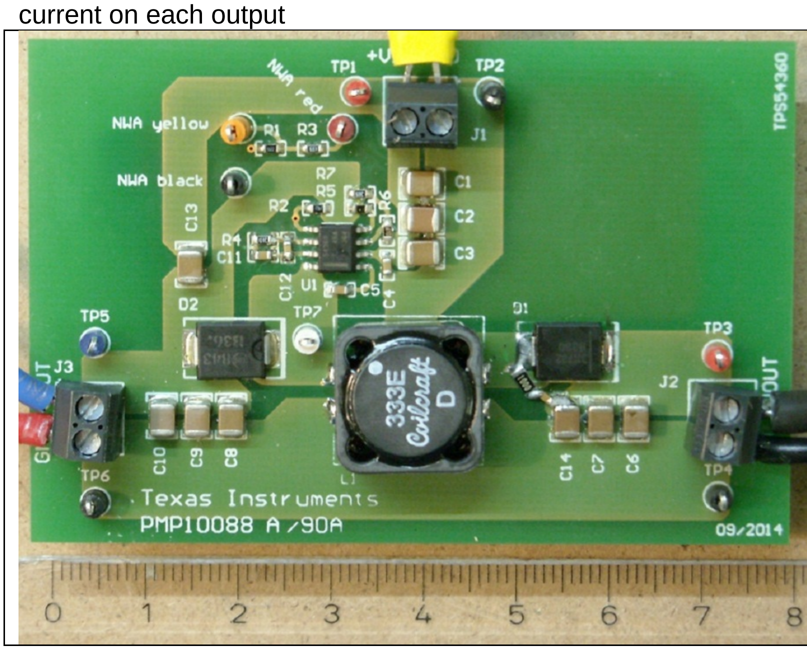
PMP10088RevB Test Results

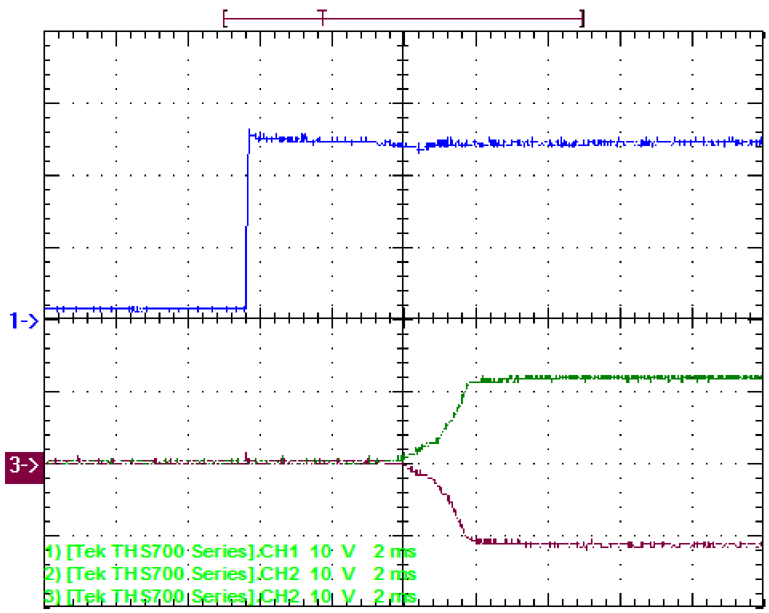
Topology:Dual Inverting Buck-Boost (negative and positive output on second winding).
Device: TPS54360

Unless otherwise mentioned all measurements were done with 24V input voltage and 0.7A output current on each output



1 Startup

The startup waveform is shown in the Figure 1. The input voltage was set at 24V, with 0.7A load at the output on each output. Power supply was connected.



Ch1=> input voltage 10V/div

Ch2=> output voltage 10V/div (+VOUT)

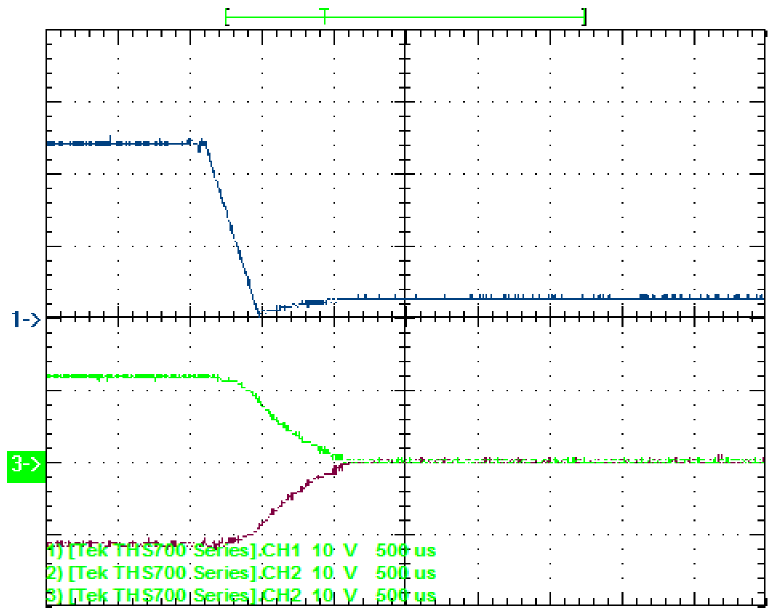
Ch3=> output voltage 10V/div (-VOUT)

2ms/div

Figure 1

2 Shutdown

The shutdown waveform is shown in the Figure 2. The input voltage was set at 24V, with 0.7A load on each output. Power supply was disconnected.



Ch1=> input voltage
10V/div

Ch2=> output voltage
10V/div (VOUT+)

Ch3=> output voltage
10V/div (VOUT-)

500µs/div

Figure 2

3 Efficiency

The efficiency is shown in the Figure 3 below. The input voltage was set to 24V. The output currents were modified simultaneous (-IOUT = +IOUT). The discontinuity in the curve reflects the transition from discontinuous to continuous mode.

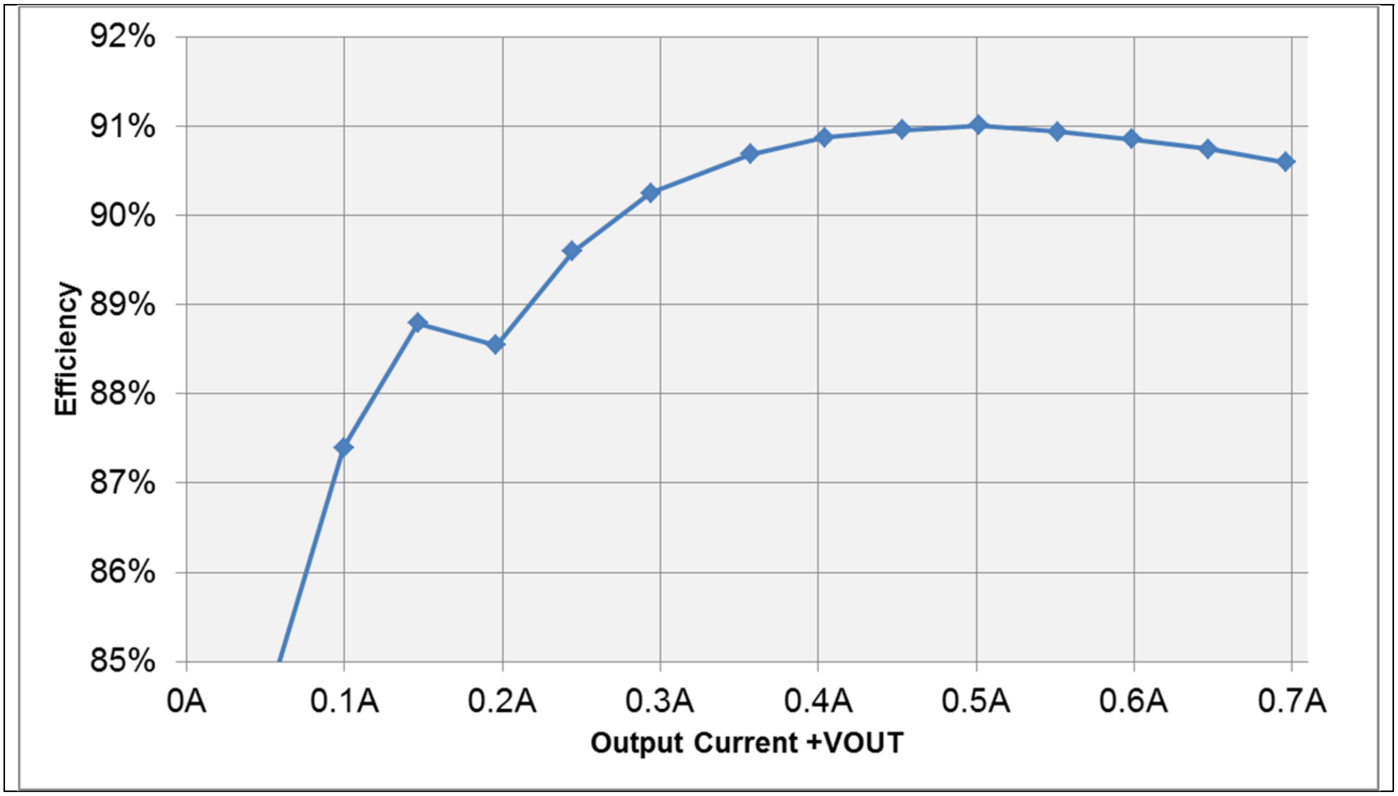


Figure 3

4 Load Regulation

The load regulation of the output is shown in the Figure 4 below.

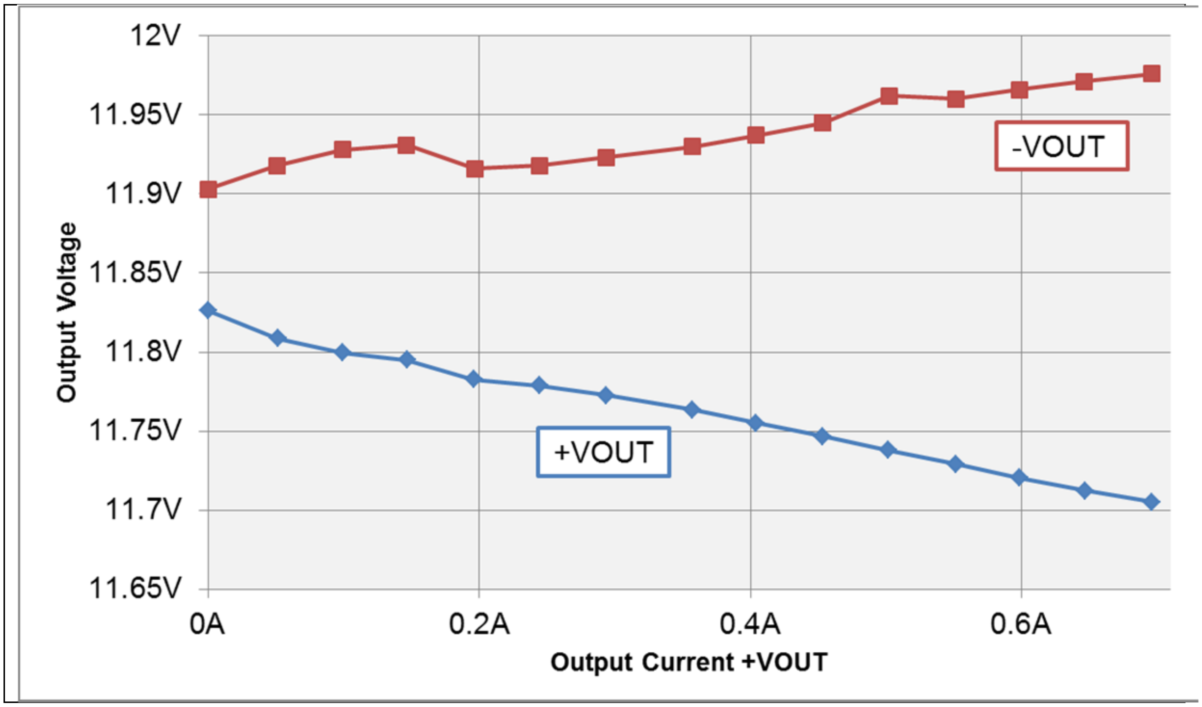
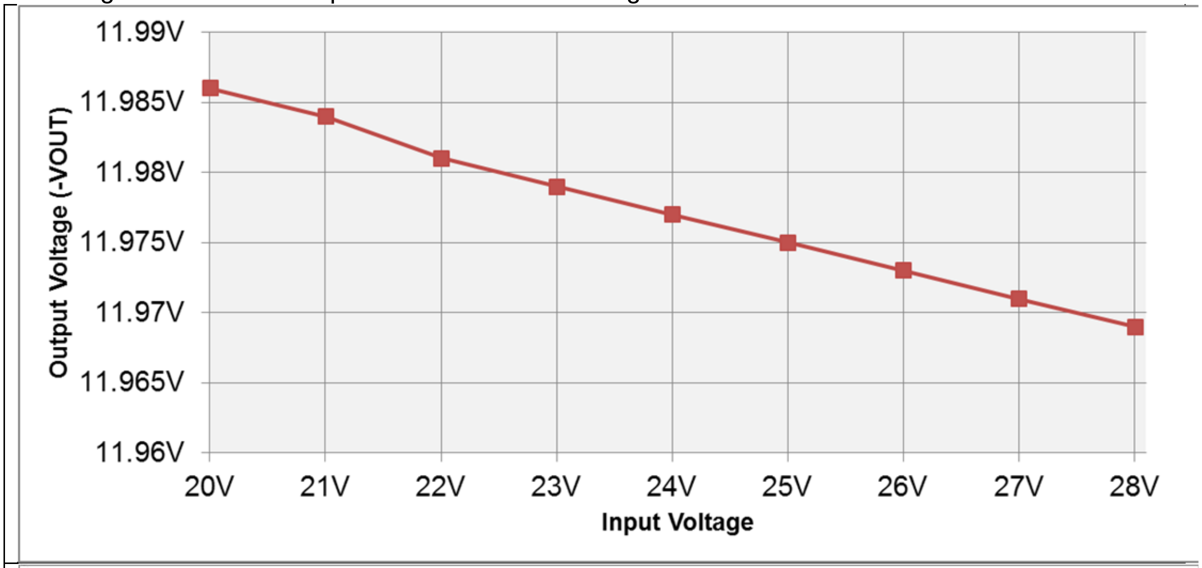


Figure 4

Deviation on load of negative rail <100mV, less than 1%
Deviation of positive rail around 120mV, roughly 1%

5 Line Regulation

Line regulation at 0.7A output current is shown in Figure 5



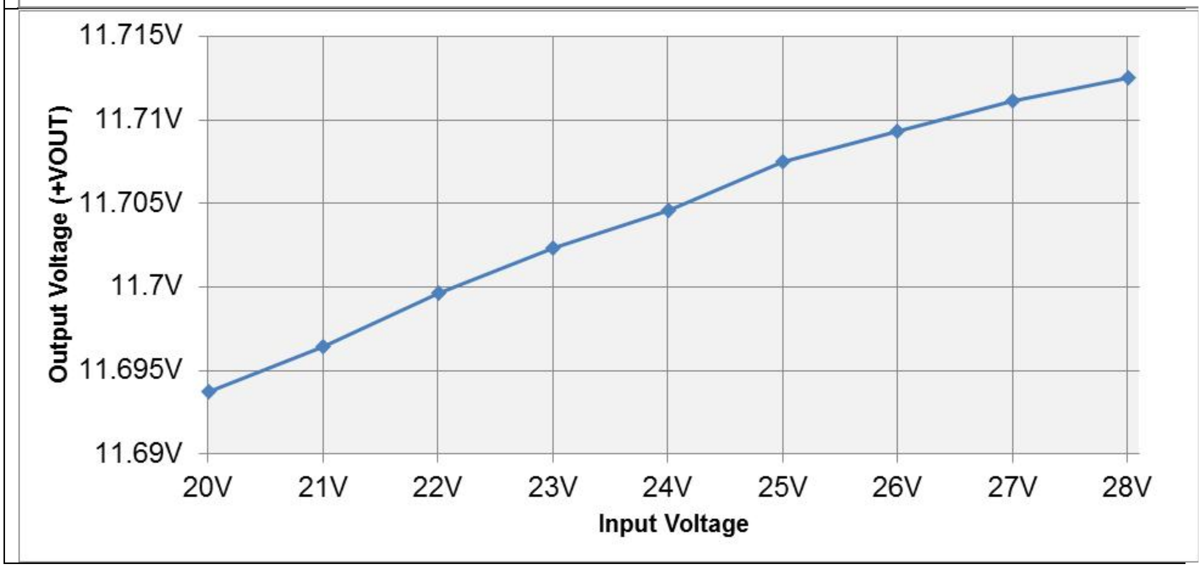


Figure 5

Deviation on input voltage is around 20mV, insignificant low.

With the same measurement the full load efficiencies across input voltage were calculated

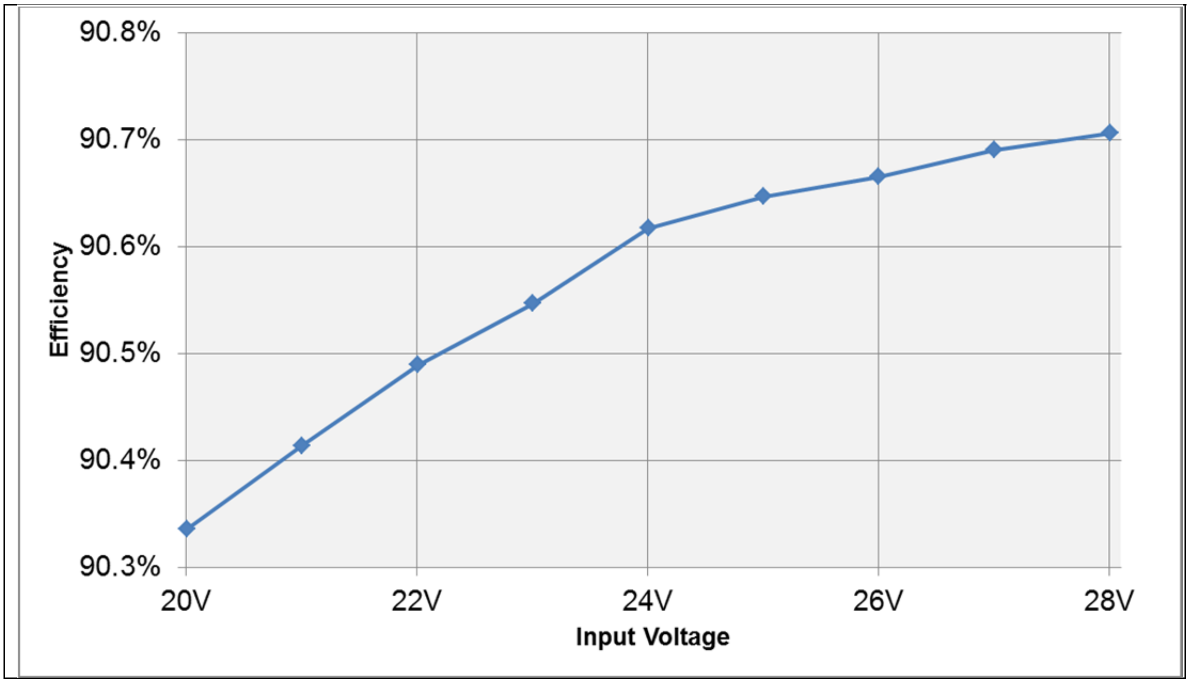


Figure 6

Full load efficiency across input voltage range +90%.

6 Cross Regulation

The output currents were changed separately (0A, 0.2A, 0.4A, 0.7A)
Figure 7 shows the effects on the positive output voltage, if the negative output current is varied. The different curves represent the positive output current settings

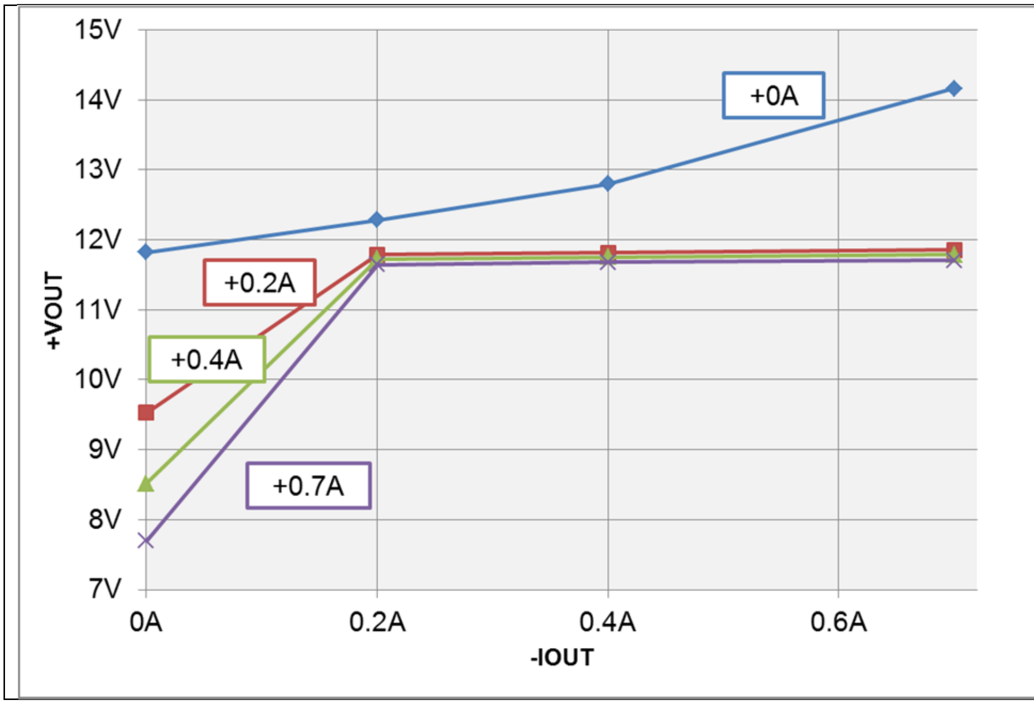


Figure 7

Figure 8 shows the effects on the negative output voltage, if the positive output current is varied. The different curves represent the negative output current settings.

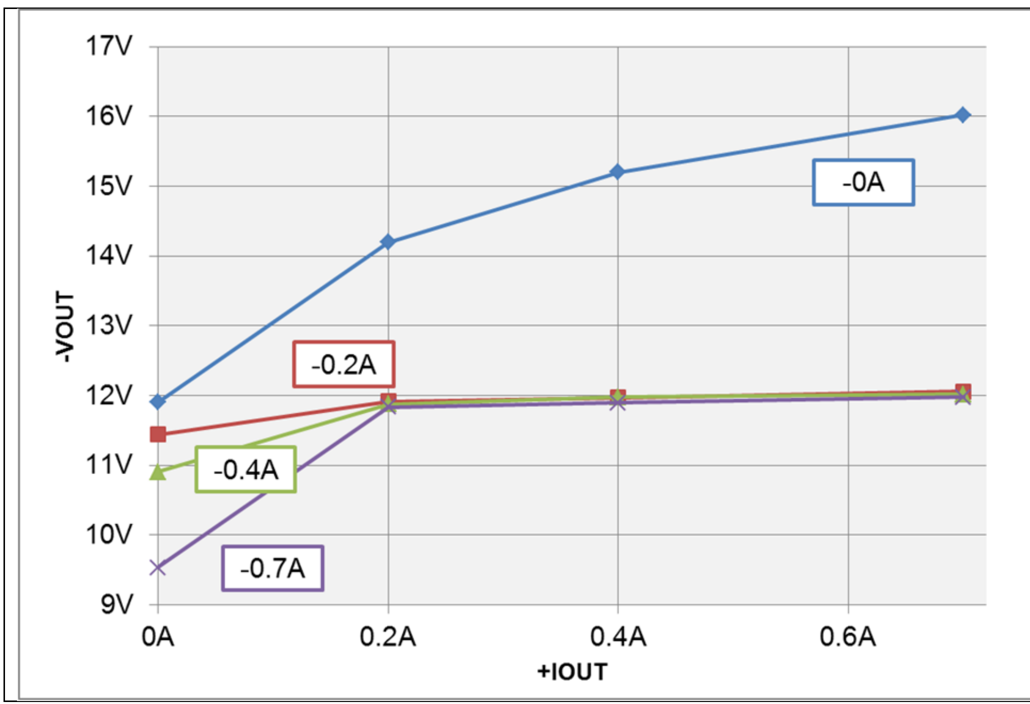


Figure 8

7 Ripple Voltage

7.1 Positive Output

The output ripple voltage is shown in Figure 9. The image was taken with a 0.7A and 24V at the input.

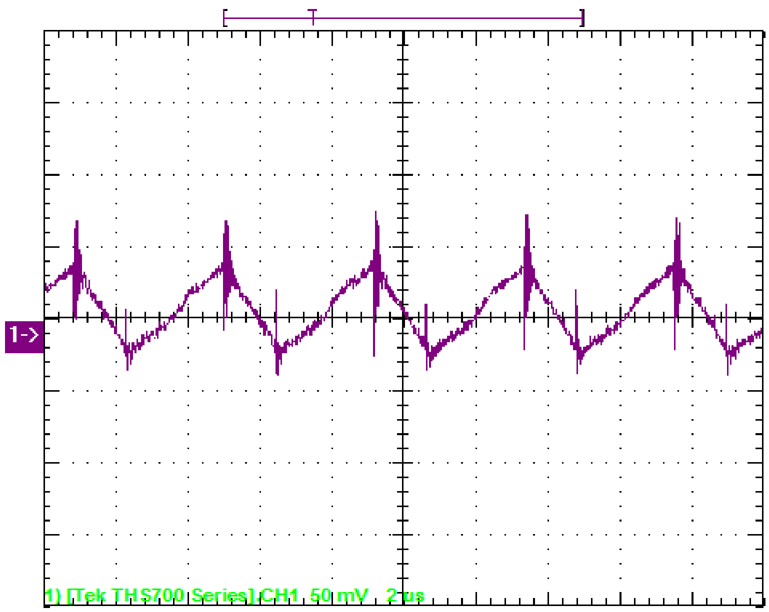
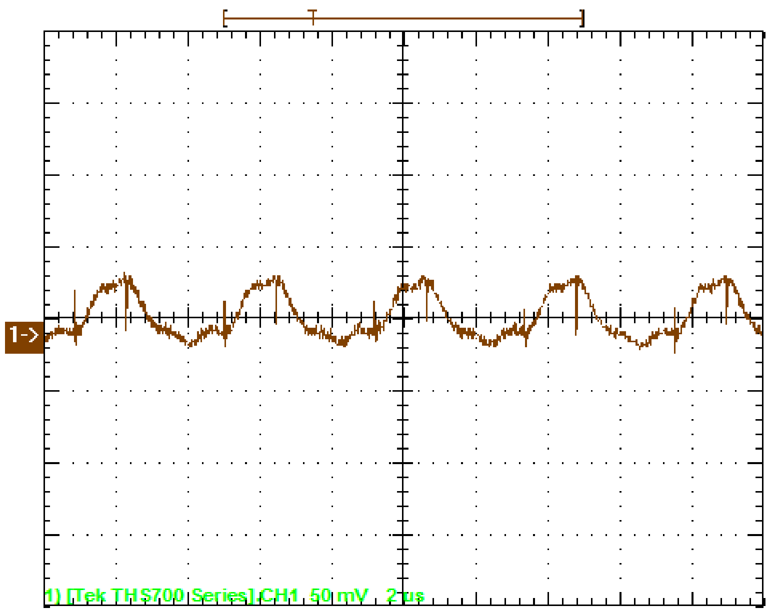
	Ch1 => output voltage (+VOUT) 50mV/div AC coupled 20MHz bandwidth setting 2µs/div

Figure 9

Output ripple around 100mVpp, so less than 1% of output voltage.

7.2 Negative Output

The negative output ripple voltage is shown in Figure 10. The image was taken with a 0.7A load 24V at the input.



Ch1 => output voltage (-VOUT)

50mV/div

AC coupled

20MHz bandwidth setting

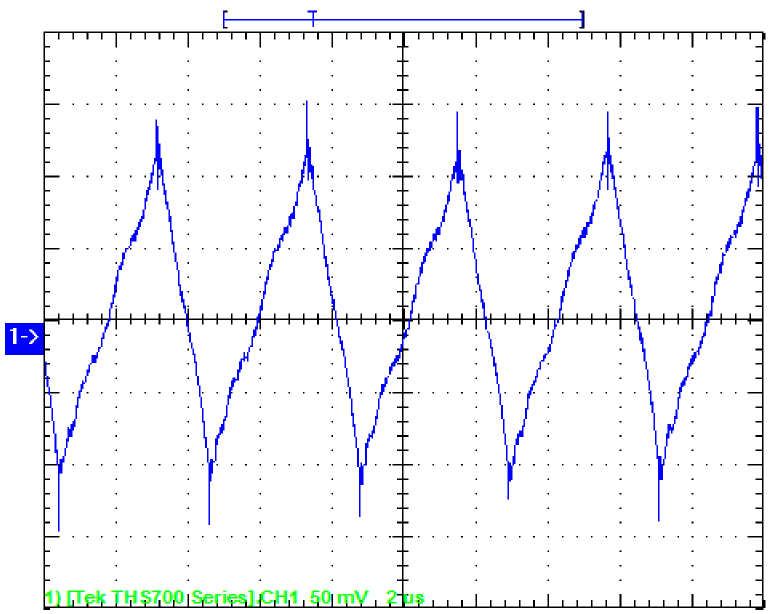
2µs/div

Figure 10

Output ripple around 50mVpp, so less than 1% of output voltage.

7.3 Input Voltage

The input ripple voltage is shown in Figure 11.



Ch1 => input voltage

50mV/div

AC coupled

20MHz bandwidth setting

1µs/div

Figure 11

8 Control Loop Frequency Response

Figure 12 shows the loop response with 0.7A load and 20V,24V and 28V input.

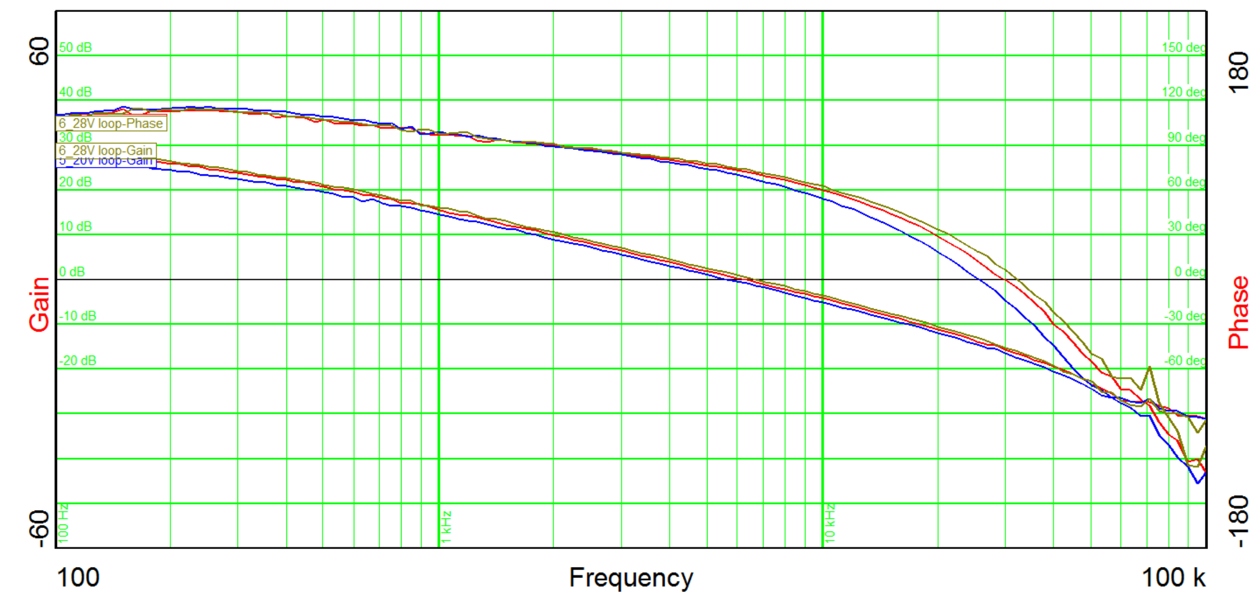


Figure 12

Table 1 summarizes the results

	20V	24V	28V
Bandwidth (kHz)	5.65	6.2	6.65
Phasemargin	71°	72.4°	72.5°
slope (20dB/decade)	-1.2	-1	-1.1
gain margin (dB)	-14.67	-15.7	-16.1
slope (20dB/decade)	-1.44	-2.15	-1.5
freq (kHz)	25.5	29.9	32.1

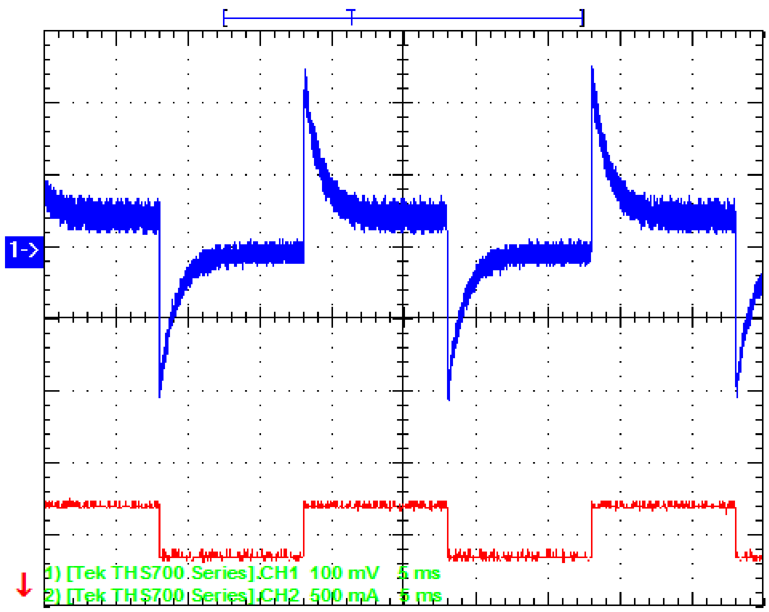
Table 1

The loop was designed for PM>65degs and GM around -15dB;
The bandwidth of 6kHz for the flyback topology is fair, the slope of -1 at Fco is perfect.

9 Load Transients

9.1 Transient applied at negative VOUT (-VOUT)

The Figure 13 shows the response to load transients. The load is switching from 0.35A to 0.7A (50 Hz). Negative VOUT was measured



Ch1 => output voltage (-VOUT) 100mV/div

20MHz bandwidth setting

Ch2 => output current 500mA/div

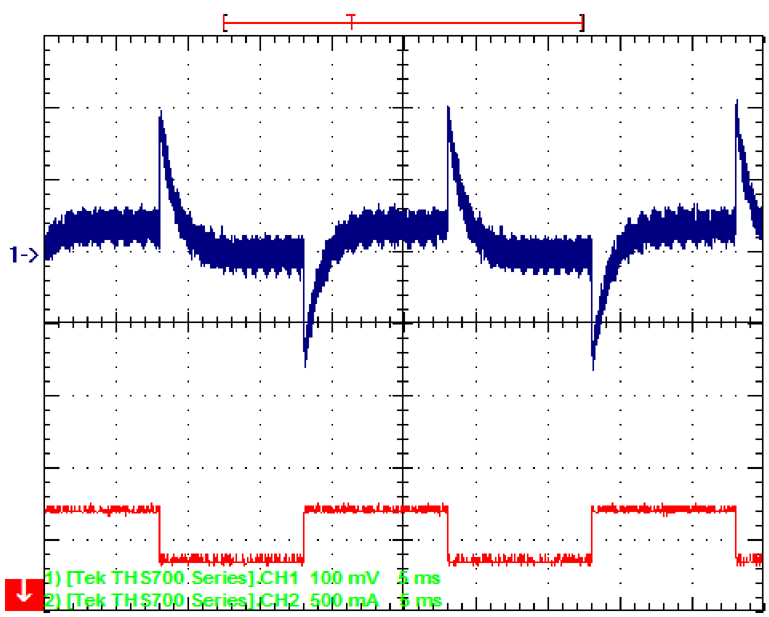
5ms/div

Deviation:

240mV, 2%

Figure 13

The Figure 14 shows the response to load transients. The load is switching from 0.35A to 0.7A (50 Hz). Positive VOUT was measured



Ch1 => output voltage 100mV/div

20MHz bandwidth setting

Ch2 => output current 500mA/div

5ms/div

Figure 14

9.2 *Transient applied at positive VOUT (+VOUT)*

The Figure 13 shows the response to load transients. The load is switching from **0.36A to 0.87A** (load precision !) (50 Hz). Negative VOUT was measured

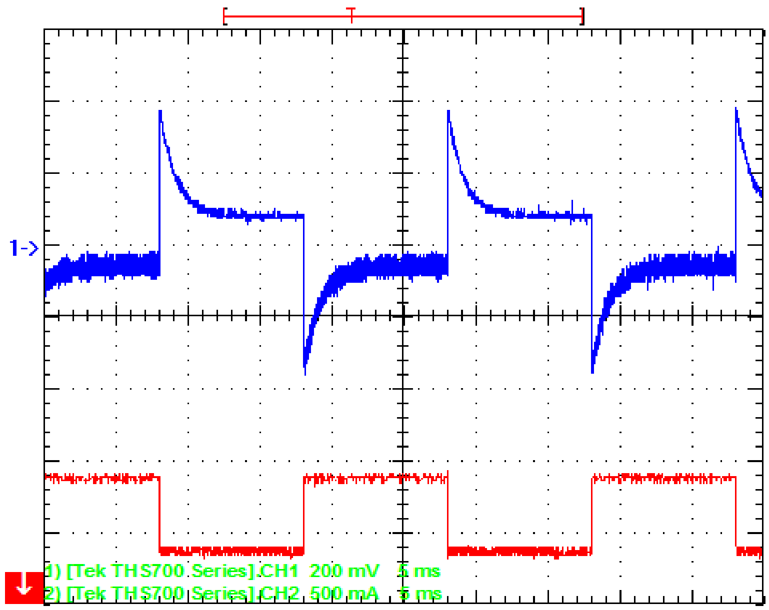
	Ch1 => output voltage (-VOUT) 200mV/div 20MHz bandwidth setting Ch2 => output current 500mA/div 5ms/div Deviation: **400mV, <4%**

Figure 15

The Figure 14 shows the response to load transients. The load is switching from **0.36A to 0.87A** (50 Hz). Positive VOUT was measured

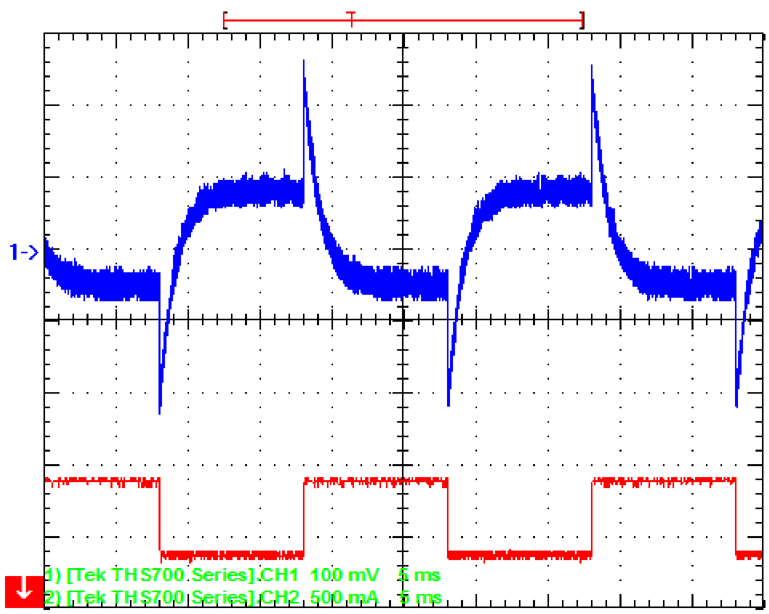
	Ch1 => output voltage (+VOUT) **100mV/div** 20MHz bandwidth setting Ch2 => output current 500mA/div 5ms/div

Figure 16

10 Miscellaneous Waveforms

Switch node ("SW" to -VOUT)) waveform shown in Figure 17

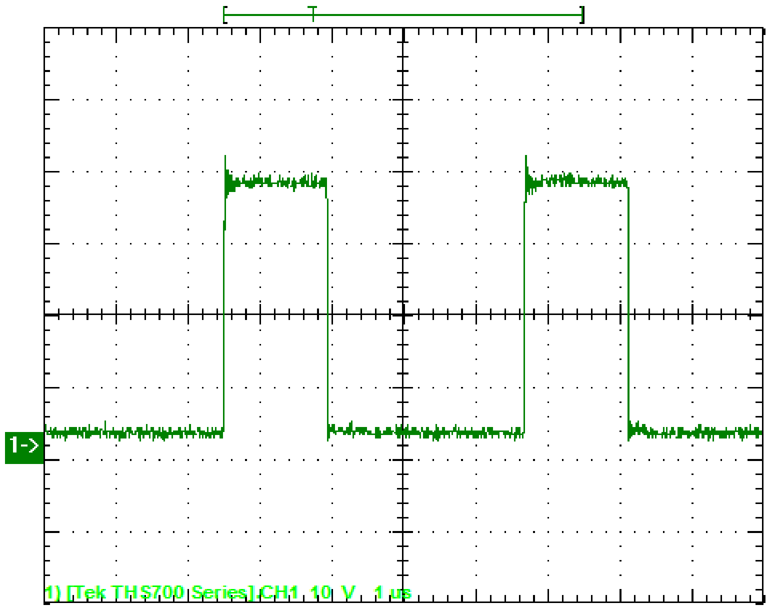
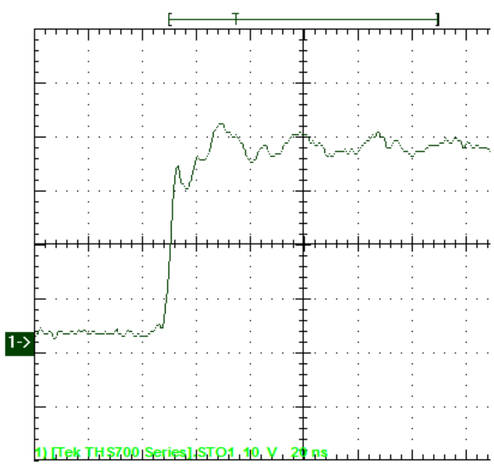
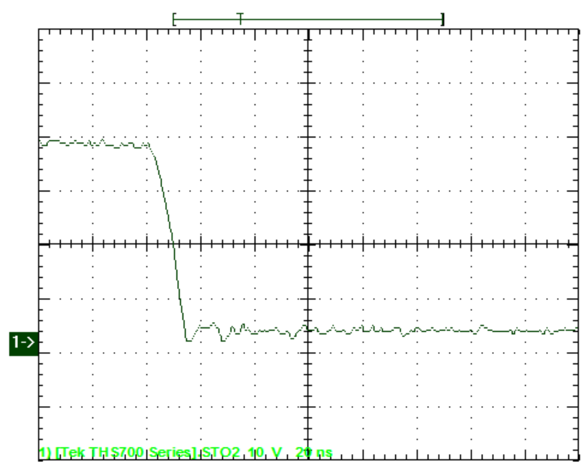
	Ch1 => 10V/div 1µs/div
 	Ch1 => 10V/div 20ns/div

Figure 17

Switchnode ("SW" to GND measured at the inductor pads) results in the waveform shown in Figure 18.

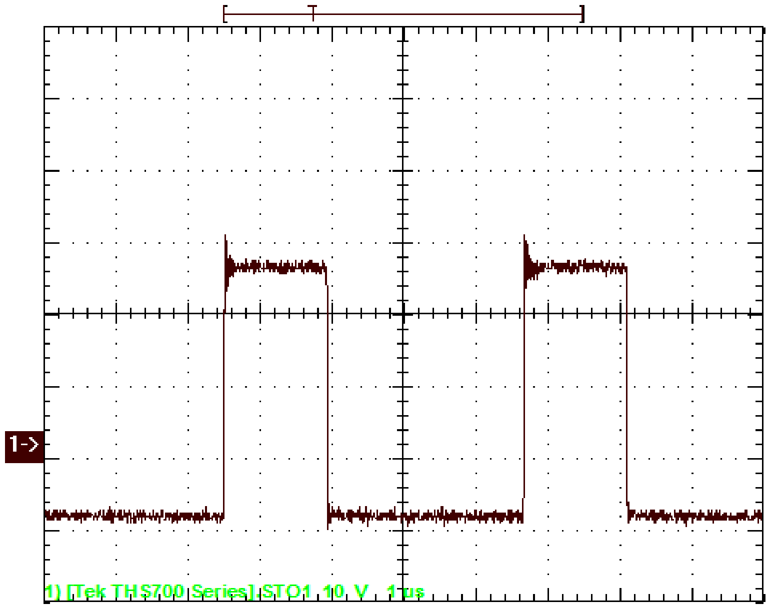
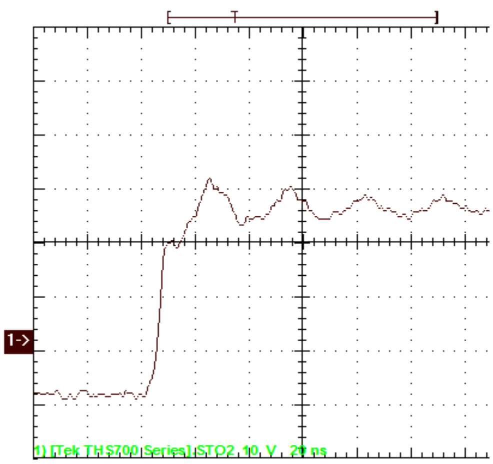
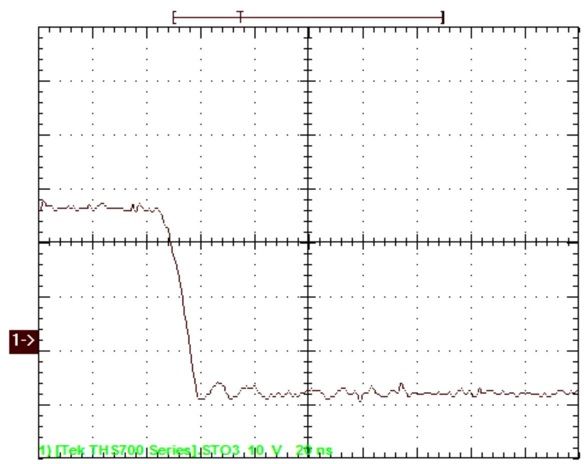
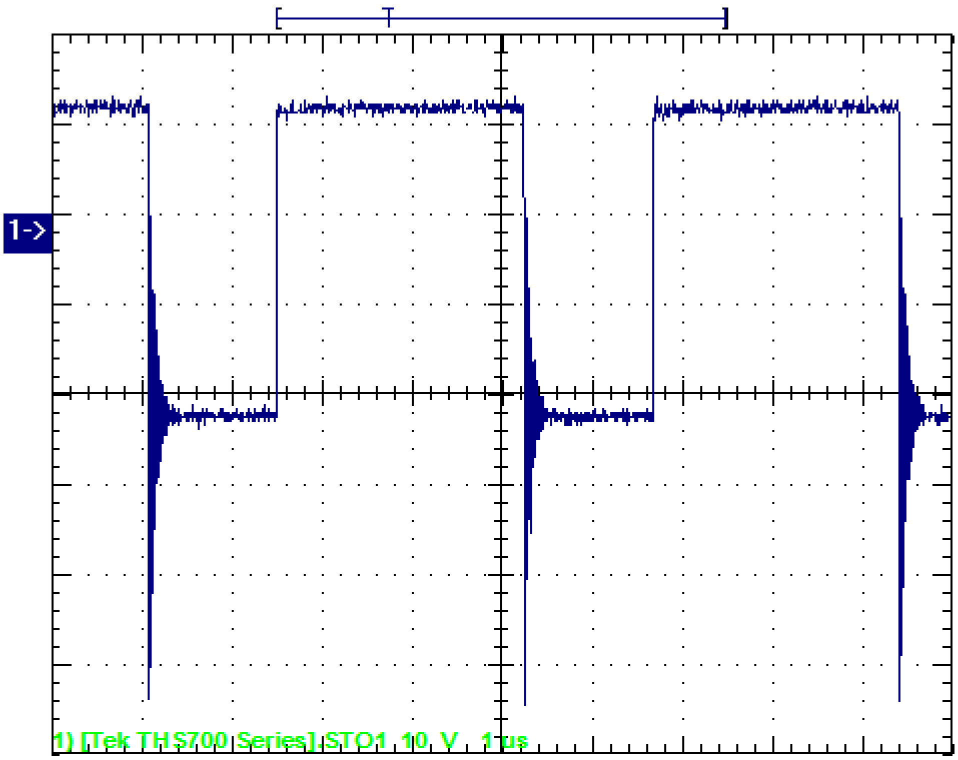
	Ch1 => 10V/div 1µs/div
 	Ch1 => 10V/div 20ns/div

Figure 18

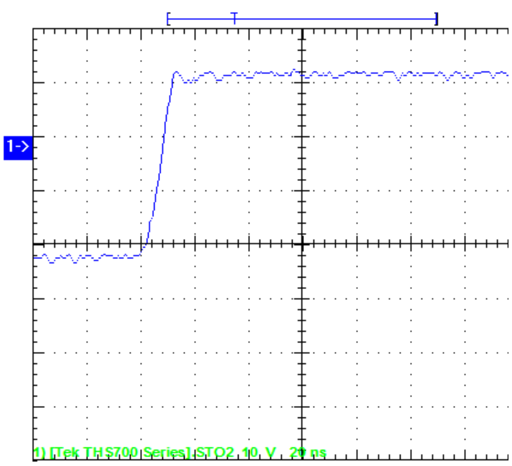
"Secondary" switchchnode (measured at the inductor pads): the waveform is shown in **Figure 19**. Measured without snubber.

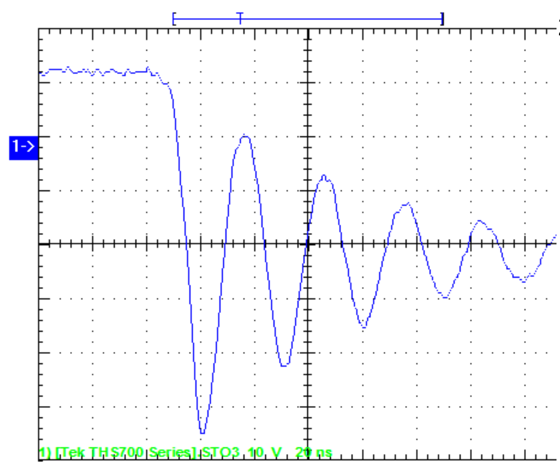


Ch1 =>
10V/div

1µs/div

full bandwidth





Ch1=>10V/div
20ns/div

Figure 19

Secondary switchnode (SW2 to +VOUT) the waveform is shown in Figure 20.
Applied RC snubber across diode D1 (100Ohm + 470pF in series)

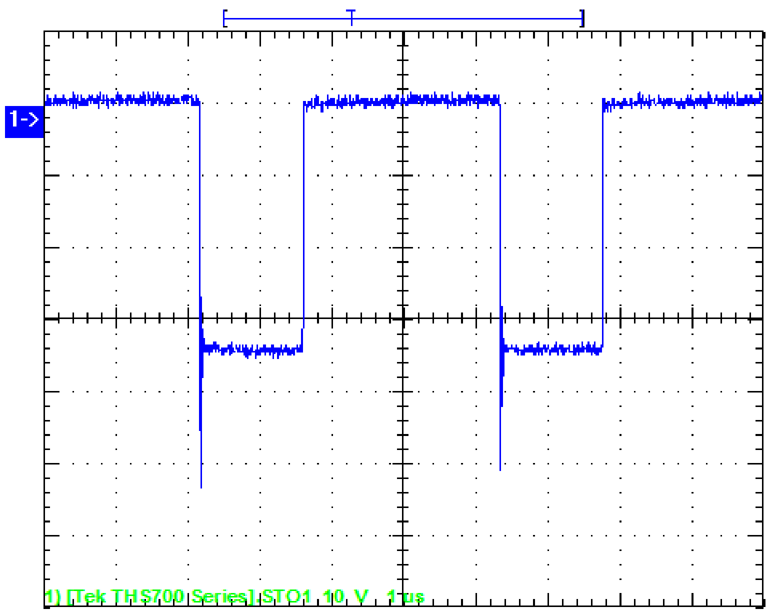
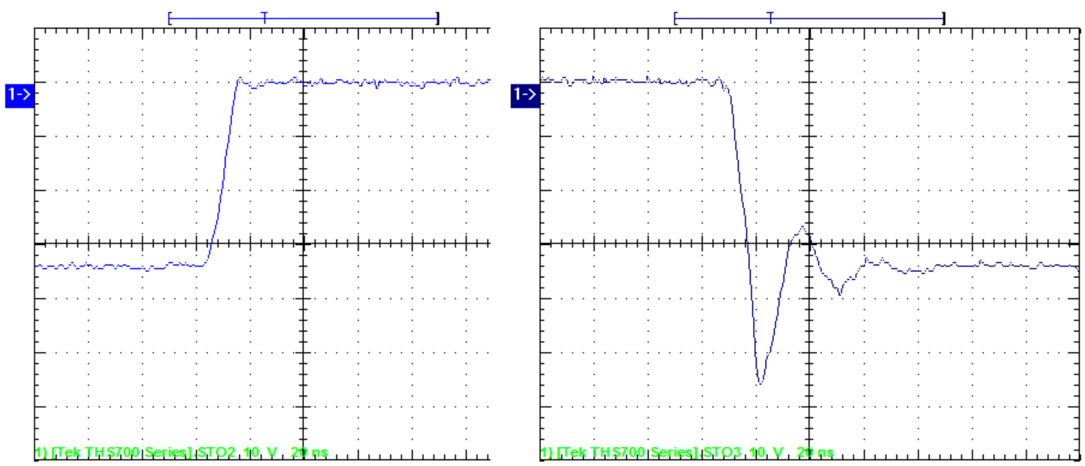
	Ch1 => 10V/div 1µs/div
	Ch1 => 10V/div 20ns/div

Figure 20

RC snubber deduced voltage stress below 60Vpk

11 Thermal Image

Thermal image is shown in Figure 21. Input voltage was set to 24V and both output currents at full load 700mA for more than 30minutes:

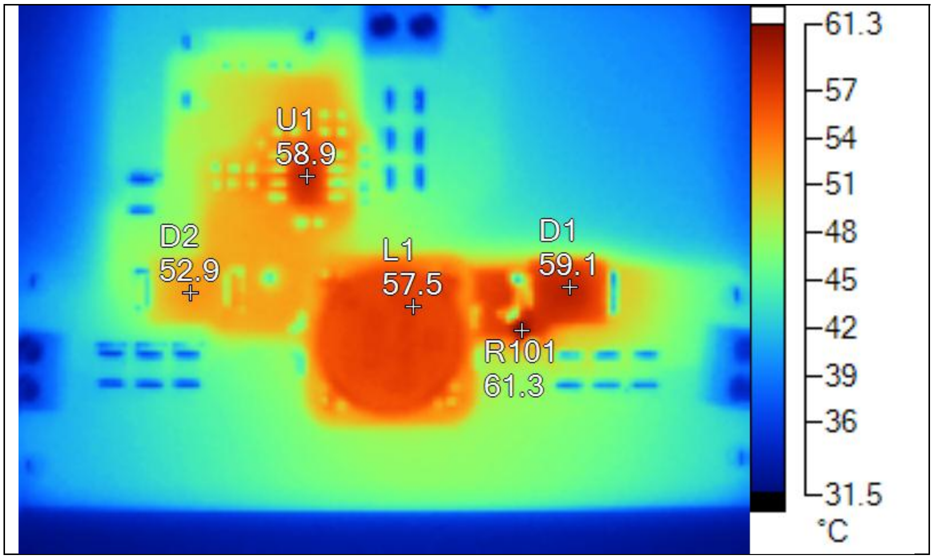


Figure 21

Name	Temperature
R101	61.3°C
U1	58.9°C
D1	59.1°C
L1	57.5°C
D2	52.9°C

Table 2

Thermall stress at the semiconductors is low, dT < 40K