# LM27403 Synchronous Buck Converter

## TI reference design number: PMP7935 Rev B

## Input: 12V
## Output: 0.9V @ 45A

## DC – DC Test Results

# Table of Contents

# 1 Circuit Description

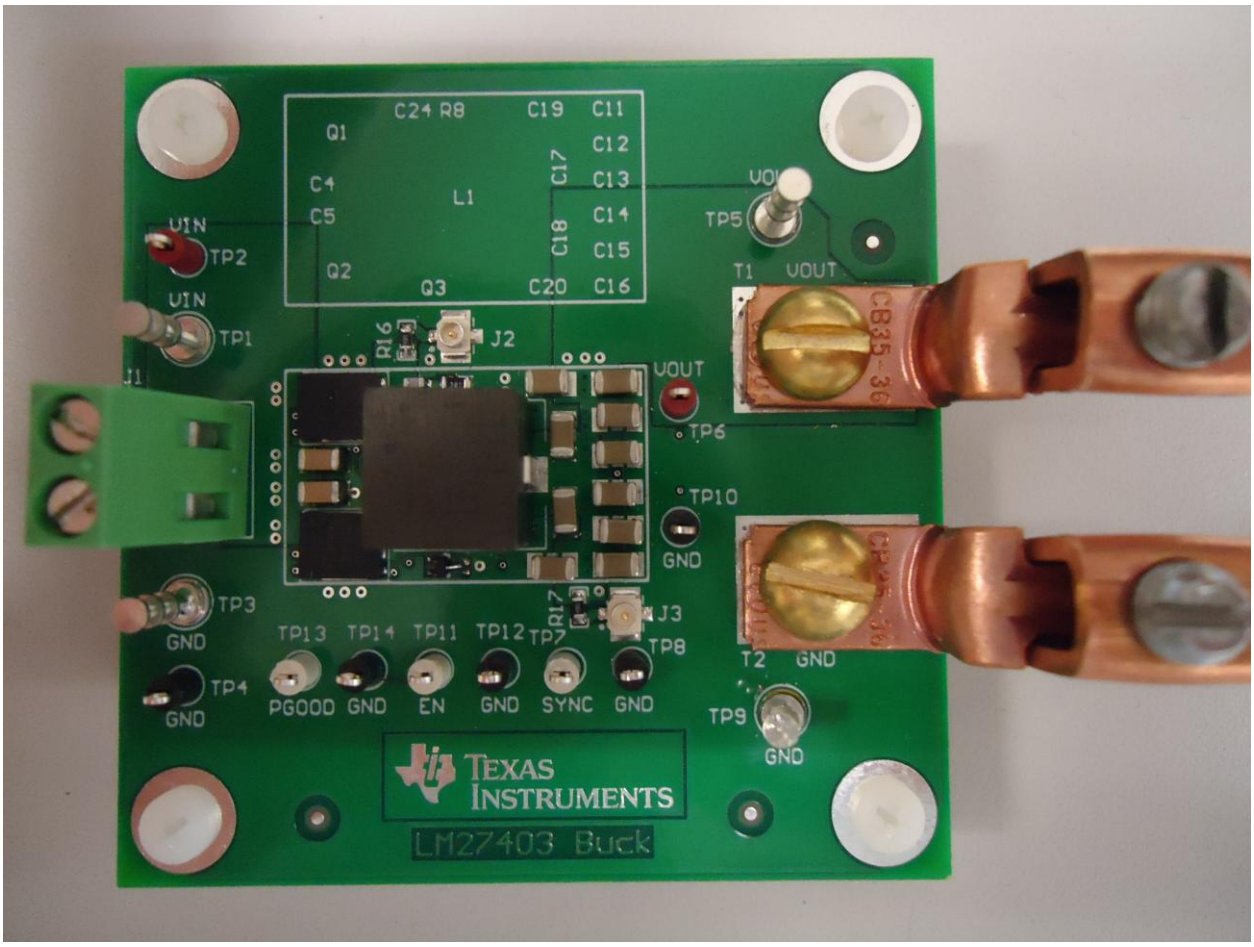
PMP7935 is a single-phase synchronous buck converter rated for 0.9V output at 45A from an input voltage of 12V. This design uses the LM27403 synchronous buck controller at a switching frequency of 300 kHz. CSD87350Q5D power block MOSFETs provide maximum efficiency when combined with a 250 nH ferrite output inductor. The design solution uses all ceramic capacitors to fit into a minimum board area.

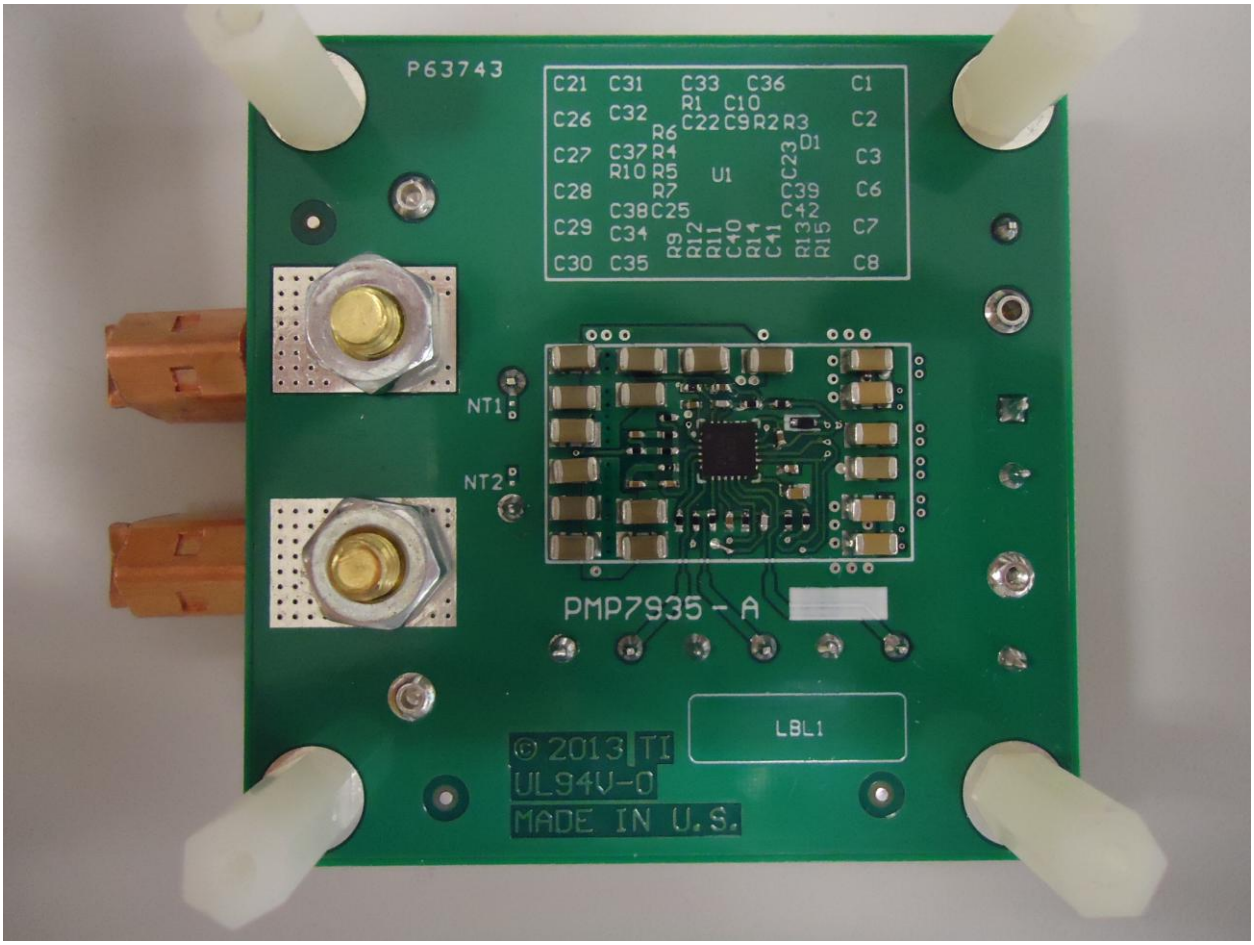
The effective output capacitance with dc bias and operating conditions is 1250 µF out of the total 2200 µF. With no external output capacitance, the output voltage transient is 60 mV for a load step of 20A. Adding an additional 16 x 100 µF ceramic or 4 x 330 µF polymer aluminum reduces the output voltage transient to 30 mV for the 20A load step. In general any combination of output capacitors greater than 2200 µF with less than 0.5 mΩ effective ESR will meet the 30 mV transient. For best performance, bulk polymers can be placed at the converter, with ceramic capacitors at the load.

At tests were performed at room temperature on an open bench. A 470 µF, 25V aluminum electrolytic input capacitor was used for input filter damping.

# 2 Photos

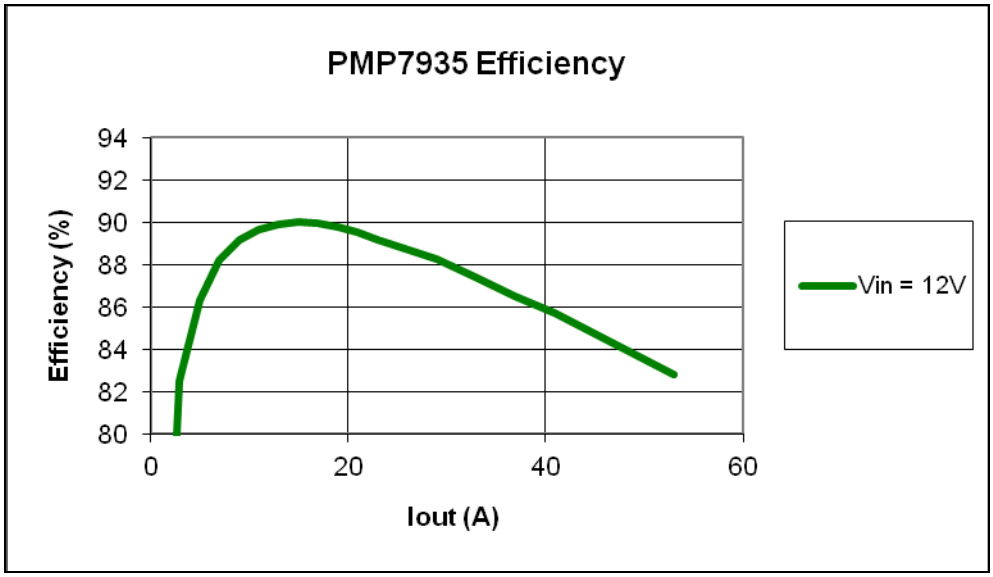
The photographs below show the PMP7935 Rev B assembly as built on PMP7935-A printed circuit board. This is a 4 layer board using 2 ounce copper on external layers and 1 ounce copper on internal layers. Power components are mounted on the top side of the board, with the control circuit on the bottom. The overall board dimensions are 2.5” x 2.5”. The solution size component area is 1.1” x 0.65”. The maximum component height is set by the inductor at 9.4 mm.




P63743
C21 C31 C33 C36 C1
R1 C10
C26 C32 C22 C9 R2 R3 C2
R6
C27 C37 R4 D1 C3
R10 R5 U1 C23
C28 R7 C39 C6
C38 C25 C42
C29 C34 R9 R12 R11 C40 R14 C41 R13 R15 C7
C30 C35 C8
NT1
NT2
PMP7935 - A
LBL1
© 2013 TI
UL94V-0
MADE IN U.S.

## 3 Efficiency

The efficiency data is shown in the tables and graph below.

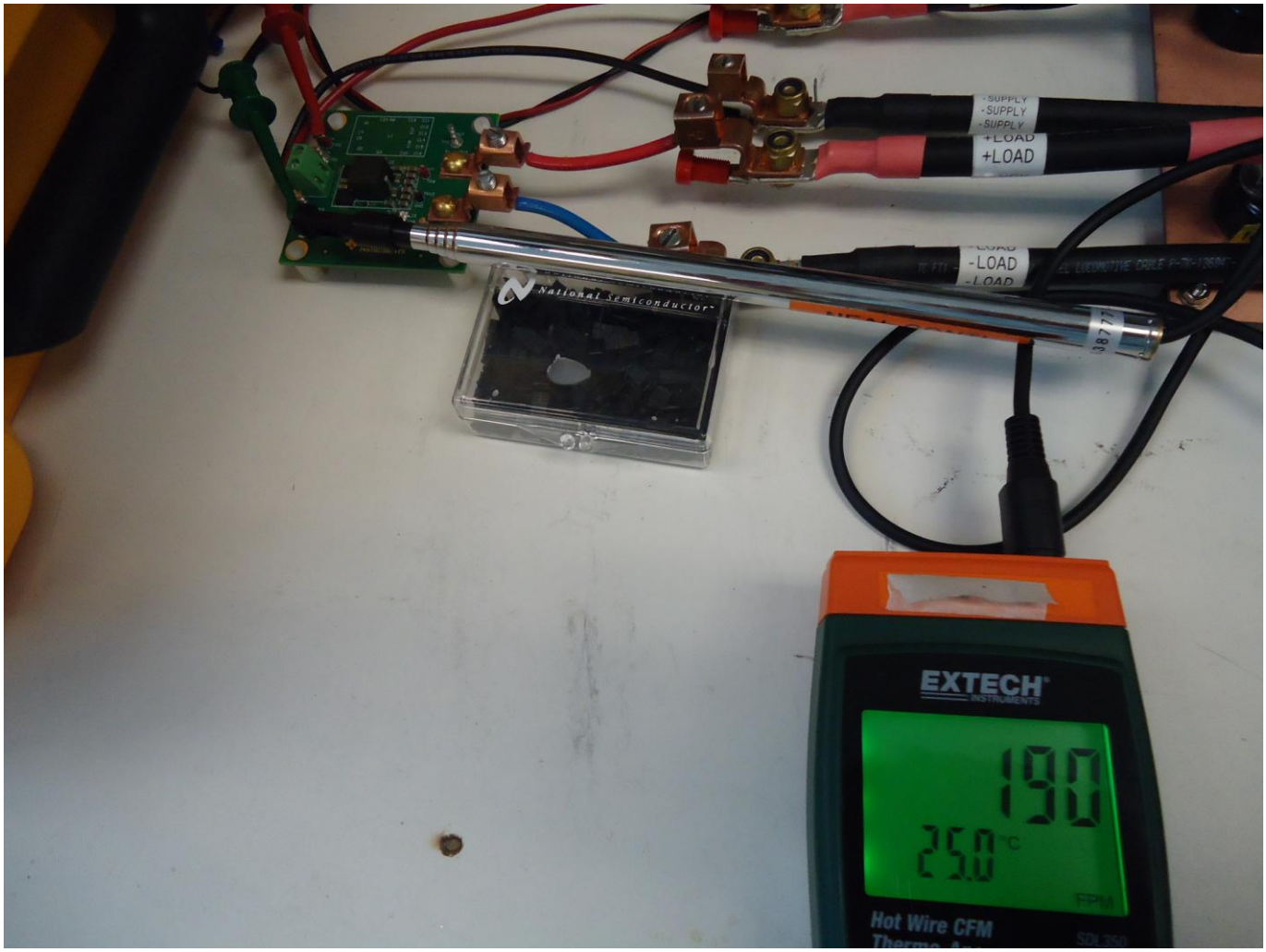



| Vin (V) | Iin (A) | Vout (V) | Iout (A) | Efficiency (%) | Pin (W) | Pout (W) | Losses (W) |
|---|---|---|---|---|---|---|---|
| 11.998 | 0.041 | 0.900 | 0.000 | 0.00 | 0.49 | 0.00 | 0.49 |
| 11.997 | 0.115 | 0.900 | 0.974 | 63.54 | 1.38 | 0.88 | 0.50 |
| 11.997 | 0.269 | 0.900 | 2.958 | 82.49 | 3.23 | 2.66 | 0.56 |
| 11.997 | 0.432 | 0.900 | 4.972 | 86.34 | 5.18 | 4.47 | 0.71 |
| 11.997 | 0.592 | 0.900 | 6.958 | 88.17 | 7.10 | 6.26 | 0.84 |
| 11.997 | 0.755 | 0.900 | 8.976 | 89.19 | 9.06 | 8.08 | 0.98 |
| 11.997 | 0.917 | 0.900 | 10.960 | 89.66 | 11.00 | 9.86 | 1.14 |
| 11.997 | 1.080 | 0.900 | 12.944 | 89.91 | 12.96 | 11.65 | 1.31 |
| 11.996 | 1.248 | 0.901 | 14.960 | 90.03 | 14.97 | 13.48 | 1.49 |
| 11.996 | 1.415 | 0.901 | 16.942 | 89.93 | 16.97 | 15.26 | 1.71 |
| 11.996 | 1.586 | 0.901 | 18.960 | 89.79 | 19.03 | 17.08 | 1.94 |
| 11.995 | 1.757 | 0.901 | 20.944 | 89.54 | 21.08 | 18.87 | 2.20 |
| 11.995 | 1.942 | 0.901 | 23.056 | 89.18 | 23.29 | 20.77 | 2.52 |
| 11.993 | 2.467 | 0.902 | 28.950 | 88.26 | 29.59 | 26.11 | 3.47 |
| 11.992 | 2.835 | 0.902 | 32.950 | 87.42 | 34.00 | 29.72 | 4.28 |
| 11.990 | 3.213 | 0.902 | 36.954 | 86.52 | 38.52 | 33.33 | 5.19 |
| 11.989 | 3.600 | 0.903 | 40.956 | 85.69 | 43.16 | 36.98 | 6.18 |
| 11.987 | 3.996 | 0.903 | 44.960 | 84.76 | 47.90 | 40.60 | 7.30 |
| 11.985 | 4.402 | 0.903 | 48.962 | 83.80 | 52.76 | 44.21 | 8.55 |
| 11.982 | 4.819 | 0.903 | 52.962 | 82.83 | 57.74 | 47.82 | 9.92 |
| 11.997 | 0.398 | 0.047 | 10.822 | 10.65 | 4.77 | 0.51 | 4.27 |

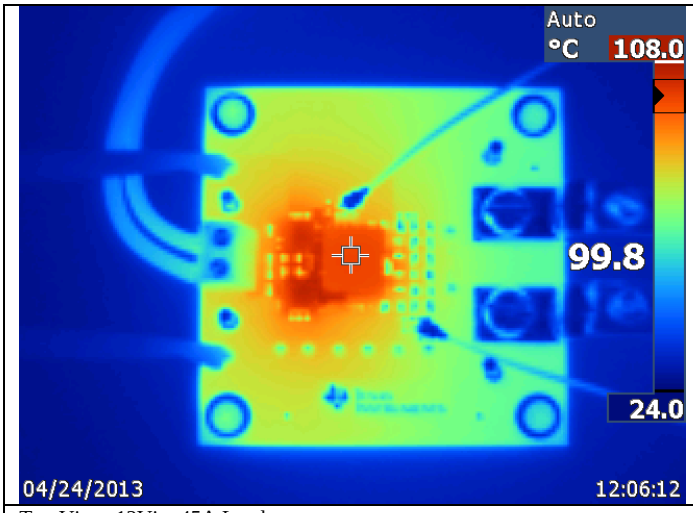
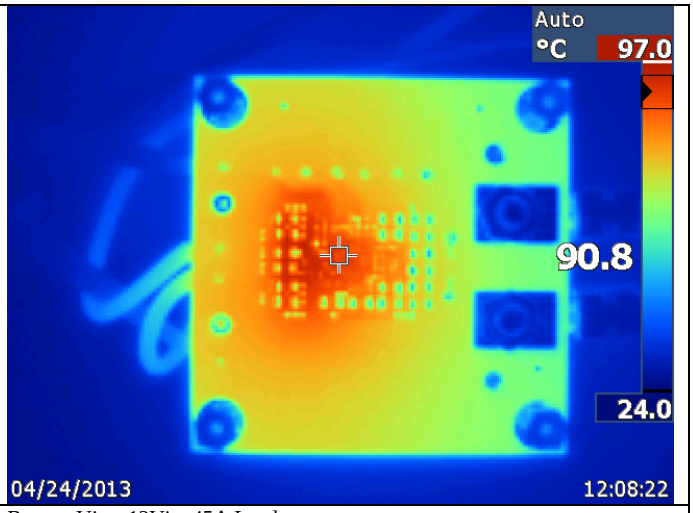
# 4 Thermal Tests

All tests were performed at room temperature on an open bench.

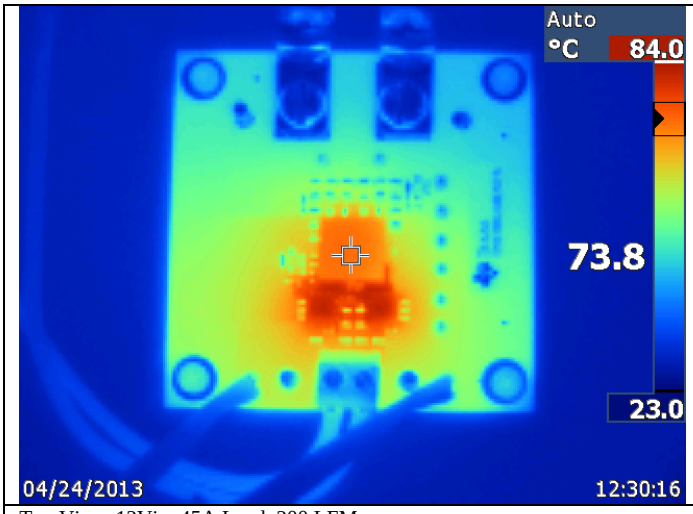
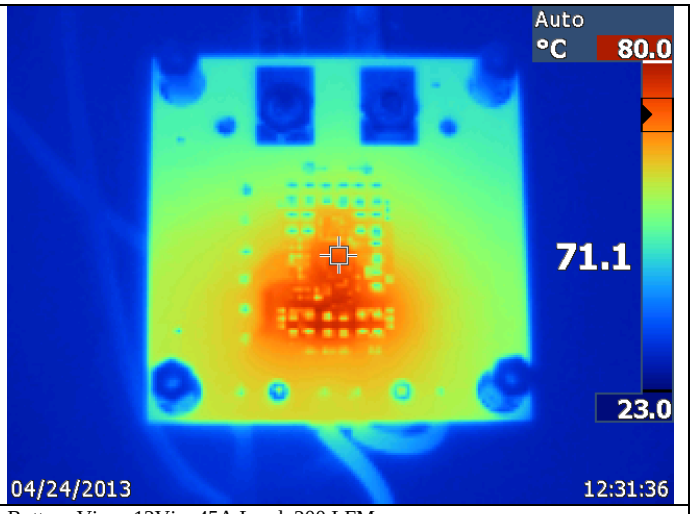
## *4.1 Test Setup*



### 4.2 45A Load, No Airflow

| | |
|---|---|
|  |  |
| Top View, 12Vin, 45A Load | Bottom View,12Vin, 45A Load |

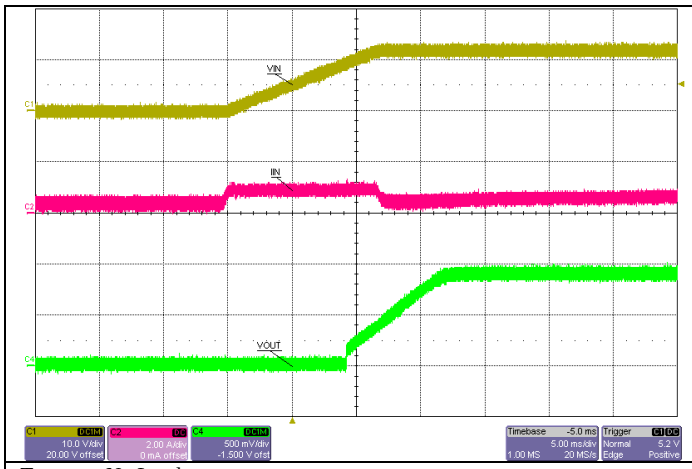
### 4.3 45A Load, 200 LFM Airflow

| | |
|---|---|
|  |  |
| Top View, 12Vin, 45A Load, 200 LFM | Bottom View, 12Vin, 45A Load, 200 LFM |

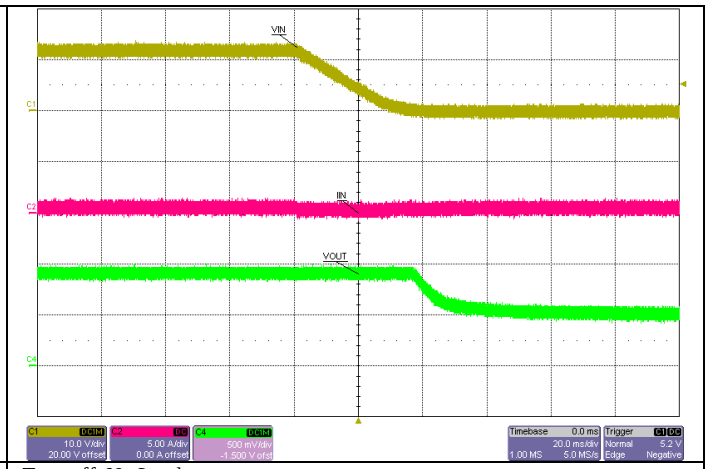
# 5 Startup and Shutdown Behavior

## 5.1 Turn-on and Turn-off from Vin

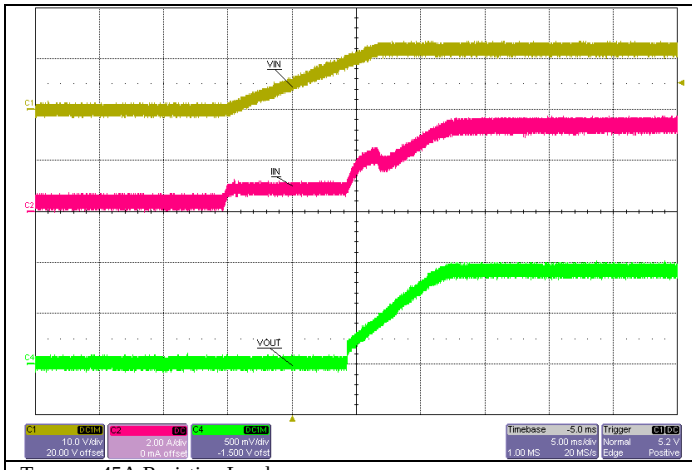
The output voltage is well controlled at turn-on, showing no evidence of over-shoot. Some ringing occurs at turn-off with load due to the output filter resonance.



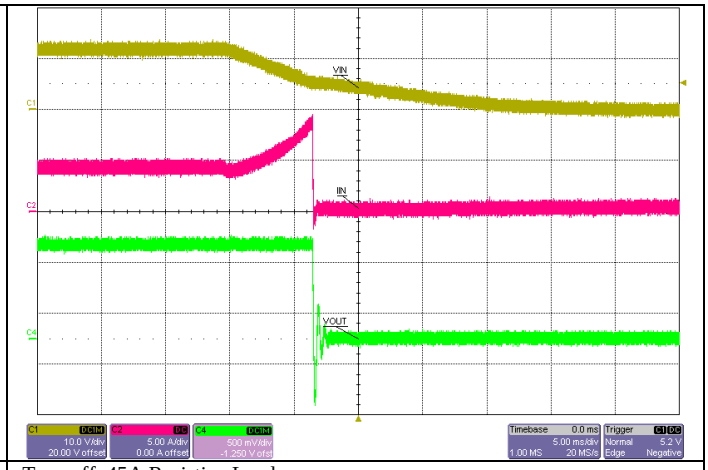

Turn-on, No Load




Turn-off, No Load



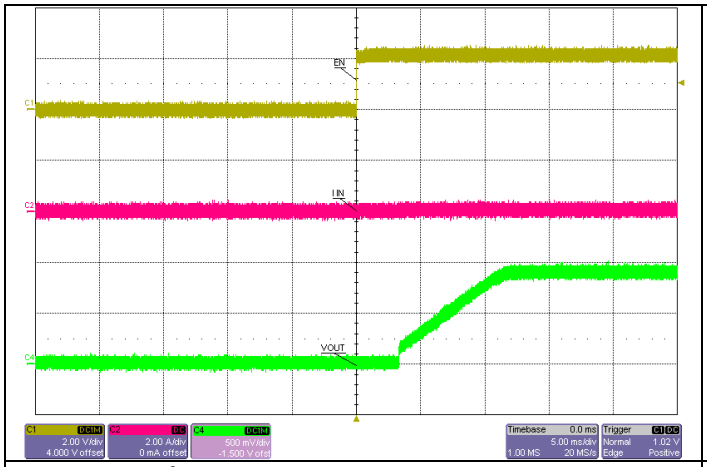

Turn-on, 45A Resistive Load



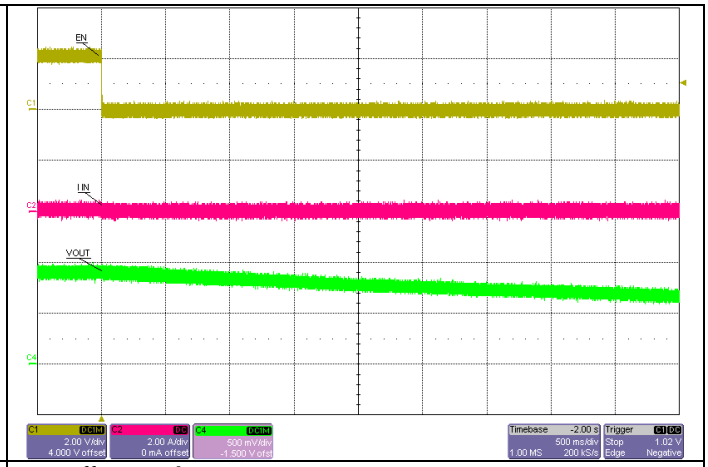

Turn-off, 45A Resistive Load

## 5.2 Turn-on and Turn-off from EN

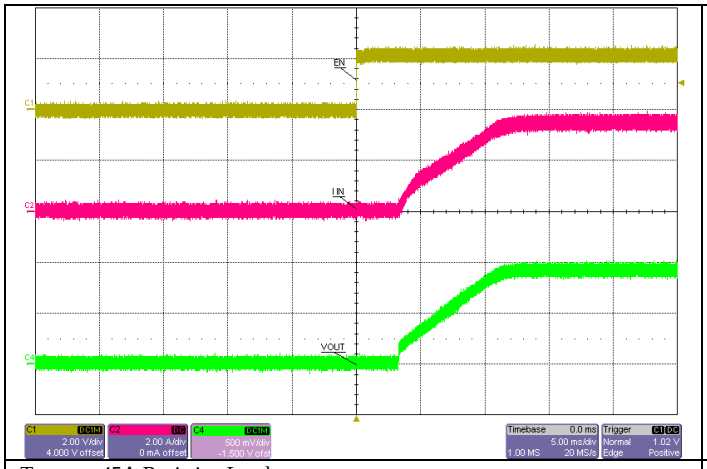
The output voltage is well controlled at turn-on, showing no evidence of over-shoot. Some ringing occurs at turn-off with load due to the output filter resonance.



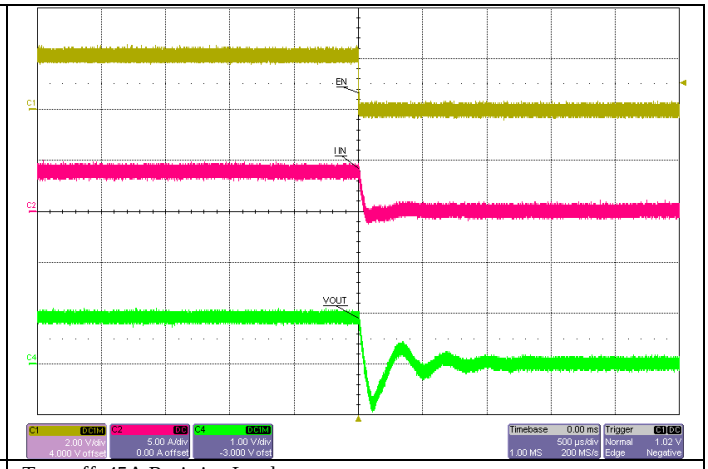

Turn-on, No Load




Turn-off, No Load




Turn-on, 45A Resistive Load

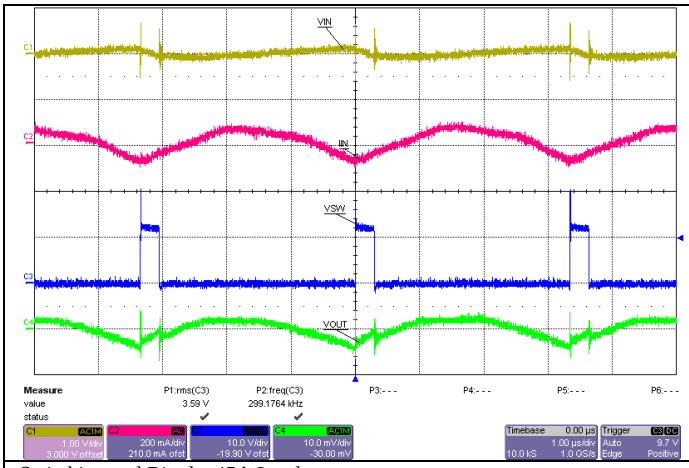



Turn-off, 45A Resistive Load

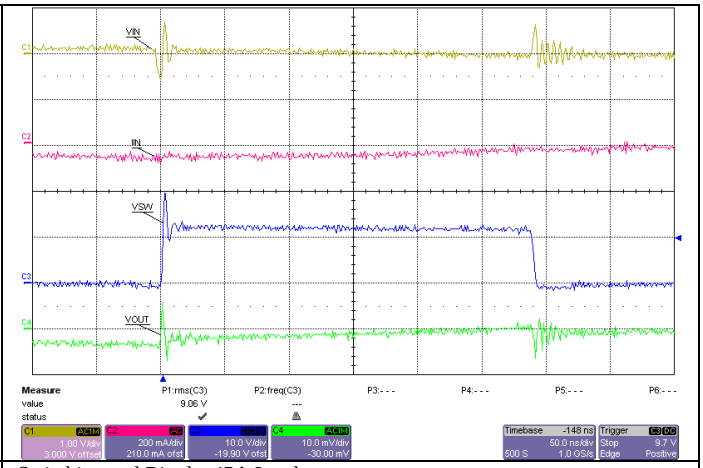
# 6 Switching and Ripple

## 6.1 Switching and Ripple

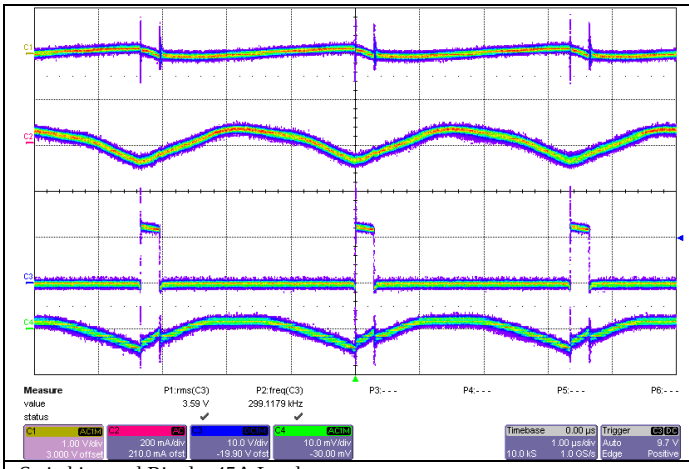
Switching and ripple tests were made with a 470 µF, 25V aluminum electrolytic input capacitor for input filter damping.




Switching and Ripple, 45A Load




Switching and Ripple, 45A Load



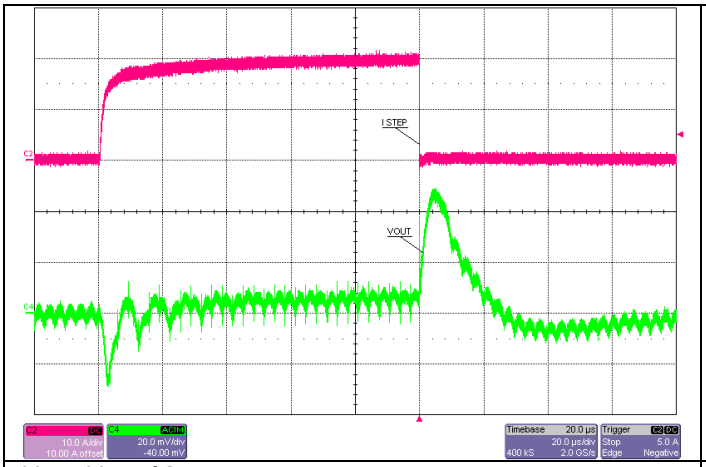

Switching and Ripple, 45A Load

# 7 Load Transient Response

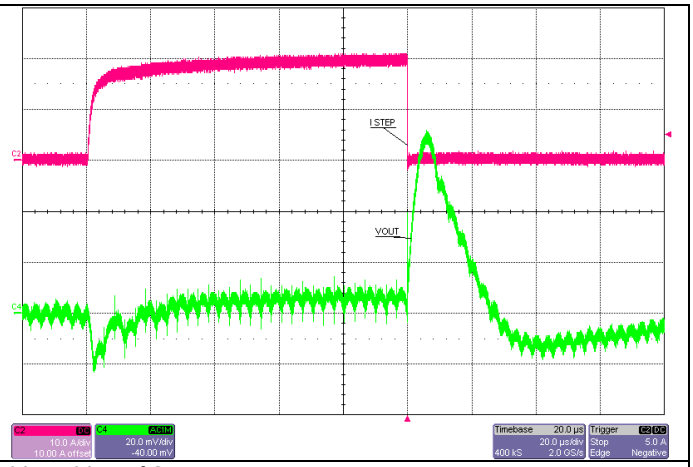
Load transient response for each condition was taken at two points to represent the minimum and maximum deviation. This difference occurs when the transient step coincides with either the converter off-time or on-time interval.

## 7.1 No External Output Capacitor

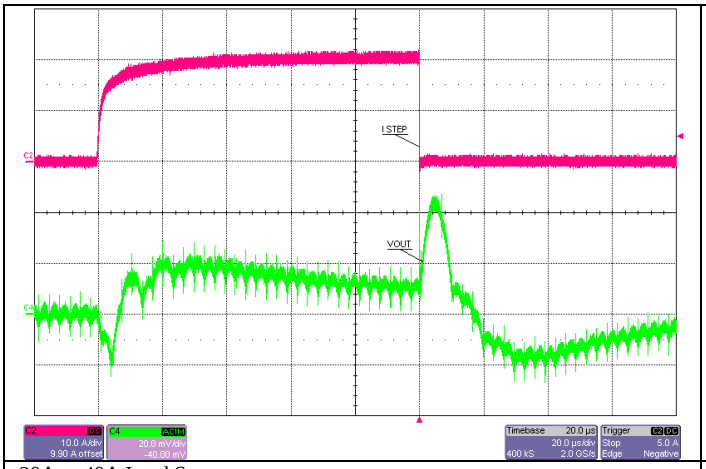
With no external capacitors, the output voltage transient is 60mV for a 20A load step.



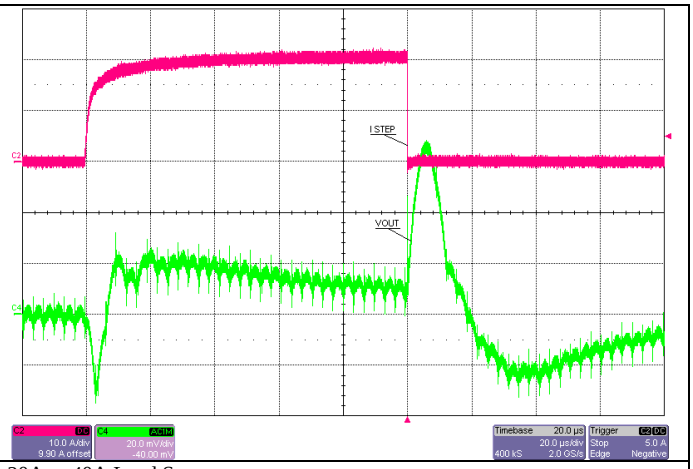

0A to 20A Load Step




0A to 20A Load Step



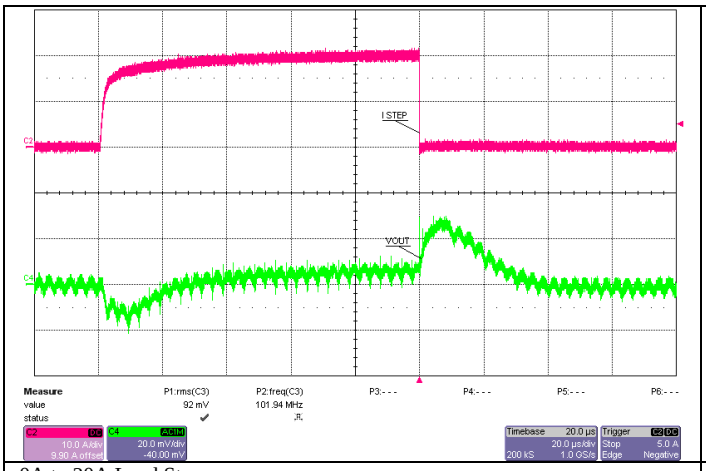

20A to 40A Load Step



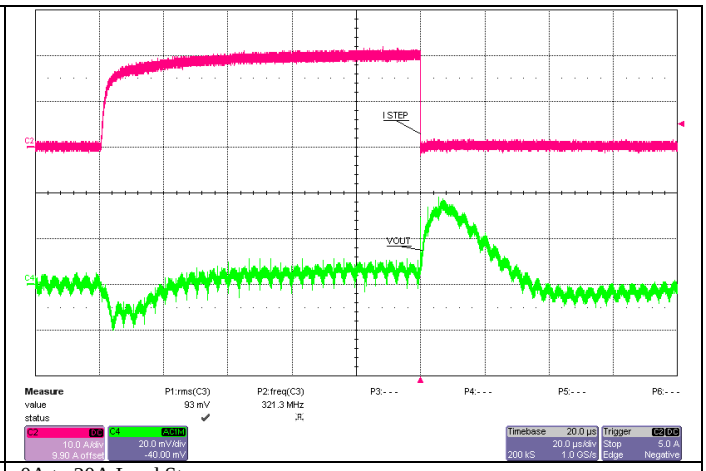

20A to 40A Load Step

## 7.2 16 x 100 µF External Output Capacitor

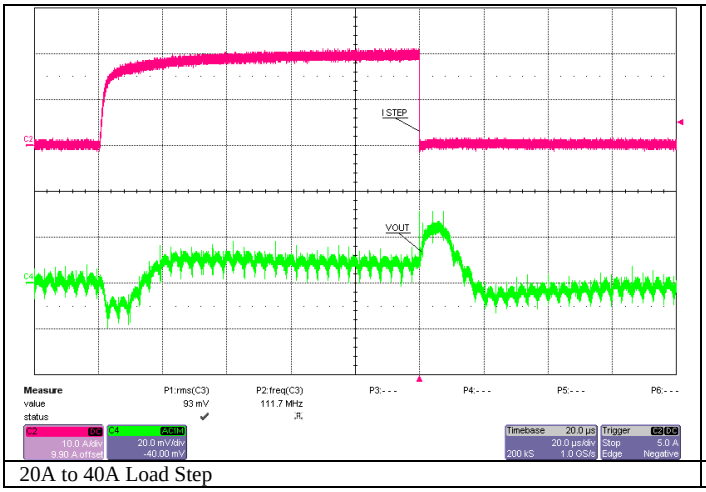
With 16 x 100 µF, 6.3V, X5R ceramic external capacitors, the output voltage transient is 30mV for a 20A load step.



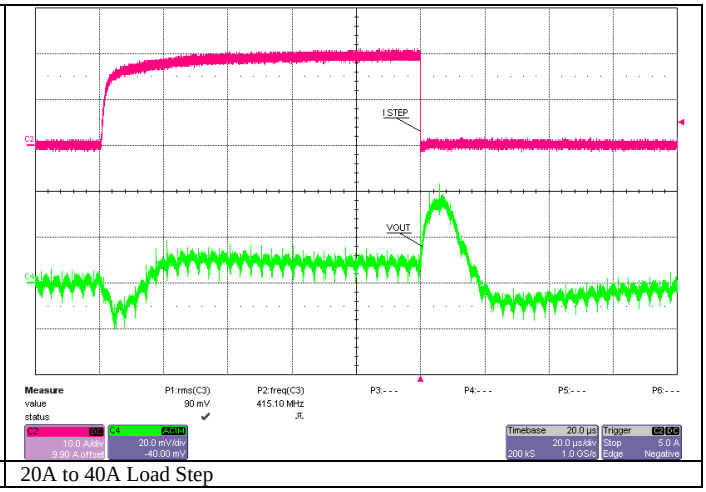

0A to 20A Load Step




0A to 20A Load Step



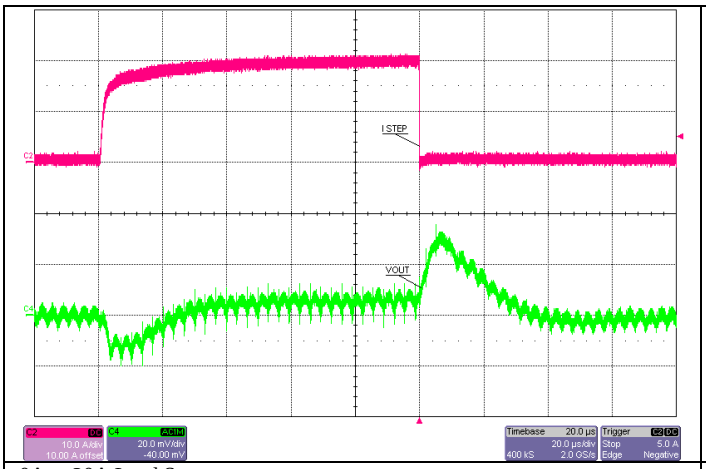

20A to 40A Load Step



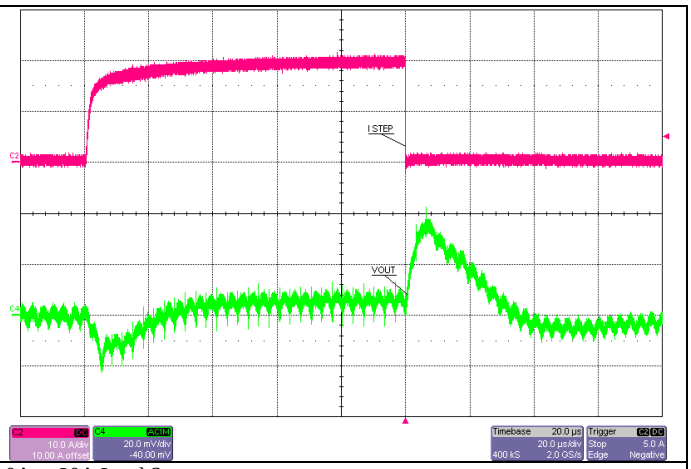

20A to 40A Load Step

### 7.3 4 x 330 µF External Output Capacitor

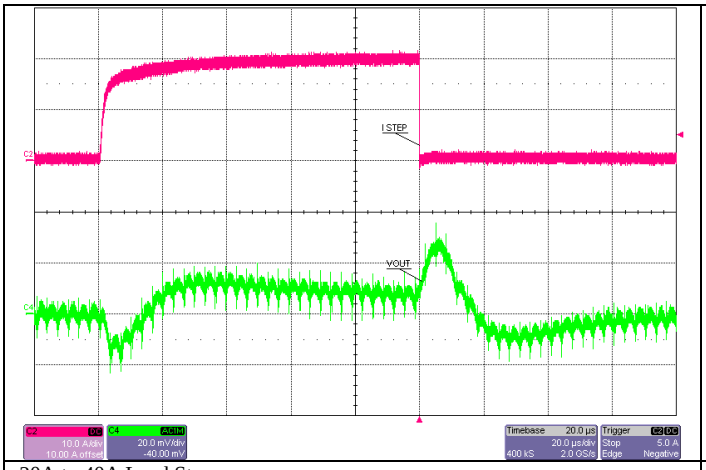
With 4 x 330 µF, 2V, 6 mΩ polymer aluminum external capacitors, the output voltage transient is 30mV for a 20A load step.



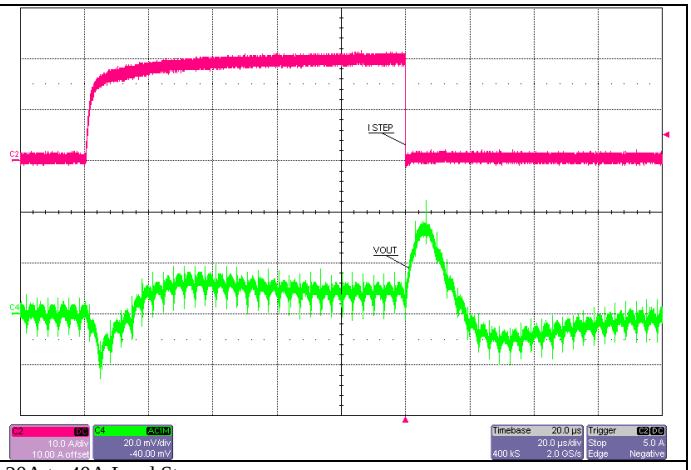

0A to 20A Load Step




0A to 20A Load Step




20A to 40A Load Step

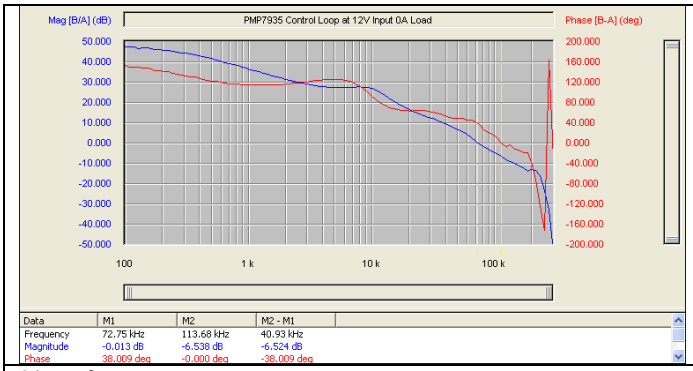



20A to 40A Load Step

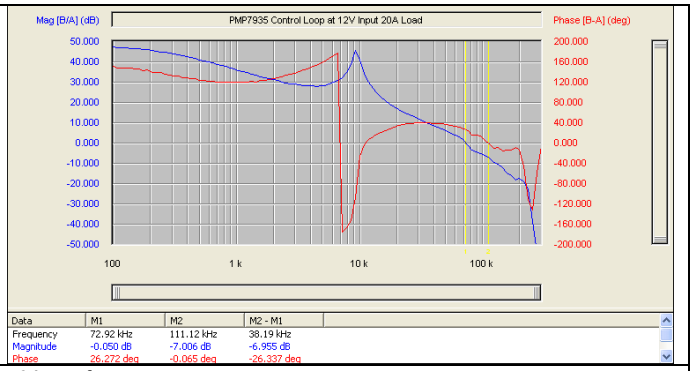
# 8 Frequency Response

## 8.1 No External Output Capacitor

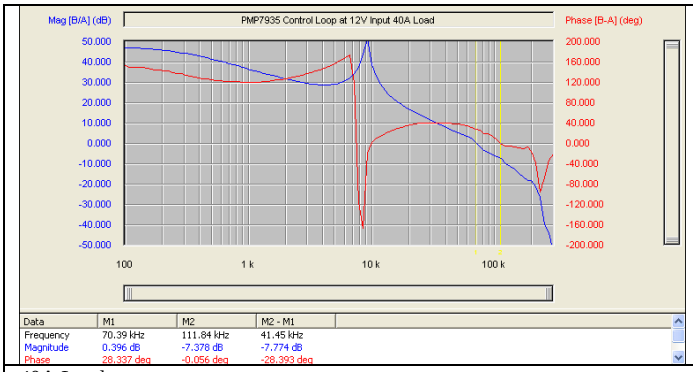
With no external capacitors, the control loop exhibits a high bandwidth of 70 kHz and low phase margin of 28° at full load.




0A Load



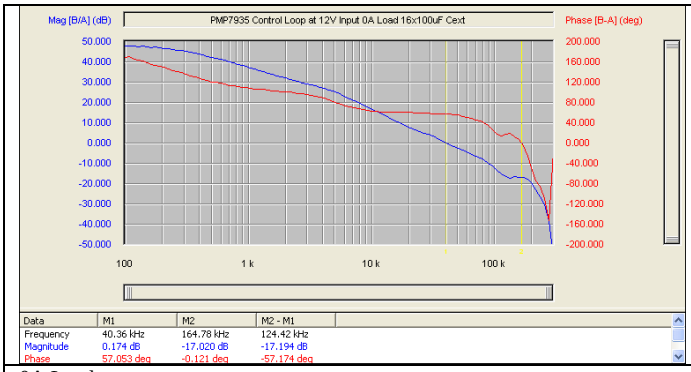

20A Load



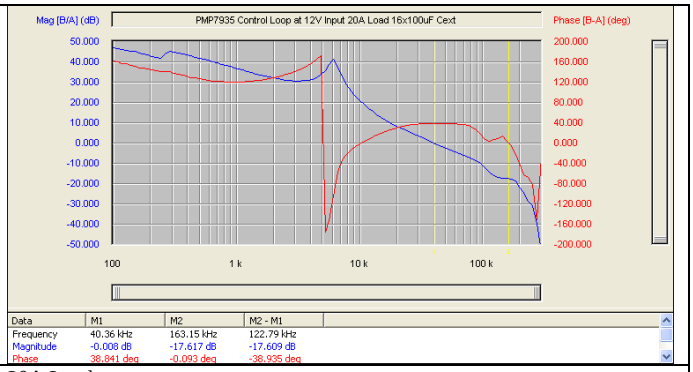

40A Load

## 8.2 16 x 100 µF External Output Capacitor

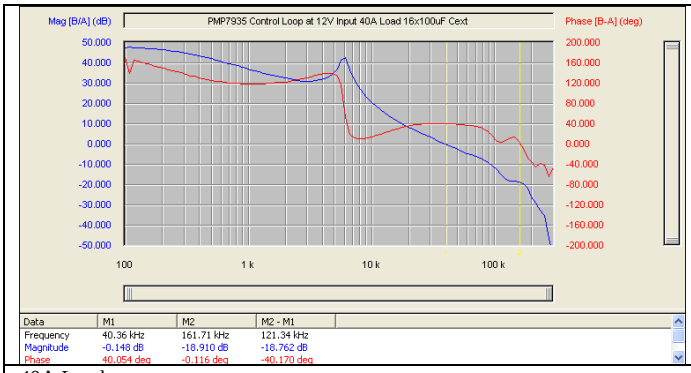
With 16 x 100 µF, 6.3V, X5R ceramic external capacitors, the control loop exhibits a bandwidth of 40 kHz and phase margin of 40° at full load.




0A Load



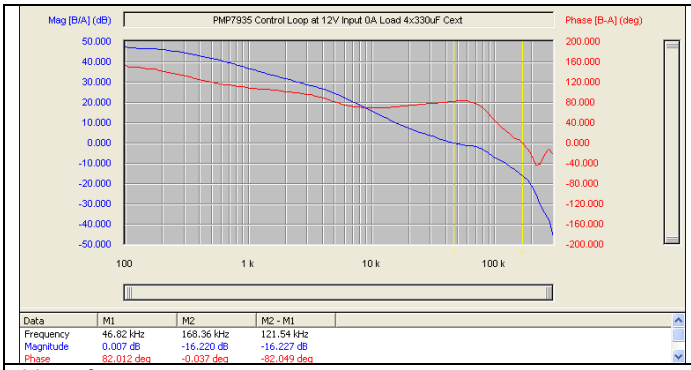

20A Load



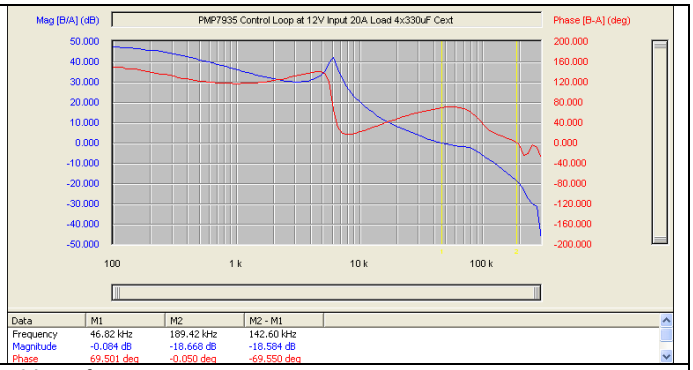

40A Load

## 8.3 4 x 330 µF External Output Capacitor

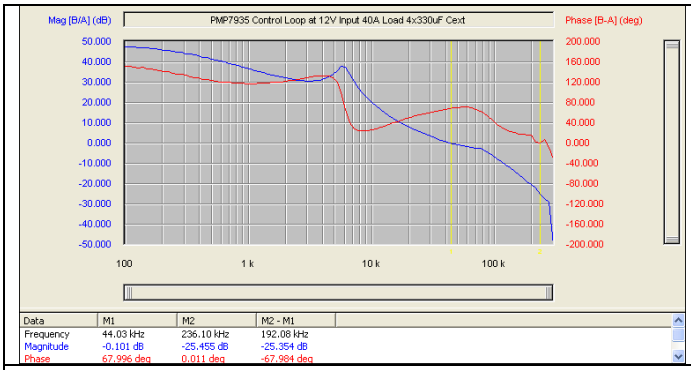
With 4 x 330 µF, 2V, 6 mΩ polymer aluminum external capacitors, the control loop exhibits a bandwidth of 44 kHz and phase margin of 67° at full load.




0A Load




20A Load

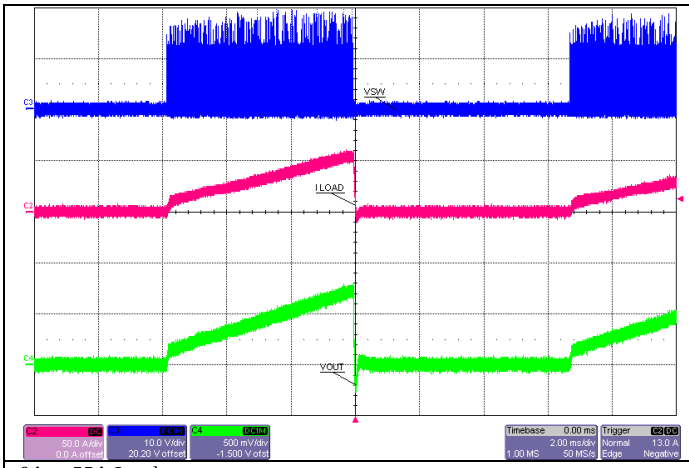



40A Load

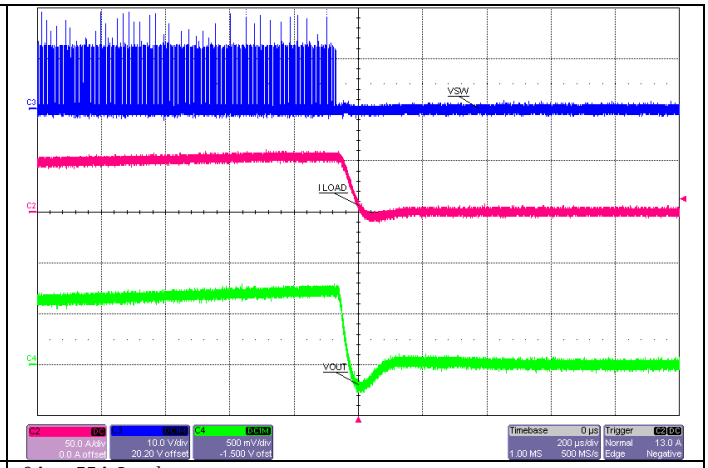
# 9 Over-Current Protection

## 9.1 Current Limit Protection

A pulsed MOSFET current limit test was performed to check the current limit threshold. The results show current limit at 55A, with hiccup protection and normal restart of the output voltage when the load is removed.



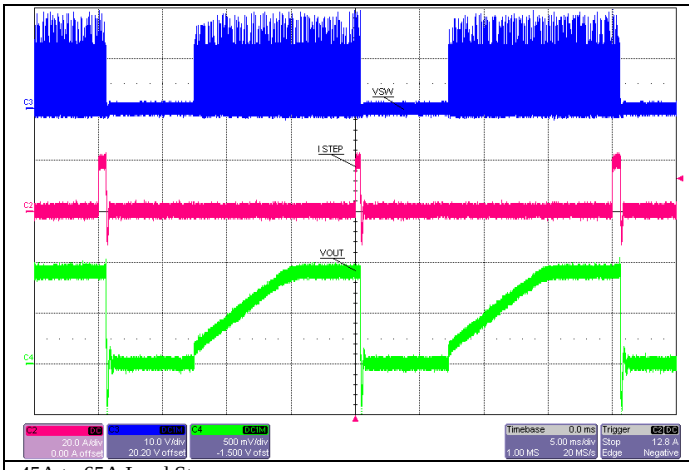

0A to 55A Load



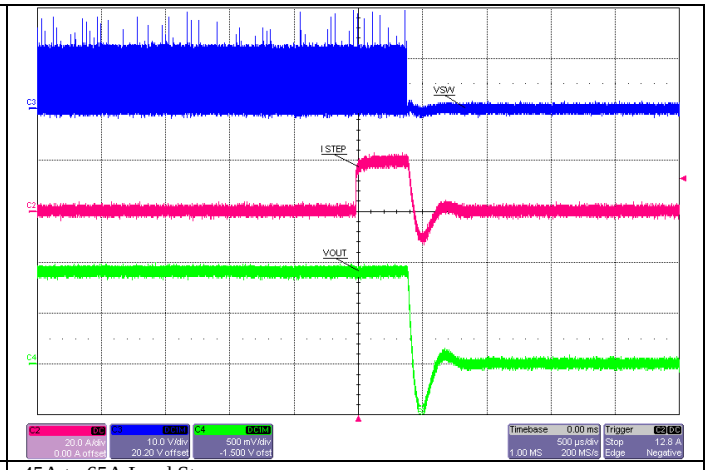

0A to 55A Load

## 9.2 Short Circuit Protection

A pulsed MOSFET load was used to check short circuit protection. The results show hiccup protection with normal restart of the output voltage when the short is removed.




45A to 65A Load Step




45A to 65A Load Step

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265