PMP10654
Test Report

TEXAS INSTRUMENTS

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I. Overview

The PMP10654 reference design is a dual output isolated Fly-Buck power module for single IGBT driver bias. It takes 12V nominal input and generates isolated +15V and -9V outputs with 200mA current capability. The two voltage rails are suitable for providing the positive and negative bias to an IGBT gate driver in motor drives for EV/HEV and industrial applications, as shown in Figure 1. The reference board is designed as a power module with a miniature size of 28 x 18 mm (1.1 x 0.7 inch), and its footprint is compatible with the standard DIP package.

The reference design employs the Fly-Buck topology, and uses the LM5160 synchronous buck converter. The Fly-Buck has the advantages of primary side regulation (with no need of opto-coupler feedback) and good cross regulation. In order to achieve the low input voltage operation (down to 8V), the primary side is configured as an inverting buck in the design.

The input voltage range of the design is 8V to 20V. The output regulation is within +/-5% tolerance over line and load variations. The peak efficiency is about 87%. The insulation voltage rating provided by the transformer is 2500VDC/1min.

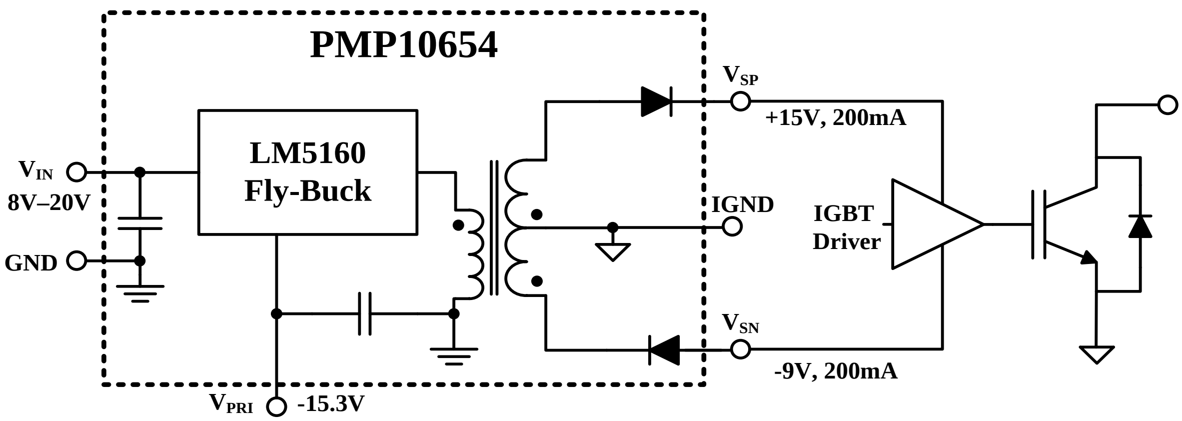

Figure 1 The single IGBT gate driver bias supply with PMP10654

II. Power Specification

Input Voltage: 12V nominal, 8V – 20V

Output: Isolated +15V, -9V @ 200mA each

Total output power: 4.8W

Switching frequency: 210 kHz

III. Reference Board

The reference board is designed as a power module in standard DIP 22-pin package (100mil pin pitch, 600mil row spacing). The footprint of the board is shown in Figure 2. Note that the pin 7, 8 (VPRI) are the -15.3V primary output voltage of the Fly-Buck, and they are unused in the design. The reference board uses 1oz copper 2- layer PCB, and its dimensions are as follows:

Board size: 28 x 18 mm (1.1 x 0.7 inch).

Total height: 12.5mm when mounted on a PCB

Component height: top side 8.5mm, bottom side 2.5mm

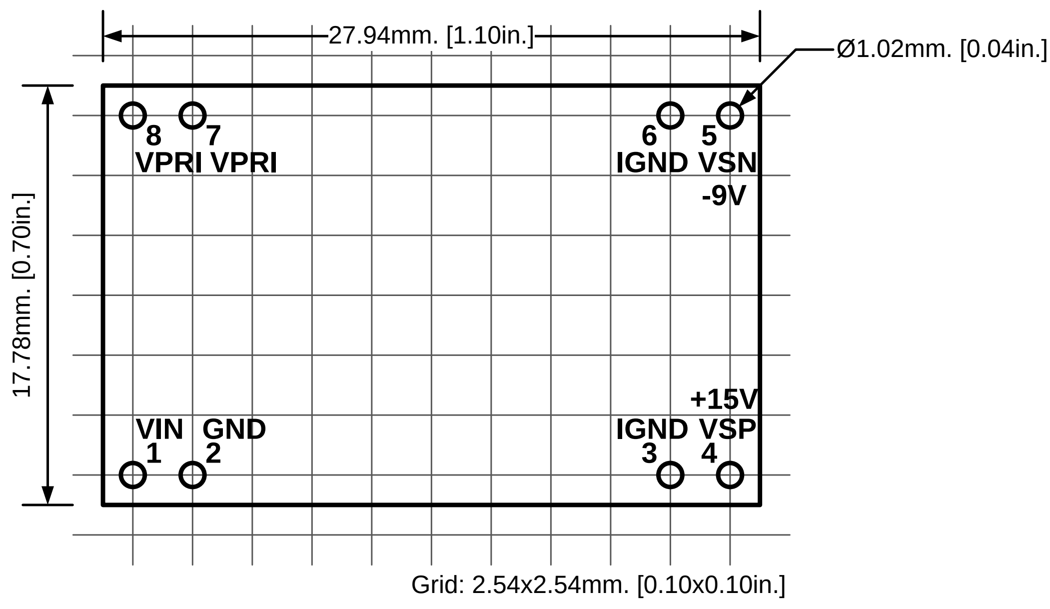

Figure 2 Reference board footprint

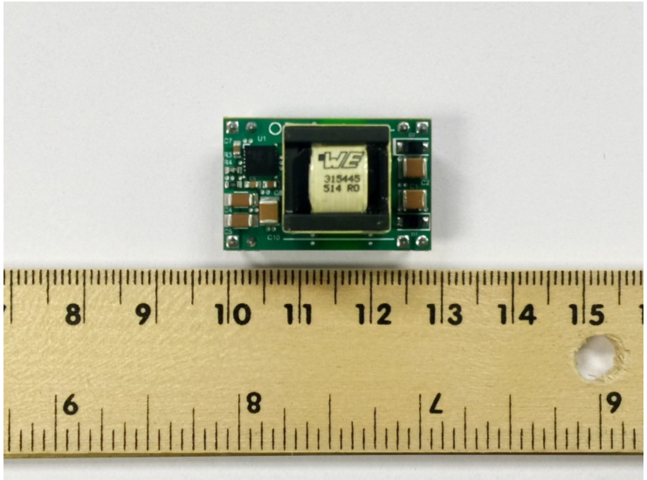

Figure 3 Reference board top view

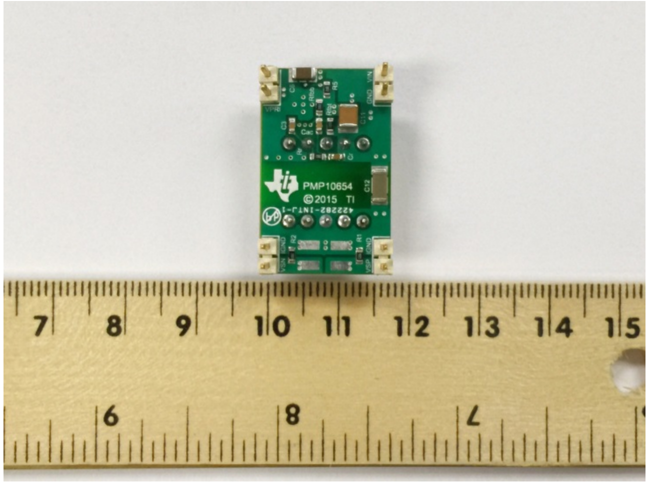

Figure 4 Reference board bottom view

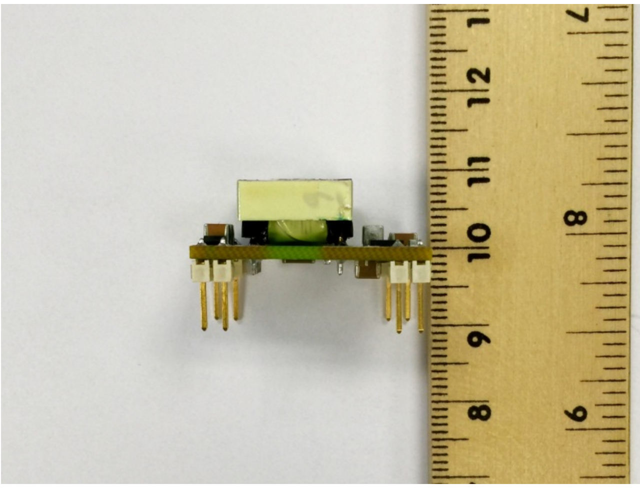

Figure 5 Reference board side view

IV. Efficiency

The efficiency was measured at different input voltages under balanced load, where both outputs were loaded with the same current.

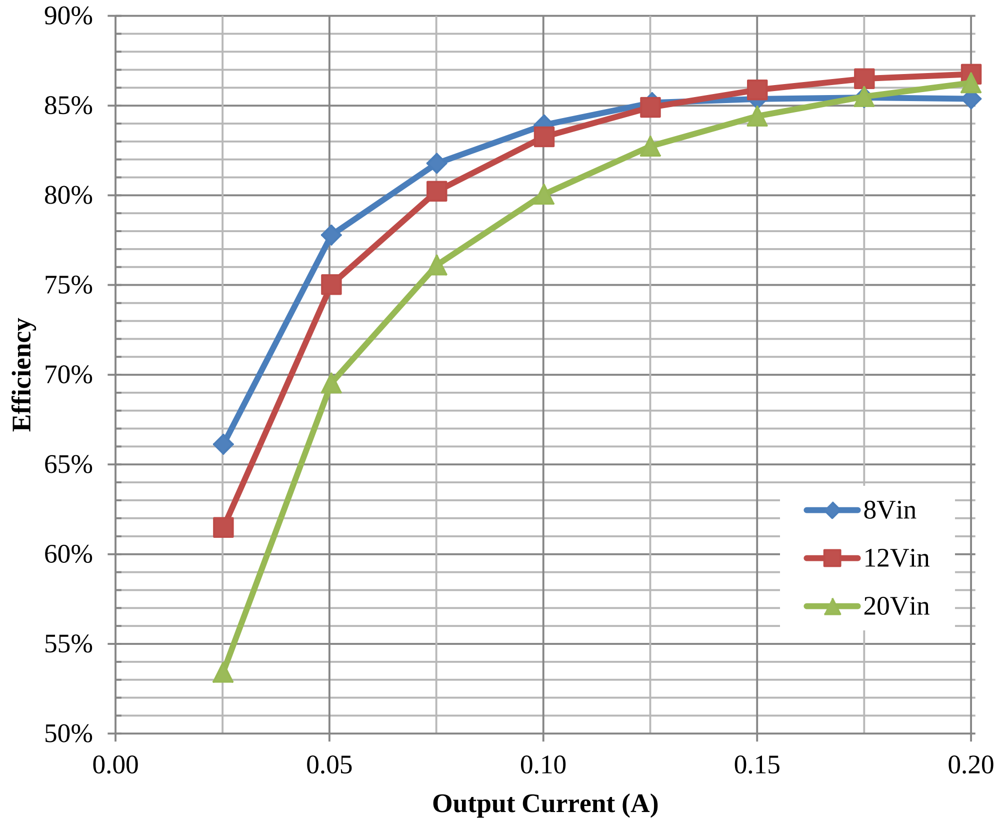

Figure 6 Power efficiency under balanced load

V. Cross Regulation

The output regulation of the reference design was examined at different input voltage under balanced and unbalanced load condition. The test results show that both outputs were within +/-5% variation under all the input and load conditions.

Under balanced load, the two outputs were loaded with the same output current. Figure 7 and Figure 8 shows the output variations under balanced load.

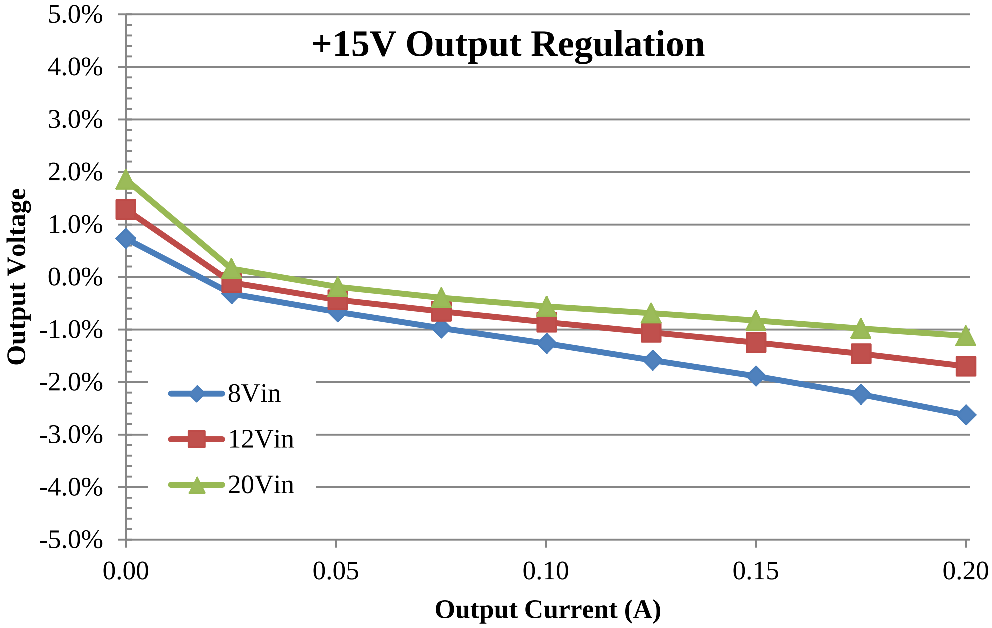

Figure 7 +15V output regulation under balanced load

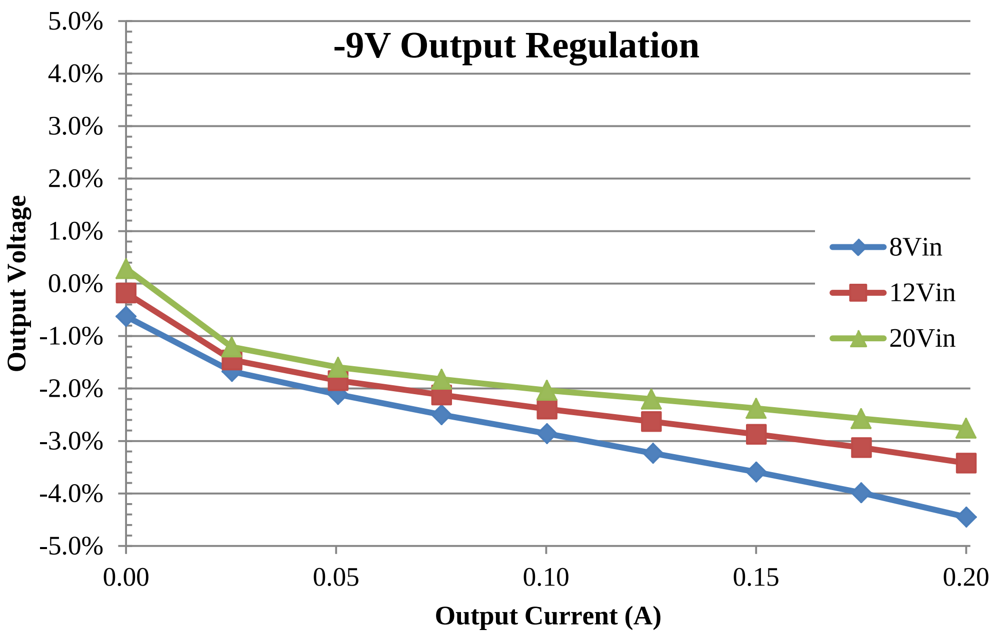

Figure 8 -9V output regulation under balanced load

The unbalanced load condition was tested by varying the load on one output while fixing the load on the other output. Figure 9 and Figure 10 show the output variations with fixed load on the -9V output, while Figure 11 and Figure 12 show the results with fixed load on the +15V output.

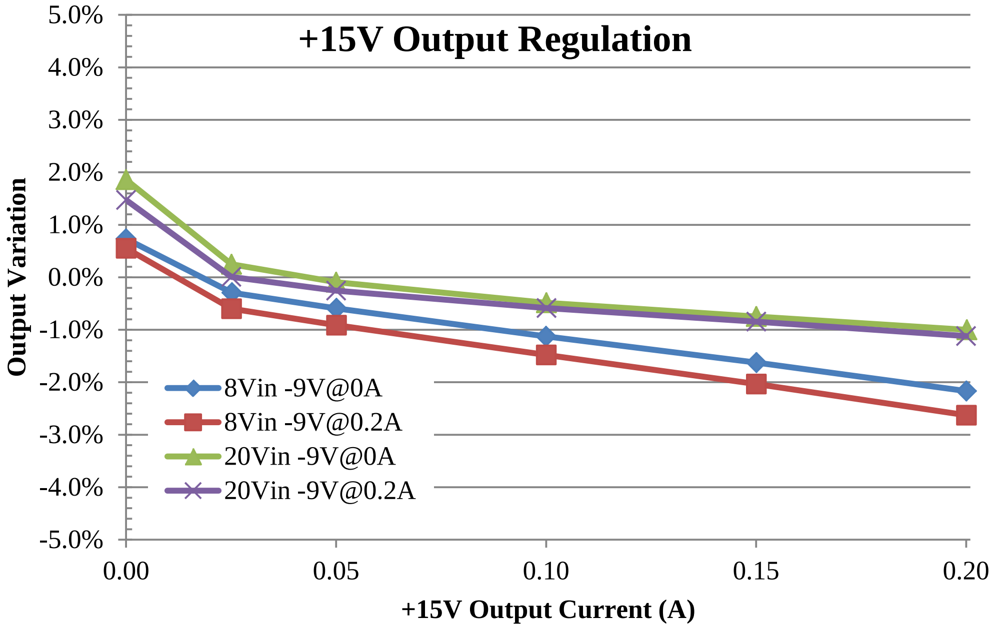

Figure 9 +15V output regulation under unbalanced load, fixed load on -9V output

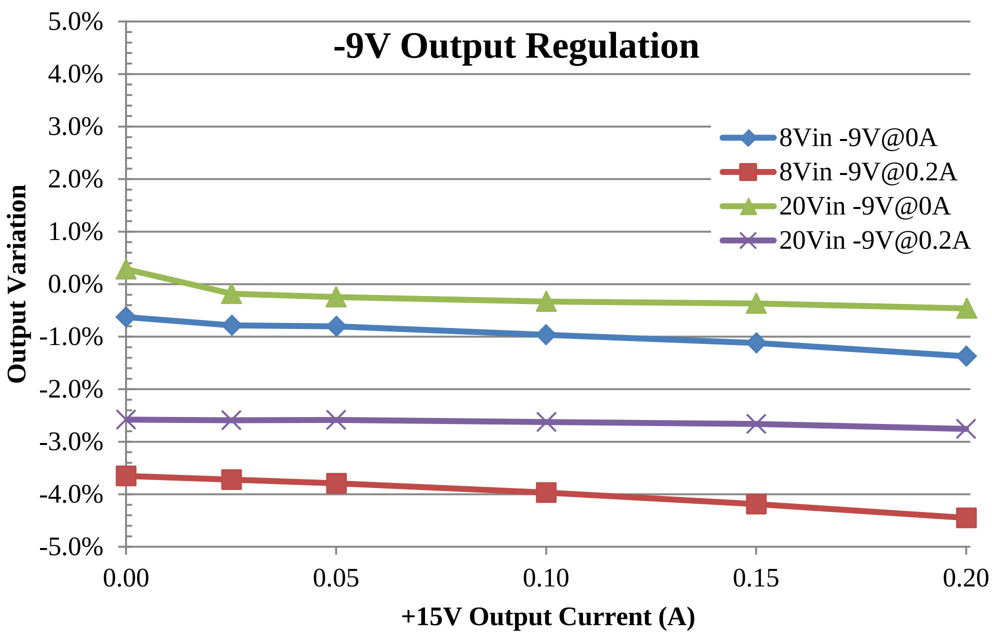

Figure 10 -9V output regulation under unbalanced load, fixed load on -9V output

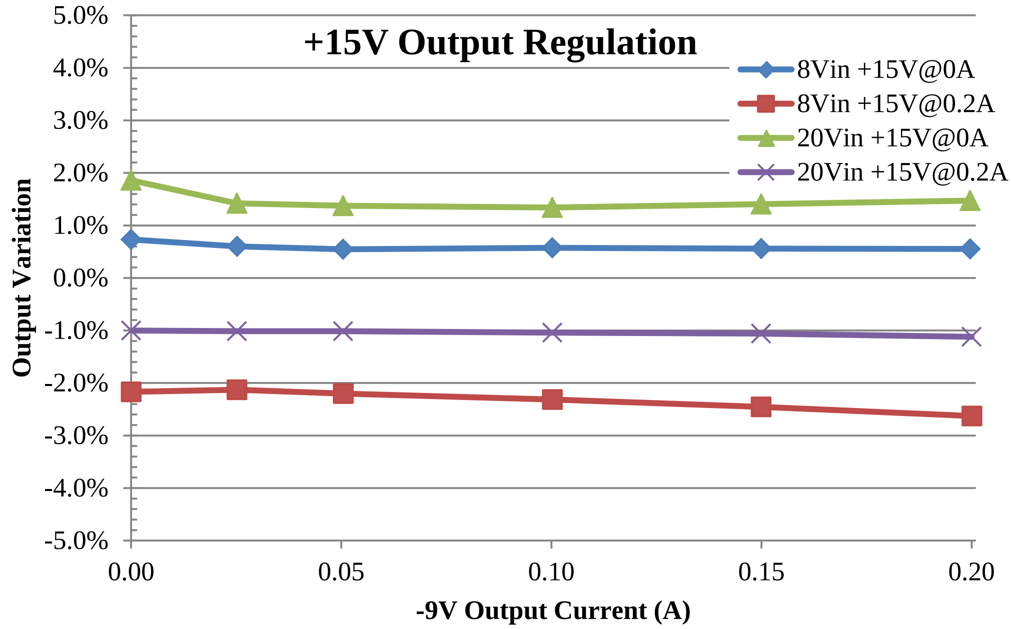

Figure 11 +15V output regulation under unbalanced load, fixed load on +15V output

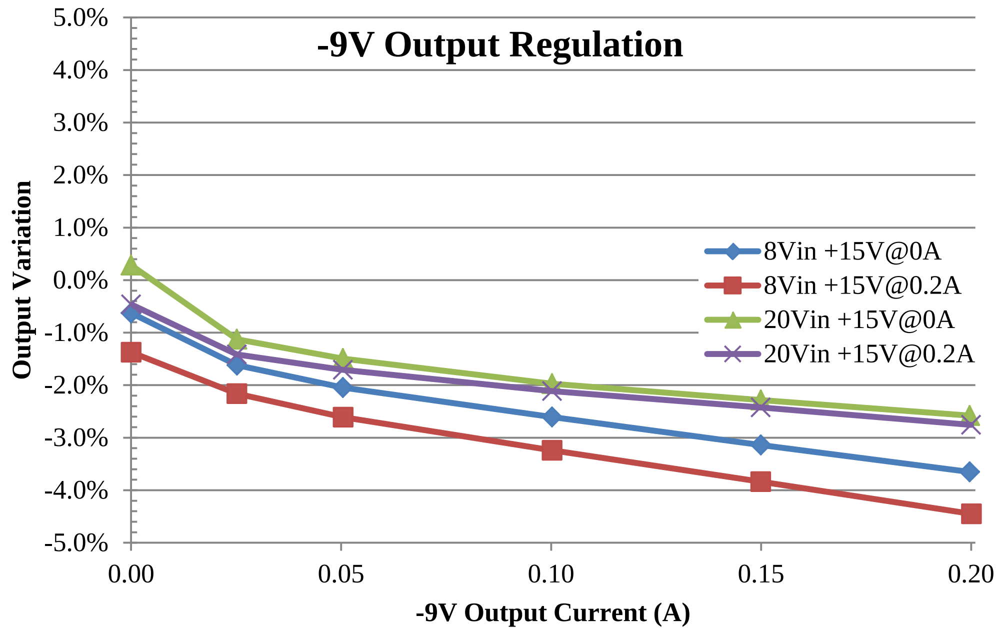

Figure 12 -9V output regulation under unbalanced load, fixed load on +15V output

VI. Thermal

The thermal image was taken at 23°C room temperature, no air flow. The board was operating at 12V input, full load on the two outputs.

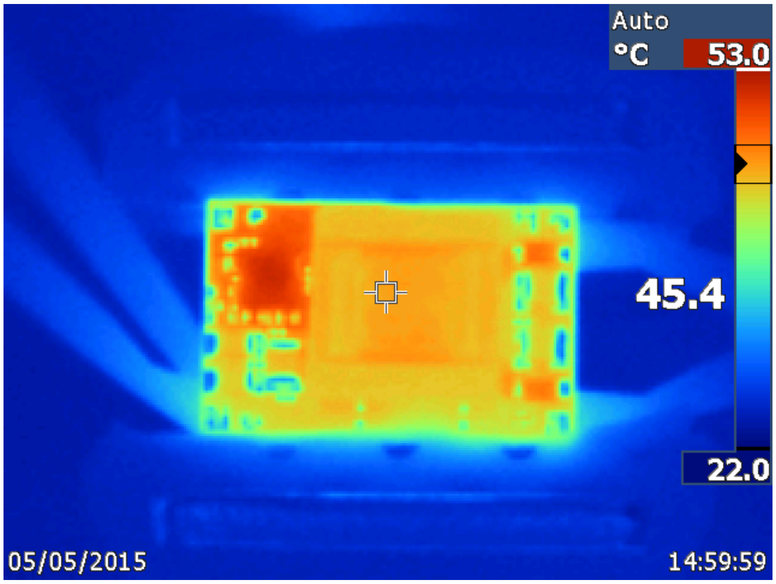

Figure 13 Thermal image from top view

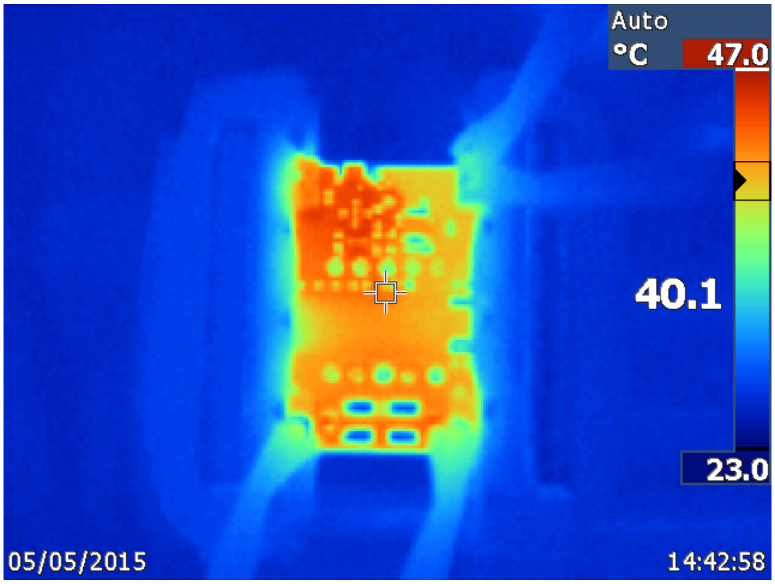

Figure 14 Thermal image from bottom view

VII. Power Up

The reference board was tested under no load and full load at 12V input. Ch1 (yellow) is the input voltage, Ch2 (green) is the +15V output voltage, Ch3 (purple) is the -9V output voltage.

Figure 15 Power up into no load at 12V input

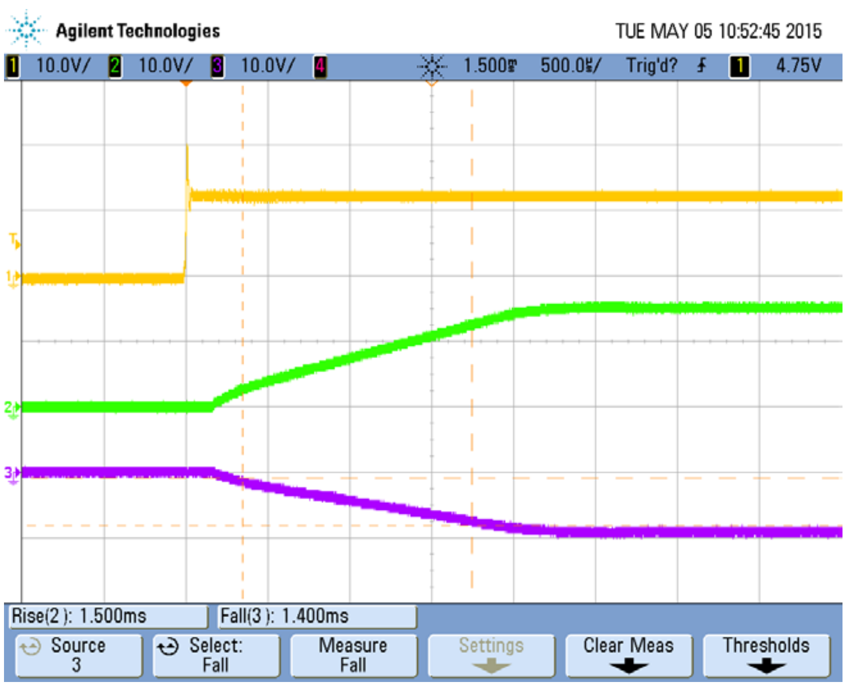

Figure 16 Power up into full load at 12V input

VIII. Switching Waveforms

The primary side switch node voltage was measured at no load and full load condition at 12V input. Ch1 (yellow) is the switch node voltage.

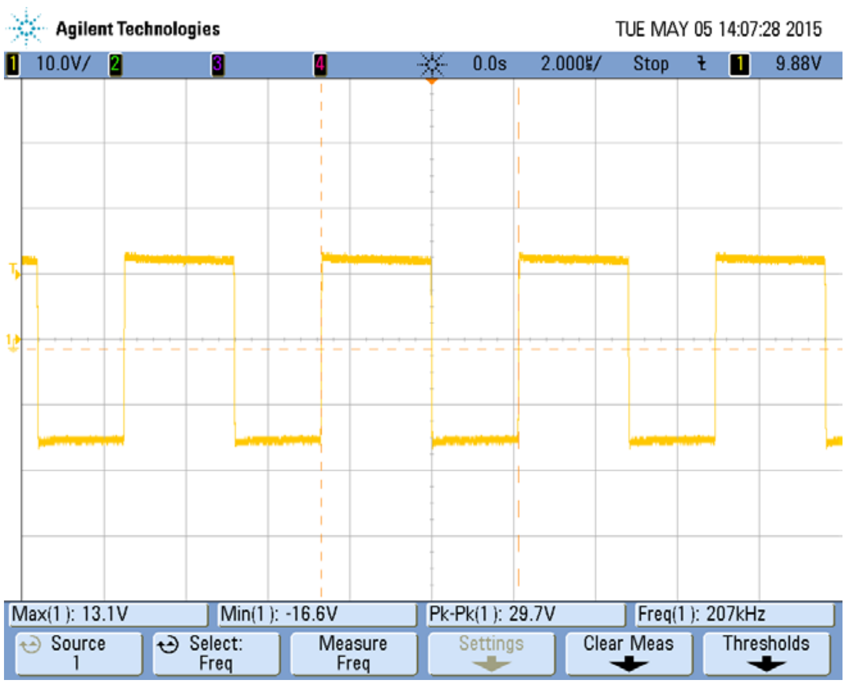

Figure 17 Switch node voltage at no load, 12V input

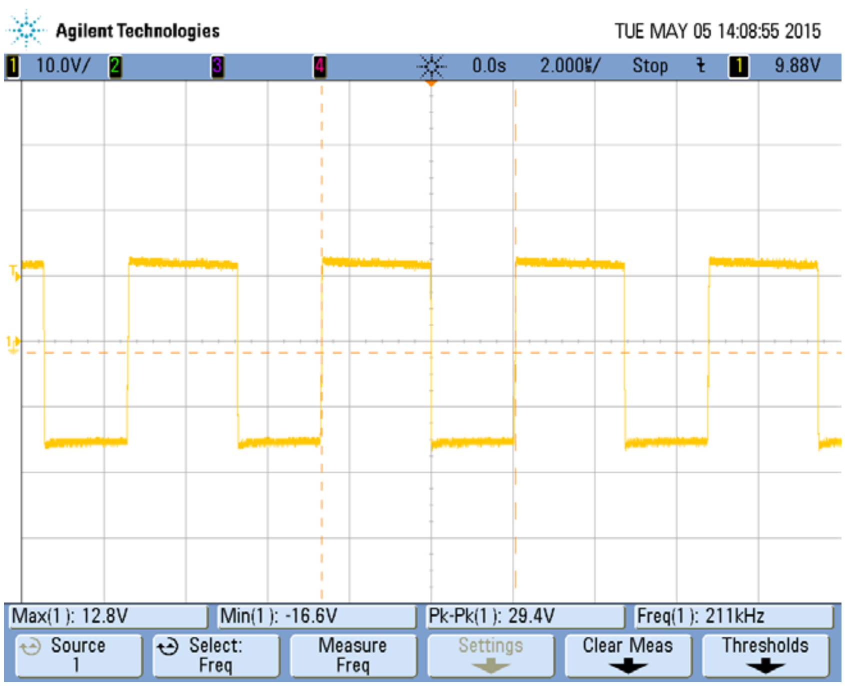

Figure 18 Switch node voltage at full load, 12V input

On the isolated secondary side, the voltages across the rectifier diodes were measured at full load and 20V input, as the condition represented the worst case for the highest blocking voltage on the diodes. Ch1 (yellow) shows the voltage across the diode.

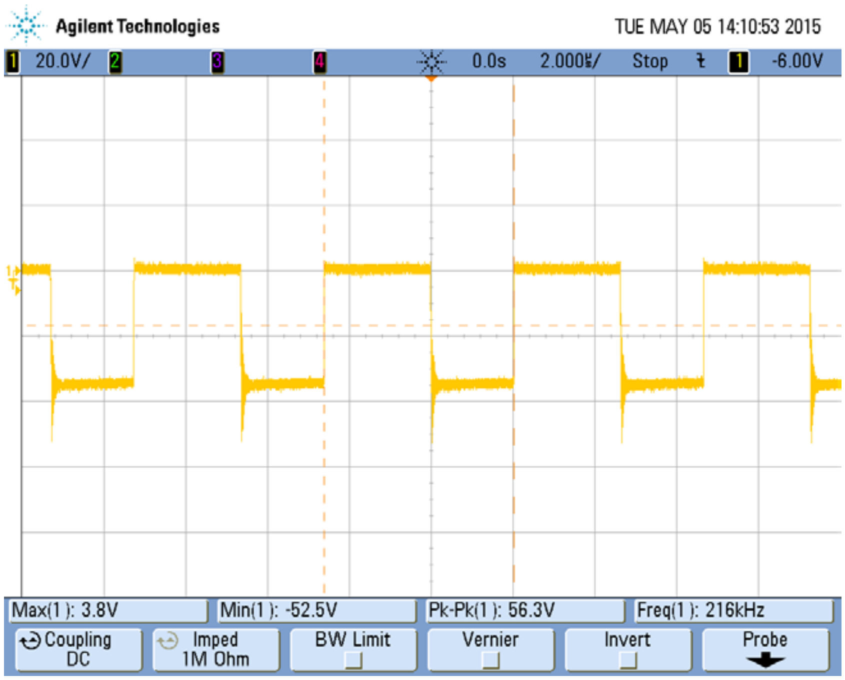

Figure 19 +15V output diode anode (+) to cathode (-) voltage at full load, 20V input

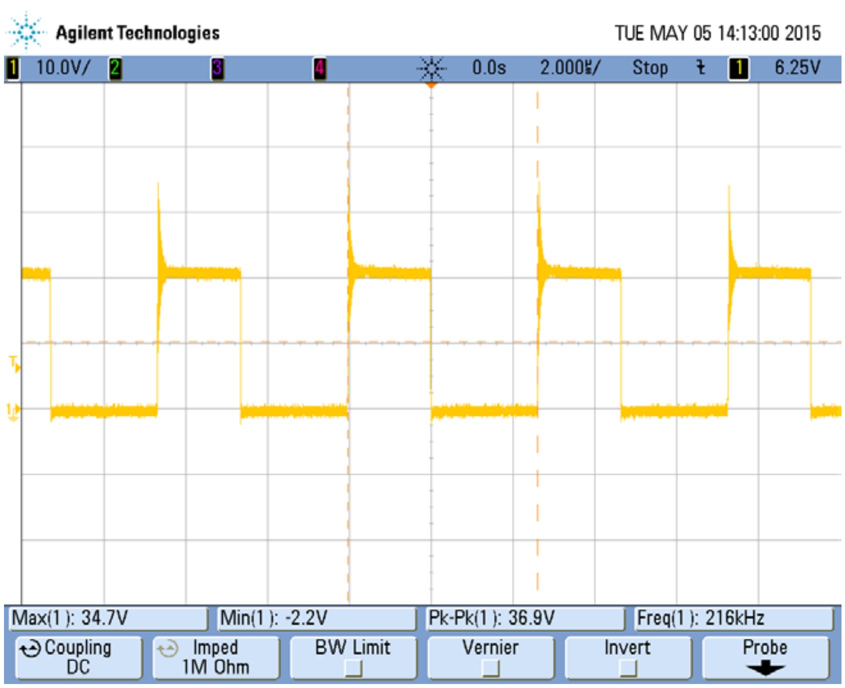

Figure 20 -9V output diode cathode (-) to anode (+) voltage at full load, 20V input

IX. Load Transients

The load transient response was tested by applying 0 to 0.2A load steps from the +15V to -9V as one output. Ch1 (yellow) is the output voltage in AC mode, and Ch4 (magenta) is the output current.

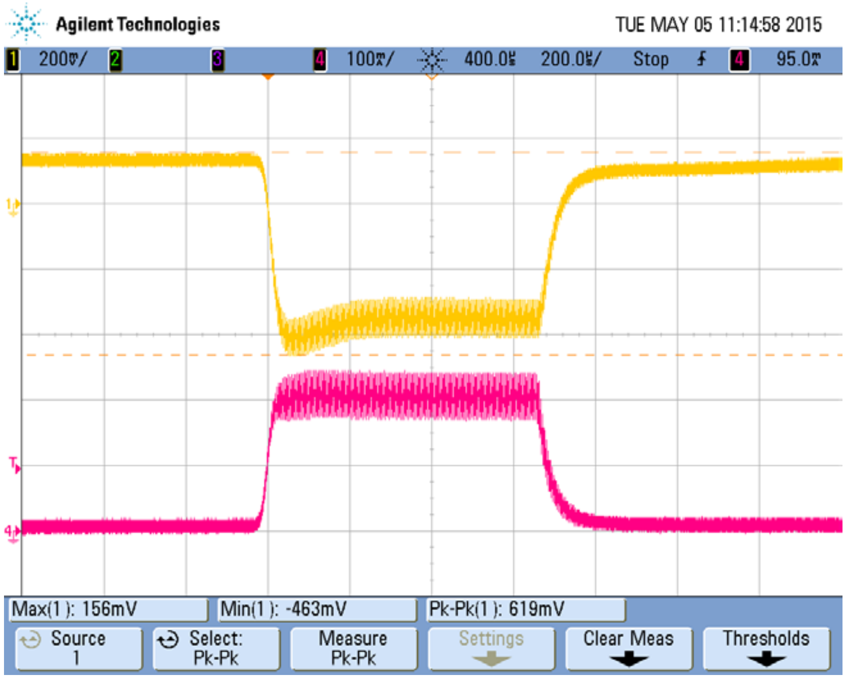

Figure 21 +15V output load transient at 12V input

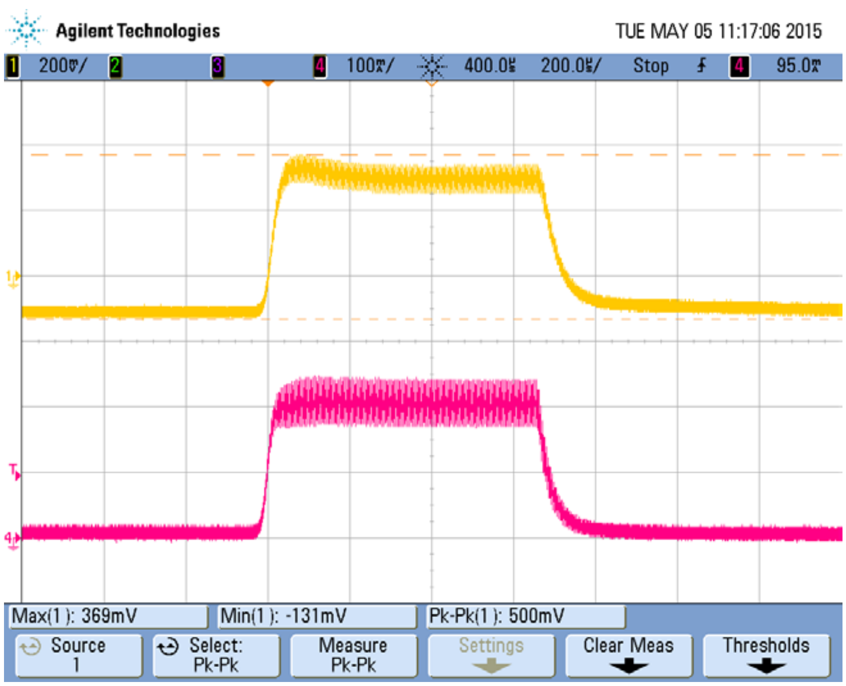

Figure 22 -9V output load transient at 12V input

X. Output Voltage Ripples

The output ripples were measured directly at the output capacitors. Ch1 (yellow) is the output voltage ripple in AC mode.

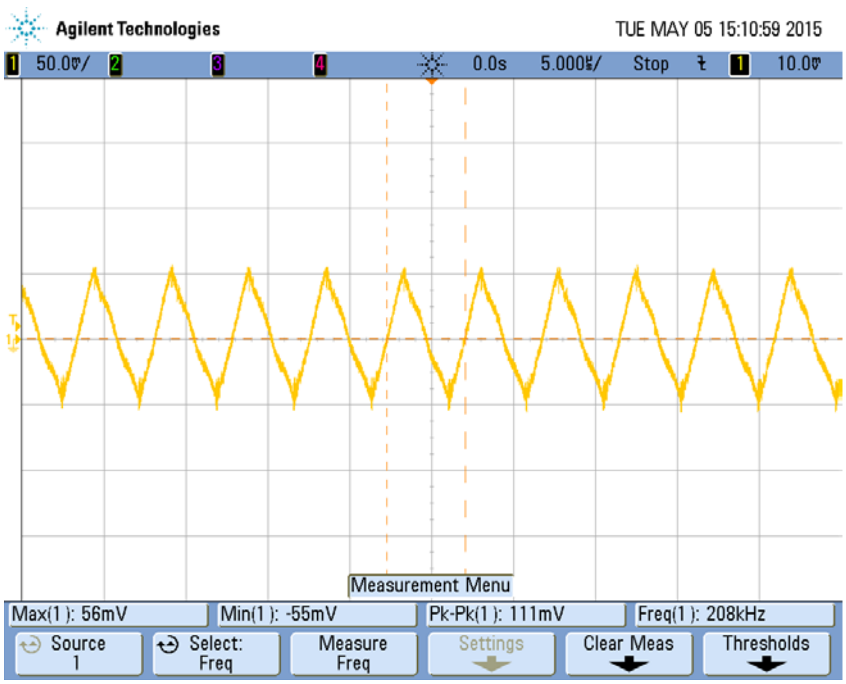

Figure 23 +15V output ripple at 12V input, full load

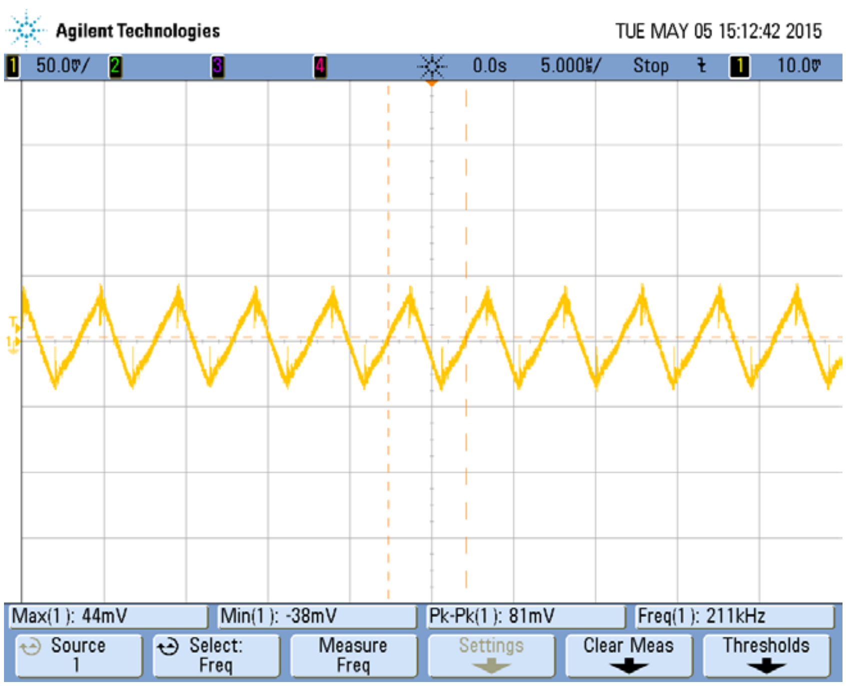

Figure 24 -9V output ripple at 12V input, full load

To further reduce the ripple, more capacitors can be added to the output. There is one extra 1210 solder pad available for each output on the bottom of the board.

XI. Short Circuit Test

The short circuit test was conducted by shorting the +15V and -9V output together when the board was operating at full load and 12V input. While in short circuit, the LM5160 IC can protect itself from over current by limiting the on-time of the integrated high side FET. The board can still recover to normal operation once the short circuit condition is released. However, the rectifier diodes on the secondary side will still experience high current pulse in short circuit, and thus have high temperature rise. To prevent damaging the diodes, it is not suggested to have the board undergo the short circuit for too long.

Ch1 (yellow) is the switch node voltage, Ch2 (green) is the +15V output voltage, Ch3 (purple) is the -9V output voltage, and Ch4 (magenta) is the input current.

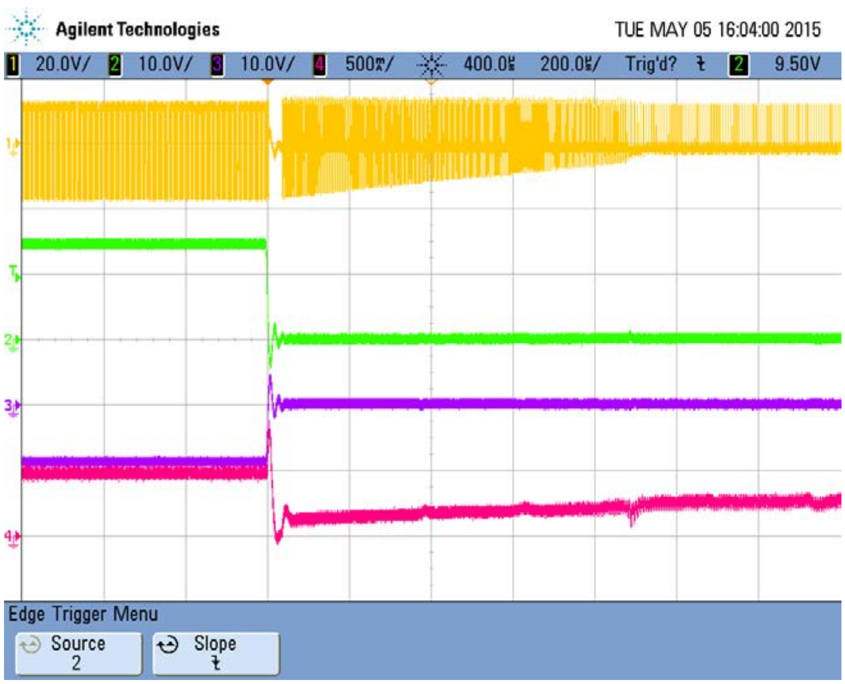

Figure 25 From full load operation to short circuit at 12V input

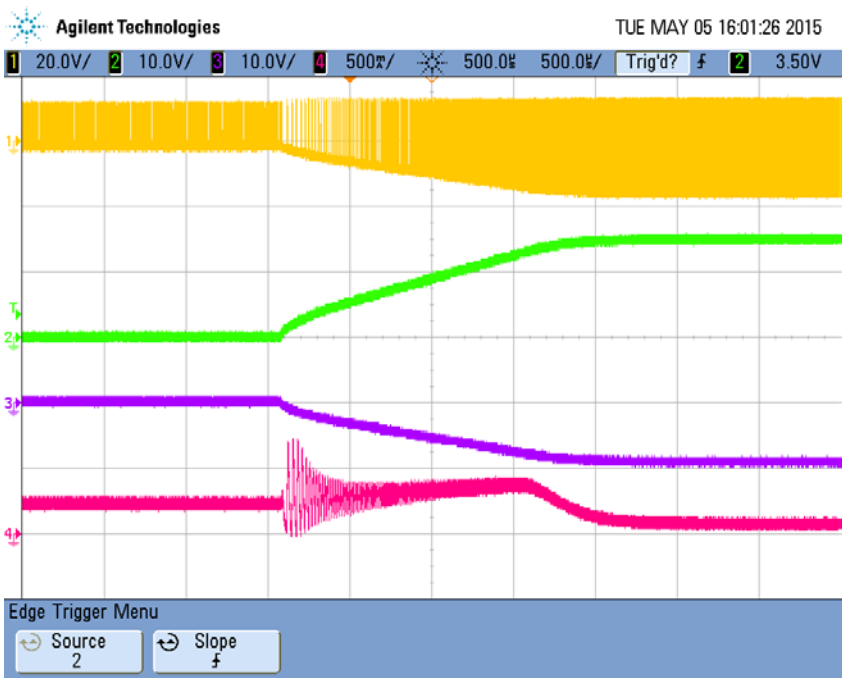

Figure 26 Short circuit removed into full load operation at 12V input

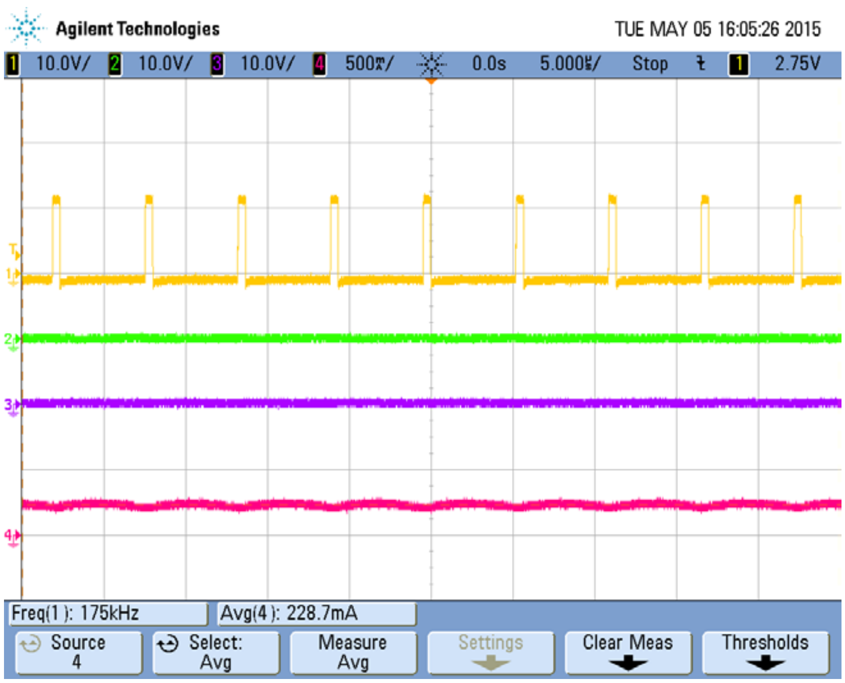

Figure 27 Operation in short circuit at 12V input