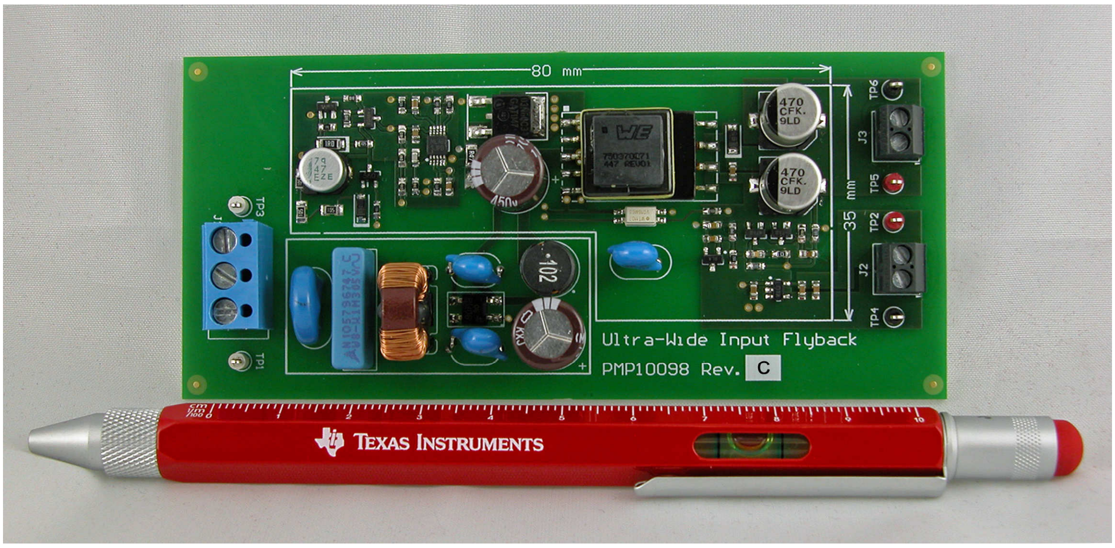
Ultra-Wide Input Isolated Low Power Flyback Converter

- Input 19 .. 375V DC / 19 .. 265V AC
- Output 1 +12.0V @ 40mA
  Output 2 +5.0V @ 15mA
- Devices LM3481, LMV431, LP2980-5.0
- Free-running switching frequency of 130 kHz
- Working in continuous conduction mode at low input voltage and discontinuous conduction mode at high input voltage
- The converter provides an isolated output with +12.0V / 40mA. A linear regulator generates +5.0V / 15mA out of the +12V rail.
  The +12V output has large output capacitors to provide sufficient power for the +5V rail, which typically supplies a microcontroller. The microcontroller can detect the falling voltage on the +12V output if the input voltage drops out and act appropriately.



1 Startup

The startup waveform at 19V DC input and no load on the outputs is shown in Figure 1.

Channel C1: **19V DC Input voltage**
5V/div, 500ms/div

Channel C2: **12V Output voltage**
2V/div, 500ms/div

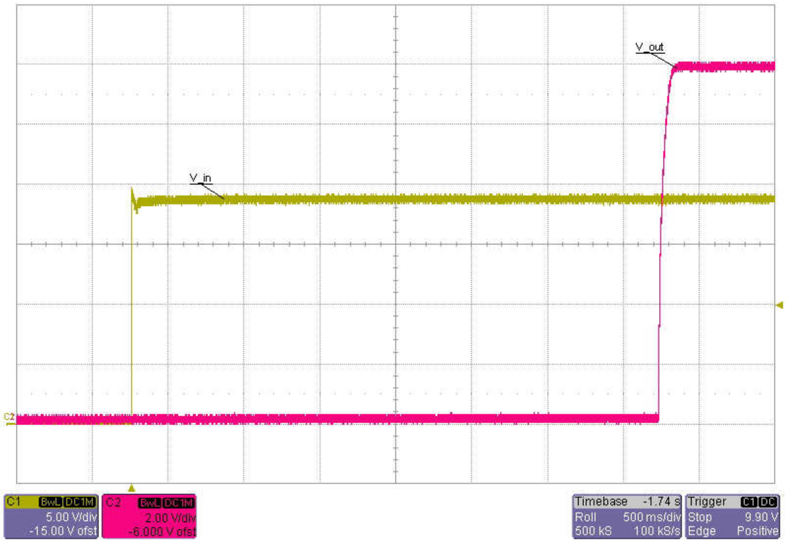


Figure 1

The startup waveform at 375V DC input and no load on the outputs is shown in Figure 13.

Channel C1: **375V DC Input voltage**
100V/div, 500ms/div

Channel C2: **12V Output voltage**
2V/div, 500ms/div

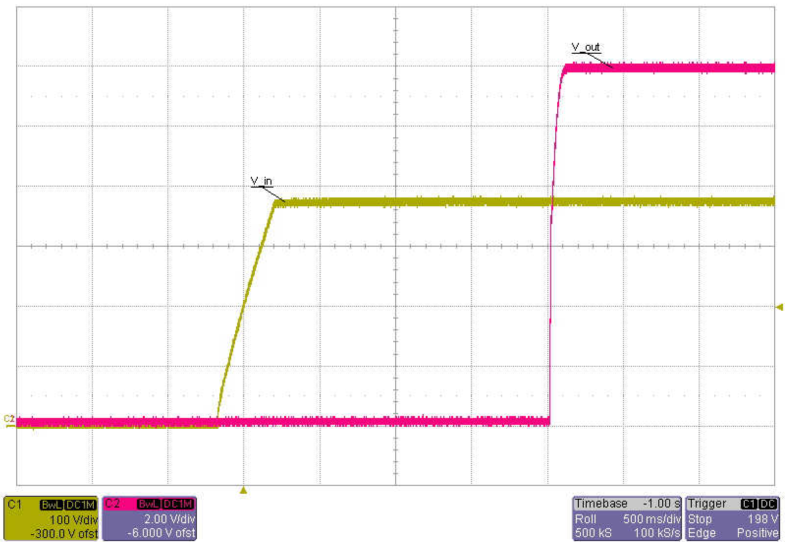


Figure 2

2 Shutdown

The shutdown waveform at 19V DC input and 55mA load on the +12V output is shown in Figure 3.

Channel C1: **19V DC Input voltage**
5V/div, 50ms/div

Channel C2: **12V Output voltage**
2V/div, 50ms/div

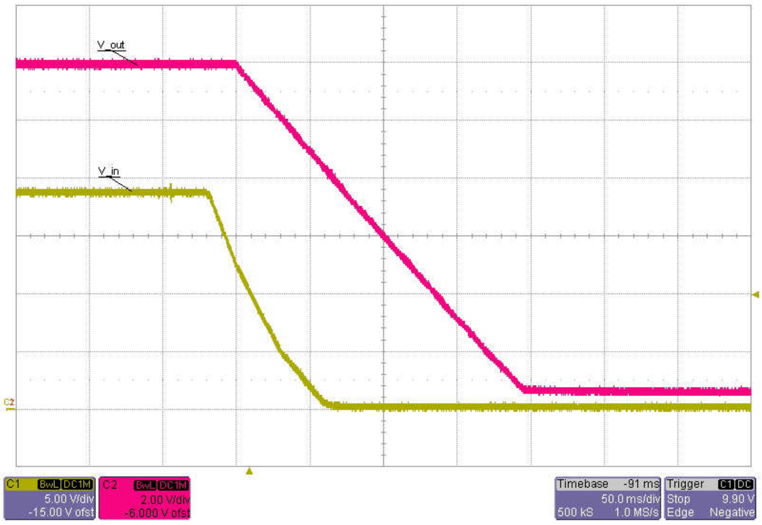


Figure 3

The shutdown waveform at 375V DC input and 55mA load on the +12V output is shown in Figure 4.

Channel C1: **375V DC Input voltage**
100V/div, 500ms/div

Channel C2: **12V Output voltage**
2V/div, 500ms/div

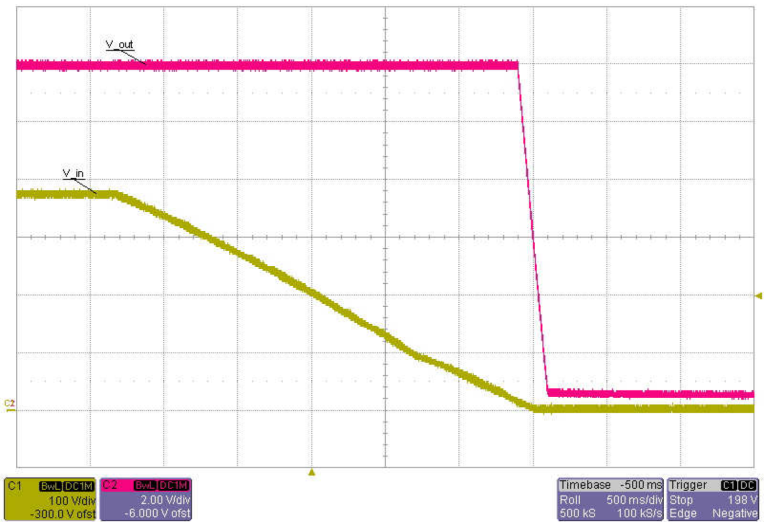


Figure 4

3 Efficiency and Load Regulation

The efficiency and load regulation of a single converter are shown in Figure 5 and Figure 6.

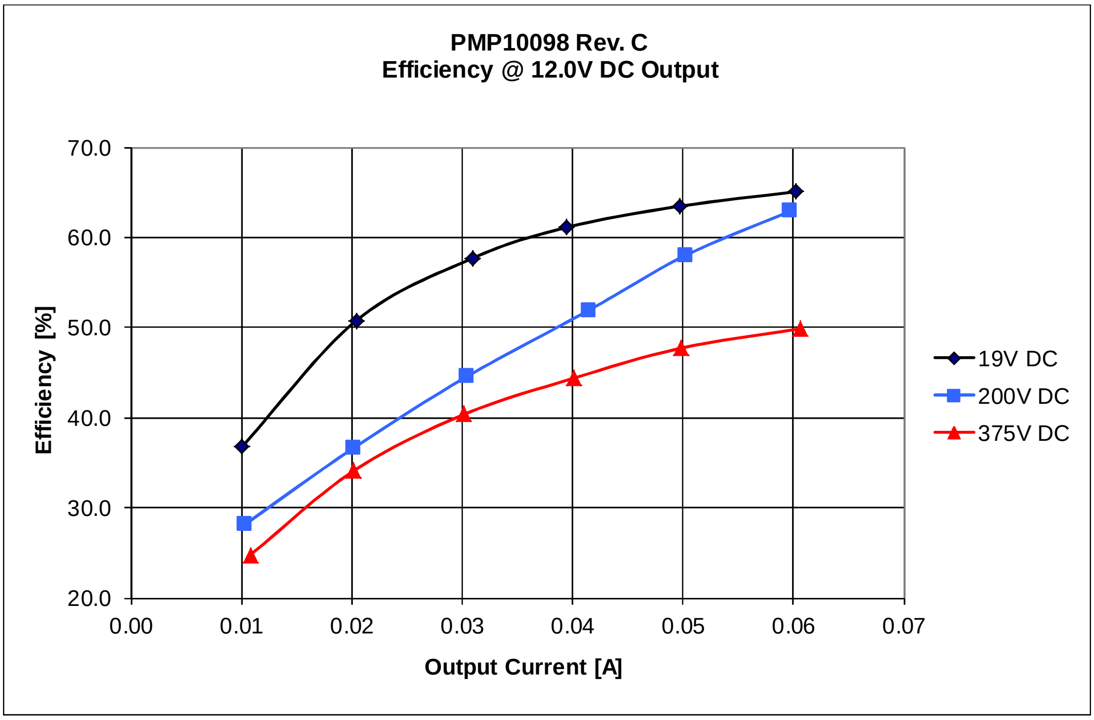


Figure 5

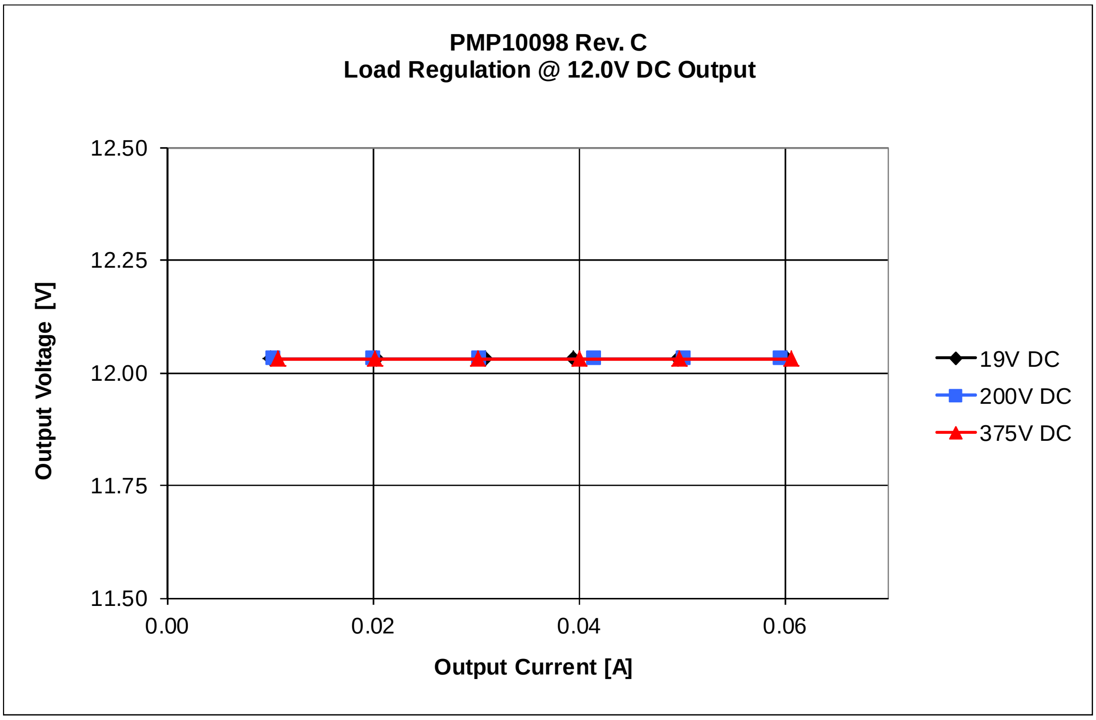


Figure 6

4 Frequency Response

Figure 7 shows the loop response at 19V DC, 100V DC, 200V DC and 300V DC input voltage with a 55mA load on the 12V output.

19V DC input
47 deg phase margin, 1.6 kHz bandwidth, -17 dB gain margin

100V DC input
71 deg phase margin, 1.5 kHz bandwidth, -21 dB gain margin

200V DC input
65 deg phase margin, 1.6 kHz bandwidth, -20 dB gain margin

300V DC input
72 deg phase margin, 0.8 kHz bandwidth, -31 dB gain margin

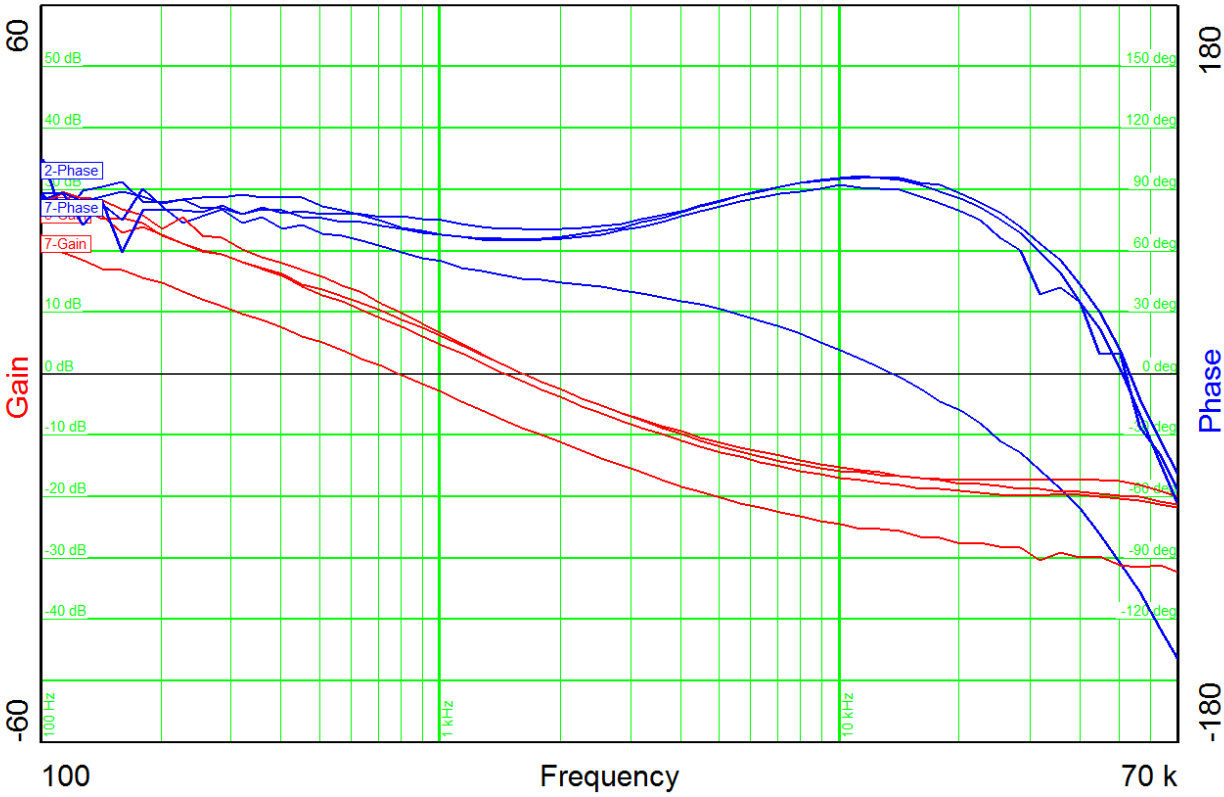


Figure 7

5 Switching Node

The drain-source voltage on the switching node at 19V DC input is shown in Figure 8. The image was captured with a 55mA load on the 12V output and the converter is working in continuous conduction mode.

Channel C2: **Drain-source voltage**, -2.1V minimum voltage, 71.5V maximum voltage 20V/div, 5us/div

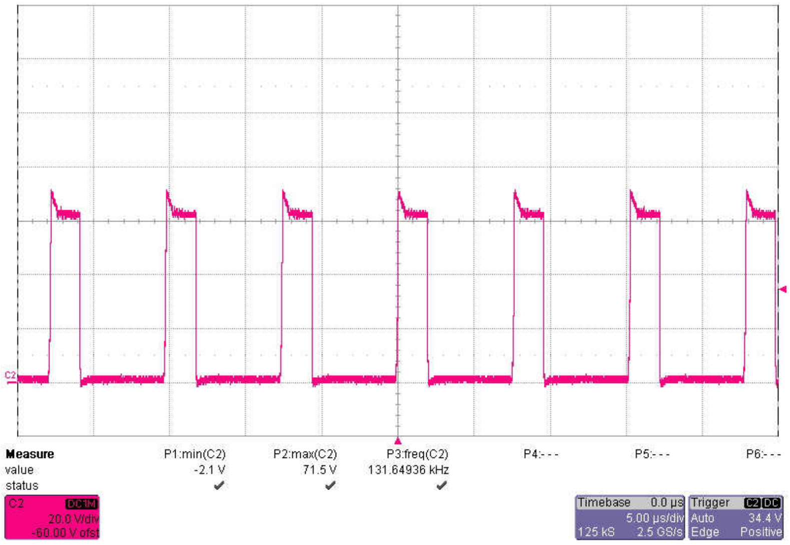


Figure 8

The drain-source voltage on the switching node at 200V DC input is shown in Figure 9. The image was captured with a 55mA load on the 12V output and the converter is working in discontinuous conduction mode.

Channel C2: **Drain-source voltage**, -2.0V minimum voltage, 254.0V maximum voltage 50V/div, 5us/div

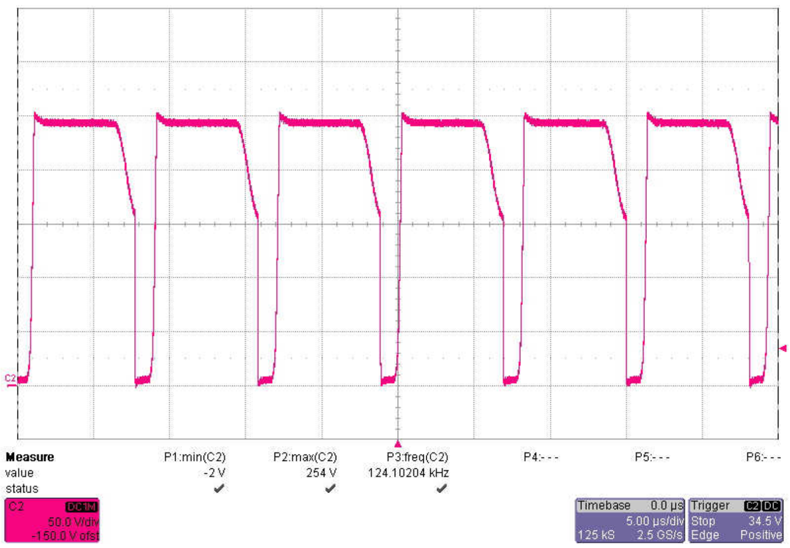


Figure 9

The drain-source voltage on the switching node at 375V DC input is shown in Figure 10. The image was captured with a 55mA load on the 12V output and the converter is working in discontinuous conduction mode. Additionally pulses are skipped to maintain the output voltage constant.

Channel C2: **Drain-source voltage**, -7.0V minimum voltage, 438.0V maximum voltage 100V/div, 5us/div

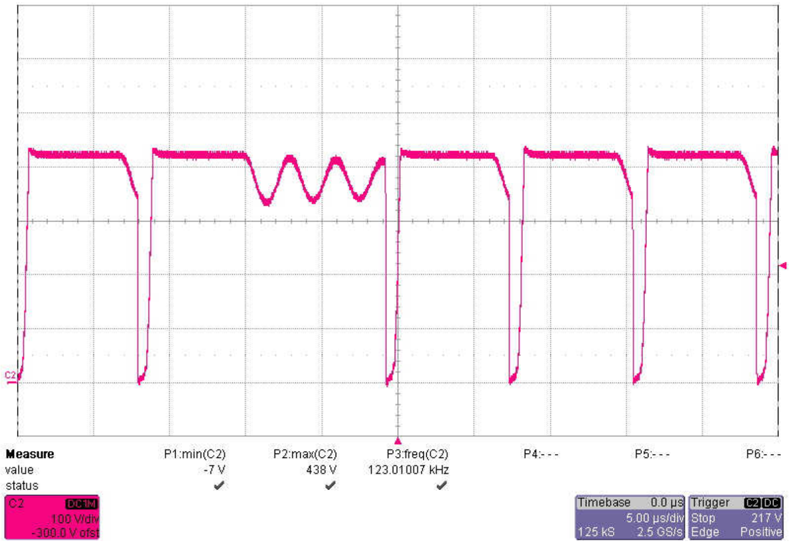


Figure 10

The drain-source voltage on the switching node at 375V DC input is shown in Figure 11. The image was captured with no load on the outputs and the converter is working in pulse skipping / burst mode.

Channel C2: **Drain-source voltage**, -6.0V minimum voltage, 432.0V maximum voltage 100V/div, 100us/div

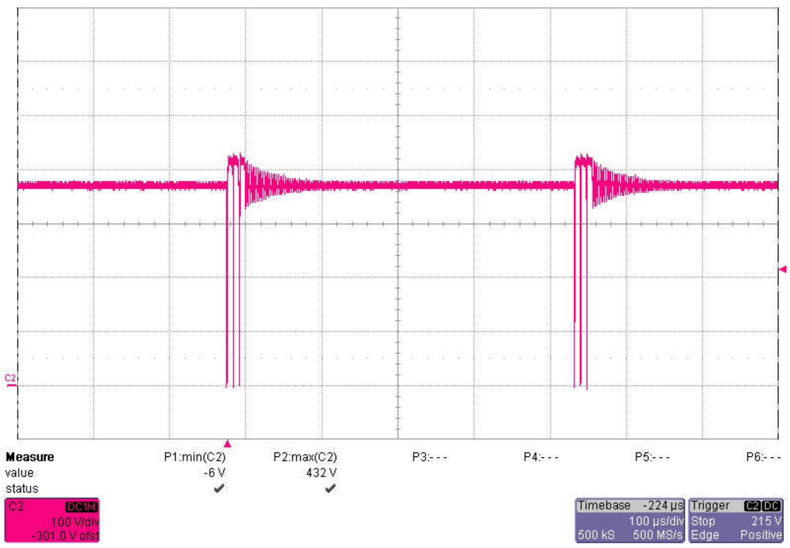


Figure 11

6 Output Ripple Voltage

The output ripple voltage of the 12V output at 55mA load for 19V DC, 200V DC and 375V DC input is shown in Figure 12.

Channel M1: **Output voltage @ 19V DC input**, 22mV peak-peak (0.2%)
20mV/div, 5us/div, AC coupled

Channel M2: **Output voltage @ 200V DC input**, 25mV peak-peak (0.2%)
20mV/div, 5us/div, AC coupled

Channel M3: **Output voltage @ 375V DC input**, 29mV peak-peak (0.2%)
20mV/div, 5us/div, AC coupled

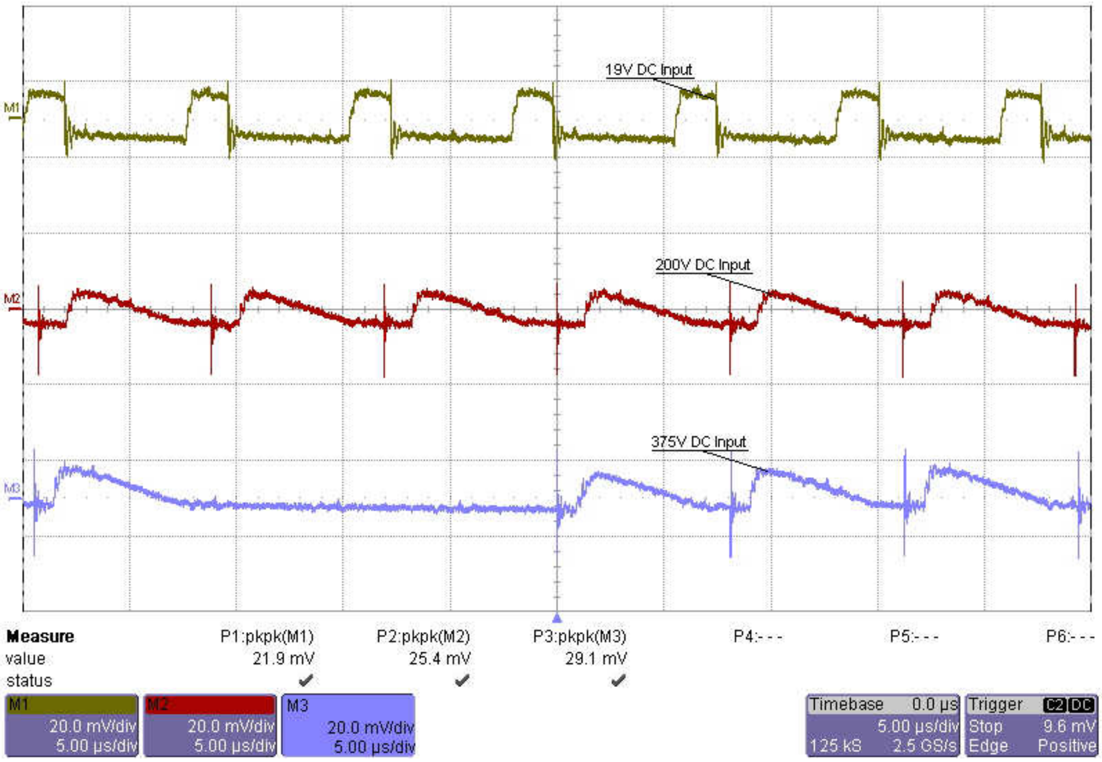


Figure 12

7 Thermal Measurement

Figure 13 shows the thermal image at an ambient temperature of 21 °C with an input voltage of 19V DC and a 55mA load on the 12V output.

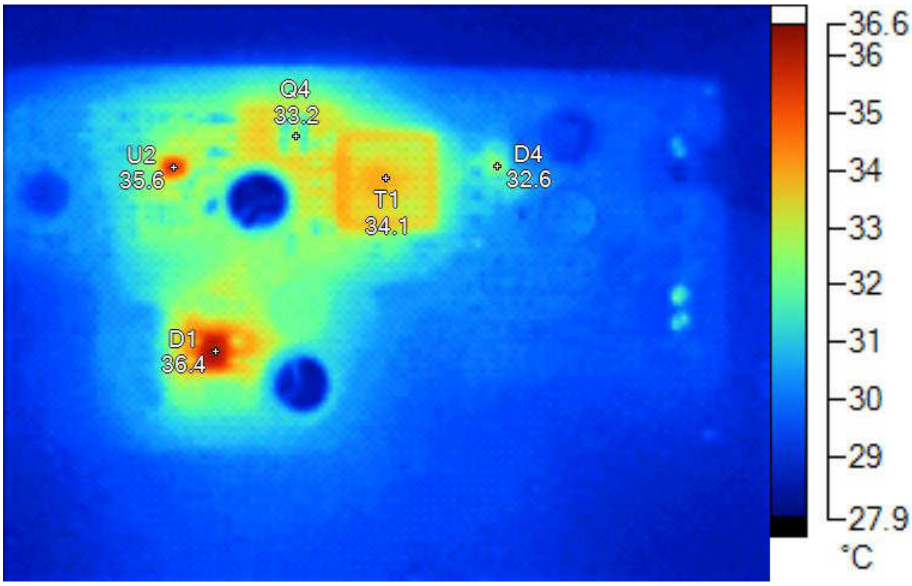


Figure 13

Markers

Label	Temperature	Emissivity	Background
U2	35.6 °C	0.95	21.0 °C
D1	36.4 °C	0.95	21.0 °C
Q4	33.2 °C	0.95	21.0 °C
T1	34.1 °C	0.95	21.0 °C
D4	32.6 °C	0.95	21.0 °C

Figure 14 shows the thermal image at an ambient temperature of 21 °C with an input voltage of 375V DC and a 55mA load on the 12V output.

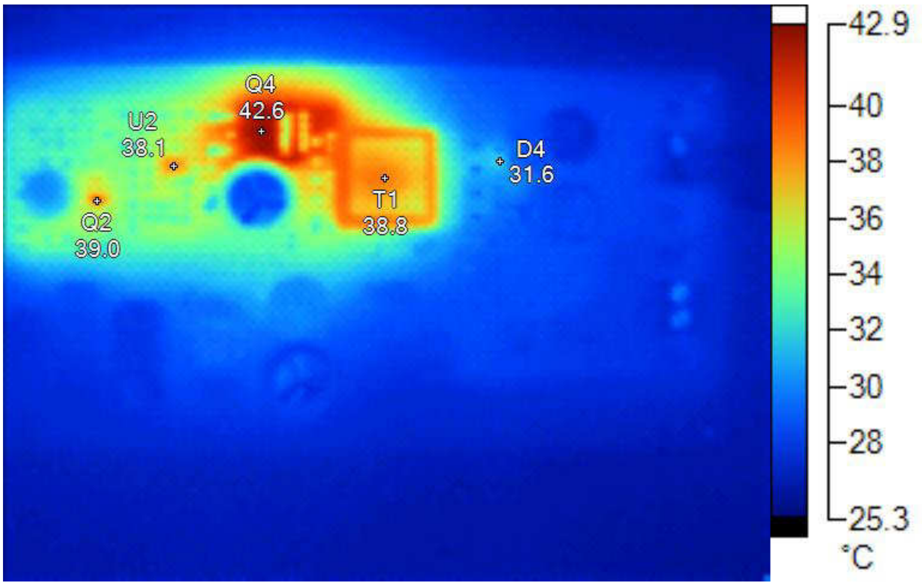


Figure 14

Markers

Label	Temperature	Emissivity	Background
U2	38.1 °C	0.95	21.0 °C
Q2	39.0 °C	0.95	21.0 °C
Q4	42.6 °C	0.95	21.0 °C
T1	38.8 °C	0.95	21.0 °C
D4	31.6 °C	0.95	21.0 °C

8 EMI Measurement

Figure 15 shows the EMI measurement of the converter connected to an isolation transformer plus a Hameg HM6050-2 LISN. The supply voltage is 230V AC.
The 12V output was loaded with 55mA by a resistor. Both converter and resistor have been placed 20cm over the ground plane. The output ground terminal has been left floating.

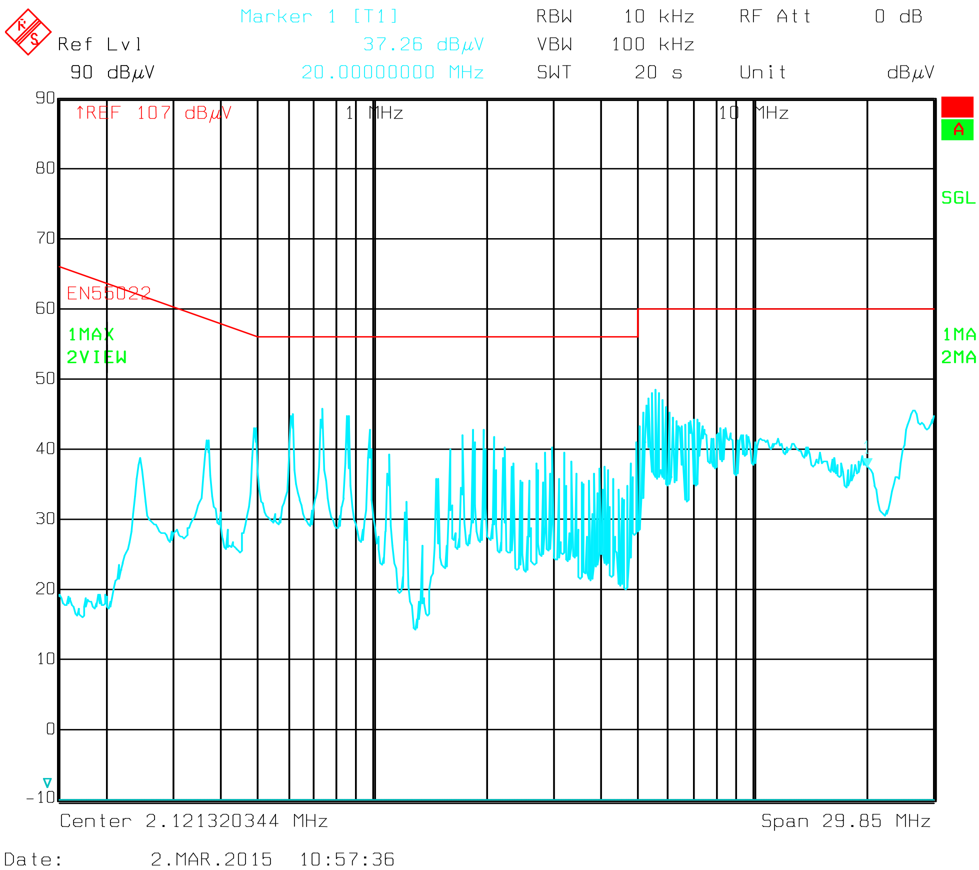


Figure 15