Test Report
For PMP9477
08/28/2014

Overview

The reference design is a conducted EMI optimized multi-output power supply for automotive cluster units. The power supply has a pre-boost stage for cold crank and start-stop operation, and two buck regulators.

The pre-boost stage features the LM3481 boost controller, and will start to operate and regulate a 9.5V output when the input voltage drops below 9.5V. In normal or higher input voltage condition, the LM3481 is in standby mode without switching bypassing the input to the following buck stage. The design has two buck regulators to generate 3 output voltages: the first stage buck generates a 5V, 2A output using the LM26003, and the second stage generates two outputs of 2.8V, 2A and 1.8V, 2A using the LM26420 (the max output power is 15W). The LM26003 is a wide Vin non-synchronous buck regulator, and the LM26420 is a 5V input dual 2A, high frequency synchronous buck regulator. All three ICs are available in automotive grade versions, qualified in AEC-Q100 Grade 1.

The board layout is optimized for improved conducted EMI performance. The power inductor in the pre-boost stage is utilized as an input EMI filter, and thus no additional filter components are required. 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.

The input voltage range of the design is 4.5V to 38V making it suitable for 12V battery systems in automotive space. When the input voltage goes as low as 4.5V, the output power of the board should be limited to 10W in total, which is a current limit of the LM3481 boost controller. There's a PFET in the input power path to control the turn on/off of the power supply via pin jumper. If the function is not desired, the PFET can be bypassed and the minimum input voltage of the board will be further extended to 4V.

Power Specification

Vin Range:	4.5V~38V
Nominal Vin:	12V
Output:	5V@2A, 2.8V@2A, 1.8V@2A the total output power should not exceed 15W
Switching Frequency:	300kHz for the LM3481 pre-boost 300kHz for the 5V output LM26003 2.2MHz for the 2.8V and 1.8V output LM26420
Shutdown Current:	<1uA, when PFET Q1 turns off

Board Photos

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

Note that there are a common mode choke filter and an input filter inductor (L1) section on the PCB board as optional. The board can pass the CISPR 25 conducted emissions test without these filter stages, and all the test in the report is carried with these parts bypassed or unpopulated.

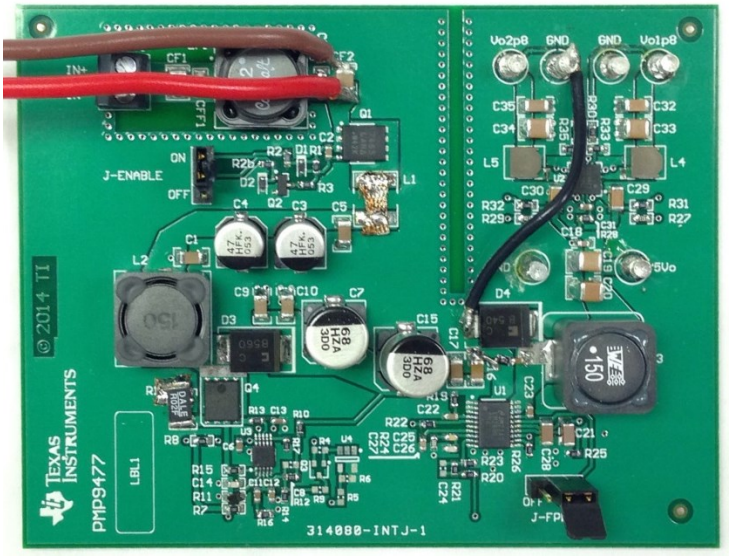

Figure 1 Board Front

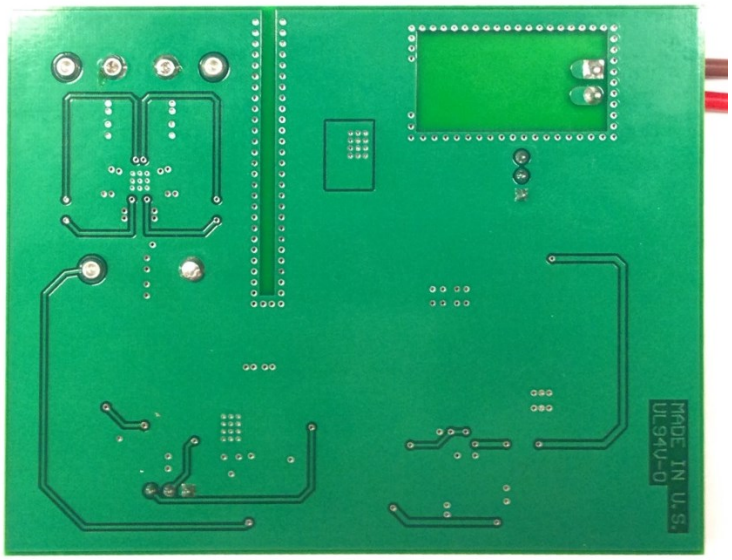

Figure 2 Board Back

Thermal Performance

The infrared thermal images are taken at 23°C room temperature, no air flow condition. The board is operating at 2A load on the 2.8V and 1.8V output each, and the images are taken at 4.5V, 12V and 38V input. The thermal performance can be further improved by removing the ground split between the LM26420 and the input side on the PCB and having full copper ground plane. There's minimum impact to the conducted emissions performance, and it is verified by applying copper tape to bridge the gap.

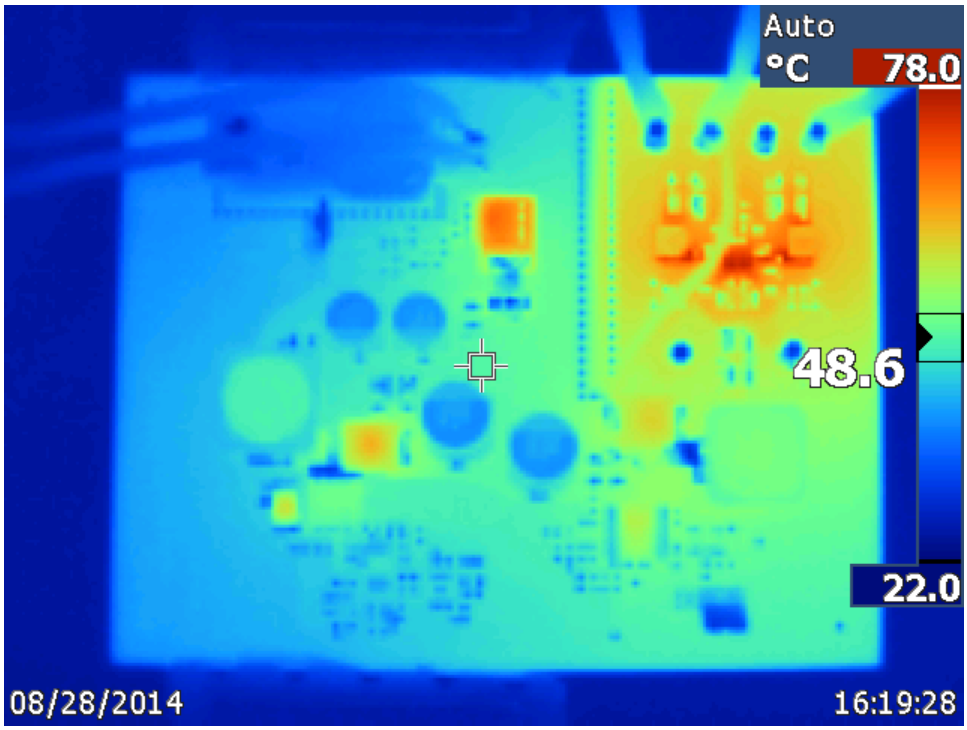

Figure 3 Board Thermal Image at 4.5V input

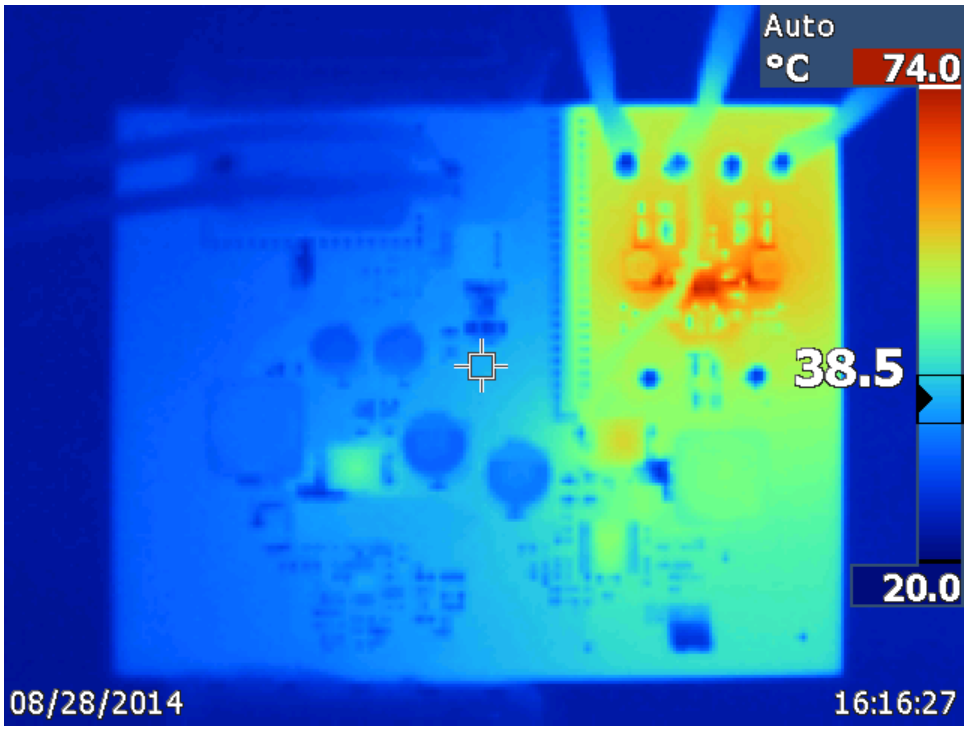

Figure 4 Board Thermal Image at 12V input

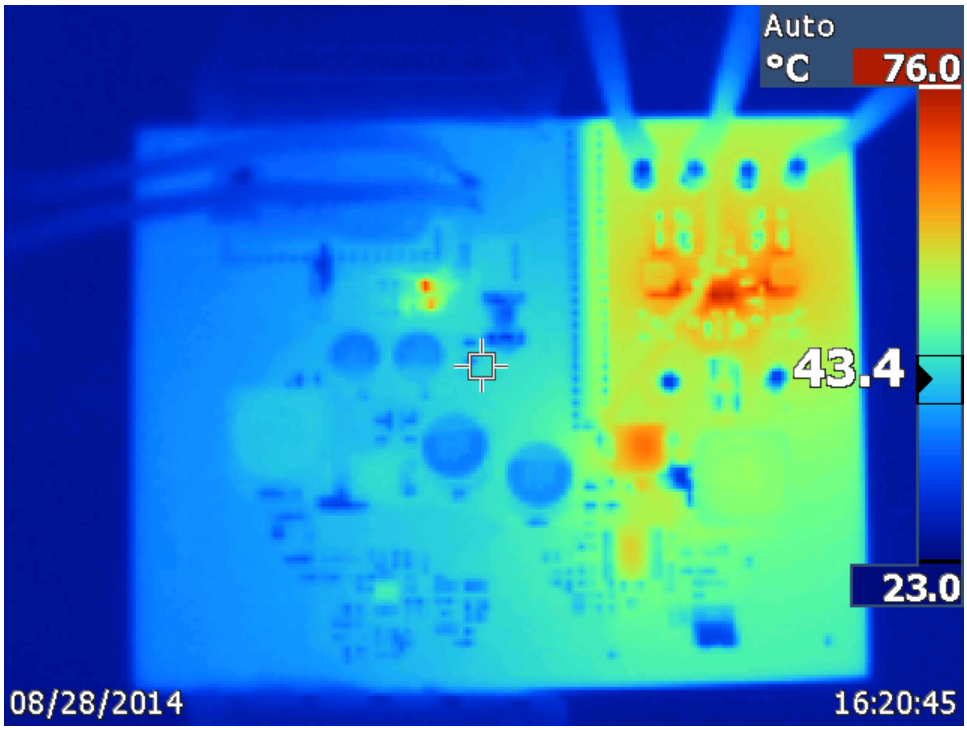

Figure 5 Board Thermal Image at 38V input

Efficiency

The efficiency is measured for each output separately with no load on other outputs and at Vin= 4.5V, 7V, 12V and 38V.

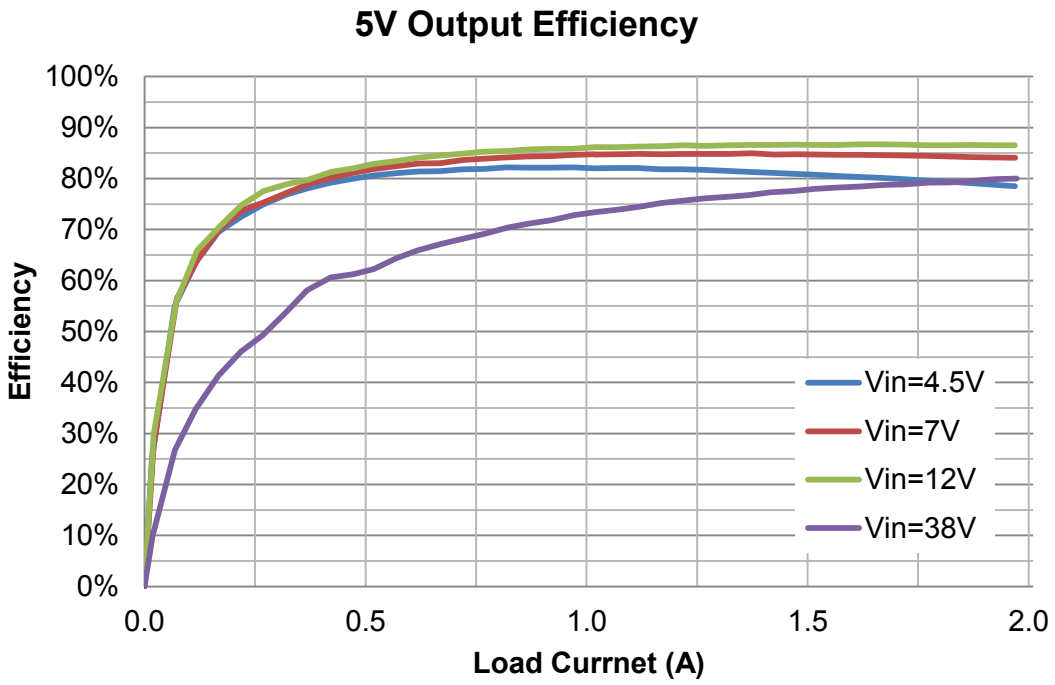

Figure 6 5V Output Efficiency

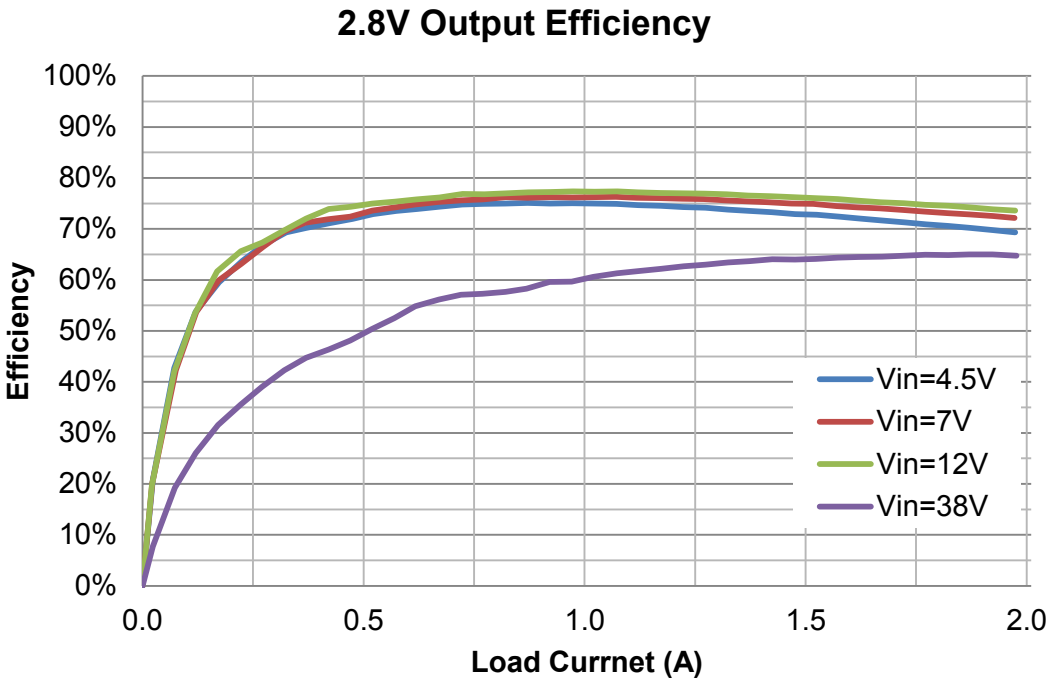

Figure 7 2.8V Output Efficiency

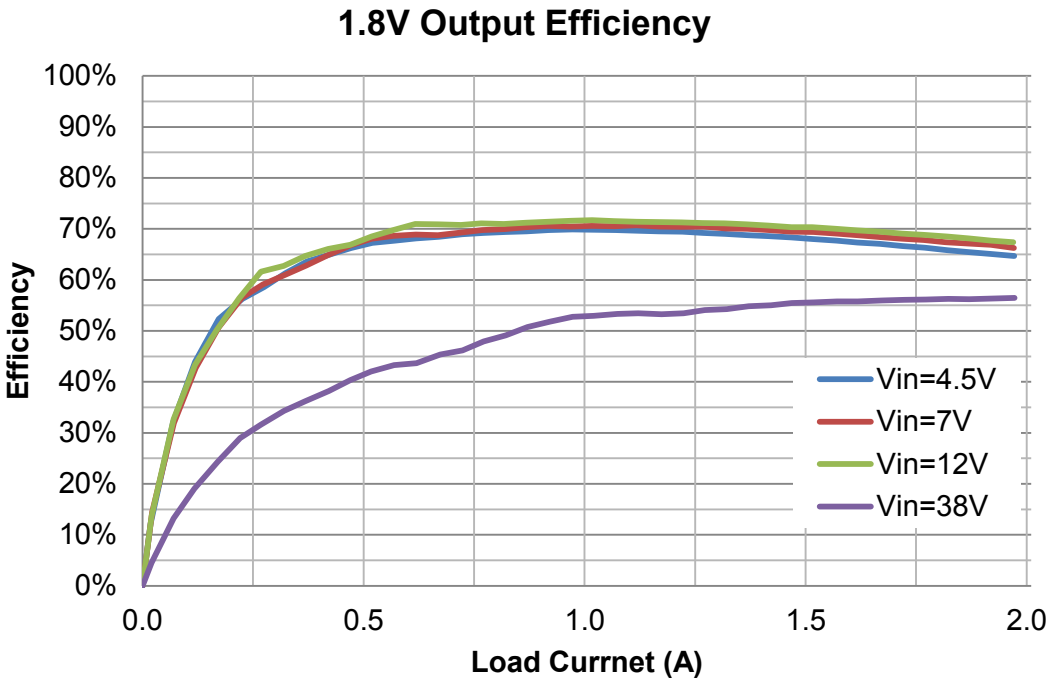

Figure 8 1.8V Output Efficiency

Switching Waveforms

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

The pre-boost LM3481 will only operate when the input voltage falls below 9.5V, and its switching is recorded at 4.5V input with 2A load on the 5V output. Ch1 (yellow) is the LM3481 boost switch node voltage, and Ch2 (green) is the LM26003 buck switch node voltage.

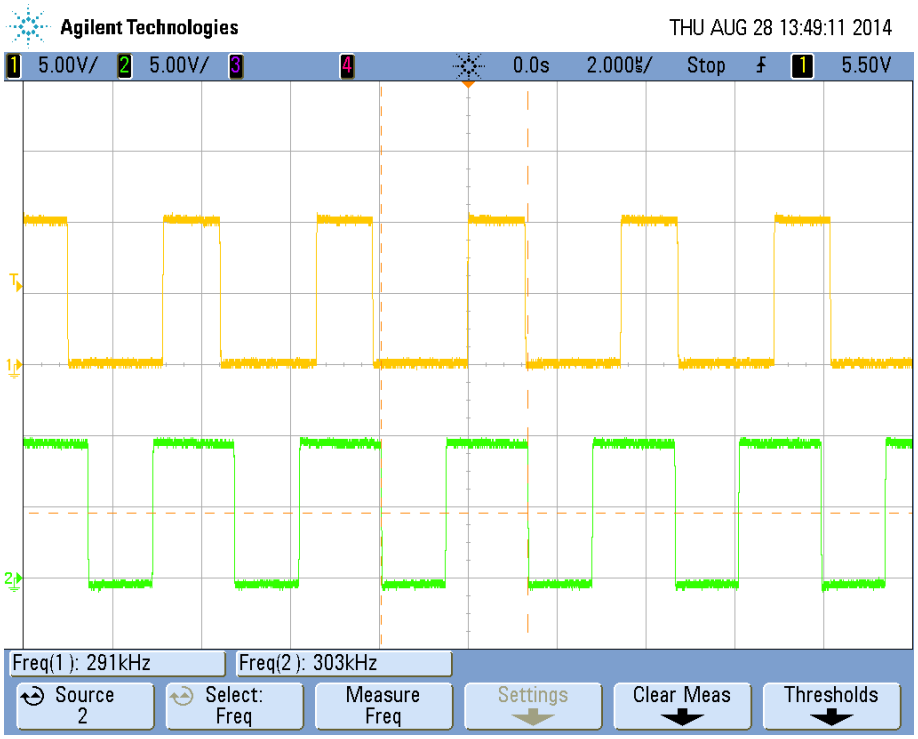

Figure 9 Switching Waveforms for the Pre-boost and the 5V Buck at 4.5Vin and 2A Load

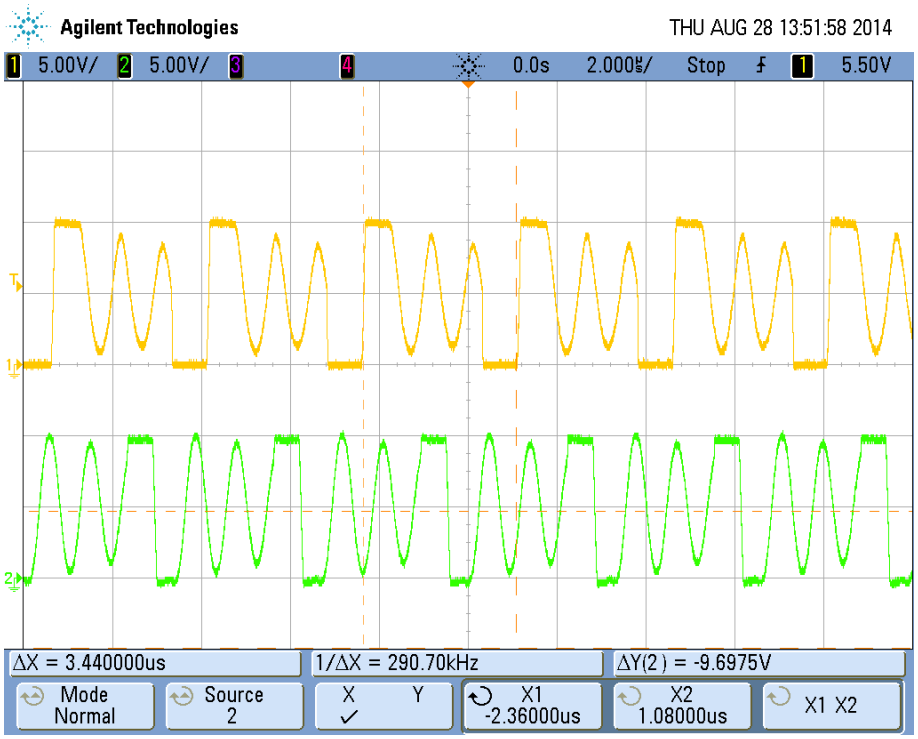

Figure 10 Switching Waveforms for the Pre-boost and the 5V Buck at 4.5Vin and No Load

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. The following switching waveforms are captured at 12V normal input condition. For the LM26420 switching waveforms, Ch1 (yellow) is the 2.8V output switch node voltage, and Ch2 (green) is the 1.8V output switch node voltage.

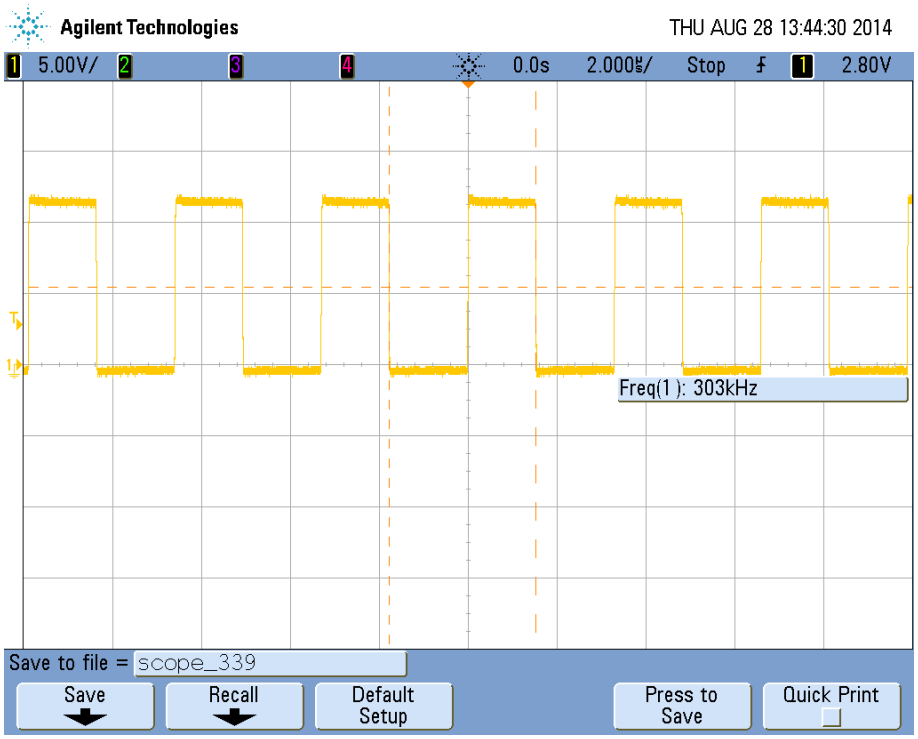

Figure 11 Switching Waveform for the 5V Buck at 12Vin and 2A Load

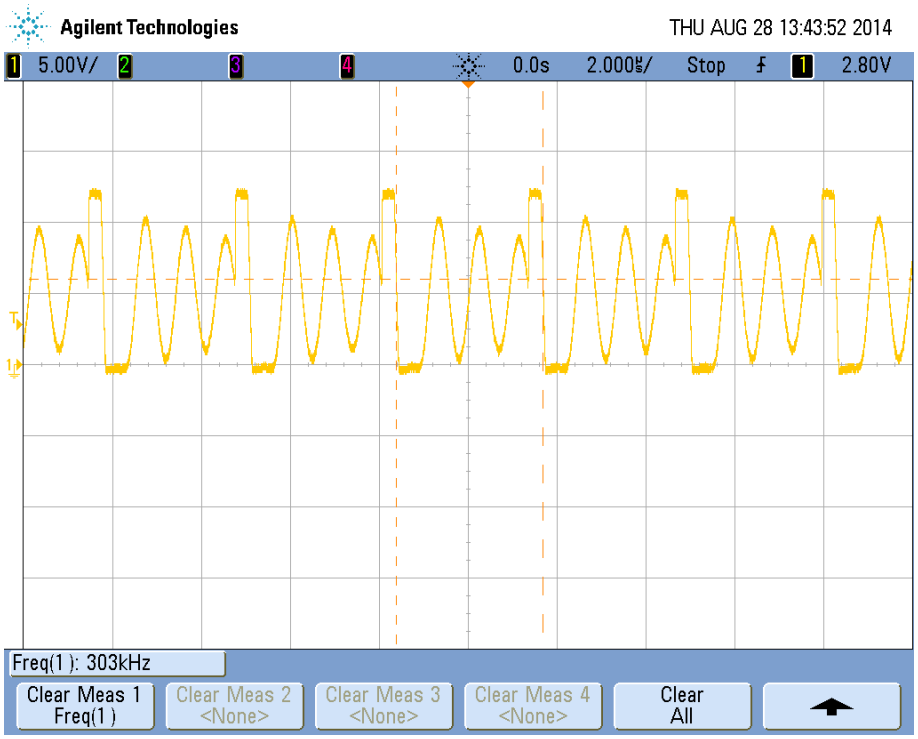

Figure 12 Switching Waveform for the 5V Buck at 12Vin and No Load

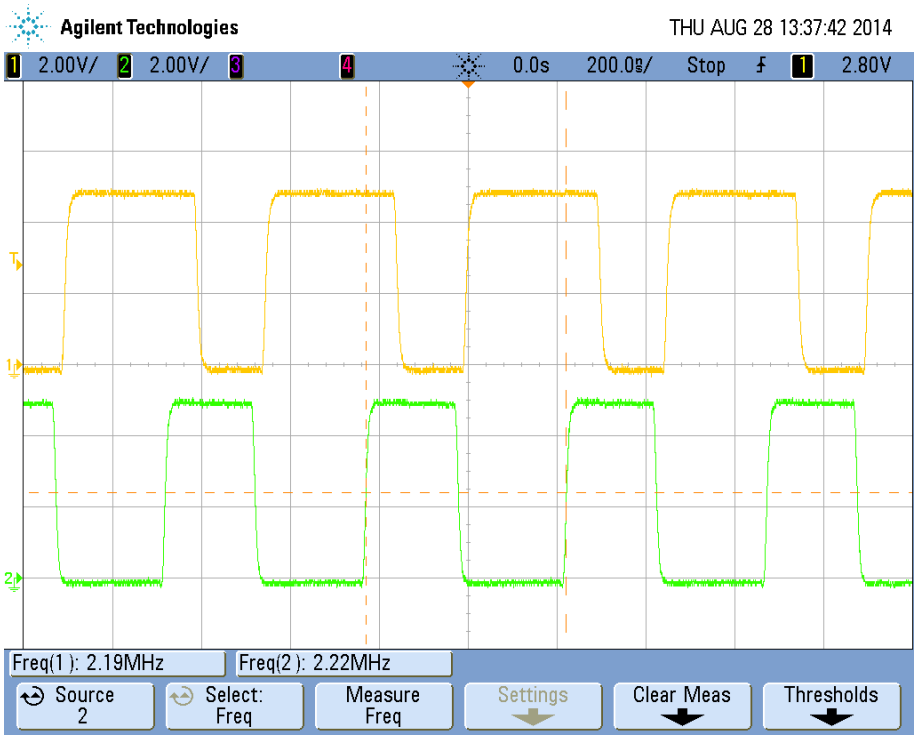

Figure 13 Switch Node Waveforms for the 2.8V and 1.8V Buck at Full Load

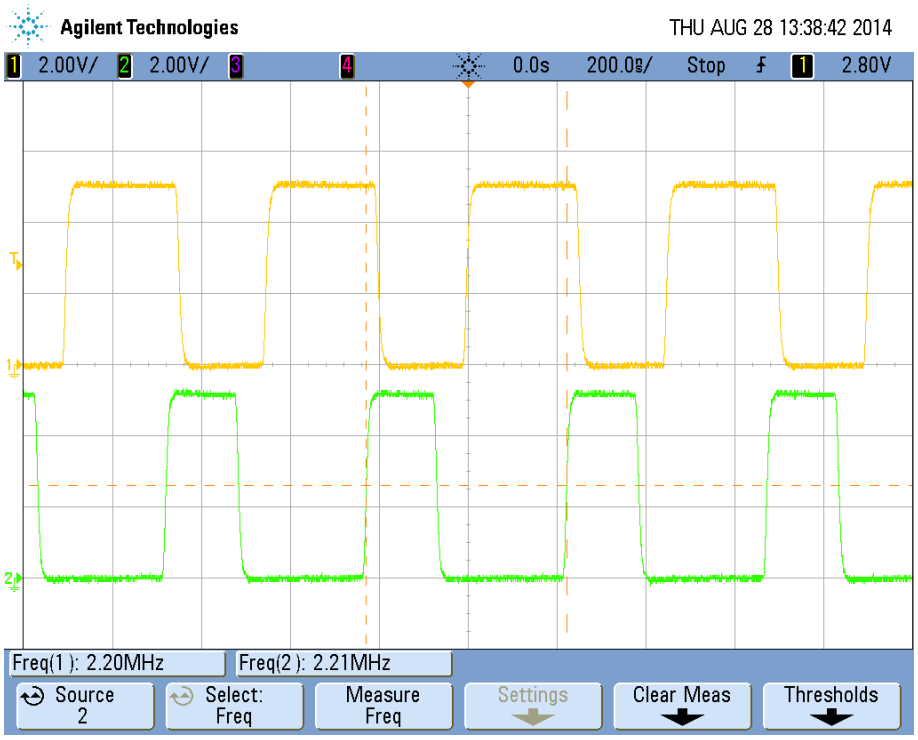

Figure 14 Switch Node Waveforms for the 2.8V and 1.8V Buck at No Load

Conducted Emissions

The tested board has the common mode choke and the filter inductor bypassed. The conducted emissions are tested under the 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 setup is shown in Figure 15: the input voltage is fed to the test board through two CISPR 25 compliant LISNs (Line Impedance Stabilization Networks), and the resistor loads are soldered on the output terminals of the test board.

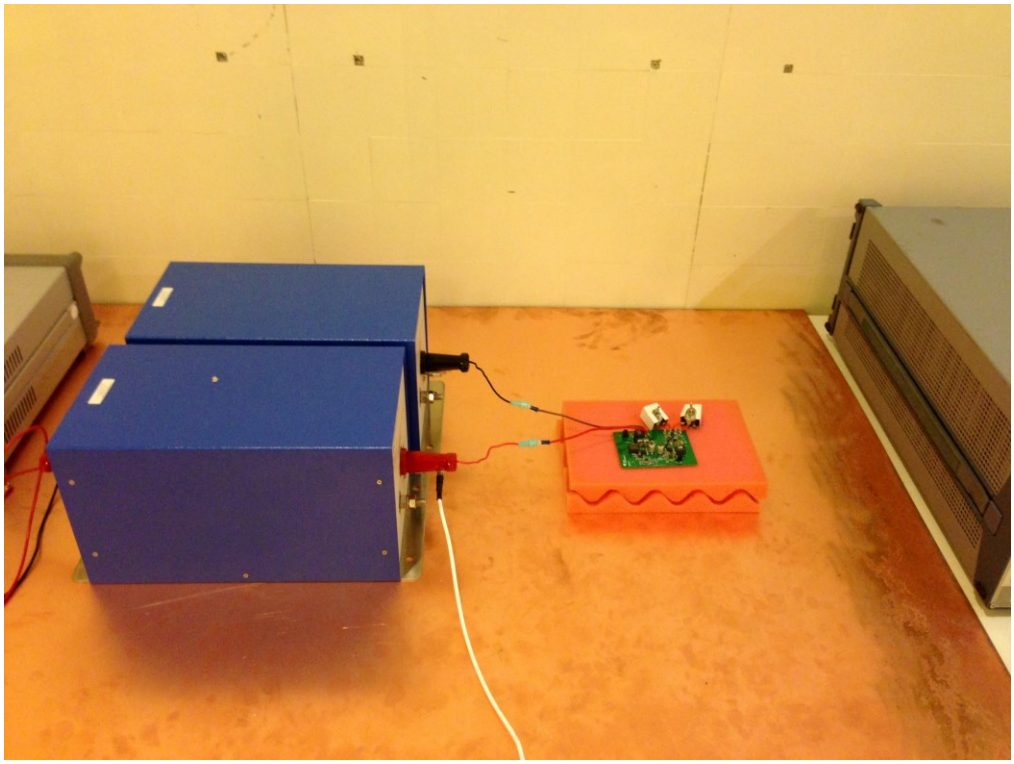

Figure 15 Conducted EMI Test Setup

The test results are shown in Figure 16, Figure 17 and Figure 18. The limit lines in red are the Class 5 limits for conducted disturbances specified in the standard. The Figure 16 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 17 and Figure 18 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 power supply board is in compliance with the CISPR 25 Class 5 conducted emissions standard.

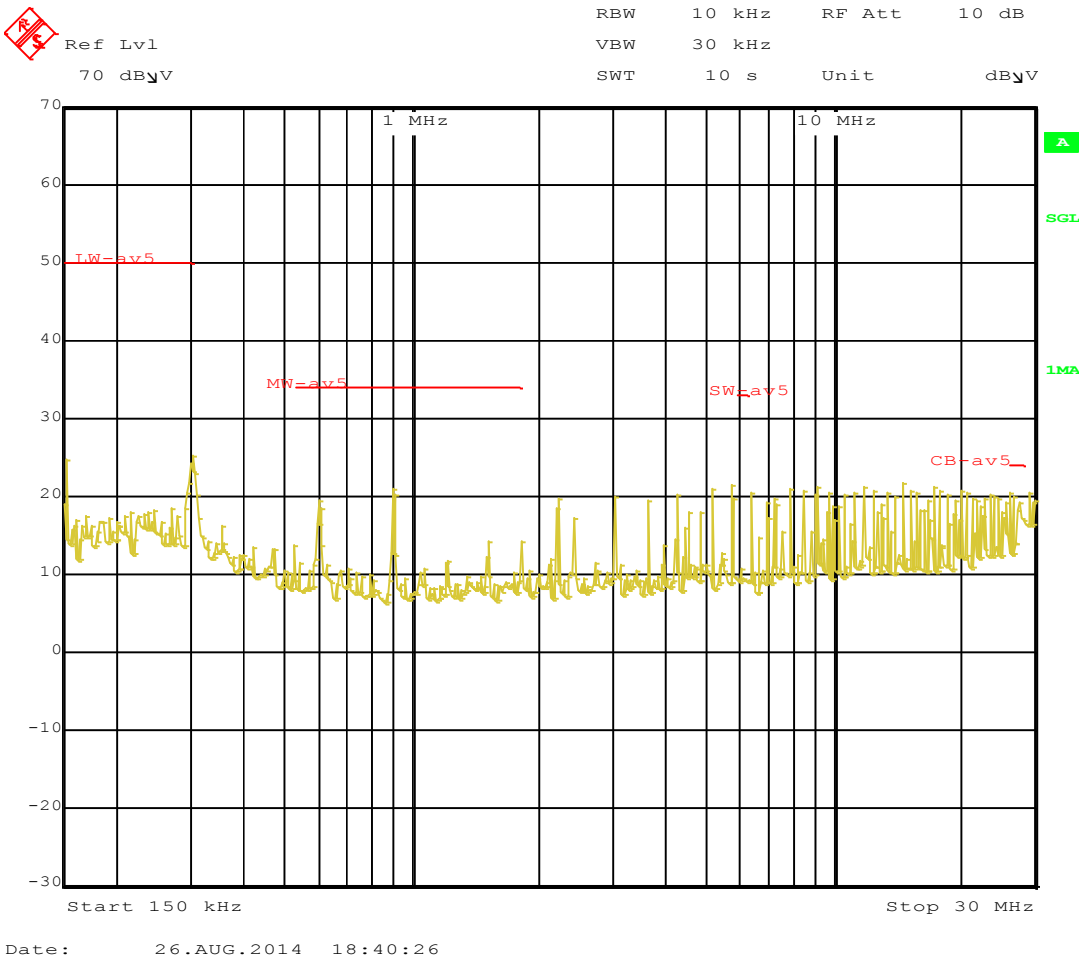

Figure 16 Peak detect, 150kHz – 30MHz

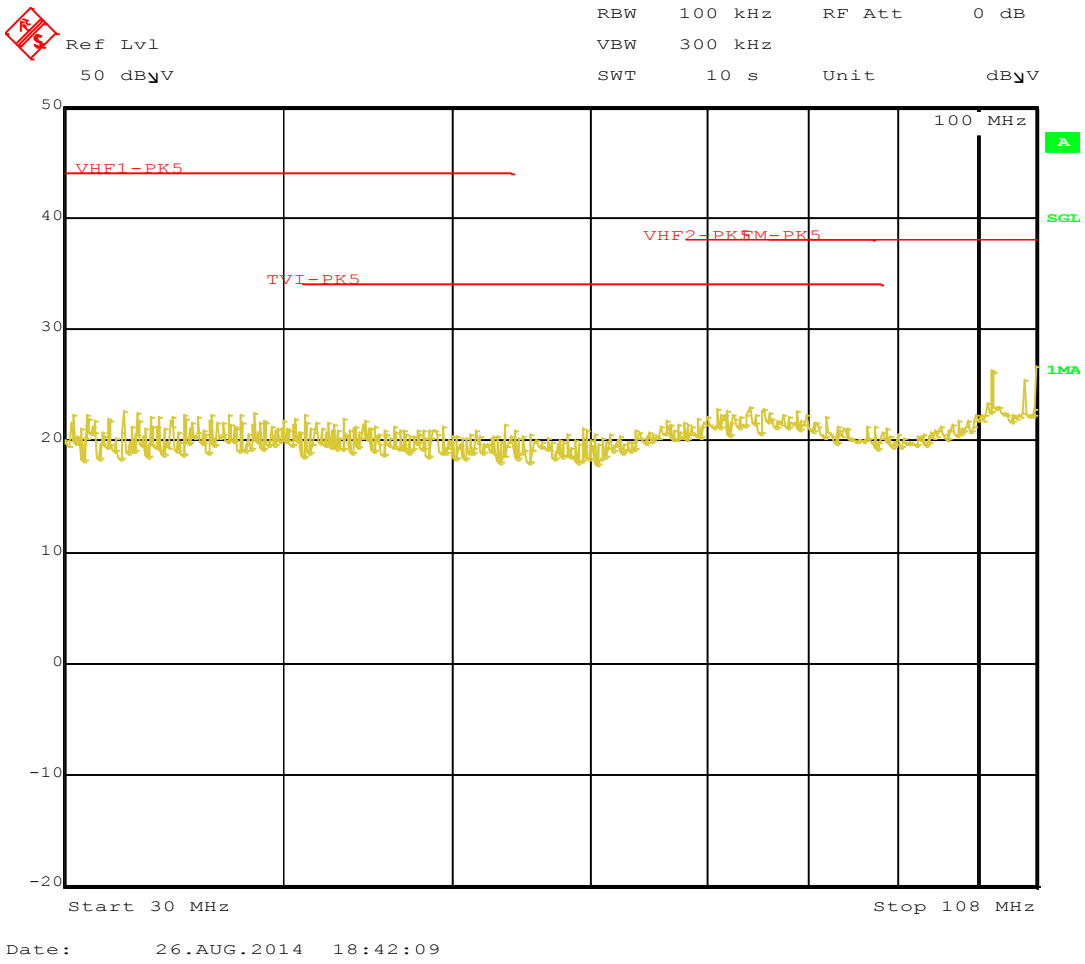

Figure 17 Peak detect, 30MHz – 108MHz

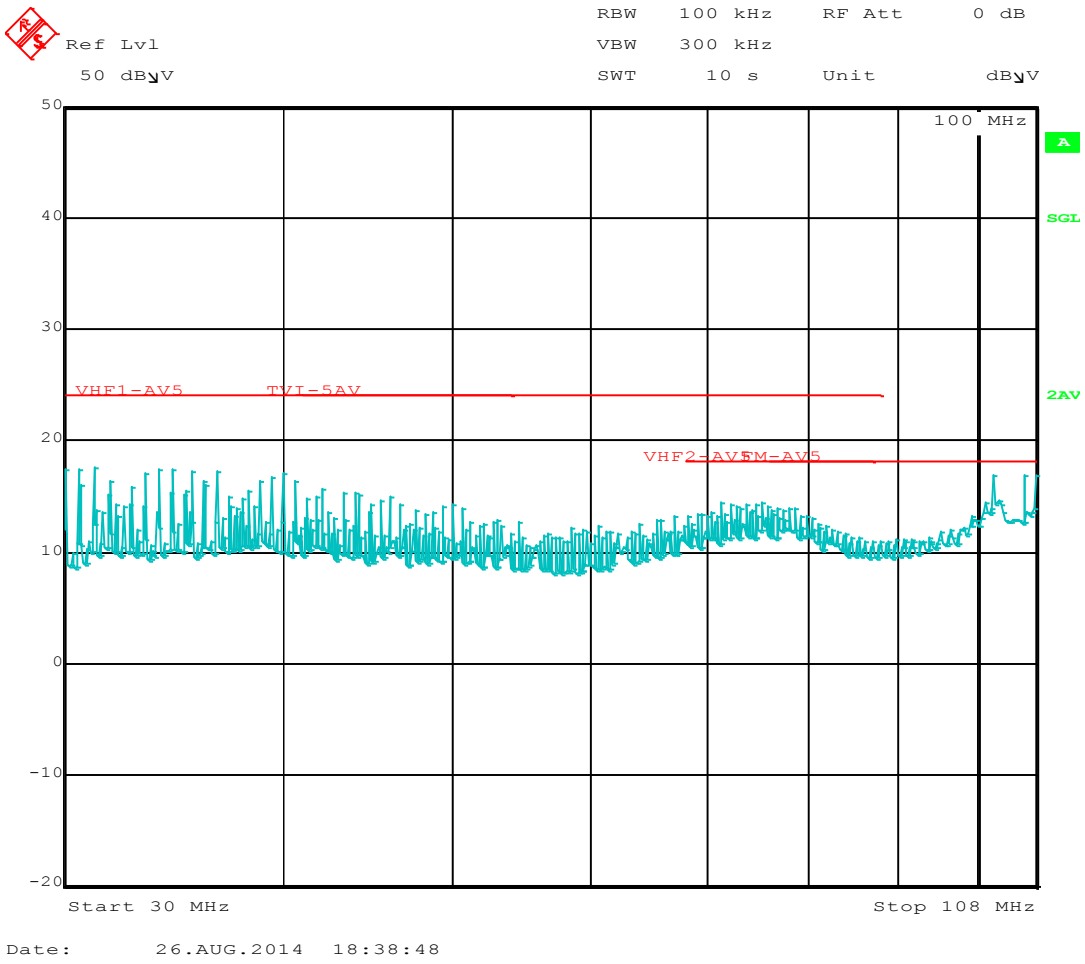

Figure 18 Average detect, 30MHz – 108MHz

Start Up

The input voltage is set at 12V, and the 2.8V and 1.8V output is set at 2A full load, and no load condition. Ch1 (yellow) is the input voltage, Ch2 (green) is the 5V output, Ch3 (indigo) is the 2.8V output and Ch4 (magenta) is the 1.8V output.

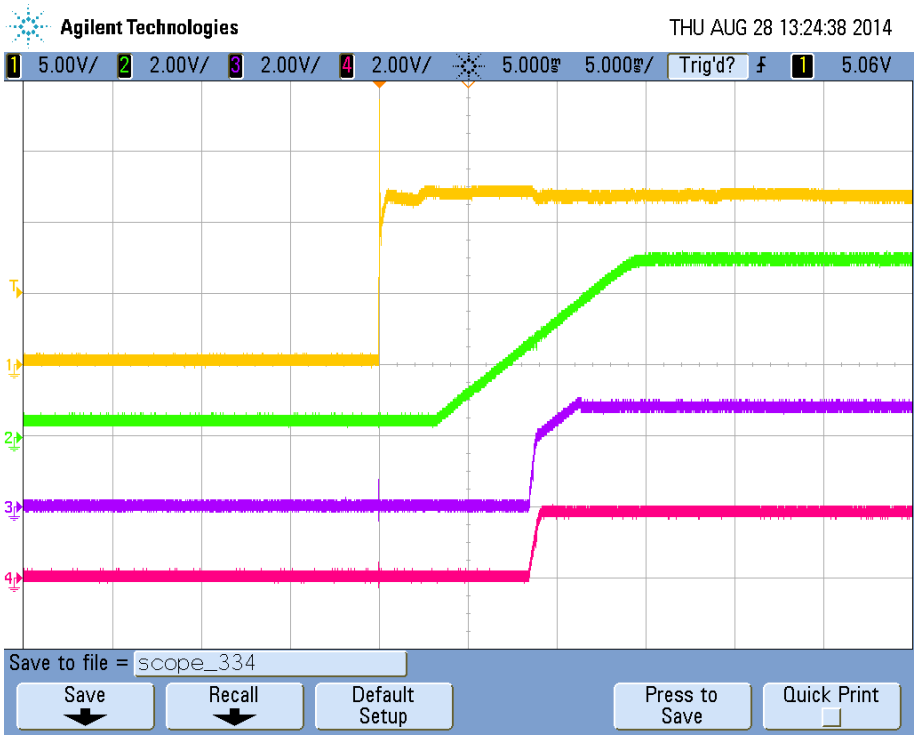

Figure 19 Start Up into Full Load at 12Vin

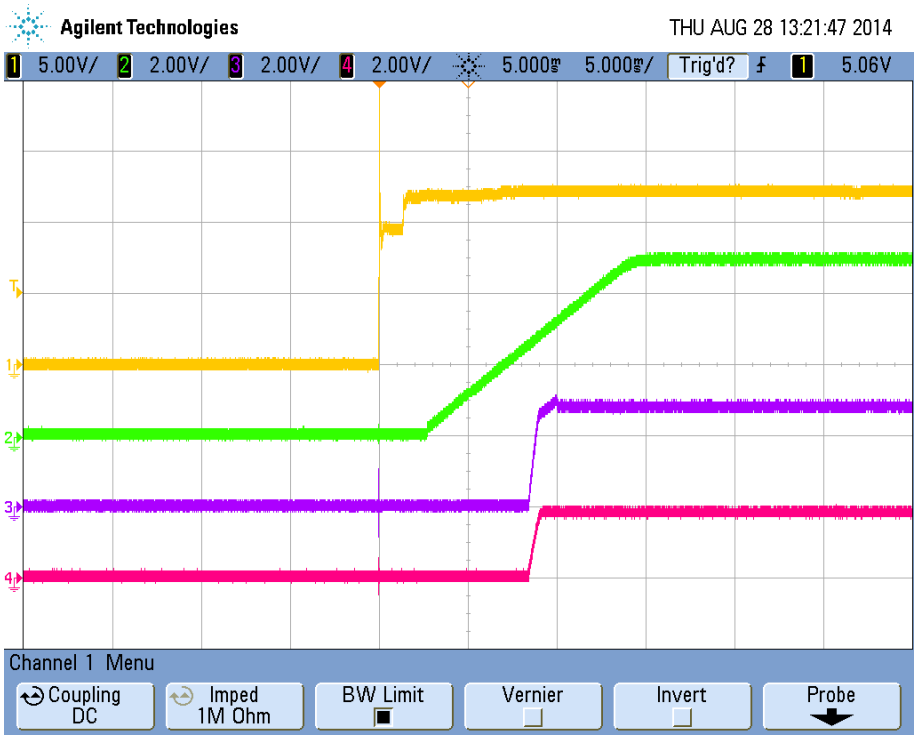

Figure 20 Start Up into No Load at 12Vin

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. Ch1 (yellow) is the output voltage in AC mode, and Ch4 (magenta) is the output load current.

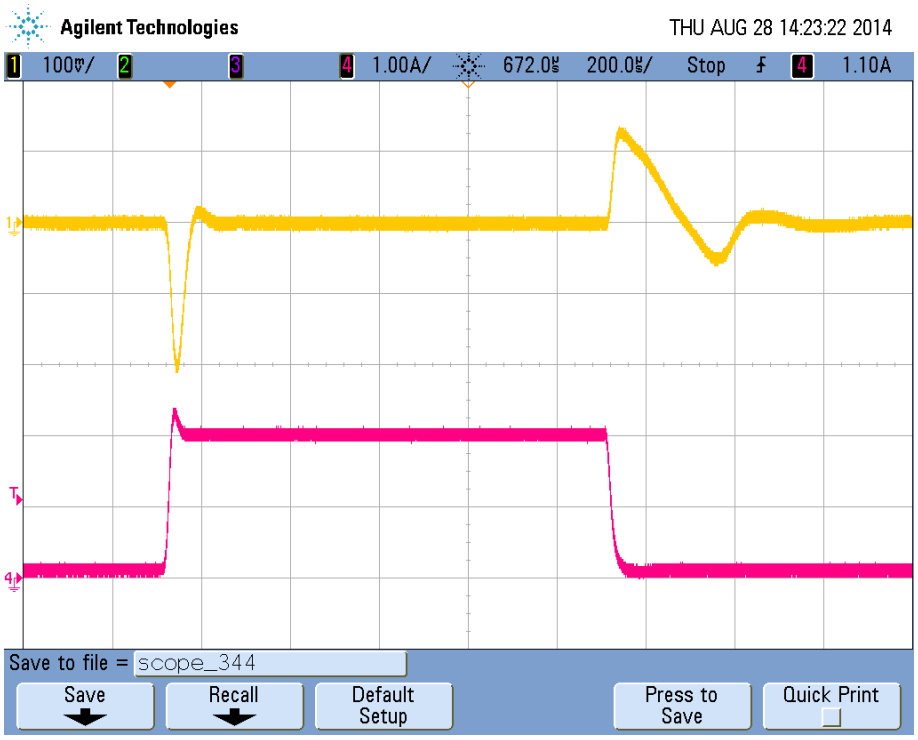

Figure 21 5V Output Buck Regulator Load Transient

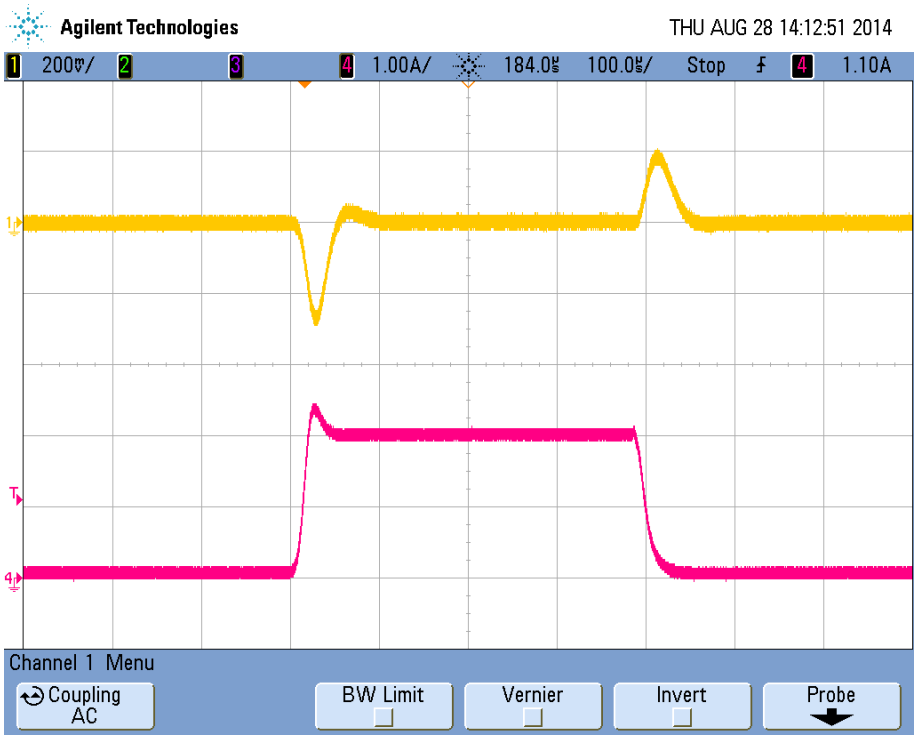

Figure 22 2.8V Output Buck Regulator Load Transient

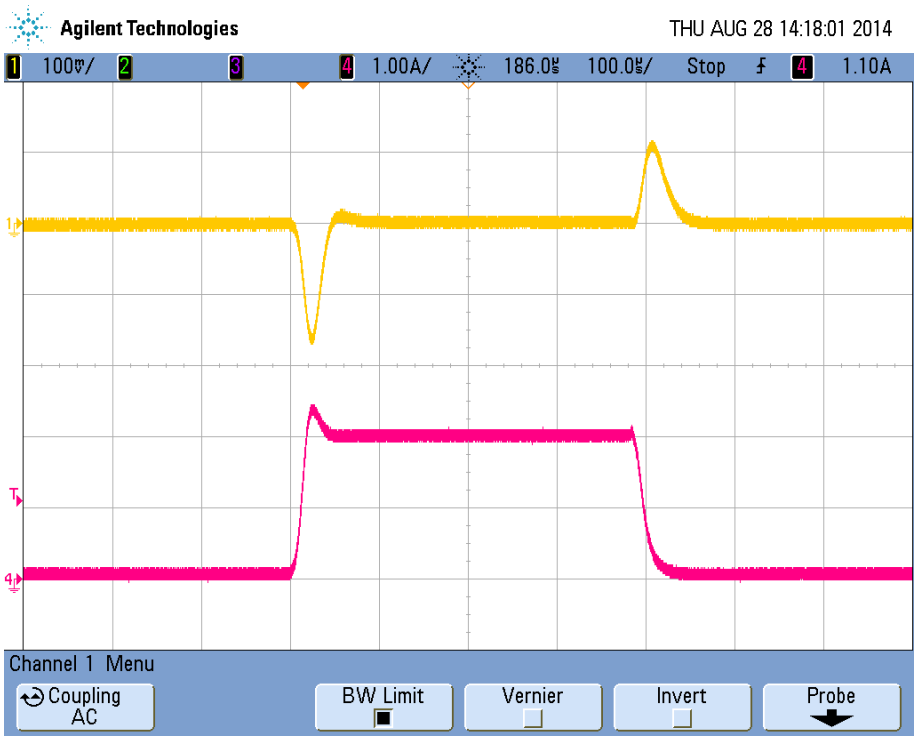

Figure 23 1.8V Output Buck Regulator Load Transient

Output Voltage Ripples

The output ripple is measured directly at the output capacitor for each output in full load condition. The 5V, 2.8V and 1.8V output are tested at 12V input. The 9.5V output of the pre-boost is tested at 4.5V input with 2A load on the 5V output. Ch1 (yellow) is the output voltage in AC mode, and Ch2 (green) is the switch node voltage.

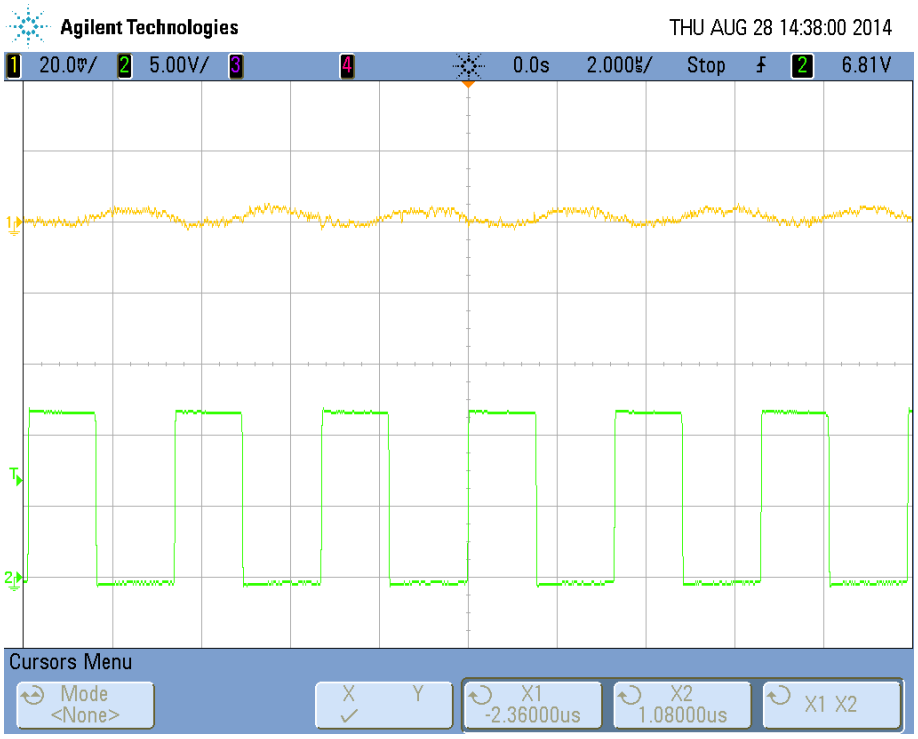

Figure 24 5V Output Ripple at 2A Load, 12Vin

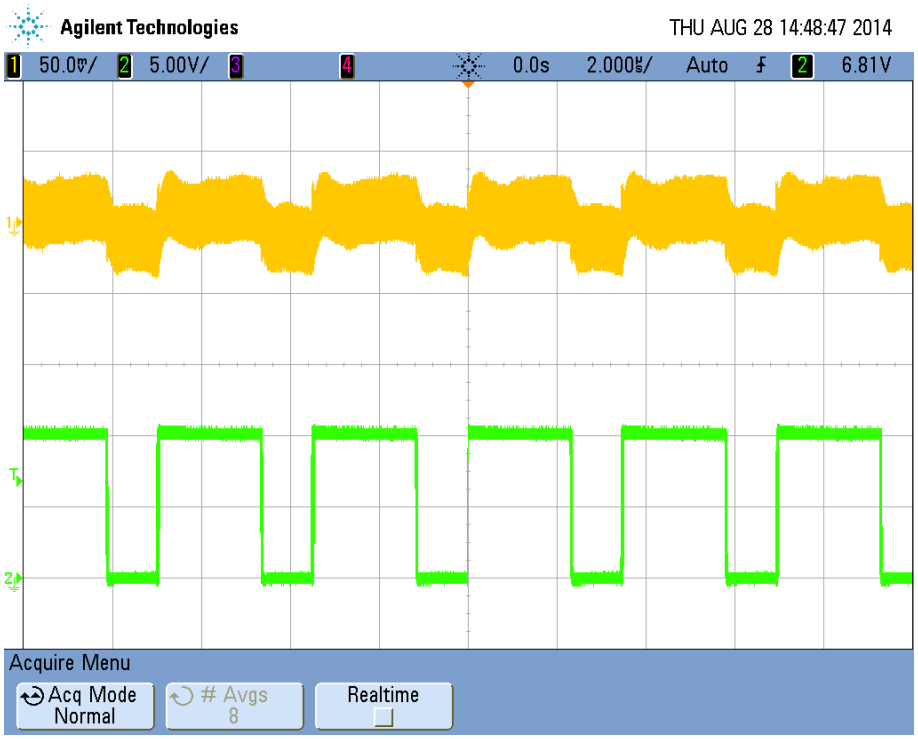

Figure 25 Pre-boost Output Ripple at 4.5Vin, 2A Load at 5Vo

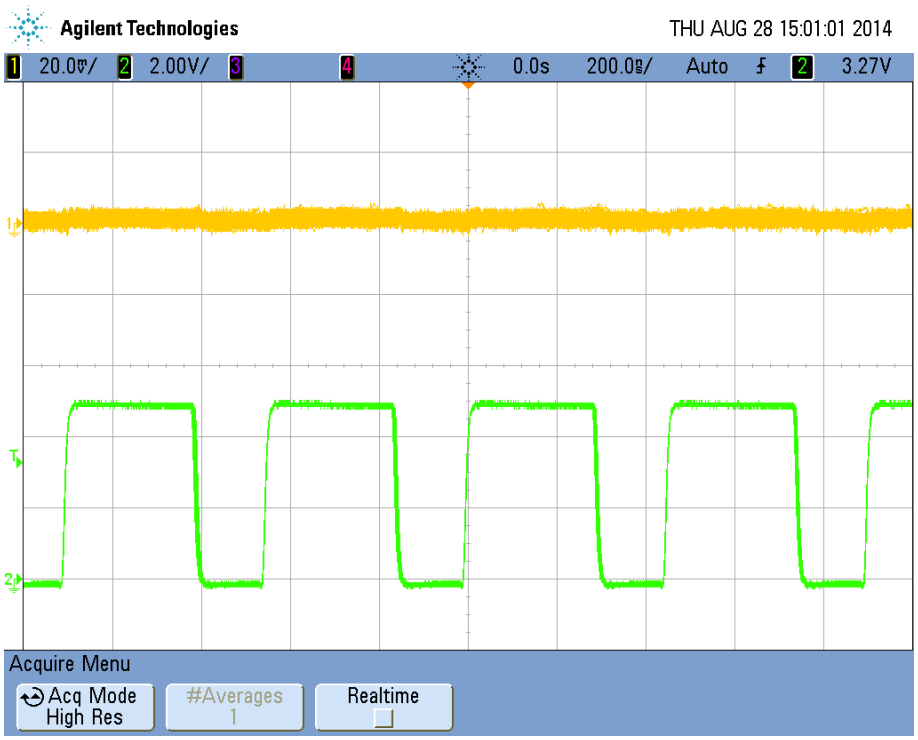

Figure 26 2.8V Output Ripple at 2A Load

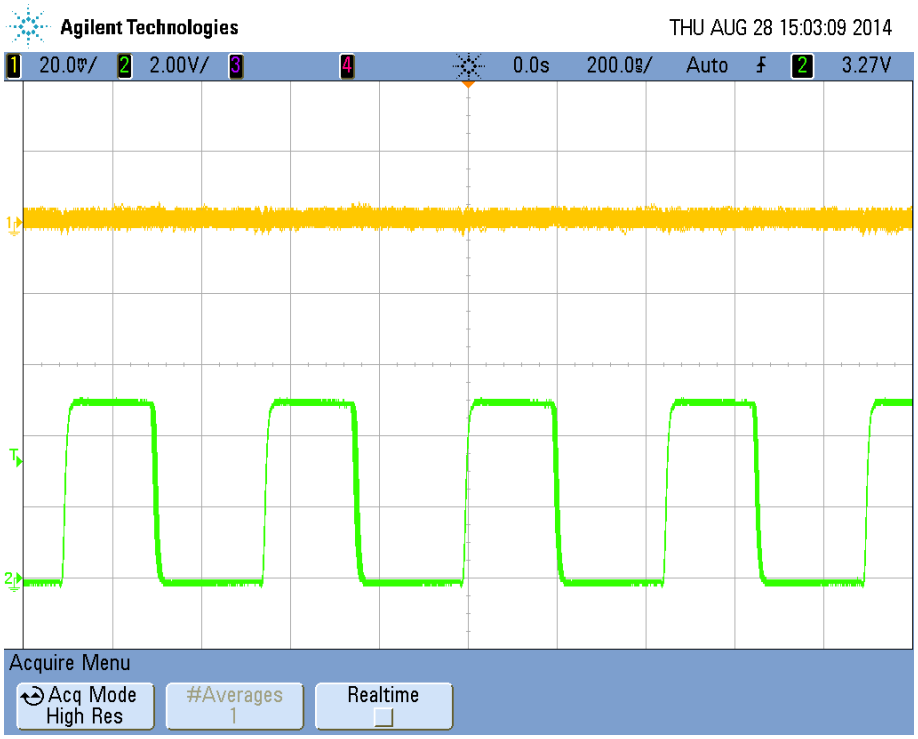

Figure 27 1.8V Output Ripple at 2A Load

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