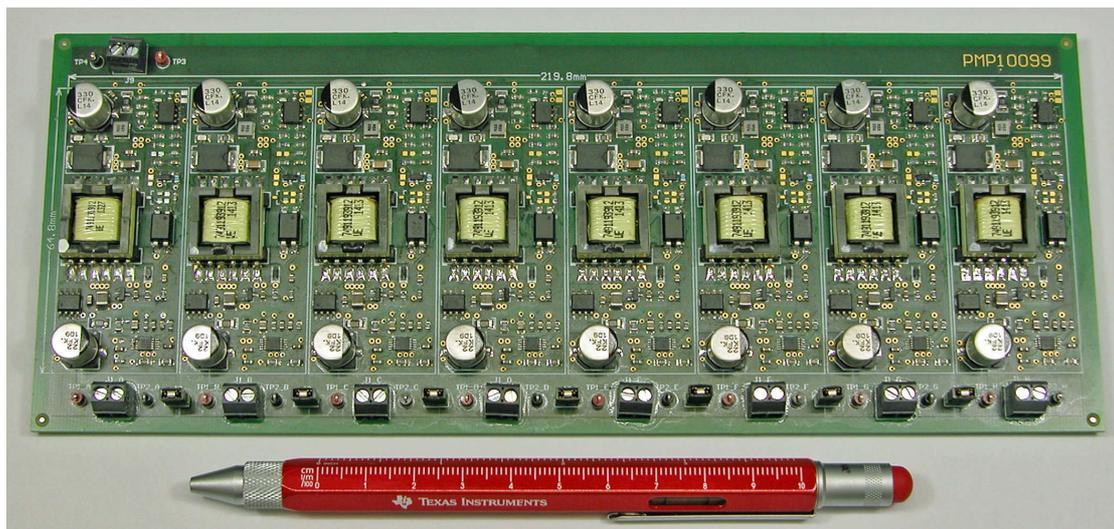


## Telecom Reverse Power Solution

- Input 27..60V DC
- Output 12.0V @ 1.1A
- Controller LM5022 + UCC29002/1
- Free-Running switching frequency of 350 kHz
- Working in continuous conduction mode
- Eight separate inputs provide one common output with 12.0V @ 1.1A. The inputs and the output are galvanic isolated by flyback converters. Each converter is capable to supply the full power (12.0V @ 1.1A). The load current is shared equally between all active converters.



## 1 Startup

The startup waveform of a single converter is shown in Figure 1. The input voltage is set at 48.0V, with no load on the 12.0V output.

- Channel C1: **48.0V Input voltage**  
10V/div, 5ms/div
- Channel C2: **12.0V Output voltage**  
5V/div, 5ms/div

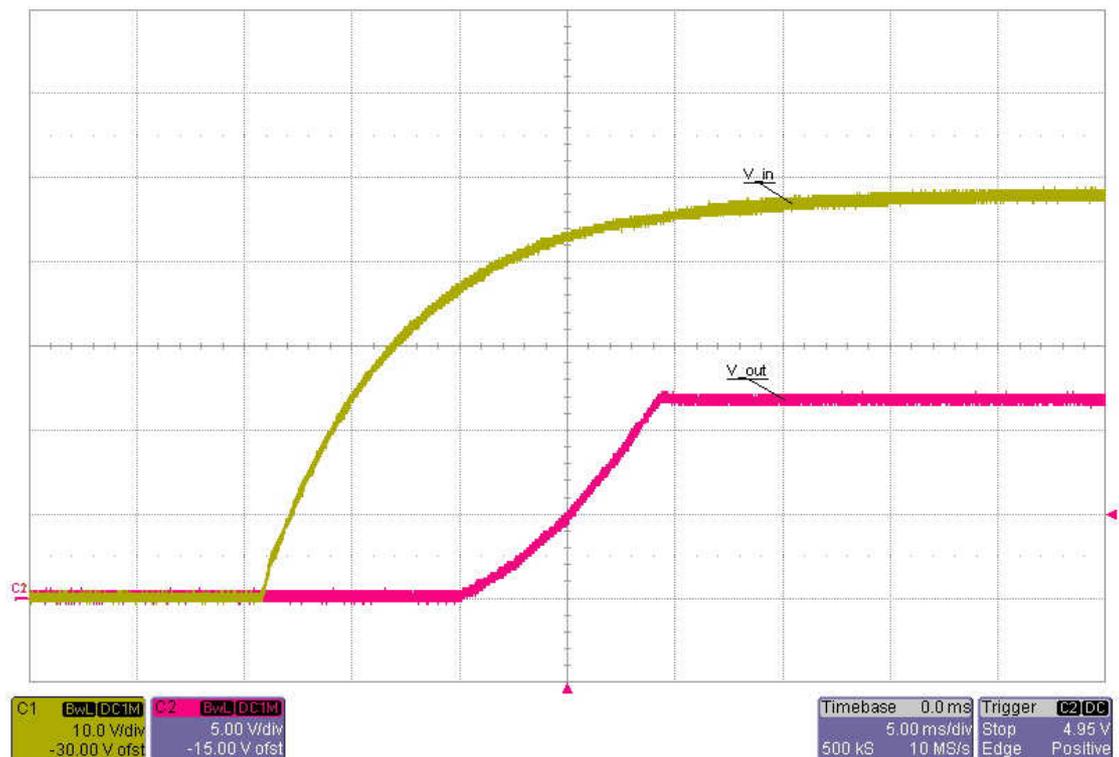


Figure 1

## 2 Shutdown

The shutdown waveform of a single converter is shown in Figure 2. The input voltage is set at 48.0V with a 1.1A load on the 12.0V output.

Channel C1: **48.0V Input voltage**  
10V/div, 20ms/div

Channel C2: **12.0V Output voltage**  
5V/div, 20ms/div

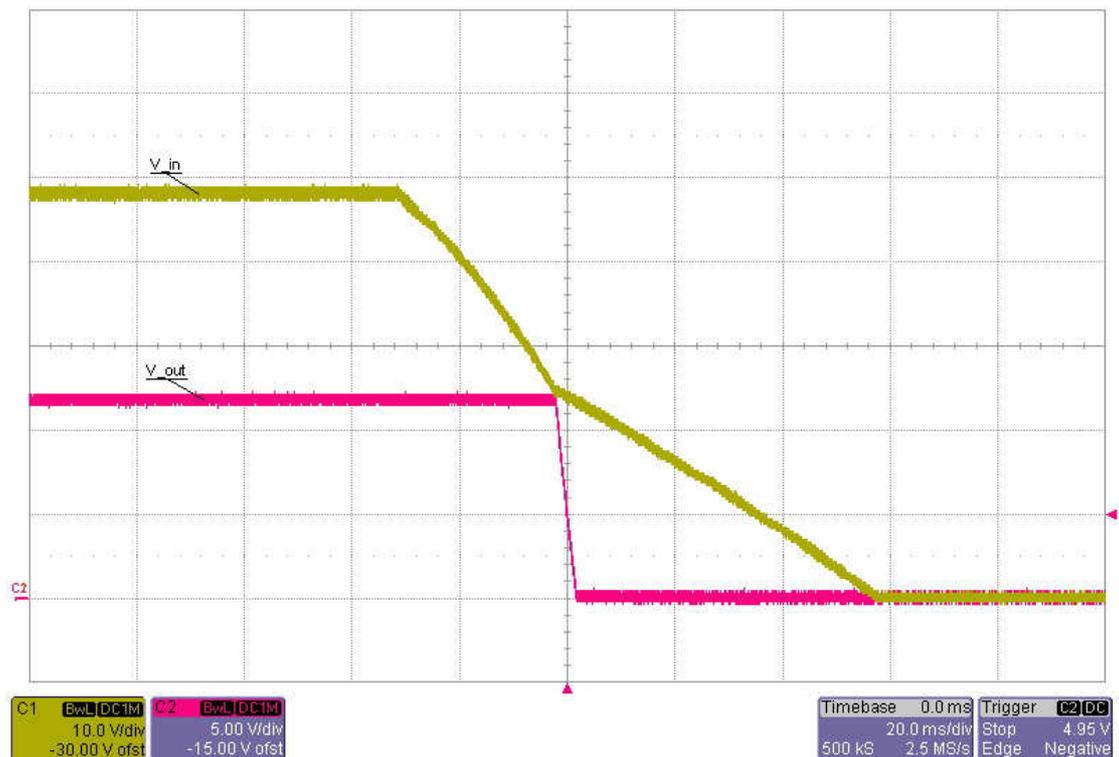


Figure 2

### 3 Efficiency

The efficiency and load regulation of a single converter are shown in Figure 3 and Figure 4.

The measurement was done without the 200 mΩ current sense resistor for the load share controller on the output.

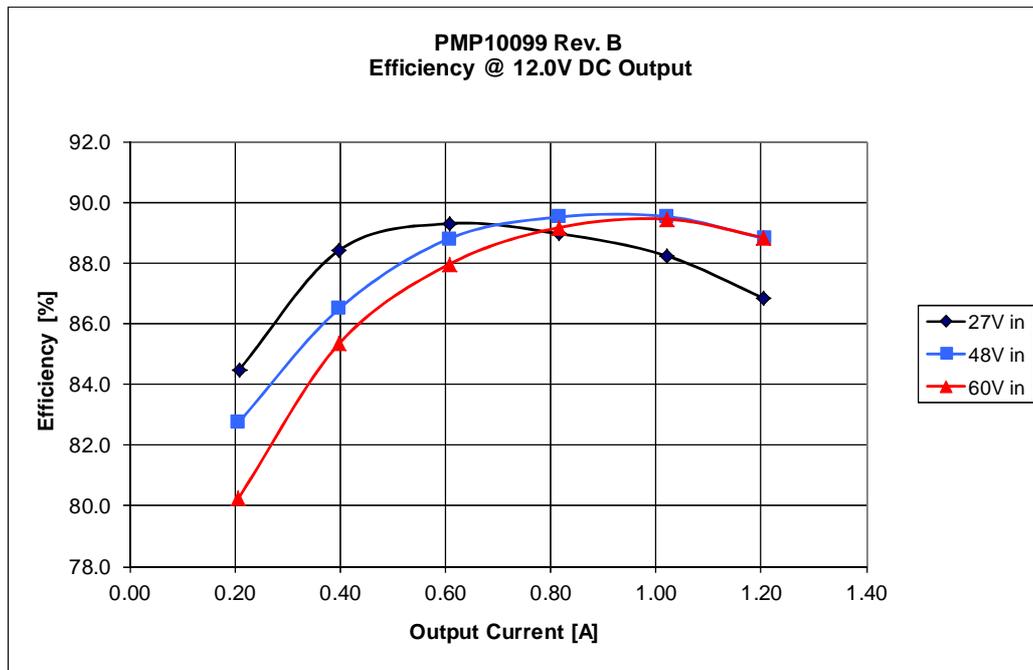


Figure 3

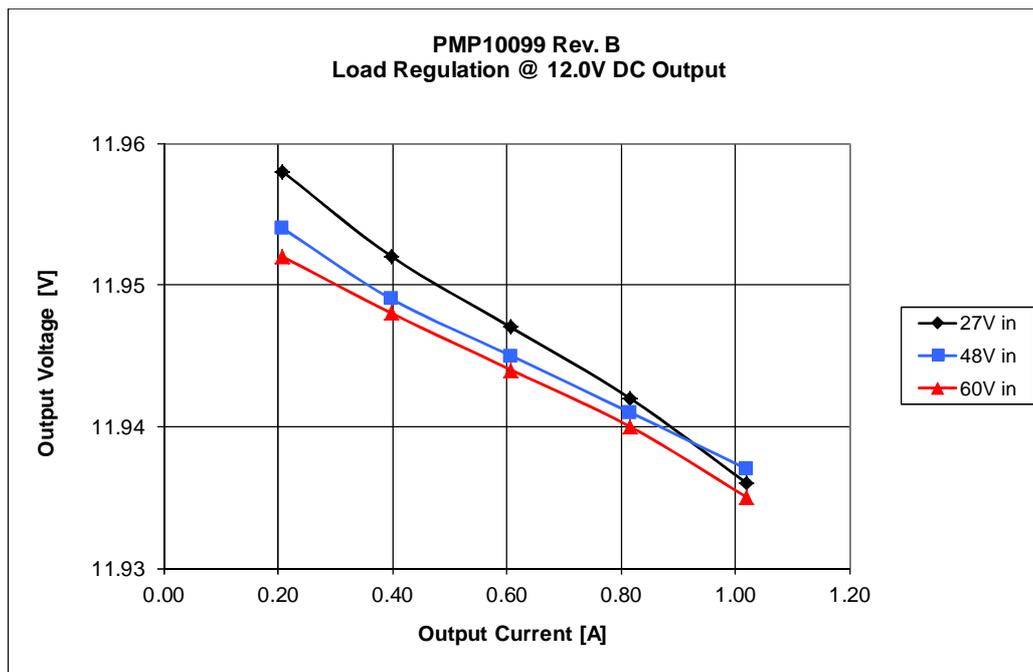


Figure 4

## 4 Load step

The response to a load step and a load dump for a single converter with an input voltage of 48.0V is shown in Figure 5.

Channel C2: **Output voltage**, -79mV undershoot (0.7%), 77mV overshoot (0.6%)  
 50mV/div, 1ms/div, AC coupled

Channel C1: **Load current**, load step 0.5A to 1.0A and vice versa  
 500mA/div, 1ms/div

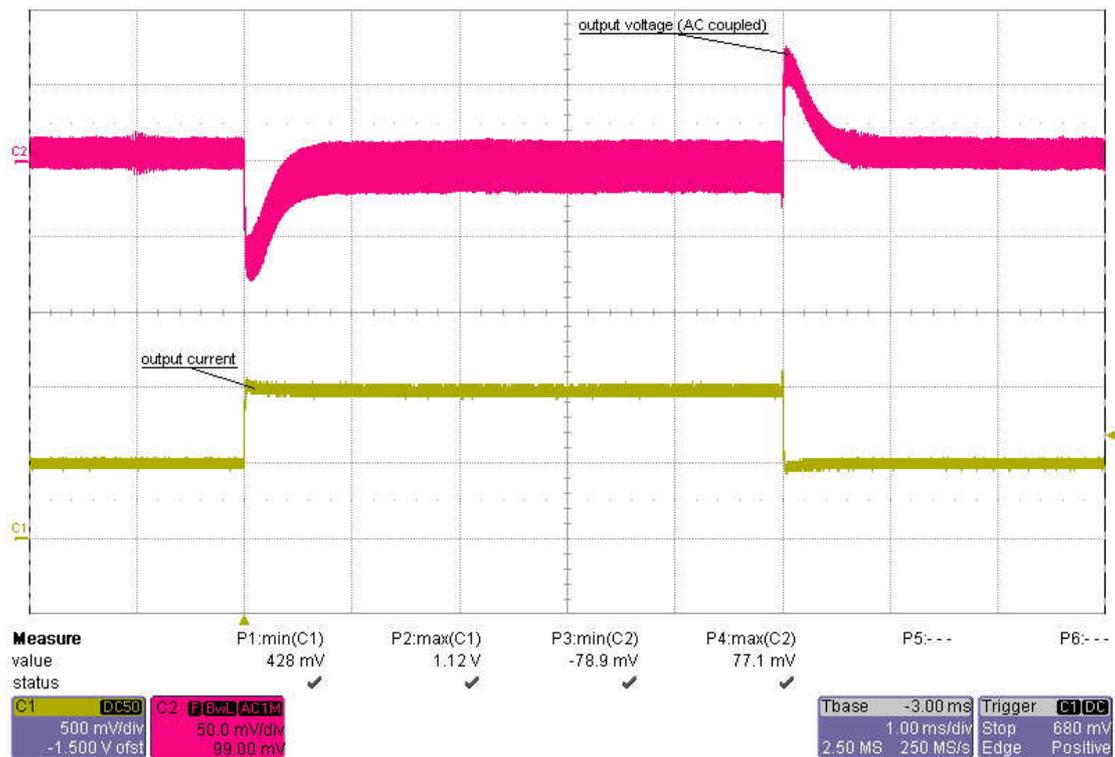


Figure 5

## 5 Frequency response

Figure 6 shows the loop response for a single converter at 27.0V, 48.0V and 60.0V input voltage and 1.1A load.

### 27.0V input

- 1.1A load 65 deg phase margin, 2.2 kHz bandwidth, -24 dB gain margin

### 48.0V input

- 1.1A load 69 deg phase margin, 3.3 kHz bandwidth, -25 dB gain margin

### 60.0V input

- 1.1A load 69 deg phase margin, 3.6 kHz bandwidth, -26 dB gain margin

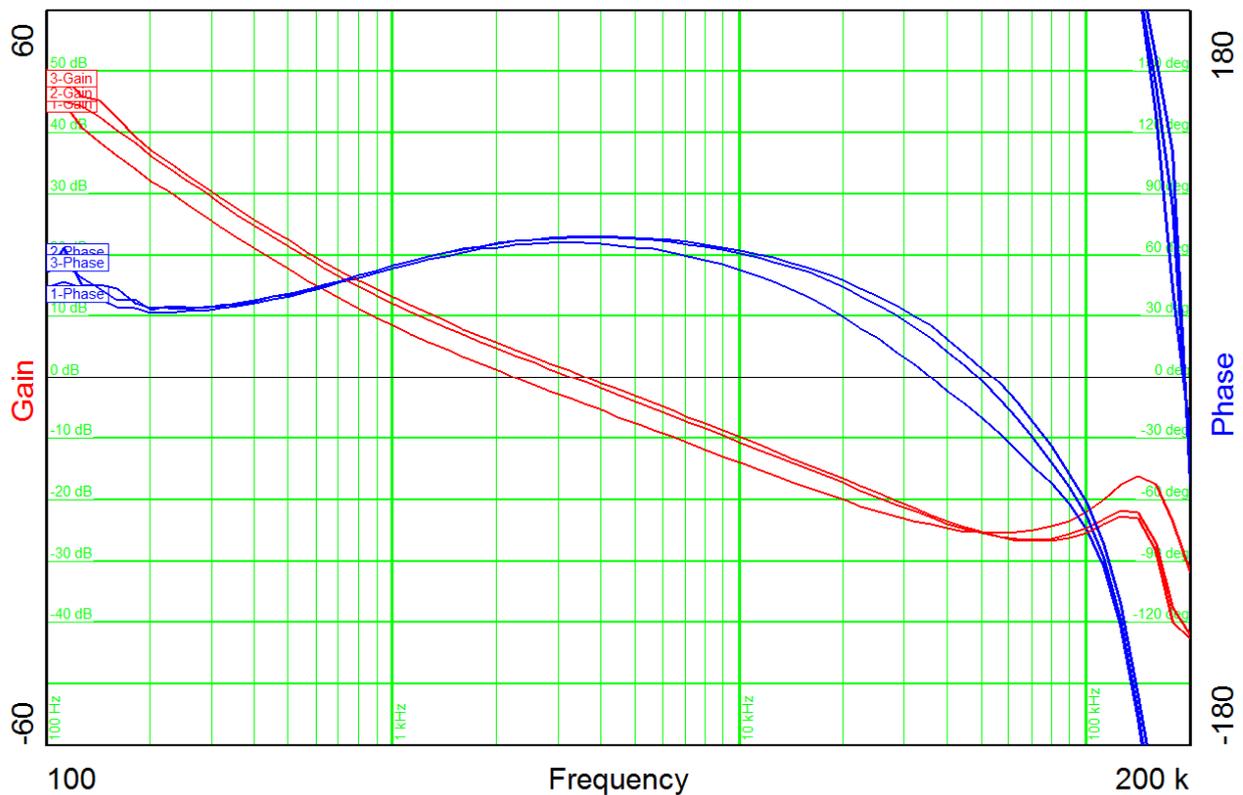


Figure 6

## 6 Switching Node

The drain-source voltage on the switching node of a single converter is shown in Figure 7. The image was captured with 60.0V input and 1.1A load.

Channel C2: **Drain-source voltage**, -4.0V minimum voltage, 119V maximum voltage  
20V/div, 1us/div

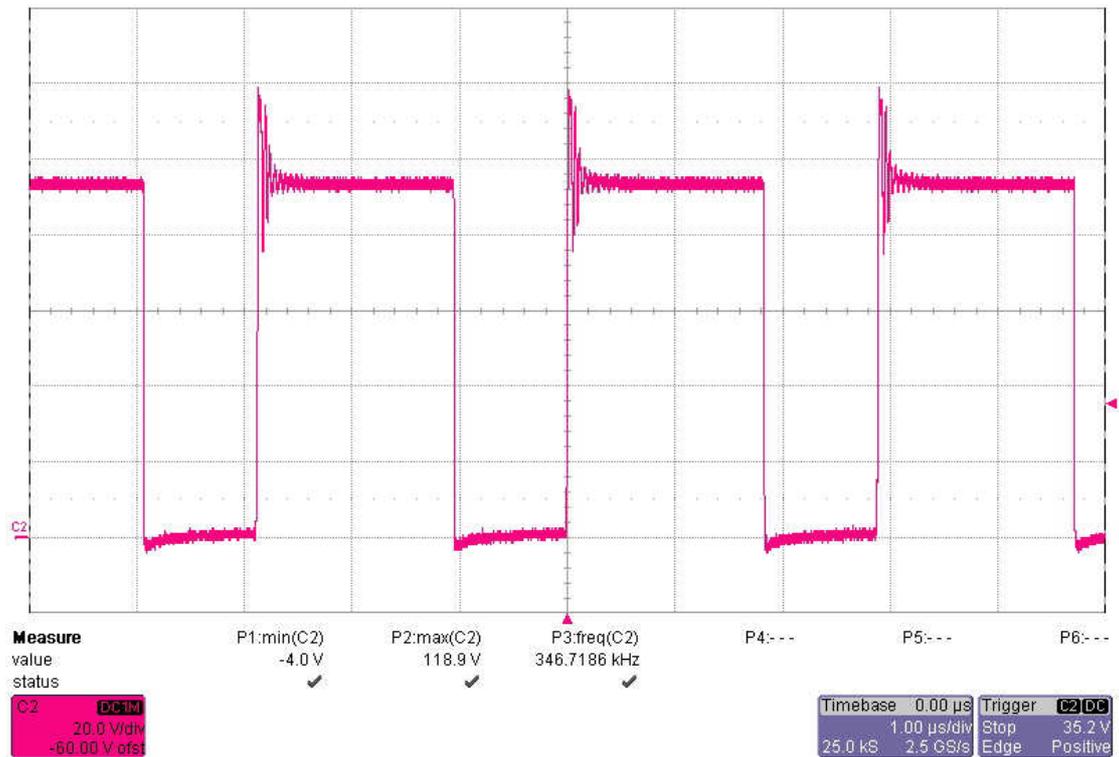


Figure 7

## 7 Output ripple voltage

The output ripple voltage of a single converter at 1.1A load and 27.0V, 48.0V and 60.0V input voltage is shown in Figure 8.

- Channel M1: **Output voltage @ 27.0V input**, 93mV peak-peak (0.8%)  
50mV/div, 5us/div, AC coupled
- Channel M2: **Output voltage @ 48.0V input**, 69mV peak-peak (0.6%)  
50mV/div, 5us/div, AC coupled
- Channel M3: **Output voltage @ 60.0V input**, 89mV peak-peak (0.7%)  
50mV/div, 5us/div, AC coupled

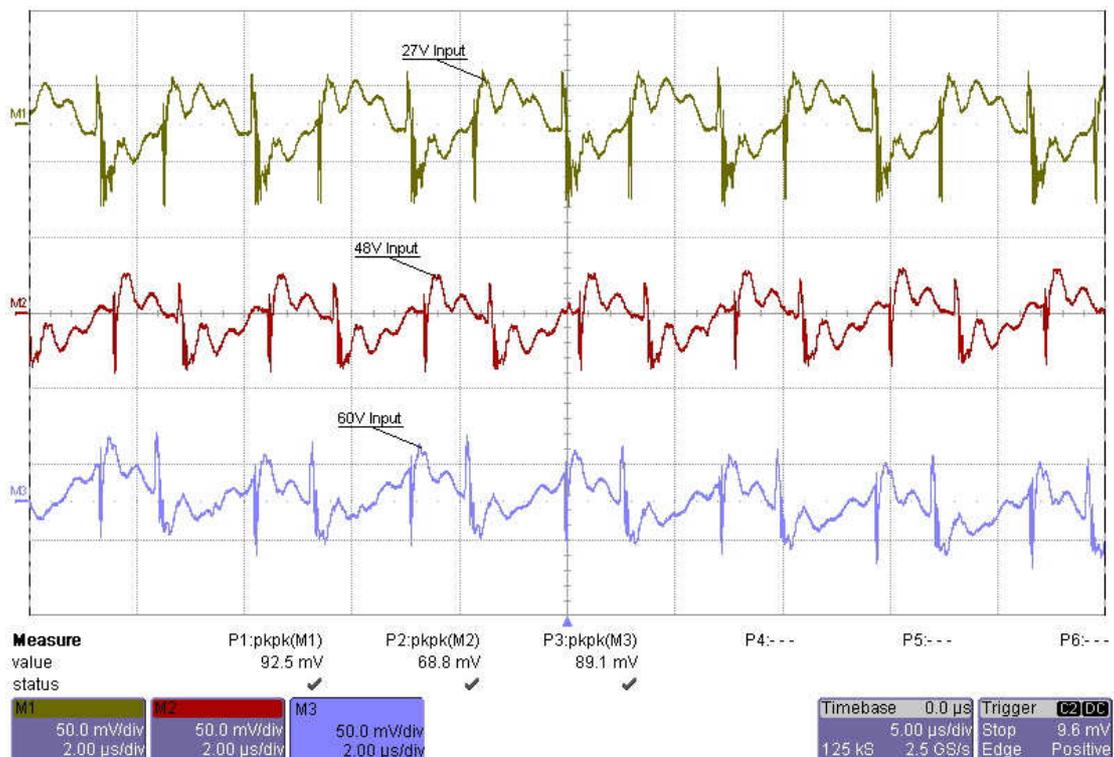


Figure 8

## 8 Thermal measurement

The thermal image (Figure 9) shows a single converter at an ambient temperature of 21 °C with an input voltage of 48.0V and a load of 1.1A.

The measurement was done without the 200 mΩ current sense resistor for the load share controller on the output.

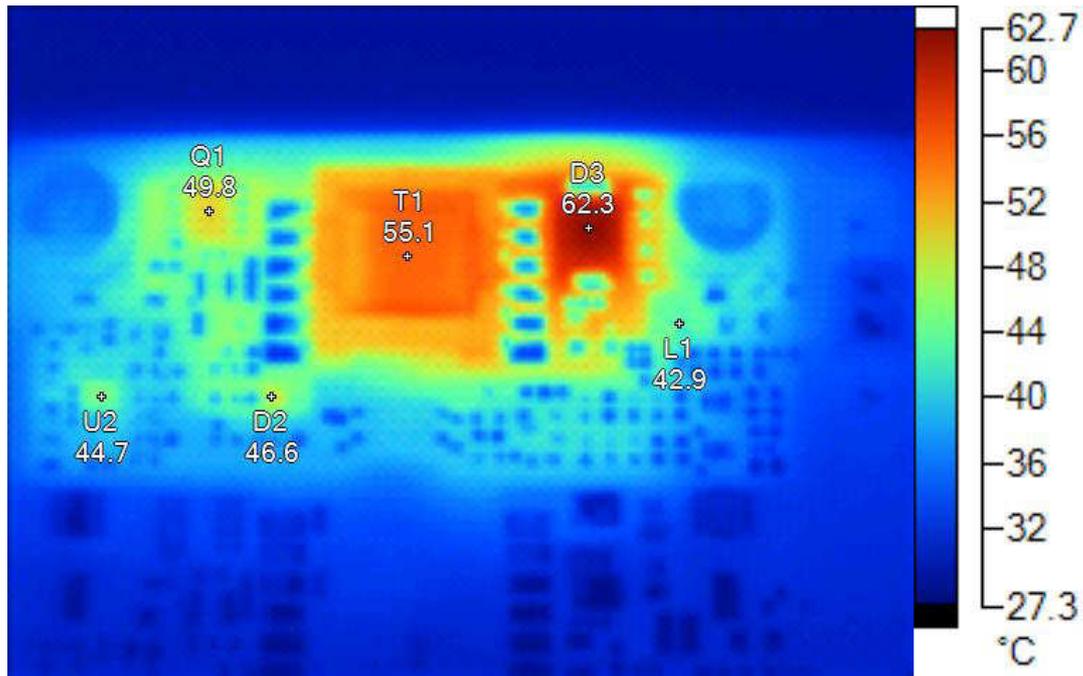


Figure 9

### Markers

Label	Temperature	Emissivity	Background
U2	44.7 °C	0.95	21.0 °C
Q1	49.8 °C	0.95	21.0 °C
D2	46.6 °C	0.95	21.0 °C
T1	55.1 °C	0.95	21.0 °C
D3	62.3 °C	0.95	21.0 °C
L1	42.9 °C	0.95	21.0 °C

## 9 Load sharing

The load share accuracy with all eight converters running and a load of 0.25A, 0.5A and 1.0A is shown in Figure 10, Figure 11 and Figure 12.

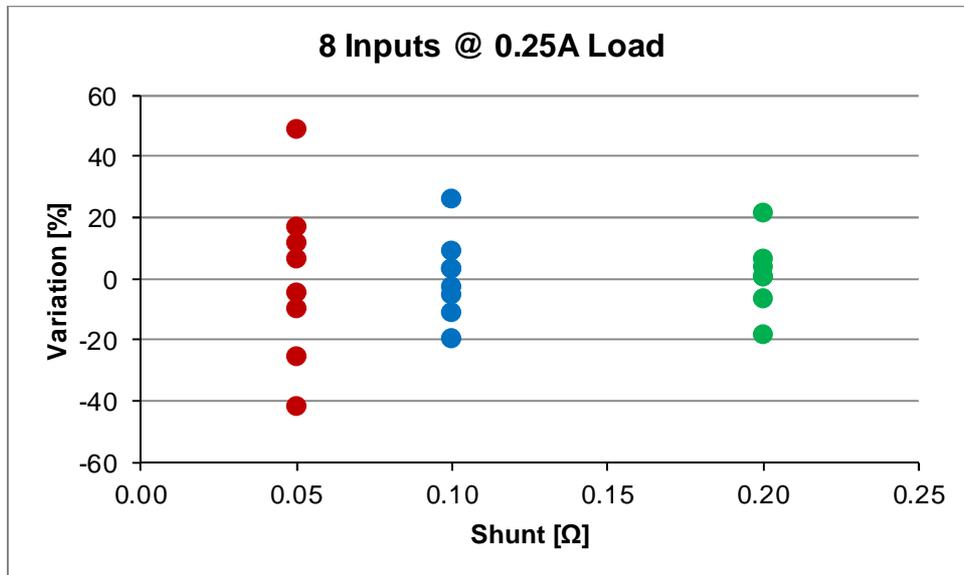


Figure 10

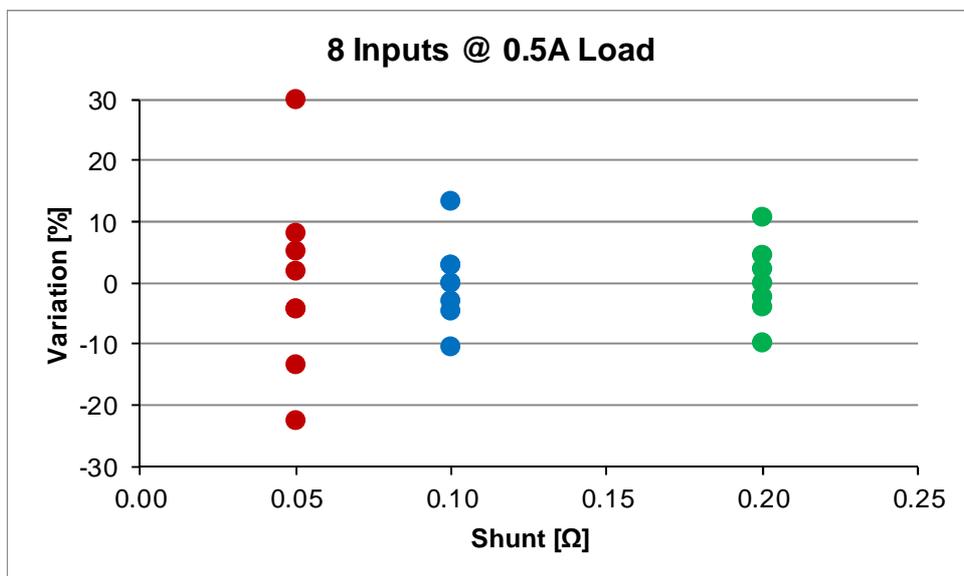
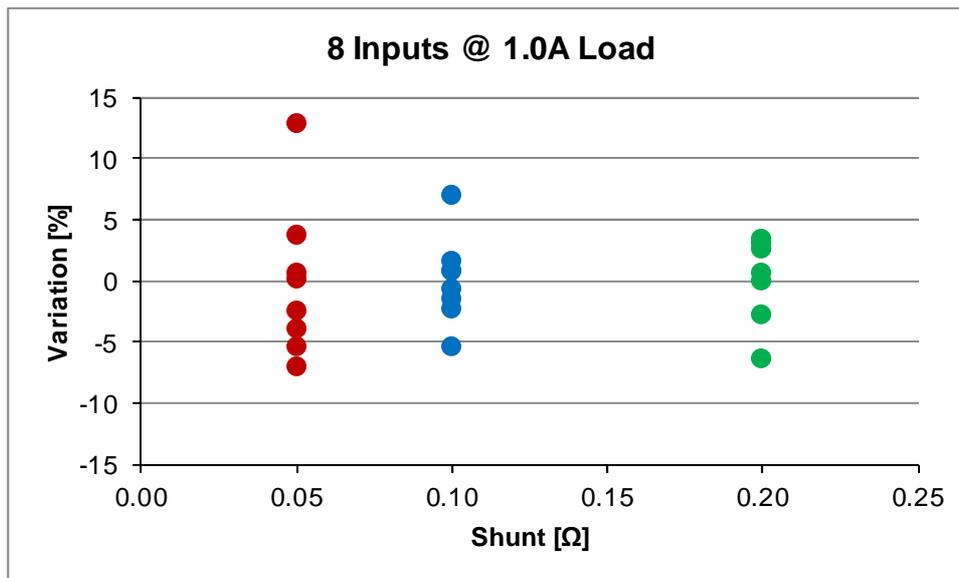


Figure 11



**Figure 12**

The measurements were done with three different current shunts (R3, 50/100/200 mΩ). As the current range on a single converter can be highly different (0.55A if only two converters are active, 0.24A if 8 converters active), a tradeoff between load share accuracy and power losses on the shunt has to be made.

The pictures show clearly that the accuracy improves, when the signal of the shunt increases. At very low load (0.25A) and a low resistive shunt (50 mΩ), the current per converter is only 31mA. Therefore the tolerances and offsets of the circuit have a big impact and load sharing has a higher tolerance (around +/-50% variation from the average current per converter).

A 200 mΩ shunt gives a good tradeoff between variation and losses. At low load (0.25A), the variation is in the range of +/-10%, at 1.0A around +/-5%.

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