

Test Data  
For PMP9495  
03/09/2015



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## 1. Design Specifications

|                                               |                |
|-----------------------------------------------|----------------|
| Vin Minimum                                   | 6              |
| Vin Maximum                                   | 33VDC          |
| Vout1                                         | 9V-13.4V       |
| Iout 1(to be used as Constant Voltage Output) | 5A             |
| Fast Charge Current (For Battery Charger)     | 5.5A           |
| LED Drive Current                             | 5.5A           |
| Approximate Switching Frequency               | 300 KHz Approx |

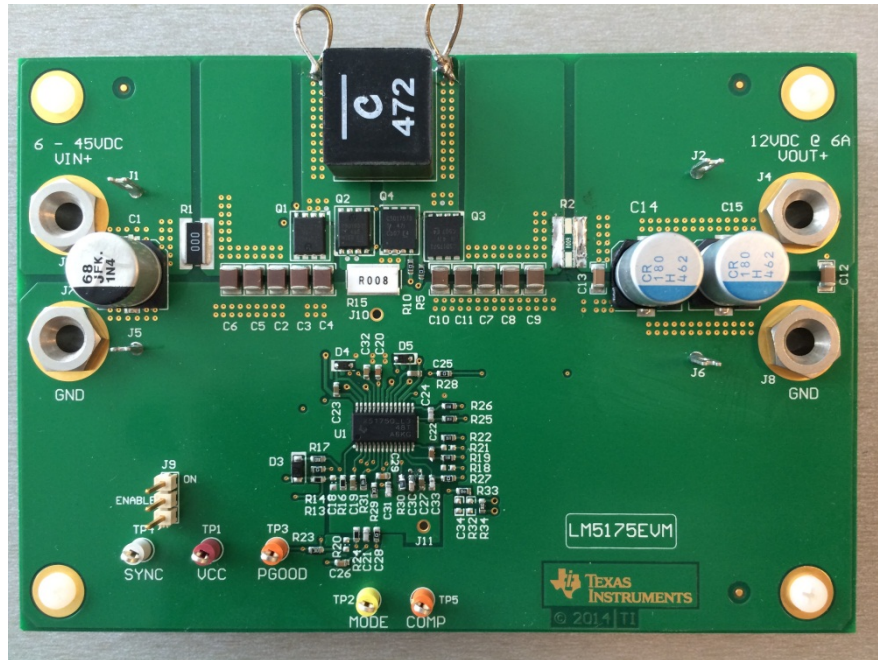
## 2. Circuit Description and PCB details

PMP9495 is a 72 W four Switch Buck –Boost Design utilizing best in Class Buck Boost Converter LM5175. The design accepts a very Wide input voltage of 6Vin to 33Vin and provides the outputs of 13.4V@5 A for Constant Voltage Output Application, 9V-13.4V @ 5.5A for CC/CV Battery Charger application, and 5.5 A for Constant Current LED Drive application. It features an inexpensive and more efficient solution to using discrete Buck and boost converters.

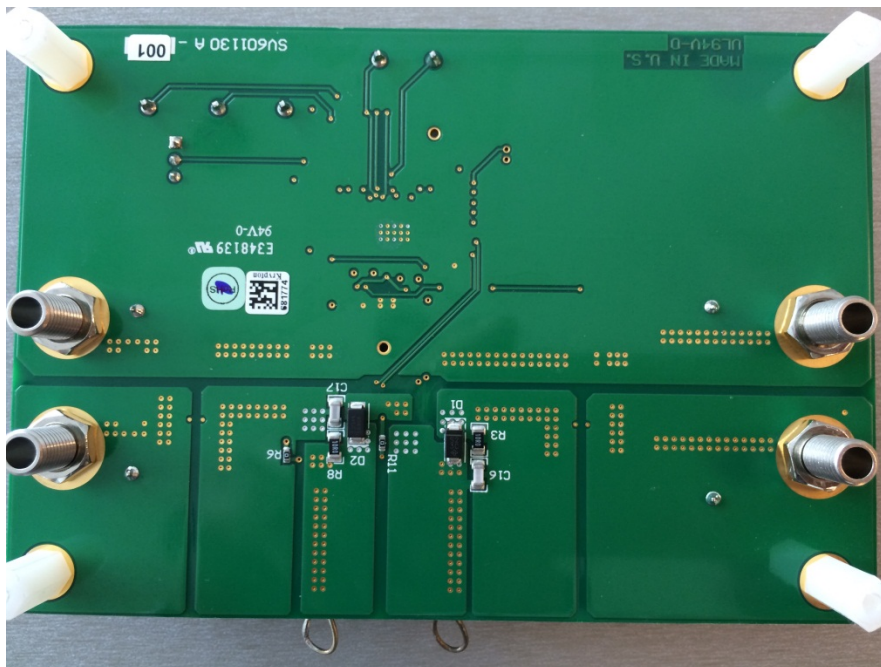
The average current regulation loop at the output is used for Battery Charging profiling with no external circuit being involved.

The Board dimension of PMP9495 PCB is 5000 mil \* 3450 mil. Four layer PCB was used for the design.

### 3. PMP9495 Board Photos



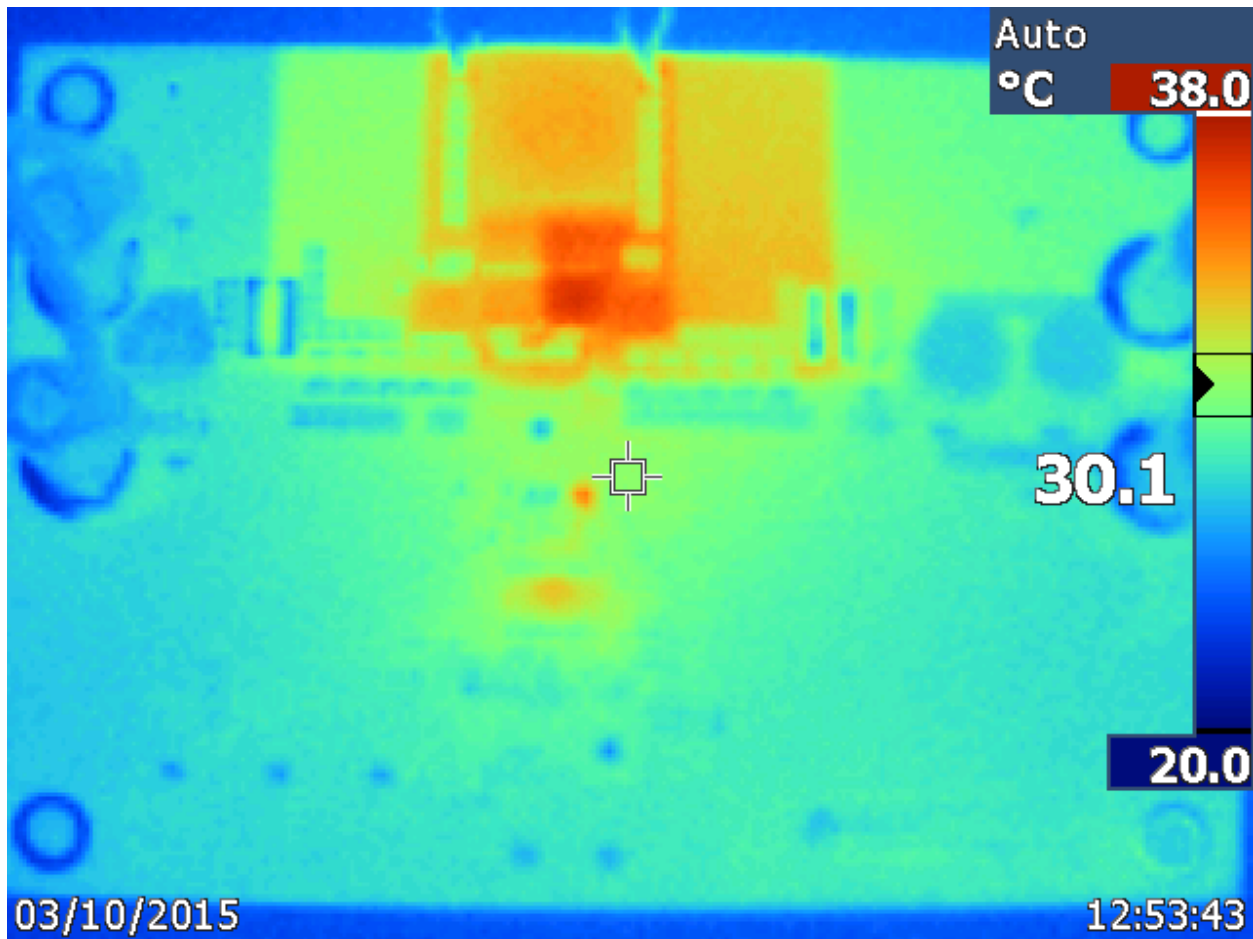
Board Photo (Top)



Board Photo (Bottom)

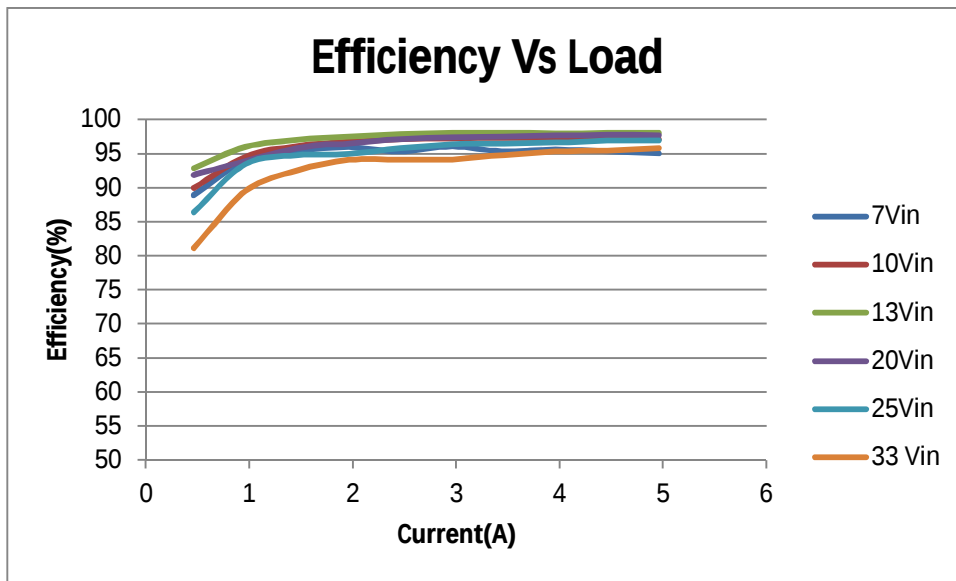
#### 4. Thermal Data

IR thermal image taken at steady state with 10 Vin and the 13V output at full load (5.5A in CC mode)



## 5. Efficiency

### 5.1 Efficiency Chart – Constant Voltage Output



## 5.2 Efficiency Data

| Vin(V) | Iin(A) | Vout(V) | Iout(A) | Efficiency(%) |
|--------|--------|---------|---------|---------------|
| =====  |        |         |         |               |
| 7.003  | 0.11   | 13.405  | 0       | 0             |
| 7.003  | 0.99   | 13.405  | 0.46    | 88.942        |
| 7.003  | 1.955  | 13.407  | 0.96    | 94.01         |
| 7.003  | 2.93   | 13.408  | 1.46    | 95.404        |
| 7.003  | 3.91   | 13.41   | 1.96    | 95.99         |
| 7.003  | 4.9    | 13.412  | 2.44    | 95.368        |
| 7.003  | 5.9    | 13.414  | 2.96    | 96.098        |
| 7.003  | 6.91   | 13.416  | 3.44    | 95.372        |
| 7.003  | 7.935  | 13.418  | 3.96    | 95.621        |
| 7.003  | 8.96   | 13.42   | 4.46    | 95.388        |
| 7.003  | 10     | 13.422  | 4.96    | 95.064        |

| Vin(V) | Iin(A) | Vout(V) | Iout(A) | Efficiency(%) |
|--------|--------|---------|---------|---------------|
| =====  |        |         |         |               |
| 10.003 | 0.065  | 13.402  | 0       | 0             |
| 10.003 | 0.685  | 13.403  | 0.46    | 89.979        |
| 10.003 | 1.36   | 13.404  | 0.96    | 94.588        |
| 10.003 | 2.035  | 13.406  | 1.46    | 96.152        |
| 10.003 | 2.715  | 13.408  | 1.96    | 96.765        |
| 10.002 | 3.395  | 13.409  | 2.46    | 97.142        |
| 10.003 | 4.08   | 13.411  | 2.96    | 97.266        |
| 10.002 | 4.765  | 13.412  | 3.46    | 97.369        |
| 10.002 | 5.46   | 13.413  | 3.96    | 97.262        |
| 10.002 | 6.155  | 13.415  | 4.46    | 97.188        |
| 10.002 | 6.85   | 13.416  | 4.96    | 97.124        |

| Vin(V) | Iin(A) | Vout(V) | Iout(A) | Efficiency(%) |
|--------|--------|---------|---------|---------------|
| =====  |        |         |         |               |
| 13.004 | 0.04   | 13.394  | 0       | 0             |
| 13.004 | 0.51   | 13.396  | 0.46    | 92.915        |
| 13.004 | 1.03   | 13.398  | 0.96    | 96.028        |
| 13.003 | 1.55   | 13.4    | 1.46    | 97.069        |
| 13.003 | 2.07   | 13.401  | 1.96    | 97.584        |
| 13.004 | 2.59   | 13.403  | 2.46    | 97.895        |
| 13.003 | 3.11   | 13.404  | 2.96    | 98.112        |
| 13.003 | 3.635  | 13.406  | 3.46    | 98.136        |
| 13.003 | 4.165  | 13.407  | 3.96    | 98.032        |
| 13.003 | 4.69   | 13.408  | 4.46    | 98.058        |
| 13.003 | 5.215  | 13.409  | 4.96    | 98.08         |

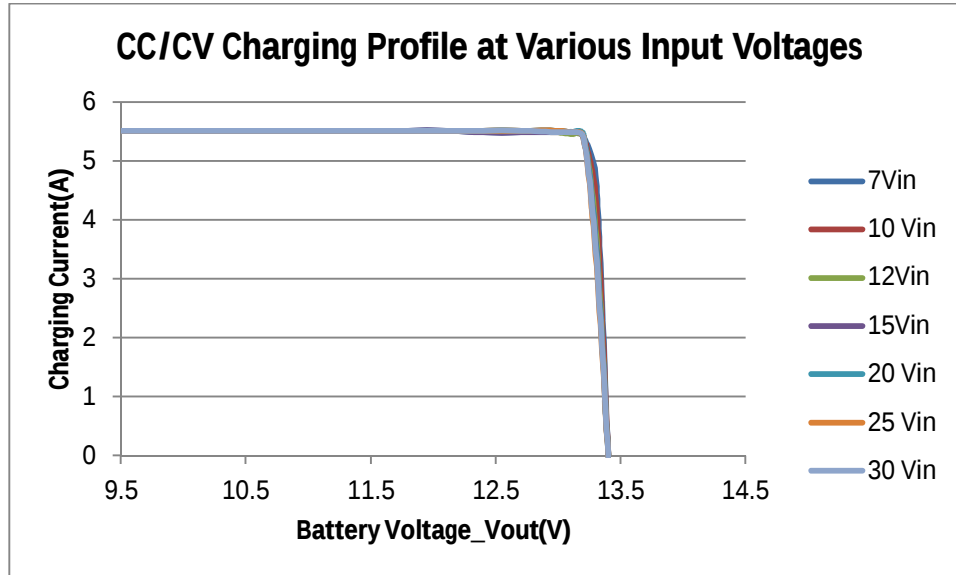
| Vin(V) | Iin(A) | Vout(V) | Iout(A) | Efficiency(%) |
|--------|--------|---------|---------|---------------|
| =====  |        |         |         |               |
| 20.01  | 0.03   | 13.394  | 0       | 0             |
| 20.01  | 0.335  | 13.395  | 0.46    | 91.92         |
| 20.01  | 0.335  | 13.395  | 0.46    | 91.92         |
| 20.01  | 1.02   | 13.398  | 1.46    | 95.84         |
| 20.01  | 1.36   | 13.399  | 1.96    | 96.503        |
| 20.01  | 1.695  | 13.4    | 2.46    | 97.19         |
| 20.009 | 2.035  | 13.401  | 2.96    | 97.418        |
| 20.009 | 2.375  | 13.403  | 3.46    | 97.586        |
| 20.009 | 2.715  | 13.404  | 3.96    | 97.709        |
| 20.009 | 3.055  | 13.405  | 4.46    | 97.806        |
| 20.009 | 3.4    | 13.406  | 4.96    | 97.741        |

| Vin(V) | Iin(A) | Vout(V) | Iout(A) | Efficiency(%) |
|--------|--------|---------|---------|---------------|
| =====  |        |         |         |               |
| 25.007 | 0.04   | 13.391  | 0       | 0             |
| 25.007 | 0.285  | 13.392  | 0.46    | 86.436        |
| 25.007 | 0.55   | 13.394  | 0.96    | 93.488        |
| 25.007 | 0.825  | 13.395  | 1.46    | 94.794        |
| 25.007 | 1.105  | 13.395  | 1.96    | 95.011        |
| 25.007 | 1.375  | 13.395  | 2.46    | 95.833        |
| 25.007 | 1.645  | 13.396  | 2.96    | 96.392        |
| 25.007 | 1.92   | 13.398  | 3.46    | 96.55         |
| 25.007 | 2.195  | 13.399  | 3.96    | 96.665        |
| 25.007 | 2.465  | 13.4    | 4.46    | 96.953        |
| 25.006 | 2.74   | 13.401  | 4.96    | 97.012        |

| Vin(V) | Iin(A) | Vout(V) | Iout(A) | Efficiency(%) |
|--------|--------|---------|---------|---------------|
| =====  |        |         |         |               |
| 33.014 | 0.045  | 13.394  | 0       | 0             |
| 33.014 | 0.23   | 13.394  | 0.46    | 81.141        |
| 33.014 | 0.435  | 13.395  | 0.96    | 89.542        |
| 33.014 | 0.64   | 13.396  | 1.46    | 92.566        |
| 33.014 | 0.845  | 13.396  | 1.96    | 94.119        |
| 33.014 | 1.06   | 13.396  | 2.46    | 94.169        |
| 33.014 | 1.275  | 13.395  | 2.96    | 94.195        |
| 33.014 | 1.48   | 13.395  | 3.46    | 94.855        |
| 33.014 | 1.685  | 13.396  | 3.96    | 95.361        |
| 33.013 | 1.895  | 13.396  | 4.46    | 95.503        |
| 33.013 | 2.1    | 13.397  | 4.96    | 95.848        |

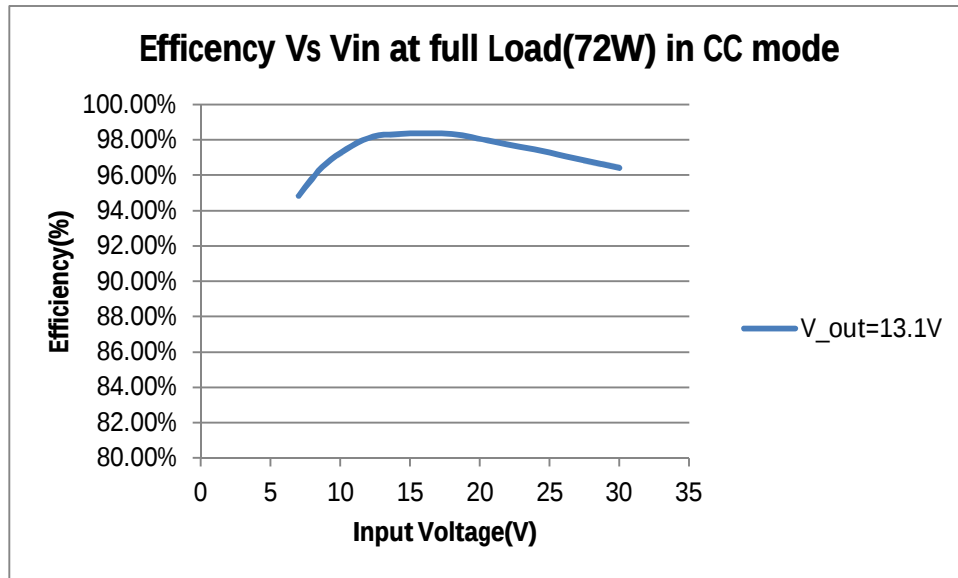
## 6. Battery Charging CC/CV profile and Efficiency data in CC mode .

The CC/CV profile was tested by Sweeping Vout (using CV mode Load) between 10.8-15V at Various Input Voltage.



| Vin (V) | Vout(V) | Charging Current(A) |  | Vin (V) | Vout(V) | Charging Current(A) |
|---------|---------|---------------------|--|---------|---------|---------------------|
| 12      | 9.5     | 5.52                |  | 20      | 9.5     | 5.52                |
| 12      | 9.8     | 5.52                |  | 20      | 9.8     | 5.52                |
| 12      | 10.1    | 5.52                |  | 20      | 10.1    | 5.52                |
| 12      | 10.4    | 5.52                |  | 20      | 10.4    | 5.52                |
| 12      | 10.7    | 5.52                |  | 20      | 10.7    | 5.52                |
| 12      | 11.1    | 5.52                |  | 20      | 11.1    | 5.52                |
| 12      | 11.5    | 5.52                |  | 20      | 11.5    | 5.52                |
| 12      | 11.8    | 5.52                |  | 20      | 11.8    | 5.52                |
| 12      | 12.1    | 5.52                |  | 20      | 12.1    | 5.52                |
| 12      | 12.4    | 5.52                |  | 20      | 12.4    | 5.52                |
| 12      | 12.7    | 5.52                |  | 20      | 12.7    | 5.52                |
| 12      | 13      | 5.49                |  | 20      | 13      | 5.52                |
| 12      | 13.1    | 5.46                |  | 20      | 13.1    | 5.49                |
| 12      | 13.2    | 5.42                |  | 20      | 13.2    | 5.46                |
| 12      | 13.3    | 3.84                |  | 20      | 13.3    | 3.6                 |
| 12      | 13.4    | 0                   |  | 20      | 13.4    | 0                   |

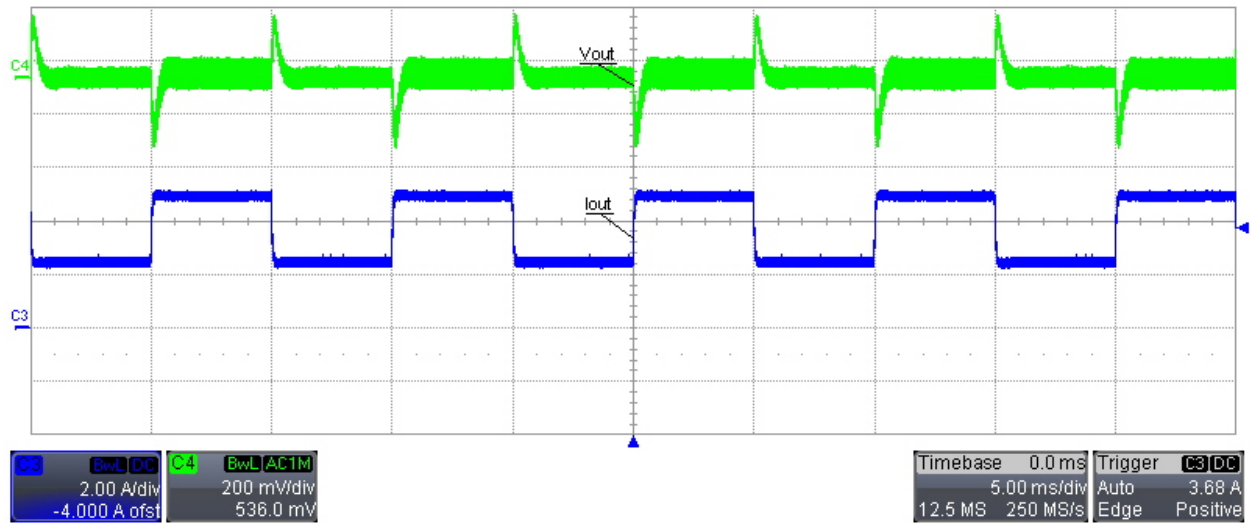
| Vin (V) | Vout(V) | Charging<br>Current(A) |  | Vin (V) | Vout(V) | Charging<br>Current(A) |
|---------|---------|------------------------|--|---------|---------|------------------------|
| 15      | 9.5     | 5.52                   |  | 25      | 9.5     | 5.52                   |
| 15      | 9.8     | 5.52                   |  | 25      | 9.8     | 5.52                   |
| 15      | 10.1    | 5.52                   |  | 25      | 10.1    | 5.52                   |
| 15      | 10.4    | 5.52                   |  | 25      | 10.4    | 5.52                   |
| 15      | 10.7    | 5.52                   |  | 25      | 10.7    | 5.52                   |
| 15      | 11.1    | 5.52                   |  | 25      | 11.1    | 5.52                   |
| 15      | 11.5    | 5.52                   |  | 25      | 11.5    | 5.52                   |
| 15      | 11.8    | 5.52                   |  | 25      | 11.8    | 5.52                   |
| 15      | 12.1    | 5.52                   |  | 25      | 12.1    | 5.52                   |
| 15      | 12.4    | 5.49                   |  | 25      | 12.4    | 5.52                   |
| 15      | 12.7    | 5.49                   |  | 25      | 12.7    | 5.52                   |
| 15      | 13      | 5.49                   |  | 25      | 13      | 5.52                   |
| 15      | 13.1    | 5.49                   |  | 25      | 13.1    | 5.49                   |
| 15      | 13.2    | 5.42                   |  | 25      | 13.2    | 5.43                   |
| 15      | 13.3    | 3.64                   |  | 25      | 13.3    | 3.4                    |
| 15      | 13.4    | 0                      |  | 25      | 13.4    | 0                      |
|         |         |                        |  |         |         |                        |
| Vin (V) | Vout(V) | Charging<br>Current(A) |  | Vin (V) | Vout(V) | Charging<br>Current(A) |
| 30      | 9.5     | 5.52                   |  | 10      | 9.5     | 5.52                   |
| 30      | 9.8     | 5.52                   |  | 10      | 9.8     | 5.52                   |
| 30      | 10.1    | 5.52                   |  | 10      | 10.1    | 5.52                   |
| 30      | 10.4    | 5.52                   |  | 10      | 10.4    | 5.52                   |
| 30      | 10.7    | 5.52                   |  | 10      | 10.7    | 5.52                   |
| 30      | 11.1    | 5.52                   |  | 10      | 11.1    | 5.52                   |
| 30      | 11.5    | 5.52                   |  | 10      | 11.5    | 5.52                   |
| 30      | 11.8    | 5.52                   |  | 10      | 11.8    | 5.52                   |
| 30      | 12.1    | 5.52                   |  | 10      | 12.1    | 5.52                   |
| 30      | 12.4    | 5.52                   |  | 10      | 12.4    | 5.52                   |
| 30      | 12.7    | 5.52                   |  | 10      | 12.7    | 5.52                   |
| 30      | 13      | 5.49                   |  | 10      | 13      | 5.49                   |
| 30      | 13.1    | 5.49                   |  | 10      | 13.1    | 5.49                   |
| 30      | 13.2    | 5.42                   |  | 10      | 13.2    | 5.42                   |
| 30      | 13.3    | 3.5                    |  | 10      | 13.3    | 4.38                   |
| 30      | 13.4    | 0                      |  | 10      | 13.4    | 0                      |



| Vin(V) | Iin(A) | Vout(V) | Iout(A) | Efficiency(%) |
|--------|--------|---------|---------|---------------|
| =====  |        |         |         |               |
| 7      | 10.86  | 13.157  | 5.48    | 94.84%        |
| 9      | 8.3    | 13.157  | 5.49    | 96.70%        |
| 12     | 6.135  | 13.157  | 5.49    | 98.11%        |
| 15     | 4.922  | 13.157  | 5.52    | 98.37%        |
| 18     | 4.103  | 13.157  | 5.52    | 98.34%        |
| 21     | 3.532  | 13.157  | 5.52    | 97.92%        |
| 25     | 2.986  | 13.157  | 5.52    | 97.29%        |
| 30     | 2.506  | 13.157  | 5.51    | 96.43%        |

## 7 Waveforms – Constant Voltage Output

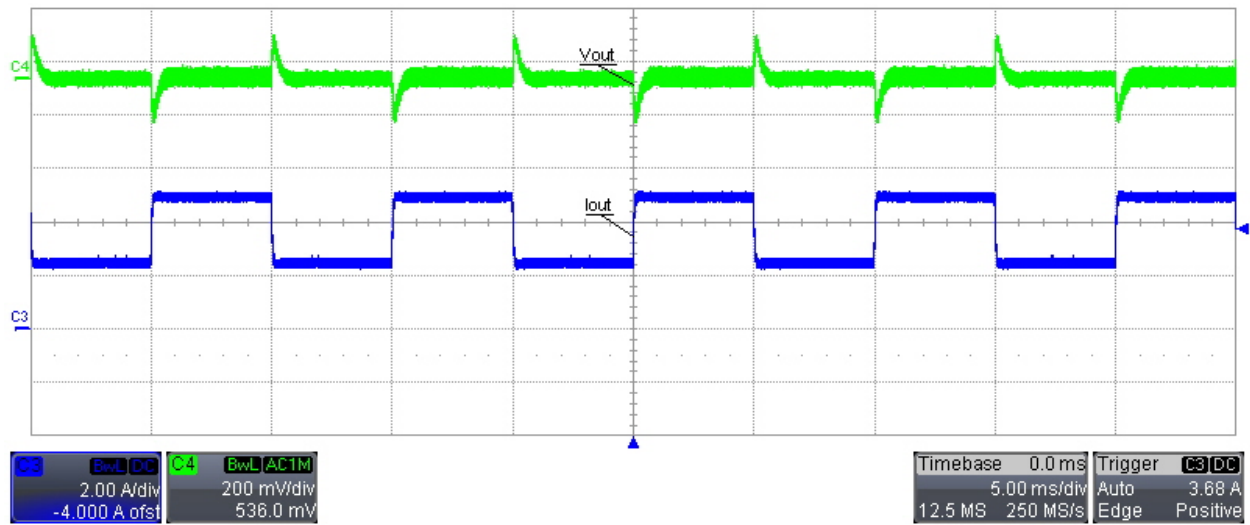
### 7.1 Load Transient Response



Load Transient Response at 7 Vin and 50%-to-100% (2.5A-to-5A) Load Step on 13.4V Output Voltage

Ch4 – Vout1 (AC coupled)

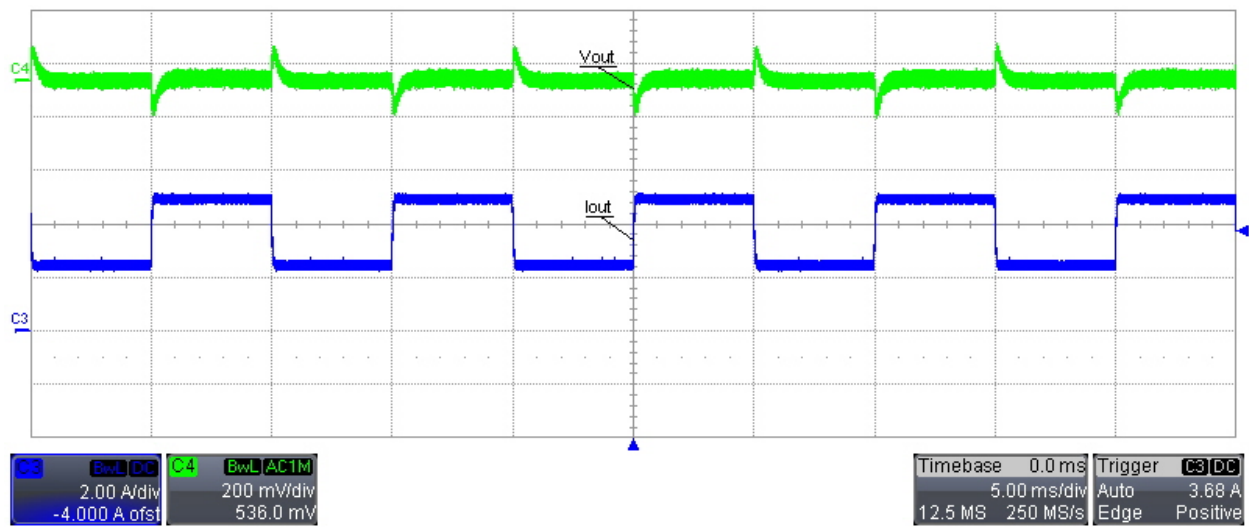
Ch3 - Iout 1



Load Transient Response at 13 Vin and 50%-to-100% (2.5A-to-5A) Load Step on 13.4V Output Voltage

Ch4 – Vout1 (AC coupled)

Ch3 - Iout 1

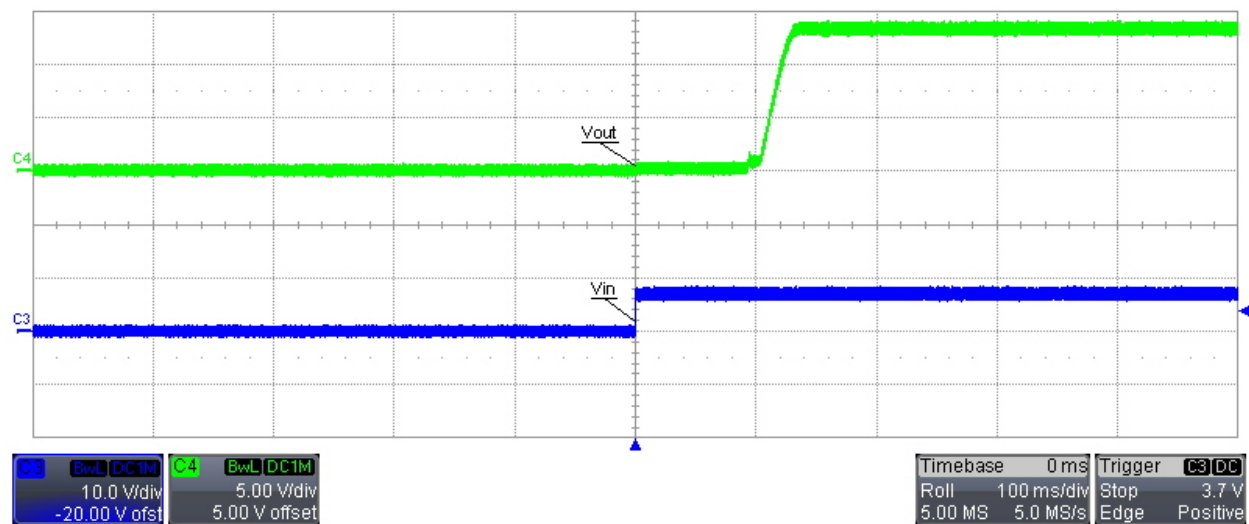


Load Transient Response at 25 Vin and 50%-to-100% (2.5A-to-5A) Load Step on 13.4V Output Voltage

Ch4 – Vout1 (AC coupled)

Ch3 - Iout 1

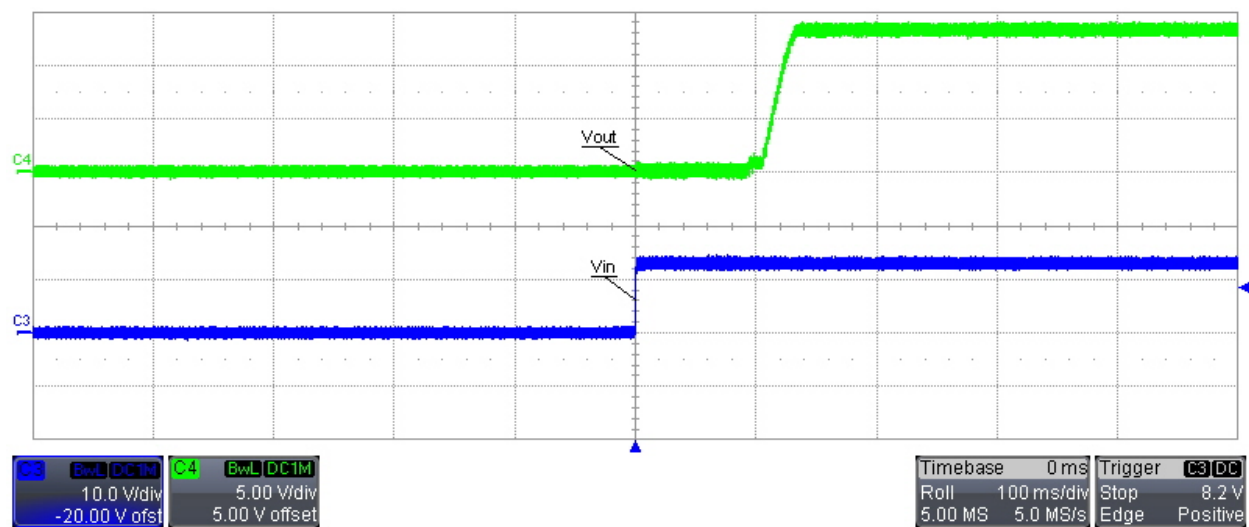
## 7.2 Startup



Startup into Full Load at 7 Vin (Iout=5A)

Ch3-Vin

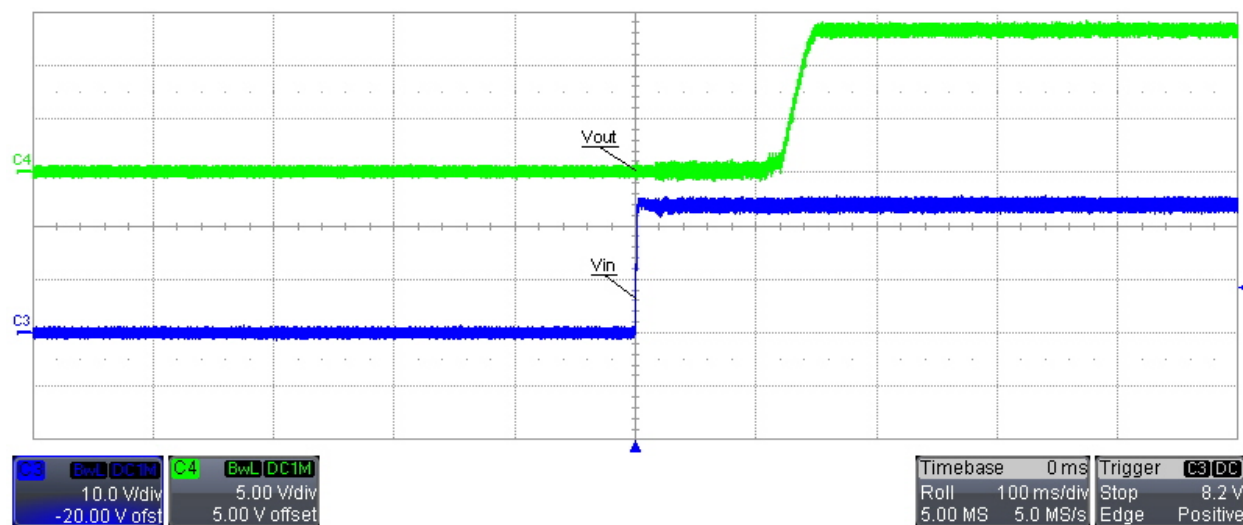
Ch4-Vout



Startup into Full Load at 13 Vin ( Iout=5A)

Ch3-Vin

Ch4-Vout

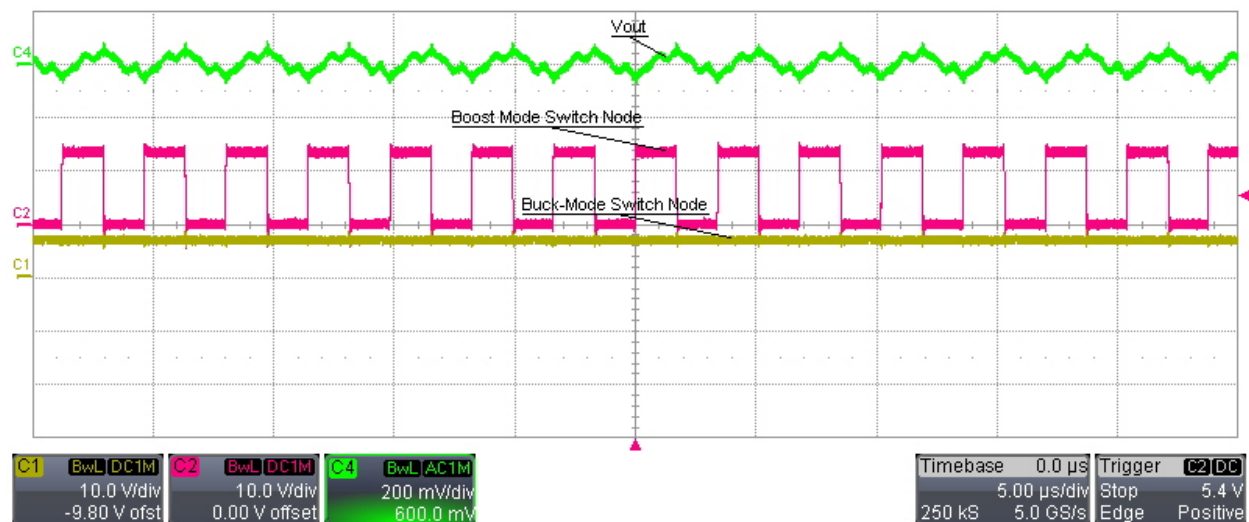


Startup into Full Load at 25 Vin ( Iout=5A)

Ch3-Vin

Ch4-Vout

### 7.3 Output Voltage Ripple and Switch Node Voltage

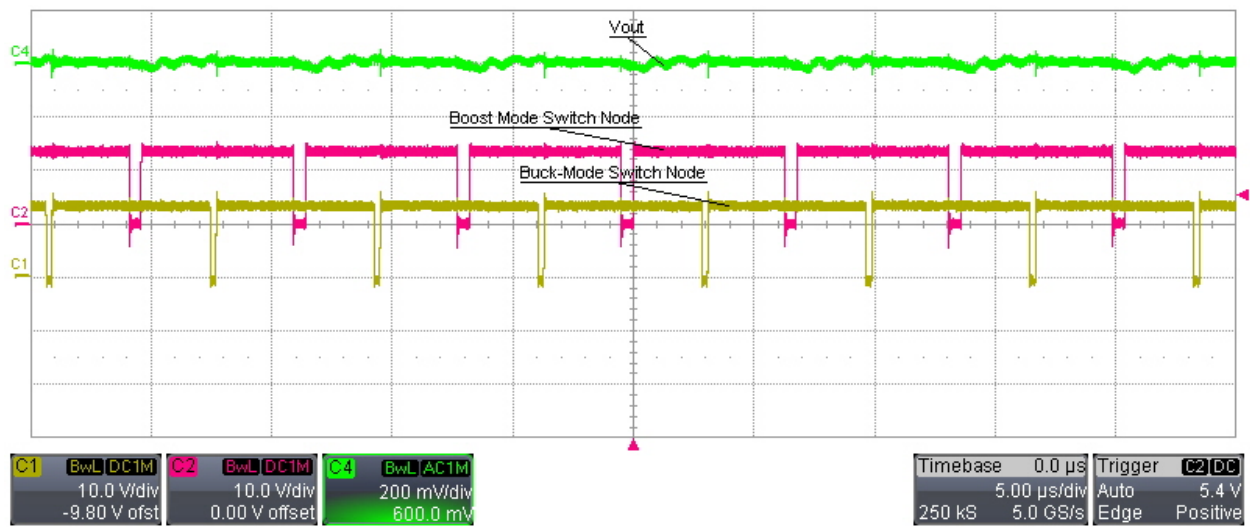


Switch Node Voltage and Output Voltage Ripple at 7 Vin and Full (5A) Load on the output.

Ch4-Output Voltage Ripple

Ch2-Boost Switch node

Ch1- Buck Switch node

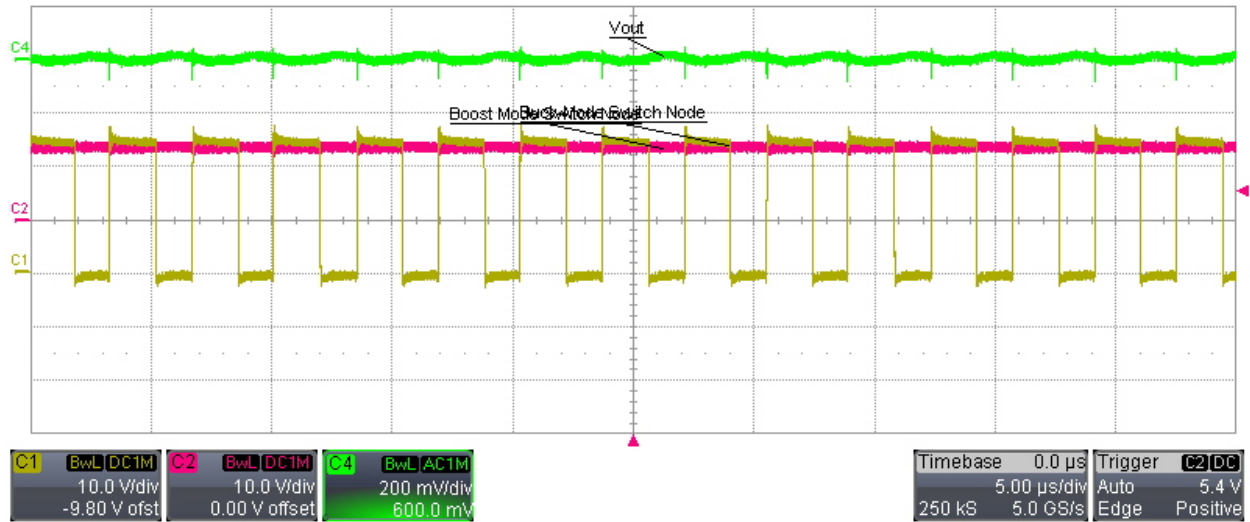


Switch Node Voltage and Output Voltage Ripple at 13 Vin and Full (5A) Load on the output.

Ch4-Output Voltage Ripple

Ch2-Boost Switch node

Ch1- Buck Switch node



Switch Node Voltage and Output Voltage Ripple at 25 Vin and Full (5A) Load on the output.

Ch4-Output Voltage Ripple

Ch2-Boost Switch node

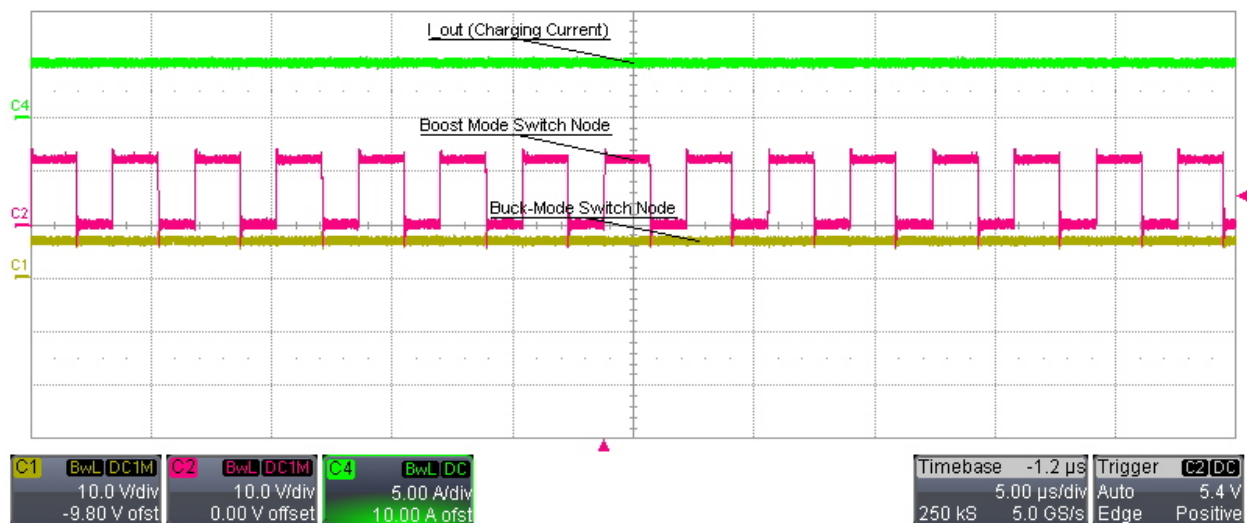
Ch1- Buck Switch node

## 8. CC/CV Battery Profiling /LED Driver

The CC/CV battery profiling is achieved through IC's average output Current regulation loop ie a slow Constant Current (CC) control loop becomes active and starts discharging the soft-start capacitor to regulate the drop across the output current sense Resistor.

The Current Regulation is achieved by placing R1=9 milliohm resistance to sense the output current such that 5.5 A output current cause the sensed voltage across the ISNS (+) and ISNS (-) pins to reach 50 mV.

### 8.1 Switch Waveforms- CC Mode

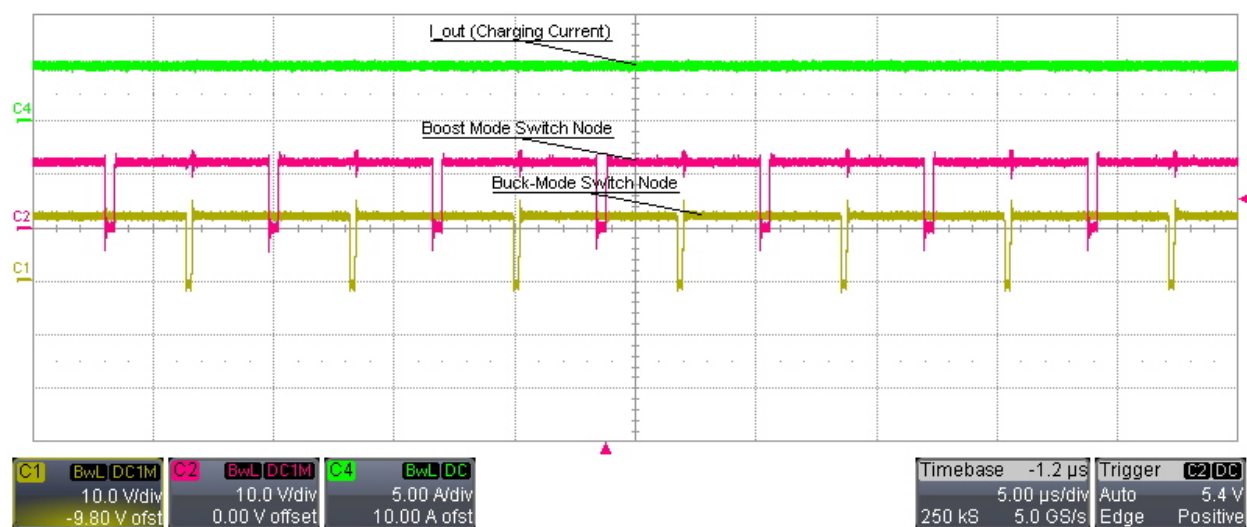


Switch Node Voltage and Charging current at 7 Vin and 12V Vout .

Ch4-Output Charging Current

Ch2-Boost Switch node

Ch1- Buck Switch node

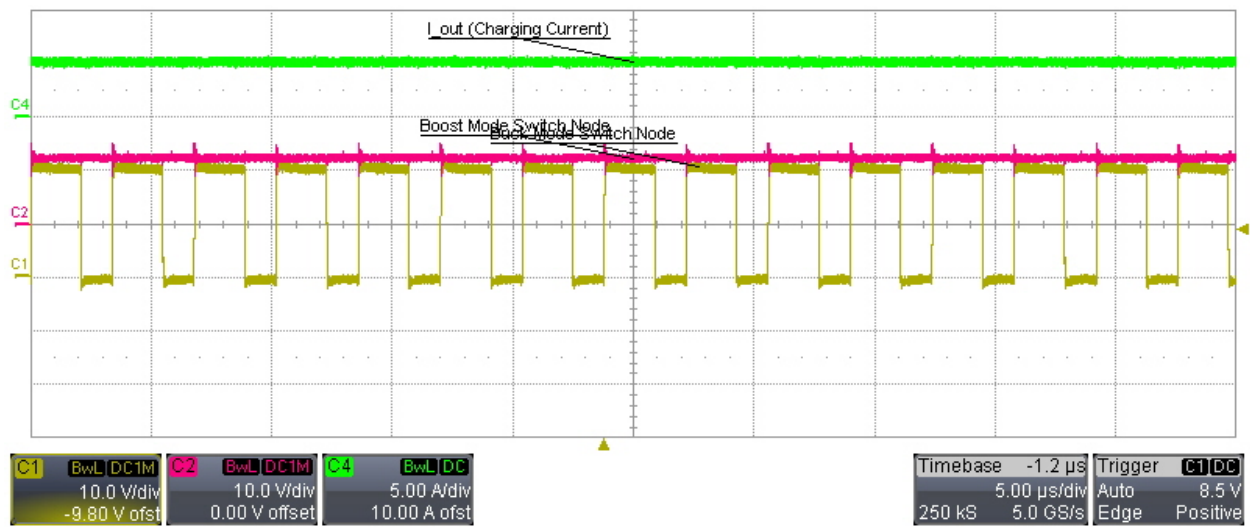


Switch Node Voltage and Charging current at 12 Vin and 12V Vout .

Ch4-Output Charging Current

Ch2-Boost Switch node

Ch1- Buck Switch node

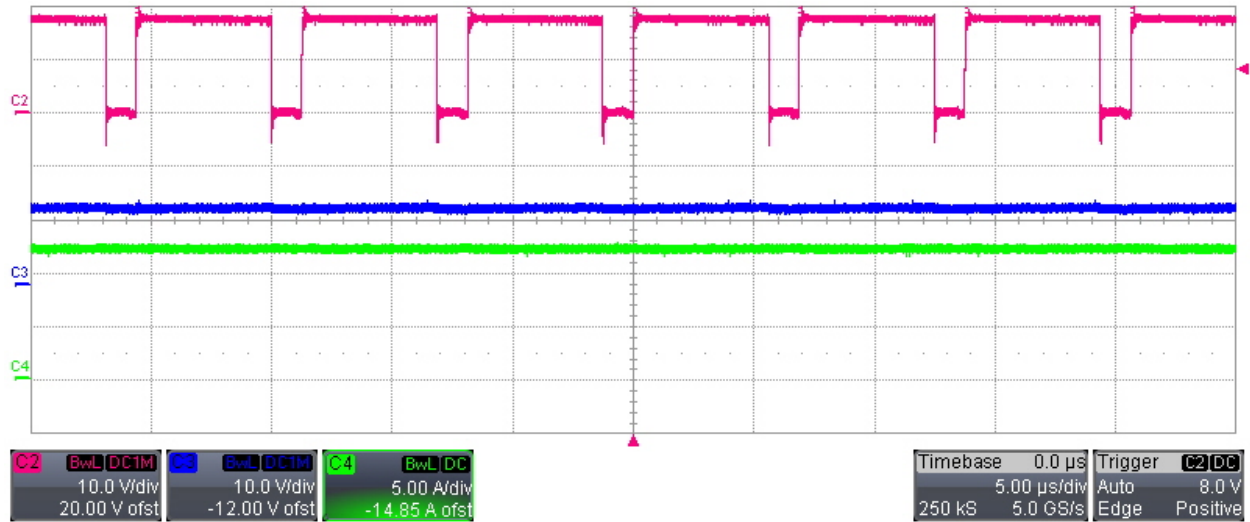


Switch Node Voltage and Charging current at 20 Vin and 12V Vout .

Ch4-Output Charging Current

Ch2-Boost Switch node

Ch1- Buck Switch node



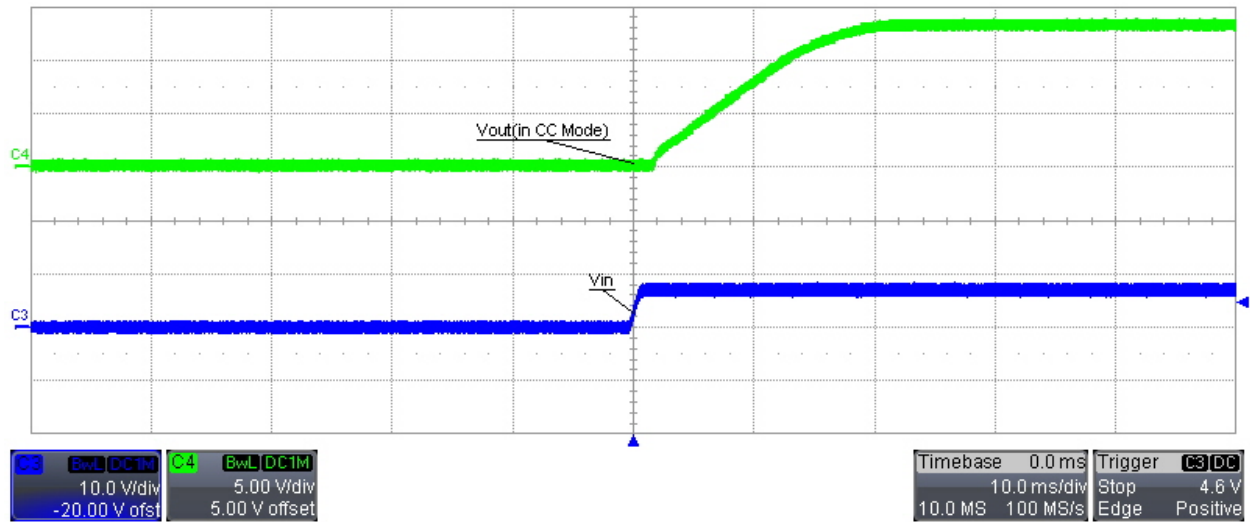
Switch Node Voltage and Charging current at 15 VIN.

Ch4-Output Charging Current

Ch3-Boost Switch node

Ch2- Buck Switch node

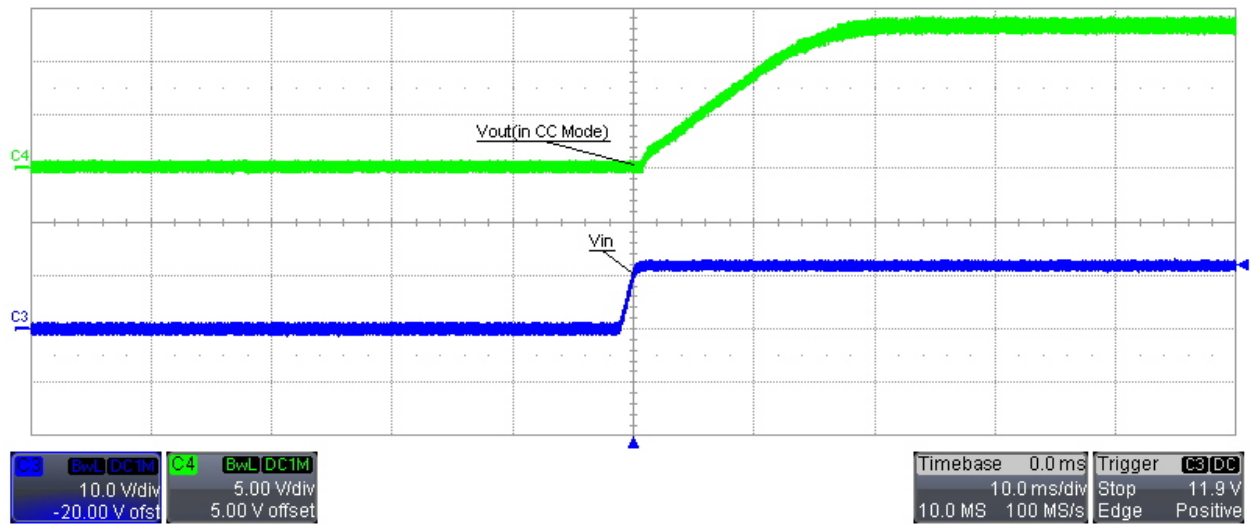
## 8.2 Startup- CC Mode



Startup into Full Load at 7 Vin- CC mode ( Iout=5.5A)

Ch3-Vin

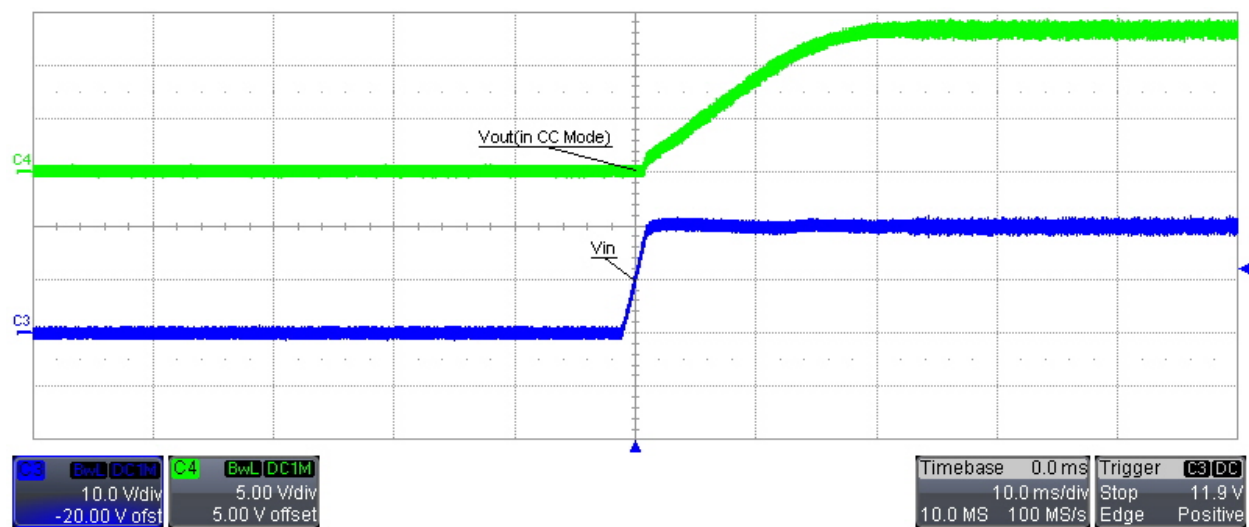
Ch4-Vout



Startup into Full Load at 12 Vin- CC mode ( Iout=5.5A)

Ch3-Vin

Ch4-Vout



Startup into Full Load at 20 Vin- CC mode ( Iout=5.5A)

Ch3-Vin

Ch4-Vout

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