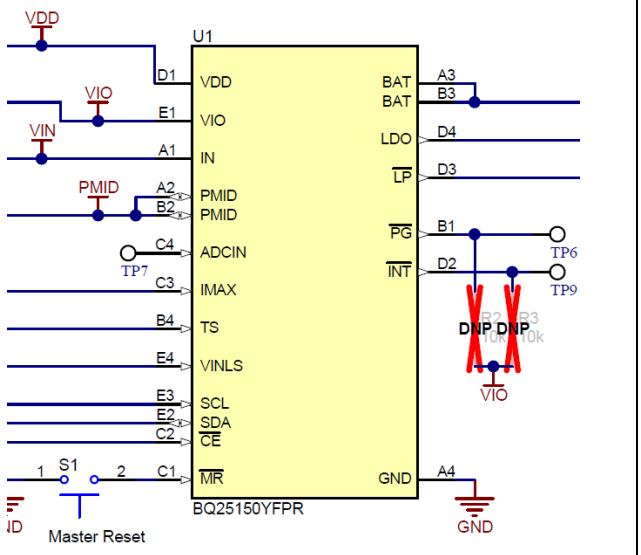
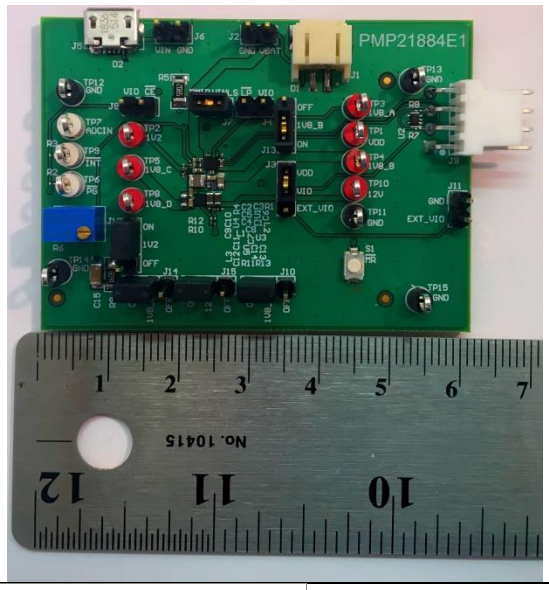
Test Report: PMP21884

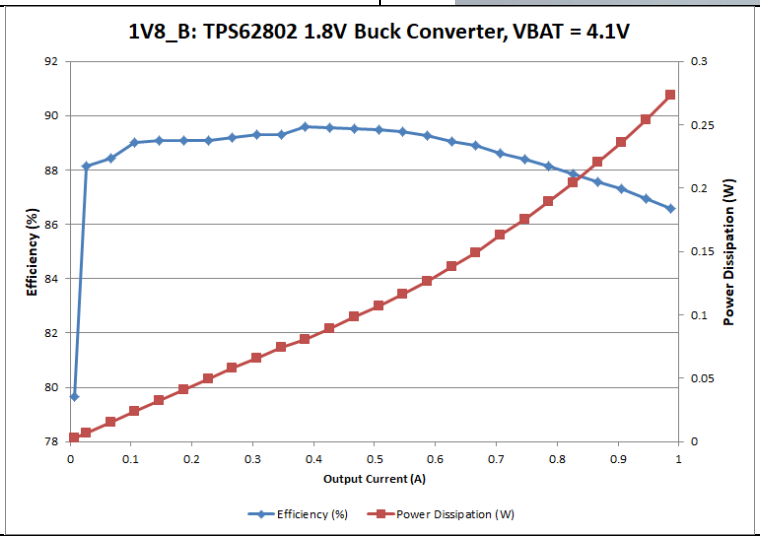
Tiny, Ultra-Low Iq DC-DC Power Supply With Battery Charging Reference Design for Wearables

Description

A highly-integrated power supply reference design for smartwatches and fitness trackers enabling ultra-low Iq in an ultra-small (48sqmm) solution size. Supply includes seven power rails for the system including battery charger, LDO, DC-DC buck converters and integrated boost converter for heart rate monitor AFE LED drive supply or PMOLED bias.







1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
VIO	1.2V-3.6V
VBAT	3V-4.4V
VIN	5V-6V
PMID	3V-6V

1.2 Required Equipment

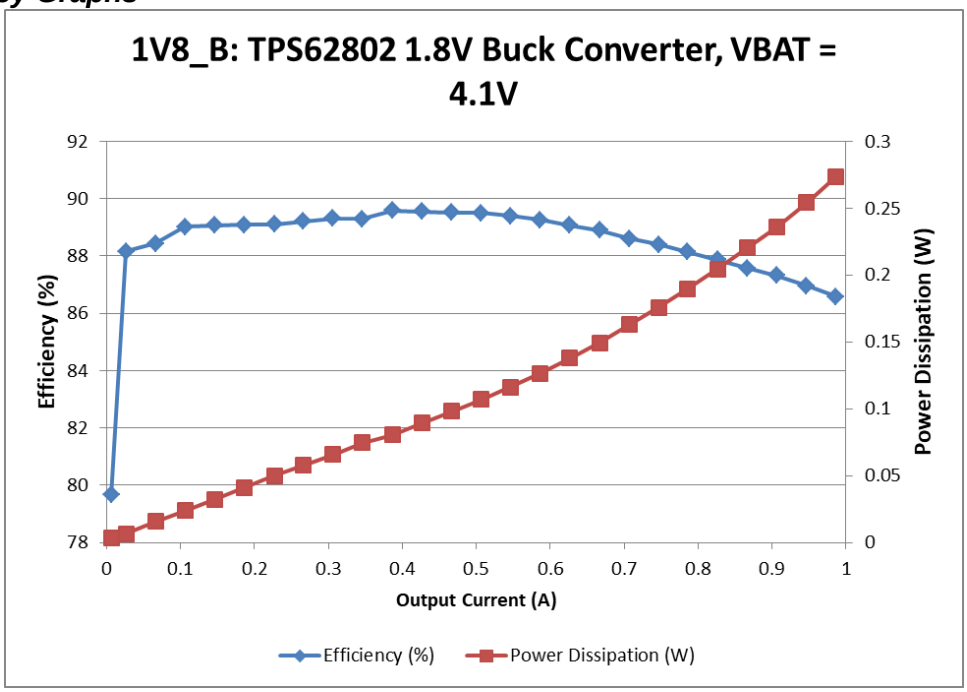
- Power Supply (x2)
- Electronic Load
- Decade Box
- Current Shunts

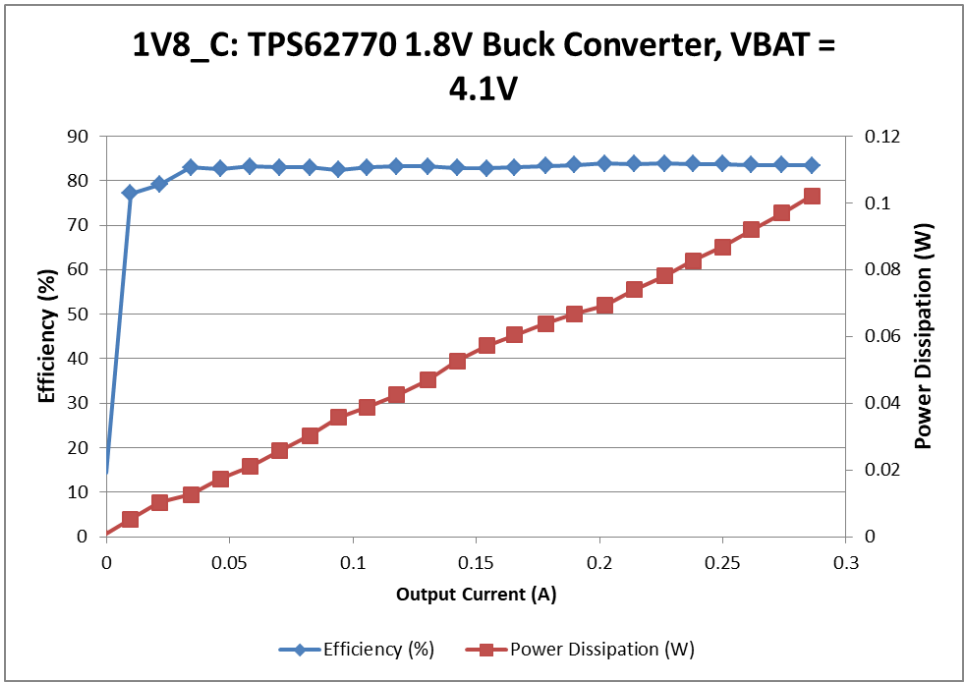
1.3 Considerations

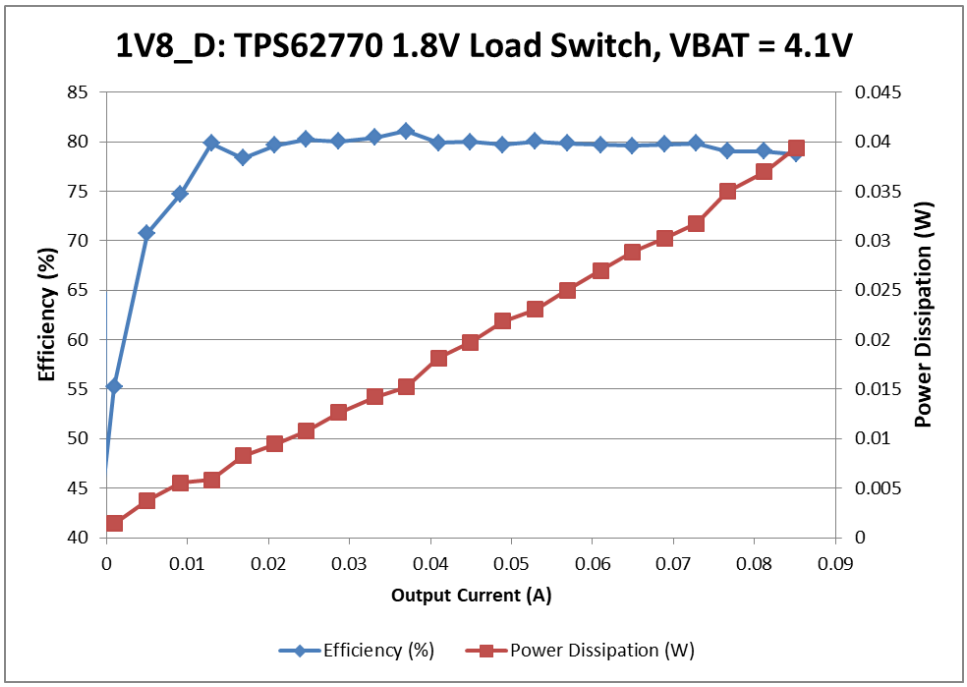
Each section has relevant details on testing methodologies and conditions.

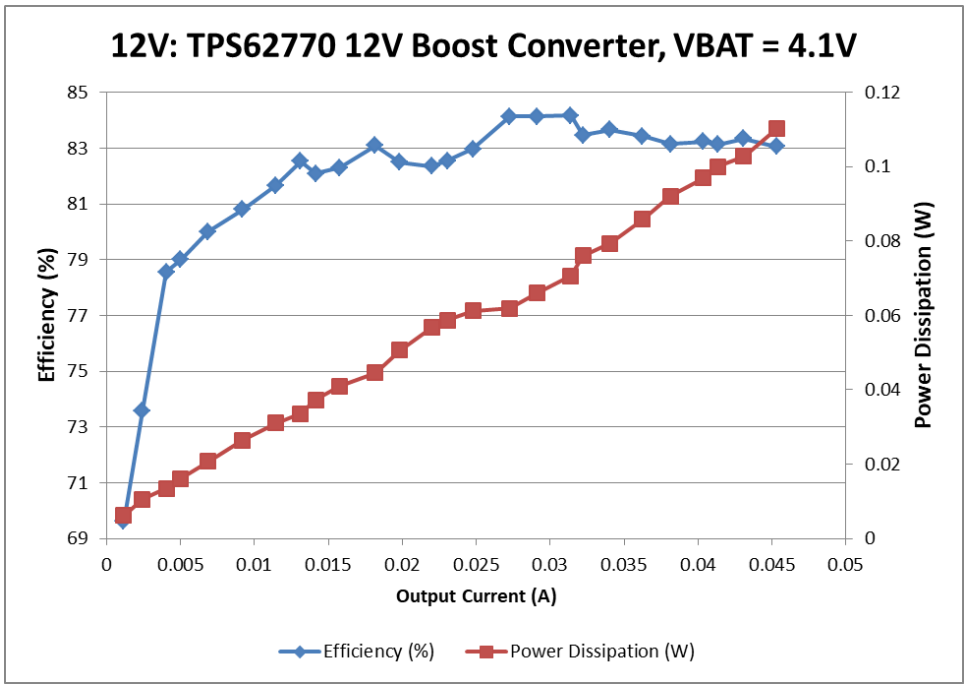
2 Testing and Results

2.1 Efficiency Graphs









2.2 Efficiency Data

1V8_B: TPS62802 1.8V Buck Converter, VBAT = 4.1V

Output Current (A)	Efficiency (%)	Power Dissipation (W)
0.006628245	79.65913321	0.003051604
0.026367385	88.15990648	0.006382493
0.066463258	88.42768434	0.015669775
0.106320004	89.02292116	0.023600513
0.146761248	89.07480929	0.032376261
0.186530718	89.08186695	0.041088054
0.2269988	89.09633876	0.049889204
0.265991159	89.20385404	0.057775743
0.306230003	89.31518997	0.06571536
0.34637017	89.28477882	0.074526685
0.386316715	89.58611875	0.08045299
0.426588754	89.54930914	0.089173948
0.46676938	89.50977314	0.098204835
0.507128393	89.49525776	0.10682903
0.546303174	89.40092056	0.116217367
0.58674573	89.26365271	0.126600483
0.626549303	89.06537918	0.137963908
0.666690882	88.90278012	0.149230399
0.706627337	88.61448685	0.162766891
0.746673871	88.40177847	0.175587549
0.786126927	88.13892002	0.189578137
0.826272138	87.86803334	0.204395624
0.866373257	87.57543117	0.220159718
0.906400722	87.31339065	0.235846741
0.946453612	86.96335523	0.254023275
0.98634204	86.58324201	0.273591601

1V8_C: TPS62770 1.8V Buck Converter, VBAT = 4.1V

Output Current (A)	Efficiency (%)	Power Dissipation (W)
-0.000108868	16.98156458	0.00134834
-0.000073352	14.38535185	0.001048629
0.009748695	77.13123236	0.005184958
0.021512006	79.06285188	0.010211948
0.034320512	82.92255516	0.012661934
0.046211559	82.66074383	0.017354554
0.058098873	83.16440967	0.021042265
0.070093744	83.01357506	0.02564677
0.082441654	82.97869094	0.030222631
0.094037879	82.4620883	0.03572708
0.105896033	82.96469232	0.038828814
0.117728964	83.17636132	0.042517283
0.130352727	83.24518334	0.046839905
0.142212092	82.83259596	0.052618518
0.154239855	82.80456569	0.057183746
0.165566584	83.00933712	0.060510861
0.178135963	83.31900526	0.063801495
0.189975149	83.56898774	0.066824644
0.201982632	83.89980307	0.069340387
0.213957423	83.79793884	0.074003989
0.226407845	83.82536755	0.078152047
0.238031918	83.75291384	0.08259865
0.25000903	83.73858968	0.086844138
0.261586287	83.5795508	0.091923572
0.274013906	83.49139133	0.096908112
0.286117543	83.36917518	0.10207989

1V8_D: TPS62770 1.8V Load Switch, VBAT = 4.1V

Output Current (A)	Efficiency (%)	Power Dissipation (W)
-0.000220158	50.38305064	0.001181252
-0.000217635	53.43589161	0.001123413
-0.000207546	64.74005367	0.000949403
-0.000248006	46.0617209	0.001413916
0.000976887	55.27059922	0.001417316
0.005049001	70.73070076	0.003739768
0.009132515	74.70953625	0.005521876
0.012995771	79.85196272	0.005844508
0.016845204	78.3373484	0.008285762
0.020810972	79.62745816	0.00945106
0.024607232	80.23625129	0.010736466
0.02870457	80.04368398	0.012648922
0.033172806	80.41707212	0.014242461
0.036986723	81.05112718	0.015215363
0.040989217	79.8556771	0.018152954
0.044946207	79.96403753	0.01972862
0.048951223	79.65711854	0.021851941
0.052920825	80.01974328	0.023047507
0.056895471	79.84506139	0.024990495
0.060996643	79.6879768	0.026993209
0.06492074	79.57754604	0.028861836
0.068916878	79.74393918	0.030259691
0.072809293	79.82672681	0.031731406
0.076619477	79.04125758	0.034958457
0.081177512	79.0326982	0.036965535
0.085148324	78.72696507	0.039403597

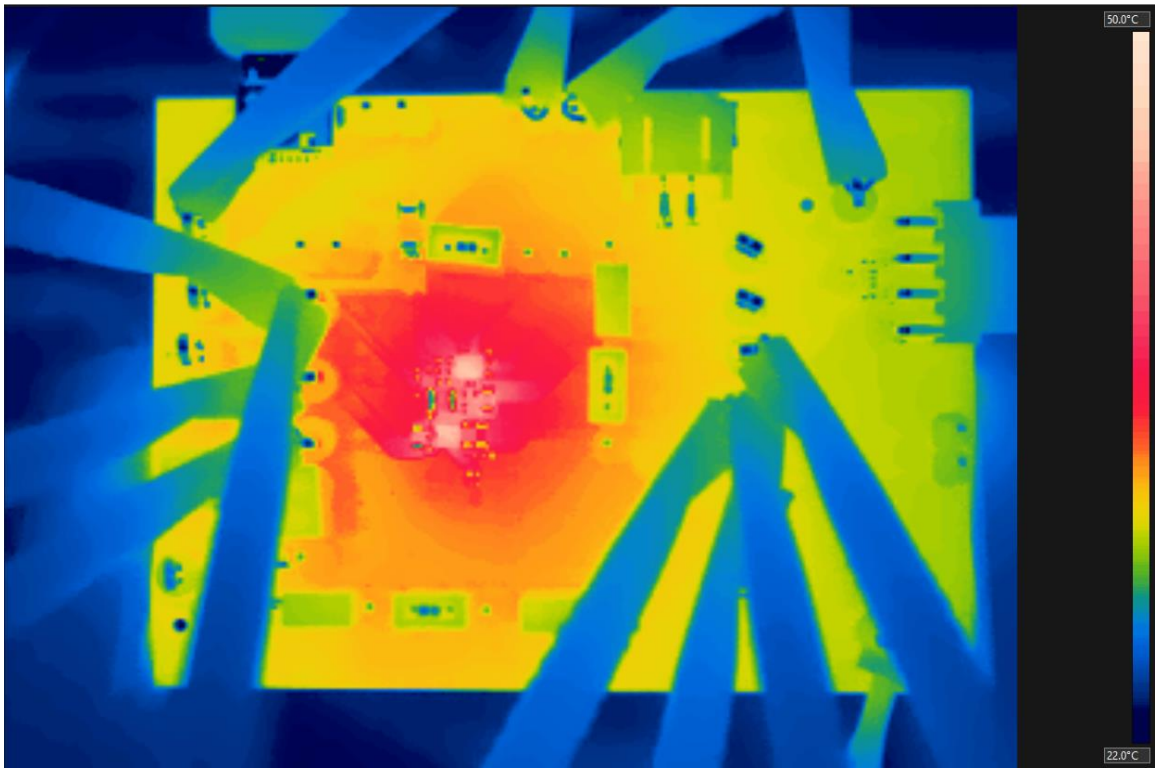
12V: TPS62770 12V Boost Converter, VBAT = 4.1V

Output Current (A)	Efficiency (%)	Power Dissipation (W)
0.001166675	69.61244828	0.006149905
0.002422039	73.58749612	0.010496915
0.004063234	78.55498275	0.013390171
0.005023676	79.00019836	0.016119664
0.006873728	80.00313628	0.02073187
0.009214747	80.79411964	0.026423318
0.011465866	81.66651146	0.031054945
0.013118563	82.52016395	0.033517355
0.014148624	82.08432131	0.037237745
0.015783462	82.28868994	0.040949149
0.018176342	83.09101074	0.044561802
0.019821472	82.48751963	0.050677554
0.021975125	82.35463324	0.056698362
0.023063403	82.540948	0.058736852
0.024788141	82.97025748	0.061238634
0.02727092	84.12927565	0.061895152
0.029103215	84.12983539	0.066035556
0.031391061	84.17083907	0.070647433
0.032223766	83.47025377	0.076102806
0.034054749	83.65430277	0.079355091
0.036238872	83.42093131	0.085888142
0.038115461	83.15000817	0.092114056
0.04034519	83.22575939	0.096974642
0.041317032	83.12132627	0.100053314
0.043079708	83.33777542	0.10271817
0.04531317	83.05951459	0.110212911

2.3 Thermal Images

The thermal image below shows operation at 4.1V input on VBAT and loaded on all buck/boost/LDO rails, with no airflow. Five outputs loaded as follows:

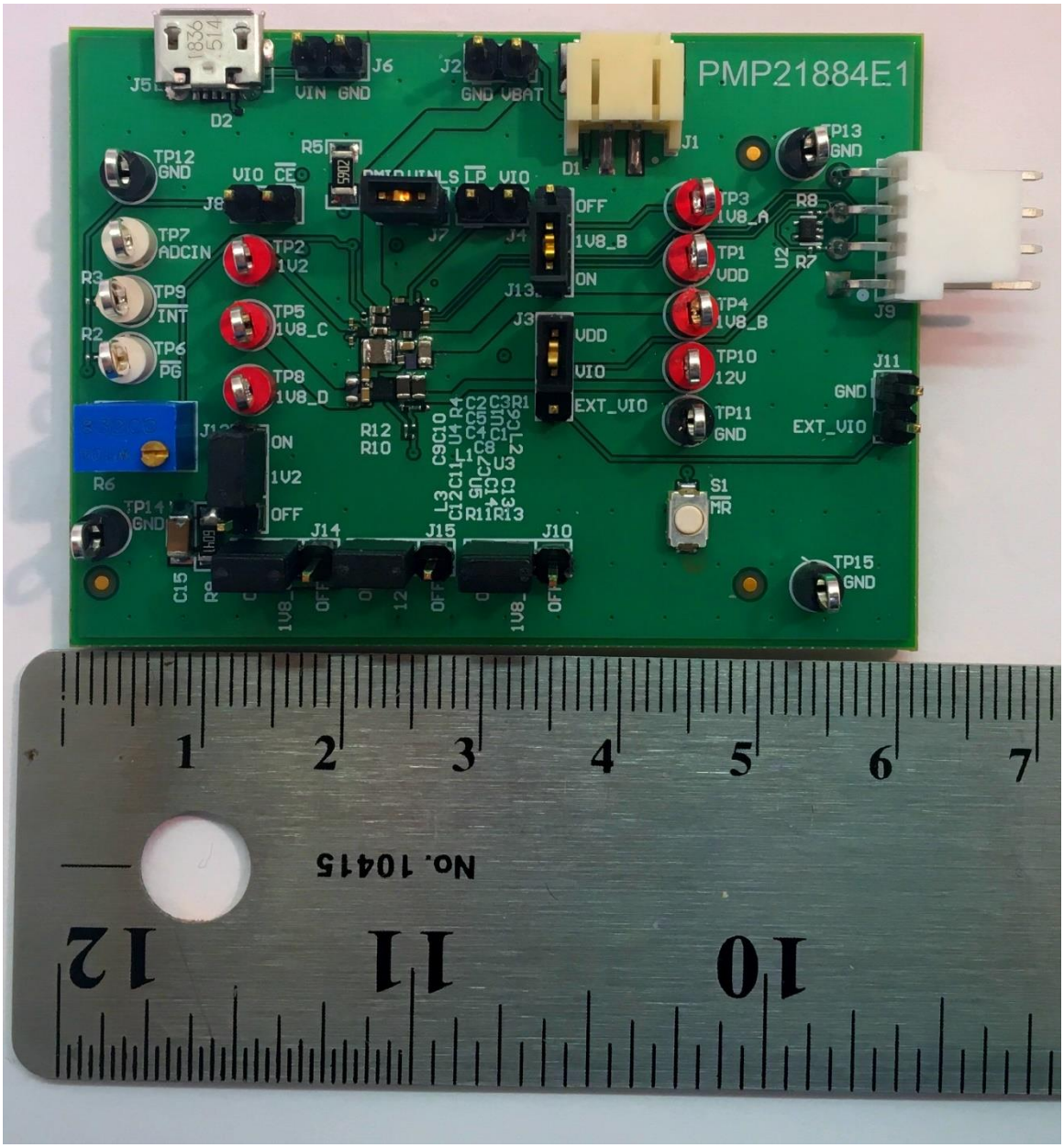
- 1V8_B
  - 0.9A load (two 1 Ohm, 3 W resistors in series)
- 1V8_C
  - 0.36A load (four 20 Ohm, ¼ W resistors in parallel)
- 1V8_D
  - 0.09A load (one 20 Ohm, ¼ W resistor)
- 12V
  - 0.048A load (four 1 kOhm, ¼ W resistors in parallel)
- 1V2
  - 0.063mA load (Electronic Load set to 65mA, measured 63mA)
  - *NOTE: can load higher (up to 200 mA) if using external VIO rail, 65mA max load with internal VIO*



2.4 Dimensions

60.44mm x 44.58mm (W x H)

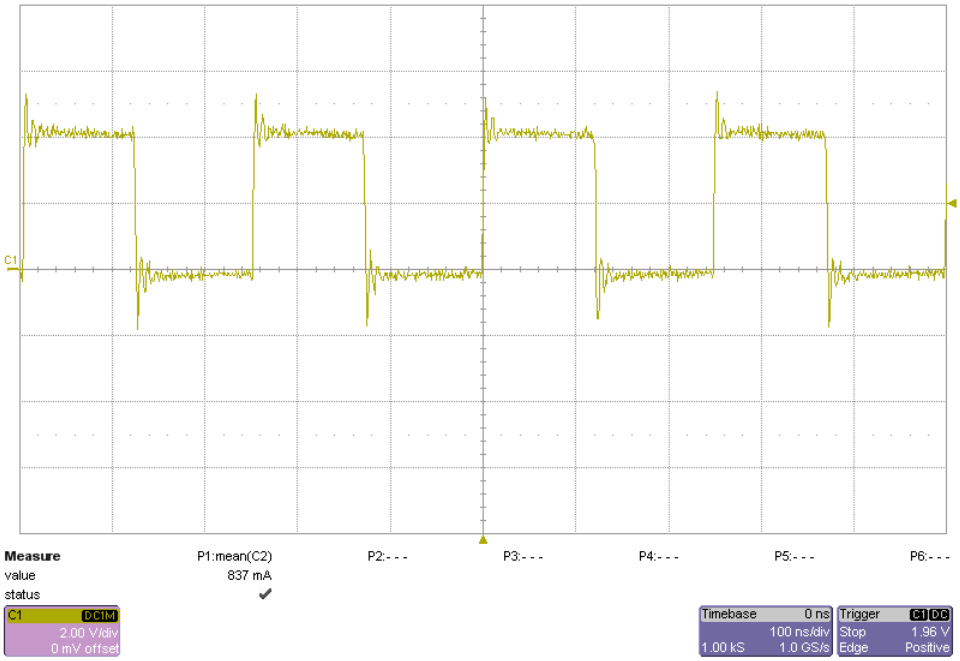
The photo below shows the PMP21884.



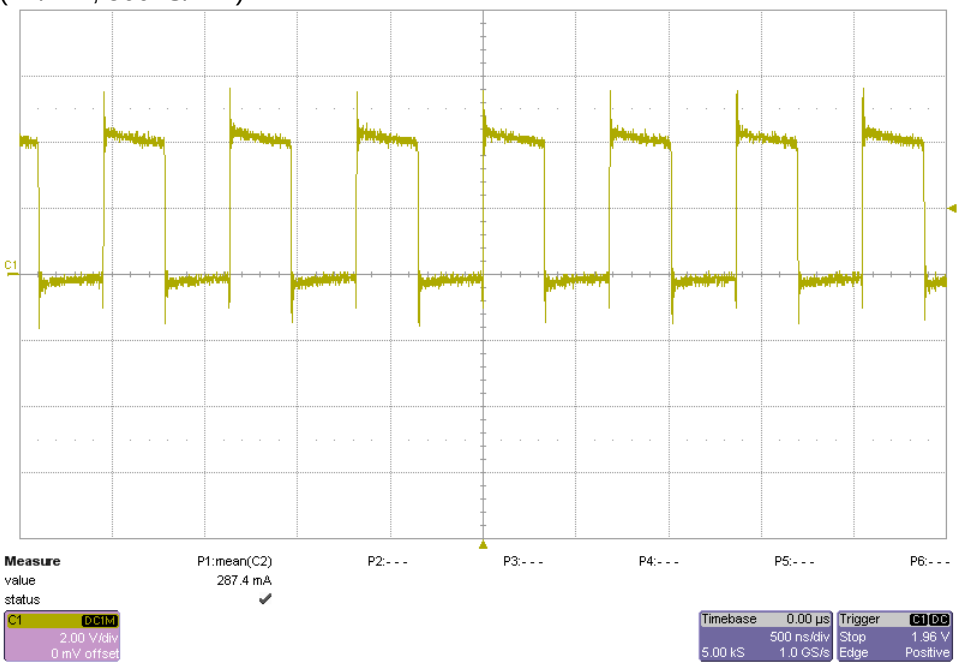
3 Waveforms

3.1 Switching

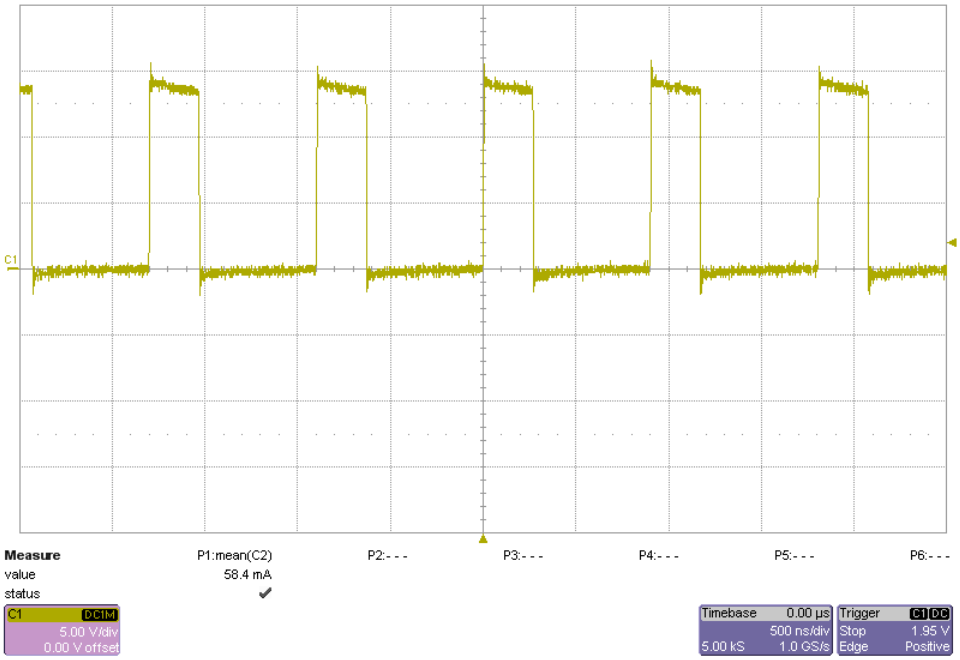
The photo below shows the switch node voltage. The input voltage VBAT is 4.1V and the 1V8_B output is loaded to 1A. (2V/DIV, 100nS/DIV)



The photo below shows the switch node voltage. The input voltage VBAT is 4.1V and the 1V8_C output is loaded to 0.3A. (2V/DIV, 500nS/DIV)



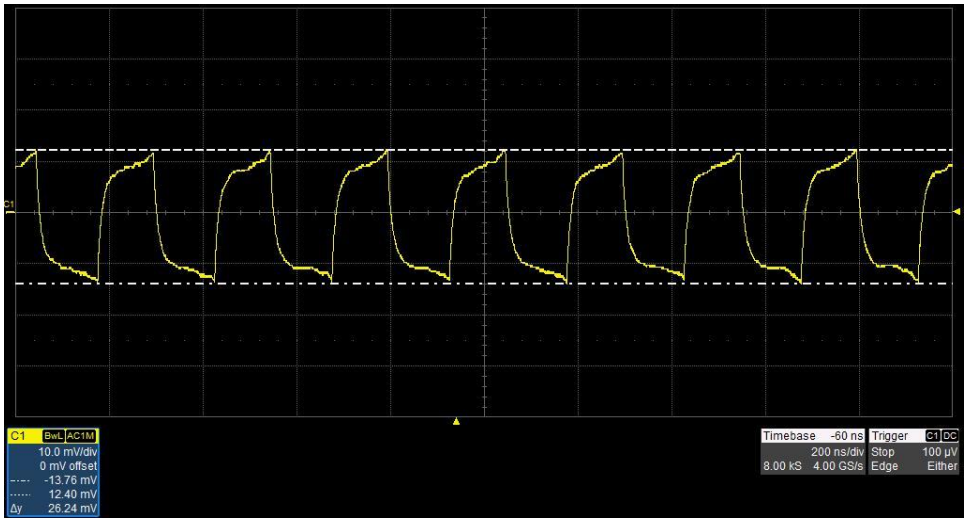
The photo below shows the switch node voltage. The input voltage VBAT is 4.1V and the 12V output is loaded to 0.06A. (5V/DIV, 500nS/DIV)



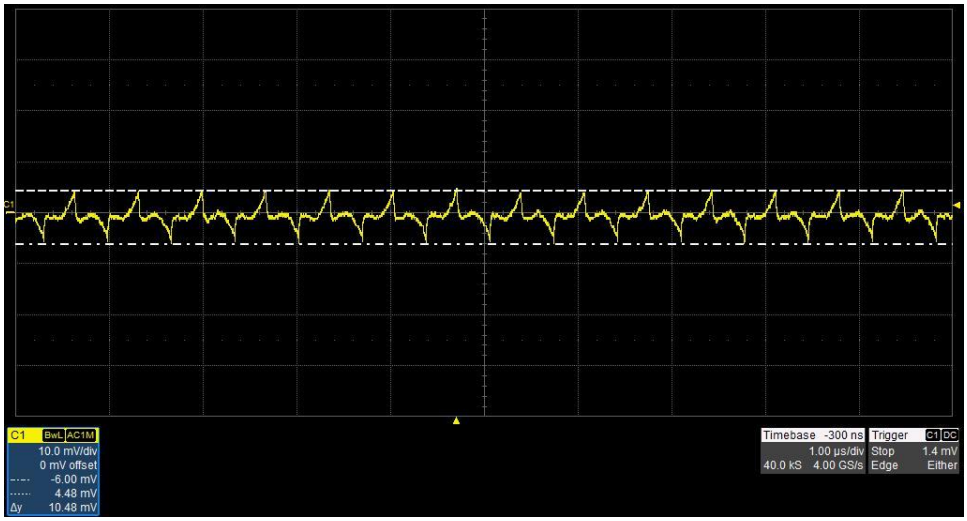
3.2 Output Voltage Ripple

(Note: Measured across connectors due to solution density)

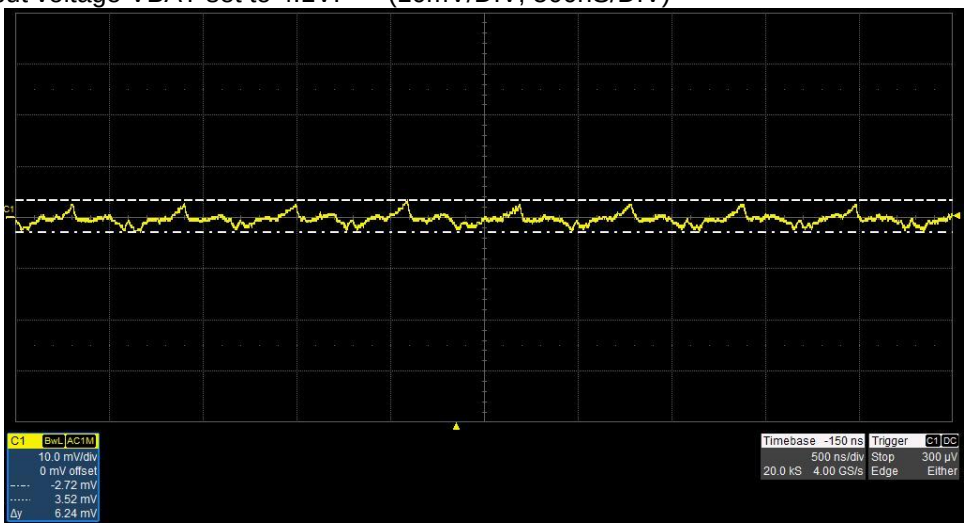
The output ripple voltage is shown in the figure below. The image was taken with the 1V8_B output loaded to 0.8A and the input voltage VBAT set to 4.1V. (10mV/DIV, 200nS/DIV)



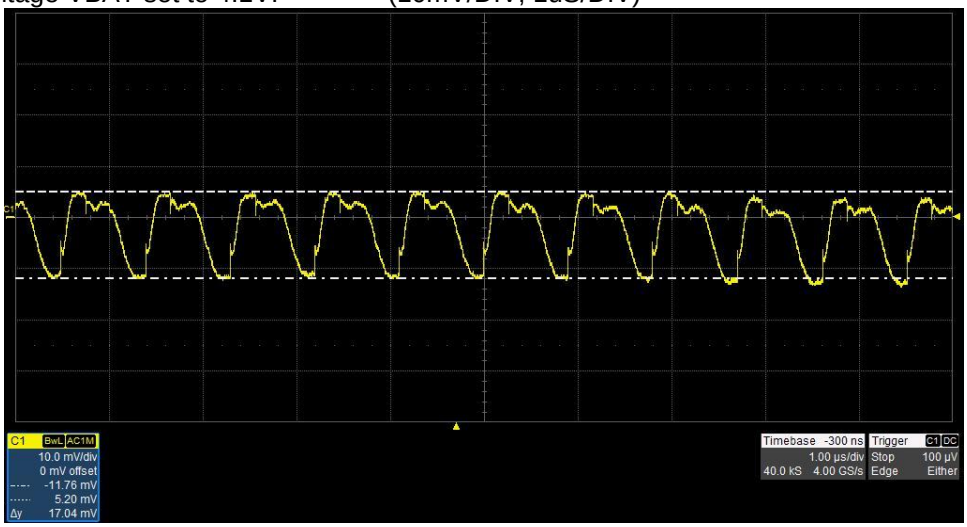
The output ripple voltage is shown in the figure below. The image was taken with the 1V8_C output loaded to 0.3A and the input voltage VBAT set to 4.1V. (10mV/DIV, 1uS/DIV)



The output ripple voltage is shown in the figure below. The image was taken with the 1V8_D output loaded to 0.1A and the input voltage VBAT set to 4.1V. (10mV/DIV, 500nS/DIV)

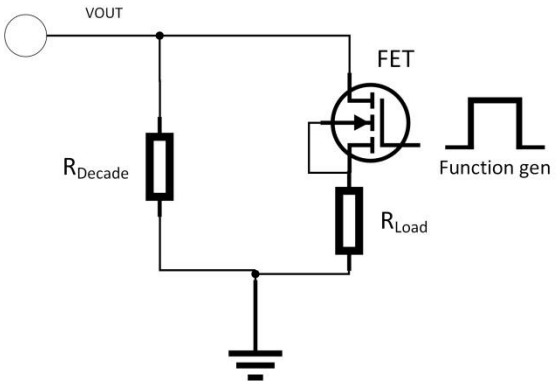


The output ripple voltage is shown in the figure below. The image was taken with the 12V output loaded to 0.06A and the input voltage VBAT set to 4.1V. (10mV/DIV, 1uS/DIV)

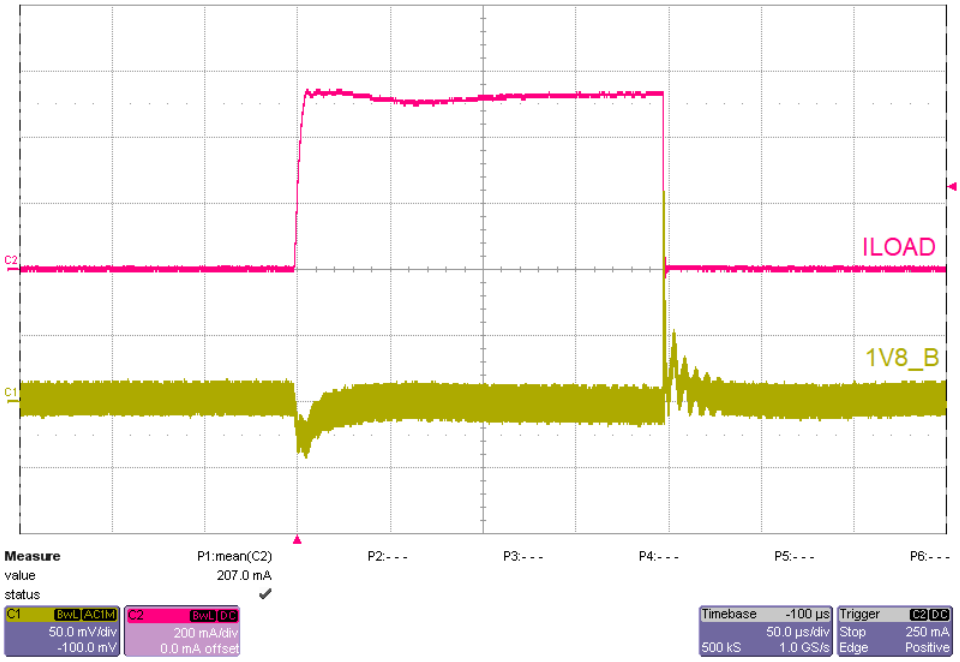


3.3 Load Transients

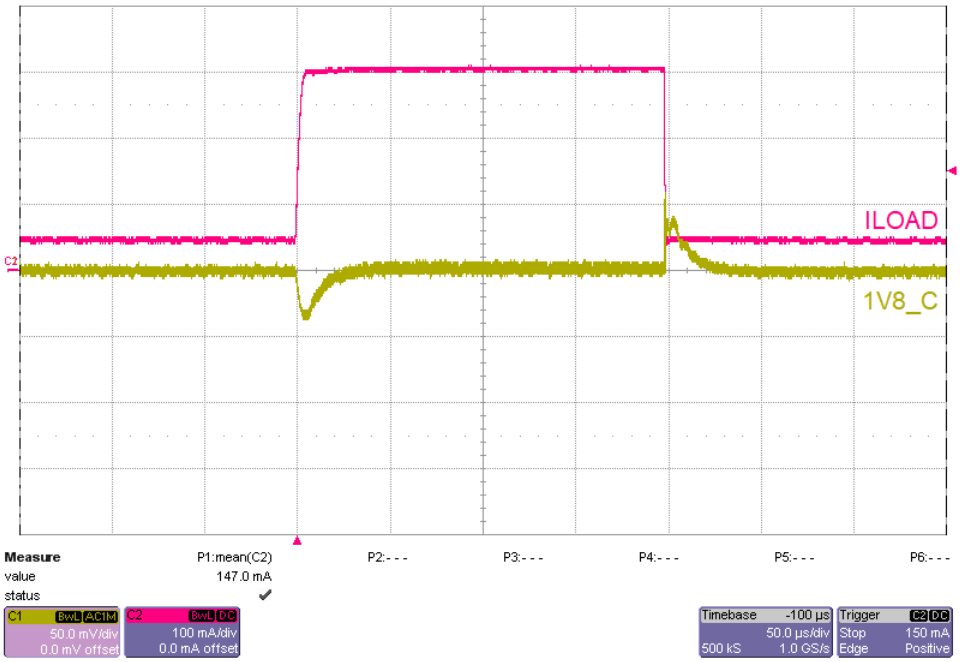
Note: Load transients for 1.8V rails taken with decade box load in parallel with function generator controlling a FET with series resistors. Function generator set to 2.3V high, 0V low, f=1Hz, leading/trailing=5ns. 12V was done similarly by manually connecting R2 rather than with a FET.



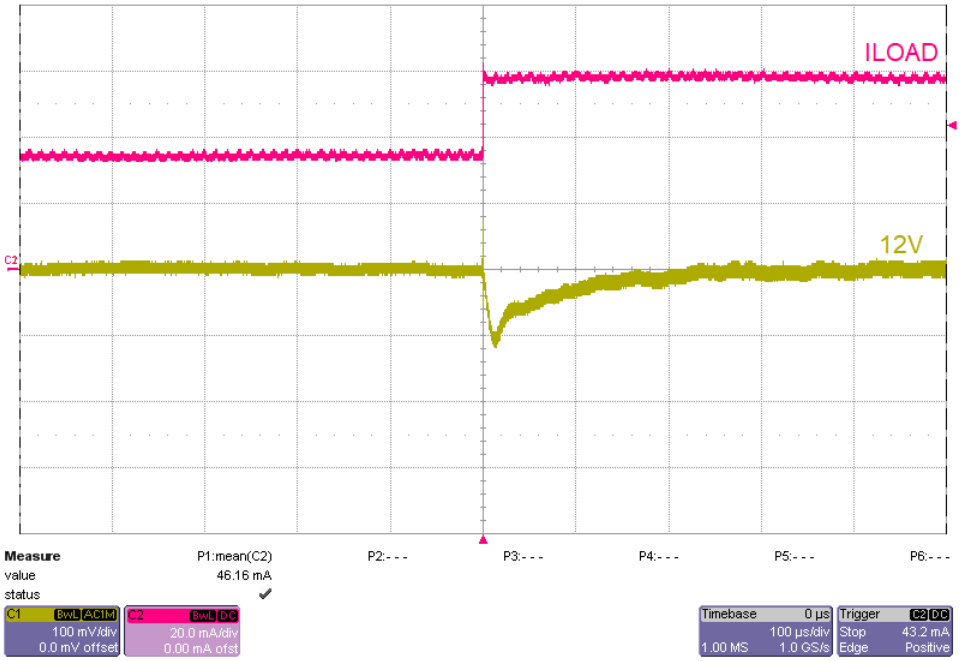
The photo below shows the 1V8_B output voltage (ac coupled) when the load current is stepped between 0.225A and 1.125A (R_{Decade} = 8Ohm, R_{Load} = 2Ohm). VBAT = 4.1V.
(50mV/DIV, 200mA/DIV, 50uS/DIV)



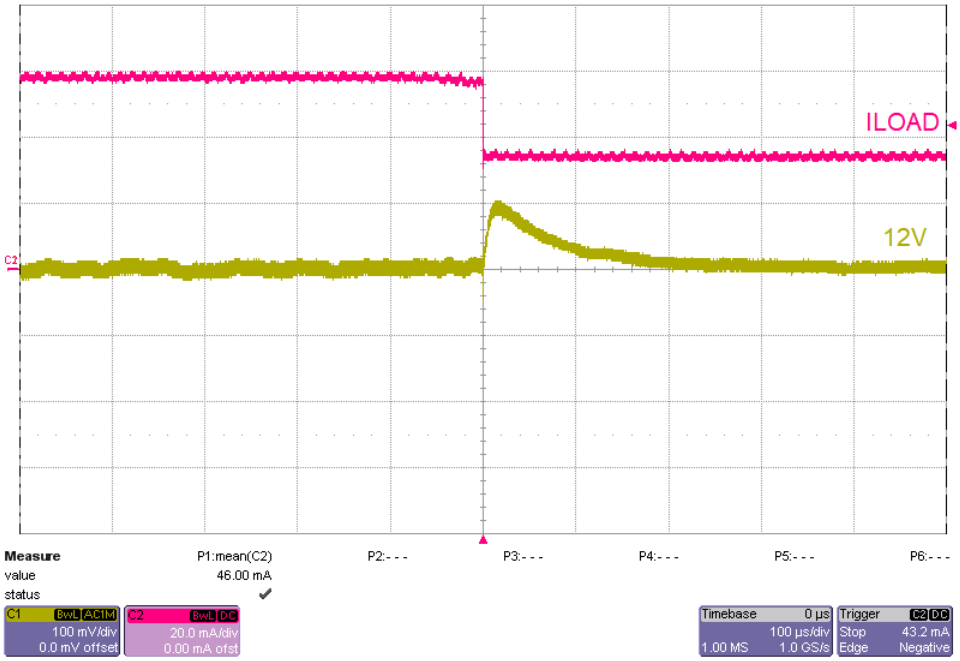
The photo below shows the 1V8_C output voltage (ac coupled) when the load current is stepped between 0.075A and 0.345A. VBAT = 4.1V (R_{Decade} = 24Ohm, R_{Load} = 6.6Ohm).
(50mV/DIV, 100mA/DIV, 50uS/DIV)



The photo below shows the 12V output voltage (ac coupled) when the load current is stepped *UP* between 0.036A and 0.060A (R_{Decade} = 333 Ohm, R_{Load} = 200 Ohm). VBAT = 4.1V.
(100mV/DIV, 20mA/DIV, 100uS/DIV)



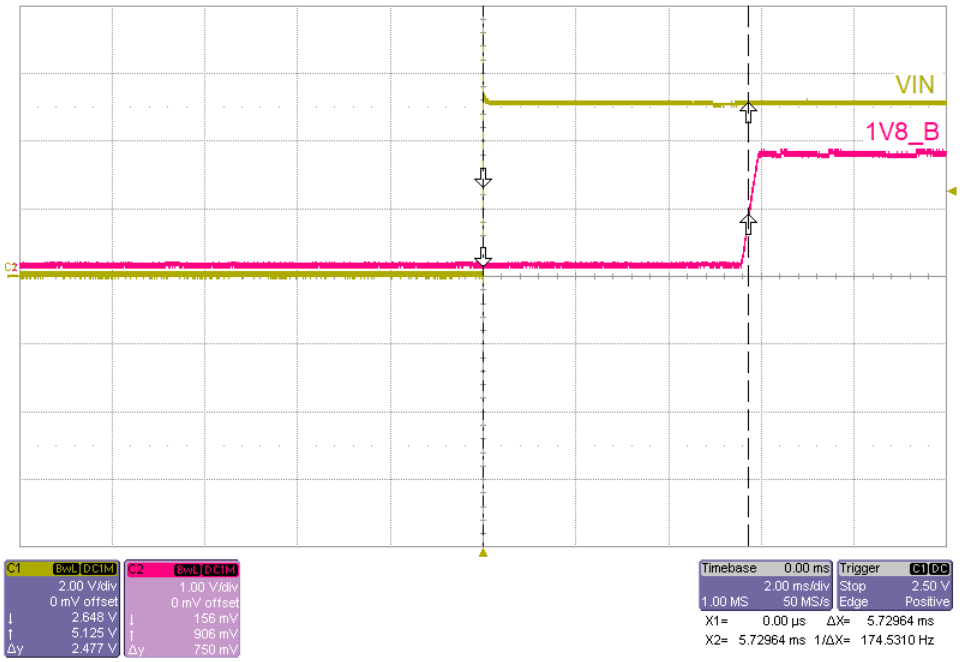
The photo below shows the 12V output voltage (ac coupled) when the load current is stepped *DOWN* between 0.036A and 0.060A (R_{Decade} = 333 Ohm, R_{Load} = 200 Ohm). VBAT = 4.1V.
(100mV/DIV, 20mA/DIV, 100uS/DIV)



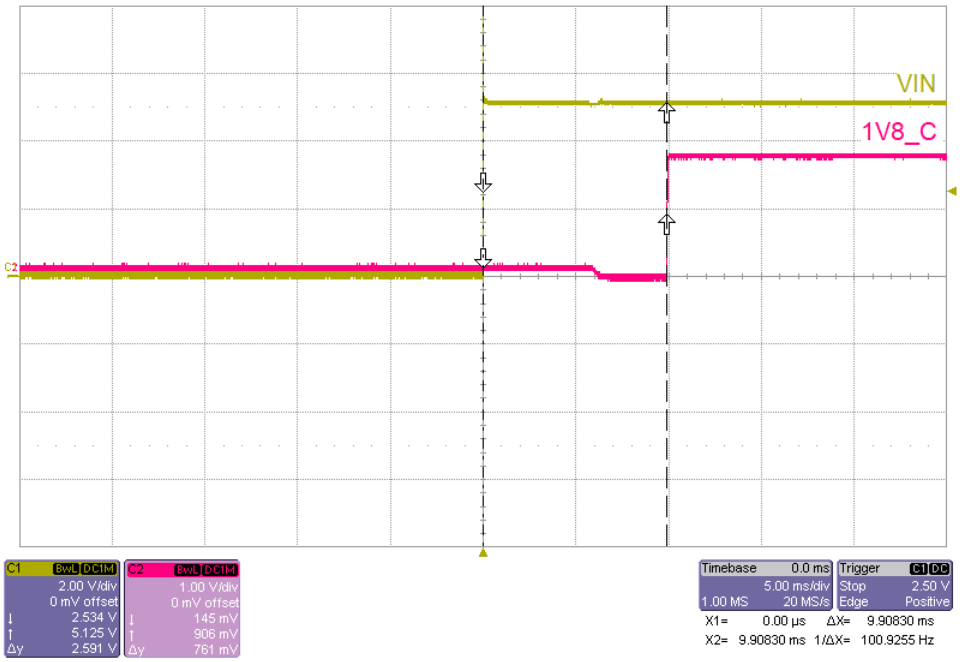
3.4 Start-up Sequence

(Time Delta: 50% voltage high level from Micro USB port to 50% output voltage level)

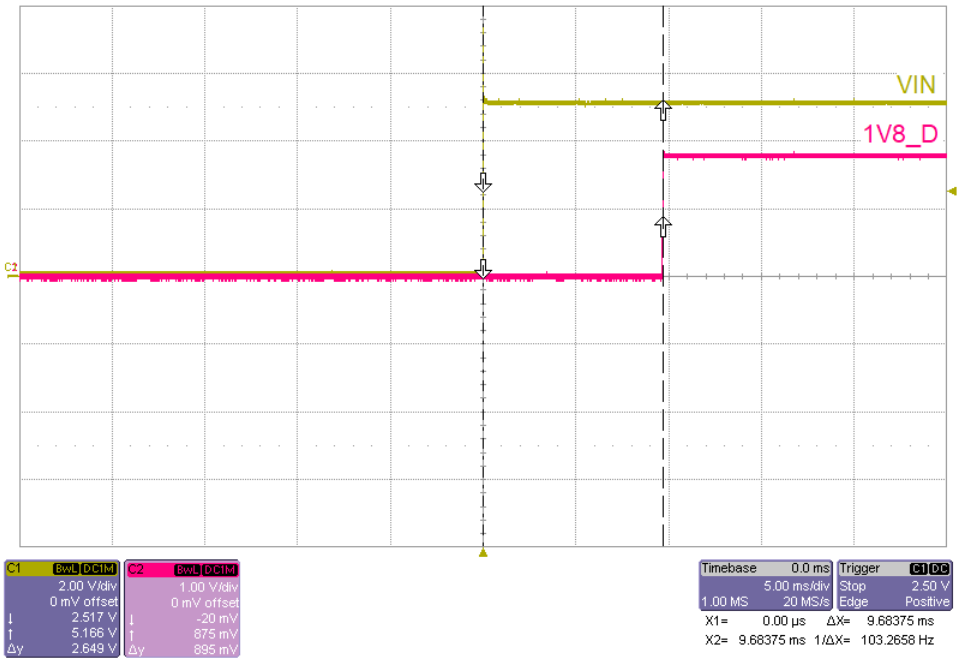
The photo below shows the output voltage startup waveform after the application of 5V in on the VIN rail with the 1V8_B output rail loaded to 0A. (1V8_B: 1V/DIV, 2mS/DIV), (VIN: 2V/DIV)



The photo below shows the output voltage startup waveform after the application of 5V in on the VIN rail with the 1V8_C output rail loaded to 0A. (1V8_C: 1V/DIV, 5mS/DIV), (VIN: 2V/DIV)

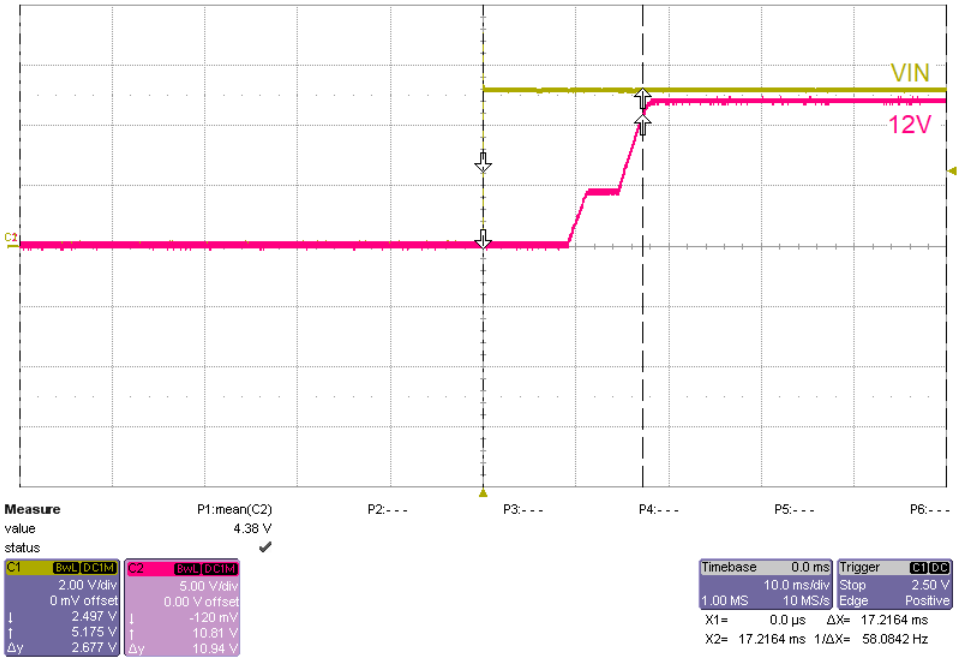


The photo below shows the output voltage startup waveform after the application of 5V in on the VIN rail with the 1V8_D output rail loaded to 0A. (1V8_D: 1V/DIV, 5mS/DIV), (VIN: 2V/DIV)



The photo below shows the output voltage startup waveform after the application of 5V in on the VIN rail with the 12V output rail loaded to 0A. (12V: 5V/DIV, 10mS/DIV), (VIN: 2V/DIV)

(Cursors from 50% VIN to 90% 12V out):



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