Test Data
For PMP9496
03/12/2015

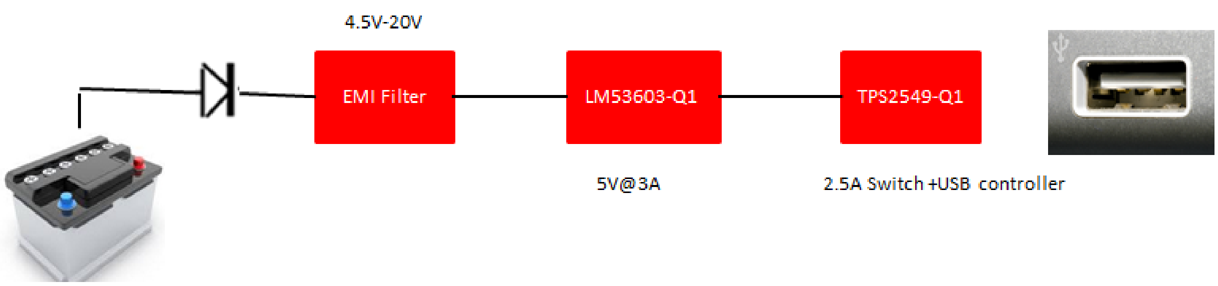
Contents

1. Design Specifications

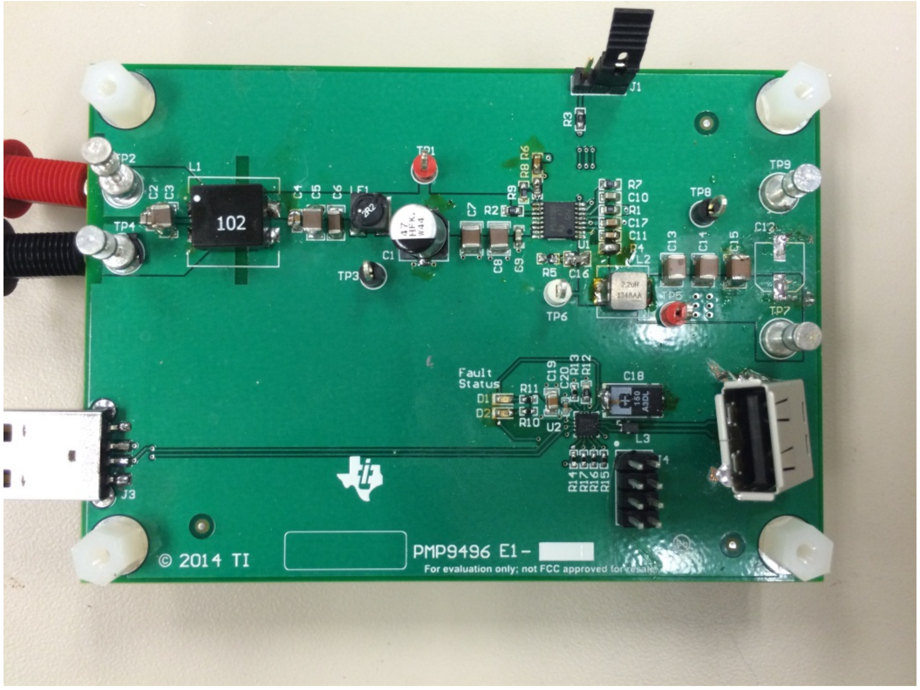
Vin Minimum	**7 VDC**
Vin Maximum	**25 VDC**
Vout1	**5 VDC**
Iout 1	**2.1 A**
Approximate Switching Frequency	**2.1MHz for Vout1**

2. Circuit Description and PCB details

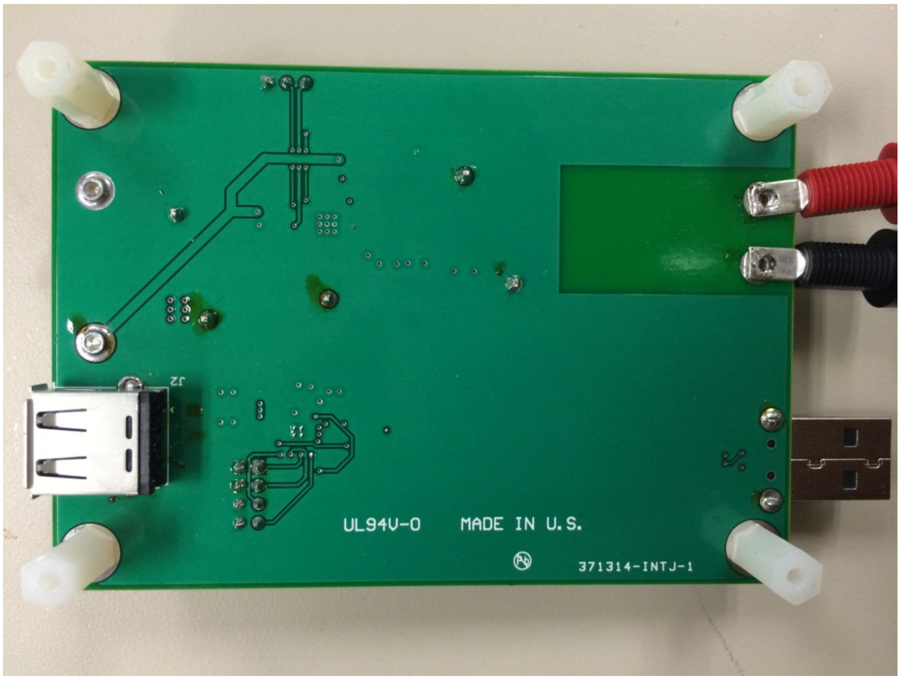
PMP9496 is a conducted EMI optimized (CISPR 25 Class 5) 10 W Design for Efficient Automotive USB Charger application utilizing LM53603 regulator IC (2.1MHz fully integrated Synchronous Buck for Automotive application) and TPS2549 USB Switch(TPS2549-Q1 Automotive USB Charging Port Controller with Integrated Power Switch & Cable Compensation). The design accepts Wide input voltage range of 7Vin to 25Vin and provides the outputs of 5V@2.1A . It features a small size and is an inexpensive and more efficient solution customized for automotive USB Charger application. The Board dimension of PMP9496 PCB is 2800mil * 4000mil. Four layer PCB was used for the design.



3. PMP9496 Board Photos



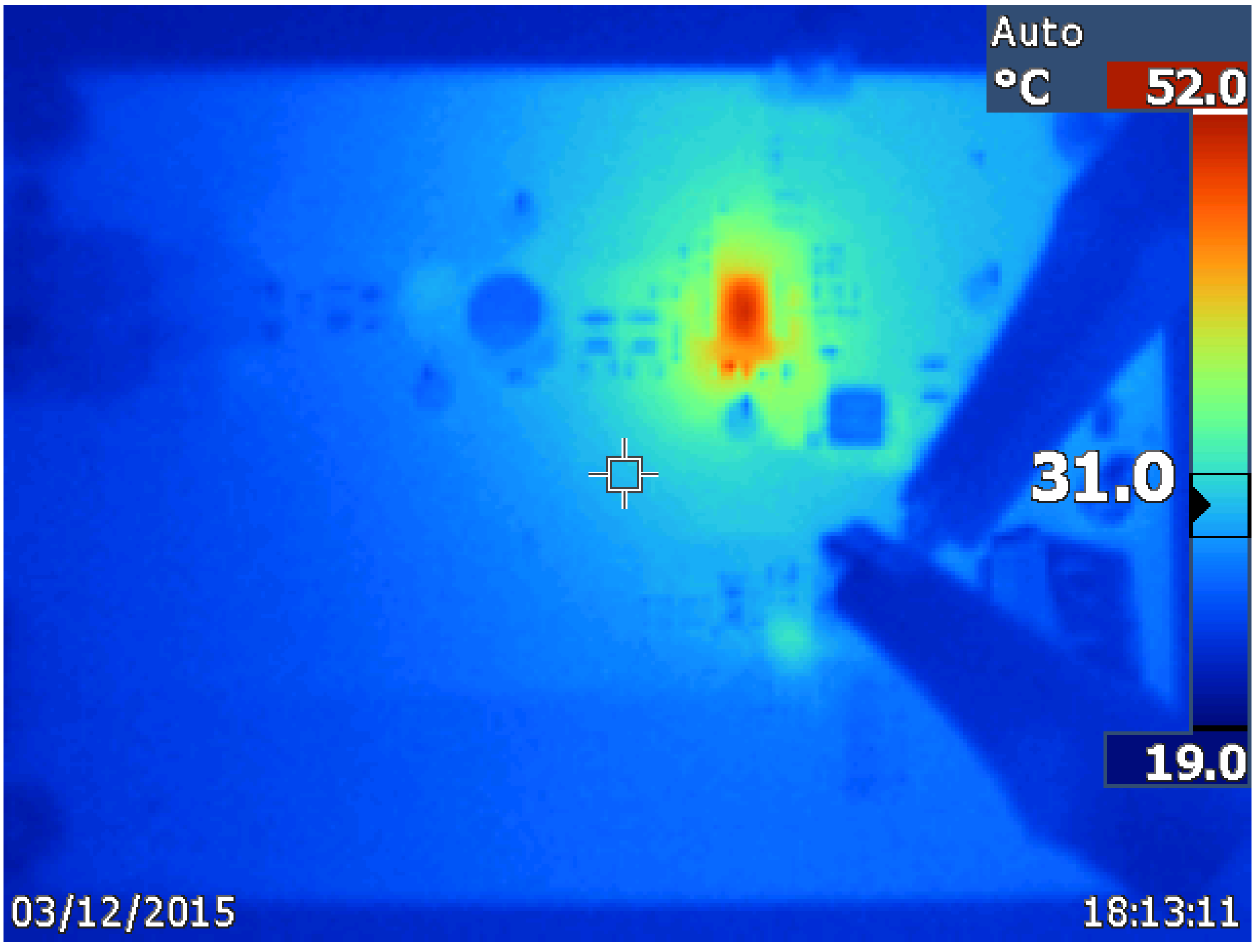
Board Photo (Top)



Board Photo (Bottom)

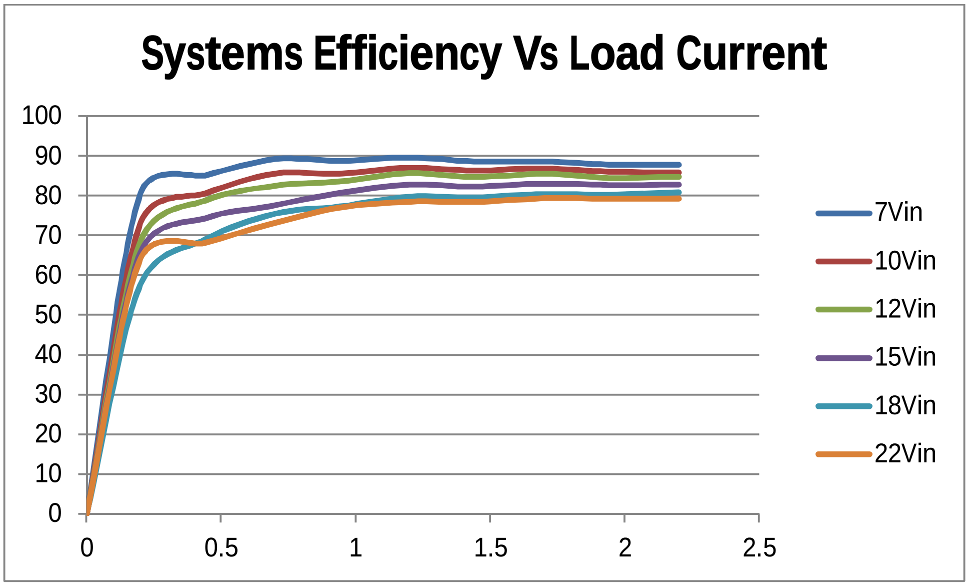
4. Thermal Data

IR thermal image taken at steady state with 12Vin and the output at full load (no airflow)



5. Efficiency

5.1 Efficiency Chart – Input Voltage Vs Efficiency with all output fully Loaded



5.2 Efficiency Data

Efficiency of System Vs Load Current

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency (%)
==				
7.003	0.025	4.933	0	0
7.003	0.175	4.94	0.2	80.619
7.003	0.365	4.949	0.44	85.191
7.003	0.555	4.957	0.7	89.277
7.003	0.75	4.965	0.94	88.859
7.003	0.95	4.974	1.2	89.718
7.003	1.155	4.982	1.44	88.695
7.003	1.365	4.989	1.7	88.725
7.003	1.575	4.997	1.94	87.891
7.003	1.79	5.003	2.2	87.804

7.003	0.57	0.027	0.64	0.433

Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency(%)
==				
10.002	0.02	4.952	0	0
10.002	0.135	4.939	0.2	73.156
10.002	0.27	4.948	0.44	80.618
10.002	0.405	4.956	0.7	85.642
10.002	0.545	4.965	0.94	85.618
10.002	0.685	4.973	1.2	87.101
10.002	0.83	4.981	1.44	86.4
10.002	0.975	4.988	1.7	86.953
10.002	1.125	4.995	1.94	86.119
10.002	1.28	5.001	2.2	85.938
10.002	0.385	0.027	0.64	0.449
Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency(%)
==				
12.001	0	4.991	0	0
12.001	0.12	4.939	0.2	68.592
12.001	0.23	4.948	0.44	78.875
12.001	0.35	4.956	0.7	82.593
12.001	0.465	4.965	0.94	83.633
12.001	0.58	4.973	1.2	85.734
12.001	0.705	4.981	1.44	84.776
12.001	0.825	4.988	1.7	85.645
12.001	0.955	4.995	1.94	84.551
12.001	1.08	5	2.2	84.869
12.001	0.325	0.026	0.64	0.427
Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency(%)
==				
15.007	0	4.991	0	0
15.007	0.1	4.939	0.2	65.823
15.007	0.195	4.947	0.44	74.382
15.007	0.29	4.956	0.68	77.437
15.007	0.385	4.964	0.94	80.762
15.007	0.48	4.972	1.2	82.828
15.007	0.58	4.98	1.44	82.389
15.007	0.68	4.988	1.7	83.095

15.007	0.78	4.995	1.94	82.784
15.007	0.885	5	2.2	82.824
15.007	0.265	0.026	0.64	0.418

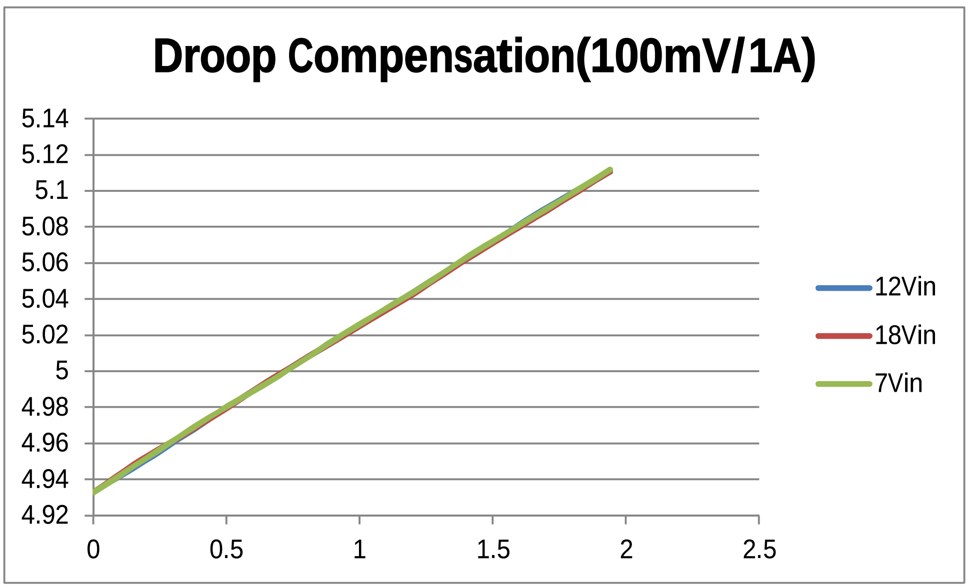
Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency(%)
==				
18.009	0	4.991	0	0
18.009	0.095	4.939	0.2	57.737
18.009	0.175	4.947	0.44	69.066
18.009	0.255	4.956	0.7	75.544
18.009	0.335	4.964	0.94	77.344
18.009	0.415	4.972	1.2	79.832
18.009	0.5	4.98	1.44	79.64
18.009	0.585	4.988	1.7	80.488
18.009	0.67	4.994	1.94	80.295
18.009	0.755	5	2.2	80.901
18.009	0.225	0.026	0.62	0.398
Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency(%)
==				
22.008	0	4.977	0	0
22.008	0.07	4.94	0.2	64.133
22.008	0.145	4.947	0.44	68.21
22.008	0.21	4.955	0.68	72.904
22.008	0.275	4.963	0.94	77.083
22.008	0.345	4.971	1.2	78.564
22.008	0.415	4.98	1.44	78.517
22.008	0.485	4.987	1.7	79.427
22.008	0.555	4.994	1.94	79.319
22.008	0.63	4.999	2.2	79.32
22.008	0.19	0.026	0.62	0.386
Vin(V)	Iin(A)	Vout(V)	Iout(A)	Efficiency(%)
==				
25.007	0	4.97	0	0
25.007	0.075	4.944	0.2	52.721
25.007	0.13	4.947	0.44	66.956
25.007	0.19	4.955	0.7	73.001
25.007	0.25	4.963	0.94	74.623
25.007	0.305	4.971	1.2	78.21
25.007	0.37	4.979	1.44	77.489
25.007	0.43	4.986	1.7	78.826

25.007	0.495	4.993	1.94	78.252
25.007	0.56	4.999	2.2	78.534
25.007	0.16	0.026	0.6	0.39

6. Cable Compensations

When a load draws current through a long or thin wire, wire resistance causes an IR drop that reduces the voltage delivered to the load. In the vehicle from DC-DC 5V output to the V_{PD_IN} (input voltage of portable device), Rds,on of power switch, long wire from 5V to USB port, charging cable existed in the charging path. The charging current of most portable device is less than their expected maximum charging current due to the IR drop.

TPS2549-Q1 detects the load currents and sets a proportional sink current at an output that can be used to control output voltage of the LM53603 adjustable regulator to compensate the drop in the charging path.



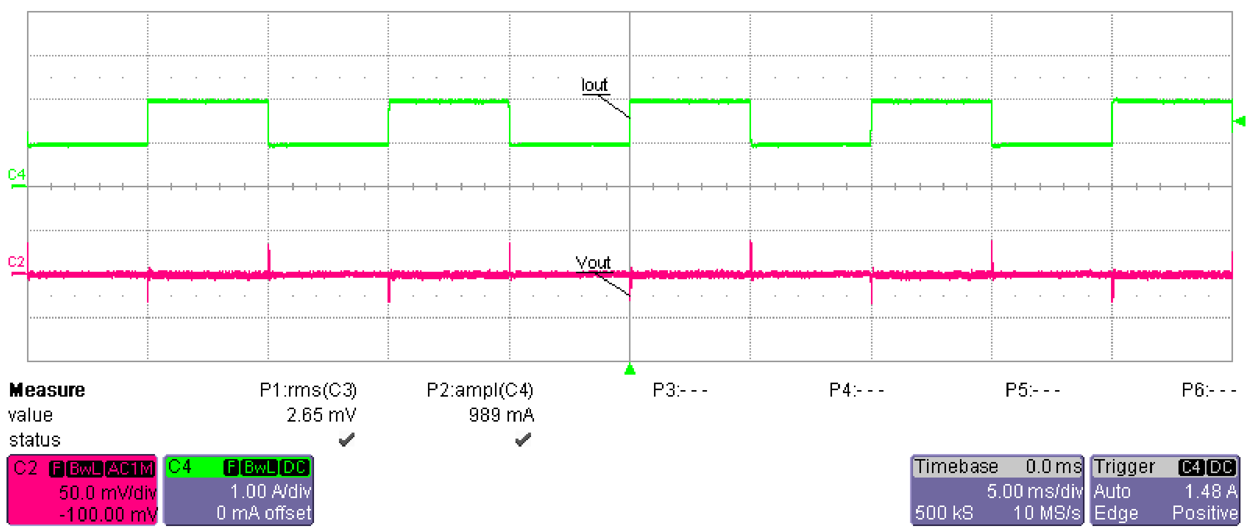
In this particular design, 100mV /1A drop across the cable is compensated. Vout mentioned below is LM53603 Output while load is connected at USB Switch Output.

Vout(V)	Iout(A)
4.933	0
4.951	0.2
4.974	0.44
4.997	0.68
5.02	0.94

5.044	1.2
5.066	1.44
5.089	1.68
5.111	1.94

7. Waveforms

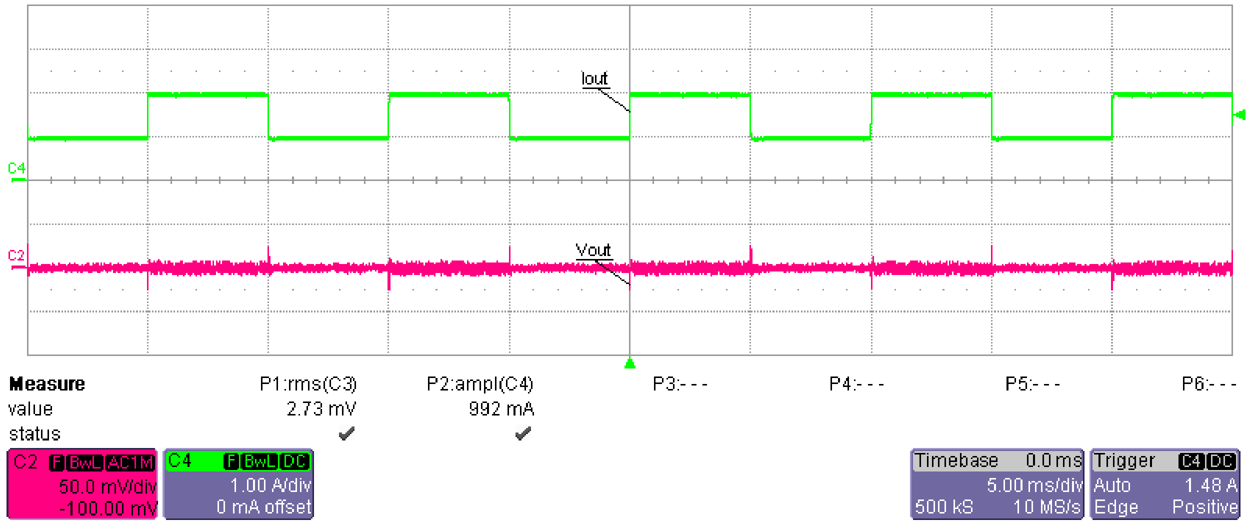
7.1 Load Transient Response



Load Transient Response at 7 Vin and 50%-to-100% Load Step(1A-2A) on 5V Output Vout(Load was connected to regulator output)

Ch2 – Vout1 (AC coupled)

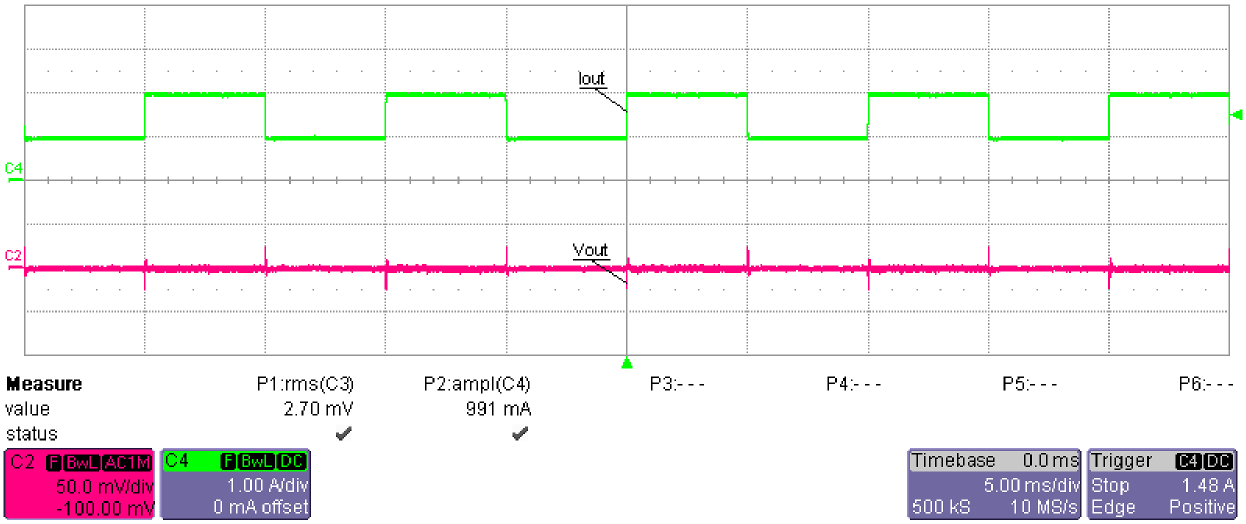
Ch4 - Iout 1



Load Transient Response at 12 Vin and 50%-to-100% Load Step(1A-2A) on 5V Output Vout(Load was connected to regulator output)

Ch2 – Vout1 (AC coupled)

Ch4 - Iout 1

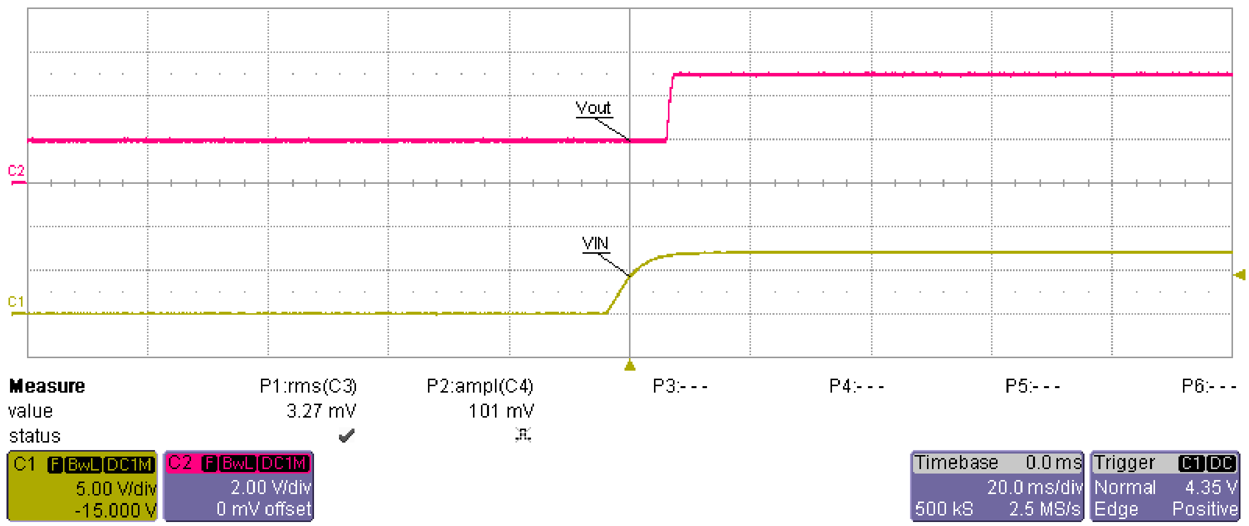


Load Transient Response at 20 Vin and 50%-to-100% Load Step(1A-2A) on 5V Output Vout(Load was connected to regulator output)

Ch2 – Vout1 (AC coupled)

Ch4 - Iout 1

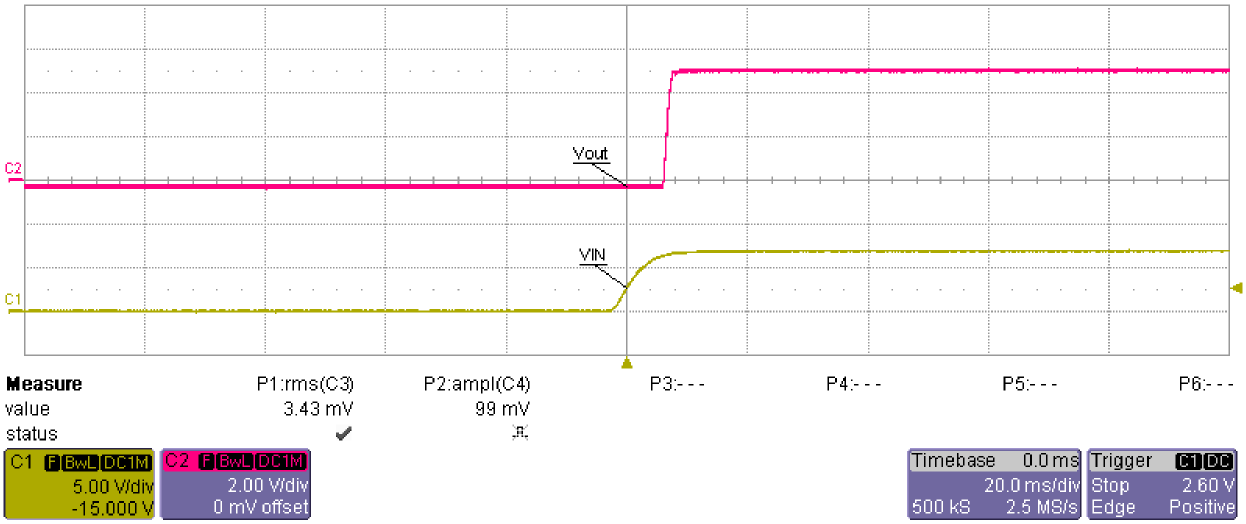
7.2 Startup



Startup into No Load at 7 Vin

Ch1-Vin

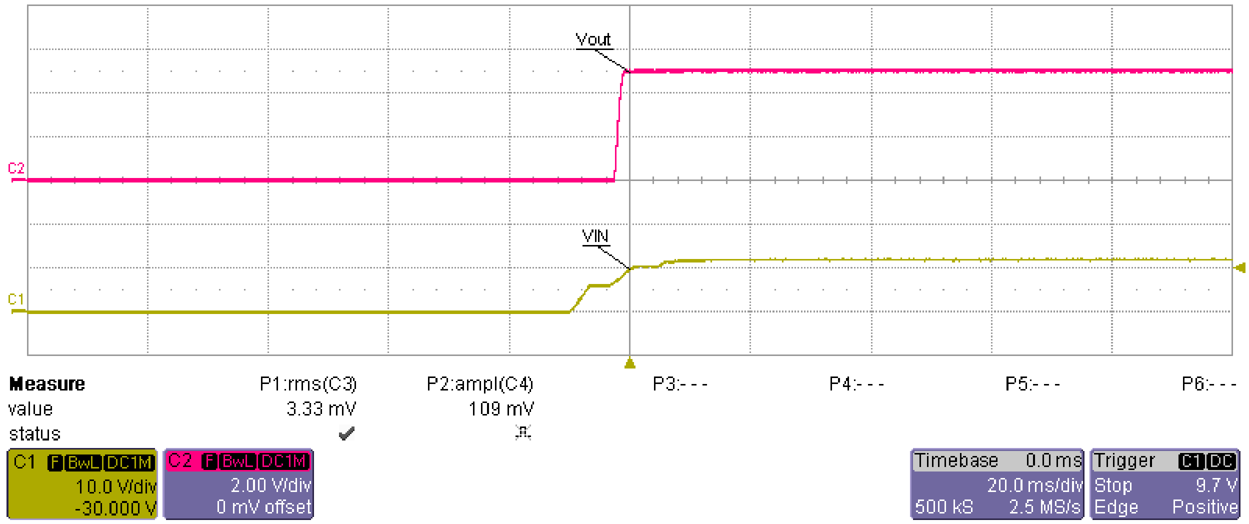
Ch2-Vout 1



Startup into full Load (Load was connected at USB switch output) at 7 Vin

Ch1-Vin

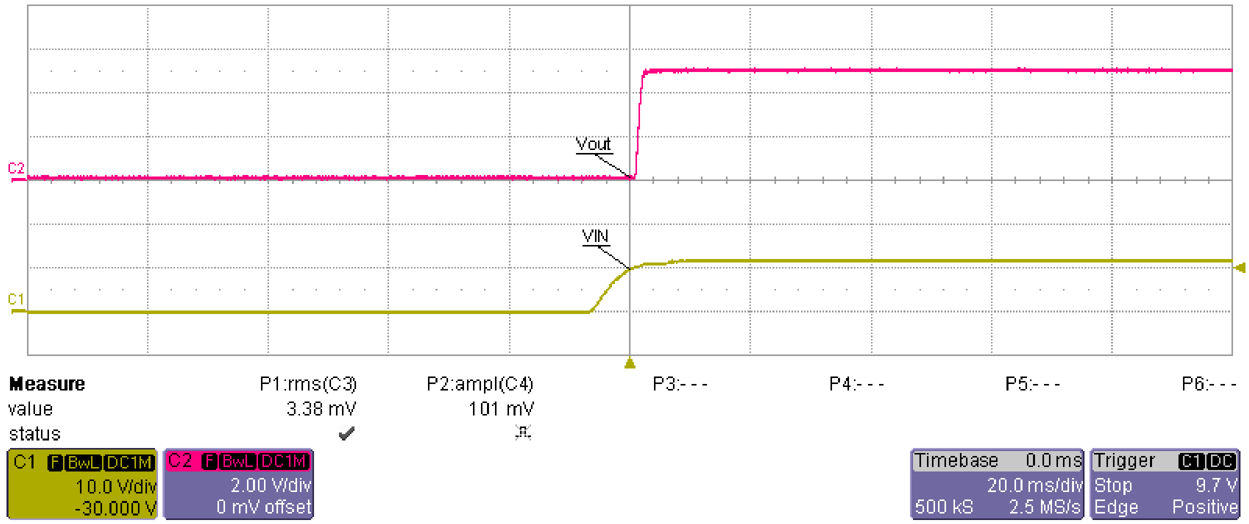
Ch2-Vout 1



Startup into No Load at 12 Vin

Ch1-Vin

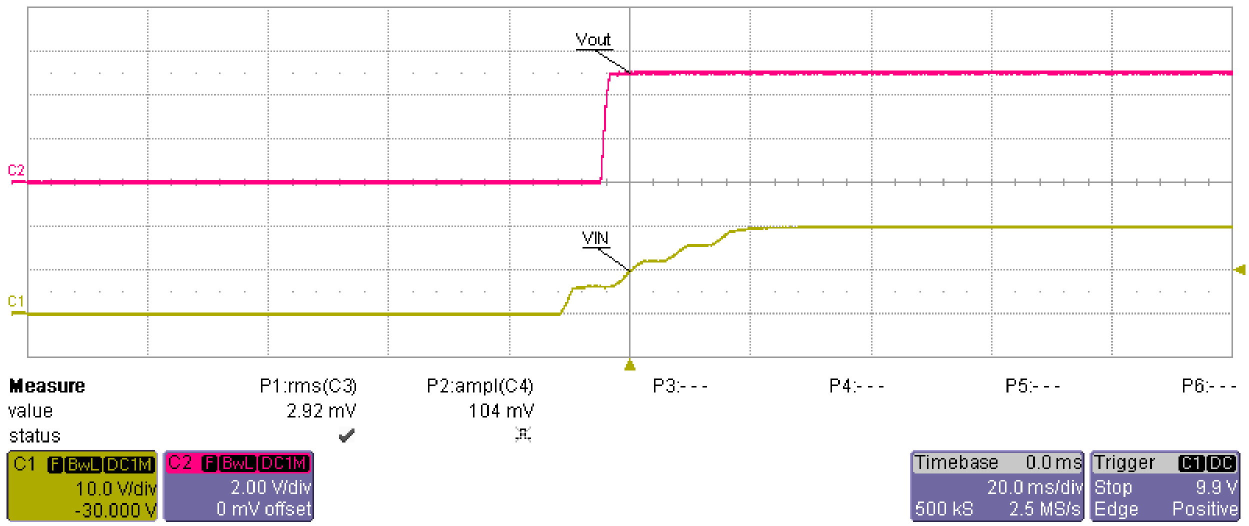
Ch2-Vout 1



Startup into full Load (Load was connected at USB switch output) at 12 Vin

Ch1-Vin

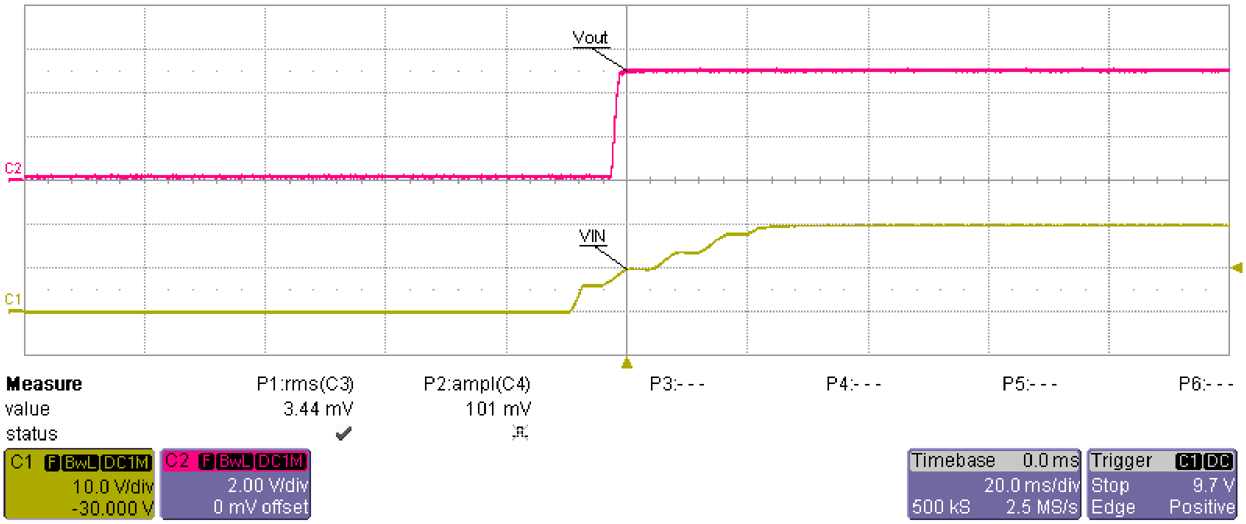
Ch2-Vout 1



Startup into No Load at 20 Vin

Ch1-Vin

Ch2-Vout 1

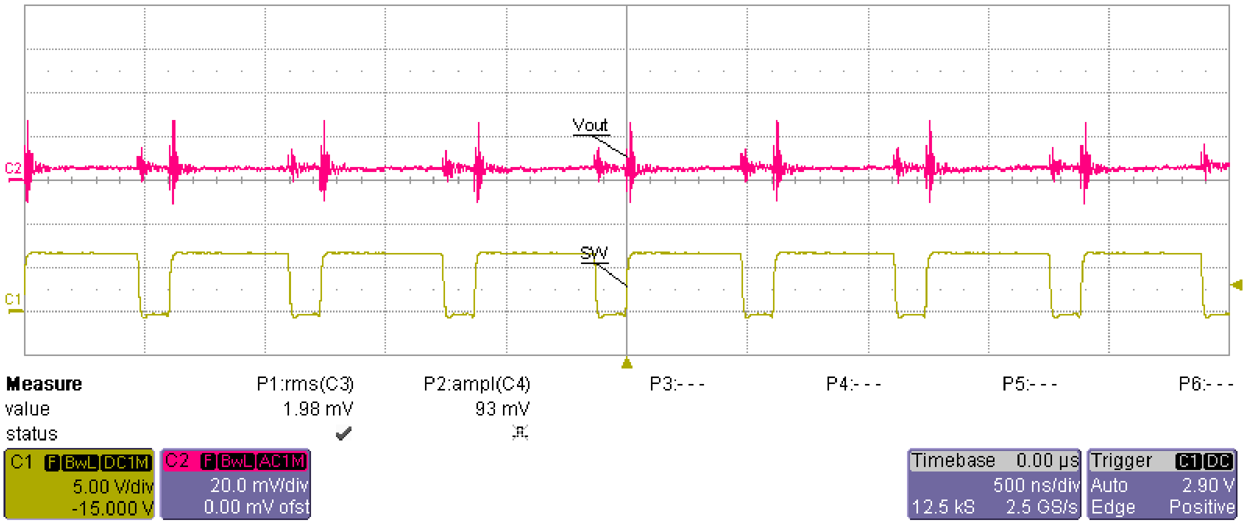


Startup into full Load (Load was connected at USB switch output) at 20 Vin

Ch1-Vin

Ch2-Vout 1

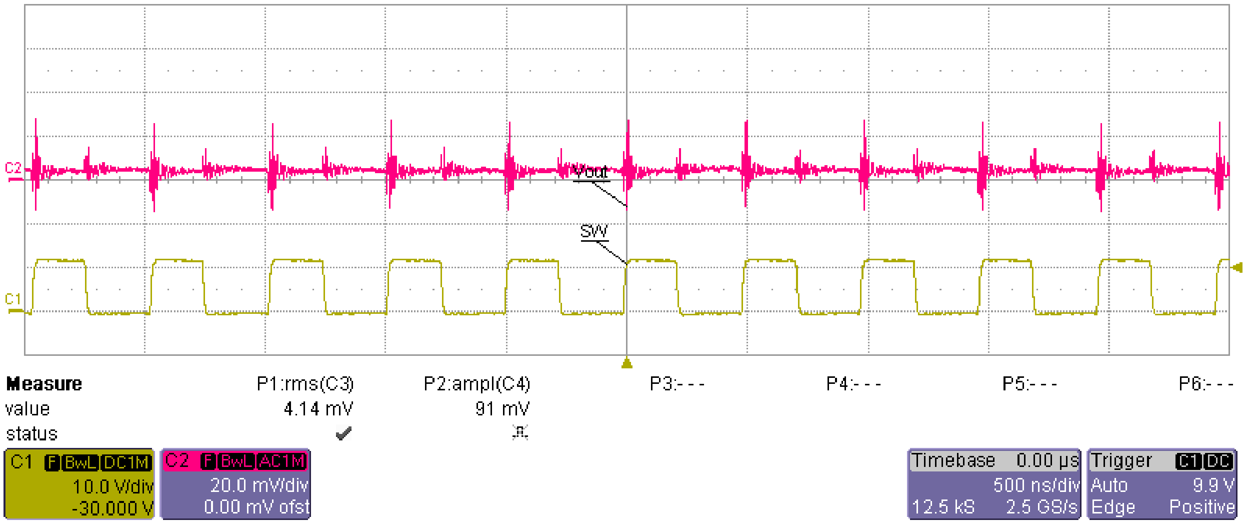
7.3 Output Voltage Ripple and Switch Node Voltage



Switch Node Voltage and Output Voltage Ripple at 7 Vin and Full Load was connected at USB switch output

Ch2-Vout1 (AC Coupled)- On USB Switch Output

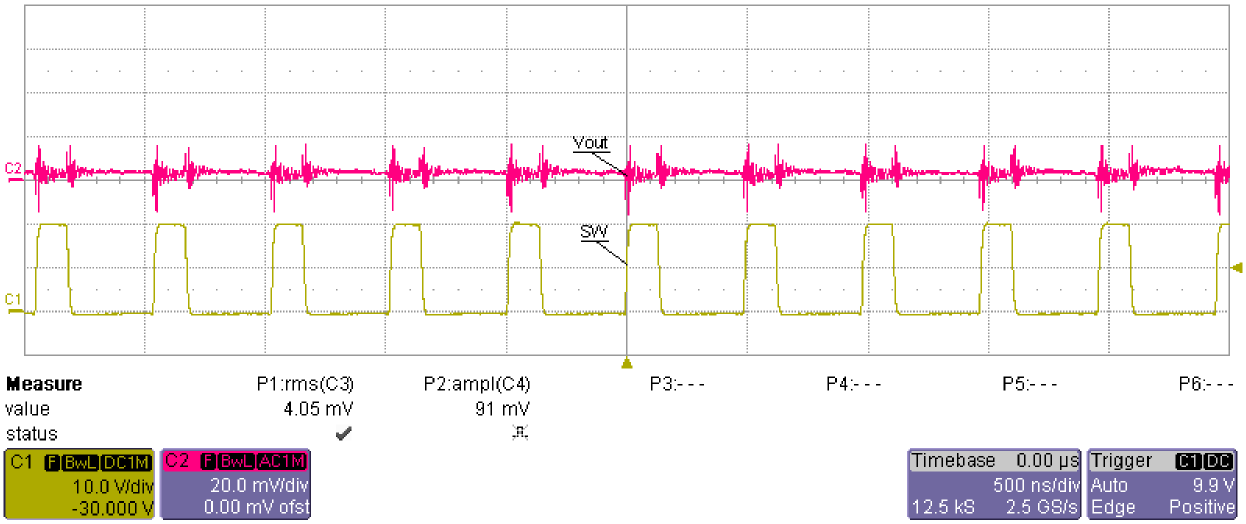
Ch1-Switching Waveform



Switch Node Voltage and Output Voltage Ripple at 12 Vin and Full Load was connected at USB switch output

Ch2-Vout1 (AC Coupled)- On USB Switch Output

Ch1-Switching Waveform



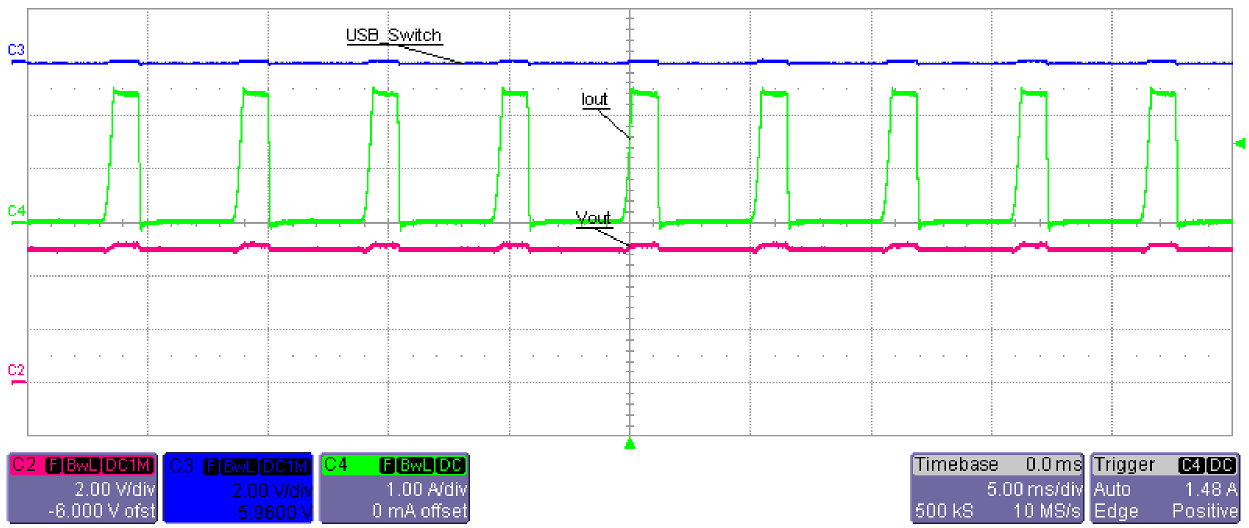
Switch Node Voltage and Output Voltage Ripple at 20 Vin and Full Load was connected at USB switch output

Ch2-Vout1 (AC Coupled)- On USB Switch Output

Ch1-Switching Waveform

8. Enable into Short – USB switch thermal Cycling

The device operates in constant-current mode after the current-limit circuit has responded. Complete Shutdown occurs only if the fault is presented long enough to activate thermal limiting. The device remains off until the junction temperature cools to approximately 20°C and then restarts. The device continues to cycle on and off until the overcurrent condition is removed.

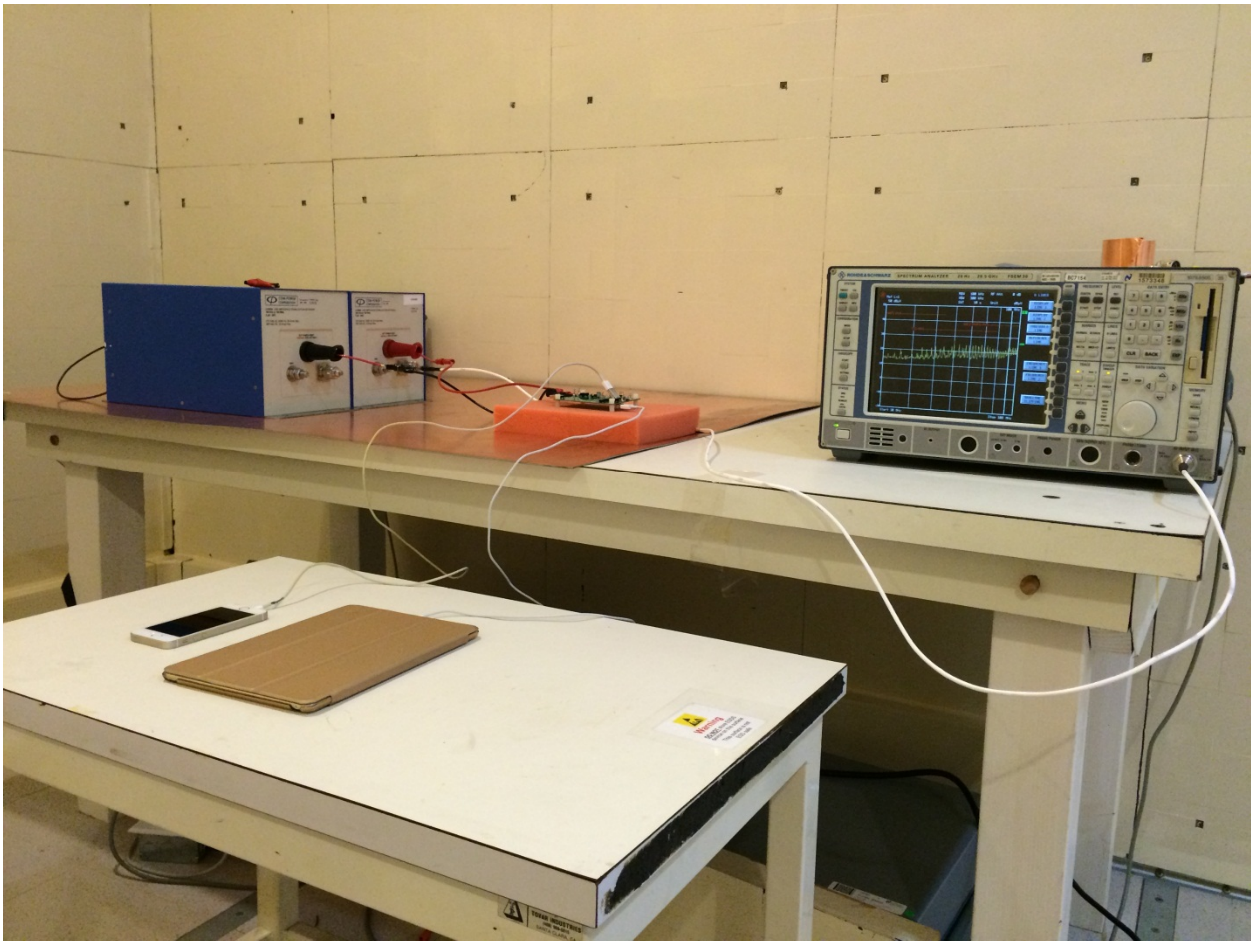


CH2-LM53603 Output
CH3-USB Switch Output
CH4-Output Current during Short condition at output .

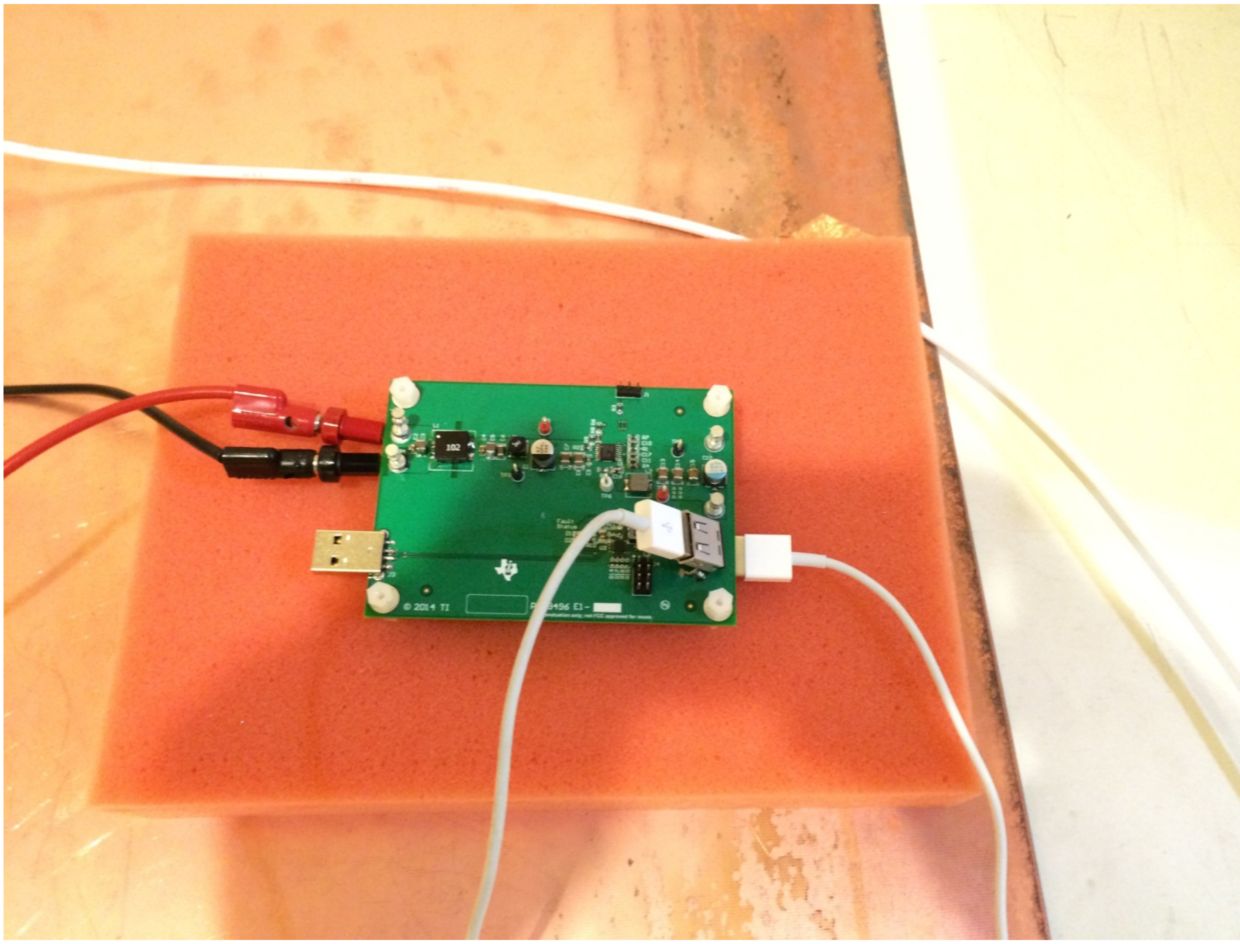
9. Conducted EMI

The conducted emissions is tested followed the of CISPR 25 standards. The frequency band examined spans from 150 kHz to 108 MHz covering the AM, FM radio bands, VHF band, and TV band specified in the CISPR 25.

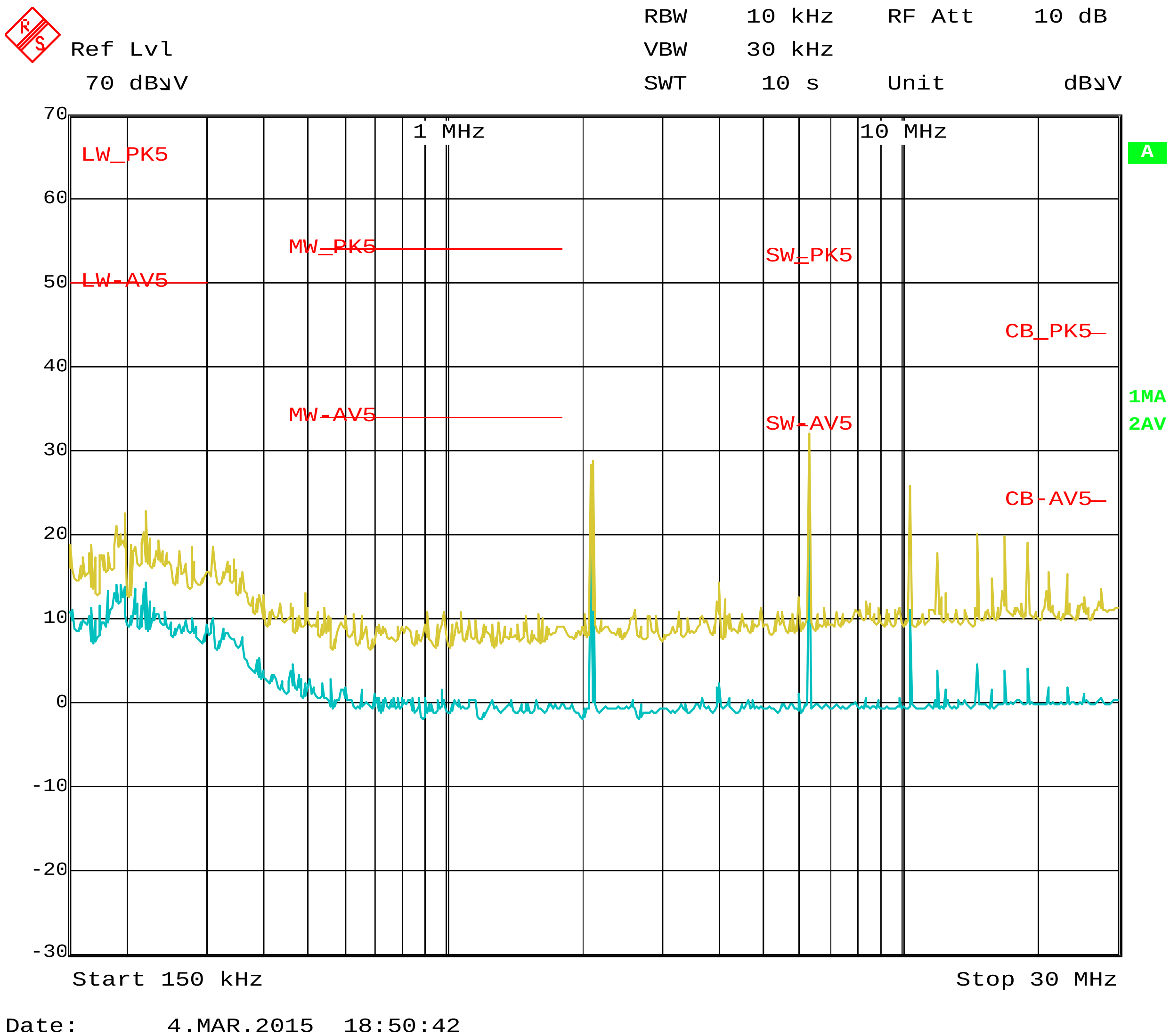
The test was conducted by connecting two phones at the output (Each Fast Charging at 5V@ 1A) to replicate the real case scenario.



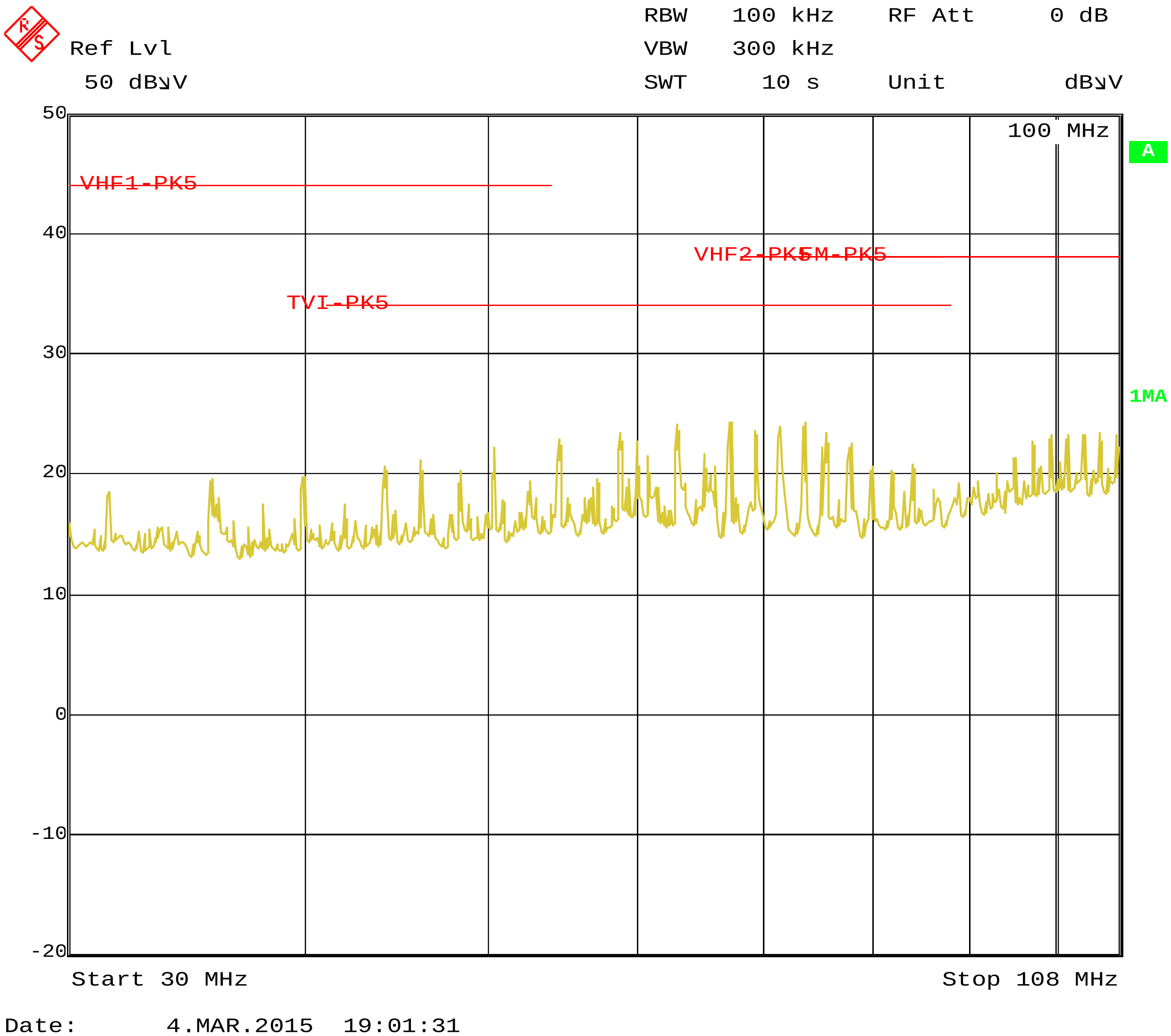
Conducted EMI Test Set up



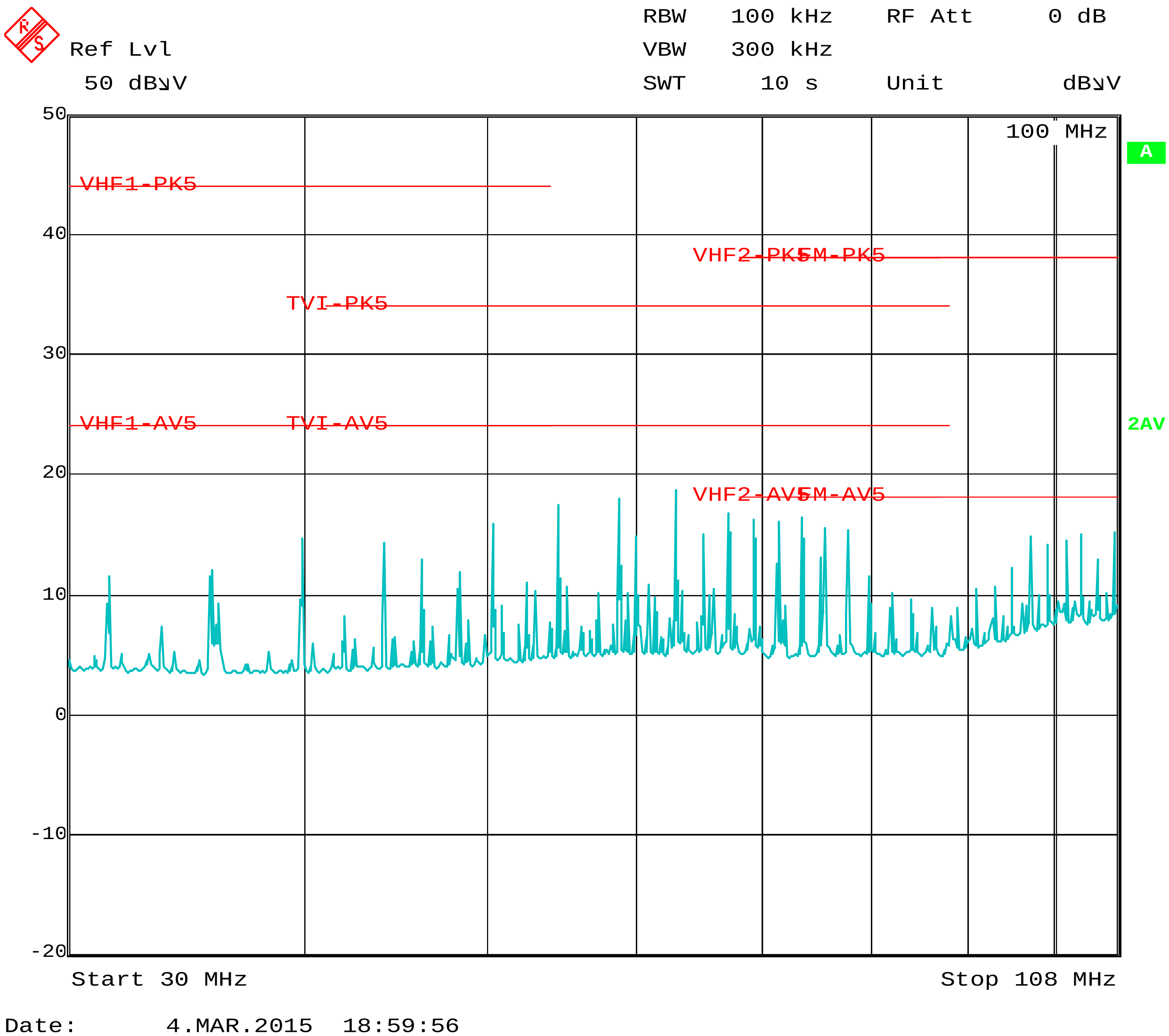
The test results are shown in below three Figures. The first Figure show the test result using peak detector and Average detector measurement up to 30MHz , and the last two Figure show the test result using average detector and Peak Detector measurement from 30MHz to 108MHz. The limit lines shown in red are the Class 5 limits for conducted disturbances specified in the CISPR 25 Class 5 ; the yellow(Peak Detector measurement) and blue(Average detector measurement) traces is the test result. It can be seen that the power supply operates quietly and the noise is below the stringent Class 5 limits too.



Test result – Upto 30MHz Conducted Emission –Peak and Average Detection



Test result –30MHz to 108MHz Conducted Emission –Peak Detection



Test result –30MHz to 108MHz Conducted Emission –Average Detection

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