

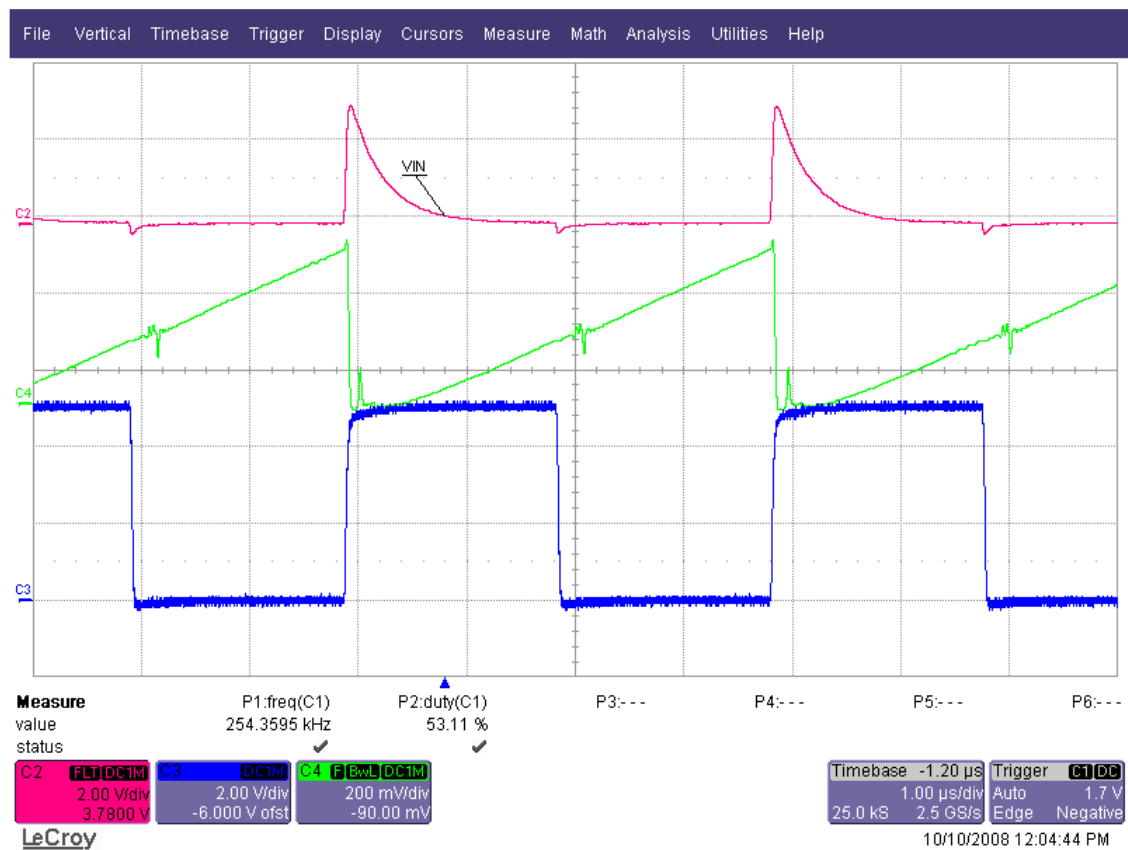
## 1 Main Waveforms

The converter is operating sharing (mostly measured by Current sense Signals) equally the currents between the two boost converters, the Master and the Slave. An indirect indication of the quality of current sharing between the two boost is also given by the thermal analysis data provided in the following.

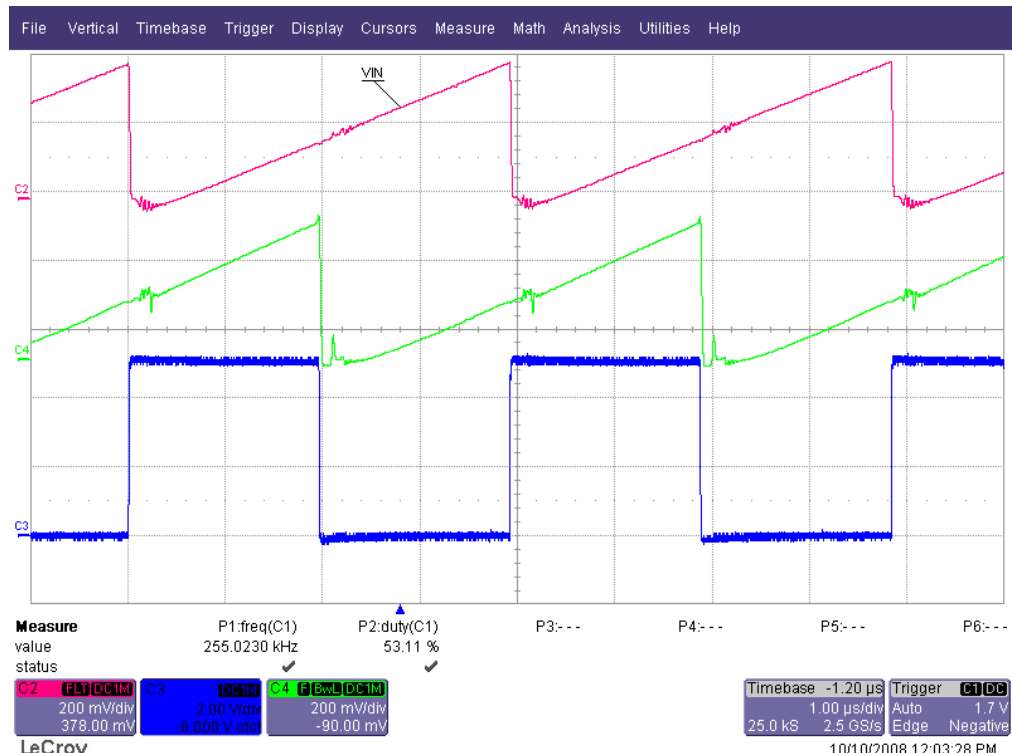
The current sharing happens down to very low values of the converter output current (total of the two boosts) where in deep discontinuous mode ( $I_{out} < 0.35A$ ) only the Slave boost is conducting.

The following pictures show the main waveforms of the Synchronizing Circuit and of the Power Stage. Synchronized (U3) Switching frequency is  $f_s = 260kHz$  (unsynchronized frequency of U1 and U2 is 200kHz).

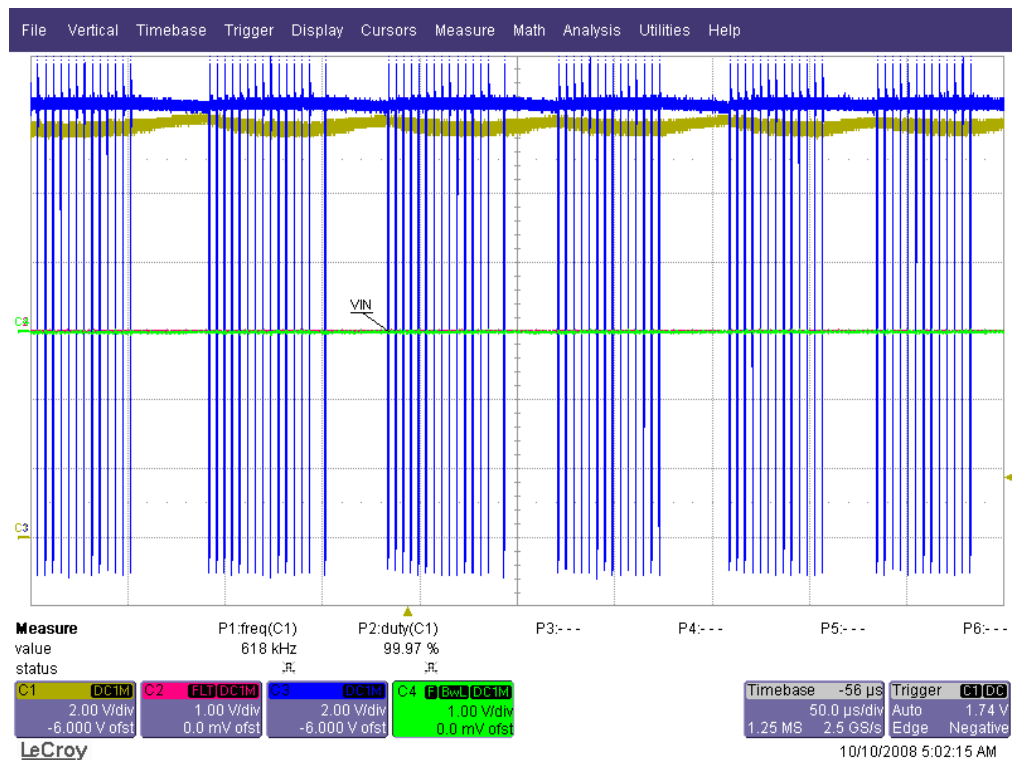
At full Load, 15A, Duty cycle is  $D=50\%$  at 6.5V input,  $D=30\%$  at 9V input,  $D=7\%$  at 12V.



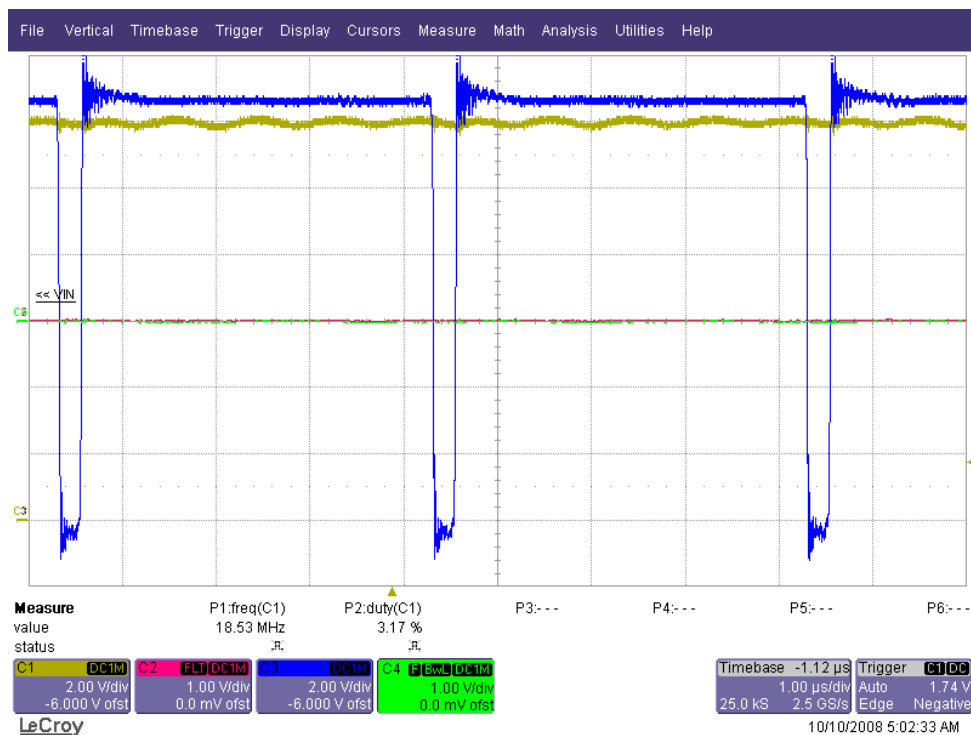
Synchronization Circuit 1: Out U3-TLC555D (C3), Gate of Q4 (C2), Synchronizing signal (C4)



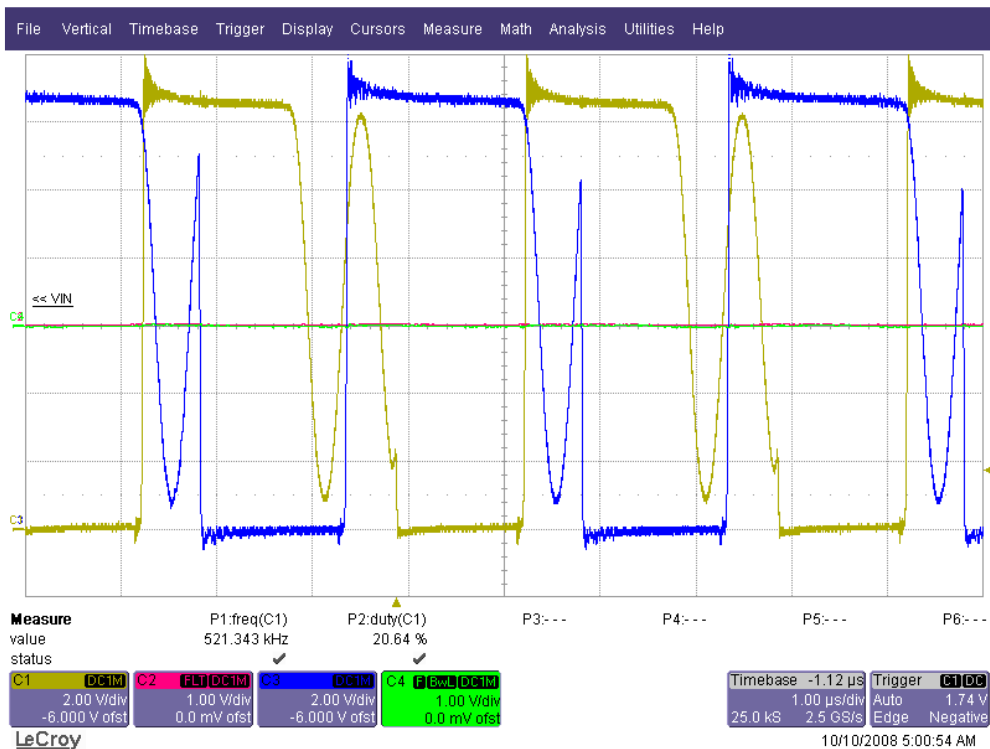
**Synchronization Circuit 2: Out U3-TLC555D (C3), Synch\_Master signal (C4), Synch Slave (C2)**



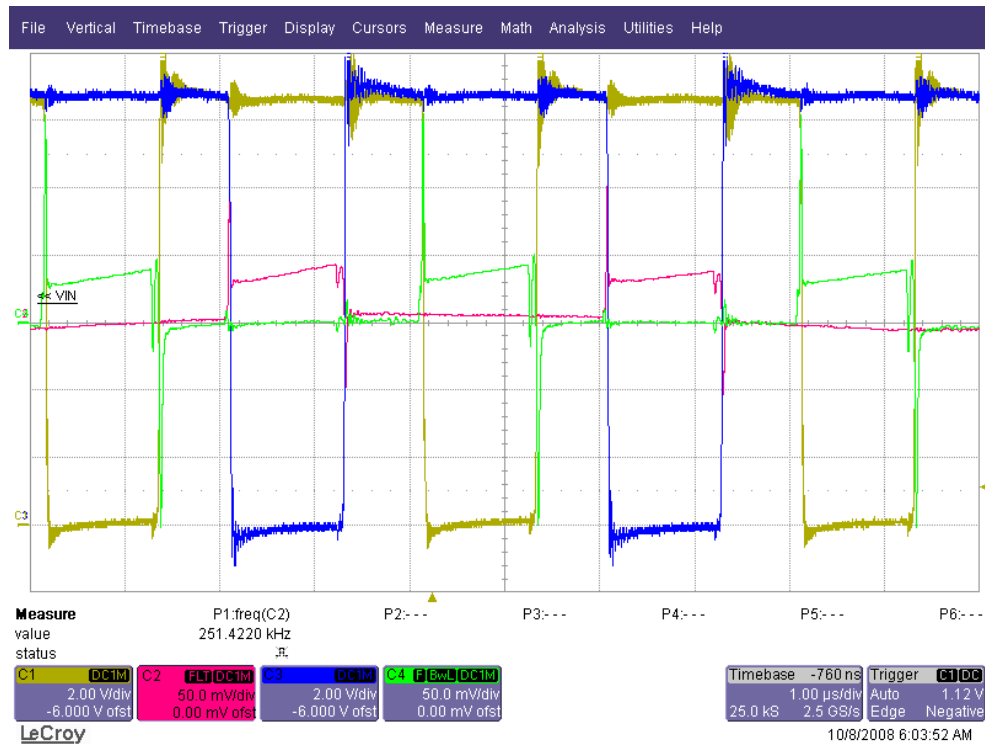
**Current Sharing 1 ( $I_{out} < 0.35A$ ) :  $V_{dsQ1}$  (C1, yellow),  $V_{dsQ2}$  (C3, blue), in deep discontinuous mode/burst mode only on slave boost (Q2)**



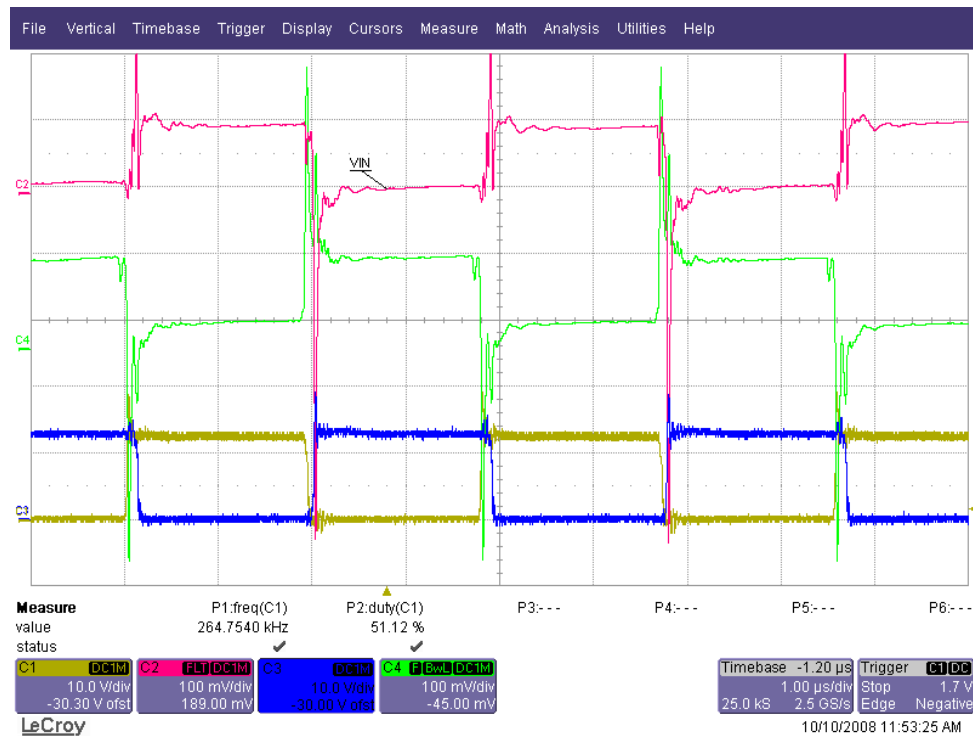
**Current Sharing 2 ( $I_{out} < 0.35A$ ) :  $V_{dsQ1}$  (C1, yellow),  $V_{dsQ2}$  (C3, blue),  
in deep discontinuous mode/burst mode only on slave boost (Q2)**



**Current Sharing 3 ( $I_{out} = 1A$ ) :  $V_{dsQ1}$  (C1, yellow),  $V_{dsQ2}$  (C3, blue),  
in discontinuous mode with both master and slave conducting**



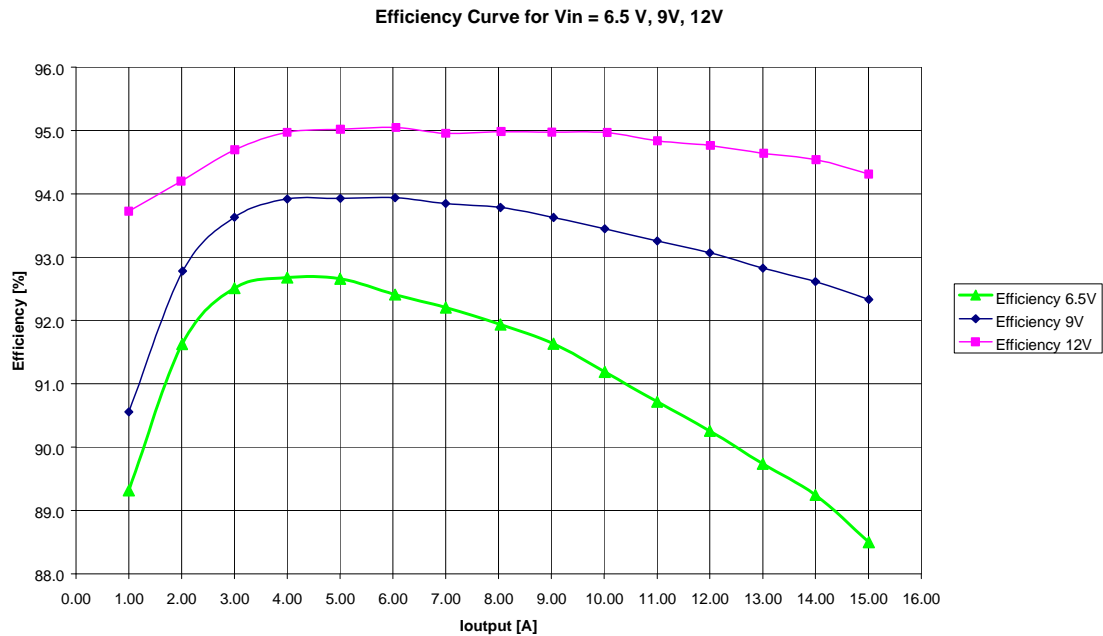
**Current Sharing 4 (Vin=9V Iout=5A): VdsQ1 (C1, yellow), VdsQ2 (C3, blue), Vsense Q1 (C4, green), Vsense Q2 (C2, purple)**



**Current Sharing 5 (Vin=6.5V Iout=10A) : VdsQ1 (C1, yellow), VdsQ2 (C3, blue), Vsense Q1 (C4, green), Vsense Q2 (C2, purple)**

## 2 Efficiency and Load Regulation

The efficiency diagrams are shown in the figure below for 6.5V, 9V, 12V input voltage, as a function of the output current.



The following table shows the measured values:

Vin[V]	Iin[mA]	Vout1[V]	Iout1[mA]	Pin[W]	Pout2[W]	η%
6.558	2.10	12.30	1.00	13.772	12.300	89.3
6.549	4.12	12.30	2.01	26.982	24.723	91.6
6.539	6.10	12.30	3.00	39.888	36.900	92.5
6.530	8.13	12.30	4.00	53.089	49.200	92.7
6.520	10.18	12.30	5.00	66.374	61.500	92.7
6.563	12.25	12.30	6.04	80.397	74.292	92.4
6.553	14.25	12.30	7.00	93.380	86.100	92.2
6.535	16.46	12.30	8.04	107.566	98.892	91.9
6.524	18.60	12.30	9.04	121.346	111.192	91.6
6.507	20.75	12.30	10.01	135.020	123.123	91.2
6.496	22.96	12.30	11.00	149.148	135.300	90.7
6.552	24.96	12.30	12.00	163.538	147.600	90.3
6.539	27.25	12.30	13.00	178.188	159.900	89.7
6.563	29.40	12.30	14.00	192.952	172.200	89.2
6.550	31.85	12.30	15.01	208.618	184.623	88.5
9.116	1.49	12.30	1.00	13.583	12.300	90.6
9.109	2.94	12.30	2.02	26.780	24.846	92.8
9.102	4.33	12.30	3.00	39.412	36.900	93.6
9.095	5.76	12.30	4.00	52.387	49.200	93.9
9.087	7.22	12.30	5.01	65.608	61.623	93.9
9.080	8.71	12.30	6.04	79.087	74.292	93.9

## PMP2663 Rev.C Test Results

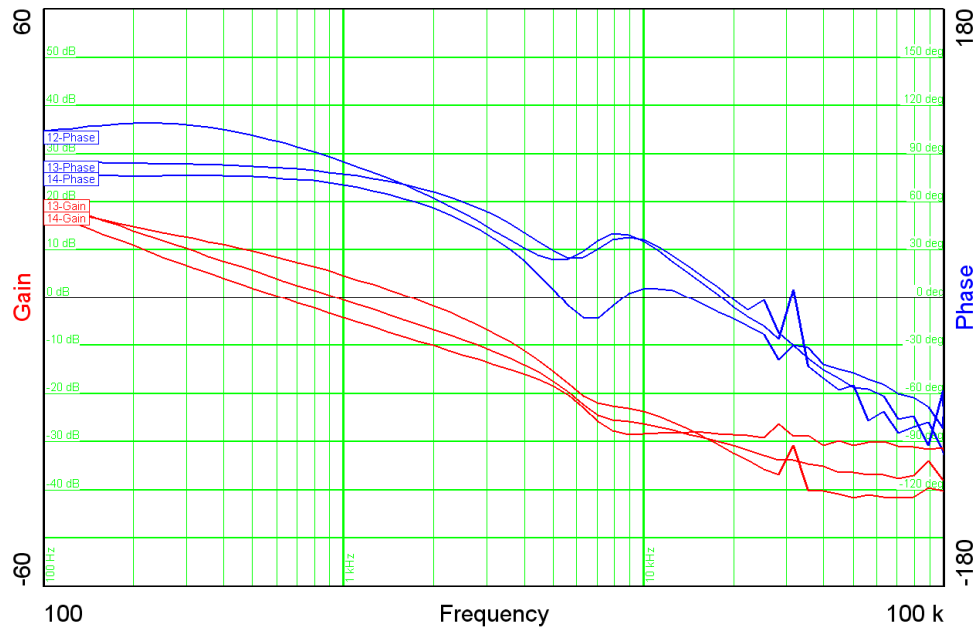



---

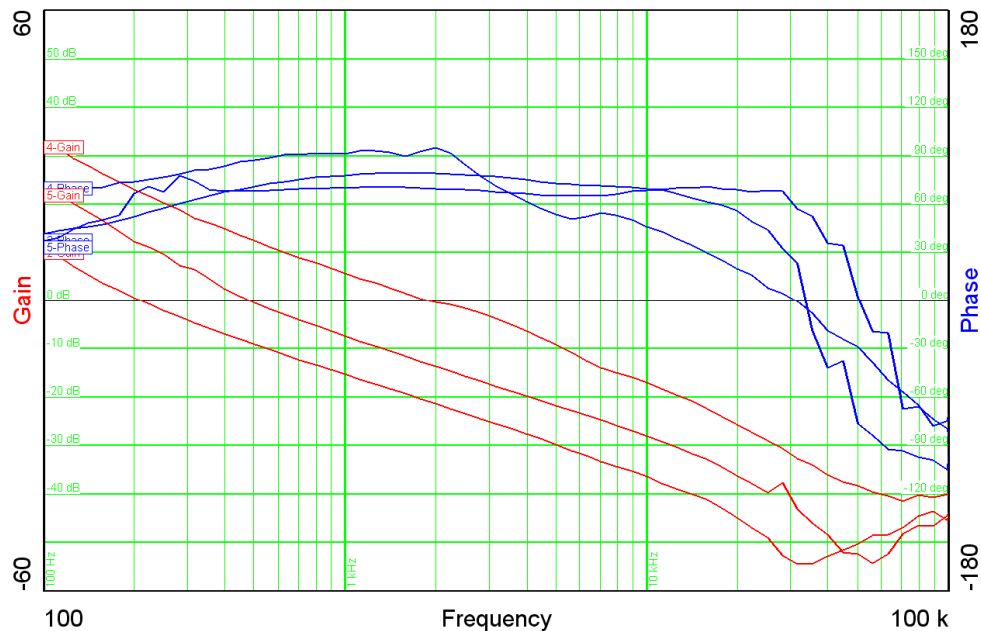
<b>9.066</b>	10.12	<b>12.30</b>	<b>7.00</b>	91.748	86.100	<b>93.8</b>
<b>9.059</b>	11.64	<b>12.30</b>	<b>8.04</b>	105.447	98.892	<b>93.8</b>
<b>9.045</b>	13.13	<b>12.30</b>	<b>9.04</b>	118.761	111.192	<b>93.6</b>
<b>9.037</b>	14.58	<b>12.30</b>	<b>10.01</b>	131.759	123.123	<b>93.4</b>
<b>9.023</b>	16.08	<b>12.30</b>	<b>11.00</b>	145.090	135.300	<b>93.3</b>
<b>9.016</b>	17.59	<b>12.30</b>	<b>12.00</b>	158.591	147.600	<b>93.1</b>
<b>9.033</b>	19.07	<b>12.30</b>	<b>13.00</b>	172.259	159.900	<b>92.8</b>
<b>9.026</b>	20.60	<b>12.30</b>	<b>14.00</b>	185.936	172.200	<b>92.6</b>
<b>9.093</b>	21.99	<b>12.30</b>	<b>15.01</b>	199.955	184.623	<b>92.3</b>
<b>12.040</b>	1.09	<b>12.30</b>	<b>1.00</b>	13.124	12.300	<b>93.7</b>
<b>12.030</b>	2.16	<b>12.30</b>	<b>1.99</b>	25.985	24.477	<b>94.2</b>
<b>12.030</b>	3.25	<b>12.30</b>	<b>3.01</b>	39.098	37.023	<b>94.7</b>
<b>12.020</b>	4.31	<b>12.30</b>	<b>4.00</b>	51.806	49.200	<b>95.0</b>
<b>12.010</b>	5.40	<b>12.30</b>	<b>5.01</b>	64.854	61.623	<b>95.0</b>
<b>12.010</b>	6.53	<b>12.30</b>	<b>6.06</b>	78.425	74.538	<b>95.0</b>
<b>12.010</b>	7.55	<b>12.30</b>	<b>7.00</b>	90.676	86.100	<b>95.0</b>
<b>12.010</b>	8.68	<b>12.30</b>	<b>8.05</b>	104.247	99.015	<b>95.0</b>
<b>12.030</b>	9.70	<b>12.30</b>	<b>9.01</b>	116.691	110.823	<b>95.0</b>
<b>12.020</b>	10.84	<b>12.30</b>	<b>10.06</b>	130.297	123.738	<b>95.0</b>
<b>12.020</b>	11.88	<b>12.30</b>	<b>11.01</b>	142.798	135.423	<b>94.8</b>
<b>12.010</b>	12.98	<b>12.30</b>	<b>12.01</b>	155.890	147.723	<b>94.8</b>
<b>12.010</b>	14.09	<b>12.30</b>	<b>13.02</b>	169.221	160.146	<b>94.6</b>
<b>12.000</b>	15.19	<b>12.30</b>	<b>14.01</b>	182.280	172.323	<b>94.5</b>
<b>12.010</b>	16.30	<b>12.30</b>	<b>15.01</b>	195.763	184.623	<b>94.3</b>

### 3 Control Loop Frequency Response

The figures below show the open loop response for 6.5V, 9V, 12V input voltage:



**Vin=6.5V (14-Gain and Phase), Vin=9V (13-Gain and Phase), Vin=12V (12-Gain and Phase) @ 15A Output**



**Vin=6.5V (2-Gain and Phase), Vin=9V (5-Gain and Phase), Vin=12V (4-Gain and Phase) @ Discontinuous Mode (no load)**

## 4 Load Transients

The figure below show the response to load transients. The current on the Output is stepping from 2 A to full load 15A load and viceversa, with  $V_{in}=6.5V$ .

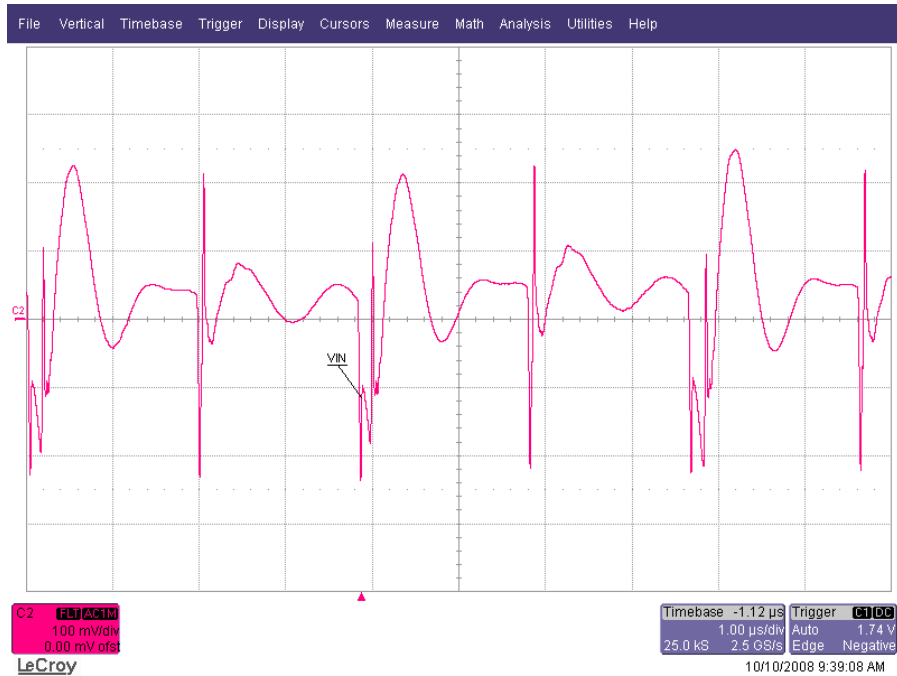


Vout (C2), Iout (C4, 10A/V current probe)

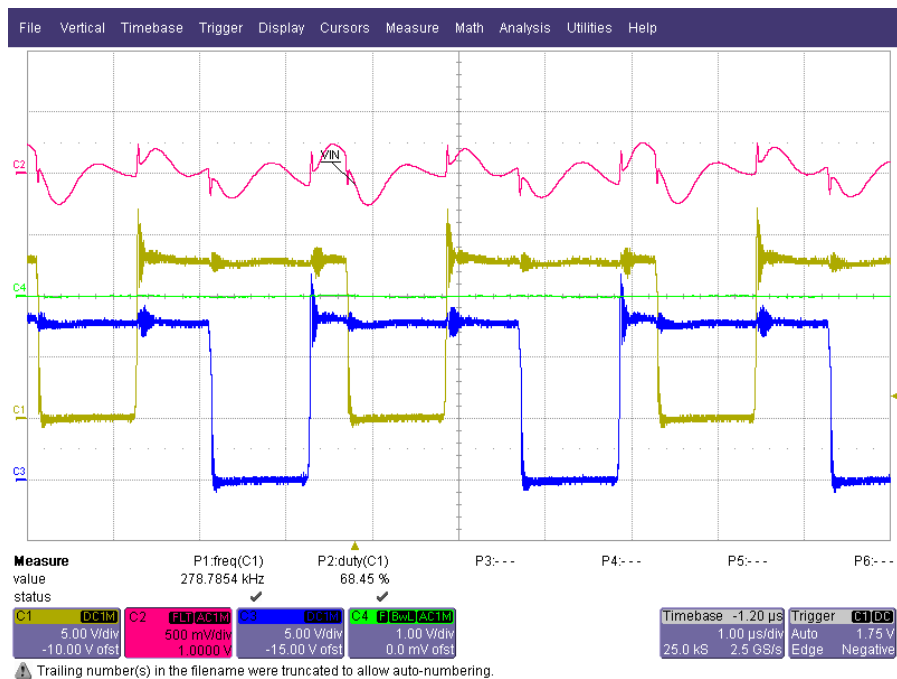


## 5 Output and Input Ripple Voltage

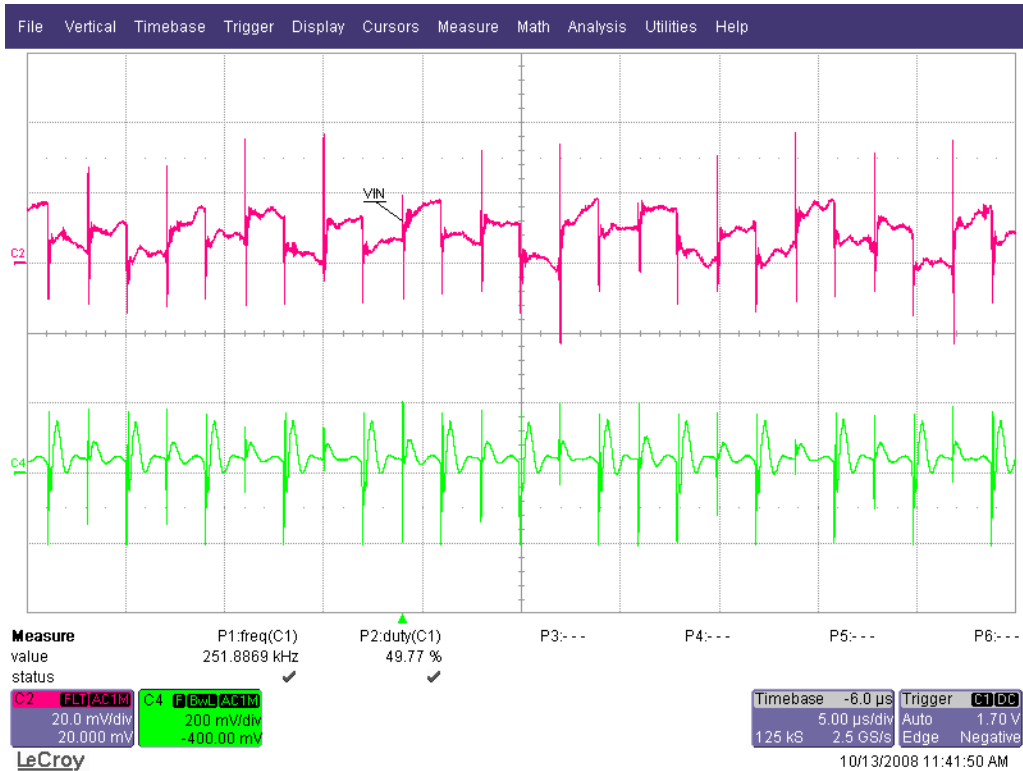
The output ripple voltage is shown in the figures below:



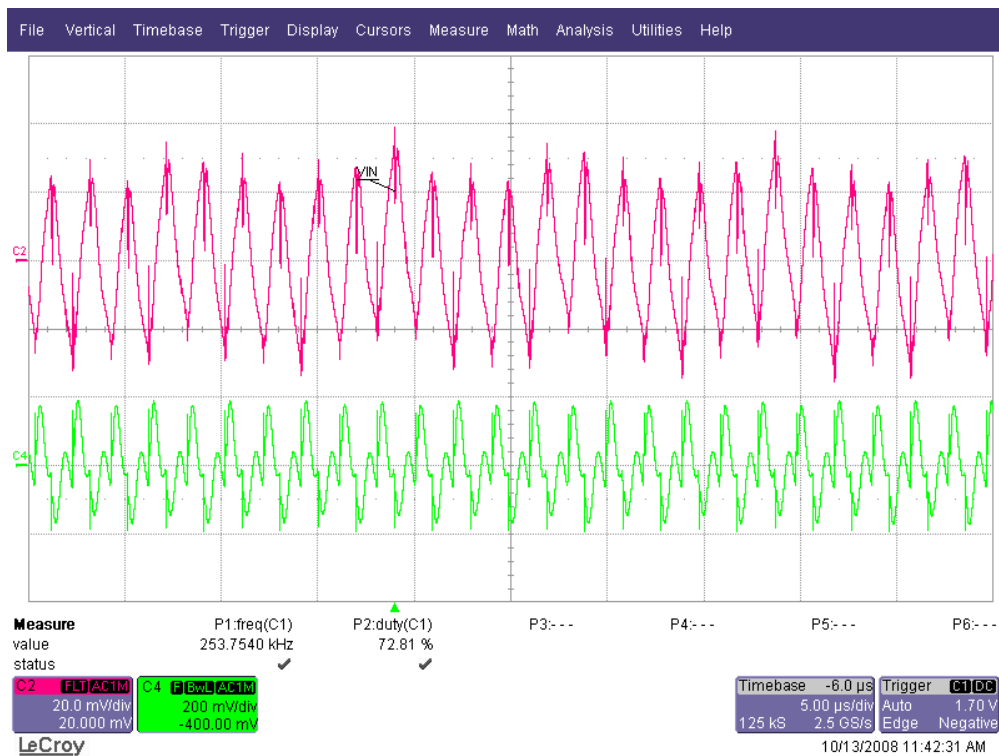
Output Voltage Ripple at full load 15A @  $V_{in}=6.5V$



Output Voltage Ripple at full load 15A @  $V_{in}=9V$  (C2),  $V_{ds}$  Q1 (C1) and  $V_{dc}$  Q2 (C3)



**Input Voltage Ripple (C2), Output Voltage Ripple (C4) at full load 15A @  $V_{in}=6.5V$**



**Input Voltage Ripple (C2), Output Voltage Ripple (C4) at full load 15A @  $V_{in}=9V$**

## 6 Thermal Images

The thermal images of board in different input and load conditions are shown in the following. In every picture the hottest spot is indicated, together with the temperature of the most significant components.

Several conditions of output load have been tested, for the three selected input voltage, to check for maximum operating temperature that could be hold by the board:

- Stop and Start application –  $I_{out}=15A$  per 5sec, followed by 20sec of no load;
- Stop and Start application – the same timing of point A is applied to Remote Shutdown (constant maximum load always present in the output);
- Continuous load 15A (maximum output current according to the design);
- Continuous load 10A (maximum allowable output current to operate up to  $T=85^{\circ}C$  ambient).

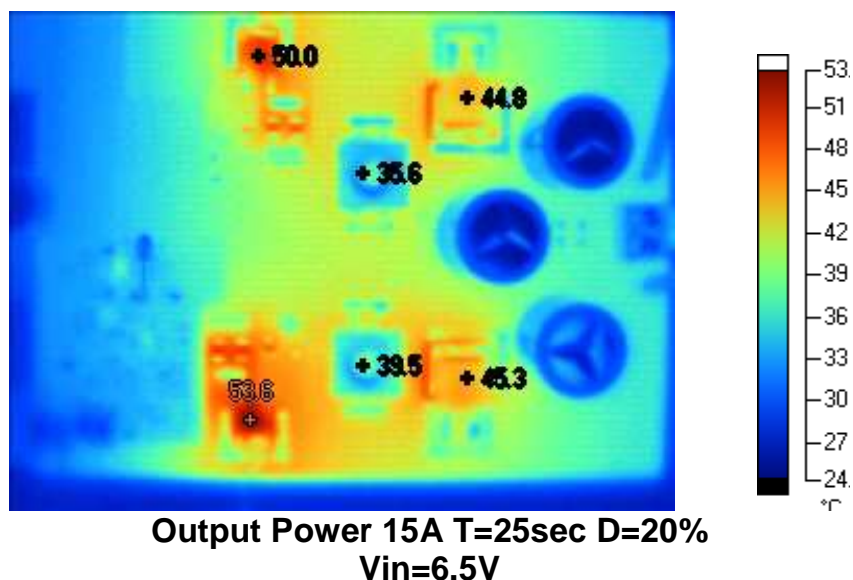
Layout of the actual revision is not completely symmetrical, showing a larger copper area on the Master boost part. This is responsible of thermal difference (up to  $14^{\circ}C$  in the worst measured case) between the hottest spot in the correspondent component in the two boost converters.

The thermal difference is to neglect (up to  $5.5^{\circ}C$ ) in the recommended conditions of operation (A, C).

Measured Maximum Temperatures (hot spot) in the different situations are summarized in the following table, and detailed in the pictures ( $T_{amb}=25^{\circ}C$ ):

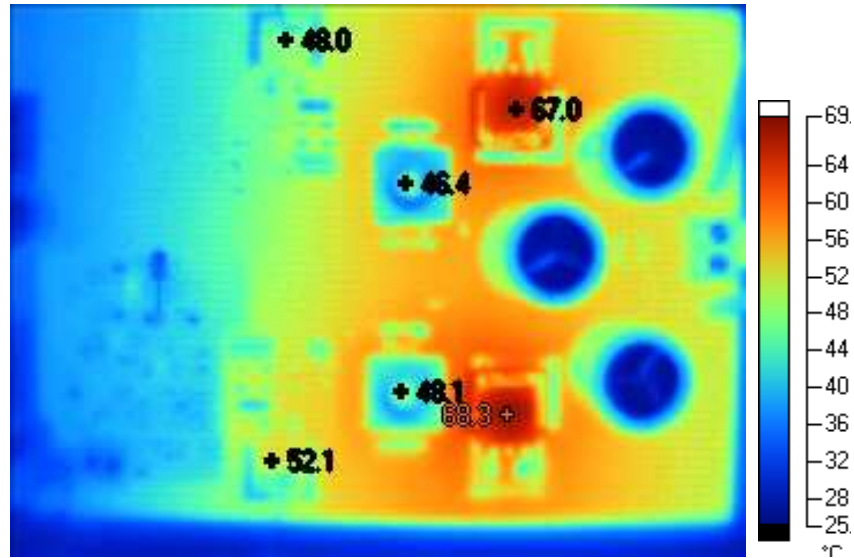
$V_{in} \Rightarrow$	6.5	9	12	
A.	53.7	52.1	51.5	<i><math>I_{out}=15A</math> <math>T=25sec</math> <math>D=20\%</math></i>
B.	69.5	68.4	70.8	<i><math>I_{out}=15A</math> <math>T=25sec</math> <math>D=20\%</math> on Shutdown input</i>
C.	118.8	90.1	85.7	<i><math>I_{out}=15A</math> continuous</i>
D.	71.5	62.3	59.5	<i><math>I_{out}=10A</math> continuous</i>

A.  *$I_{out}=15A$   $T=25^{\circ}C$   $D=20\%$*

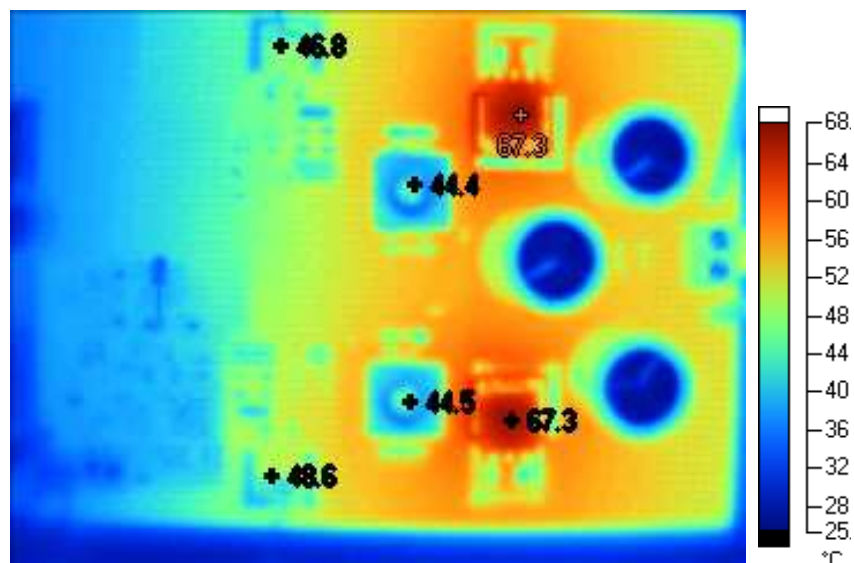


The same thermal pictures at  $V_{in}=9V$  and  $V_{in}=12V$  show neglectable temperature differences.

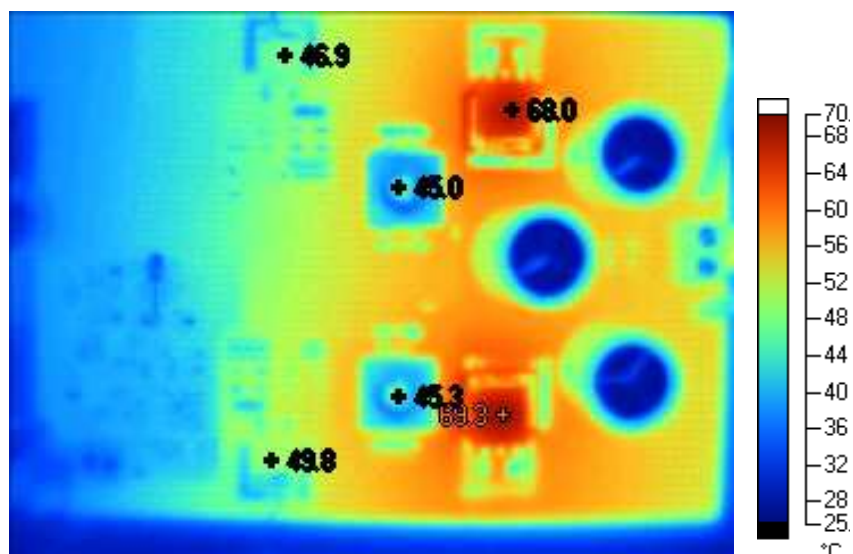
B. *I<sub>out</sub>*=15A *T*=25sec *D*=20% on Shutdown Input



Output Power 15A *T*=25sec *D*=20% on  
Shutdown *V<sub>in</sub>*=6.5V

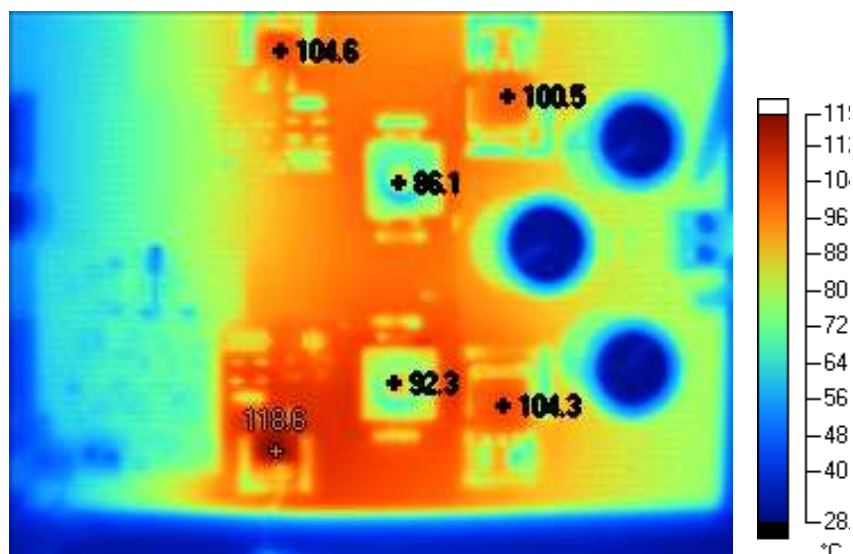


Output Power 15A *T*=25sec *D*=20% on  
Shutdown *V<sub>in</sub>*=9V

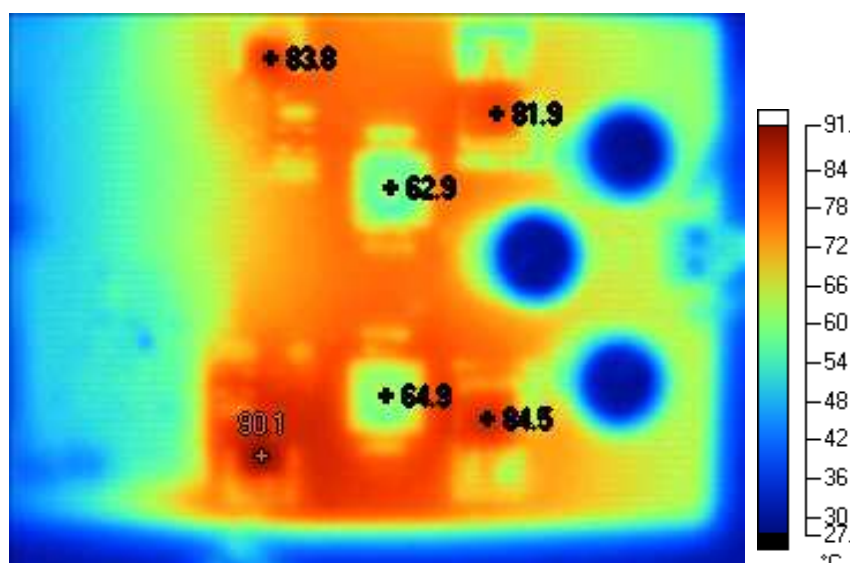
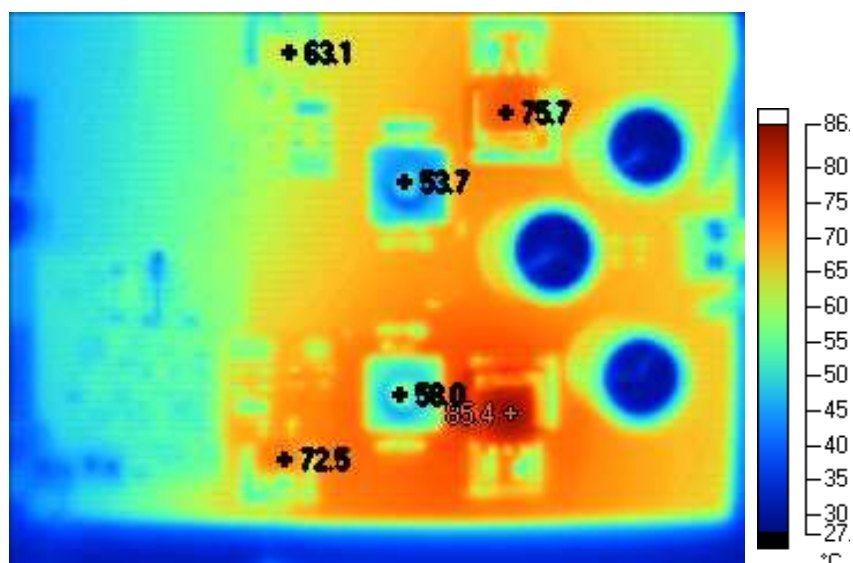


Output Power 15A T=25sec D=20% on  
Shutdown Vin=12V

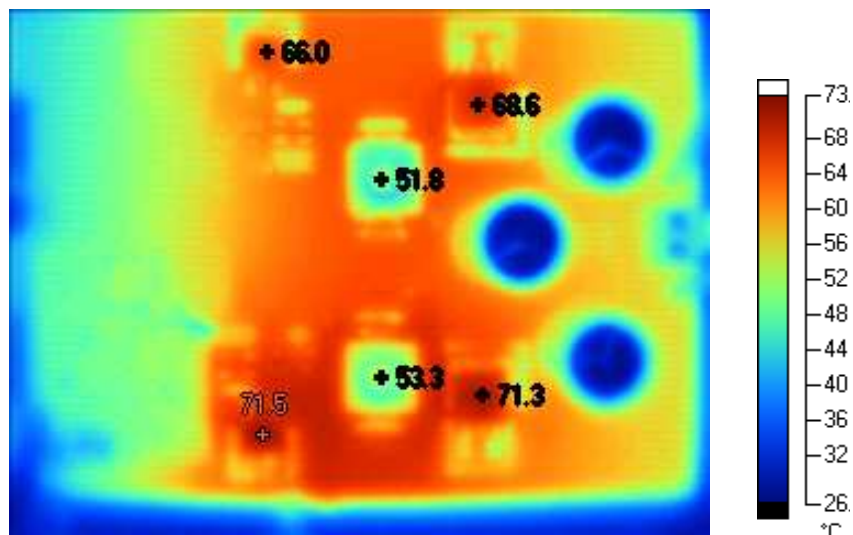
C.  $I_{out}=15A$  continuous



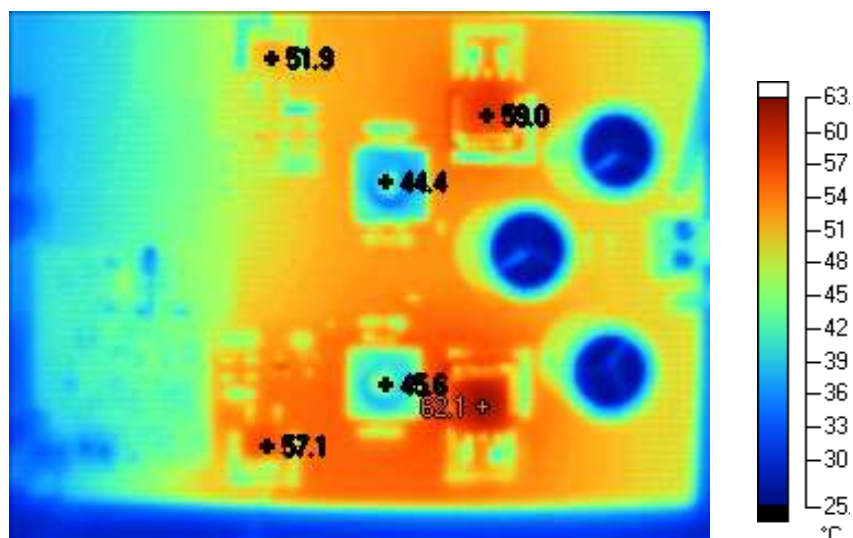
Output Power Continuous 15A  
Vin=6.5V

**Output Power Continuous 15A Vin=9V****Output Power Continuous 15A  
Vin=12V**

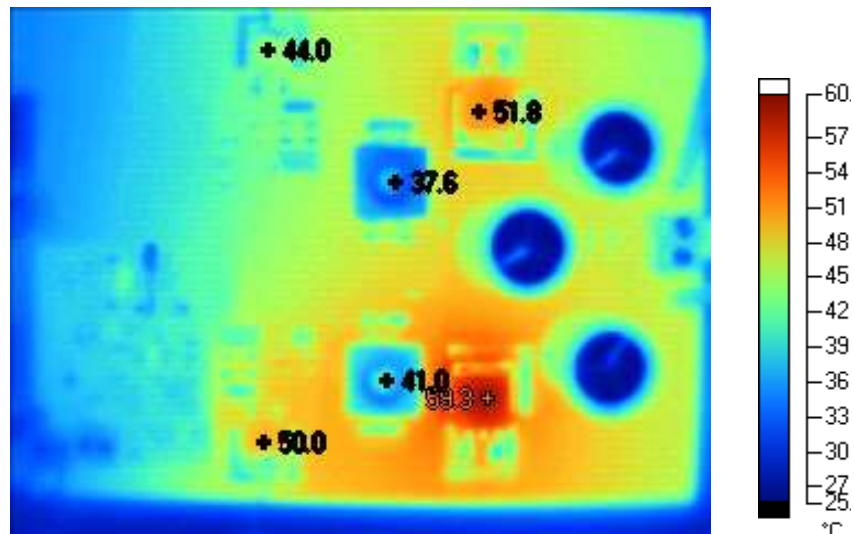


D. *I<sub>out</sub>*=10A continuous

Output Power Continuous 10A  
 $V_{in}=6.5V$



Output Power Continuous 10A  $V_{in}=9V$



**Output Power Continuous 10A  
Vin=12V**



## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2021, Texas Instruments Incorporated