AN4415
Application note

Power over Ethernet-PD converter with 3.3 V, 3 A output, standard IEEE 802.3af compliant

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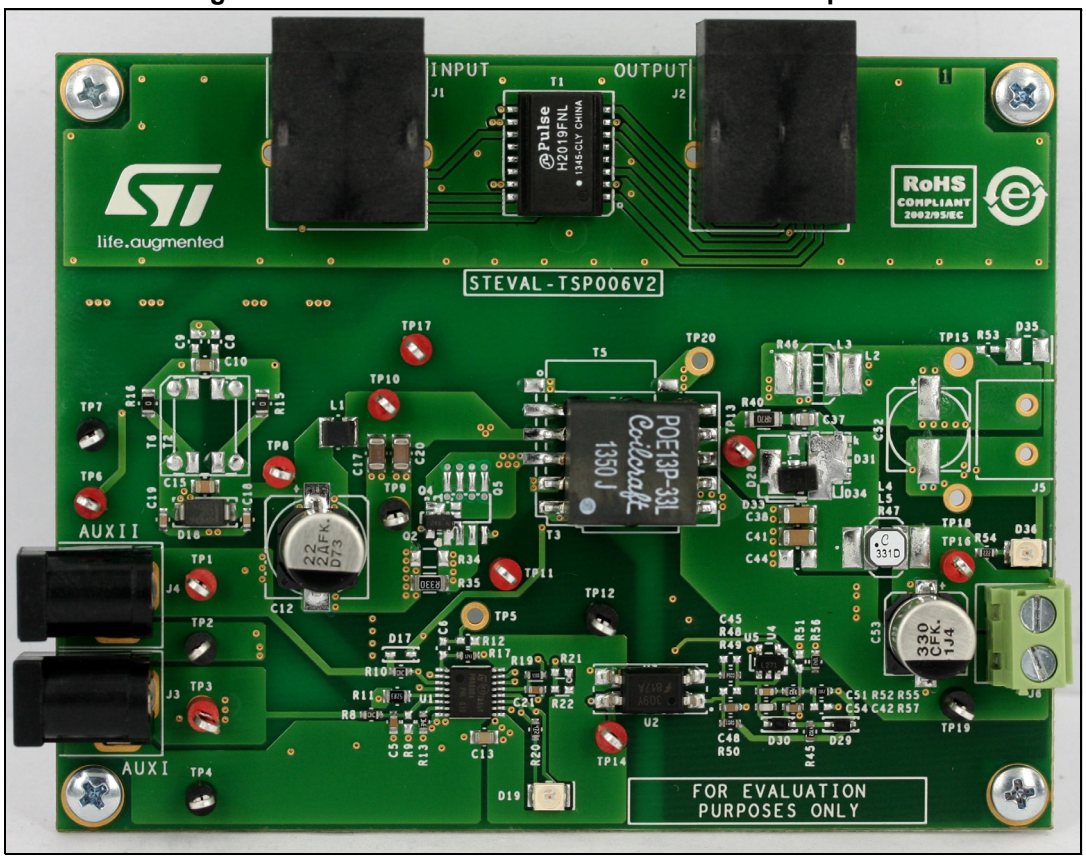
Introduction

This document focuses on a demonstration board design for a simple, low cost 3.3 V, 3 A flyback converter based on the PM8800A device.

The PM8800A is a highly integrated device embedding an IEEE 802.3af compliant “Powered Device” (PD) interface together with a PWM controller.

It can be successfully used in all low power, low cost PoE applications.

Figure 1. STEVAL-TSP006V2 demonstration board photo



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1 Main characteristics and circuit description

The main characteristics (reference and electrical specifications) of the converter are listed in *Table 2*.

Table 1. Reference

Reference code	
Device	PM8800A
Demonstration board	STEVAL-TSP006V2

Table 2. Electrical specification

Parameter	Specifications
Input voltage supplies VIN [VDC]	From 40 to 60 V at 13 W
Output voltage Vout [VDC]	3.3 VDC ± 5% at 3 A
Peak-to-peak output ripple	30 mV (100 mV without L4 output filter)
Efficiency DC-DC full-load	> 83%
Efficiency overall peak	> 80%
Transient response ΔV_{outpk} to 50% load step	< 400 mV
ΔV in load line case	< 0.5%
GLOOP bandwidth	4 kHz
GLOOP phase margin at 0 dB	64 deg.
GLOOP dB margin at 0 deg.	-11 dB

This document details the characteristics and performances of the PM8800A demonstration kit STEVAL-TSP006V2 which has been designed to cover a broad range of power over Ethernet (PoE) applications.

The PM8800A is a highly integrated device embedding an IEEE 802.3af compliant powered device (PD) interface together with a PWM controller and support for auxiliary sources.

Even though the PM8800A can be configured to work in both isolated and non-isolated topologies, single or double output; this application note focuses on a low cost isolated flyback converter topology with diode rectification, 3.3 V output voltage with an up to 3 A output current capability.

Auxiliary sources can be connected to the board on 2 input connectors. One input (AUX II) allows prevalence of the auxiliary sources with respect to the PoE, while the other input (AUX I) allows the usage of a wall adaptor with voltage lower than the internal PoE UVLO threshold and still benefits from the inherent inrush and DC current limit.

The above mentioned configurations are all supported by the PM8800A demonstration kit as options on the same PCB. *Table 3: Bill of material 3.3 V at 3 A* provides the list of components to be mounted to obtain a 3.3 V at 3 A demonstration board.

2 Electrical diagram and bill of material for 3.3 V at 3 A

Figure 2. Circuit diagram 3.3 V at 3 A

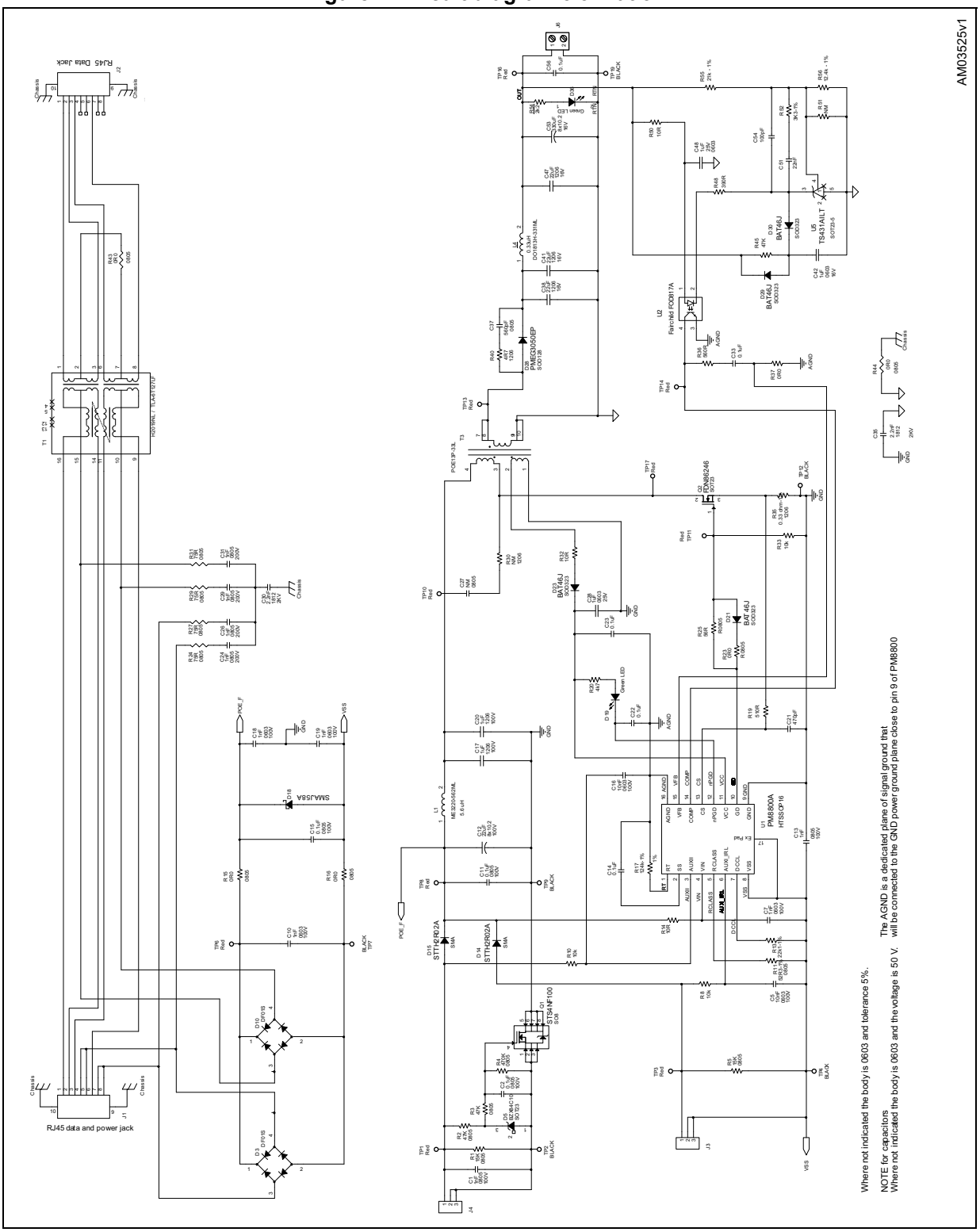


Table 3. Bill of material 3.3 V at 3 A

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
1	C1	Ceramic capacitor	1 nF	C0805	Several	100 V
2	C2	Ceramic capacitor	0.1 µF	C0805	Several	100 V
3	C5	Ceramic capacitor	10 nF	C0603	Several	100 V
4	C7	Ceramic capacitor	1 nF	C0603	Several	100 V
5	C10	Ceramic capacitor	1 nF	C0805	Several	100 V
6	C11	Ceramic capacitor	0.1 µF	C0805	Several	100 V
7	C12	Elect. capacitor	22 µF	C-POL8-10	Panasonic EEEFK2A220P	100 V
8	C13	Ceramic capacitor	1 nF	C0805	Several	100 V
9	C14	Ceramic capacitor	0.1 µF	C0603	Several	50 V
10	C15	Ceramic capacitor	0.1 µF	C0805	Several	100 V
11	C16	Ceramic capacitor	10 nF	C0603	Several	100 V
12	C17	Ceramic capacitor	1 µF	C1206	Several	100 V
13	C18	Ceramic capacitor	1 nF	C0603	Several	100 V
14	C19	Ceramic capacitor	1 nF	C0603	Several	100 V
15	C20	Ceramic capacitor	1 µF	C1206	Several	100 V
16	C21	Ceramic capacitor	470 pF	C0603	Several	50 V
17	C22	Ceramic capacitor	0.1 µF	C0603	Several	50 V
18	C23	Ceramic capacitor	0.1 µF	C0603	Several	50 V
19	C24	Ceramic capacitor	1 nF	C0805	Several	200 V
20	C26	Ceramic capacitor	1 nF	C0805	Several	200 V
21	C27	Ceramic capacitor	N. M.	C0805	Several	50 V
22	C28	Ceramic capacitor	1 µF	C0603	TDK C1608X5R1E105K	25 V
23	C29	Ceramic capacitor	1 nF	C0805	Several	200 V
24	C30	Ceramic capacitor	2.2 nF	C1812	TDK 4532X7R3D222K	2 KV
25	C31	Ceramic capacitor	1 nF	C0805	Several	200 V
26	C33	Ceramic capacitor	0.1 µF	C0603	Several	50 V
27	C35	Ceramic capacitor	2.2 nF	C1812	TDK 4532X7R3D222K	2 KV
28	C37	Ceramic capacitor	560 pF	C0805	Several	50 V
29	C38	Ceramic capacitor	22 µF	C1206	TDK C3216X5R1E226M	16 V
30	C41	Ceramic capacitor	22 µF	C1206	TDK C3216X5R1E226M	16 V
31	C42	Ceramic capacitor	1 µF	C0603	Several	16 V

Table 3. Bill of material 3.3 V at 3 A (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
32	C47	Ceramic capacitor	22 µF	C1206	TDK C3216X5R1E226M	16 V
33	C48	Ceramic capacitor	1 µF	C0603	TDK C1608X5R1E105K	25 V
34	C51	Ceramic capacitor	22 nF	C0603	Several	50 V
35	C53	Elect. capacitor	330 µF	C-POL8-6_3	Panasonic EEEFK1C331P	16 V
36	C54	Ceramic capacitor	100 pF	C0603	Several	50 V
37	C56	Ceramic capacitor	0.1 µF	C0603	Several	50 V
38	D3	Diode bridge	DF01S	DF01S	Diodes	
39	D5	Zener diode	BZX84C10	SOT23	Several	
40	D10	Diode bridge	DF01S	DF01S	Diodes	
41	D14	Diode	STTH2R02A	SMA	STMicroelectronics®	
42	D15	Diode	STTH2R02A	SMA	STMicroelectronics	
43	D18	TVS diode	SMAJ58A	SMA	STMicroelectronics	
44	D19	LED diode	Green LED	LED-TLGE1100B	TOSHIBA	
45	D21	Diode	BAT46J	SOD323	STMicroelectronics	
46	D23	Diode	BAT46J	SOD323	STMicroelectronics	
47	D28	Schottky diode	PMEG3050EP	SOD128	NXP	
48	D29	Diode	BAT46J	SOD323	STMicroelectronics	
49	D30	Diode	BAT46J	SOD323	STMicroelectronics	
50	D36	LED diode	Green LED	LED-TLGE1100B	TOSHIBA	
51	J1	Connector	RJ45 data and power jack	RJ45-8PIN	Several	
52	J2	Connector	RJ45 data jack	RJ45-8PIN	Several	
53	J3	Connector	CON3	P-JACK-RAPC722	Switchcraft	
54	J4	Connector	CON3	P-JACK-RAPC722	Switchcraft	
55	J6	Connector	MOR-10X10.5-P5-2PIN	MOR-2POLI-508	Several	
56	L1	Inductor	5.6 µH	ME3220-562ML	Coilcraft	
57	L4	Inductor	0.33 µH	LPS4012-331L	Coilcraft	
58	Q1	MOSFET	STS4NF100	SO8	STMicroelectronics	
59	Q2	MOSFET	FDN86246	SOT23	FAIRCHILD	
60	R1	Resistor	15 KΩ	R0805	Several	
61	R2	Resistor	47 KΩ	R0805	Several	
62	R3	Resistor	47 KΩ	R0805	Several	
63	R4	Resistor	470 KΩ	R0805	Several	
64	R5	Resistor	15 KΩ	R0805	Several	

Table 3. Bill of material 3.3 V at 3 A (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
65	R8	Resistor	10 kΩ	R0603	Several	
66	R10	Resistor	10 kΩ	R0603	Several	
67	R11	Resistor	52.3 Ω -1%	R0805	Several	
68	R13	Resistor	22.1 kΩ -1%	R0603	Several	
69	R14	Resistor	10 Ω	R0603	Several	
70	R15	Resistor	0 Ω	R0805	Several	
71	R16	Resistor	0 Ω	R0805	Several	
72	R17	Resistor	124 kΩ-1%	R0603	Several	
73	R19	Resistor	510 Ω	R0603	Several	
74	R20	Resistor	4.7 kΩ	R0603	Several	
75	R23	Resistor	0 Ω	R0805	Several	
76	R24	Resistor	75 Ω	R0805	Several	
77	R25	Resistor	56 Ω	R0805	Several	
78	R27	Resistor	75 Ω	R0805	Several	
79	R29	Resistor	75 Ω	R0805	Several	
80	R30	Resistor	N. M.	R1206	Several	
81	R31	Resistor	75 Ω	R0805	Several	
82	R32	Resistor	10 Ω	R0603	Several	
83	R33	Resistor	10 kΩ	R0603	Several	
84	R35	Sense resistor	0.33 Ω -1%	R1206	Vishay - RCWE1206R330FKE	
85	R36	Resistor	560 Ω	R0603	Several	
86	R37	Resistor	0 Ω	R0603	Several	
87	R40	Resistor	4.7 Ω	R1206	Several	
88	R43	Resistor	0 Ω	R0805	Several	
89	R44	Resistor	0 Ω	R1206	Several	
90	R45	Resistor	47 KΩ	R0603	Several	
91	R48	Resistor	390 Ω	R0603	Several	
92	R50	Resistor	10 Ω	R0603	Several	
93	R51	Resistor	N. M.	R0603	Several	
94	R52	Resistor	3.3 KΩ -1%	R0603	Several	
95	R54	Resistor	2.2 kΩ	R0603	Several	
96	R55	Resistor	21 kΩ - 1%	R0603	Several	
97	R56	Resistor	12.4 kΩ - 1%	R0603	Several	
98	TP1	Test point	Red	TH-5013	KEYSTONE	

Table 3. Bill of material 3.3 V at 3 A (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
99	TP2	Test point	Black	TH-5013	KEYSTONE	
100	TP3	Test point	Red	TH-5013	KEYSTONE	
101	TP4	Test point	Black	TH-5013	KEYSTONE	
102	TP6	Test point	Red	TH-5013	KEYSTONE	
103	TP7	Test point	Black	TH-5013	KEYSTONE	
104	TP8	Test point	Red	TH-5013	KEYSTONE	
105	TP9	Test point	Black	TH-5013	KEYSTONE	
106	TP10	Test point	Red	TH-5013	KEYSTONE	
107	TP11	Test point	Red	TH-5013	KEYSTONE	
108	TP12	Test point	Black	TH-5013	KEYSTONE	
109	TP13	Test point	Red	TH-5013	KEYSTONE	
110	TP14	Test point	Red	TH-5013	KEYSTONE	
111	TP16	Test point	Red	TH-5013	KEYSTONE	
112	TP17	Test point	Red	TH-5013	KEYSTONE	
113	TP19	Test point	Black	TH-5013	KEYSTONE	
114	T1	Data transfo.	H2019NL / TLA-6T127LF	Pulse-H2019	Pulse	
115	T3	Power transfo.	POE13P-33L	POE13P	Coilcraft	
116	U1	Controller IC	PM8800A	HTSSOP16	STMicroelectronics	
117	U2	Optocoupler	FAIRCHILD FOD817A	FOD817	FAIRCHILD	
118	U5	Voltage reference	TS431AILT	SOT23-5L	STMicroelectronics	

3 Measurements results

3.1 Efficiency

Figure 3. Overall and DC-DC efficiency

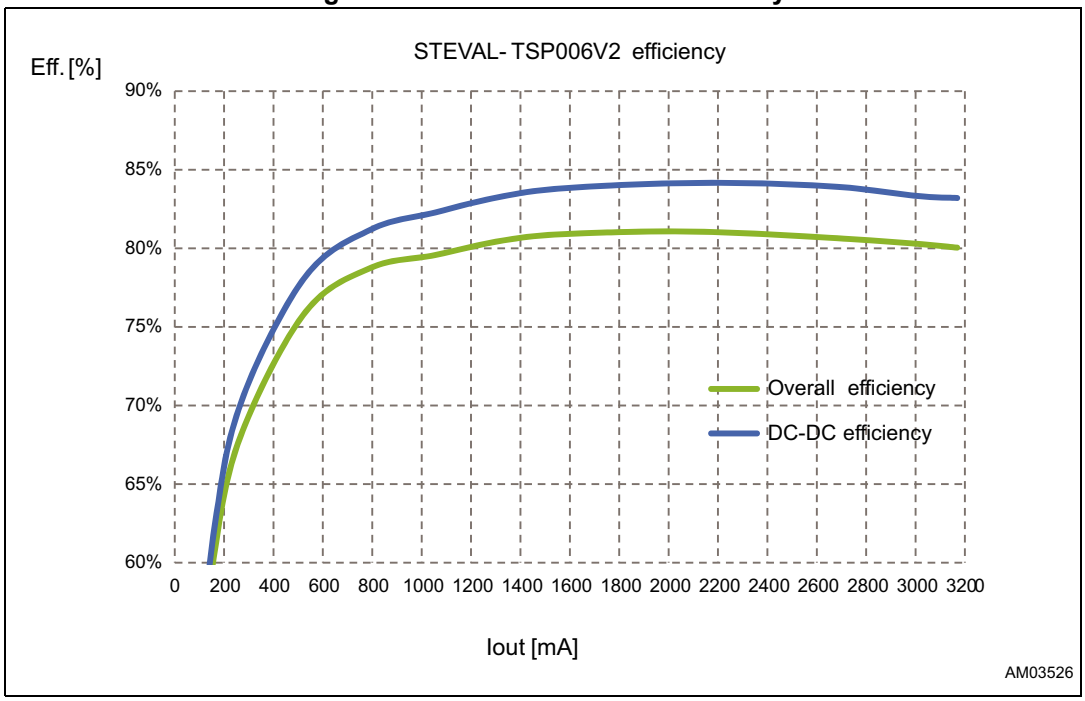


Figure 3 shows overall and DC-DC efficiencies for the converter. Overall efficiency includes all loss from the RJ45 to the 3.3 V output voltage rail. DC-DC efficiency is a figure of a merit of the converter standalone and typically does not include the losses associated to the PoE interface section, that are: the RJ45 connector, data transformer, bridges, power consumption of the I/F section of the PM8800A device.

Figure 4. Efficiency input stage

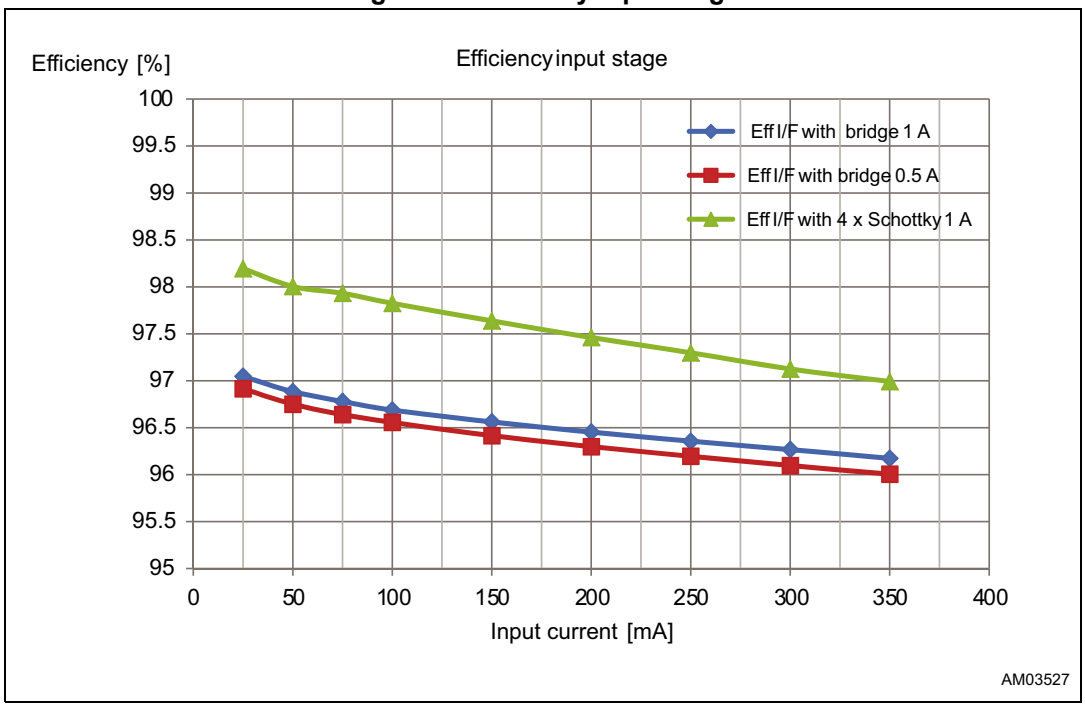
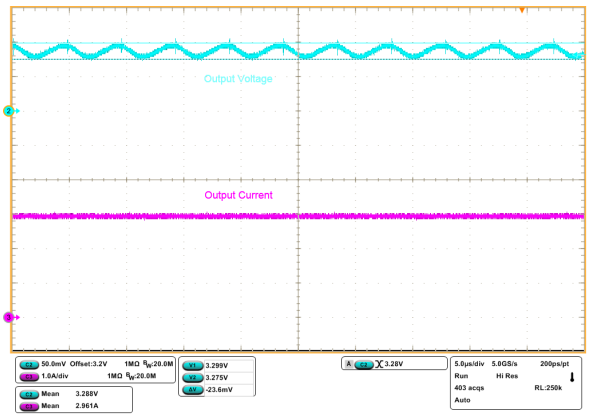


Figure 4 shows the efficiency comparison implementing three different settings of bridge rectification on the board. No relevant differences have been highlighted using a standard diode bridge (1 A or 0.5 A). The best efficiency has been captured using a bridge with four discrete 1 A Schottky diodes, reaching even a gain of about 1%.

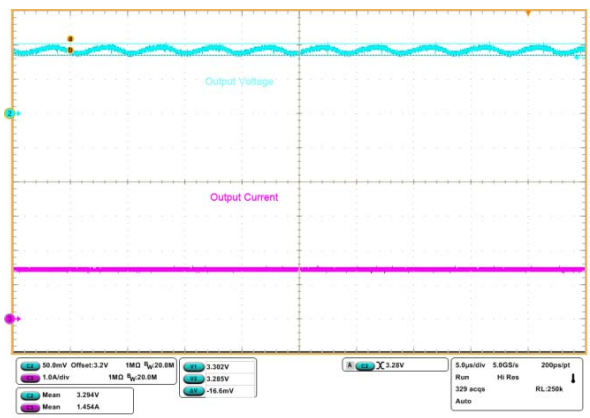
3.2 Output voltage ripple

Figure 5. Ripple 3.3 V at 3 A



CH2: output voltage
CH3: output current

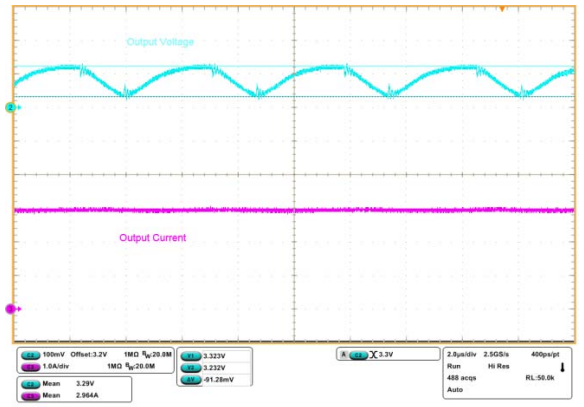
Figure 6. Ripple 3.3 V at 1.5 A



CH2: output voltage
CH3: output current

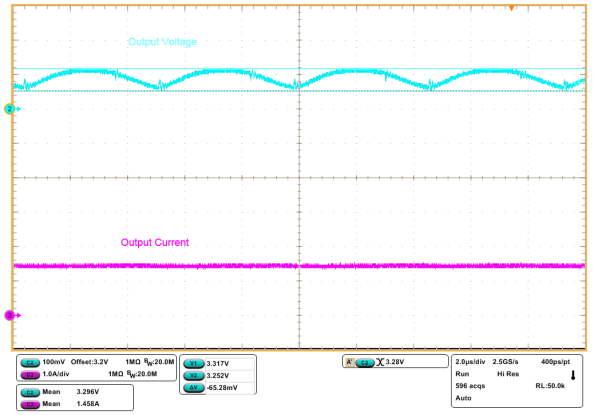
Above measurement are referred to the output voltage ripple (around 30 mV in full load condition). A ripple voltage comparison has been done replacing a 0.33 µH inductor on the L4 position with a resistor R47 = 0 Ω. The output voltage ripple, as shown in *Figure 7*, is around 100 mV in full load condition.

Figure 7. Ripple 3.3 V at 3 A removing L4 filter



CH2: output voltage
CH3: output current

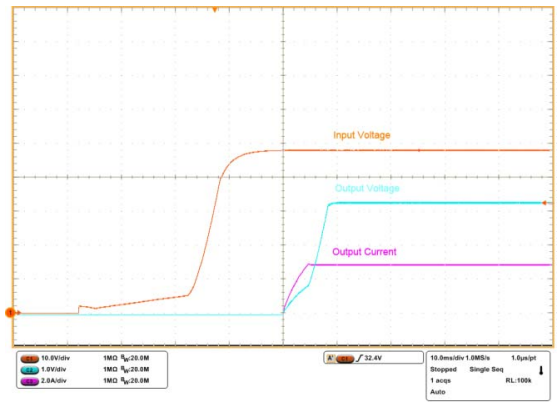
Figure 8. Ripple 3.3 V at 1.5 A removing L4 filter



CH2: output voltage
CH3: output current

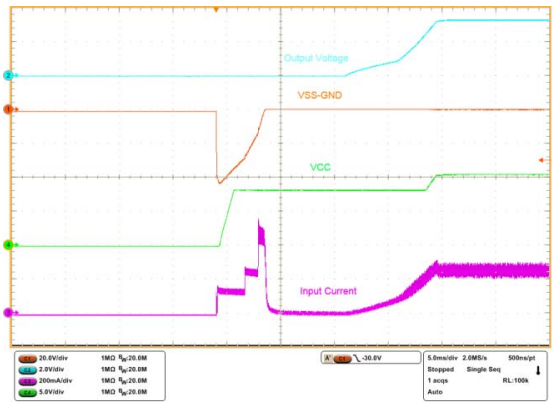
3.3 Startup

Figure 9. Startup - full load



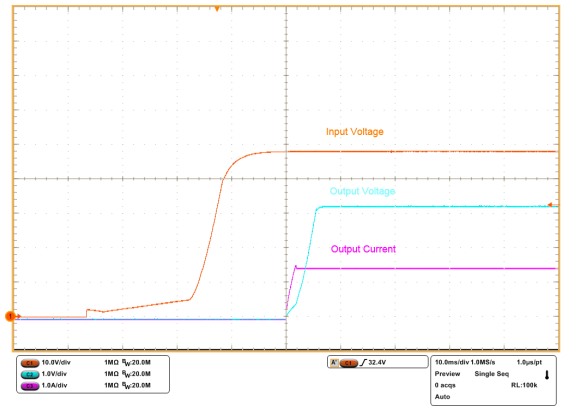
CH1: input voltage
CH2: output voltage
CH3: output current

Figure 10. Startup - full load sequencing



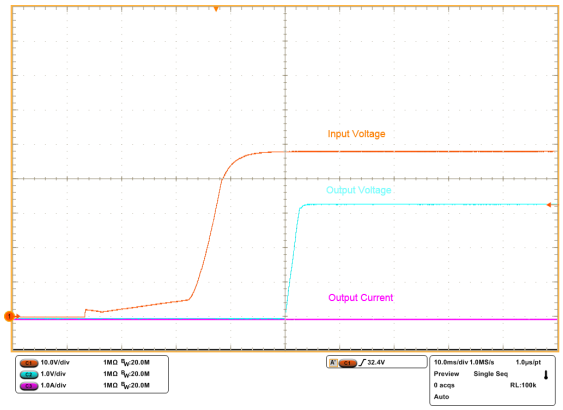
CH1: VSS - GND
CH2: output voltage
CH3: input current
CH4: VCC

Figure 11. Startup - 1.5 A



CH1: input voltage
CH2: output voltage
CH3: output current

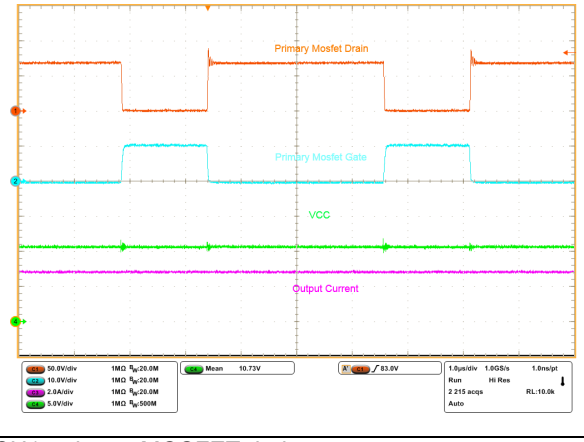
Figure 12. Startup - no load



CH1: input voltage
CH2: output voltage
CH3: output current

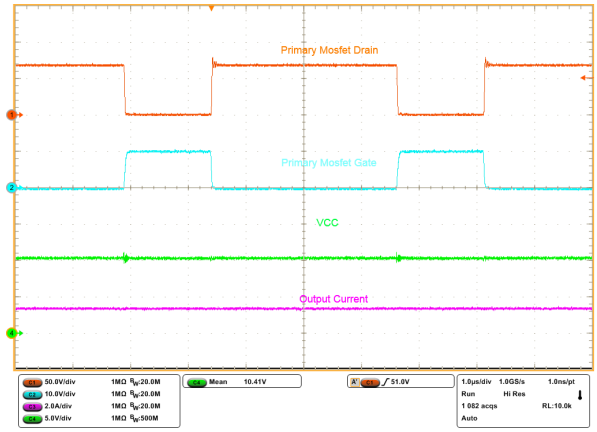
3.4 Primary side waveforms

Figure 13. Steady state 3 A



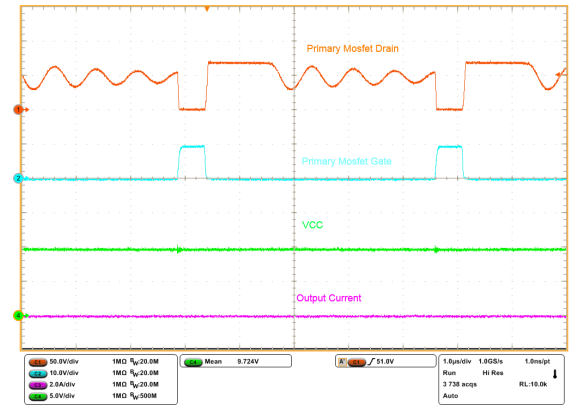
CH1: primary MOSFET drain
CH2: primary MOSFET gate
CH3: output current
CH4: VCC

Figure 14. Steady state 1.5 A



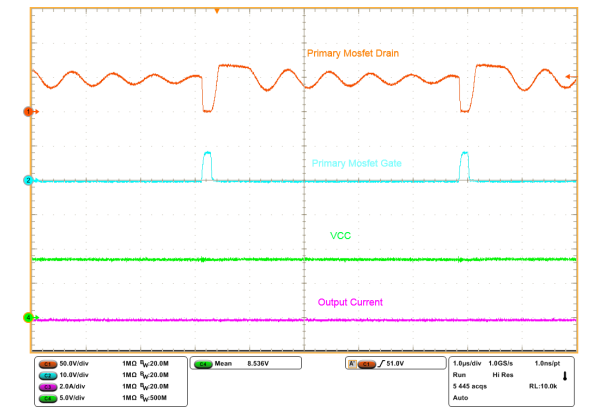
CH1: primary MOSFET drain
CH2: primary MOSFET gate
CH3: output current
CH4: VCC

Figure 15. Steady state 100 mA



CH1: primary MOSFET drain
CH2: primary MOSFET gate
CH3: output current
CH4: VCC

Figure 16. Steady state no load



CH1: primary MOSFET drain
CH2: primary MOSFET gate
CH3: output current
CH4: VCC

3.5 Dynamic load

Figure 17. Dynamic load 3 A - 1.5 A

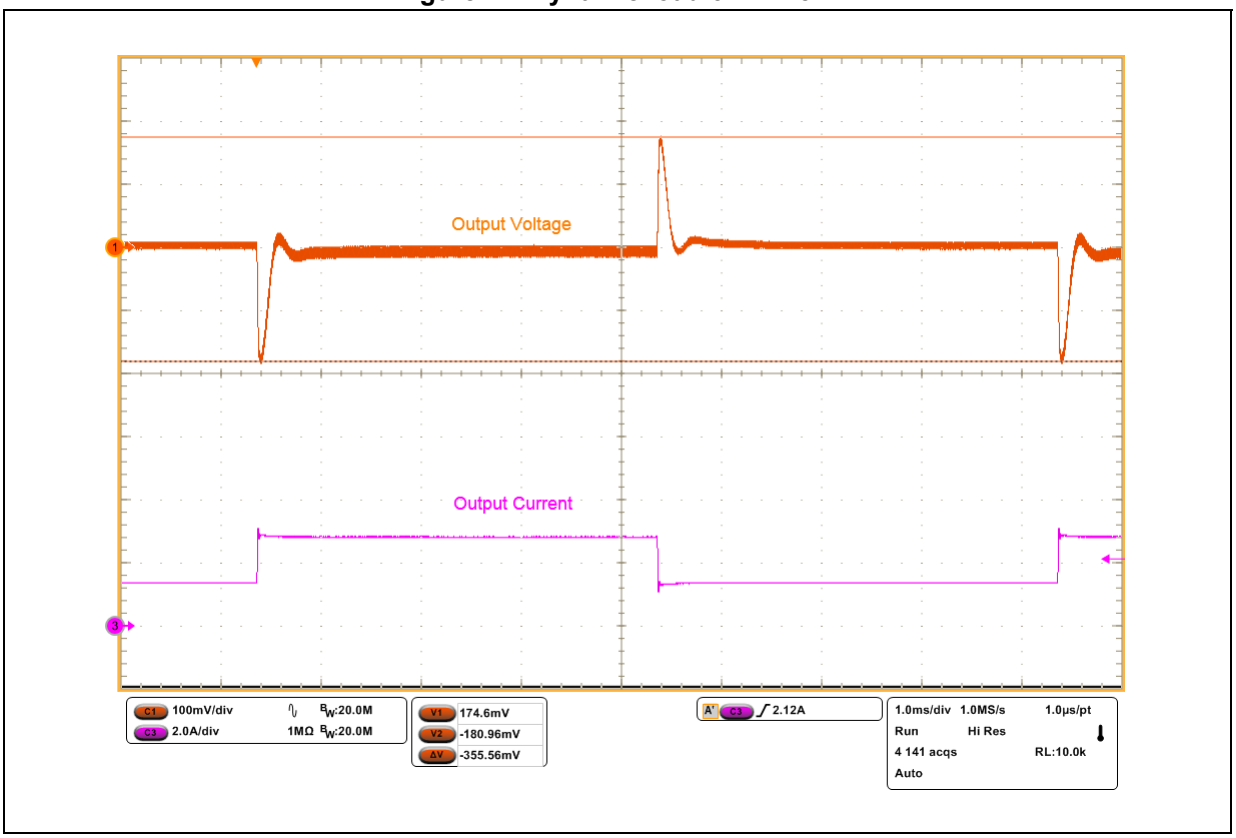
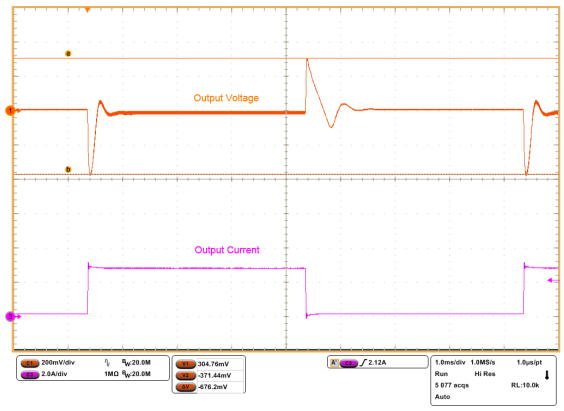
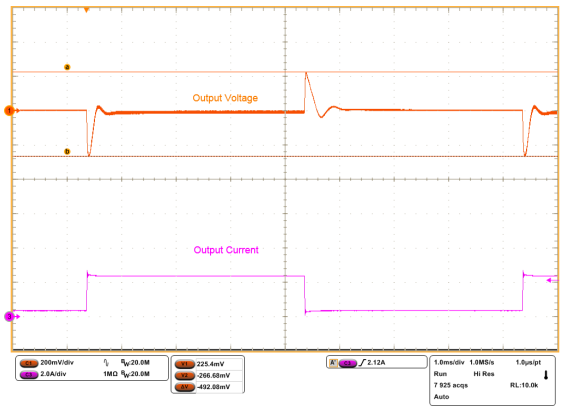


Figure 18. Dynamic load 3 A - 300 mA



CH1: output voltage
CH3: output current

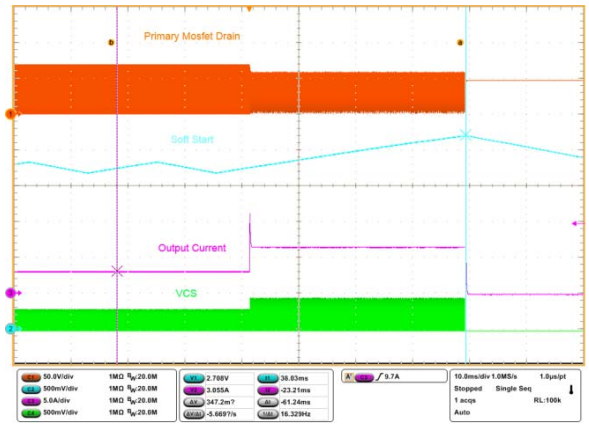
Figure 19. Dynamic load 2500 mA - 500 mA



CH1: output voltage
CH3: output current

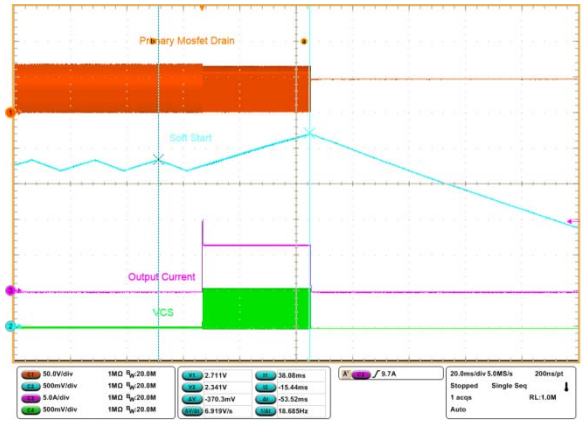
3.6 Short-circuit behavior

Figure 20. OCP detection - full load



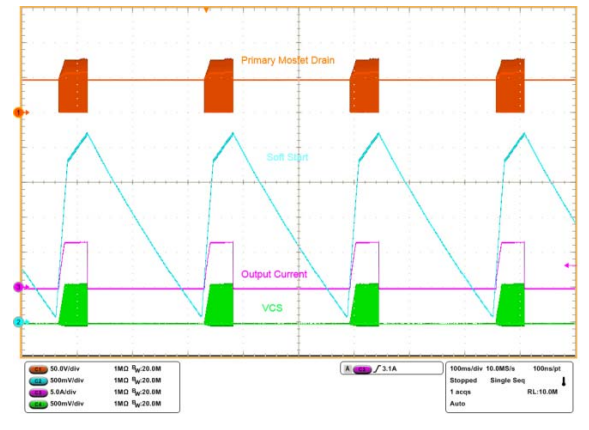
CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 21. OCP detection - no load



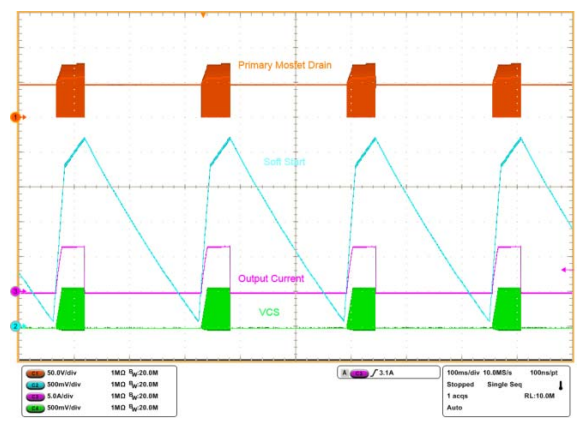
CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 22. OCP steady state - full load



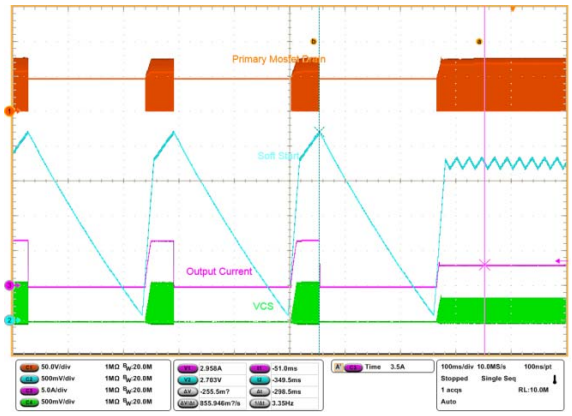
CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 23. OCP steady state- no load



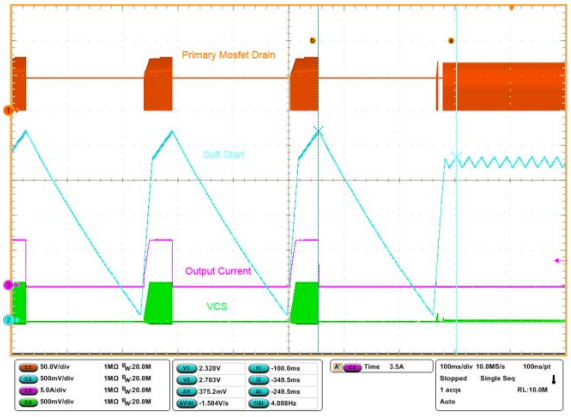
CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 24. OCP removed - full load



CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 25. OCP removed - no load



CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

4 Loop compensation

Figure 26. Gain loop full load 48 V

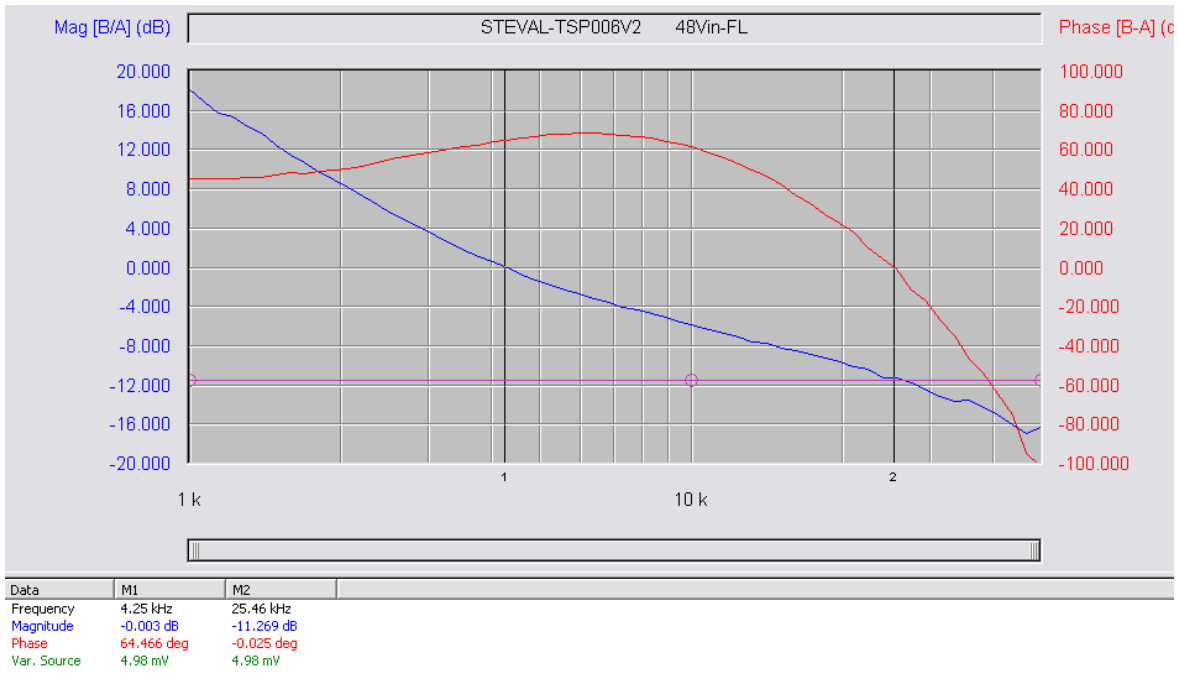


Figure 27. Gain loop half load 48 V

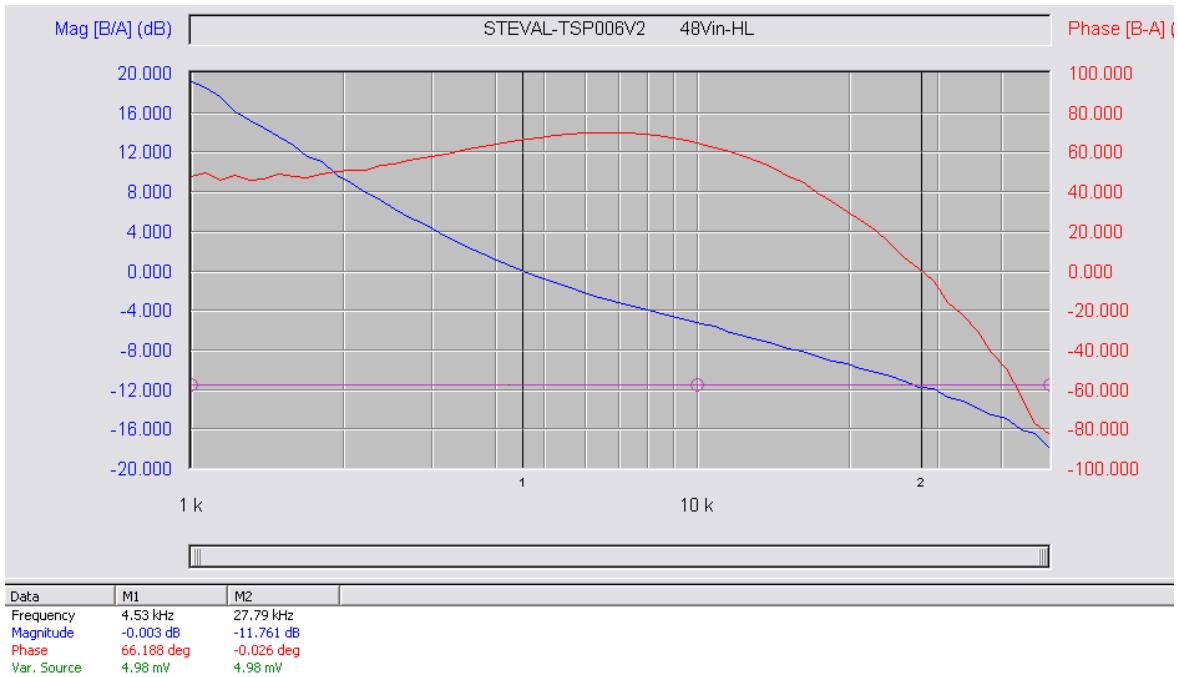


Figure 28. Gain loop full load 40 V

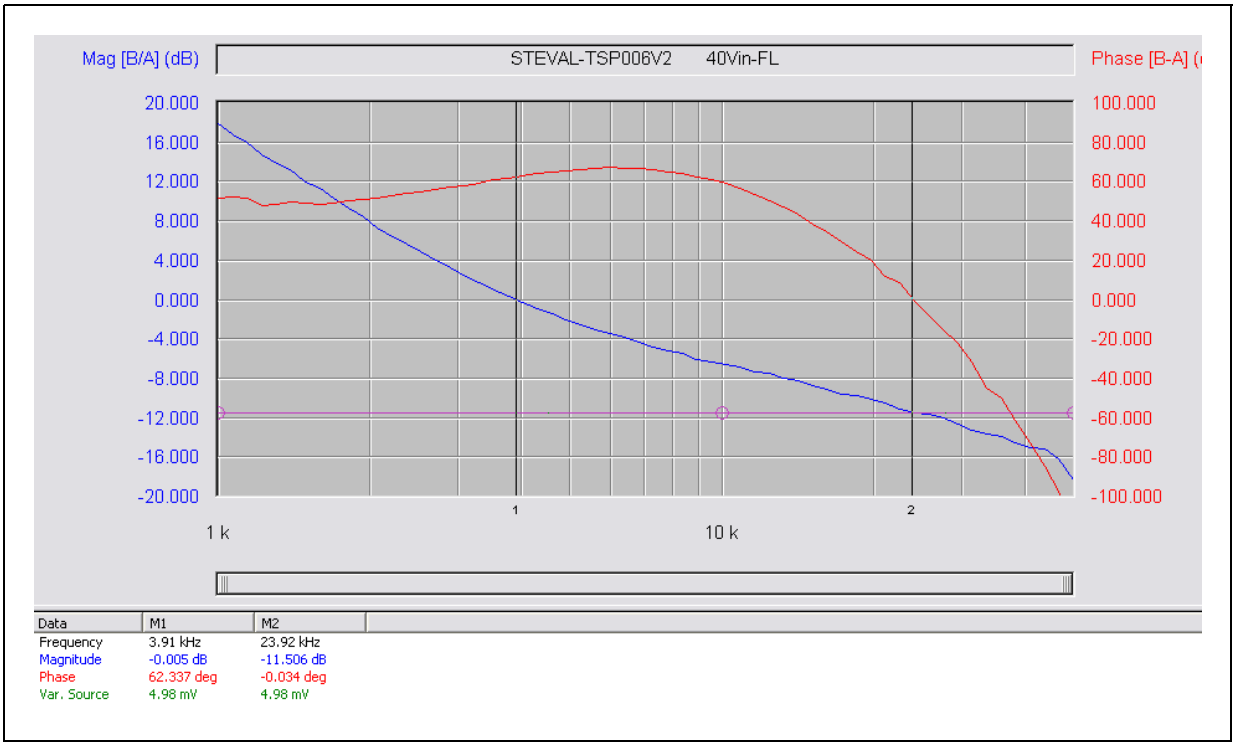


Figure 29. Gain loop full load 60 V

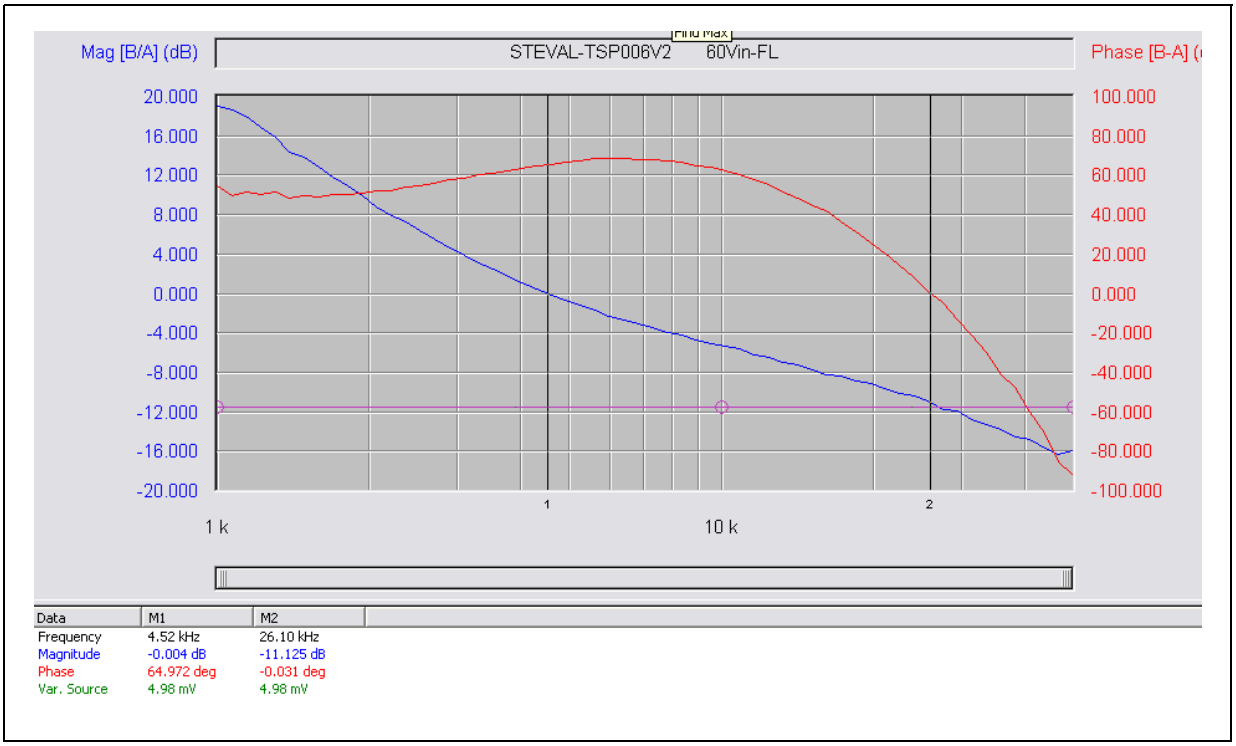


Table 4. Gain loop measurement

12 Vout	48 V, 3 A	40 V, 3 A	60 V, 3 A	48 V, 1.5 A
BW [kHz]	4.25	3.91	4.52	4.53
Phase margin [deg.] at 0 db	64	62	65	66
Gain margin [dB] at 0 deg.	-11	-11	-11	-11

5 Supporting material

Figure 30. Electrical diagram (general)

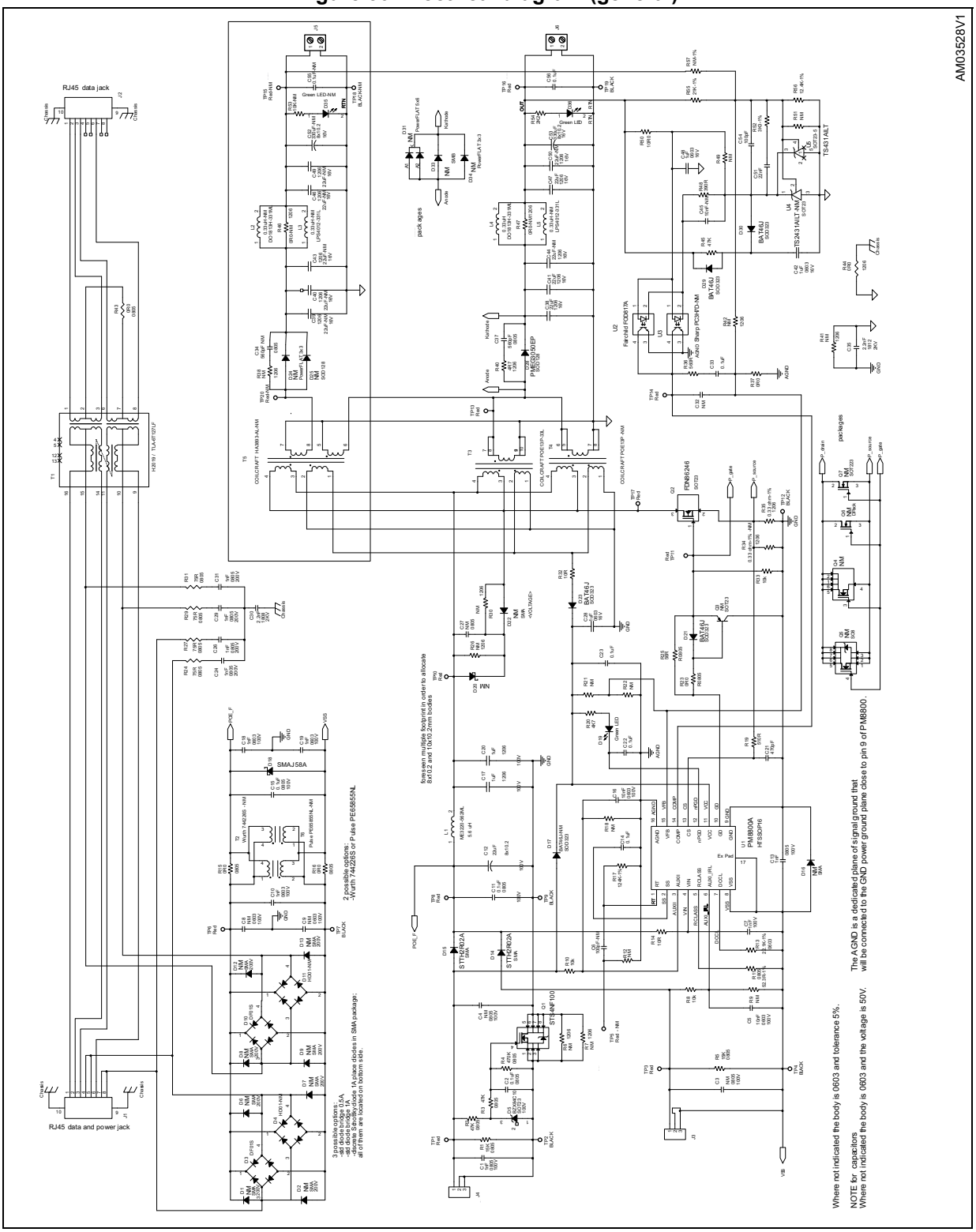


Table 5. Bill of material (general)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
1	C1	Ceramic capacitor	1 nF	C0805	Several	100 V
2	C2	Ceramic capacitor	0.1 µF	C0805	Several	100 V
3	C3	Ceramic capacitor	N. M.	C0805	Several	100 V
4	C4	Ceramic capacitor	N. M.	C0805	Several	100 V
5	C5	Ceramic capacitor	10 nF	C0603	Several	100 V
6	C6	Ceramic capacitor	100 pF - N. M.	C0603	Several	50 V
7	C7	Ceramic capacitor	1 nF	C0603	Several	100 V
8	C8	Ceramic capacitor	N. M.	C0603	Several	100 V
9	C9	Ceramic capacitor	N. M.	C0603	Several	100 V
10	C10	Ceramic capacitor	1 nF	C0805	Several	100 V
11	C11	Ceramic capacitor	0.1 µF	C0805	Several	100 V
12	C12	Electrol. capacitor	22 µF	C-POL8-10	Panasonic EEEFK2A220P	100 V
13	C13	Ceramic capacitor	1 nF	C0805	Several	100 V
14	C14	Ceramic capacitor	0.1 µF	C0603	Several	50 V
15	C15	Ceramic capacitor	0.1 µF	C0805	Several	100 V
16	C16	Ceramic capacitor	10 nF	C0603	Several	100 V
17	C17	Ceramic capacitor	1 µF	C1206	Several	100 V
18	C18	Ceramic capacitor	1 nF	C0603	Several	100 V
19	C19	Ceramic capacitor	1 nF	C0603	Several	100 V
20	C20	Ceramic capacitor	1 µF	C1206	Several	100 V
21	C21	Ceramic capacitor	470 pF	C0603	Several	50 V
22	C22	Ceramic capacitor	0.1 µF	C0603	Several	50 V
23	C23	Ceramic capacitor	0.1 µF	C0603	Several	50 V
24	C24	Ceramic capacitor	1 nF	C0805	Several	200 V
25	C26	Ceramic capacitor	1 nF	C0805	Several	200 V
26	C27	Ceramic capacitor	N. M.	C0805	Several	50 V
27	C28	Ceramic capacitor	1 µF	C0603	TDK C1608X5R1E105K	16 V
28	C29	Ceramic capacitor	1 nF	C0805	Several	200 V
29	C30	Ceramic capacitor	2.2nF	C1812	TDK 4532X7RD222K	2KV
30	C31	Ceramic capacitor	1 nF	C0805	Several	200 V
31	C32	Ceramic capacitor	N. M.	C0603	Several	50 V
32	C33	Ceramic capacitor	0.1 µF	C0603	Several	50 V
33	C34	Ceramic capacitor	560 pF N. M.	C0805	Several	50 V

Table 5. Bill of material (general) (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
34	C35	Ceramic capacitor	2.2 nF	C1812	TDK 4532X7RD222K	2KV
35	C37	Ceramic capacitor	560 pF	C0805	Several	50 V
36	C38	Ceramic capacitor	22 µF	C1206	TDK C3216X5R1E226M	16 V
37	C39	Ceramic capacitor	22 µF - N. M.	C1206	TDK C3216X5R1E226M	16 V
38	C40	Ceramic capacitor	22 µF - N. M.	C1206	TDK C3216X5R1E226M	16 V
39	C41	Ceramic capacitor	22 µF	C1206	TDK C3216X5R1E226M	16 V
40	C42	Ceramic capacitor	1 µF	C0603	Several	16 V
41	C43	Ceramic capacitor	22 µF - N. M.	C1206	TDK C3216X5R1E226M	16 V
42	C44	Ceramic capacitor	22 µF - N. M.	C1206	TDK C3216X5R1E226M	16 V
43	C45	Ceramic capacitor	10 nF - N. M.	C0603	Several	50 V
44	C46	Ceramic capacitor	22 µF - N. M.	C1206	TDK C3216X5R1E226M	16 V
45	C47	Ceramic capacitor	22 µF	C1206	TDK C3216X5R1E226M	16 V
46	C48	Ceramic capacitor	1 µF	C0603	TDK C1608X5R1E105K	16 V
47	C49	Ceramic capacitor	22 µF - N. M.	C1206	TDK C3216X5R1E226M	16 V
48	C50	Ceramic capacitor	22 µF - N. M.	C1206	TDK C3216X5R1E226M	16 V
49	C51	Ceramic capacitor	22 nF	C0603	Several	50 V
50	C52	Electrol. capacitor	330 µF - N. M.	C-POL8-6_3	Panasonic EEEFK1C331P	16 V
51	C53	Electrol. capacitor	330 µF	C-POL8-6_3	Panasonic EEEFK1C331P	16 V
52	C54	Ceramic capacitor	100 pF	C0603	Several	50 V6 V
53	C55	Ceramic capacitor	0.1 µF - N. M.	C0603	Several	50 V
54	C56	Ceramic capacitor	0.1 µF	C0603	Several	50 V
55	D1	Diode	N. M.	SMA	Several	
56	D2	Diode	N. M.	SMA	Several	
57	D3	Diode bridge	DF01S	DF01S	Diodes	
58	D4	Diode bridge	HD01 - N. M.	HD01	Diodes	
59	D5	Zener diode	BZX84C10	SOT23	Several	

Table 5. Bill of material (general) (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
60	D6	Diode	N. M.	SMA	Several	
61	D7	Diode	N. M.	SMA	Several	
62	D8	Diode	N. M.	SMA	Several	
63	D9	Diode	N. M.	SMA	Several	
64	D10	Diode bridge	DF01S	DF01S	Diodes	
65	D11	Diode bridge	HD01 - N. M.	HD01	Diodes	
66	D12	Diode	N. M.	SMA	Several	
67	D13	Diode	N. M.	SMA	Several	
68	D14	Diode	STTH2R02A	SMA	STMicroelectronics	
69	D15	Diode	STTH2R02A	SMA	STMicroelectronics	
70	D16	Diode	N. M.	SMA	Several	
71	D17	Diode	BAT46J-N. M.	SOD323	STMicroelectronics	
72	D18	TVS diode	SMAJ58A	SMA	STMicroelectronics	
73	D19	LED diode	Green LED	LED-TLGE1100B	TOSHIBA	
74	D20	Diode	N. M.	SMA	Several	
75	D21	Diode	BAT46J	SOD323	STMicroelectronics	
76	D22	Diode	N. M.	SMA	Several	
77	D23	Diode	BAT46J	SOD323	STMicroelectronics	
78	D24	Diode	N. M.	PFLAT_3_3X3_3-2PIN		
79	D25	Diode	N. M.	SOD128		
80	D28	Schottky diode	PMEG3050EP	SOD128	NXP	
81	D29	Diode	BAT46J	SOD323	STMicroelectronics	
82	D30	Diode	BAT46J	SOD323	STMicroelectronics	
83	D31	Diode	N. M.	PFLAT_6X5-3LEADS		
84	D33	Diode	N. M.	SMB		
85	D34	Diode	N. M.	PFLAT_3_3X3_3-2PIN		
86	D35	LED diode	Green LED-N. M.	LED-TLGE1100B	TOSHIBA	
87	D36	LED diode	Green LED	LED-TLGE1100B	TOSHIBA	
88	J1	Connector	RJ45 data and power jack	RJ45-8PIN	Several	
89	J2	Connector	RJ45 data jack	RJ45-8PIN	Several	
90	J3	Connector	CON3	P-JACK-RAPC722	Switchcraft	
91	J4	Connector	CON3	P-JACK-RAPC722	Switchcraft	

Table 5. Bill of material (general) (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
92	J5	Connector	MOR-10X10.5-P5-2PIN-N. M.	MOR-2POLI-508	Several	
93	J6	Connector	MOR-10X10.5-P5-2PIN	MOR-2POLI-508	Several	
94	L1	Inductor	5.6 µH	ME3220	Coilcraft	
95	L2	Inductor	0.33 µH - N. M.	DO1813H-331ML	Coilcraft	
96	L3	Inductor	0.33 µH - N. M.	LPS4012-331L	Coilcraft	
97	L4	Inductor	0.33 µH	DO1813H-331ML	Coilcraft	
98	L5	Inductor	0.33 µH - N. M.	LPS4012-331L	Coilcraft	
99	Q1	MOSFET	STS4NF100	SO8	STMicroelectronics	
100	Q2	MOSFET	FDN86246	SOT23	FAIRCHILD	
101	Q3	Transistor	N. M.	SOT23	Several	
102	Q4	MOSFET	N. M.	SOT23-6L		
103	Q5	MOSFET	N. M.	SO8		
104	Q6	MOSFET	N. M.	DPAK		
105	Q7	MOSFET	N. M.	SOT-223		
106	R1	Resistor	15 KΩ	R0805	Several	
107	R2	Resistor	47 KΩ	R0805	Several	
108	R3	Resistor	47 KΩ	R0805	Several	
109	R4	Resistor	470 KΩ	R0805	Several	
110	R5	Resistor	15 KΩ	R0805	Several	
111	R6	Resistor	N. M.	R1206	Several	
112	R7	Resistor	N. M.	R1206	Several	
113	R8	Resistor	10 kΩ	R0603	Several	
114	R9	Resistor	N. M.	R0603	Several	
115	R10	Resistor	10 kΩ	R0603	Several	
116	R11	Resistor	52.3 Ω - 1%	R0805	Several	
117	R12	Resistor	N. M.	R0603	Several	
118	R13	Resistor	22.1 Ω - 1%	R0603	Several	
119	R14	Resistor	10 Ω	R0603	Several	
120	R15	Resistor	0 Ω	R0805	Several	
121	R16	Resistor	0 Ω	R0805	Several	
122	R17	Resistor	124 KΩ - 1%	R0603	Several	
123	R18	Resistor	N. M.	R0603	Several	
124	R19	Resistor	510 Ω	R0603	Several	
125	R20	Resistor	4.7 KΩ	R0603	Several	

Table 5. Bill of material (general) (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
126	R21	Resistor	N. M.	R0603	Several	
127	R22	Resistor	N. M.	R0603	Several	
128	R23	Resistor	0 Ω	R0805	Several	
129	R24	Resistor	75 Ω	R0805	Several	
130	R25	Resistor	56 Ω	R0805	Several	
131	R26	Resistor	N. M.	R1206	Several	
132	R27	Resistor	75 Ω	R0805	Several	
133	R29	Resistor	75 Ω	R0805	Several	
134	R30	Resistor	N. M.	R1206	Several	
135	R31	Resistor	75 Ω	R0805	Several	
136	R32	Resistor	10 Ω	R0603	Several	
137	R33	Resistor	10 Ω	R0603	Several	
138	R34	Sense resistor	0.33 Ω - 1% - N. M.	R1206	Vishay - RCWE1206R330FKE	
139	R35	Sense resistor	0.33 Ω1%	R1206	Vishay - RCWE1206R330FKE	
140	R36	Resistor	560 Ω	R0603	Several	
141	R37	Resistor	0 Ω	R0603	Several	
142	R38	Resistor	N. M.	R1206	Several	
143	R40	Resistor	4.7 Ω	R1206	Several	
144	R41	Resistor	N. M.	R1206	Several	
145	R42	Resistor	N. M.	R1206	Several	
146	R43	Resistor	0 Ω	R0805	Several	
147	R44	Resistor	0 Ω	R1206	Several	
148	R45	Resistor	47 K Ω	R0603	Several	
149	R46	Resistor	0 Ω - N. M.	R1206	Several	
150	R47	Resistor	0 Ω - N. M.	R1206	Several	
151	R48	Resistor	390 Ω	R0603	Several	
152	R49	Resistor	N. M.	R0603	Several	
153	R50	Resistor	10.0 Ω	R0603	Several	
154	R51	Resistor	N. M.	R0603	Several	
155	R52	Resistor	3.3 KΩ - 1%	R0603	Several	
156	R53	Resistor	10 KΩ - N. M.	R0603	Several	
157	R54	Resistor	2.2 KΩ	R0603	Several	
158	R55	Resistor	21 KΩ - 1%	R0603	Several	

Table 5. Bill of material (general) (continued)

Item	Ref.	Description	Value	PCB footprint	Supplier	Voltage
159	R56	Resistor	12.4 KΩ - 1%	R0603	Several	
160	R57	Resistor	N. M.- 1%	R0603	Several	
161	TP1	Test point	Red	TH-5013	Keystone	
162	TP2	Test point	Black	TH-5013	Keystone	
163	TP3	Test point	Red	TH-5013	Keystone	
164	TP4	Test point	Black	TH-5013	Keystone	
165	TP5	Test point	Red - N. M.	TH-5013	Keystone	
166	TP6	Test point	Red	TH-5013	Keystone	
167	TP7	Test point	Black	TH-5013	Keystone	
168	TP8	Test point	Red	TH-5013	Keystone	
169	TP9	Test point	Black	TH-5013	Keystone	
170	TP10	Test point	Red	TH-5013	Keystone	
171	TP11	Test point	Red	TH-5013	Keystone	
172	TP12	Test point	Black	TH-5013	Keystone	
173	TP13	Test point	Red	TH-5013	Keystone	
174	TP14	Test point	Red	TH-5013	Keystone	
175	TP15	Test point	Red - N. M.	TH-5013	Keystone	
176	TP16	Test point	Red	TH-5013	Keystone	
177	TP17	Test point	Red	TH-5013	Keystone	
178	TP18	Test point	Black - N. M.	TH-5013	Keystone	
179	TP19	Test point	Black	TH-5013	Keystone	
180	TP20	Test point	Red - N. M.	TH-5013	Keystone	
181	T1	Data transfo.	H2019 / TLA-6T127LF	Pulse-H2019	Pulse	
182	T2	CM choke	Würth 744226S - N. M.	744226S	Würth	
183	T3	Power transfo.	COILCRAFT POE13P-33L	POE13P	Coilcraft	
184	T4	Power transfo.	COILCRAFT POE70P-33L-NM	POE70P	Coilcraft	
185	T5	Power transfo.	COILCRAFT HA3893-AL - N. M.	HA3893-AL-COILCRAFT	Coilcraft	
186	T6	CM choke	Pulse PE65855NL - N. M.	PE-65855NL-PULSE	Pulse	
187	U1	Controller IC	PM8800A	HTSSOP16	STMicroelectronics	
188	U2	Optocoupler	FAIRCHILD FOD817A	FOD817	FAIRCHILD	
189	U3	Optocoupler	Sharp PC3H7D - N. M.	PC3H7	Sharp	
190	U4	Voltage reference	TS2431AILT-N. M.	SOT23	STMicroelectronics	
191	U5	Voltage reference	TS431AILT	SOT23-5L	STMicroelectronics	

6 PCB layers

Figure 31. PCB layer: top view

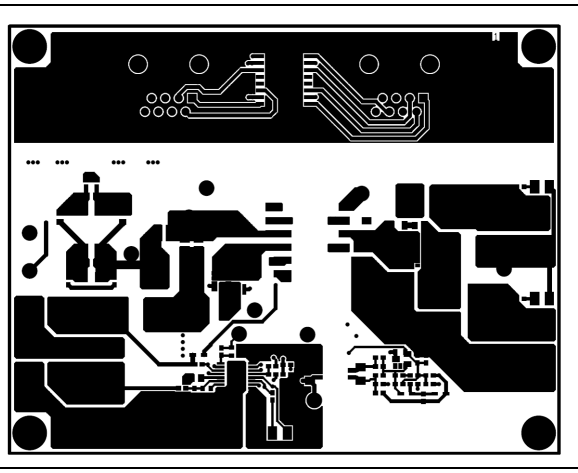


Figure 32. PCB layer: layer 2

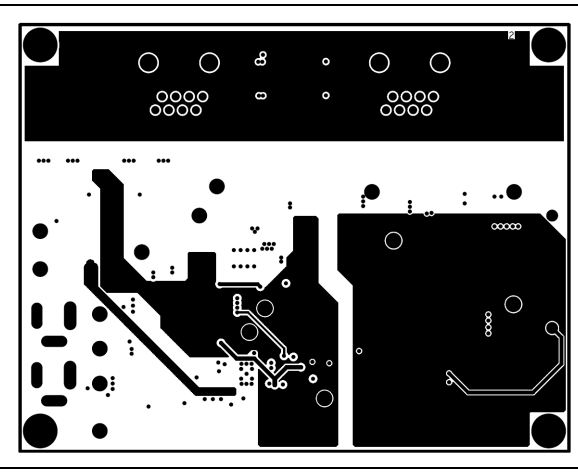


Figure 33. PCB layer: layer 3

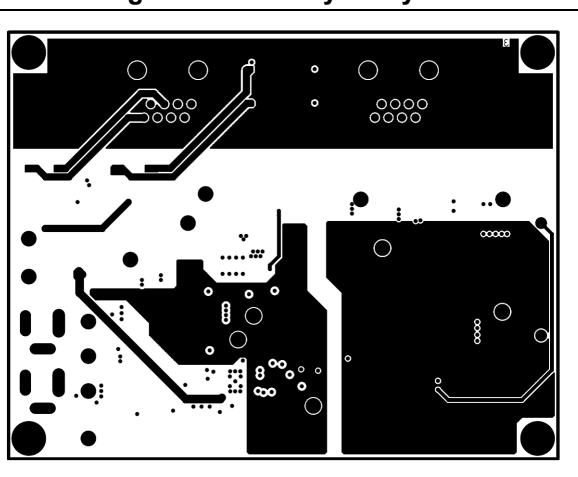


Figure 34. PCB layer: bottom view

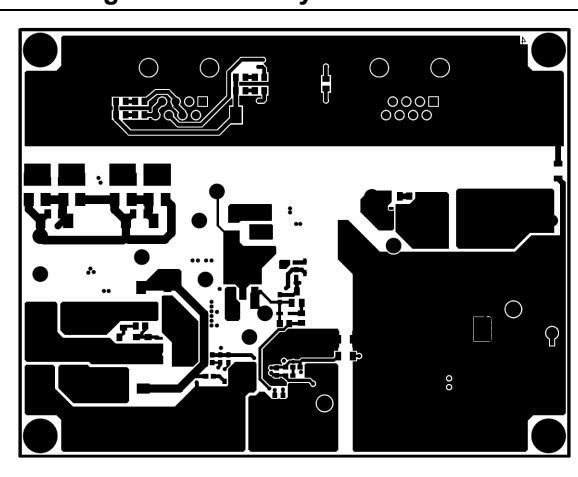


Figure 35. PCB Layer: components on top side

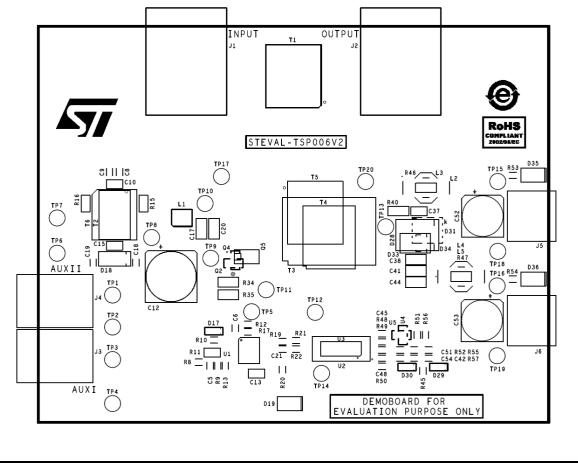
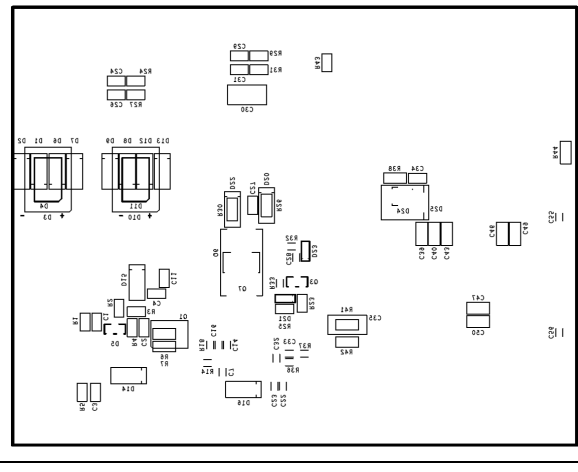


Figure 36. PCB layer: components on bottom side



7 Revision history

Table 6. Document revision history

Date	Revision	Changes
30-May-2014	1	Initial release.