PMP10618-Test Report
Wide V_{IN} Multi-Rail Design
LM46002 SIMPLE SWITCHER® Converter and LMZ21701 SIMPLE SWITCHER® Nano Module

Overview

This reference design demonstrates the wide input voltage capability and small solution size of the LM46002 SIMPLE SWITCHER® Synchronous Buck Converter and the LMZ21701 SIMPLE SWITCHER® Nano Module. Figure 1 shows the block diagram of this design. The LM46002 provides a regulated 12V rail from an input of 15V to 60V. The 12V rail is then regulated down to 5V, 3.3V, and 1.8V rails using three LMZ21701 nano modules. Each rail can provide up to 1A of load current.

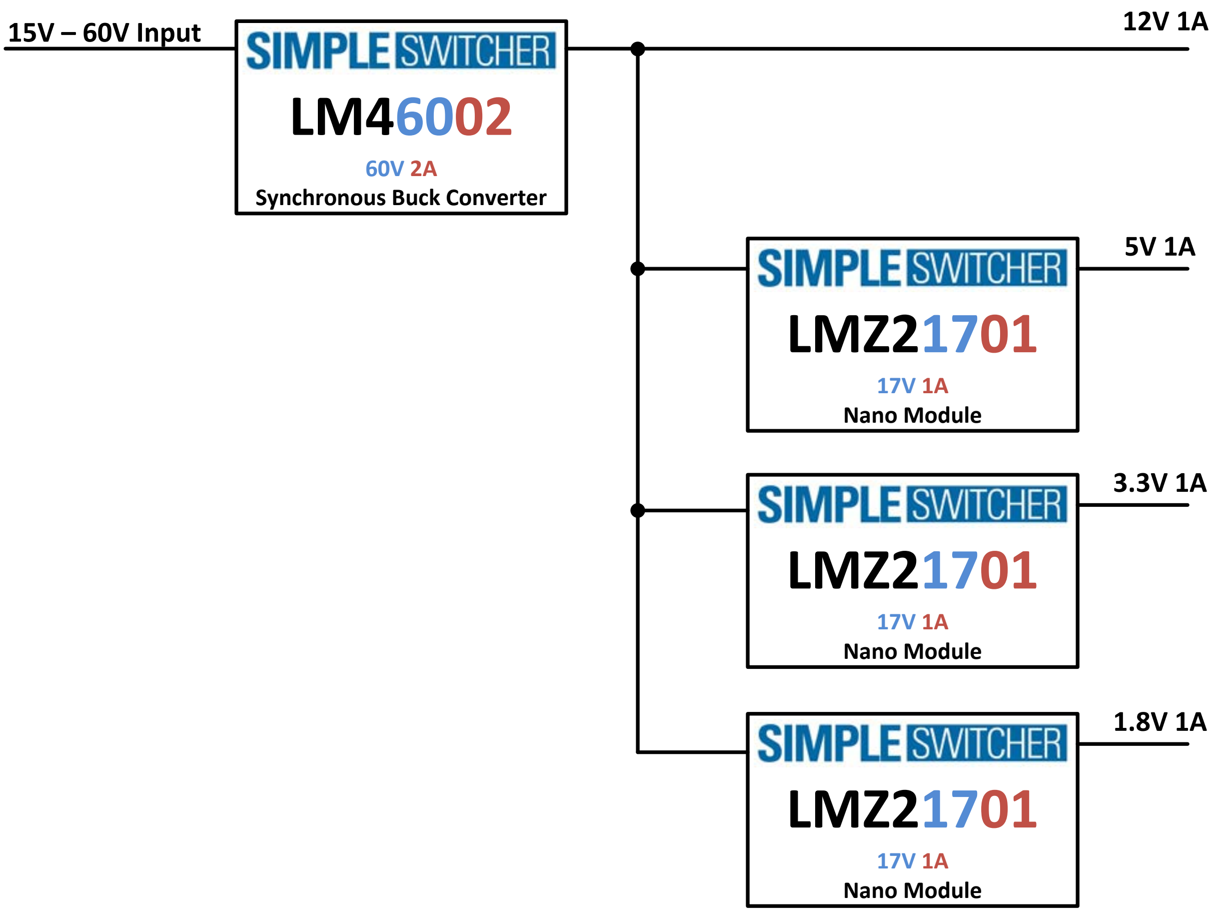


Figure 1. Block Diagram

Table of Contents

Design Specification

Input Voltage: 15V to 60V

Output 1 Voltage: 12V
Output 1 Current: 1A

Output 2 Voltage: 5V
Output 2 Current: 1A

Output 3 Voltage: 3.3V
Output 3 Current: 1A

Output 4 Voltage: 1.8V
Output 4 Current: 1A

Schematic

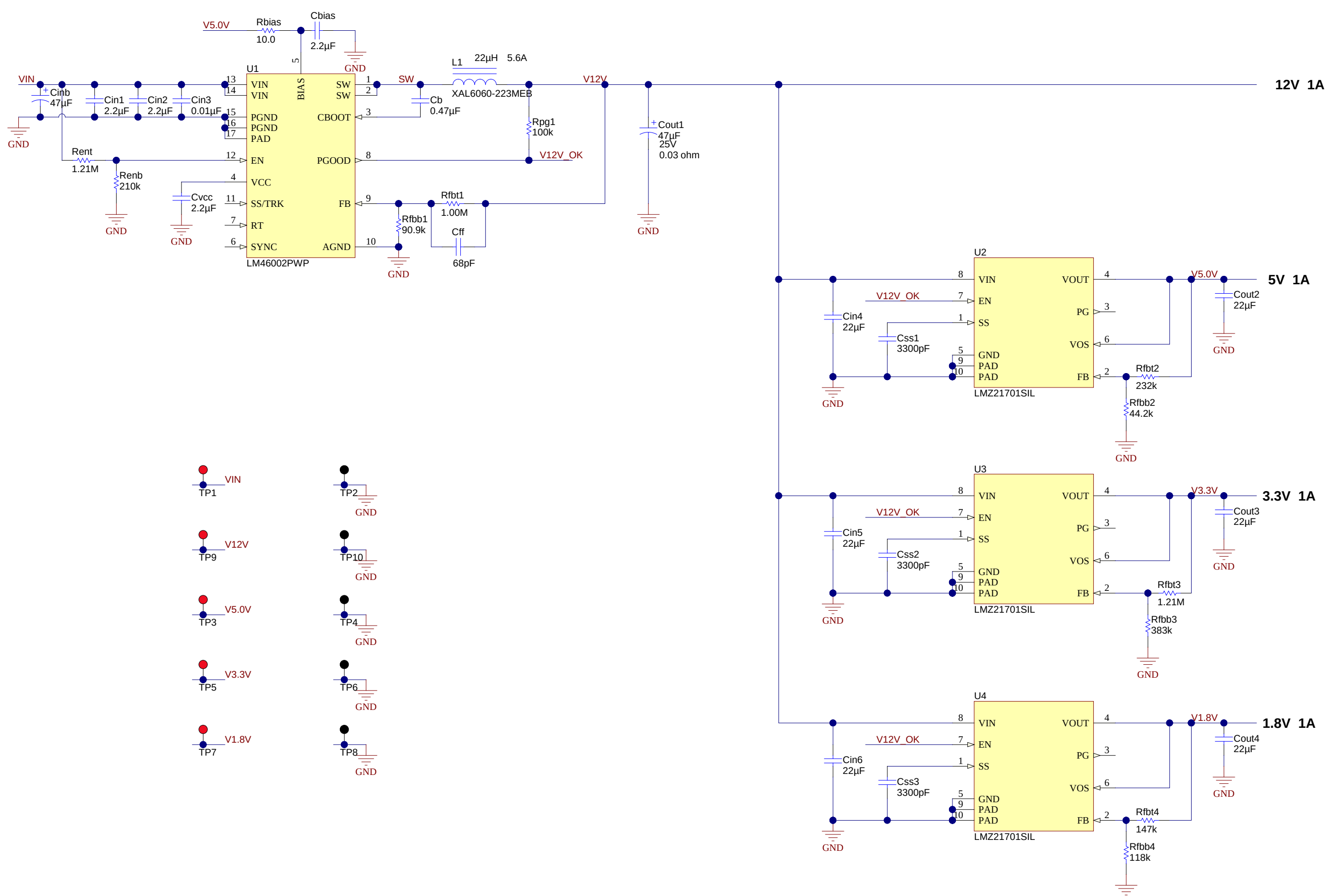


Figure 2. Schematic

Board Layout

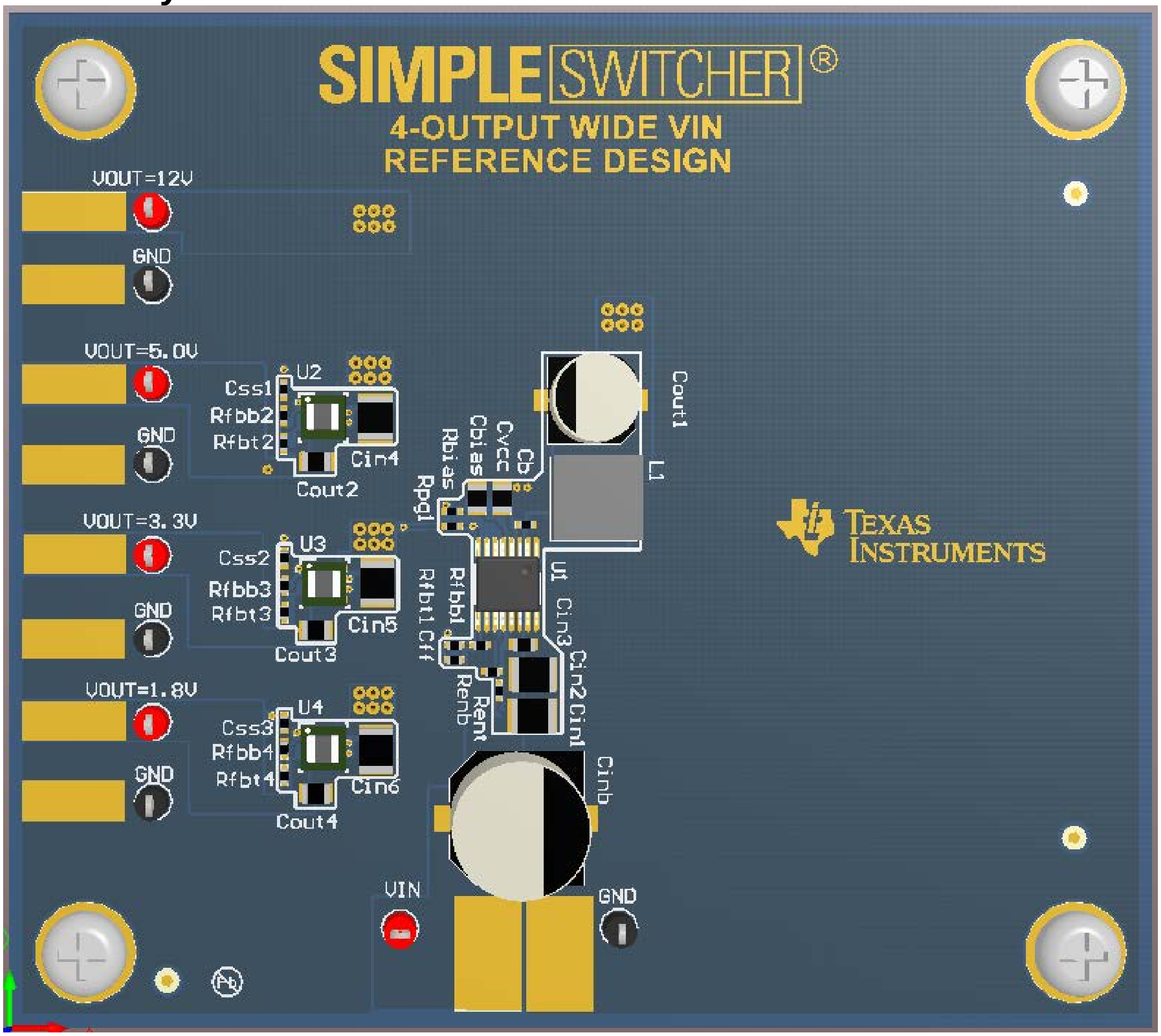


Figure 3. PCB Layout – 3D View

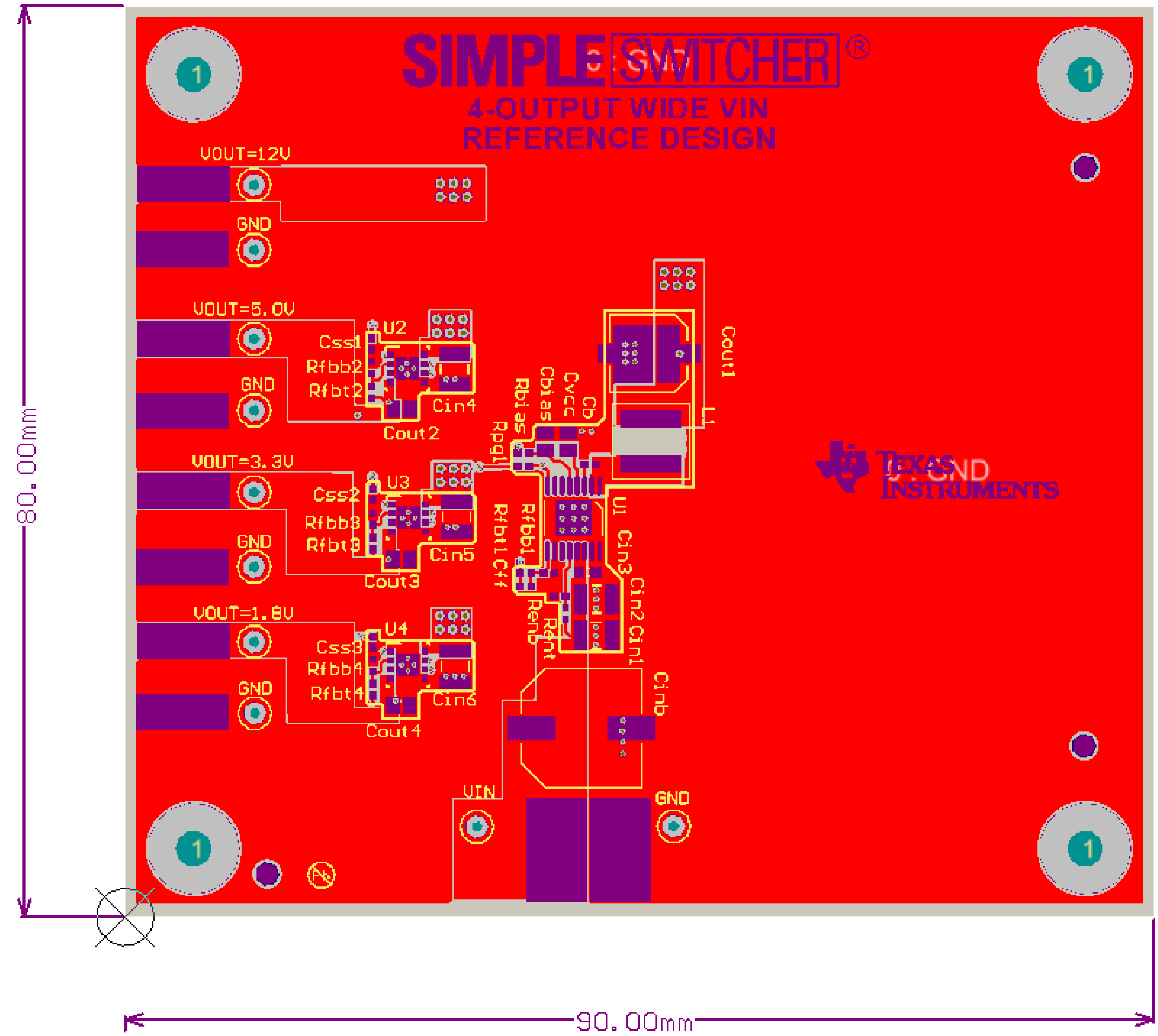


Figure 4. Top Layer Copper with Top Overlay and Top Solder

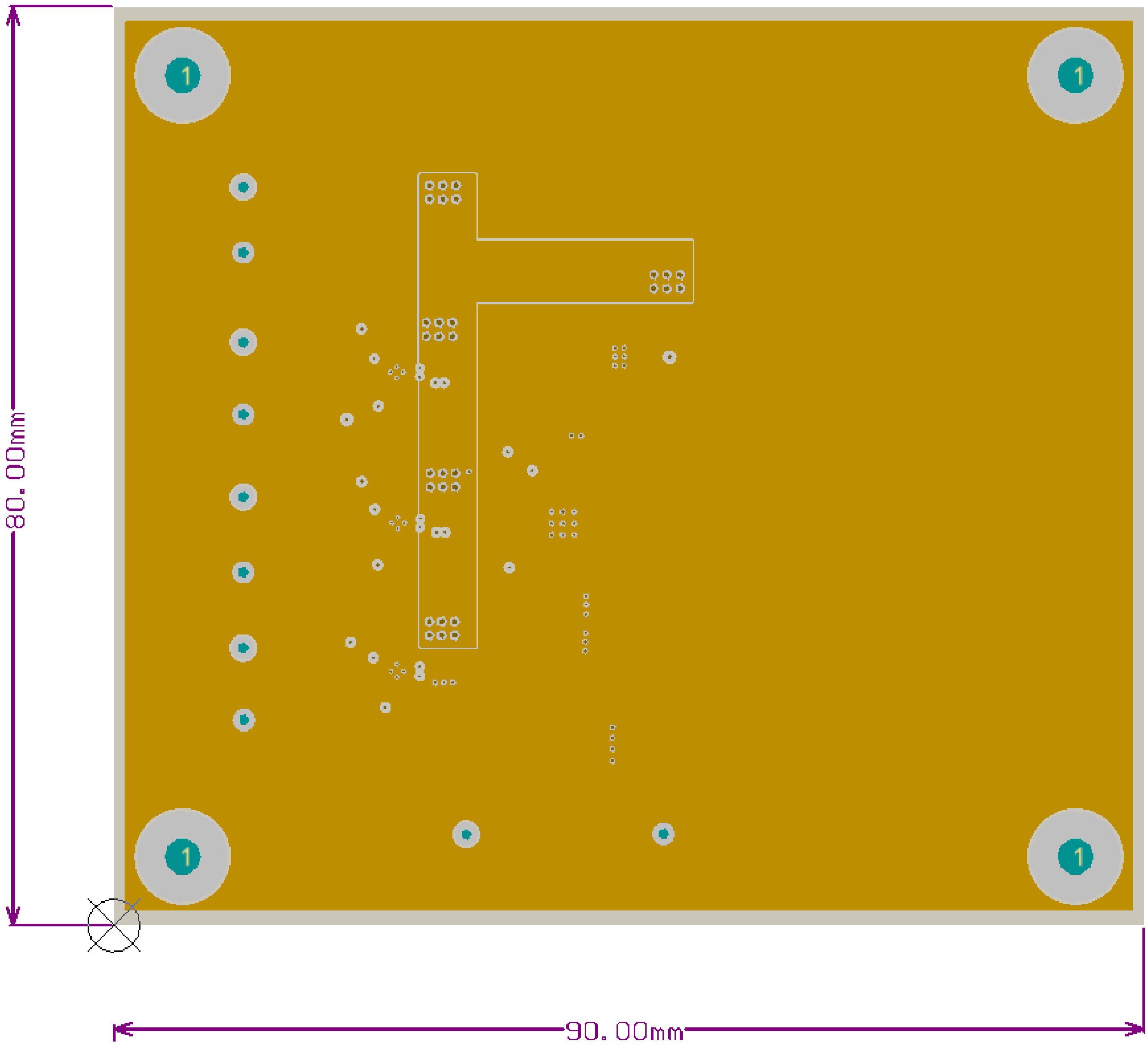


Figure 5. Mid Layer 1 Copper

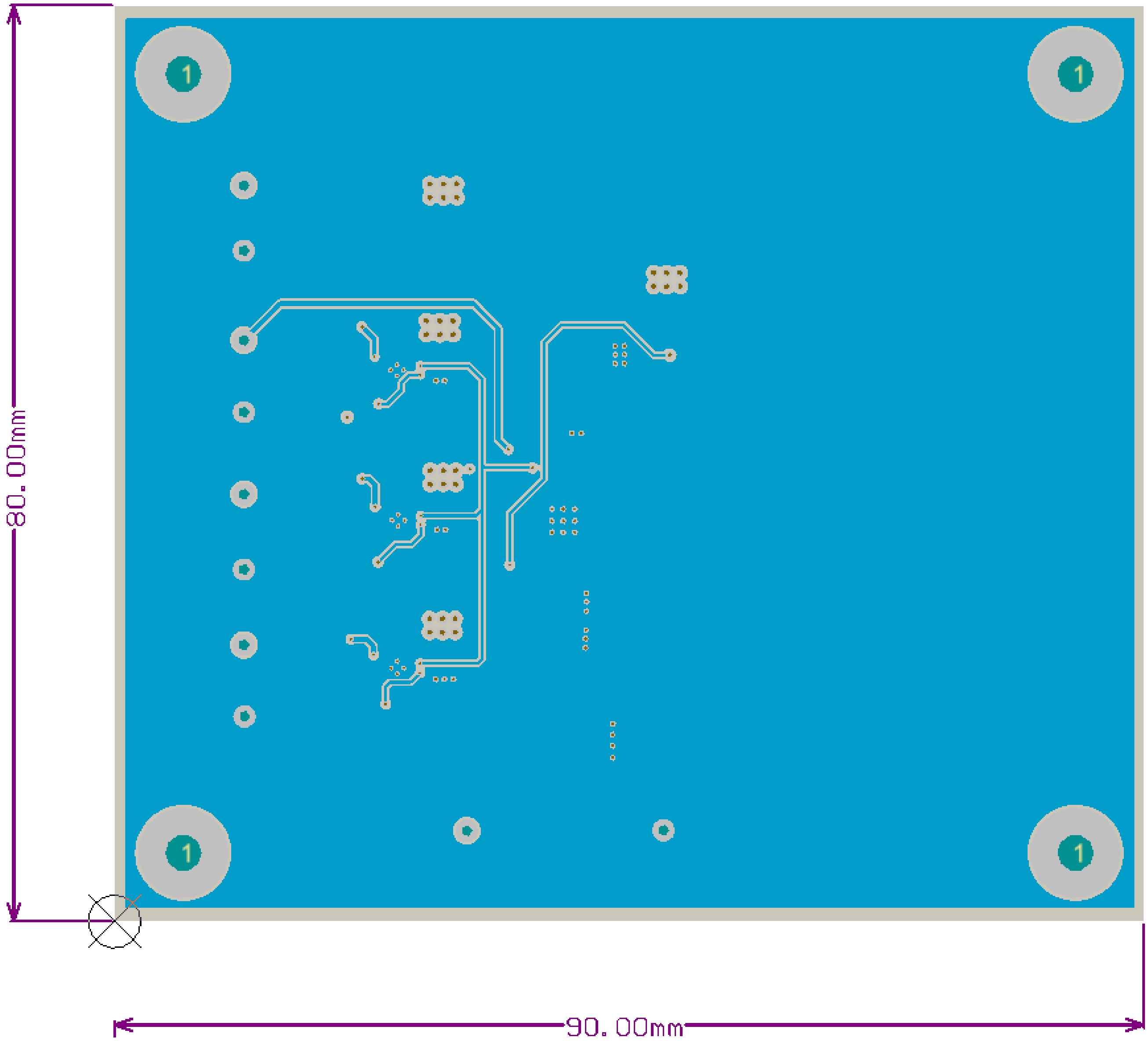


Figure 6. Mid Layer 2 Copper

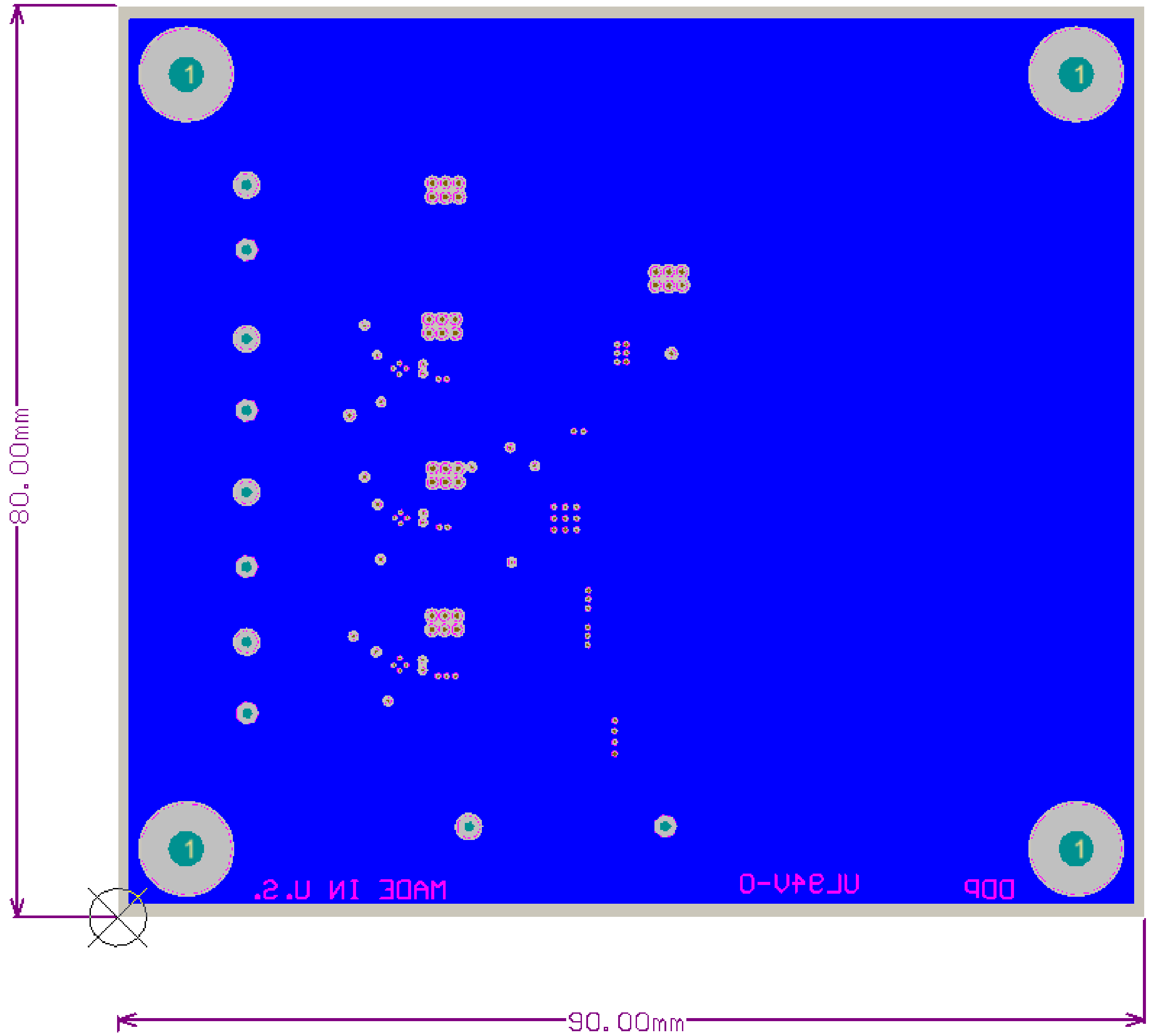


Figure 7. Bottom Layer Copper

Bill of Materials

Designator	Description	Manufacturer	PartNumber	Quantity
Cb	CAP, CERM, 0.47 µF, 16 V, +/- 10%, X5R, 0402	MuRata	GRM155R61C474KE01	1
Cbias, Cvcc	CAP, CERM, 2.2 µF, 16 V, +/- 10%, X7R, 0805	TDK	C2012X7R1C225K	2
Cff	CAP, CERM, 68 pF, 50 V, +/- 5%, C0G/NP0, 0402	MuRata	GRM1555C1H680JA01D	1
Cin1, Cin2	CAP, CERM, 2.2 µF, 100 V, +/- 10%, X7R, 1210	MuRata	GRM32ER72A225KA35L	2
Cin3	CAP, CERM, 0.01 µF, 100 V, +/- 10%, X7R, 0603	AVX	06031C103KAT2A	1
Cin4, Cin5, Cin6	CAP, CERM, 22 µF, 25 V, +/- 10%, X7R, 1210	MuRata	GRM32ER71E226KE15L	3
Cinb	CAP, AL, 47 µF, 80 V, +/- 20%, 0.7 ohm, SMD	Panasonic	EEE-FK1K470P	1
Cout1	CAP, AL, 47 µF, 25 V, +/- 20%, 0.03 ohm, SMD	Panasonic	25SVPF47M	1
Cout2, Cout3, Cout4	CAP, CERM, 22 µF, 16 V, +/- 10%, X5R, 0805	TDK	C2012X5R1C226K125AC	3
Css1, Css2, Css3	CAP, CERM, 3300 pF, 50 V, +/- 10%, X7R, 0402	TDK	C1005X7R1H332K	3
FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	3
H1, H2, H3, H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	4
H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	4
L1	Inductor, Shielded, Composite, 22 µH, 5.6 A, 0.06 ohm, SMD	Coilcraft	XAL6060-223MEB	1
Rbias	RES, 10.0, 1%, 0.063 W, 0402	Vishay-Dale	CRCW040210R0FKED	1
Renb	RES, 210 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW0402210KFKED	1
Rent, Rfbt3	RES, 1.21 M, 1%, 0.063 W, 0402	Vishay-Dale	CRCW04021M21FKED	2
Rfbb1	RES, 90.9 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW040290K9FKED	1
Rfbb2	RES, 44.2 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW040244K2FKED	1
Rfbb3	RES, 383 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW0402383KFKED	1
Rfbb4	RES, 118 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW0402118KFKED	1
Rfbt1	RES, 1.00 M, 1%, 0.063 W, 0402	Vishay-Dale	CRCW04021M00FKED	1
Rfbt2	RES, 232 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW0402232KFKED	1
Rfbt4	RES, 147 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW0402147KFKED	1
Rpg1	RES, 100 k, 1%, 0.063 W, 0402	Vishay-Dale	CRCW0402100KFKED	1
TP1	Test Point, Miniature, Red, TH	Keystone	VIN	1
TP2, TP4, TP6, TP8, TP10	Test Point, Miniature, Black, TH	Keystone	GND	5
TP3	Test Point, Miniature, Red, TH	Keystone	VOUT=5.0V	1
TP5	Test Point, Miniature, Red, TH	Keystone	VOUT=3.3V	1
TP7	Test Point, Miniature, Red, TH	Keystone	VOUT=1.8V	1

TP9	Test Point, Miniature, Red, TH	Keystone	VOUT=12V	1
U1	3.5V to 60V 2A Synchronous Step-Down Voltage Regulator, PWP0016A	Texas Instruments	LM46002PWP	1
U2, U3, U4	1A SIMPLE SWITCHER Nano Module with 17V Maximum Input Voltage, SIL0008E	Texas Instruments	LMZ21701SIL	3

Other Design Details

Input Under Voltage Lock-out (UVLO)

The UVLO of the design is set using the precision enable feature of the LM46002. The resistive divider formed by Rent and Renb in Figure 8 set the UVLO rising point to 14.5V. The converter will wait until VIN has reached 14.5V before it turns on. This provides enough headroom and helps avoid loading up the input supply with excessive load during startup.

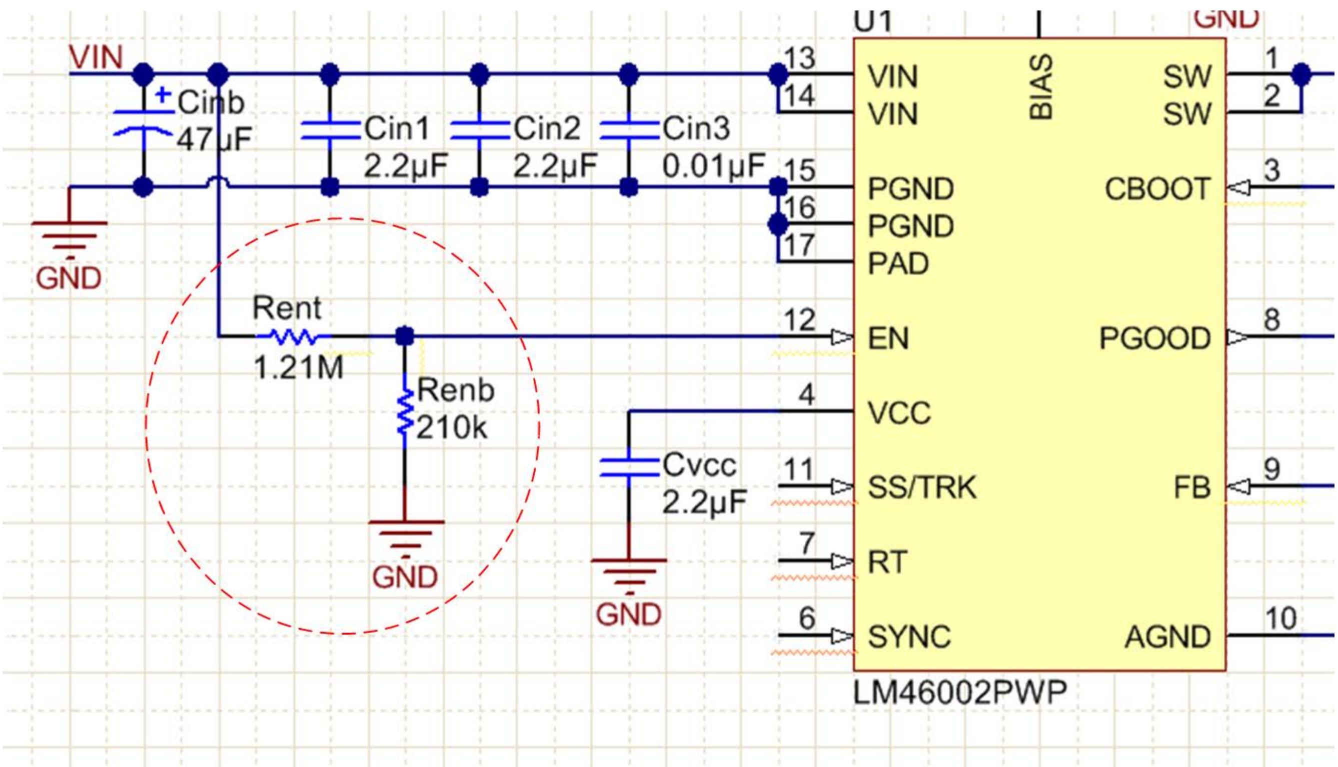
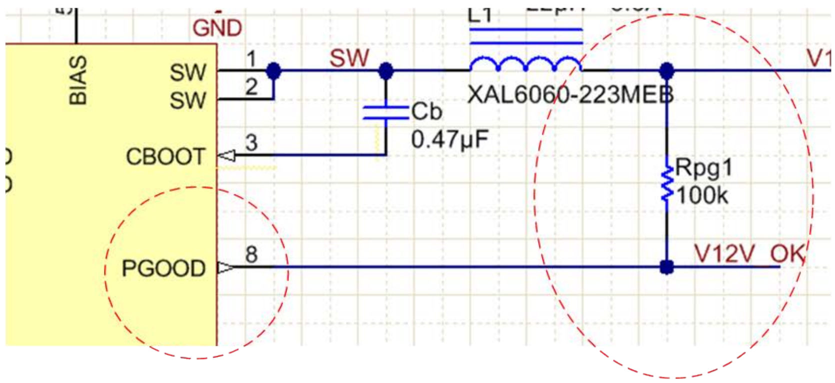


Figure 8. Input Under Voltage Lock-out setting.

Power Good as Downstream Enable

The LM46002 Power Good (PG) flag is utilized to enable the other three downstream converters. The logic signal named "V12V_OK" in the schematic (Figure 9) indicates the status of the 12V rail. Once this PG flag is up, the three LMZ21701's are enabled and start ramping up their output voltages. The ramp up rate of each of the LMZ21701 output rails is set by their soft start capacitors Css1, Css2, and Css3.



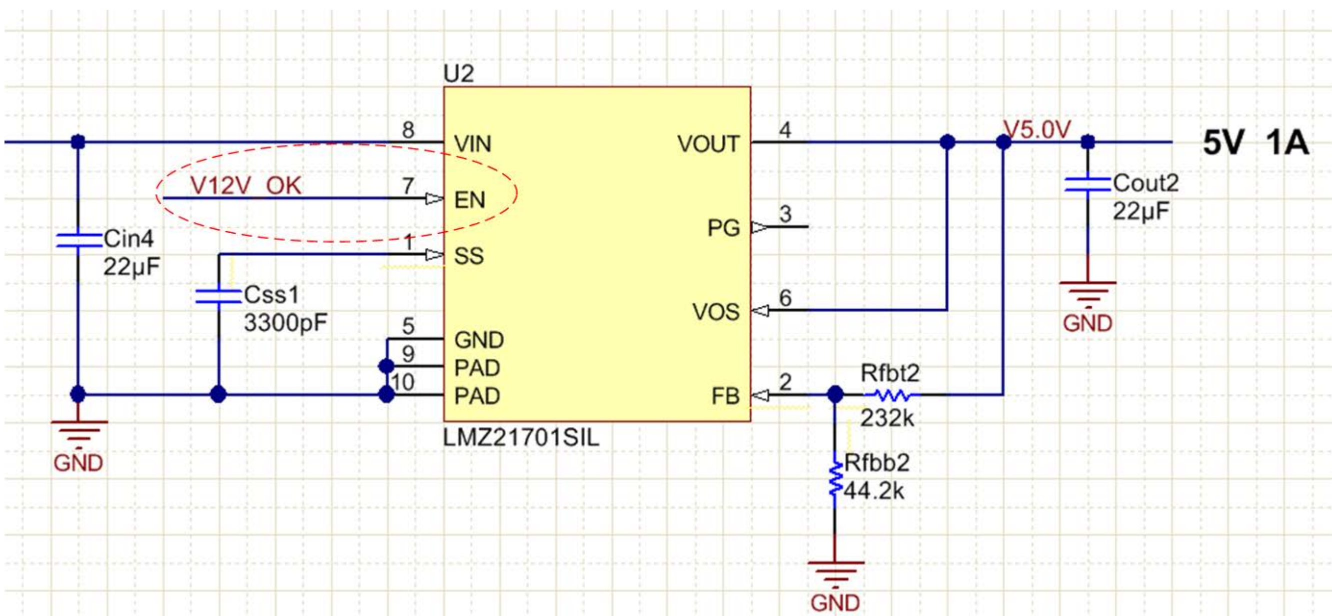


Figure 9. Power Good driving the downstream converters.

Back-Biasing for Improved Efficiency

The LM46002 has a BIAS pin which can be used to provide back-bias to the LM46002 and improve the conversion efficiency. The 5V rail is used to provide the back-bias as show in Figure 10. The Rbias and Cbias RC network provides a low pass filter for the BIAS rail.

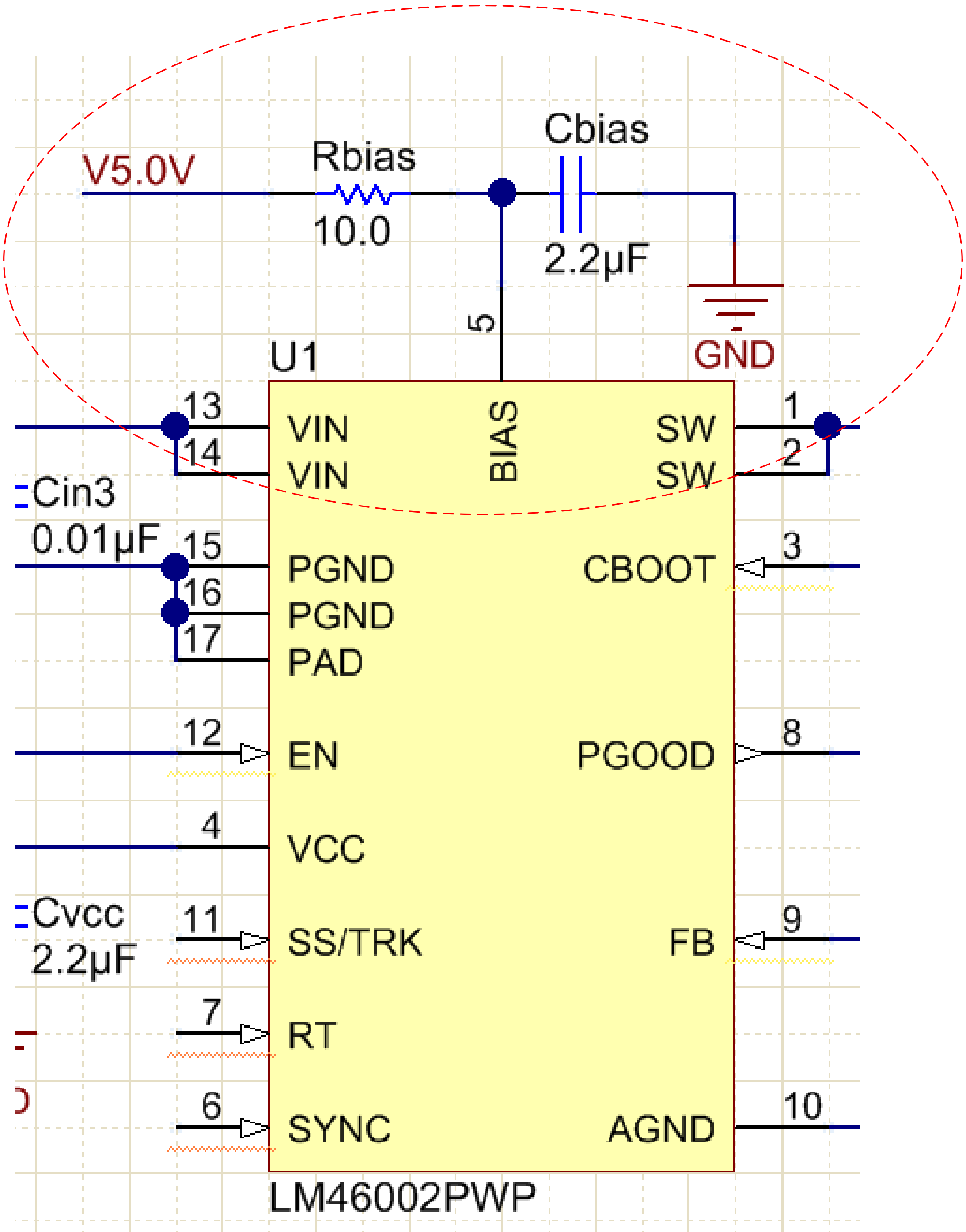


Figure 10. Bias connection for LM46002

Typical Performance

Conversion Efficiency with Various Loads

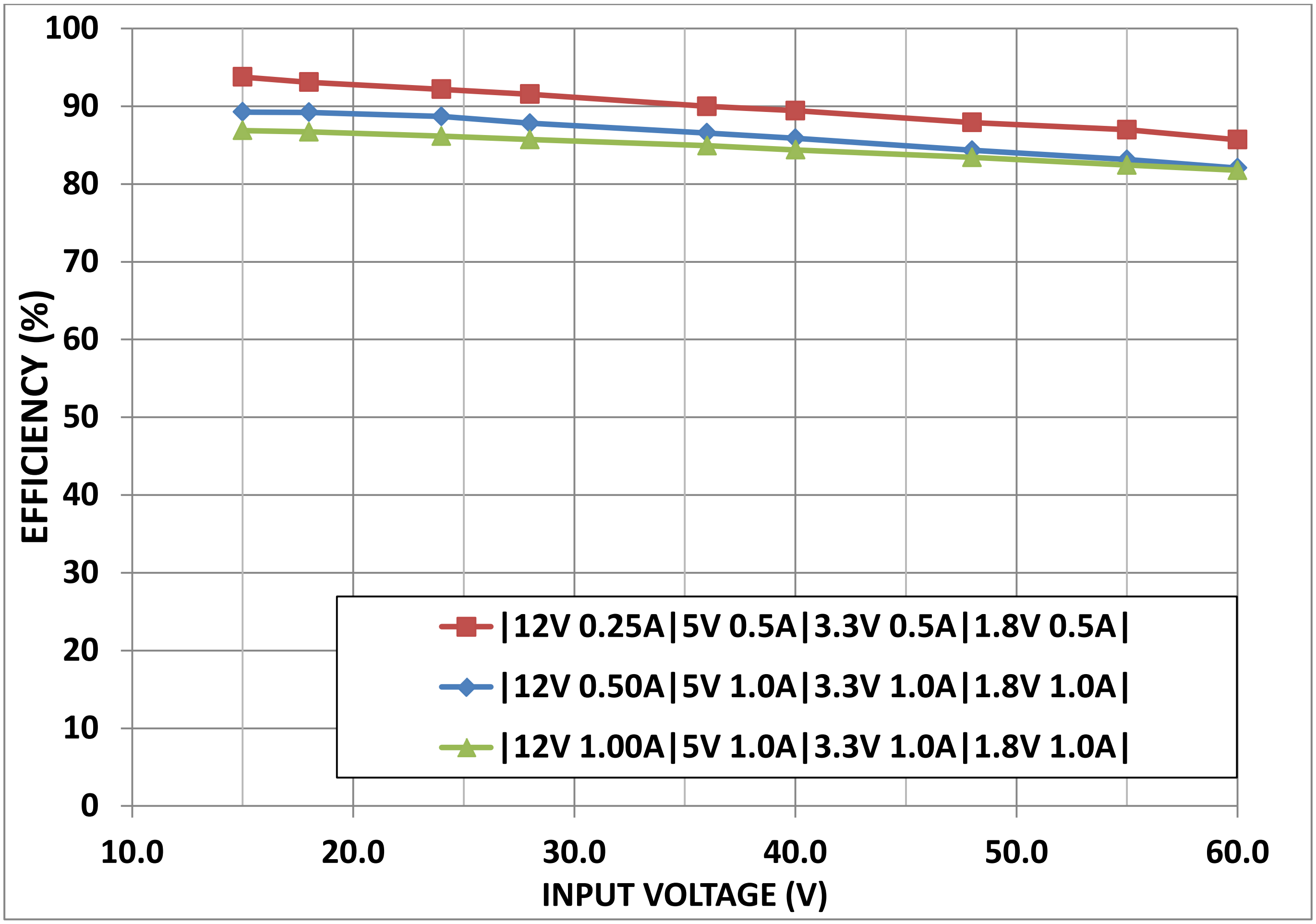


Figure 11. Efficiency

Input Voltage UVLO

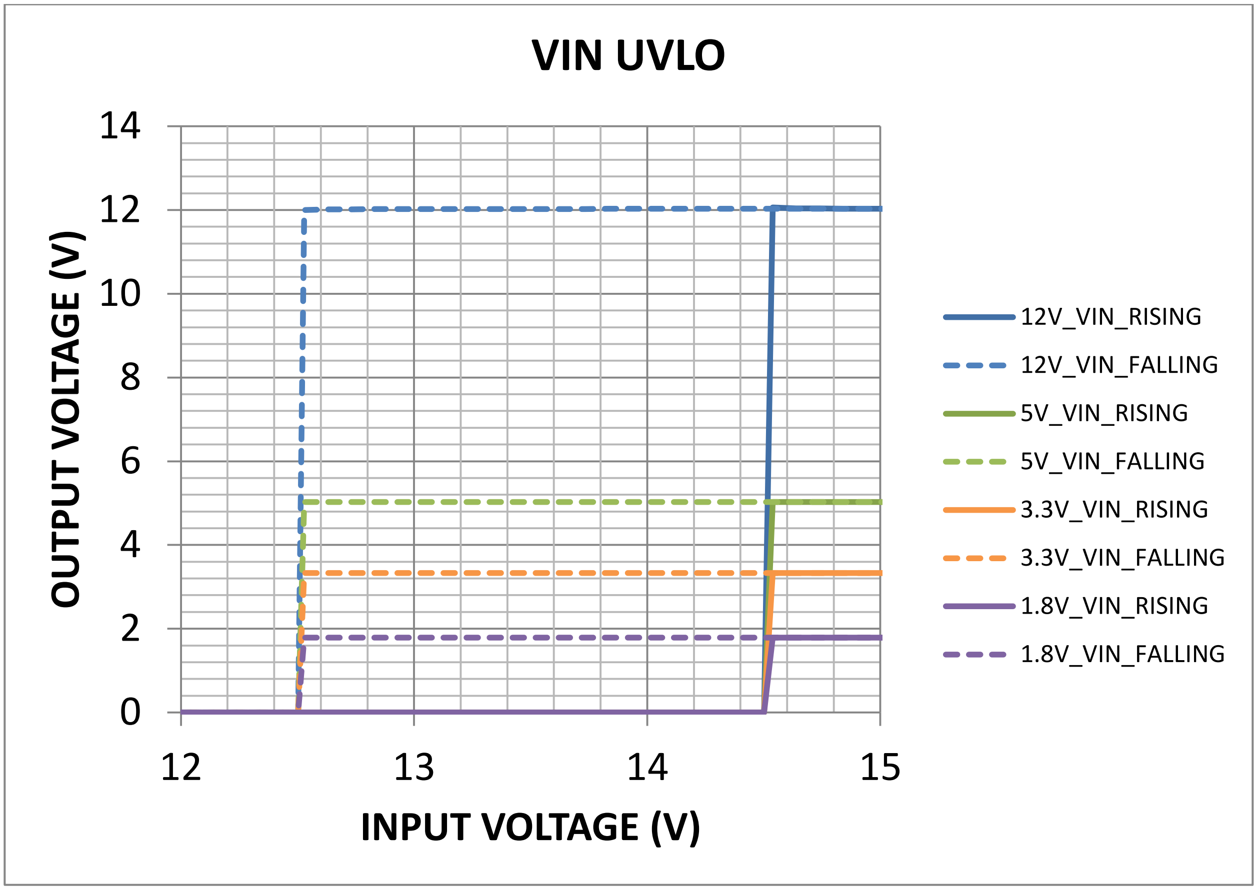


Figure 12. Input UVLO

Start Up

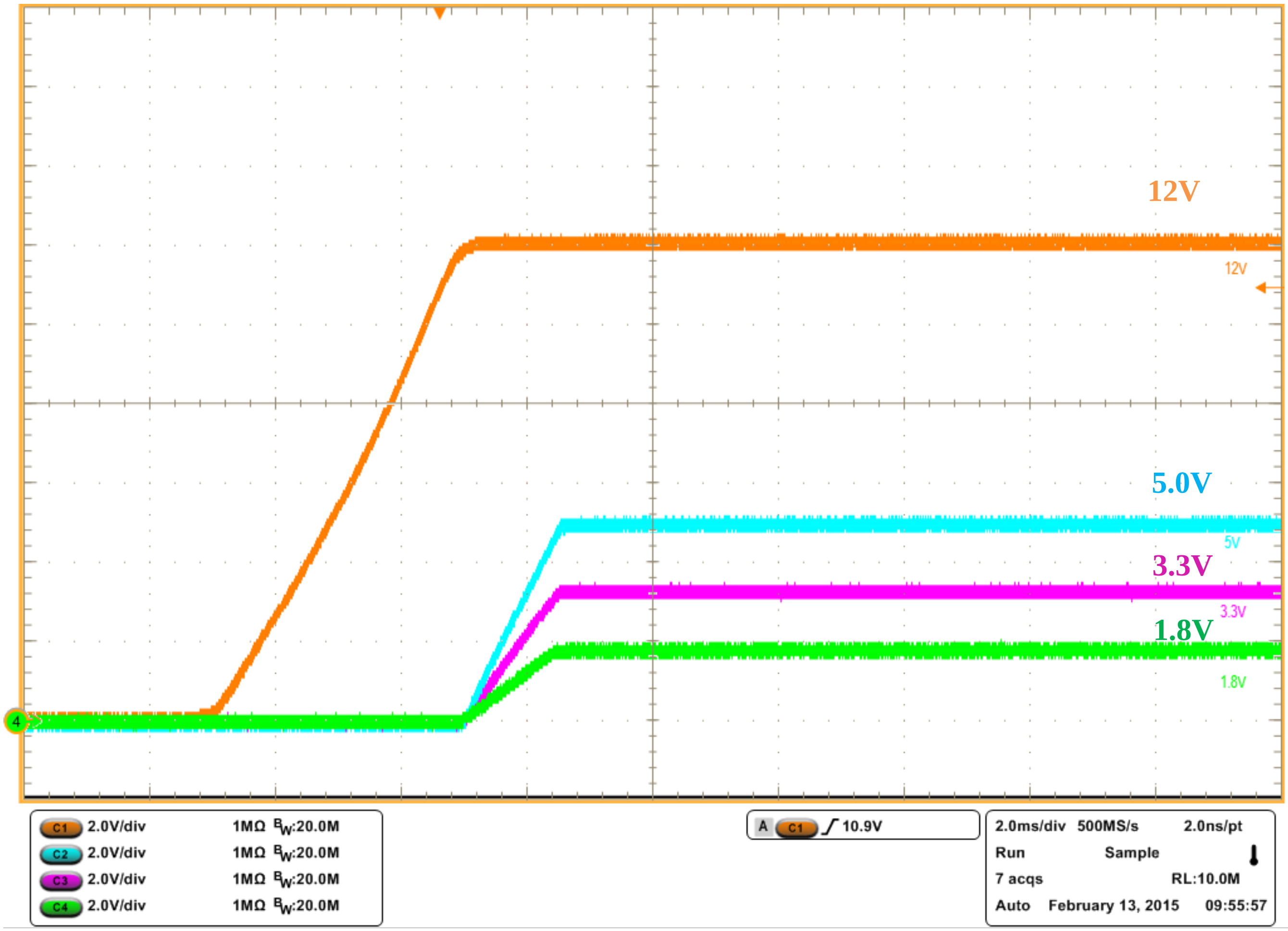


Figure 13. Startup 15V input

The 12V rail ramps up first with the default soft start time of the LM46002. Then the Power Good flag (not shown) on the 12V rail enables the other three regulators. The soft start time of the rest of the regulators is guided by their soft start capacitors (all using 3300pF).

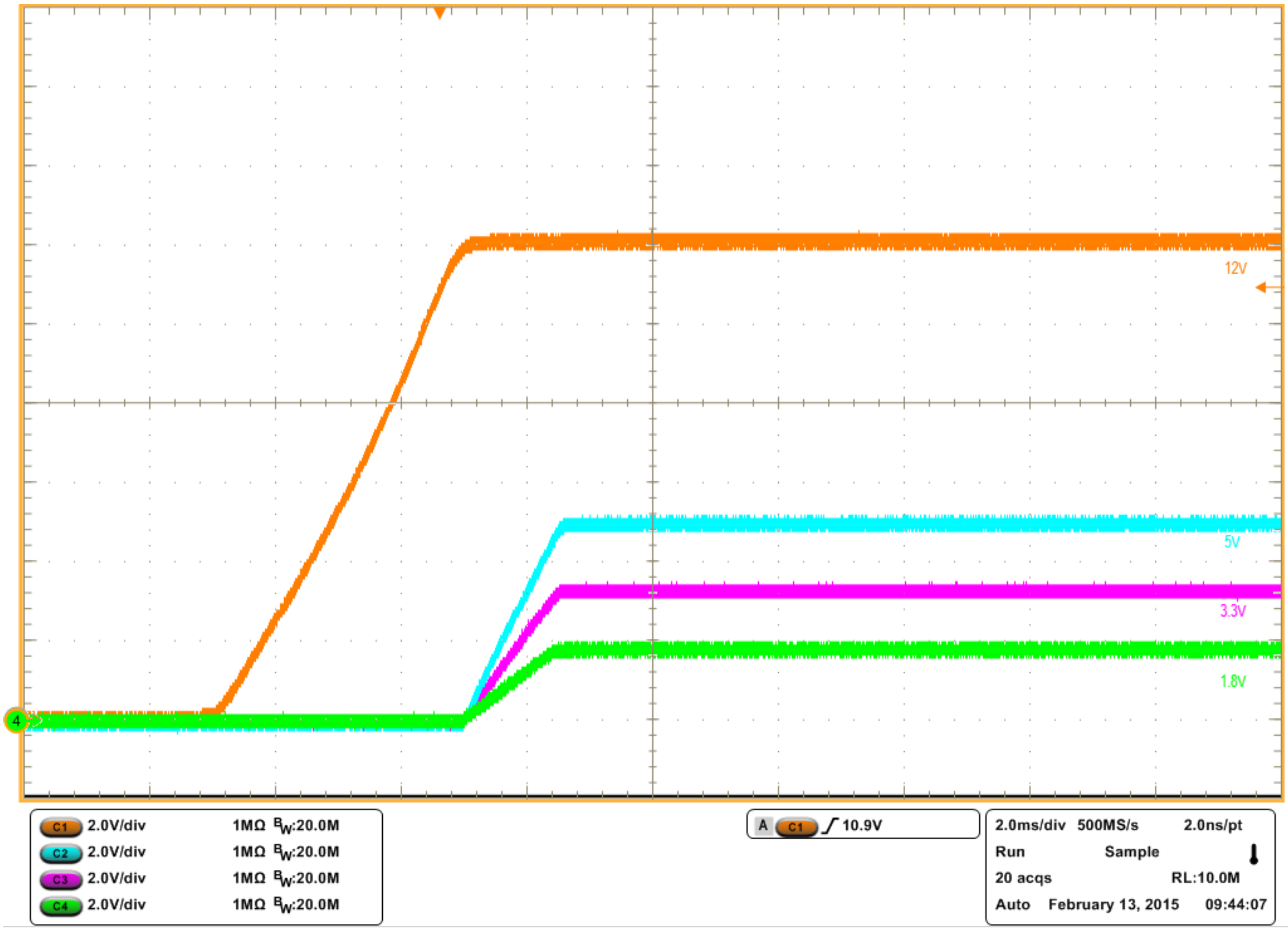


Figure 14. Startup 24V input

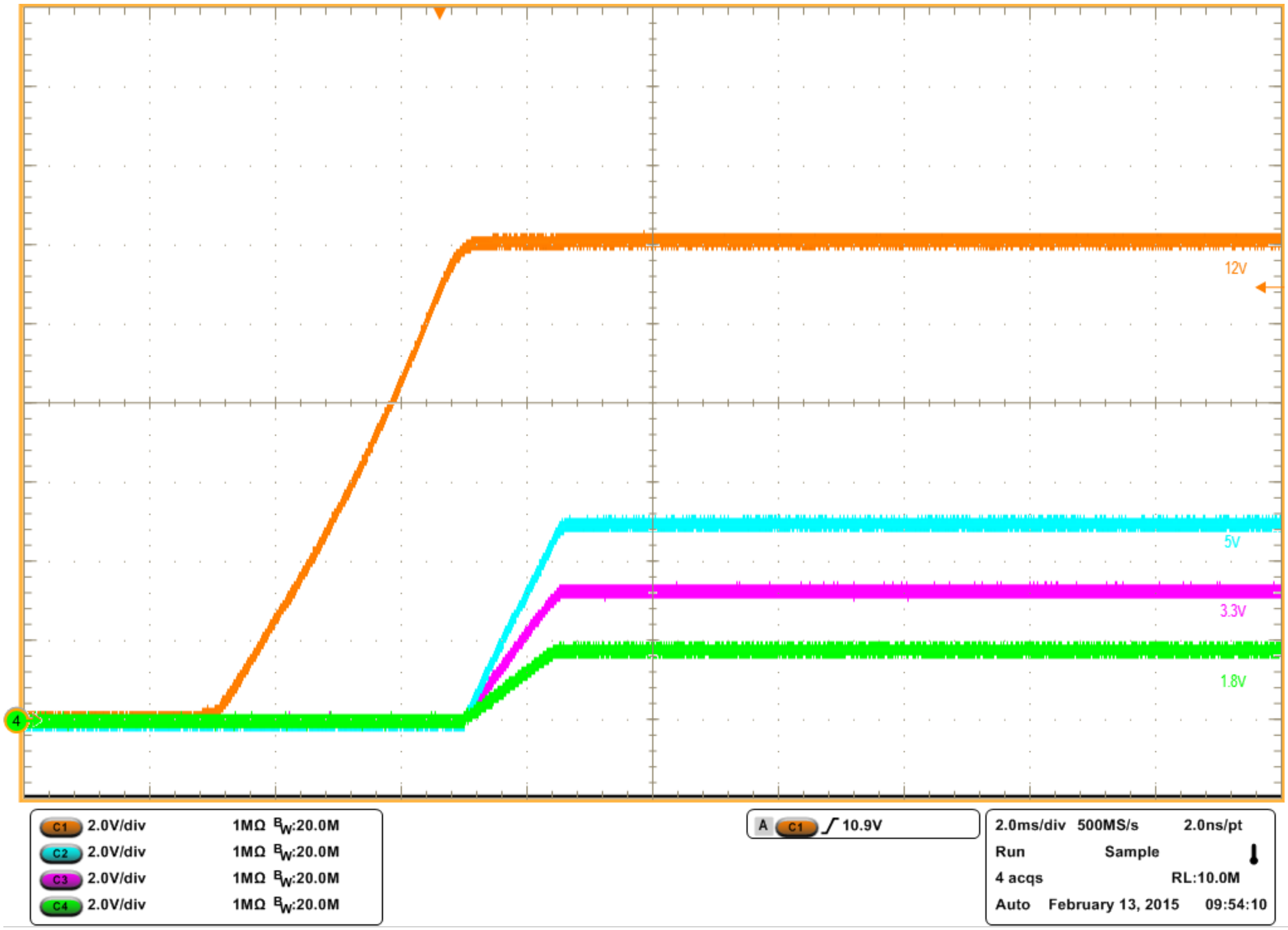


Figure 15. Startup 48V input

Shut Down

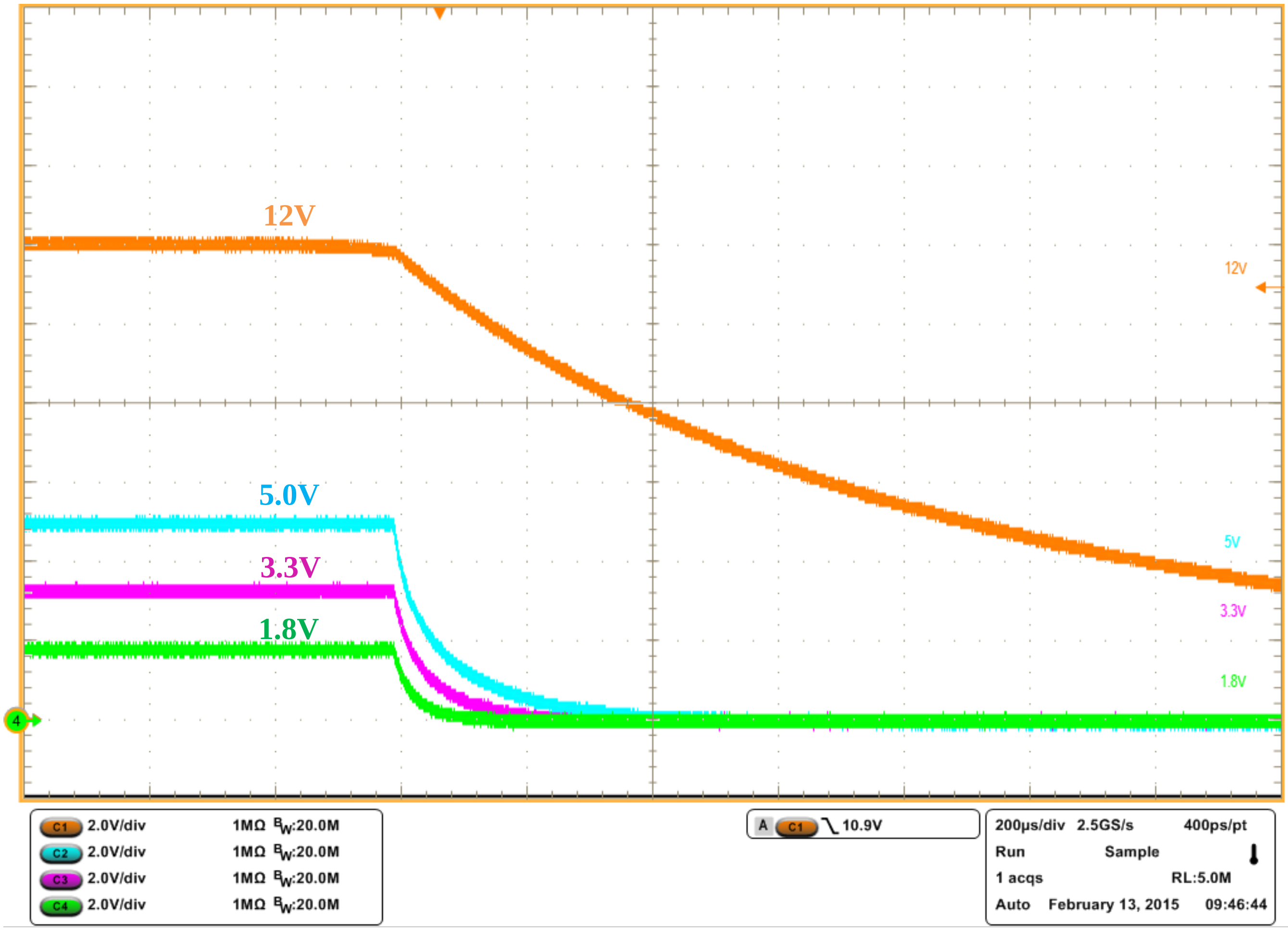


Figure 16. Shutdown

Thermal Performance with Various Loads and Input Voltages

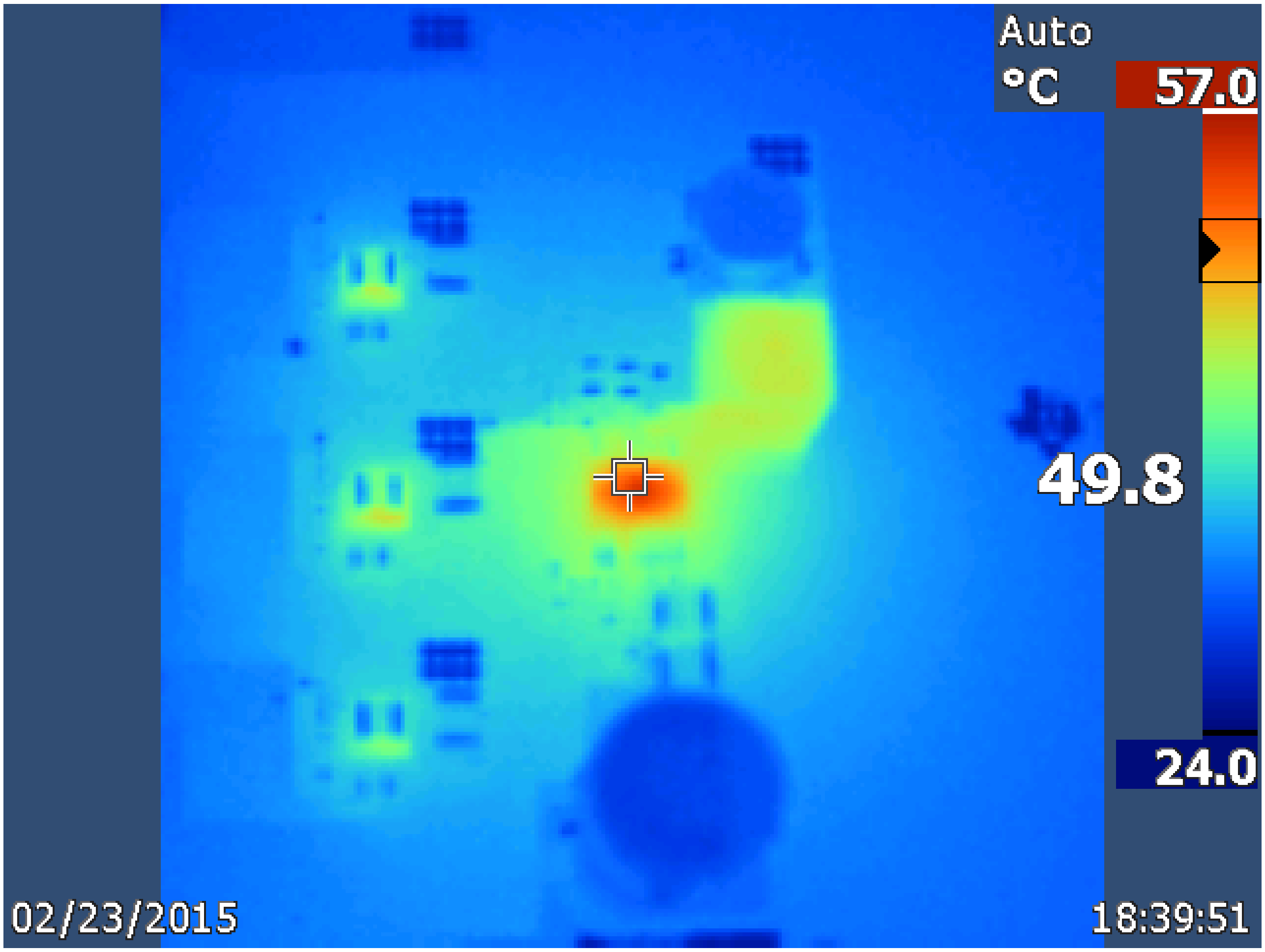


Figure 17. 60V input, 0.5A load on 12V, 1A load on each of the rest rails.

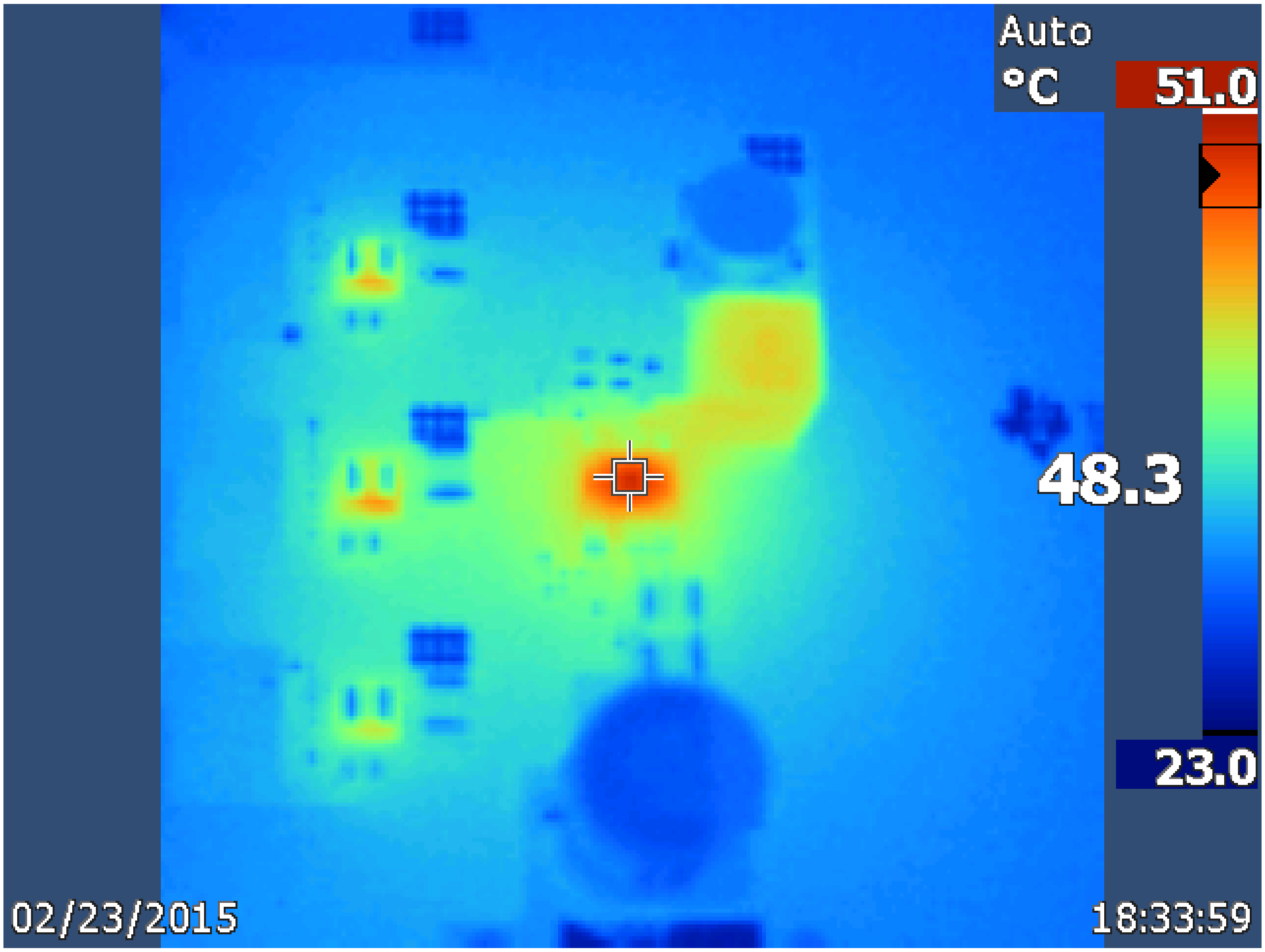


Figure 18. 48V input, 0.5A load on 12V, 1A load on each of the rest rails.

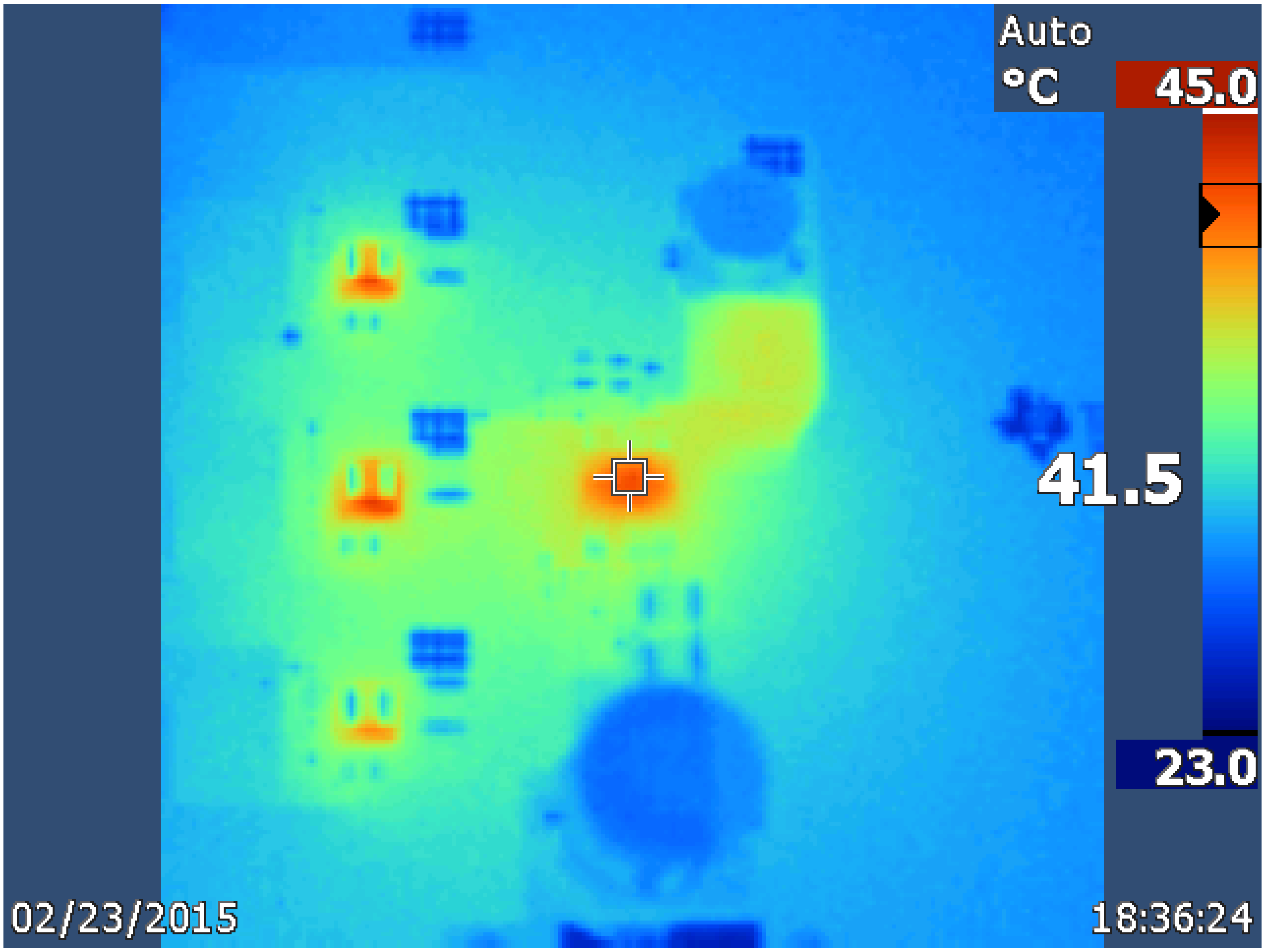


Figure 19. 24V input, 0.5A load on 12V, 1A load on each of the rest rails.

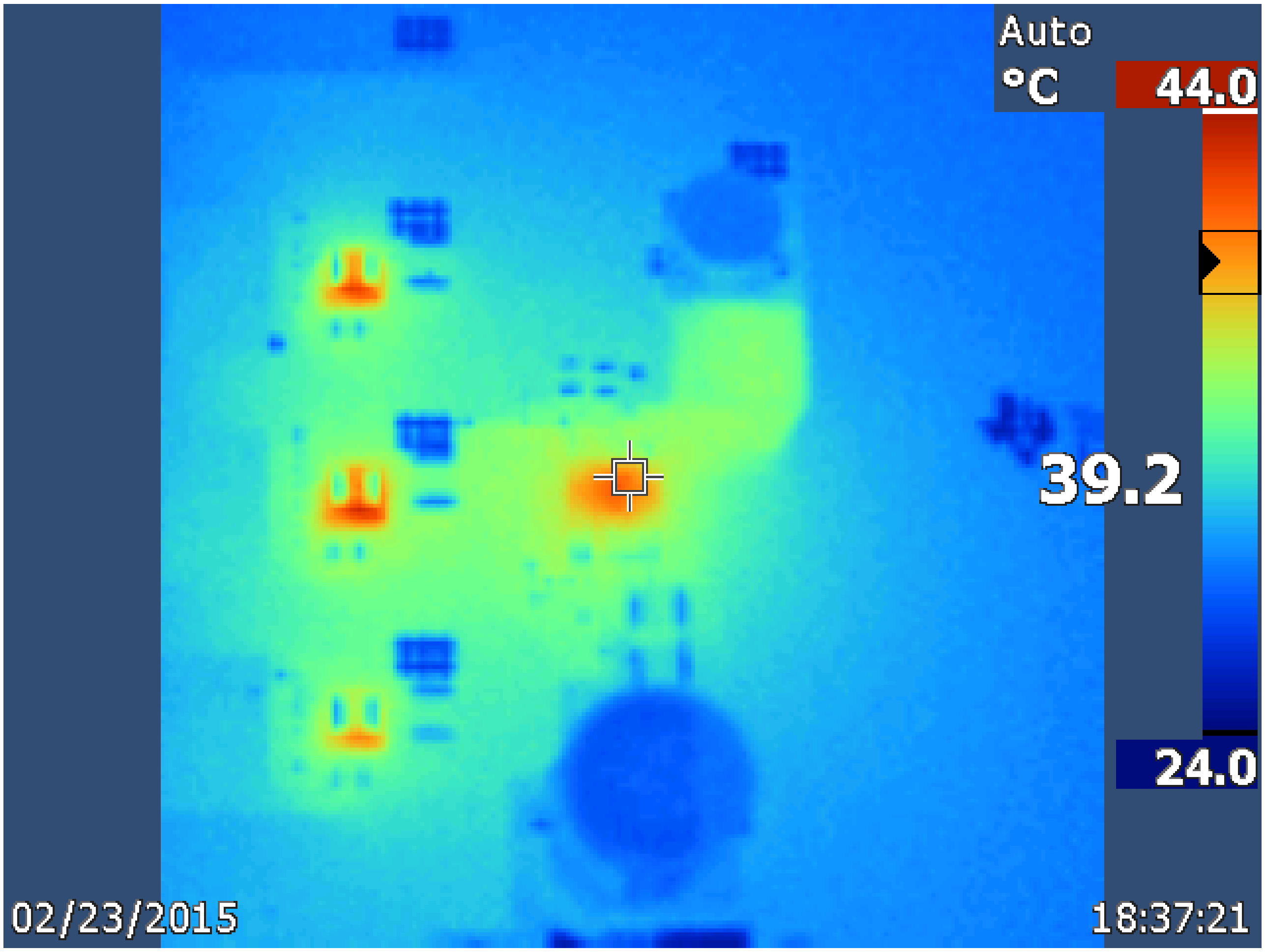


Figure 20. 15V input, 0.5A load on 12V, 1A load on each of the rest rails.

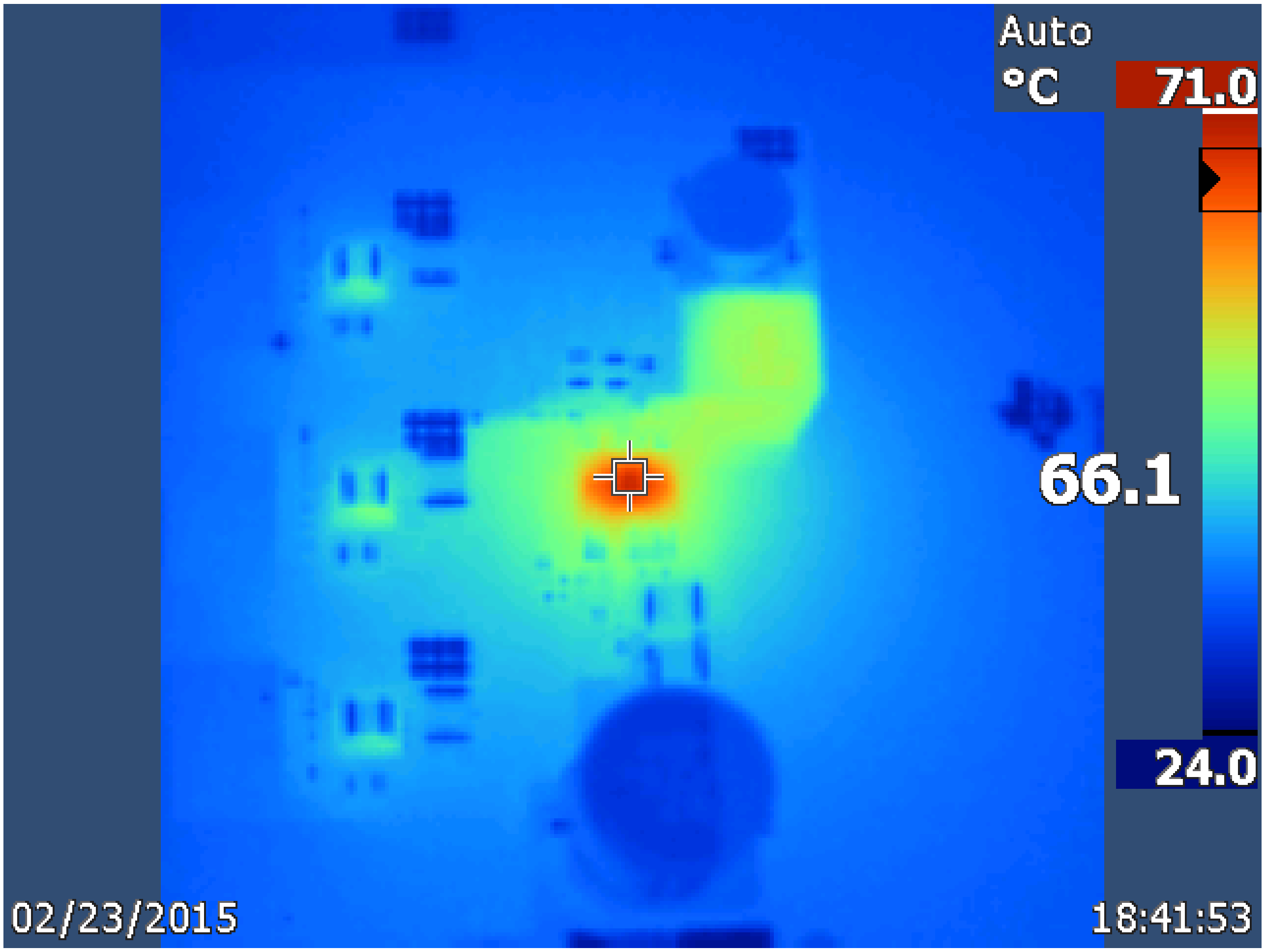


Figure 21. 60V input, 1A load on each rail.

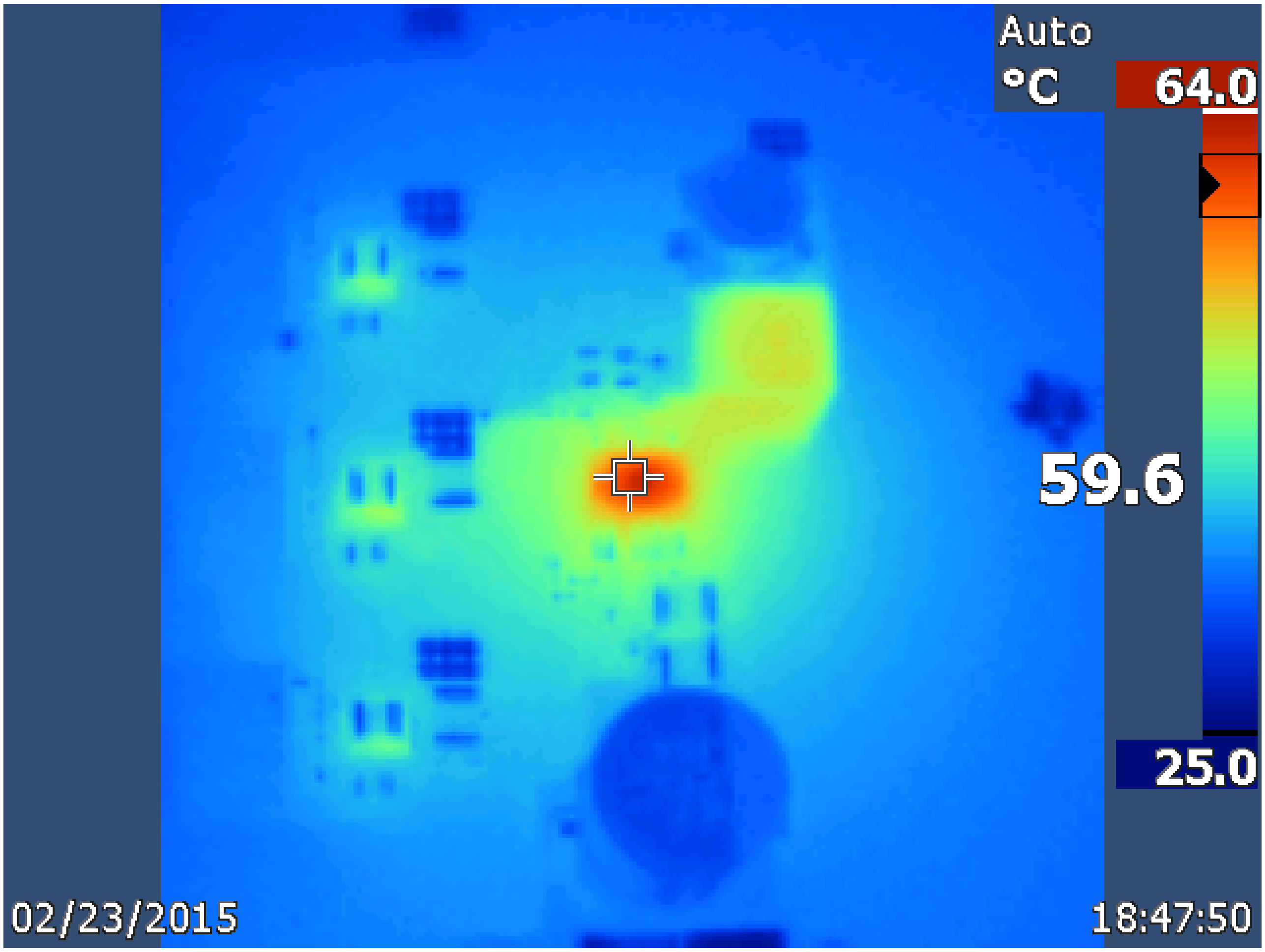


Figure 22. 48V input, 1A load on each rail.

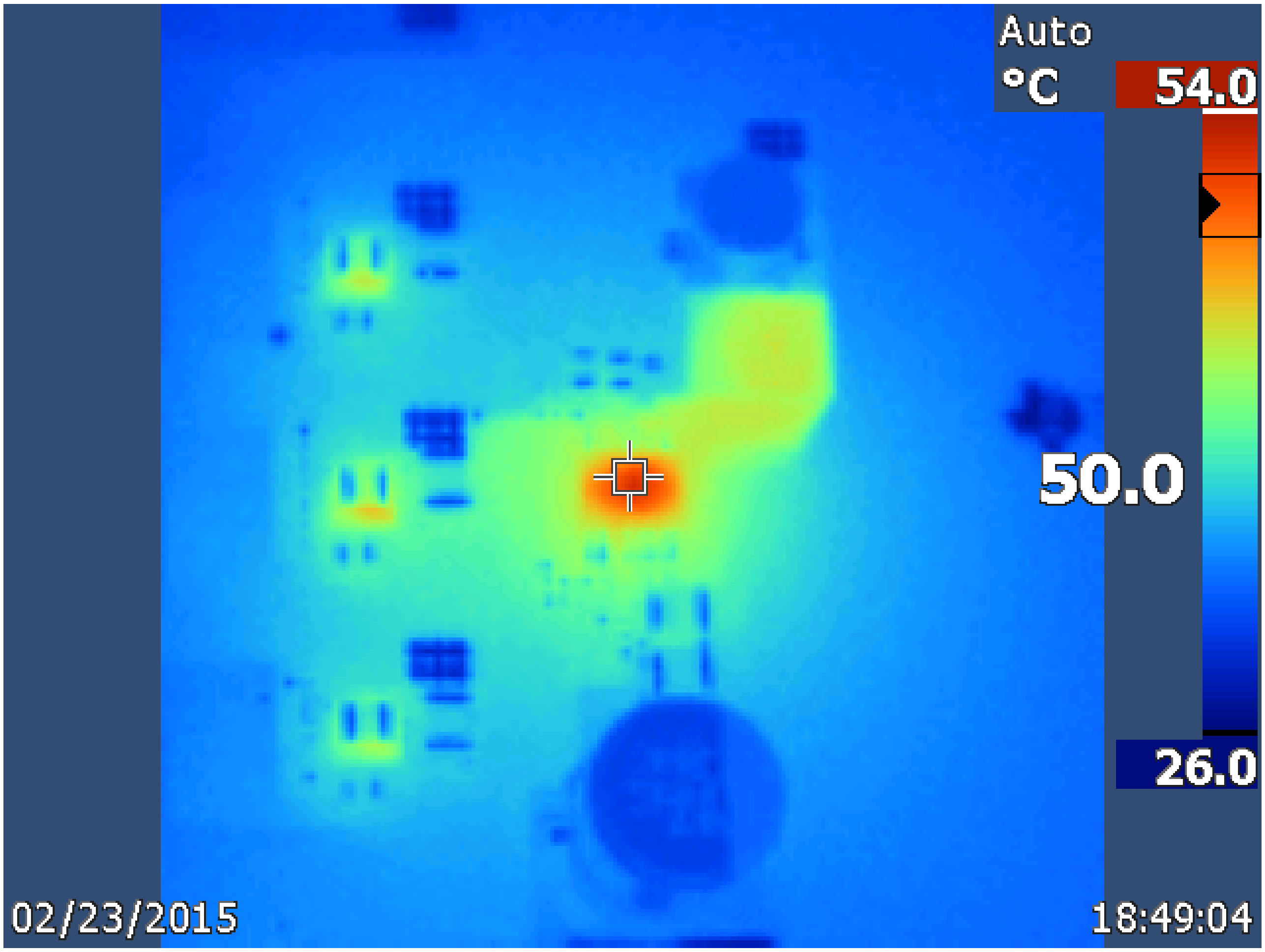


Figure 23. 24V input, 1A load on each rail.

Output Voltage Ripple

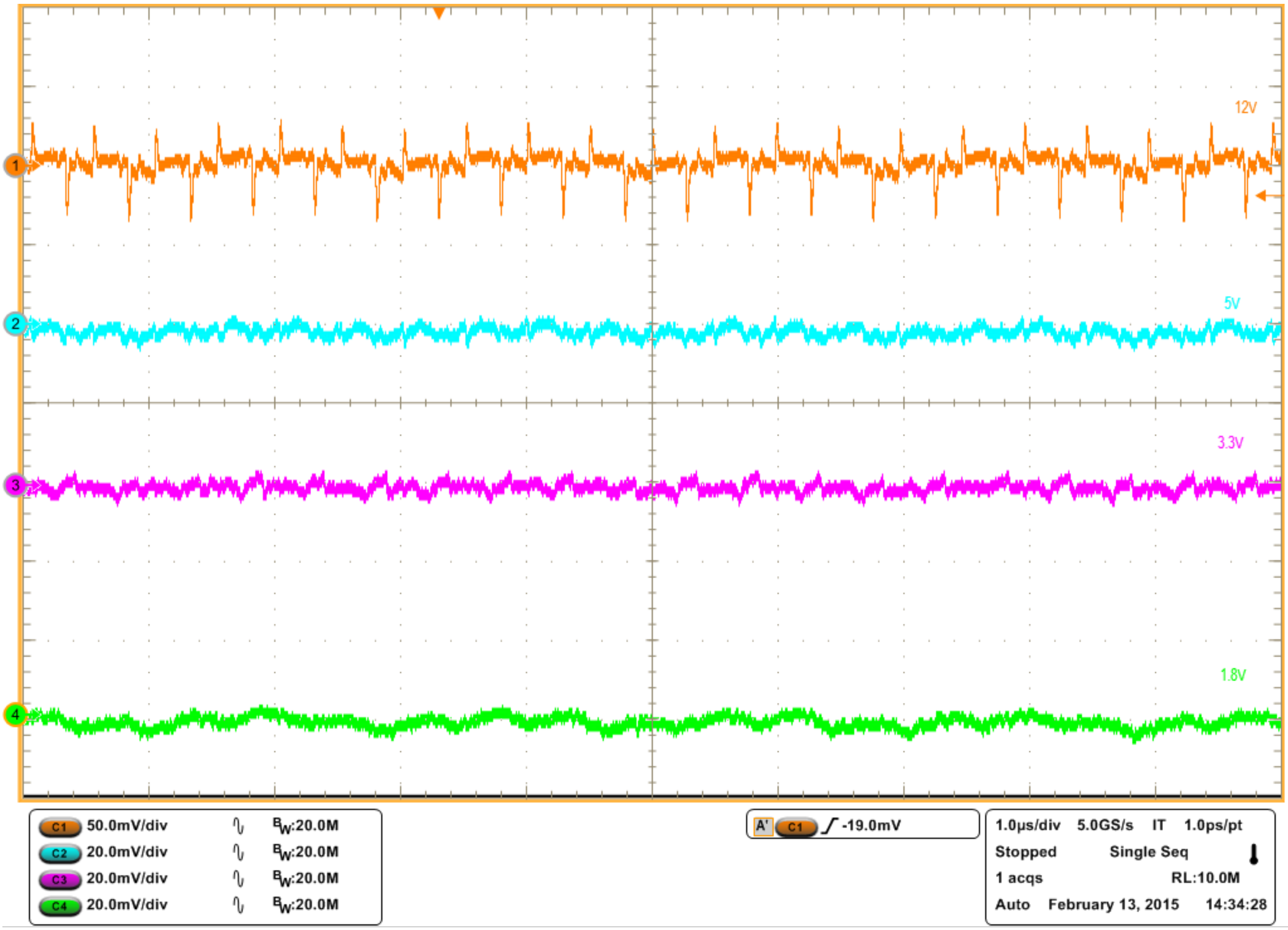


Figure 23. Output voltage ripple, 48V input, 1A load on each rail.

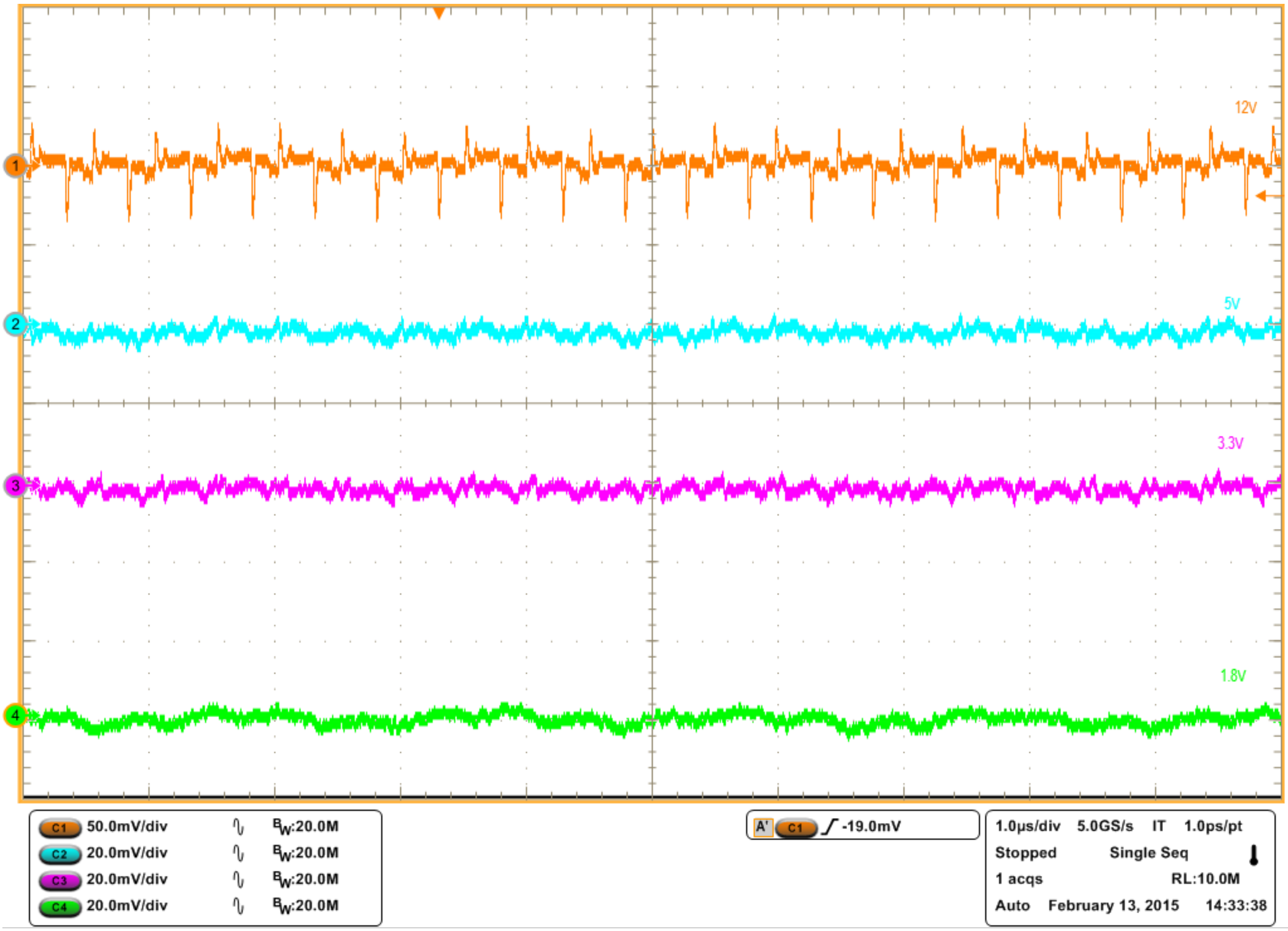


Figure 24. Output voltage ripple, 24V input, 1A load on each rail.

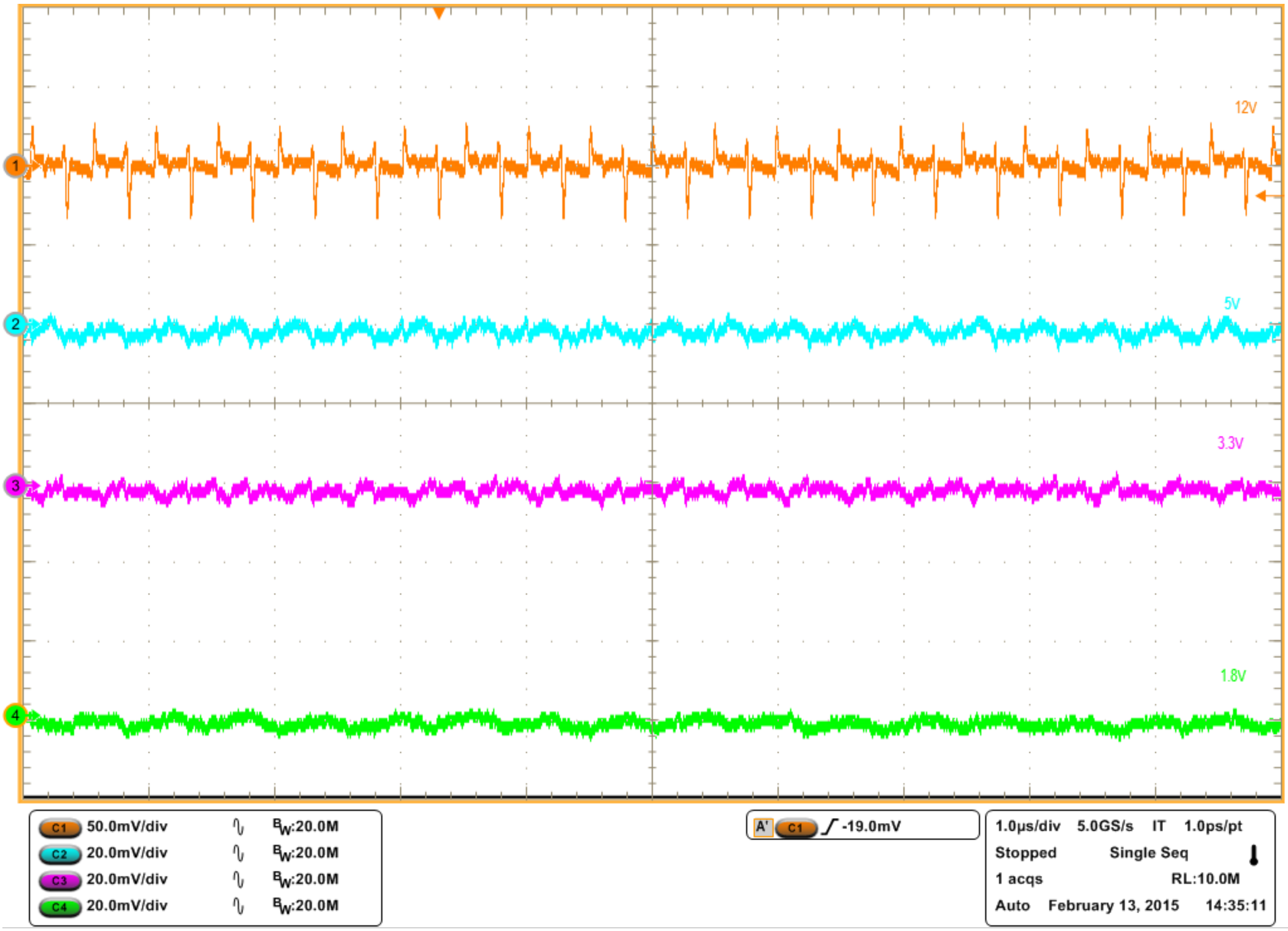


Figure 25. Output voltage ripple, 15V input, 1A load on each rail.

Load Transient

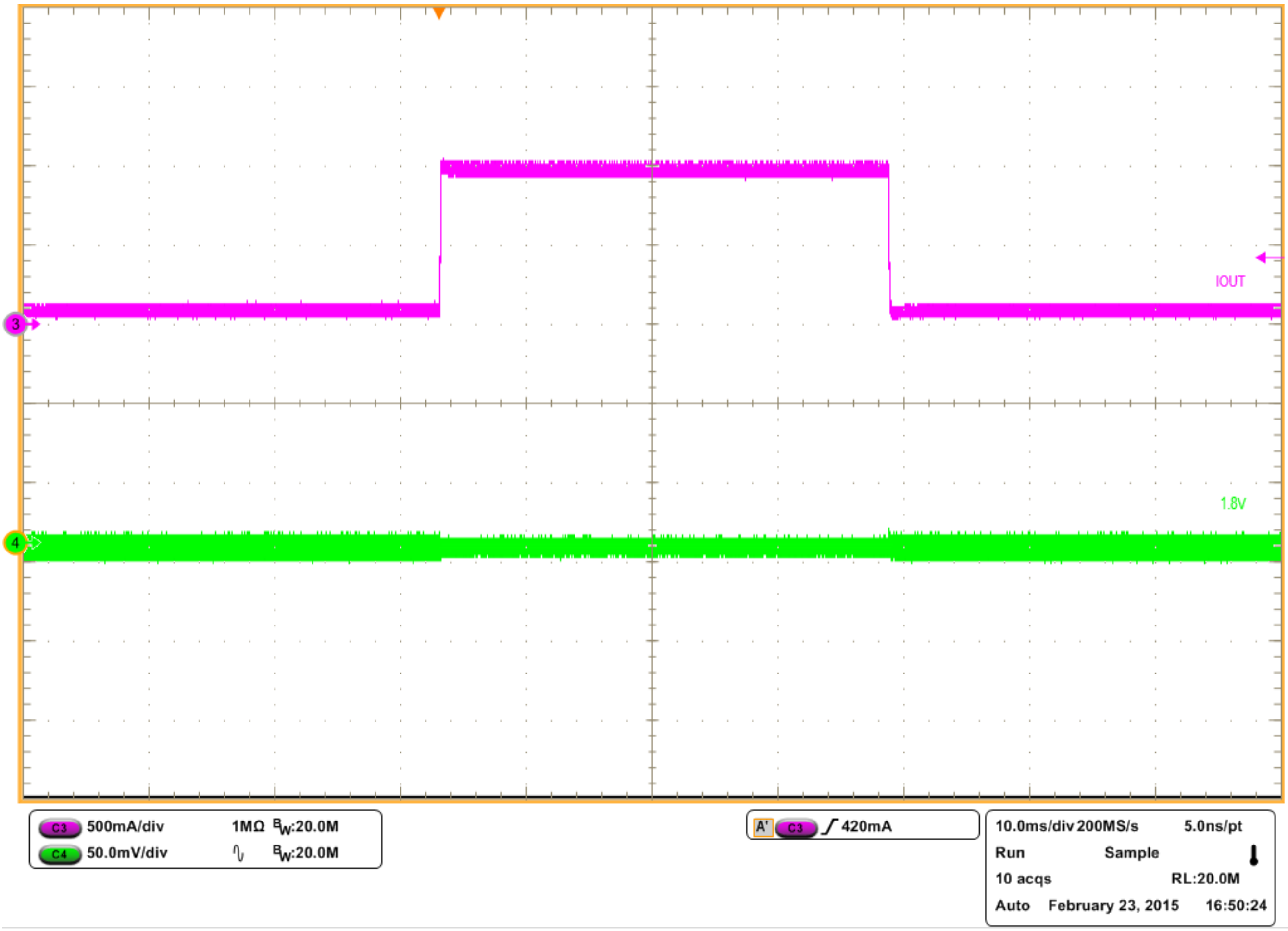


Figure 26. 10% to 100% load step on the 1.8V rail

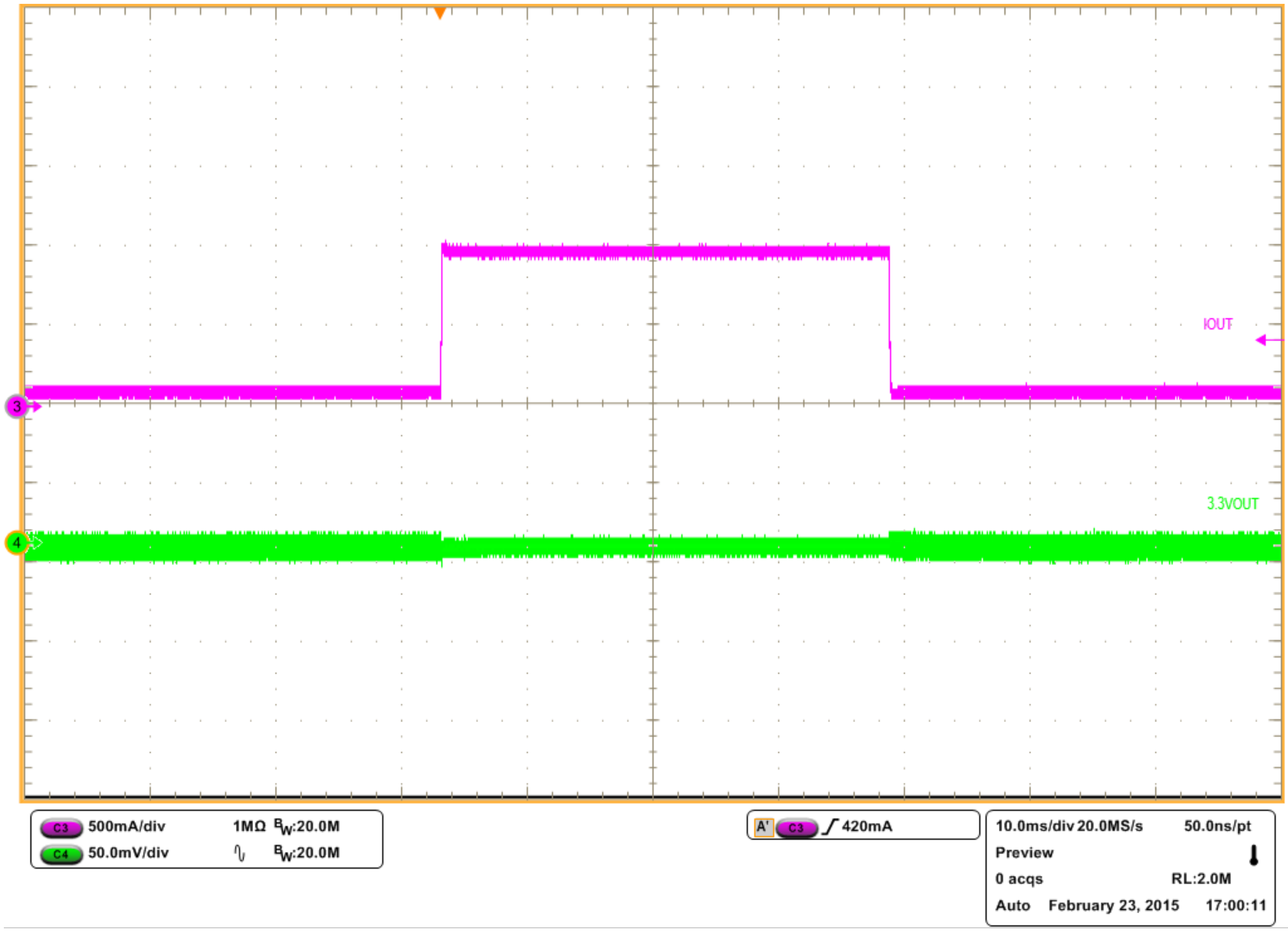


Figure 27. 10% to 100% load step on the 3.3V rail

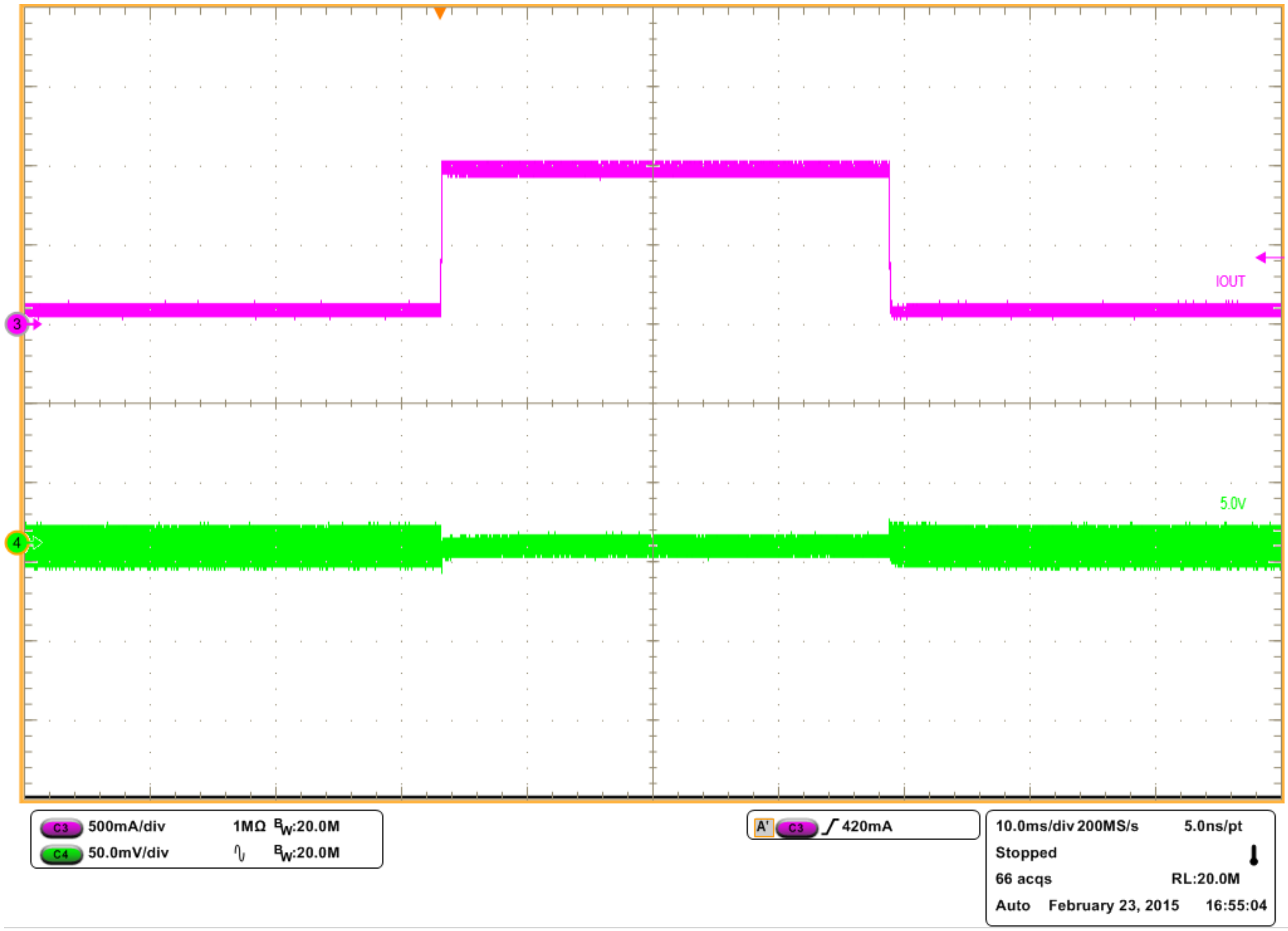


Figure 28. 10% to 100% load step on the 5.0 V rail

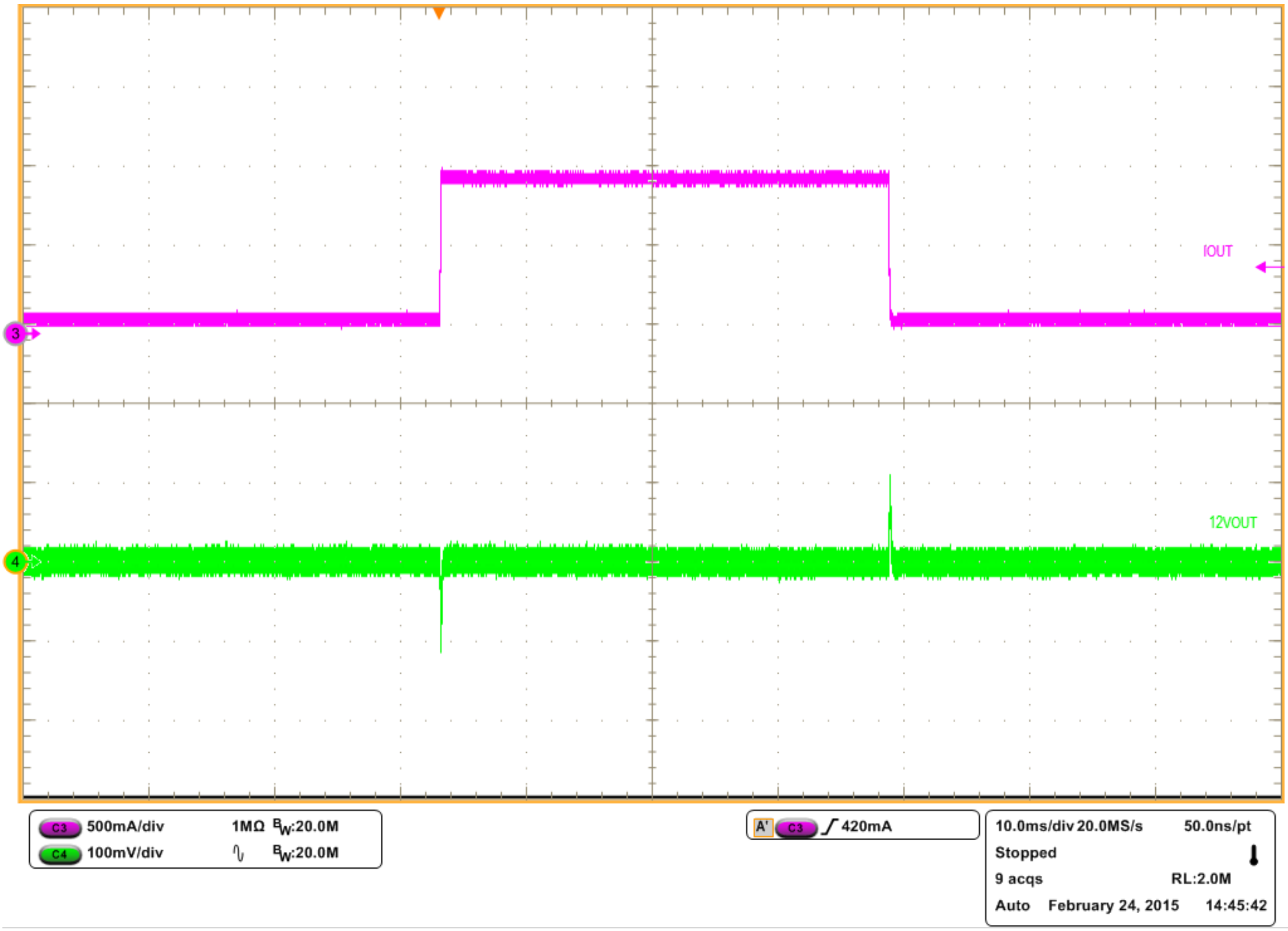


Figure 29. 10% to 100% load step on the 12V rail

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