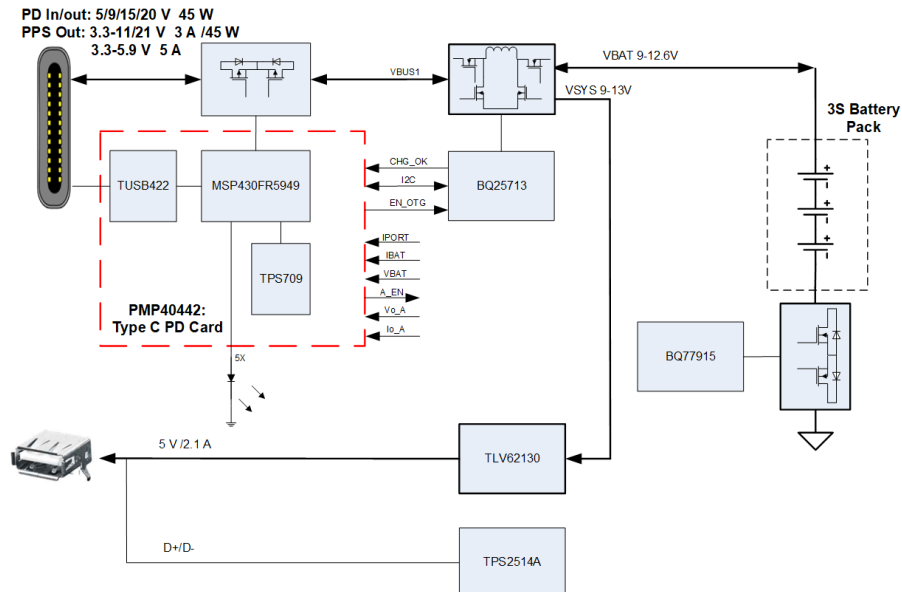
## Test Report: PMP40441

# Multi-Cell Buck-Boost Battery Charger System Reference Design for USB PD PPS

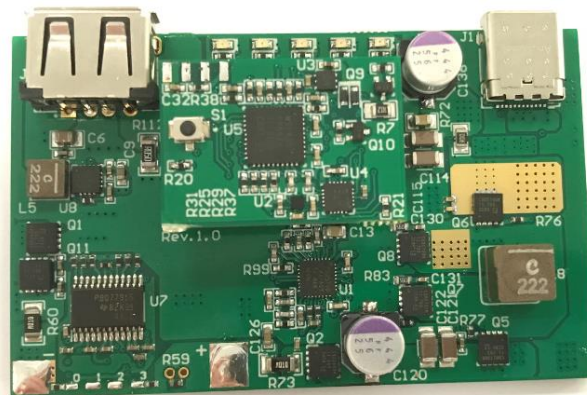


### Description

This reference design is for USB Power Delivery (PD) battery charging applications, such as power banks or other portable devices. It employs the Buck-Boost charger BQ25713 for a wide input and output range for USB PD charging. The USB PD controller card (PMP40442) can configure the charger to run both charging or OTG via the same power path. The PMP40441/2 is compatible with PD2.0. It also demonstrates BQ25713's capability to support PD's Programmable Power Supply (PPS) standard. In the OTG direction (i.e. the power bank as a power source), the USB port can output a fixed USB PD voltage – 5/9/15/20 V and USB PD PPS voltage from 3.3 V to 5.9 V with smaller than 20 mV step. A USB-A port is also included as a dedicated OTG source.



PMP40441: Multi-Cell Buck-Boost Battery Charger System Reference Design for USB PD PPS



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## 1 Test Prerequisites

### 1.1 Voltage and Current Requirements

**Table 1. Voltage and Current Requirements**

PARAMETER	SPECIFICATIONS
Type-C Input Voltage	5~20V
Type-C Maximum Input Current	3A
Battery Voltage	9~12.6V
Type-C Output Voltage	4~20V
Type-C Maximum Output Power	45W
Type-A Output Voltage	5V
Type-A Maximum Output Current	2.1A

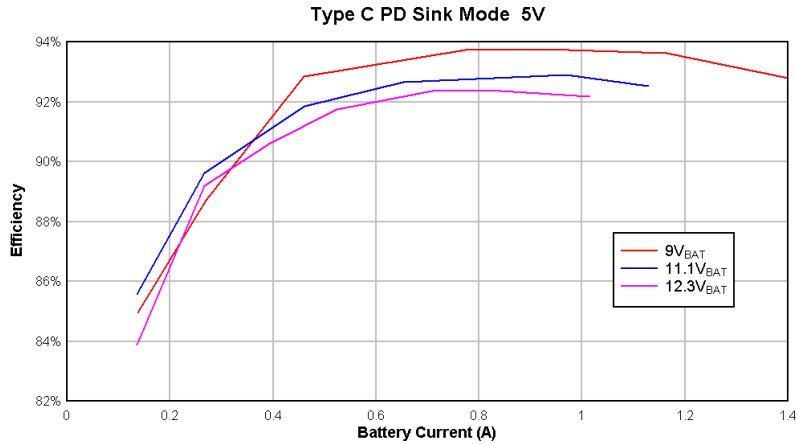
### 1.2 Required Equipment

- Multi-meter (current): Fluke 287C
- Multi-meter (voltage): Fluke 287C
- DC Source: Chroma 62006P-100-25
- Battery Simulator: ASunDar ASD906A
- E-Load: Chroma 63105A module
- Oscilloscope: Tektronix DPO3054
- Electrical Thermography: Fluke Ti9

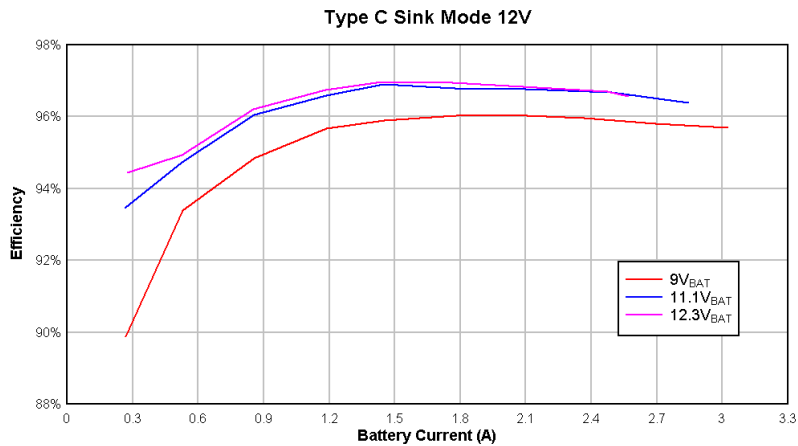
## 2 Testing and Results

### 2.1 Efficiency Graphs

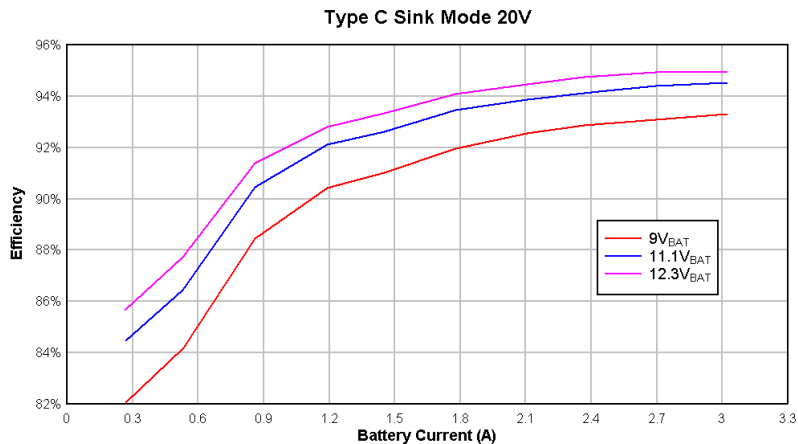
#### 2.1.1 USB Type-C PD Sink Mode 5V



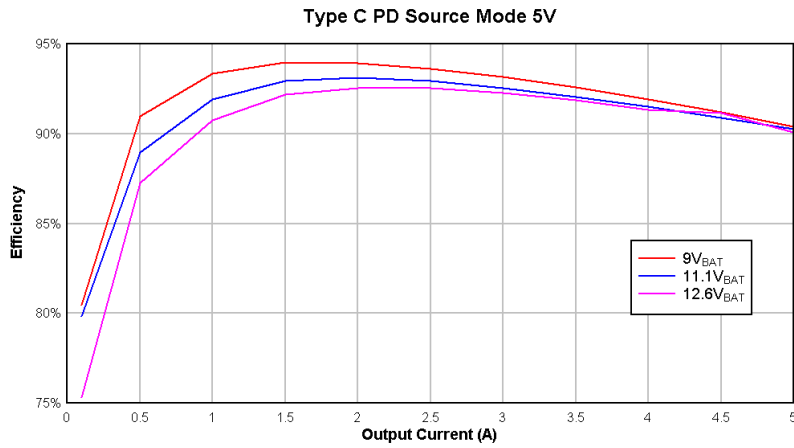
#### 2.1.2 USB Type-C PD Sink Mode 12V



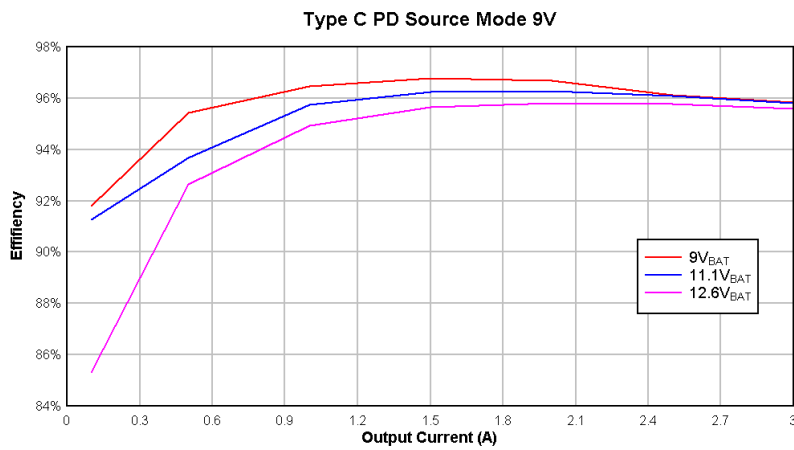
#### 2.1.3 USB Type-C PD Sink Mode 20V



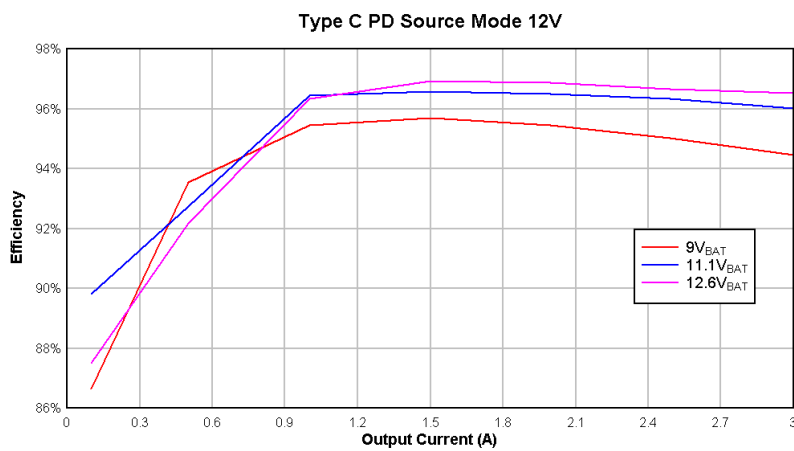
### 2.1.4 USB Type-C PD Source Mode 5V



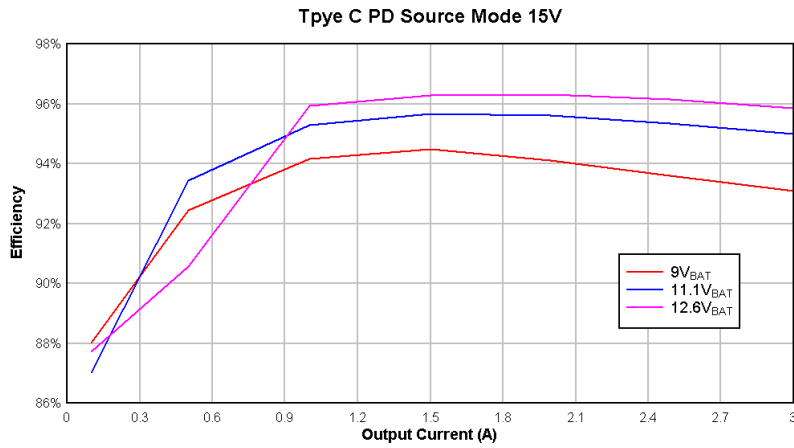
### 2.1.5 USB Type-C Source Mode 9V



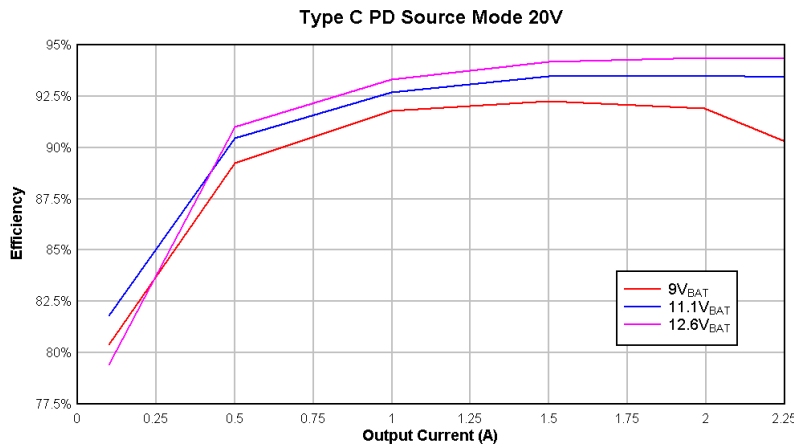
### 2.1.6 USB Type-C PD Source Mode 12V



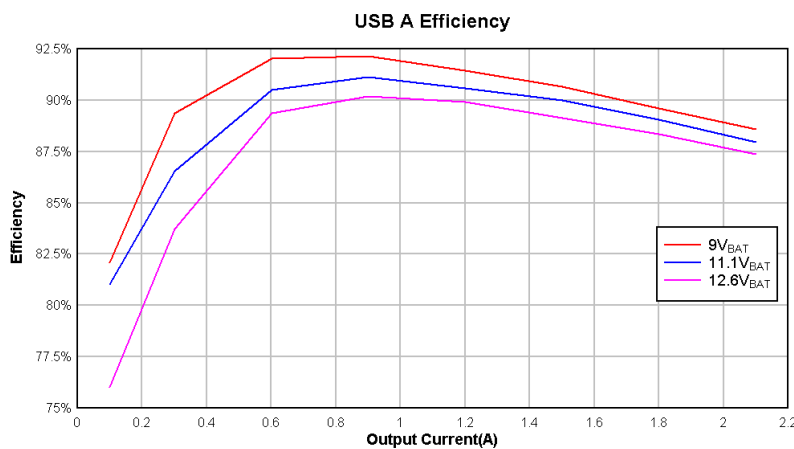
### 2.1.7 USB Type-C PD Source Mode 15V



### 2.1.8 USB Type-C PD Source Mode 20V



### 2.1.9 USB A



## 2.2 Efficiency Data

### 2.2.1 USB Type-C PD Sink Mode 5V

V <sub>IN</sub> /V	I <sub>IN</sub> /A	V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	loss/W	Eff/%
5.082	0.286	9.006	0.137	0.219	84.95%
5.052	0.540	9.007	0.269	0.308	88.71%
5.013	0.890	9.005	0.460	0.319	92.84%
5.041	1.492	9.009	0.783	0.470	93.75%
4.997	1.871	9.000	0.974	0.587	93.72%
5.052	2.218	9.005	1.165	0.714	93.63%
4.998	2.718	9.007	1.400	0.979	92.79%
5.077	0.344	11.103	0.135	0.252	85.57%
5.041	0.654	11.104	0.266	0.342	89.63%
5.089	1.094	11.103	0.461	0.454	91.84%
5.033	1.557	11.100	0.654	0.575	92.67%
5.046	2.295	11.100	0.969	0.821	92.91%
4.998	2.710	11.109	1.128	1.011	92.53%
5.070	0.390	12.305	0.135	0.319	83.89%
5.031	0.728	12.301	0.266	0.395	89.20%
5.091	1.052	12.301	0.395	0.502	90.63%
5.049	1.392	12.302	0.524	0.579	91.75%
5.089	1.876	12.301	0.717	0.726	92.40%
5.050	2.222	12.305	0.842	0.858	92.36%
4.998	2.711	12.300	1.015	1.061	92.17%

### 2.2.2 USB Type-C PD Sink Mode 12V

V <sub>IN</sub> /V	I <sub>IN</sub> /A	V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	loss/W	Eff/%
12.001	0.223	9.000	0.267	0.270	89.89%
12.074	0.422	9.000	0.529	0.337	93.39%
12.043	0.676	9.006	0.857	0.420	94.84%
12.014	0.931	9.005	1.188	0.483	95.68%
12.090	1.126	9.002	1.451	0.559	95.90%
12.058	1.384	9.005	1.780	0.660	96.04%
12.026	1.642	9.002	2.107	0.785	96.03%
12.003	1.852	9.009	2.368	0.899	95.96%
12.070	2.099	9.006	2.695	1.064	95.80%
12.041	2.363	9.006	3.024	1.224	95.70%
12.089	0.261	11.101	0.266	0.207	93.45%
12.056	0.512	11.099	0.527	0.325	94.74%
12.026	0.822	11.105	0.855	0.391	96.05%
11.989	1.137	11.101	1.186	0.464	96.59%

12.062	1.376	11.098	1.449	0.512	96.91%
12.022	1.693	11.102	1.775	0.653	96.79%
11.990	2.010	11.104	2.100	0.781	96.76%
12.040	2.376	11.104	2.491	0.948	96.69%
12.000	2.733	11.108	2.846	1.185	96.39%
12.089	0.295	12.303	0.274	0.198	94.45%
12.056	0.565	12.303	0.526	0.345	94.93%
12.015	0.908	12.306	0.853	0.412	96.22%
11.978	1.254	12.301	1.182	0.490	96.74%
12.048	1.517	12.300	1.441	0.555	96.96%
12.010	1.865	12.304	1.765	0.685	96.94%
12.068	2.195	12.300	2.086	0.836	96.84%
12.019	2.617	12.305	2.472	1.034	96.71%
12.008	2.727	12.304	2.570	1.125	96.57%

### 2.2.3 USB Type-C PD Sink Mode 20V

V <sub>IN</sub> /V	I <sub>IN</sub> /A	V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	loss/W	Eff/%
20.007	0.147	9.005	0.268	0.528	82.06%
19.989	0.285	9.000	0.533	0.900	84.20%
20.072	0.436	9.000	0.860	1.011	88.44%
20.055	0.591	9.004	1.190	1.137	90.41%
20.045	0.716	9.004	1.450	1.289	91.01%
20.025	0.869	8.998	1.778	1.401	91.95%
20.004	1.023	9.002	2.105	1.523	92.56%
19.993	1.147	9.000	2.366	1.635	92.87%
20.075	1.297	9.000	2.693	1.798	93.10%
20.058	1.454	9.005	3.022	1.950	93.31%
20.000	0.177	11.102	0.269	0.550	84.46%
19.984	0.341	11.100	0.531	0.924	86.44%
20.062	0.526	11.097	0.860	1.006	90.47%
20.042	0.716	11.100	1.191	1.129	92.13%
20.020	0.869	11.100	1.451	1.282	92.62%
20.000	1.056	11.100	1.779	1.379	93.47%
19.981	1.246	11.100	2.106	1.524	93.88%
20.063	1.429	11.102	2.432	1.666	94.19%
20.044	1.581	11.106	2.693	1.778	94.39%
20.020	1.773	11.103	3.022	1.947	94.52%
20.000	0.191	12.300	0.266	0.548	85.65%
19.982	0.372	12.300	0.530	0.913	87.72%
20.058	0.577	12.297	0.860	0.994	91.41%
20.033	0.787	12.300	1.190	1.135	92.80%

20.013	0.955	12.305	1.450	1.271	93.35%
19.990	1.163	12.304	1.778	1.372	94.10%
20.066	1.365	12.296	2.104	1.514	94.47%
20.046	1.533	12.303	2.367	1.613	94.75%
20.018	1.743	12.300	2.693	1.766	94.94%
20.001	1.956	12.296	3.021	1.971	94.96%

## 2.2.4 USB Type-C PD Source Mode 5V

$V_{BAT}/V$	$I_{BAT}/A$	$V_{OUT}/V$	$I_{OUT}/A$	loss/W	Eff/%
9.003	0.070	5.041	0.100	0.123	80.45%
9.001	0.308	5.027	0.501	0.249	90.99%
9.002	0.596	5.009	1.000	0.358	93.33%
9.002	0.886	4.992	1.501	0.479	93.99%
9.001	1.177	4.975	2.000	0.641	93.94%
9.000	1.471	4.956	2.500	0.847	93.60%
9.000	1.768	4.938	3.001	1.090	93.15%
9.002	2.066	4.919	3.501	1.379	92.58%
9.000	2.369	4.899	4.000	1.725	91.91%
9.001	2.676	4.879	4.501	2.124	91.18%
9.001	2.985	4.856	5.000	2.584	90.38%
11.101	0.057	5.041	0.100	0.128	79.81%
11.101	0.255	5.027	0.501	0.313	88.94%
11.101	0.491	5.009	1.000	0.442	91.90%
11.102	0.726	4.992	1.501	0.567	92.96%
11.100	0.962	4.973	2.000	0.737	93.10%
11.101	1.200	4.955	2.500	0.938	92.96%
11.100	1.442	4.936	3.001	1.191	92.56%
11.102	1.684	4.916	3.500	1.488	92.04%
11.099	1.928	4.896	4.000	1.819	91.50%
11.101	2.175	4.875	4.501	2.206	90.87%
11.102	2.423	4.854	5.000	2.625	90.24%
12.601	0.053	5.039	0.100	0.165	75.31%
12.601	0.229	5.025	0.501	0.367	87.28%
12.601	0.438	5.008	1.000	0.511	90.74%
12.600	0.645	4.991	1.501	0.634	92.19%
12.600	0.853	4.973	2.000	0.799	92.56%
12.602	1.062	4.955	2.500	0.996	92.56%
12.603	1.274	4.936	3.001	1.241	92.27%
12.603	1.487	4.917	3.501	1.522	91.87%
12.603	1.702	4.897	4.000	1.860	91.33%
12.603	1.911	4.877	4.501	2.133	91.14%
12.600	2.139	4.855	5.000	2.673	90.08%



## 2.2.5 USB Type-C PD Source Mode 9V

V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	V <sub>OUT</sub> /V	I <sub>OUT</sub> /A	loss/W	Eff/%
9.000	0.110	9.016	0.101	0.081	91.81%
9.002	0.525	9.005	0.501	0.216	95.42%
9.000	1.036	8.992	1.000	0.329	96.47%
9.004	1.547	8.979	1.501	0.447	96.79%
9.001	2.062	8.966	2.001	0.615	96.69%
9.000	2.587	8.952	2.500	0.904	96.12%
9.001	3.109	8.936	3.001	1.164	95.84%
11.098	0.090	9.016	0.101	0.087	91.27%
11.100	0.434	9.007	0.501	0.305	93.67%
11.102	0.846	8.993	1.000	0.402	95.73%
11.104	1.262	8.982	1.501	0.527	96.24%
11.100	1.679	8.969	2.001	0.694	96.28%
11.101	2.099	8.955	2.500	0.912	96.08%
11.102	2.523	8.941	3.001	1.176	95.80%
12.600	0.084	9.018	0.100	0.155	85.31%
12.600	0.386	9.008	0.500	0.358	92.63%
12.600	0.752	8.996	1.000	0.482	94.92%
12.600	1.119	8.982	1.501	0.611	95.66%
12.600	1.486	8.969	2.000	0.784	95.81%
12.603	1.855	8.955	2.500	0.987	95.78%
12.601	2.227	8.941	3.001	1.234	95.60%

## 2.2.6 USB Type-C PD Source Mode 12V

V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	V <sub>OUT</sub> /V	I <sub>OUT</sub> /A	loss/W	Eff/%
8.996	0.154	12.004	0.100	0.185	86.65%
9.001	0.713	12.003	0.500	0.414	93.54%
9.001	1.396	11.991	1.000	0.570	95.46%
8.998	2.088	11.978	1.501	0.807	95.70%
9.000	2.780	11.964	1.996	1.140	95.44%
9.001	3.481	11.952	2.491	1.556	95.03%
8.998	4.214	11.938	3.000	2.103	94.45%
11.104	0.120	12.007	0.100	0.136	89.81%
11.097	0.583	12.002	0.500	0.471	92.73%
11.102	1.120	11.992	1.000	0.442	96.44%
11.104	1.676	11.982	1.500	0.638	96.57%
11.098	2.229	11.967	1.995	0.862	96.51%
11.097	2.786	11.954	2.491	1.133	96.33%
11.099	3.362	11.940	3.000	1.489	96.01%

12.604	0.110	12.086	0.100	0.173	87.49%
12.599	0.516	11.989	0.500	0.509	92.17%
12.596	0.987	11.979	1.000	0.456	96.33%
12.599	1.470	11.968	1.500	0.569	96.93%
12.600	1.954	11.957	1.995	0.771	96.87%
12.600	2.443	11.943	2.491	1.031	96.65%
12.600	2.943	11.930	3.000	1.288	96.53%

## 2.2.7 USB Type-C PD Source Mode 15V

V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	V <sub>OUT</sub> /V	I <sub>OUT</sub> /A	loss/W	Eff/%
9.006	0.189	14.987	0.100	0.204	88.00%
9.004	0.900	14.984	0.500	0.613	92.43%
9.003	1.764	14.969	0.999	0.930	94.15%
9.000	2.640	14.954	1.501	1.314	94.47%
9.006	3.515	14.936	1.995	1.861	94.12%
9.002	4.410	14.922	2.490	2.539	93.60%
9.003	5.337	14.907	3.000	3.324	93.08%
11.100	0.155	14.984	0.100	0.223	87.03%
11.099	0.722	14.984	0.500	0.526	93.44%
11.104	1.415	14.969	1.000	0.740	95.29%
11.099	2.113	14.955	1.500	1.014	95.67%
11.099	2.815	14.940	2.000	1.368	95.62%
11.098	3.513	14.928	2.490	1.813	95.35%
11.102	4.241	14.910	3.000	2.352	95.00%
12.603	0.136	14.982	0.100	0.210	87.73%
12.600	0.656	14.981	0.500	0.780	90.57%
12.597	1.239	14.968	1.000	0.636	95.92%
12.600	1.849	14.955	1.500	0.865	96.29%
12.599	2.463	14.943	2.000	1.145	96.31%
12.598	3.069	14.931	2.490	1.485	96.16%
12.598	3.705	14.912	3.000	1.937	95.85%

## 2.2.8 USB Type-C PD Source Mode 20V

V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	V <sub>OUT</sub> /V	I <sub>OUT</sub> /A	loss/W	Eff/%
9.000	0.276	19.942	0.100	0.486	80.40%
9.003	1.241	19.938	0.500	1.200	89.26%
8.998	2.410	19.922	0.999	1.779	91.80%
9.000	3.596	19.910	1.500	2.503	92.27%
8.996	4.801	19.891	1.995	3.503	91.89%
9.005	5.500	19.883	2.249	4.811	90.29%
11.097	0.220	19.946	0.100	0.443	81.81%

11.097	0.993	19.940	0.500	1.052	90.46%
11.102	1.935	19.927	0.999	1.571	92.69%
11.101	2.879	19.915	1.500	2.087	93.47%
11.102	3.822	19.895	1.995	2.746	93.53%
11.103	4.312	19.889	2.249	3.149	93.42%
12.600	0.201	20.063	0.100	0.520	79.42%
12.600	0.870	19.946	0.500	0.986	91.00%
12.600	1.693	19.925	0.999	1.429	93.30%
12.598	2.517	19.906	1.500	1.851	94.16%
12.595	3.339	19.898	1.995	2.358	94.39%
12.606	3.761	19.890	2.249	2.677	94.35%

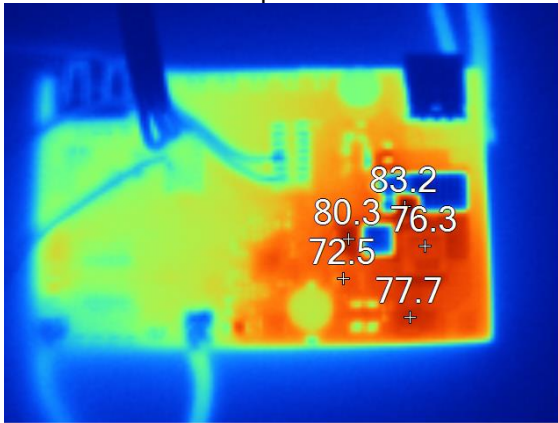
## 2.2.9 USB Type-A

V <sub>BAT</sub> /V	I <sub>BAT</sub> /A	V <sub>OUT</sub> /V	I <sub>OUT</sub> /A	loss/W	Eff/%
9.000	0.070	5.164	0.100	0.113	82.09%
9.001	0.193	5.154	0.301	0.185	89.35%
8.997	0.373	5.390	0.601	0.116	96.53%
9.003	0.557	5.124	0.901	0.393	92.15%
9.005	0.745	5.110	1.200	0.572	91.46%
8.996	0.938	5.096	1.501	0.788	90.66%
9.001	1.135	5.082	1.801	1.063	89.59%
9.003	1.335	5.068	2.101	1.375	88.57%
11.102	0.057	5.164	0.100	0.121	81.04%
11.100	0.161	5.152	0.301	0.241	86.56%
11.101	0.307	5.138	0.601	0.323	90.52%
11.102	0.456	5.123	0.901	0.449	91.14%
11.098	0.610	5.108	1.200	0.637	90.59%
11.100	0.766	5.095	1.501	0.849	90.00%
11.099	0.926	5.081	1.801	1.127	89.04%
11.098	1.091	5.067	2.101	1.457	87.96%
12.600	0.054	5.163	0.100	0.163	76.02%
12.596	0.147	5.152	0.301	0.301	83.75%
12.600	0.274	5.137	0.601	0.368	89.36%
12.600	0.406	5.123	0.901	0.502	90.19%
12.602	0.542	5.109	1.201	0.689	89.90%
12.601	0.680	5.095	1.500	0.930	89.15%
12.600	0.822	5.081	1.801	1.208	88.34%
12.596	0.967	5.067	2.101	1.536	87.39%

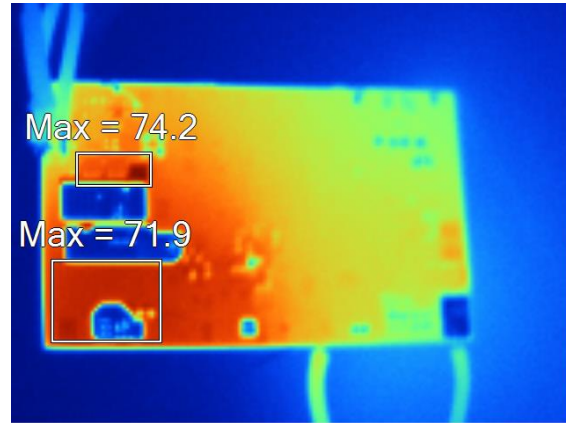
## 2.3 Thermal Images

V<sub>BAT</sub> 9V, 20V/45W output

Top View



Bottom View

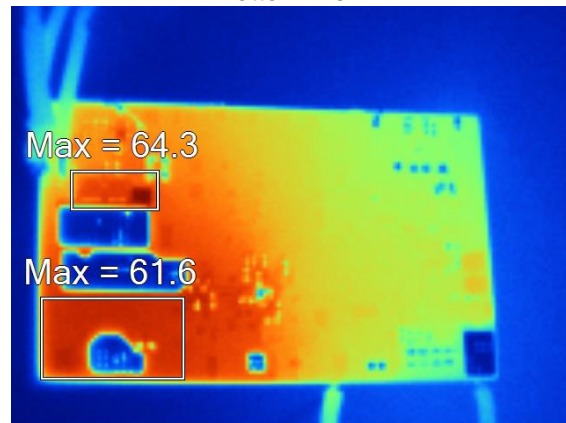


V<sub>BAT</sub> 11.1V, 20V/45W output

Top View

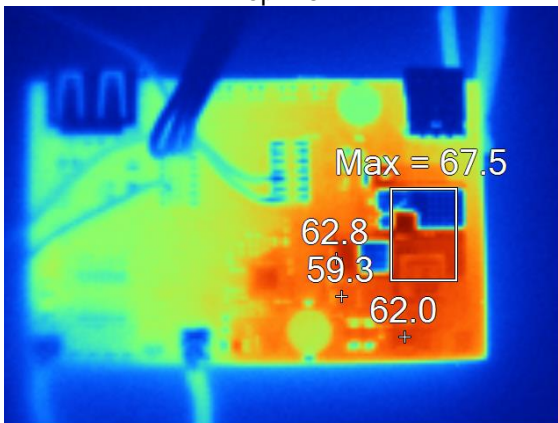


Bottom View

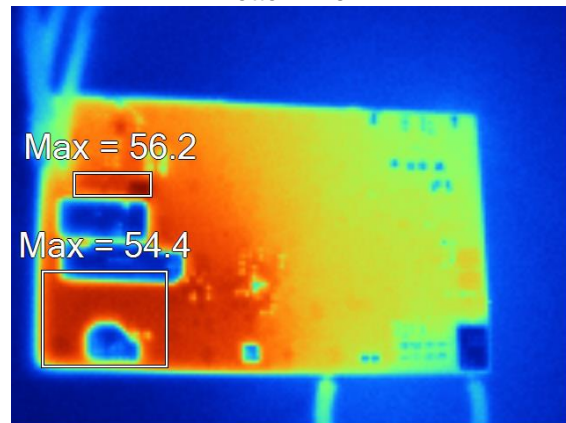


V<sub>BAT</sub> 12.6V, 20V/45W output

Top View



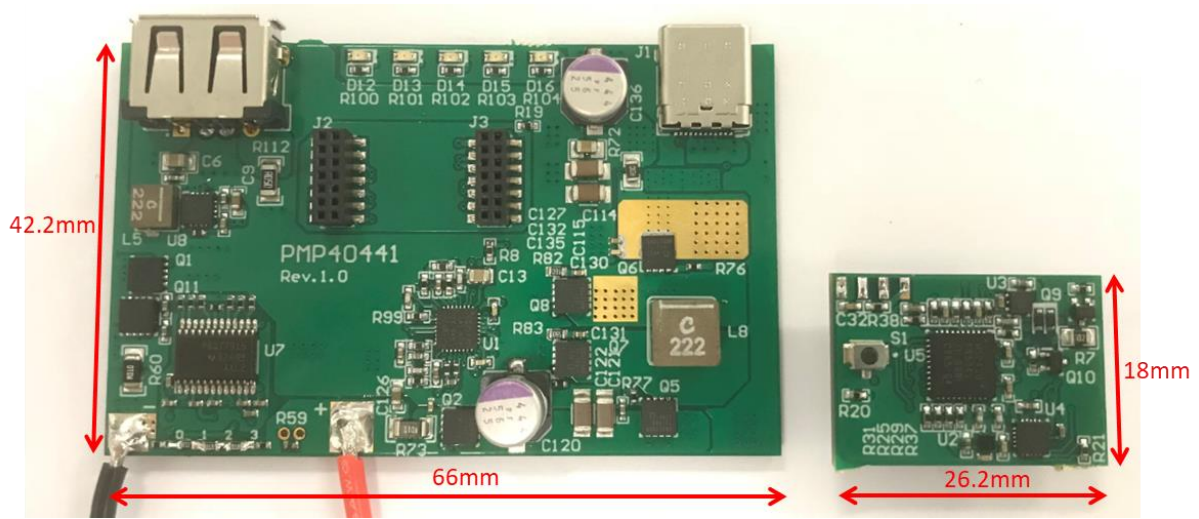
Bottom View



## 2.4 Standby consumption

PARAMETER		TEST CONDITION	TYP	UNIT
I <sub>STD</sub>	Standby current	V <sub>BAT</sub> =9 V, Ports Unattached	256.3	uA
		V <sub>BAT</sub> =11.1V, Ports Unattached	259.1	uA
		V <sub>BAT</sub> =12.4V, Ports Unattached	260.0	uA

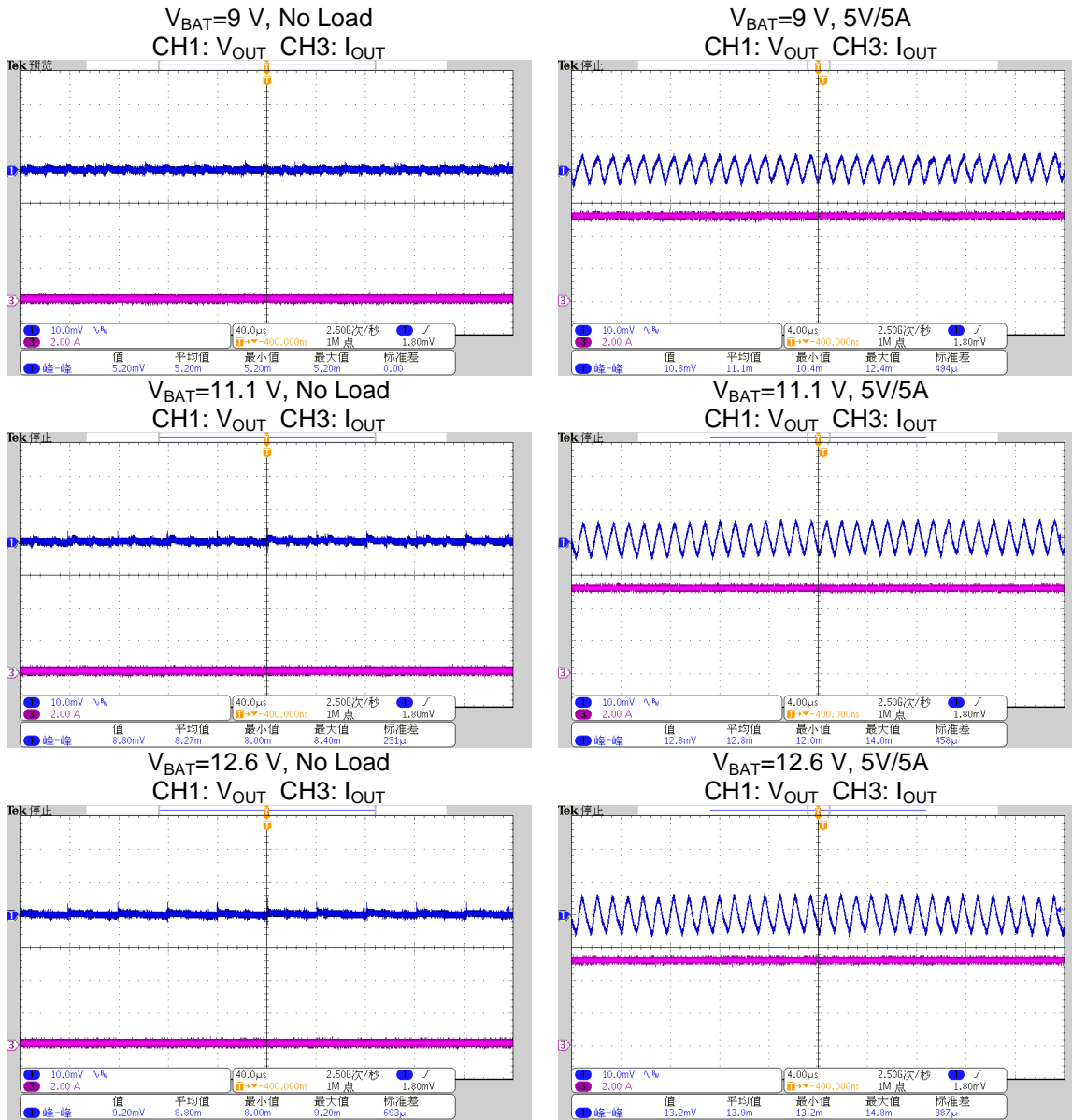
## 2.5 Dimensions



### 3 Waveforms

#### 3.1 Output Voltage Ripple

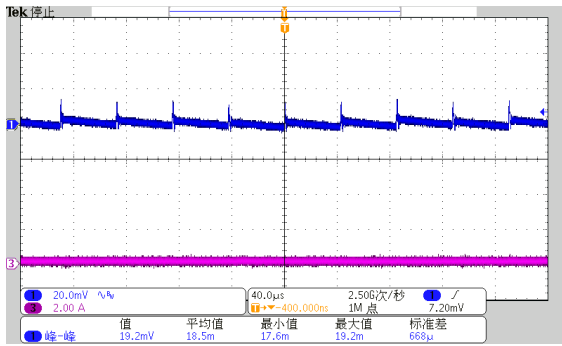
##### 3.1.1 Out Voltage: 5V



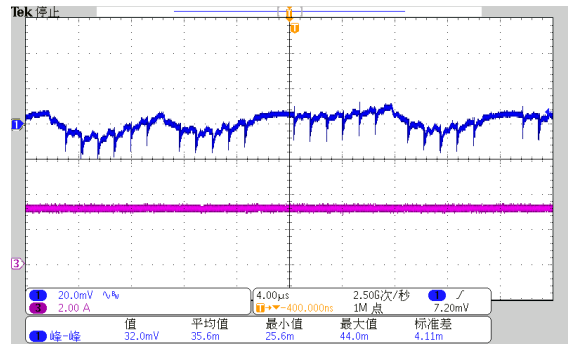
##### 3.1.2 Out Voltage: 9V

V<sub>BAT</sub>=9 V, No Load  
CH1: V<sub>OUT</sub> CH3: I<sub>OUT</sub>

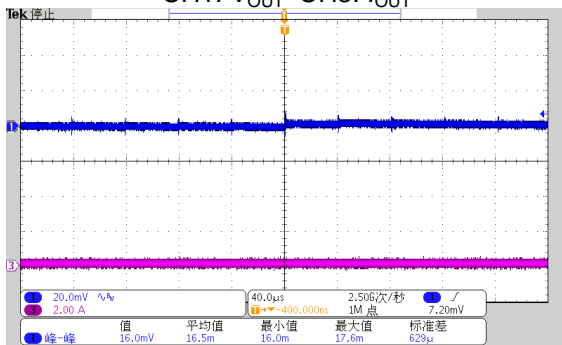
V<sub>BAT</sub>=9 V, 9V/3A  
CH1: V<sub>OUT</sub> CH3: I<sub>OUT</sub>



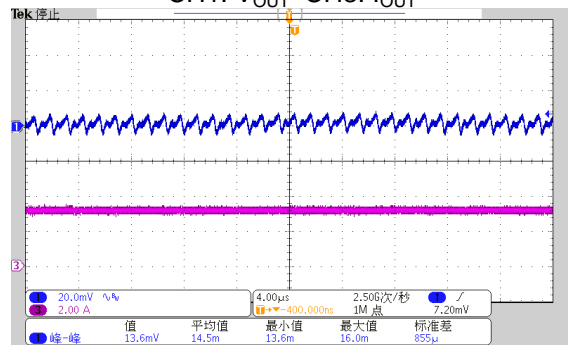
$V_{BAT}=11.1\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



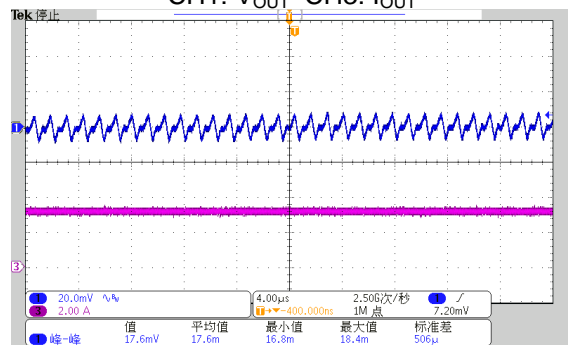
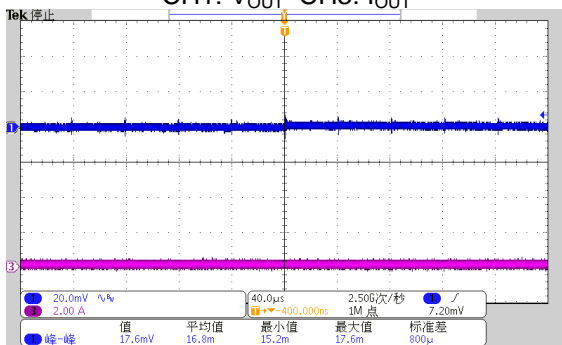
$V_{BAT}=11.1\text{ V}$ , 9V/3A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



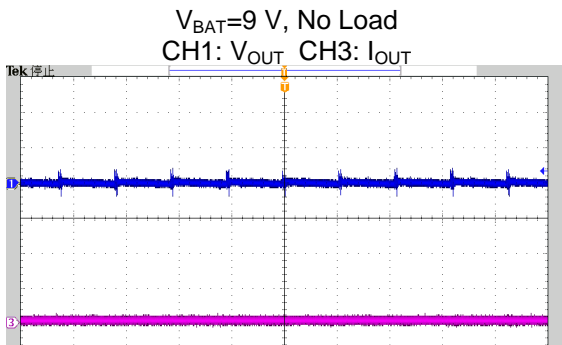
$V_{BAT}=12.6\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



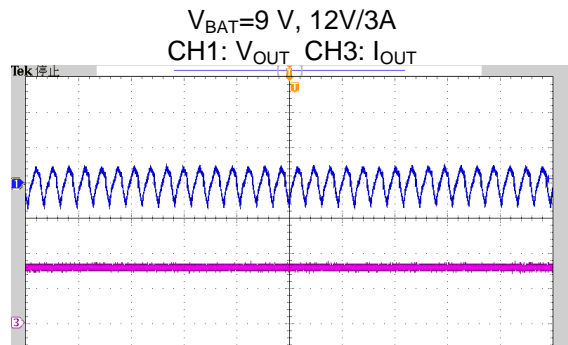
$V_{BAT}=12.6\text{ V}$ , 9V/3A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



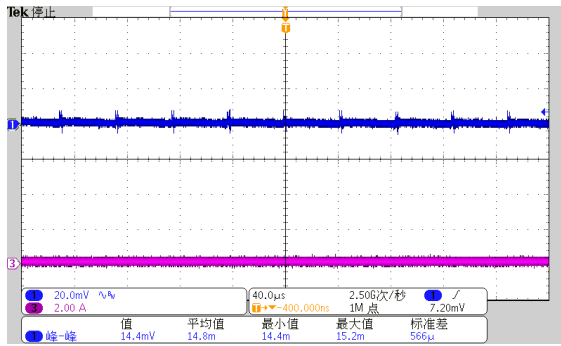
### 3.1.3 Out Voltage: 12V



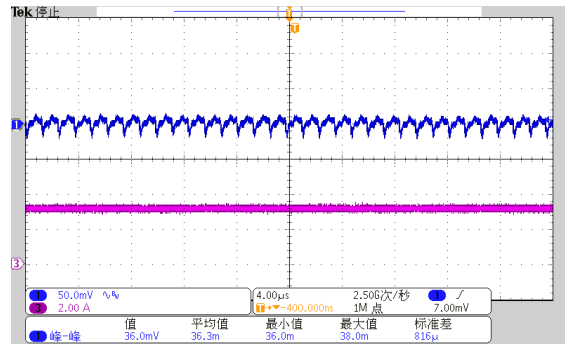
$V_{BAT}=11.1\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



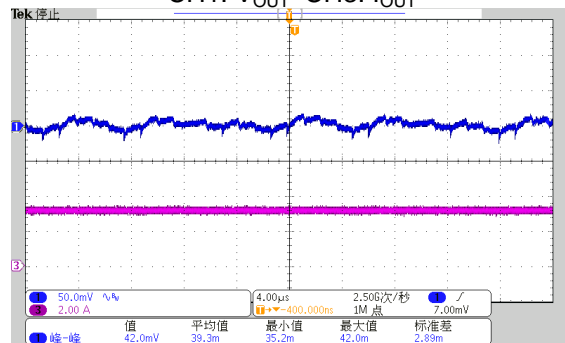
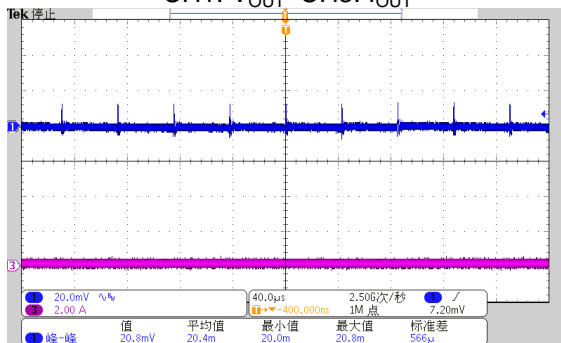
$V_{BAT}=11.1\text{ V}$ , 12V/3A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



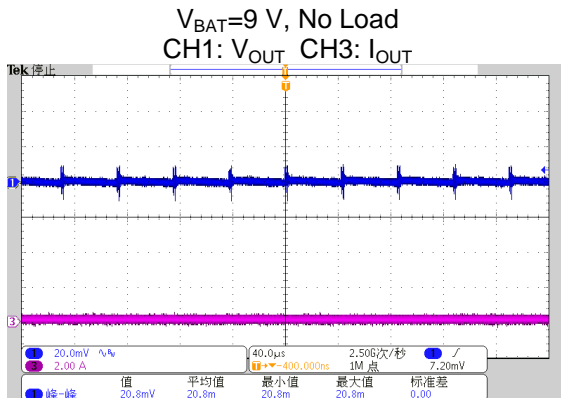
$V_{BAT}=12.6\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



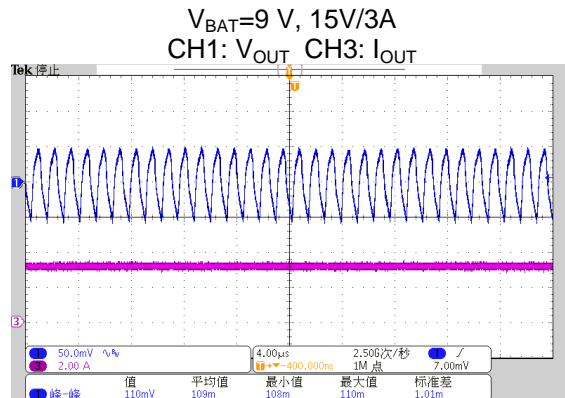
$V_{BAT}=12.6\text{ V}$ , 12V/3A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



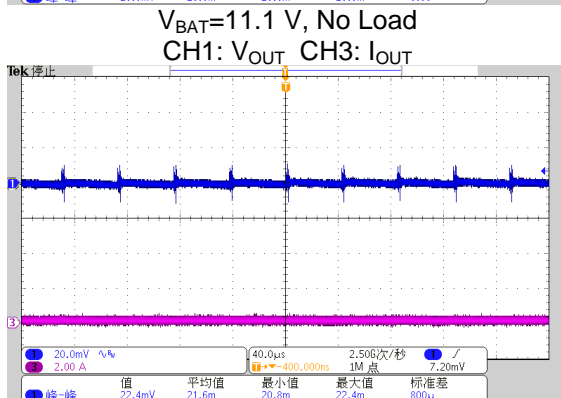
### 3.1.4 Out Voltage: 15V



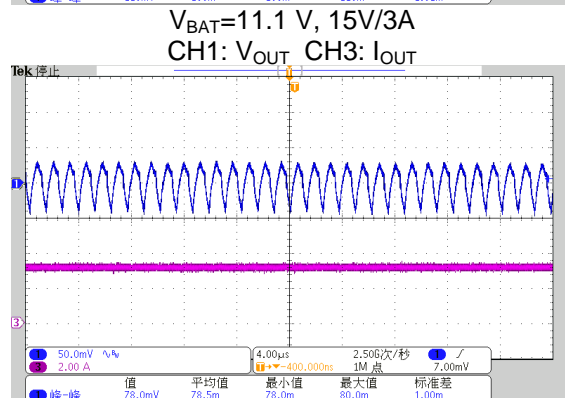
$V_{BAT}=9\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



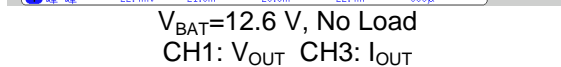
$V_{BAT}=9\text{ V}$ , 15V/3A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



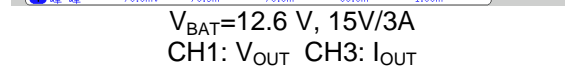
$V_{BAT}=11.1\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



$V_{BAT}=11.1\text{ V}$ , 15V/3A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$

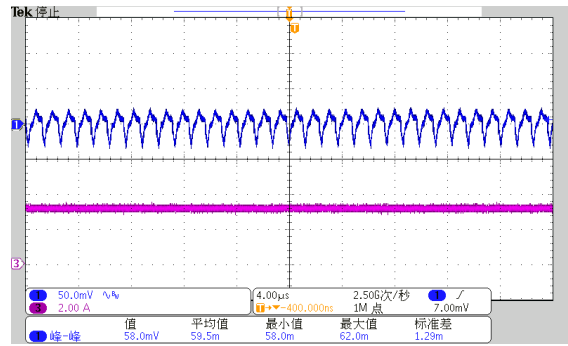
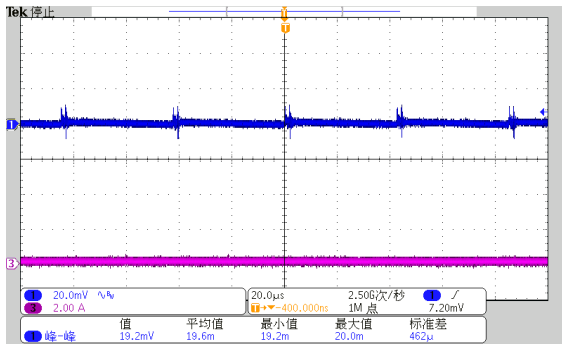


$V_{BAT}=12.6\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



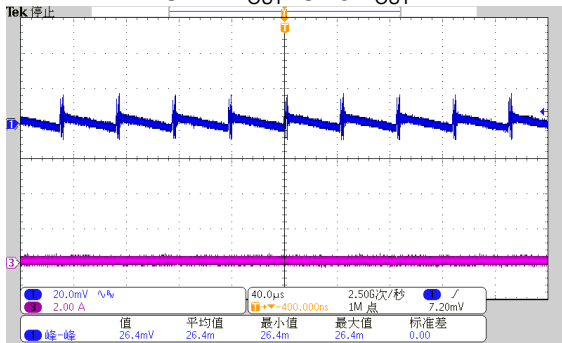
$V_{BAT}=12.6\text{ V}$ , 15V/3A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



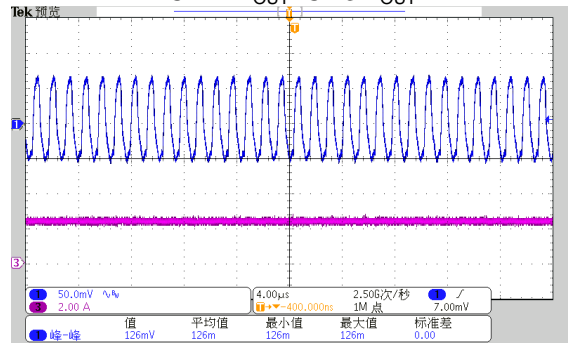


### 3.1.5 Out Voltage: 20V

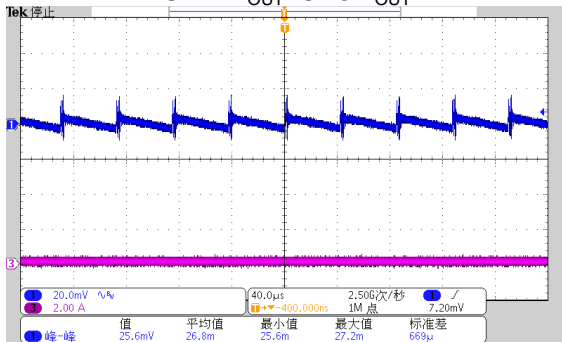
$V_{BAT}=9\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



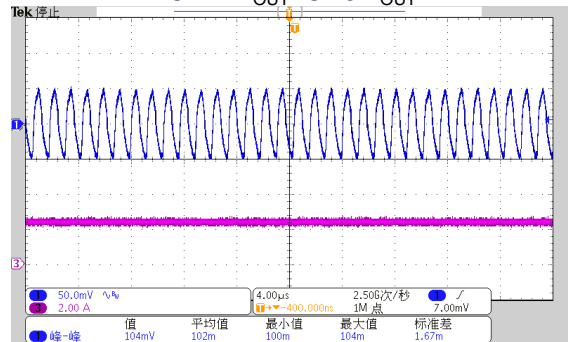
$V_{BAT}=9\text{ V}$ , 20V/2.25A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



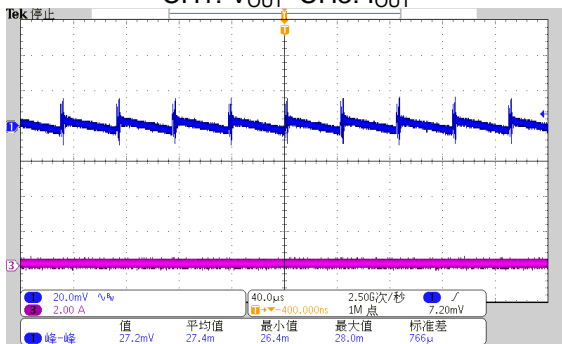
$V_{BAT}=11.1\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



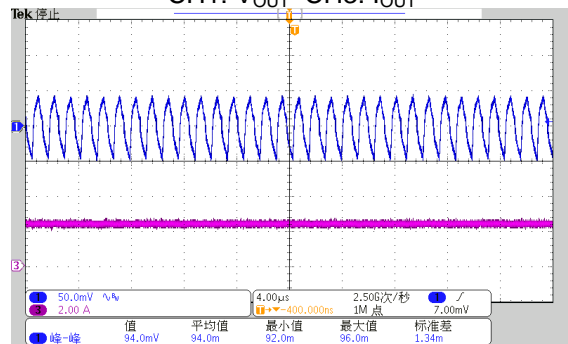
$V_{BAT}=11.1\text{ V}$ , 20V/2.25A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



$V_{BAT}=12.6\text{ V}$ , No Load  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



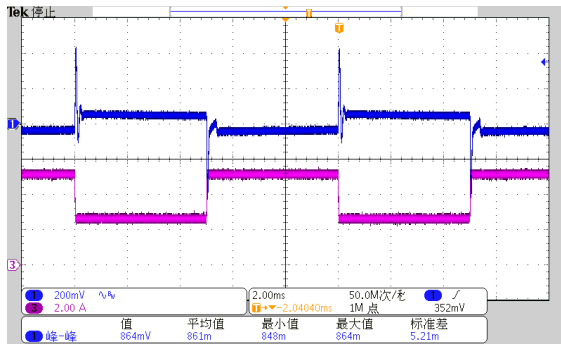
$V_{BAT}=12.6\text{ V}$ , 20V/2.25A  
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



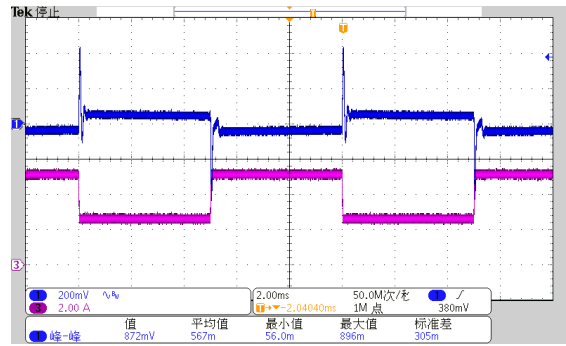
### 3.2 Output Dynamic Response

$V_{BAT}=9\text{ V}$ ,  $V_{OUT}=5\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$

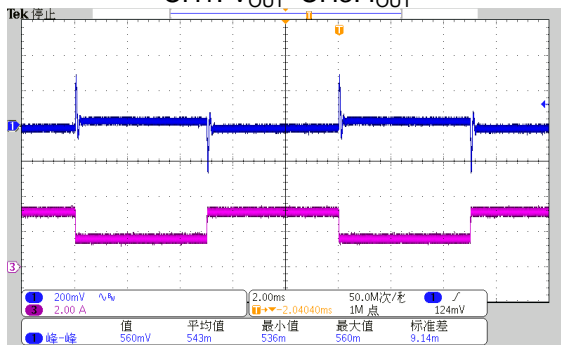
$V_{BAT}=12.6\text{ V}$ ,  $V_{OUT}=5\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



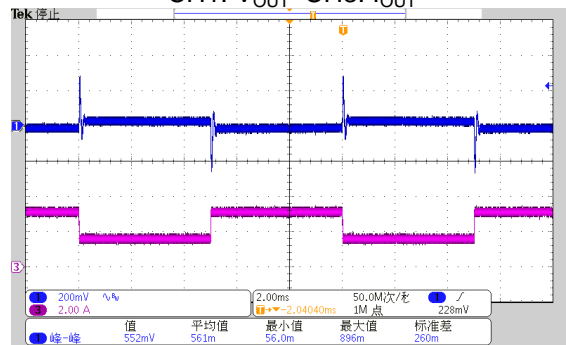
$V_{BAT}=9\text{ V}, V_{OUT}=9\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



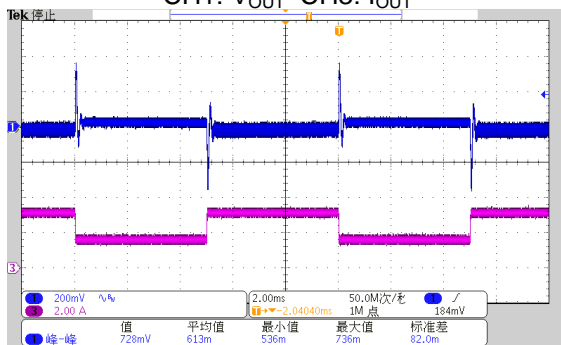
$V_{BAT}=12.6\text{ V}, V_{OUT}=9\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



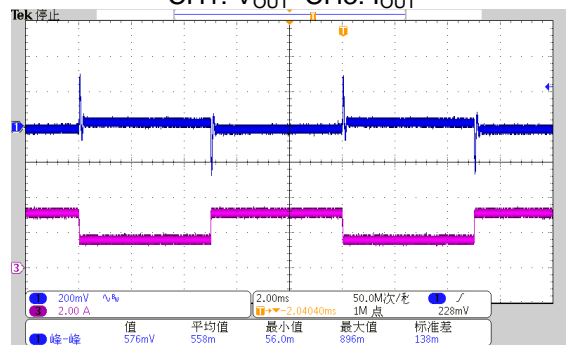
$V_{BAT}=9\text{ V}, V_{OUT}=12\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



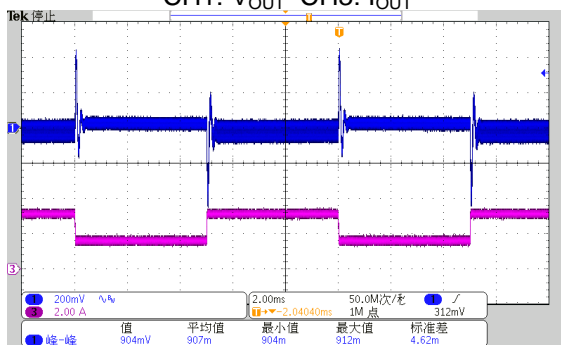
$V_{BAT}=12.6\text{ V}, V_{OUT}=12\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



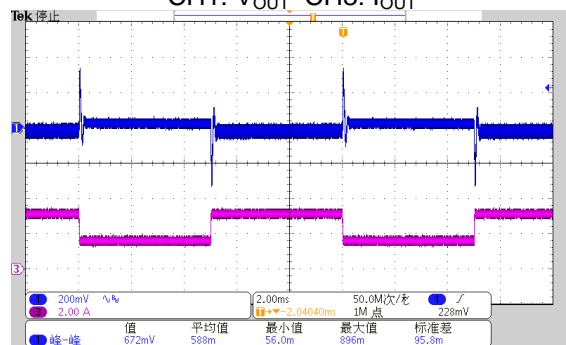
$V_{BAT}=9\text{ V}, V_{OUT}=15\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



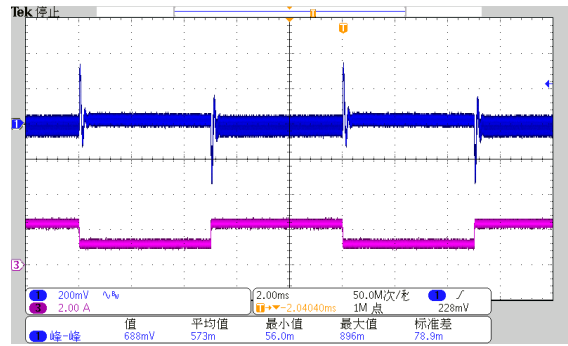
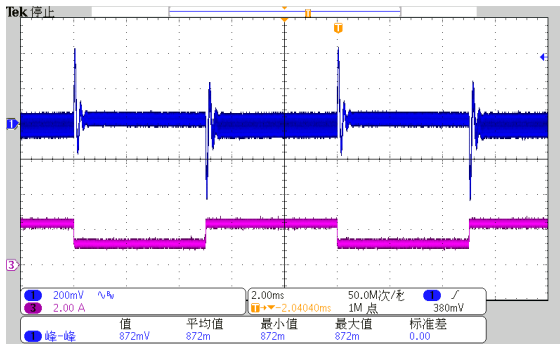
$V_{BAT}=12.6\text{ V}, V_{OUT}=15\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$



$V_{BAT}=9\text{ V}, V_{OUT}=20\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$

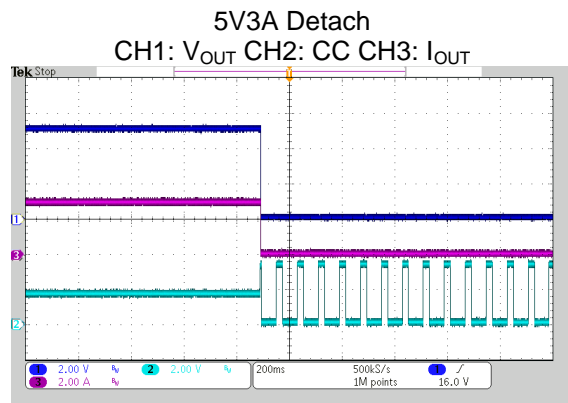
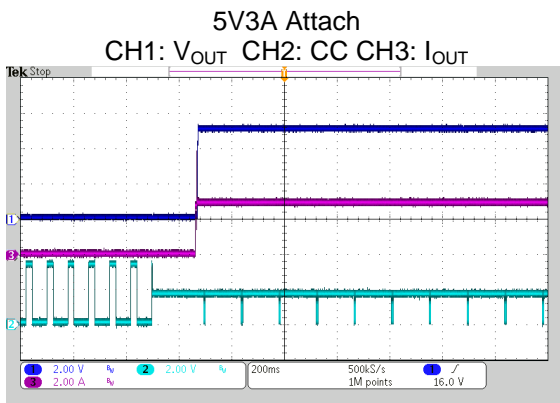


$V_{BAT}=12.6\text{ V}, V_{OUT}=20\text{ V}$   
CH1:  $V_{OUT}$  CH3:  $I_{OUT}$

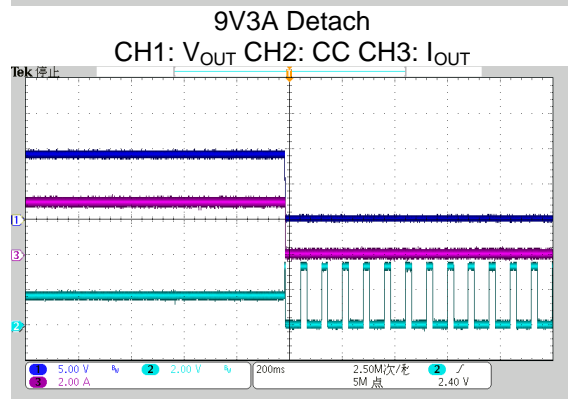
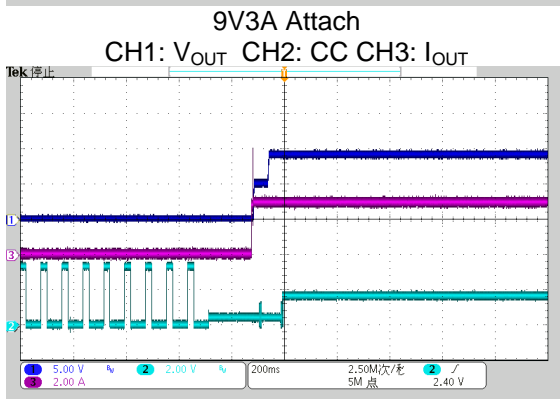
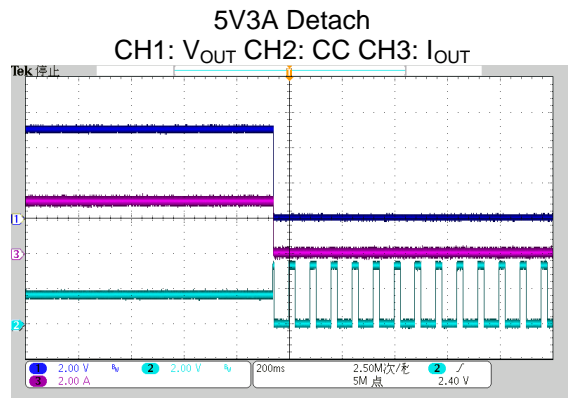
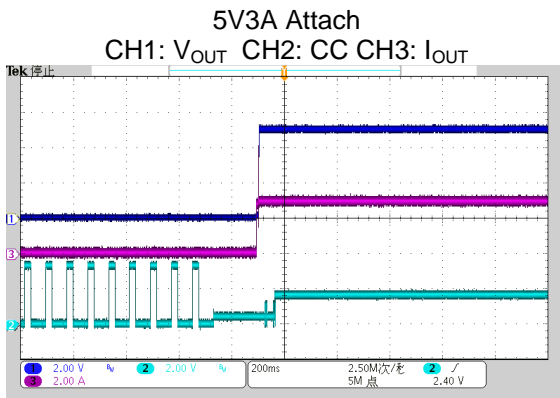


### 3.3 Port Attach and Detach

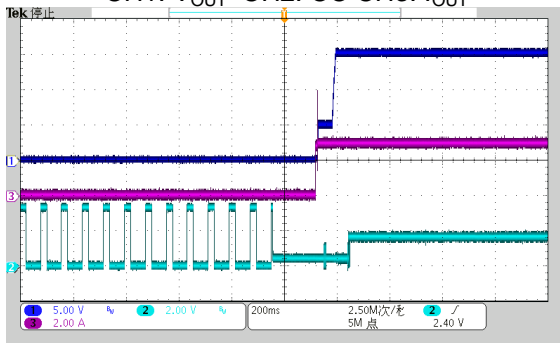
#### 3.3.1 Type C non-PD Source Mode



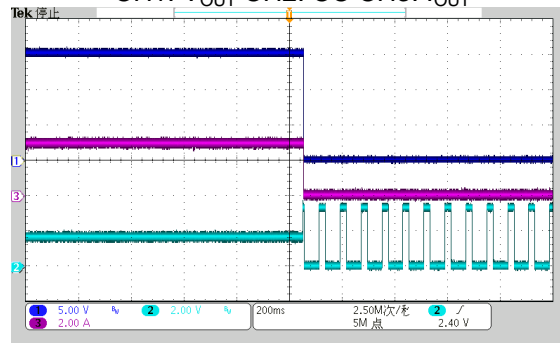
#### 3.3.2 Type C PD Source Mode



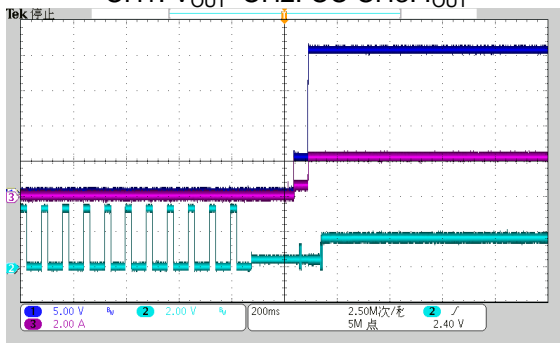
15V3A Attach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



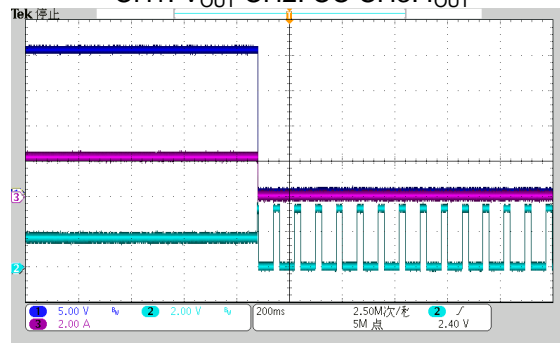
15V3A Detach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



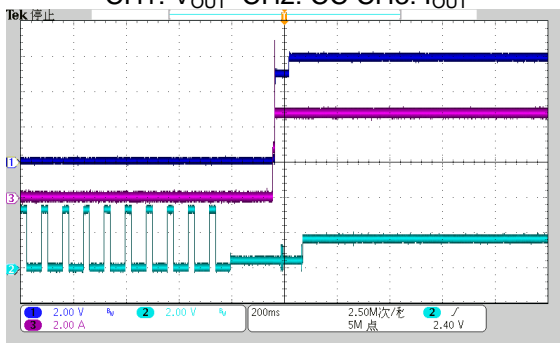
20V2.25A Attach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



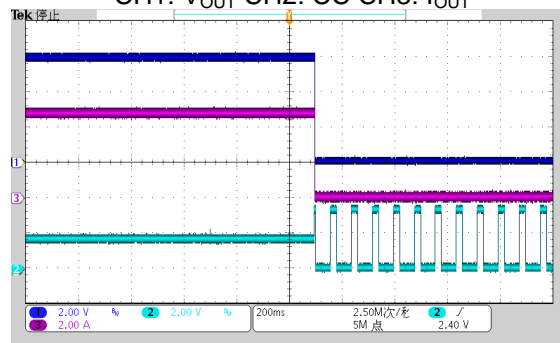
20V2.25A Detach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



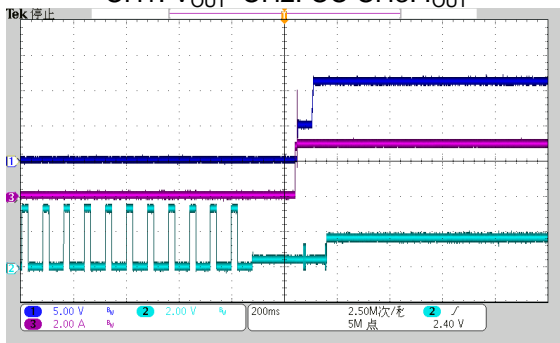
PPS 5.9V5A Attach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



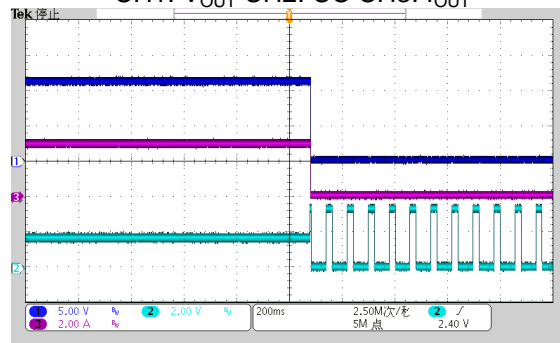
PPS 5.9V5A Detach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



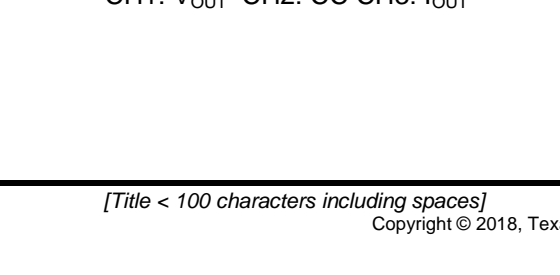
PPS 11V3A Attach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



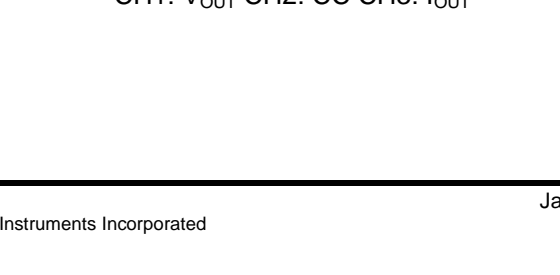
PPS 11V3A Detach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>

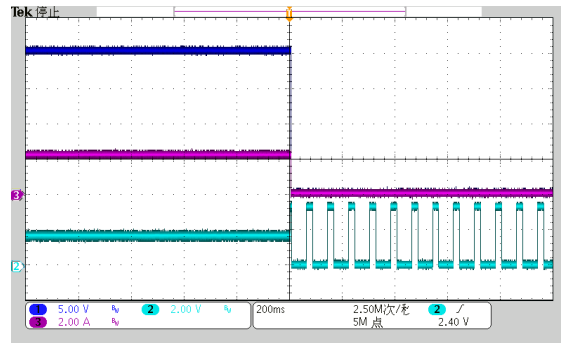
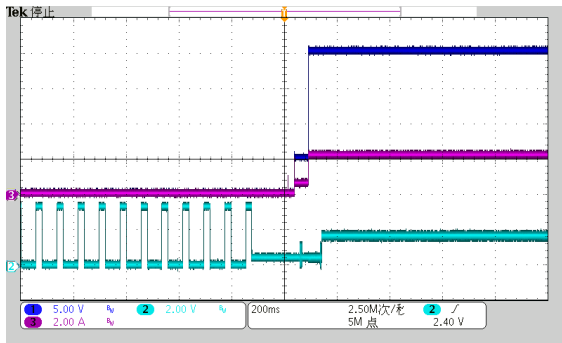


PPS 21V2.25A Attach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



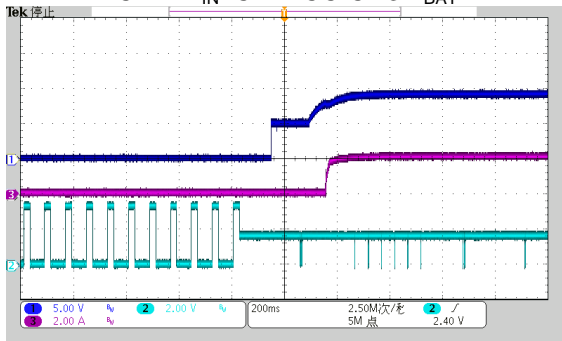
PPS 21V2.25A Detach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>OUT</sub>



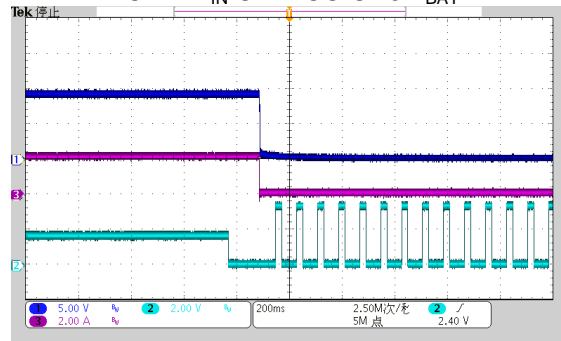


### 3.3.3 Type C PD Sink Mode

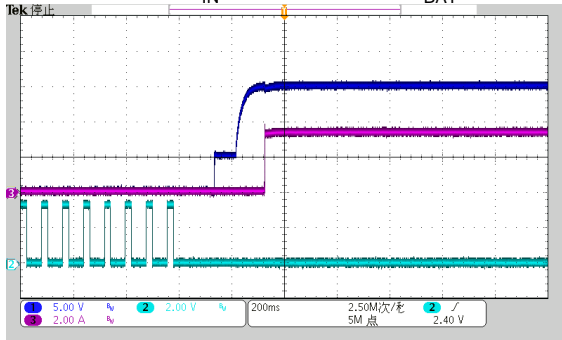
9V3A Attach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$



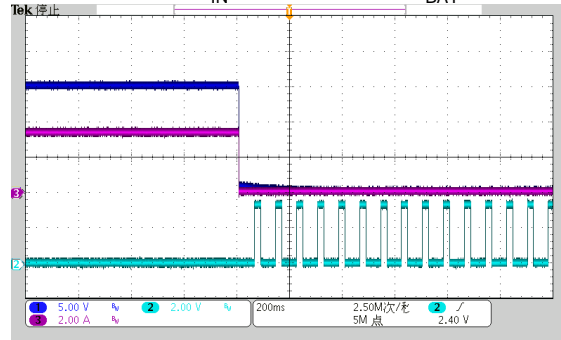
9V3A Detach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$



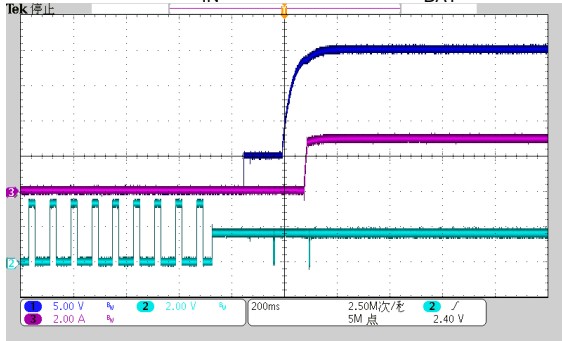
15V3A Attach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$



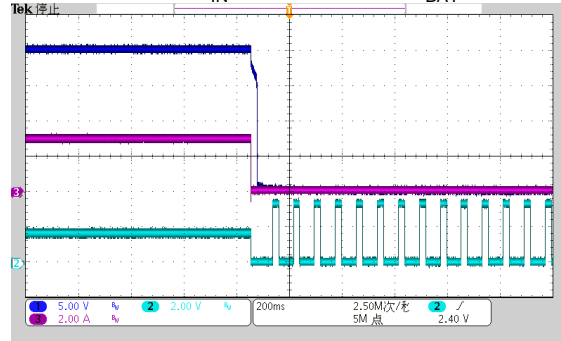
15V3A Detach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$



20V2.25A Attach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$



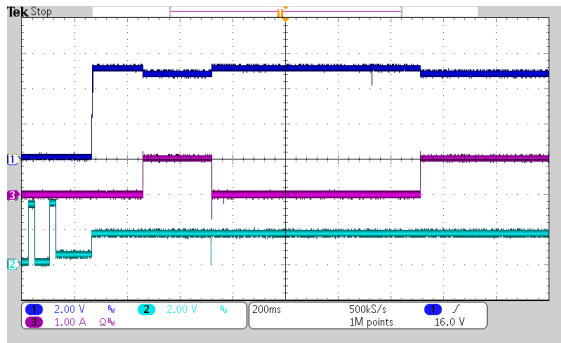
20V2.25A Detach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$



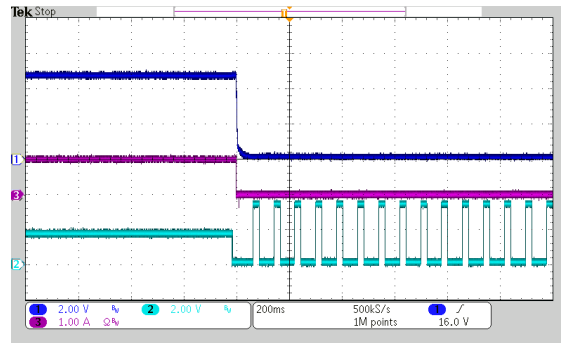
### 3.3.4 Type C non-PD Sink Mode or USB Adaptor

Type-C 5V3A Attach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$

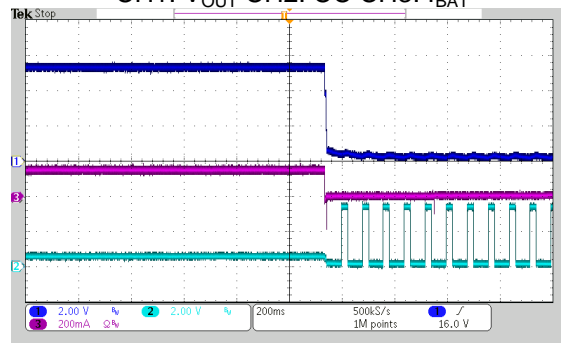
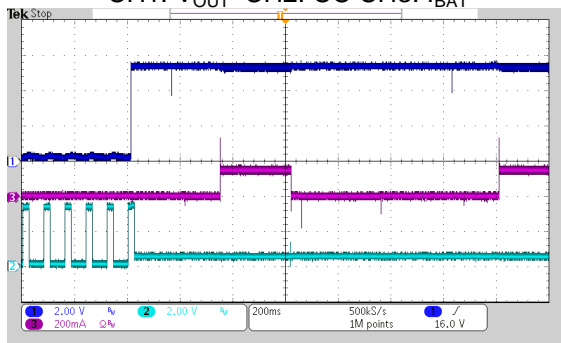
Type-C 5V3A Detach  
CH1:  $V_{IN}$  CH2: CC CH3:  $I_{BAT}$



USB 5V2A Attach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>BAT</sub>



USB 5V2A Detach  
CH1: V<sub>OUT</sub> CH2: CC CH3: I<sub>BAT</sub>



### 3.4 PPS Voltage Regulation

PPS Step Down	5.9V	11V	21V
1	5.877	11.092	20.181
2	5.849	11.075	20.165
3	5.832	11.051	20.136
4	5.807	11.035	20.120
5	5.790	11.012	20.096
6	5.765	10.996	20.079
7	5.749	10.972	20.055
8	5.724	10.957	20.039
9	5.707	10.934	20.014
10	5.683	10.918	19.998
11	5.666	10.894	19.975
12	5.642	10.878	19.959
13	5.625	10.855	19.936
14	5.601	10.835	19.920
15	5.580	10.811	19.896
16	5.556	10.795	19.874
17	5.540	10.771	19.850
18	5.514	10.756	19.835
19	5.498	10.732	19.811
20	5.473	10.717	19.795

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