Test Report
For PMP9458
08/07/2014

TEXAS INSTRUMENTS

Overview

The reference design is a conducted EMI optimized 2-layer board power supply for automotive cluster units. The power supply has two buck regulators in cascaded connection: the first stage buck generates a 5V, 2A output using the LM26003, and the second stage generates two outputs of 2.8V, 1.5A and 1.8V, 2A using the LM26420 (The max output power in total is 14W). The LM26003 is a wide Vin non-synchronous buck regulator, and the LM26420 is a 5V input dual 2A, high frequency synchronous buck regulator. They both have automotive grade versions, qualified in AEC-Q100 Grade 1. The input voltage range of the design is 6.5V to 38V making it suitable for automotive 12V battery systems. The 2-layer board design has the PCB layout optimized and adds an input filter stage to improve the conducted EMI performance. The board is tested under the automotive EMC standard, CISPR 25, and its conducted emissions are in compliance with the CISPR 25 Class 5 requirements.

Power Specification

Vin Range:	6.5V~38V
Nominal Vin:	12V
Output:	5V@2A, 2.8V@1.5A, 1.8V@2A The total output power should not exceed 14W
Switching Frequency:	300kHz for the 5V output LM26003 2.2MHz for the 2.8V and 1.8V output LM26420

Board Photos

Board Size: 3.7x2.9 inch (94x74 mm)

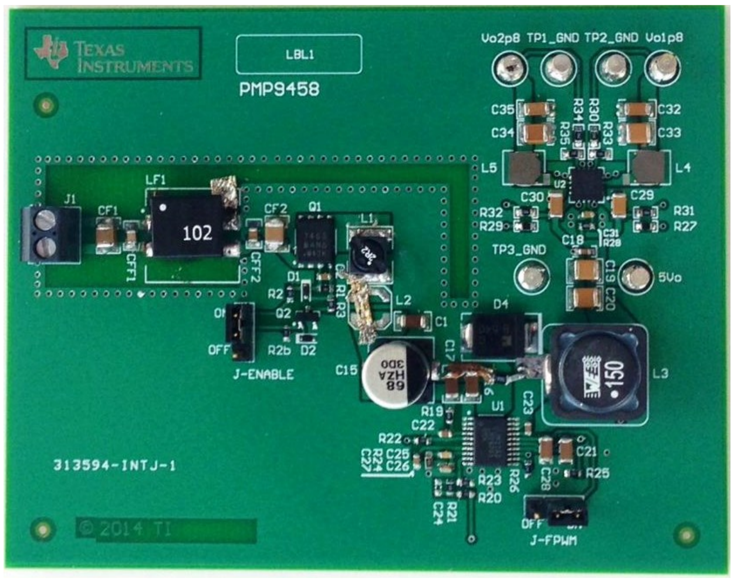

Figure 1 Board Front

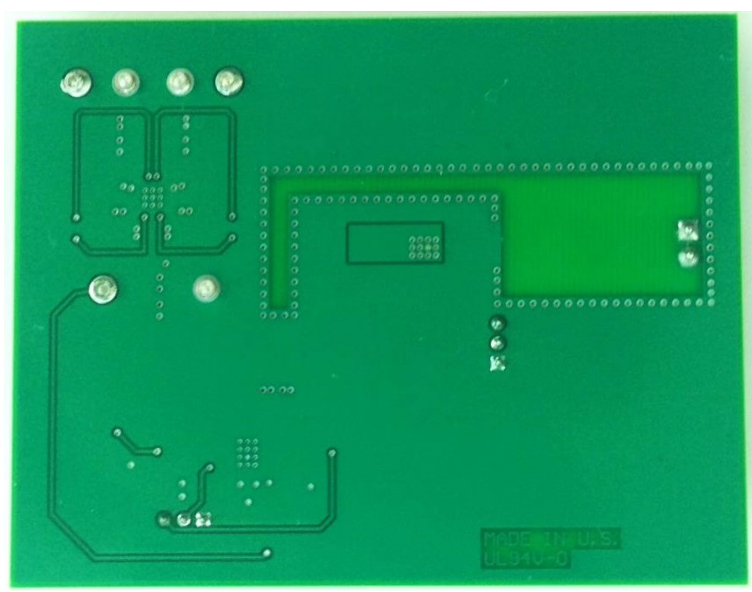

Figure 2 Board Back

Thermal Performance

The infrared thermal images are taken at 23°C room temperature, no air flow condition. The board is operating in steady state at 12V input with 1.5A load on the 2.8V output and 2A load on 1.8V output. To improve the thermal performance, thicker copper layer or larger board area or airflow should be applied to the LM26420 dual-output buck regulator to help dissipate the heat.

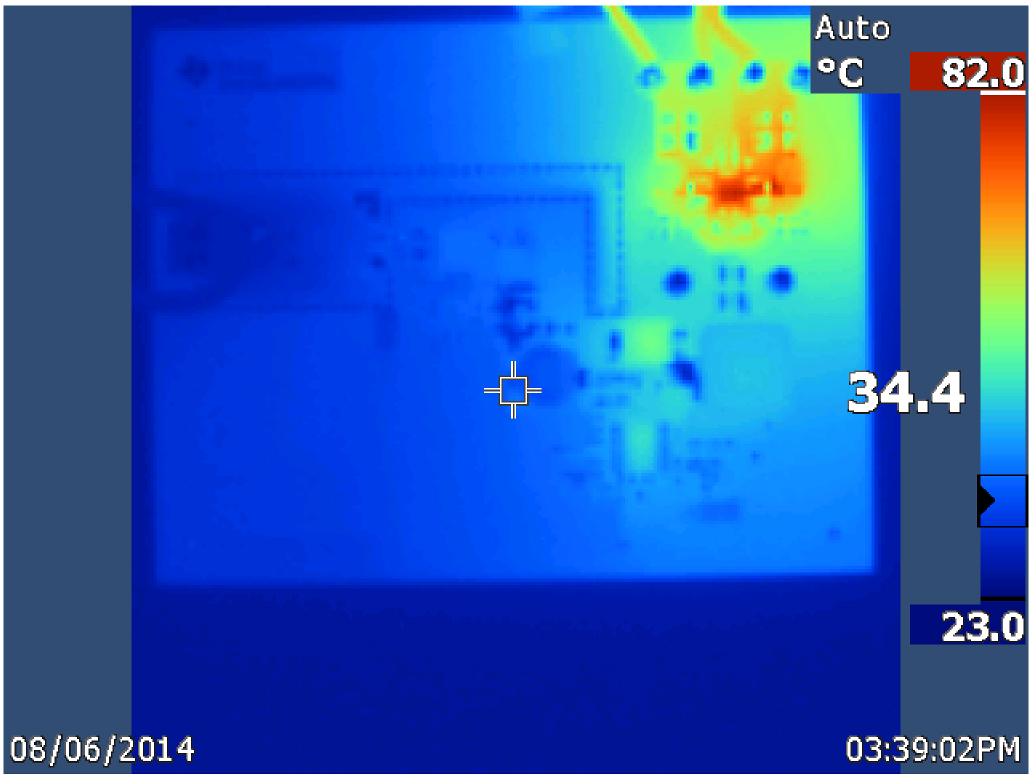

Figure 3 Board Front Thermal Image

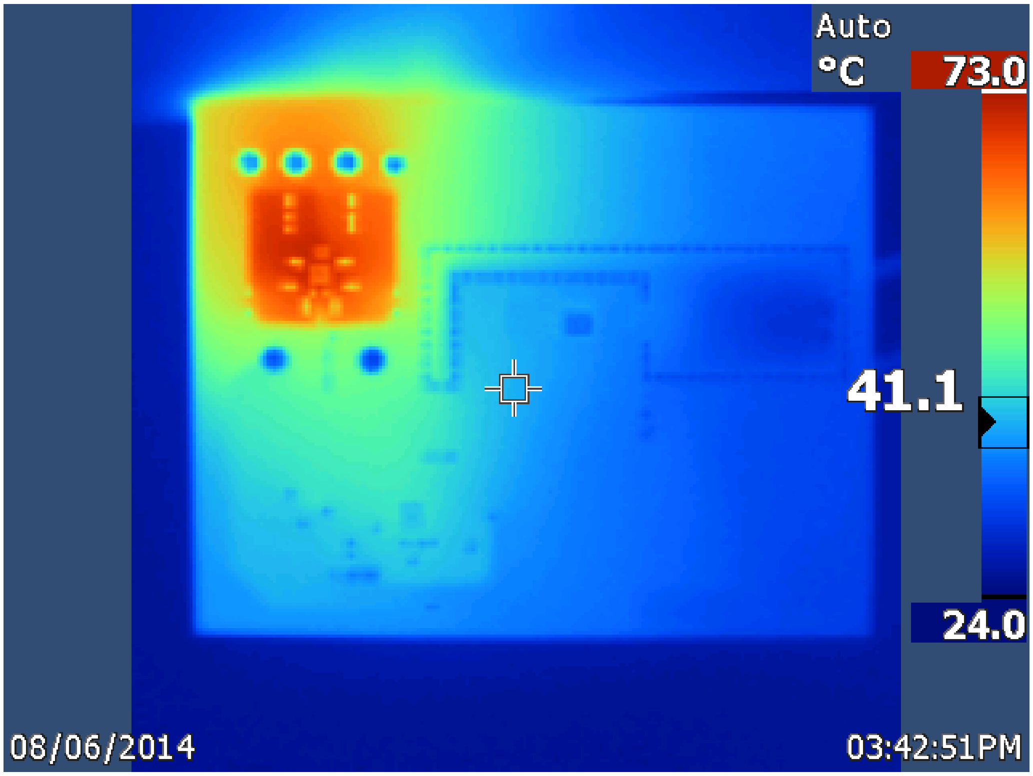

Figure 4 Board Back Thermal Image

Efficiency

The efficiency is measured for each output separately with no load on other outputs and at Vin= 6.5V, 12V and 38V. See appendix for the efficiency test data.

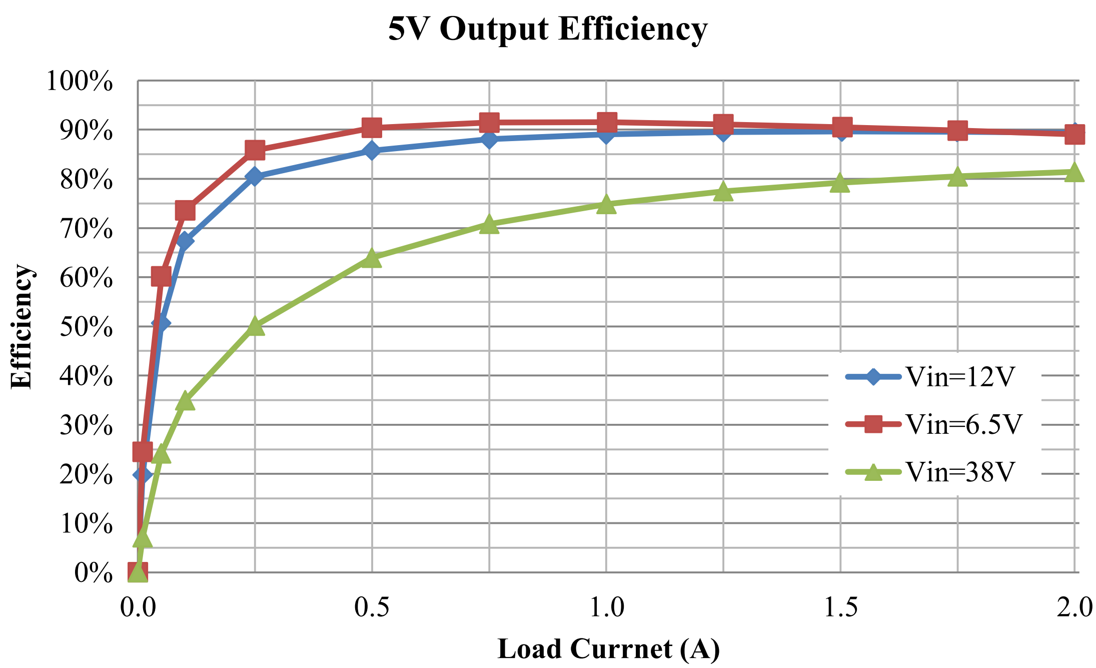

Figure 5 5V Output Efficiency

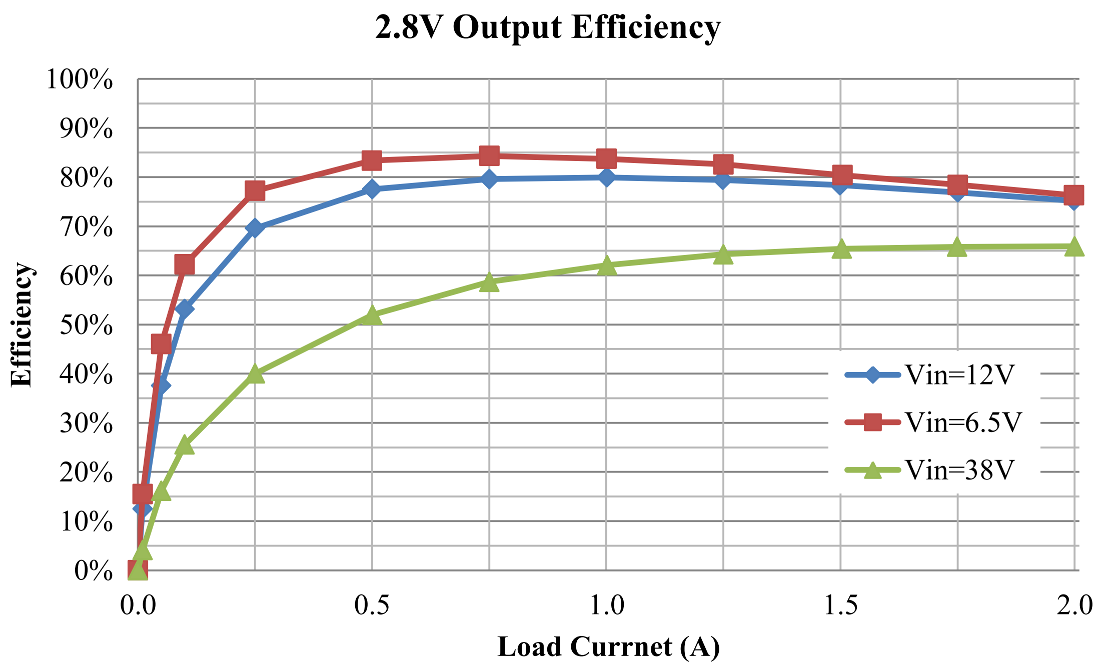

Figure 6 2.8V Output Efficiency

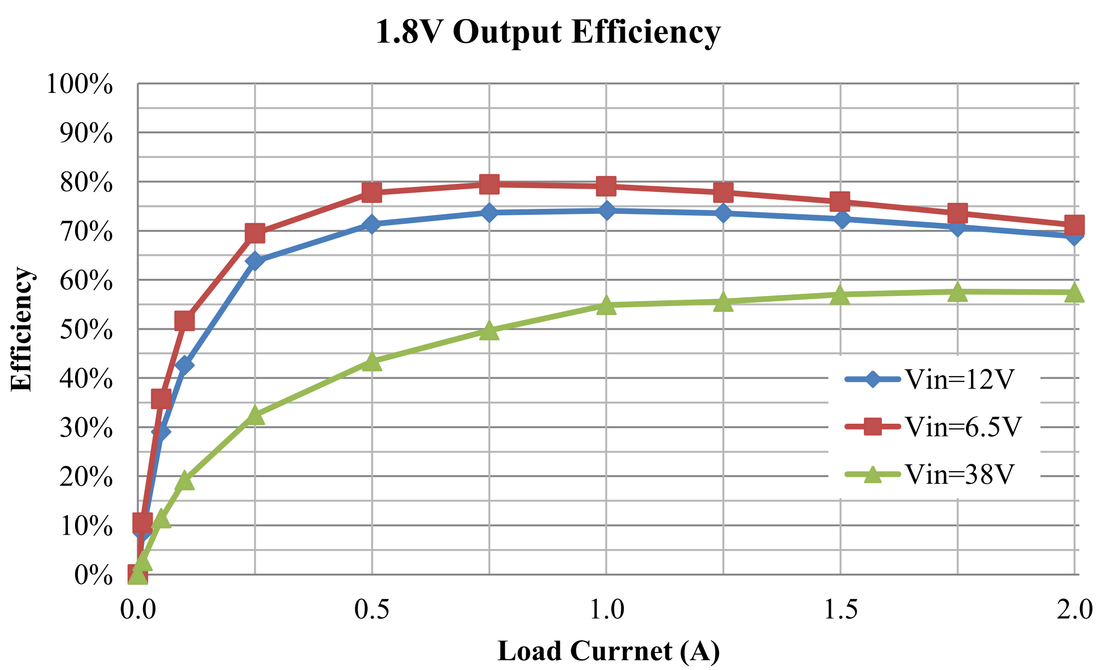

Figure 7 1.8V Output Efficiency

Switching Waveforms

The switch node voltage waveform is measured at full load and no load condition for each output.

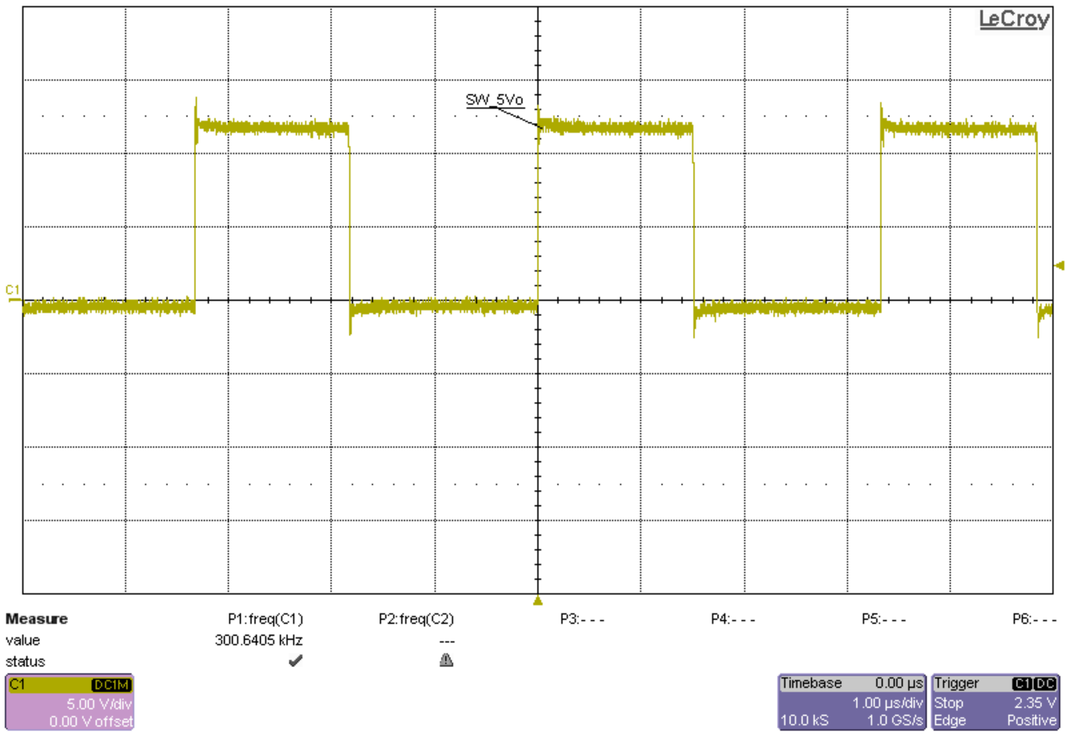

Figure 8 Switch Node Waveform for 5V Output at 12Vin and 2A Load

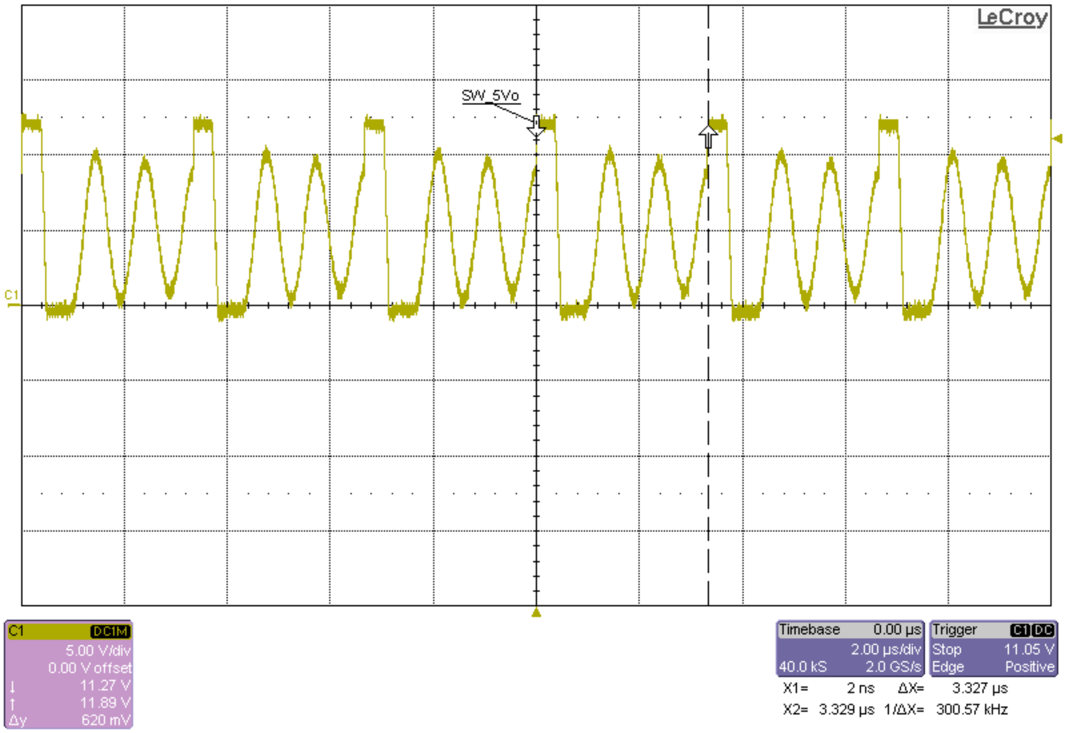

Figure 9 Switch Node Waveform for 5V Output at 12Vin and No Load

Note that the LM26003 is configured in FPWM mode via jumper pin J-FPWM, and thus the switching frequency remains 300 kHz at no load condition.

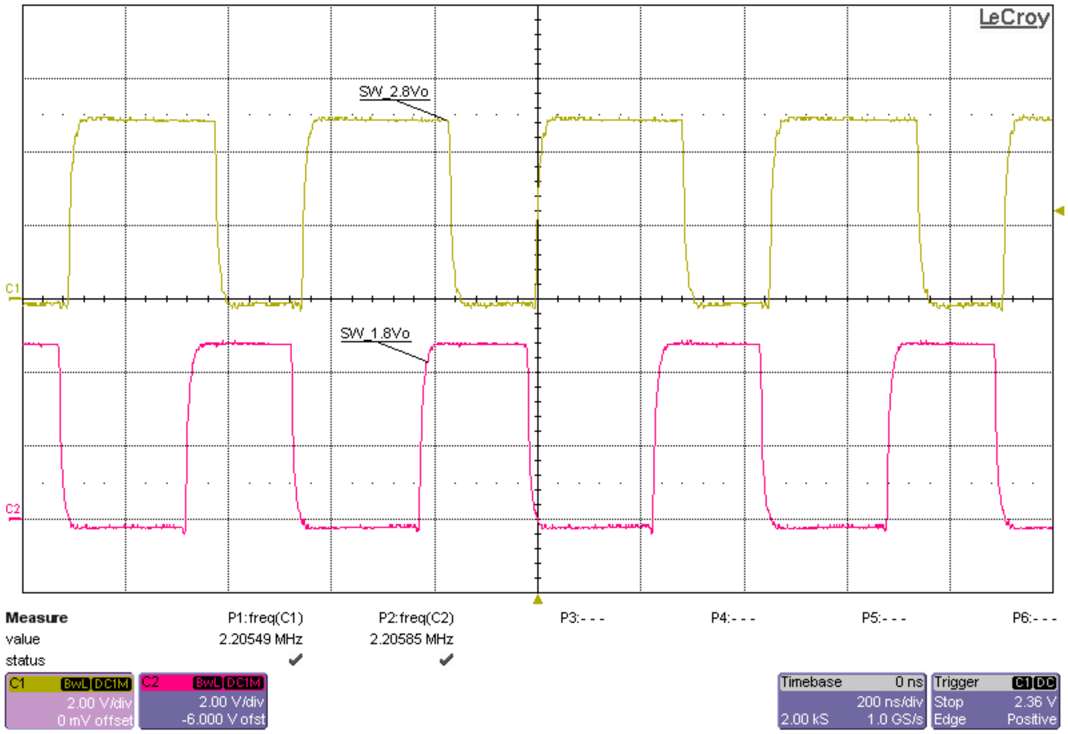

Figure 10 Switch Node Waveforms for 2.8V and 1.8V Output at Full Load

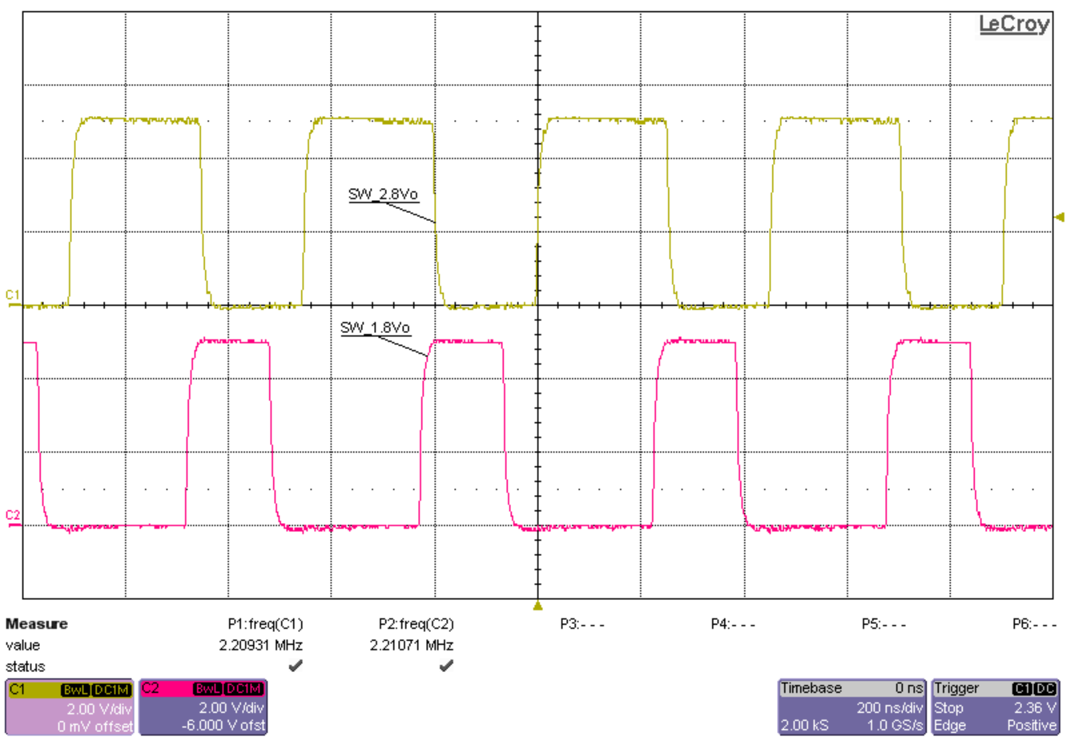

Figure 11 Switch Node Waveforms for 2.8V and 1.8V Output at No Load

Conducted Emissions

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 results are shown in Figure 12, Figure 13 and Figure 14. The limit lines in red are the Class 5 limits for conducted disturbances specified in the CISPR 25. The Figure 12 shows the conducted EMI noise from 150kHz to 30MHz using peak detector, and the limit lines are the Class 5 average limits. It can be seen the peak measurement result is well below the average limits. The Figure 13 and Figure 14 show the noise scan result from 30MHz to 108MHz using peak and average detector, with the Class 5 peak and average limits respectively. It can be seen the peak/average noise is lower than the corresponding peak/average limits. Therefore, the whole 2-layer power supply board can operate in compliance with the CISPR 25 Class 5 conducted emissions standard.

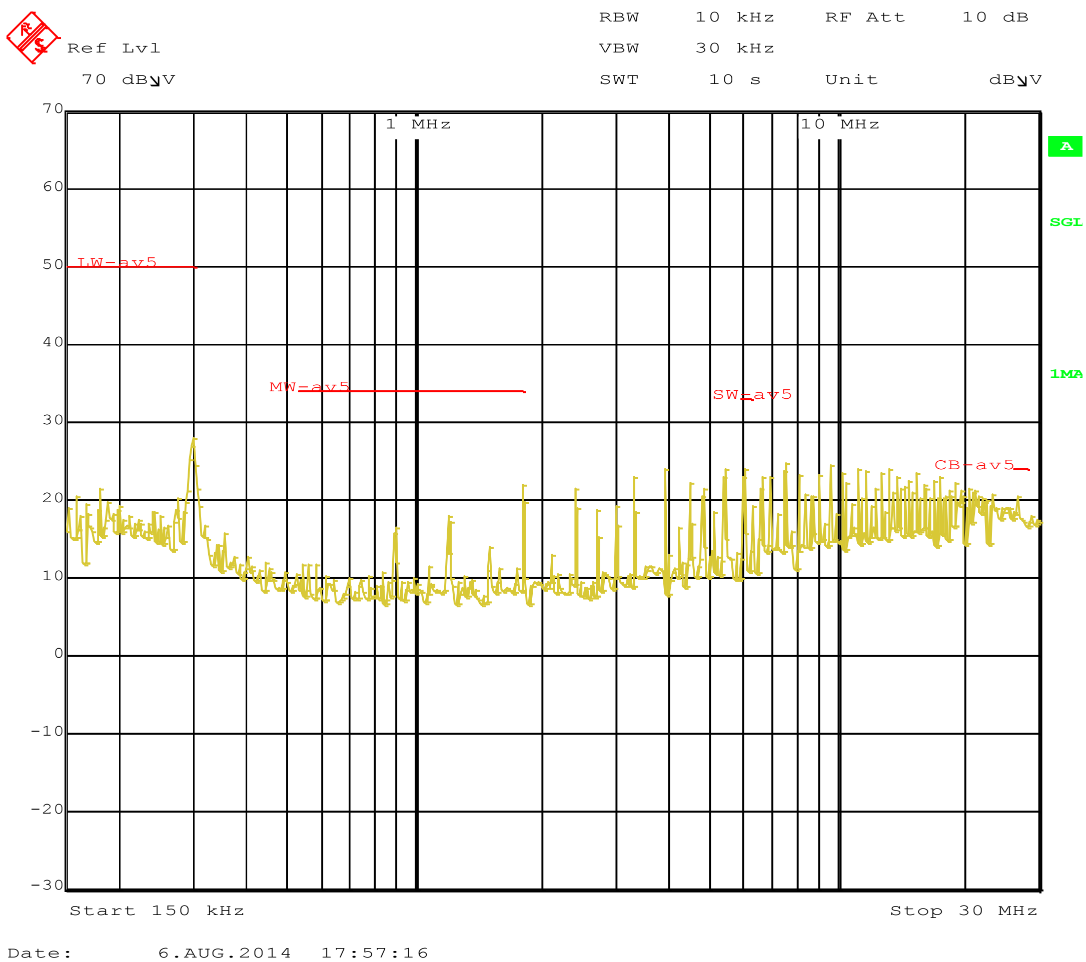

Figure 12 Peak detect, 150kHz – 30MHz

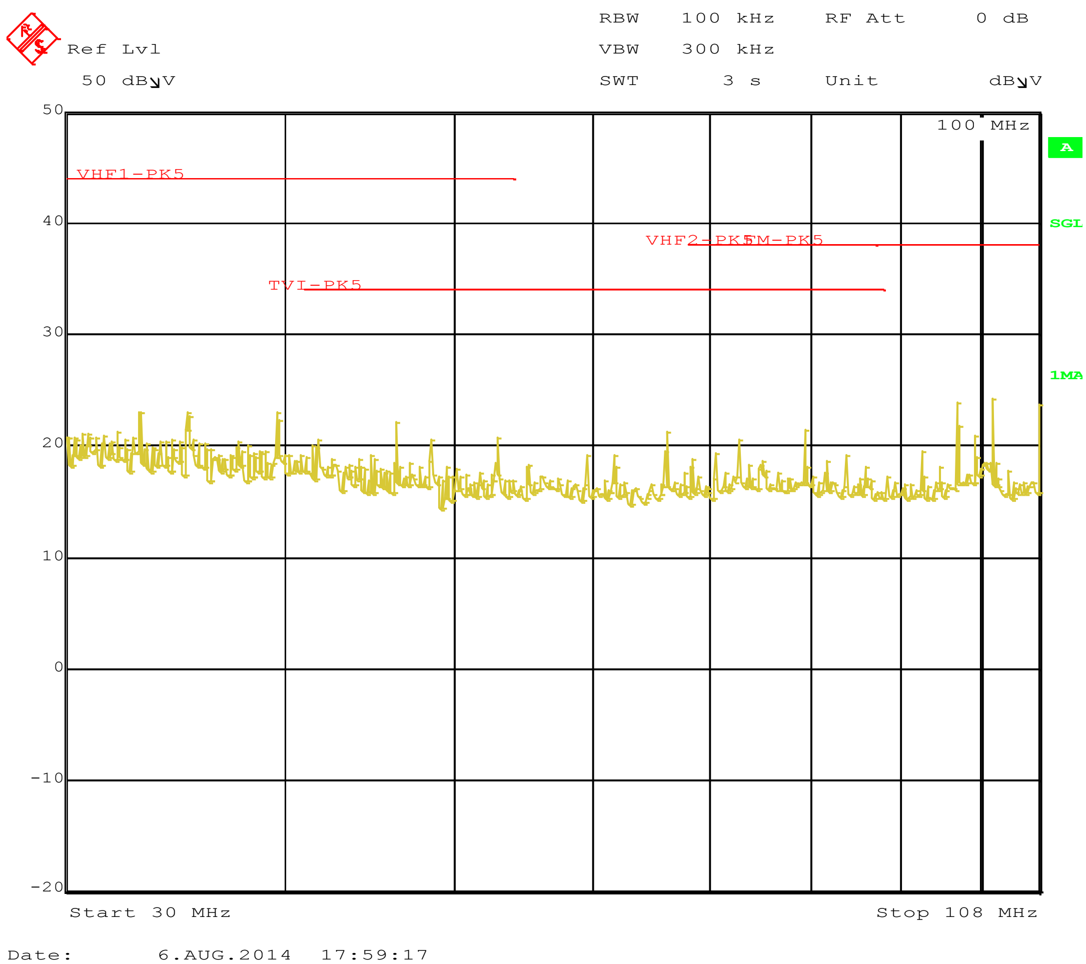

Figure 13 Peak detect, 30MHz – 108MHz

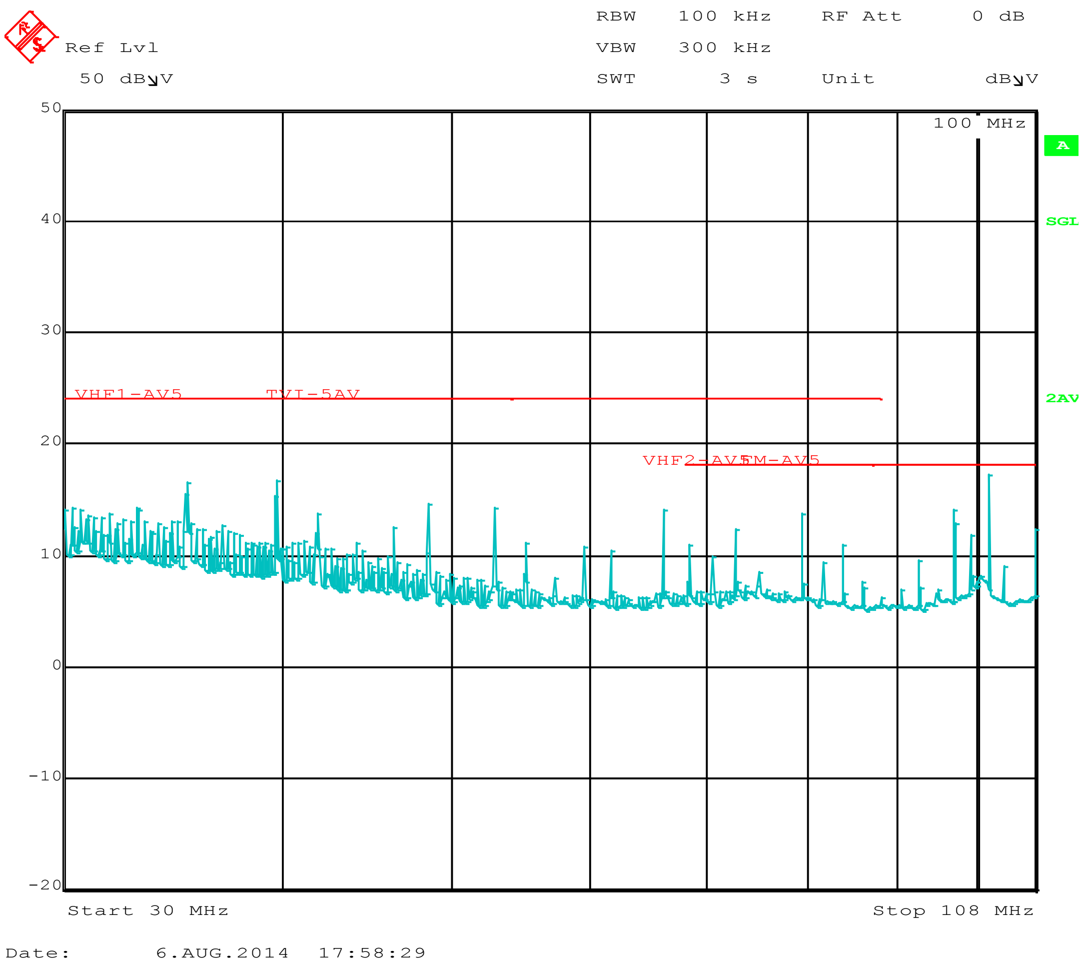

Figure 14 Average detect, 30MHz – 108MHz

Start Up

The input voltage is set at 12V, and the 2.8V and 1.8V output is set at full load, 1.5A and 2A respectively, and no load condition.

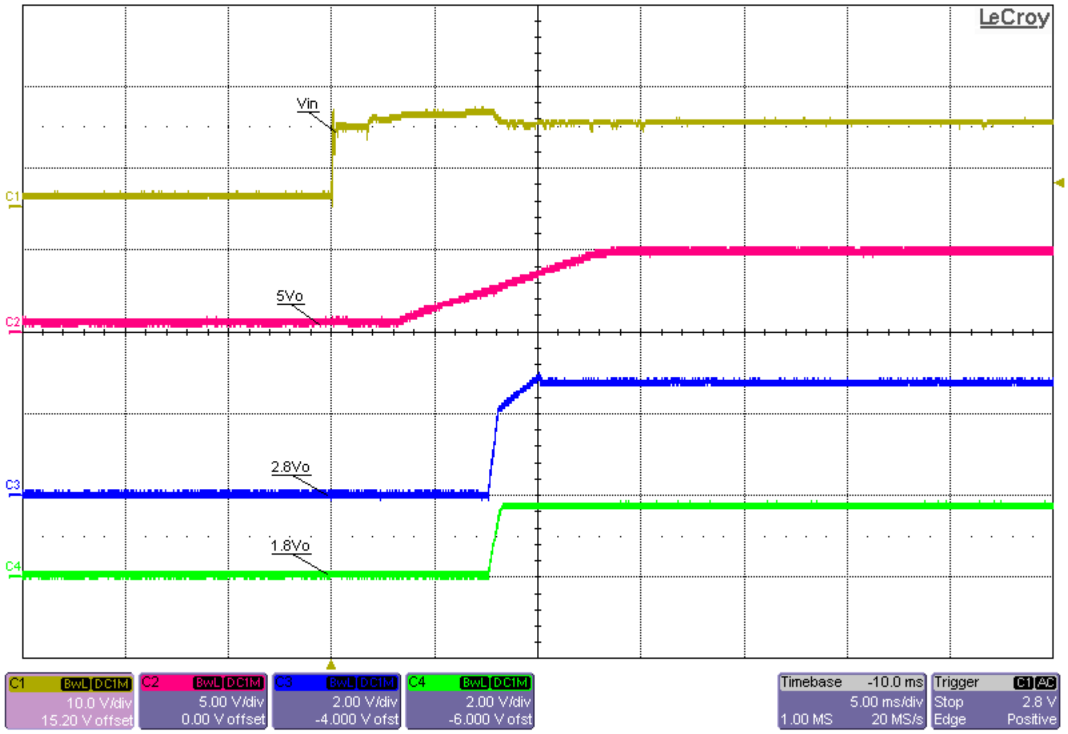

Figure 15 Power Up into Full Load at 12Vin

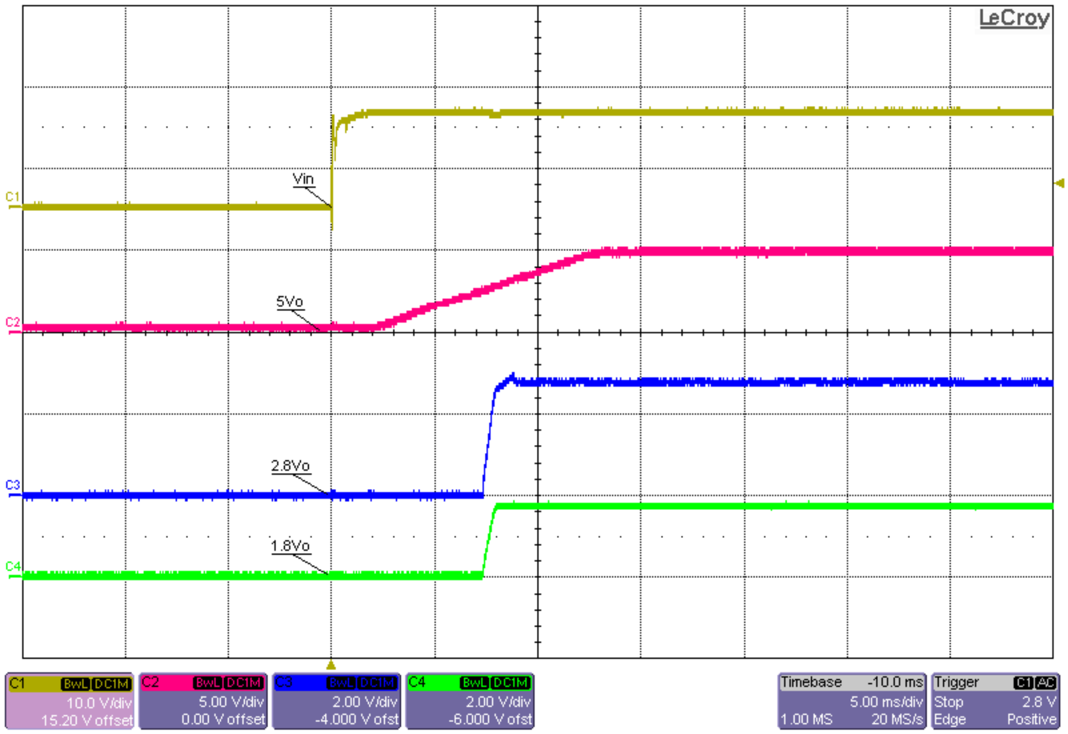

Figure 16 Power Up into No Load at 12Vin

Load Transient Response

The load transient response is tested by having switched load step on one output and no load on other two outputs at 12V input.

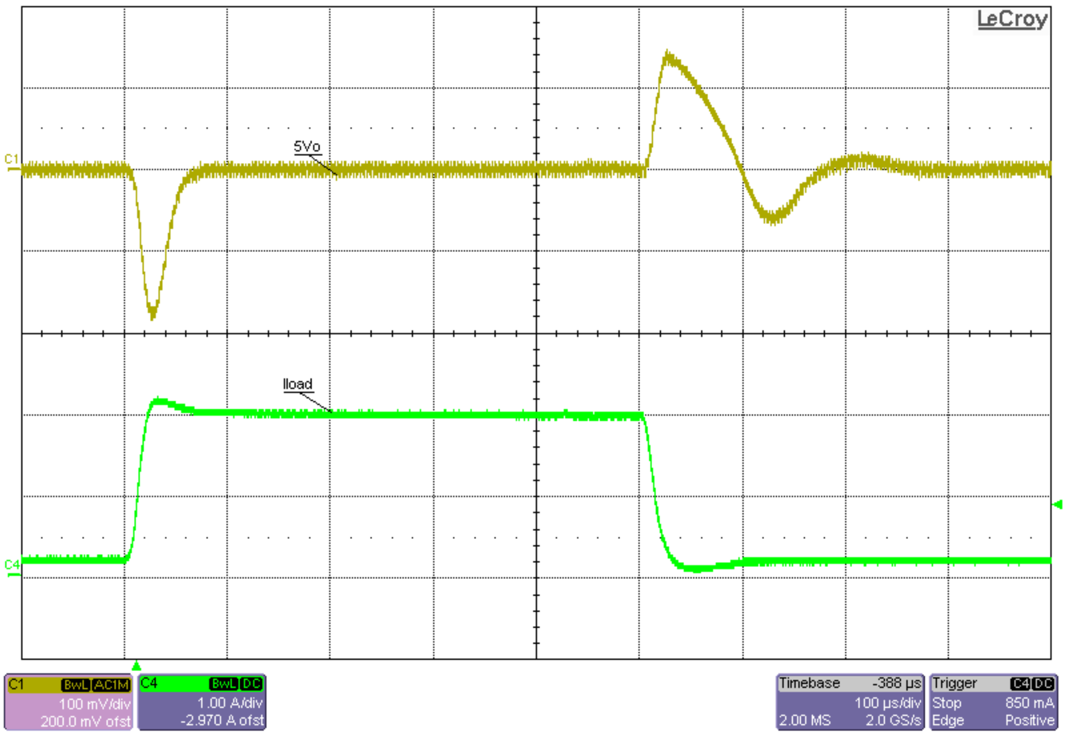

Figure 17 5V Output Buck Regulator Load Transient

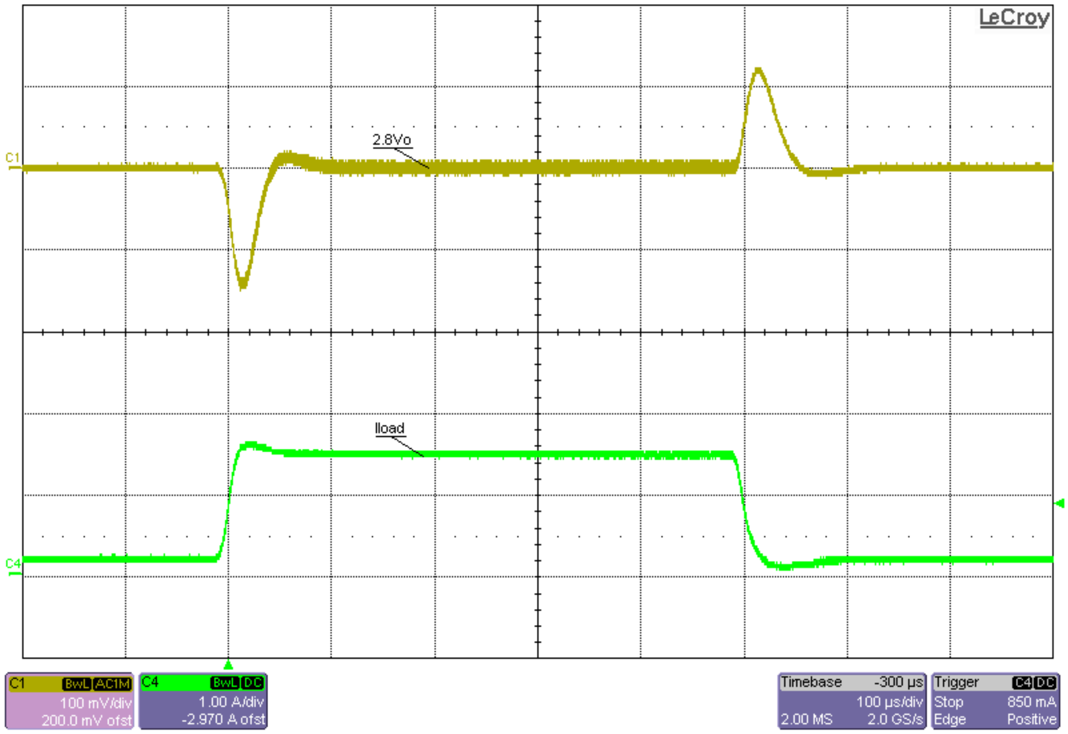

Figure 18 2.8V Output Buck Regulator Load Transient

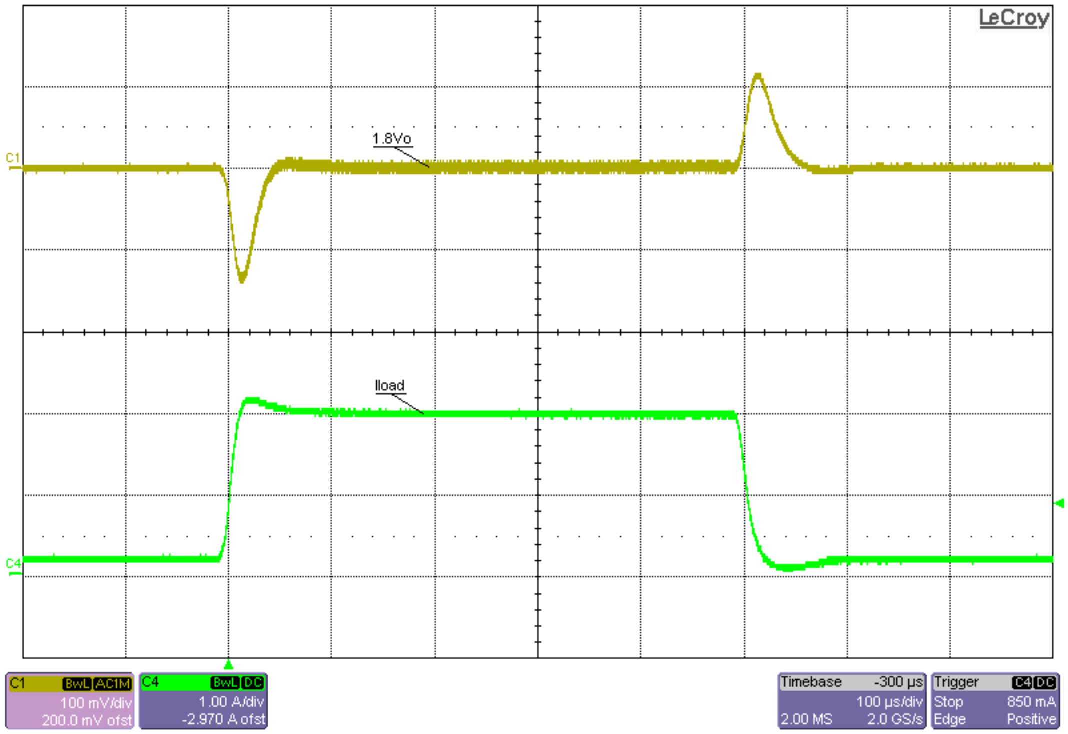

Figure 19 1.8V Output Buck Regulator Load Transient

Output Voltage Ripples

The output ripple is measured directly at the output capacitor for each output in full load condition at 12V input.

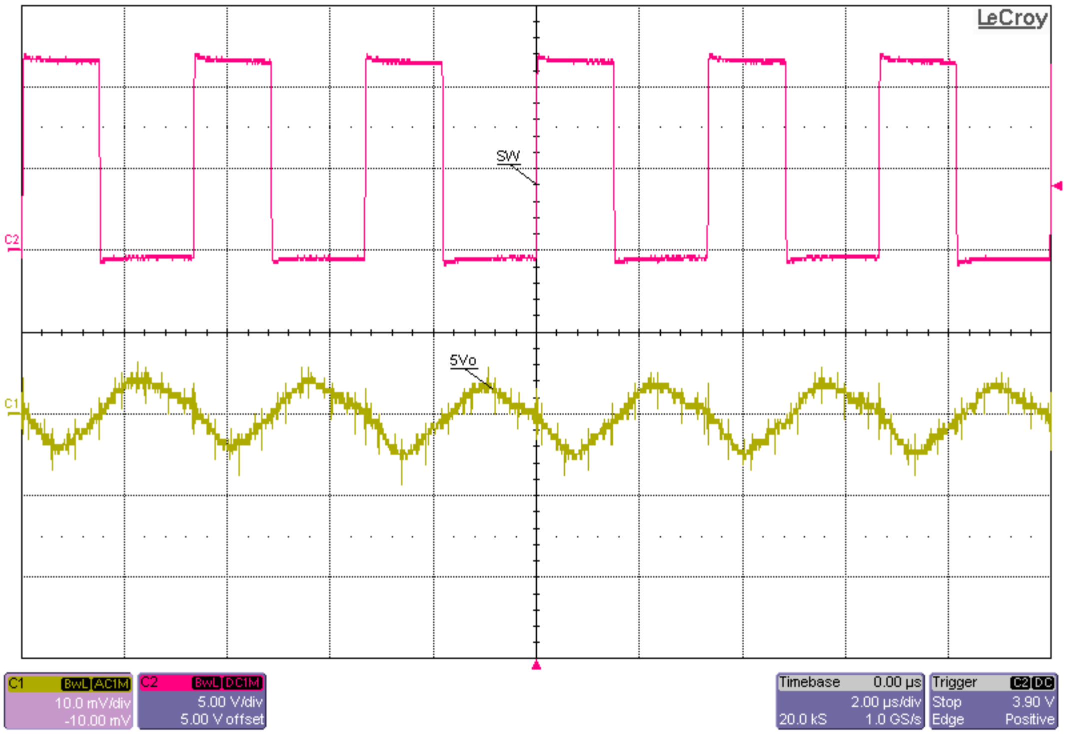

Figure 20 5V Output Ripple at 2A Load, 12Vin

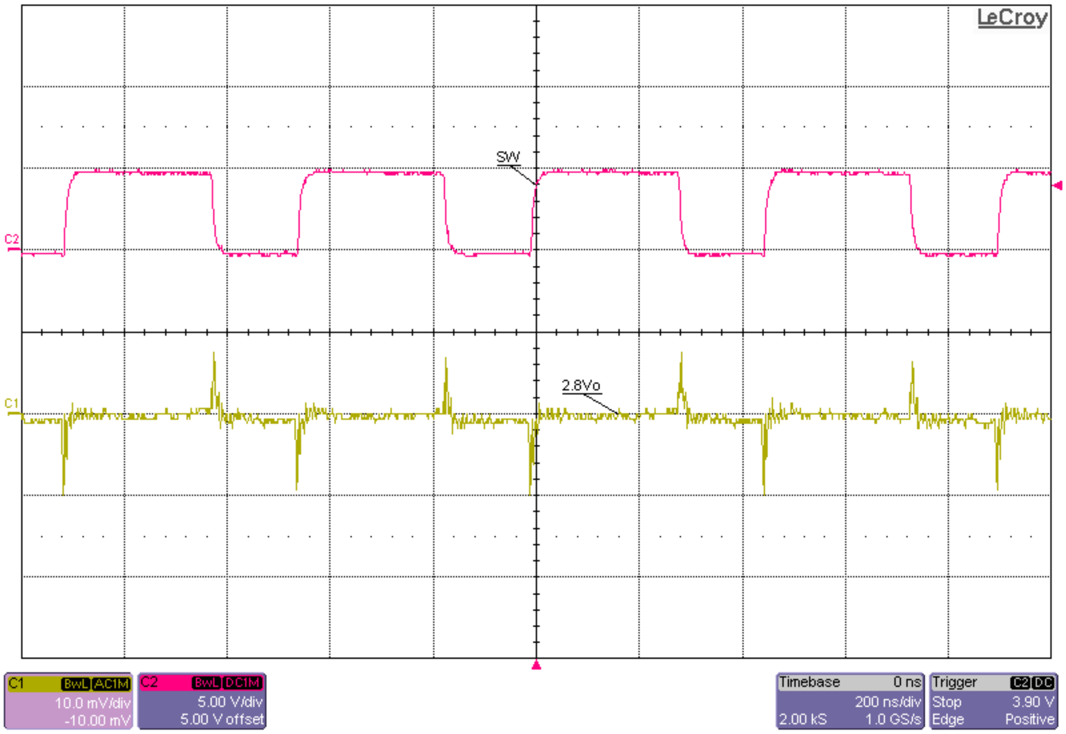

Figure 21 2.8V Output Ripple at 1.5A Load

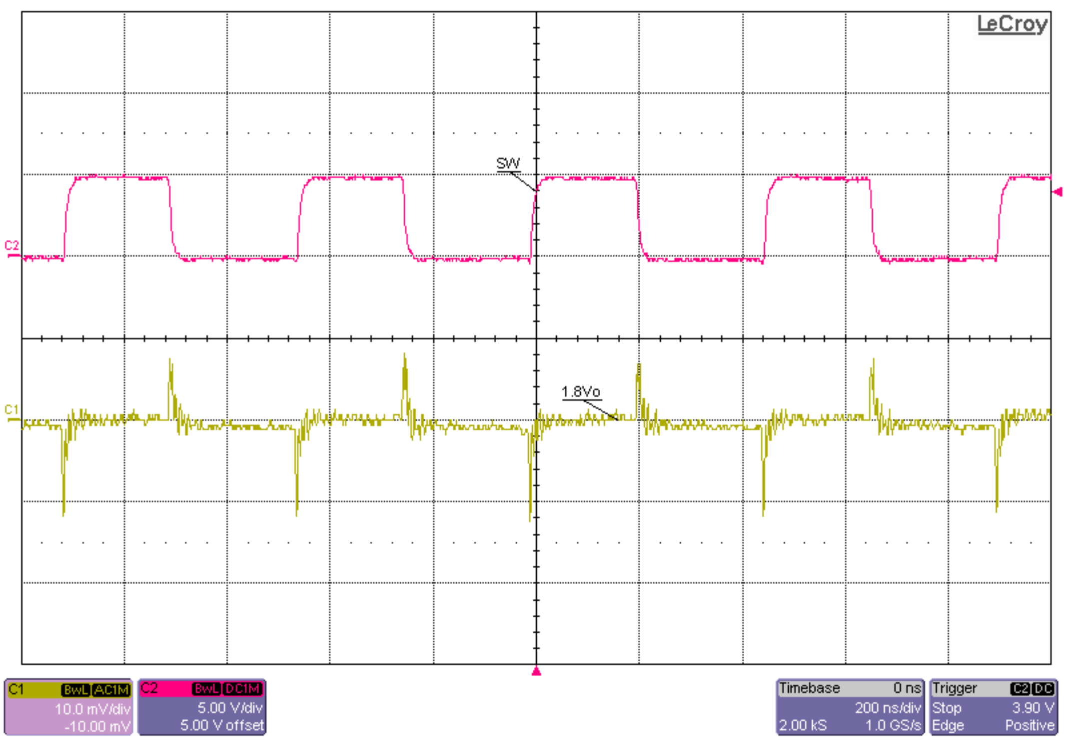

Figure 22 1.8V Output Ripple at 2A Load

Appendix - Efficiency Data

The electronic load is only on one tested output, and the other two outputs have no load.

5V output					
Vin=12V	Vin (V)	Iin (A)	Vout (V)	Io (A)	Eff
	12.005	0.016	4.993	0.000	0.00%
	12.016	0.021	4.993	0.010	19.80%
	12.006	0.041	4.993	0.050	50.68%
	12.051	0.062	4.993	0.100	67.36%
	12.019	0.129	4.992	0.249	80.47%
	11.952	0.243	4.992	0.500	85.75%
	12.006	0.354	4.991	0.751	88.06%
	12.020	0.466	4.990	1.000	89.04%
	12.001	0.581	4.990	1.250	89.50%
	12.002	0.697	4.989	1.503	89.61%
	12.002	0.812	4.988	1.750	89.57%
	12.012	0.929	4.987	2.001	89.40%
Vin=6.5V	6.501	0.024	4.992	0.000	0.00%
	6.505	0.032	4.993	0.010	24.48%
	6.507	0.064	4.993	0.050	60.14%
	6.504	0.105	4.993	0.101	73.60%
	6.501	0.224	4.992	0.250	85.82%
	6.499	0.425	4.991	0.500	90.38%
	6.506	0.630	4.991	0.751	91.43%
	6.508	0.840	4.990	1.002	91.51%
	6.508	1.052	4.989	1.250	91.07%
	6.500	1.276	4.988	1.505	90.51%
	6.505	1.494	4.988	1.751	89.83%
	6.505	1.723	4.987	2.001	89.05%
Vin=38V	37.982	0.017	5.028	0.000	0.00%
	38.050	0.019	5.028	0.010	7.09%
	38.003	0.028	5.026	0.050	24.16%
	38.003	0.038	5.024	0.101	34.97%
	38.009	0.065	4.987	0.250	50.12%
	38.014	0.103	4.987	0.500	63.97%
	38.093	0.139	4.986	0.751	70.85%
	38.072	0.175	4.986	1.001	74.88%
	38.009	0.212	4.985	1.250	77.49%
	37.987	0.248	4.985	1.499	79.25%
	38.006	0.285	4.984	1.751	80.49%
	37.983	0.322	4.983	2.000	81.41%

2.8V output					
Vin=12V	Vin (V)	Iin (A)	Vout (V)	Io (A)	Eff
	12.005	0.016	2.802	0.000	0.00%
	12.019	0.019	2.802	0.010	12.48%
	12.002	0.031	2.802	0.050	37.57%
	12.009	0.044	2.802	0.100	53.17%
	12.004	0.084	2.802	0.250	69.59%
	11.995	0.151	2.802	0.501	77.53%
	12.003	0.220	2.802	0.751	79.59%
	12.000	0.292	2.802	1.001	79.97%
	12.010	0.367	2.801	1.249	79.43%
	11.991	0.447	2.801	1.499	78.37%
	12.000	0.531	2.801	1.751	76.90%
	12.007	0.620	2.800	1.999	75.19%
Vin=6.5V	6.501	0.024	2.802	0.000	0.00%
	6.506	0.028	2.802	0.010	15.49%
	6.501	0.047	2.802	0.050	46.02%
	6.506	0.069	2.802	0.100	62.24%
	6.505	0.139	2.802	0.250	77.21%
	6.504	0.258	2.802	0.500	83.36%
	6.509	0.383	2.802	0.751	84.31%
	6.509	0.515	2.801	1.001	83.74%
	6.508	0.652	2.801	1.251	82.60%
	6.502	0.806	2.802	1.505	80.42%
	6.508	0.961	2.801	1.751	78.44%
	6.507	1.127	2.801	1.999	76.30%
Vin=38V	37.982	0.017	2.803	0.000	0.00%
	37.995	0.018	2.802	0.010	4.10%
	37.969	0.023	2.802	0.050	16.16%
	38.005	0.029	2.802	0.100	25.58%
	38.017	0.046	2.803	0.250	40.05%
	38.018	0.071	2.802	0.501	51.97%
	38.047	0.094	2.802	0.751	58.68%
	38.005	0.119	2.802	1.003	62.08%
	38.020	0.143	2.802	1.250	64.28%
	38.005	0.169	2.801	1.503	65.43%
	38.009	0.196	2.801	1.750	65.82%
	37.992	0.224	2.800	2.000	65.93%

1.8V output					
Vin=12V	Vin (V)	Iin (A)	Vout (V)	Io (A)	Eff
	12.005	0.016	1.803	0.000	0.00%
	12.056	0.018	1.802	0.010	8.51%
	12.011	0.026	1.802	0.050	29.06%
	12.058	0.035	1.802	0.100	42.58%
	12.005	0.059	1.803	0.250	63.80%
	12.032	0.105	1.803	0.500	71.34%
	12.044	0.153	1.803	0.751	73.65%
	12.013	0.203	1.803	1.002	74.09%
	12.042	0.254	1.803	1.250	73.58%
	12.007	0.312	1.803	1.505	72.38%
	12.051	0.370	1.804	1.751	70.74%
	12.011	0.436	1.804	2.000	68.89%
Vin=6.5V	6.501	0.024	1.802	0.000	0.00%
	6.506	0.027	1.802	0.010	10.58%
	6.507	0.039	1.802	0.050	35.73%
	6.504	0.054	1.802	0.100	51.64%
	6.500	0.100	1.802	0.250	69.48%
	6.506	0.178	1.802	0.500	77.74%
	6.506	0.262	1.802	0.751	79.44%
	6.503	0.351	1.802	1.000	79.04%
	6.505	0.446	1.803	1.250	77.76%
	6.502	0.548	1.803	1.499	75.90%
	6.504	0.660	1.803	1.751	73.57%
	6.501	0.780	1.804	2.000	71.15%
Vin=38V	37.982	0.017	1.802	0.000	0.00%
	38.008	0.018	1.802	0.010	2.74%
	38.041	0.021	1.802	0.050	11.45%
	38.018	0.025	1.802	0.100	19.22%
	38.032	0.036	1.802	0.250	32.47%
	37.980	0.055	1.802	0.500	43.41%
	37.994	0.072	1.802	0.751	49.73%
	38.000	0.087	1.803	1.001	54.88%
	37.997	0.107	1.803	1.250	55.58%
	38.021	0.125	1.803	1.499	57.00%
	38.009	0.144	1.804	1.751	57.59%
	37.996	0.165	1.804	2.000	57.46%

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