

Power over Ethernet - PD converter with 12 V 1 A output, standard IEEE 802.3af compliant

By Antonio Rotta

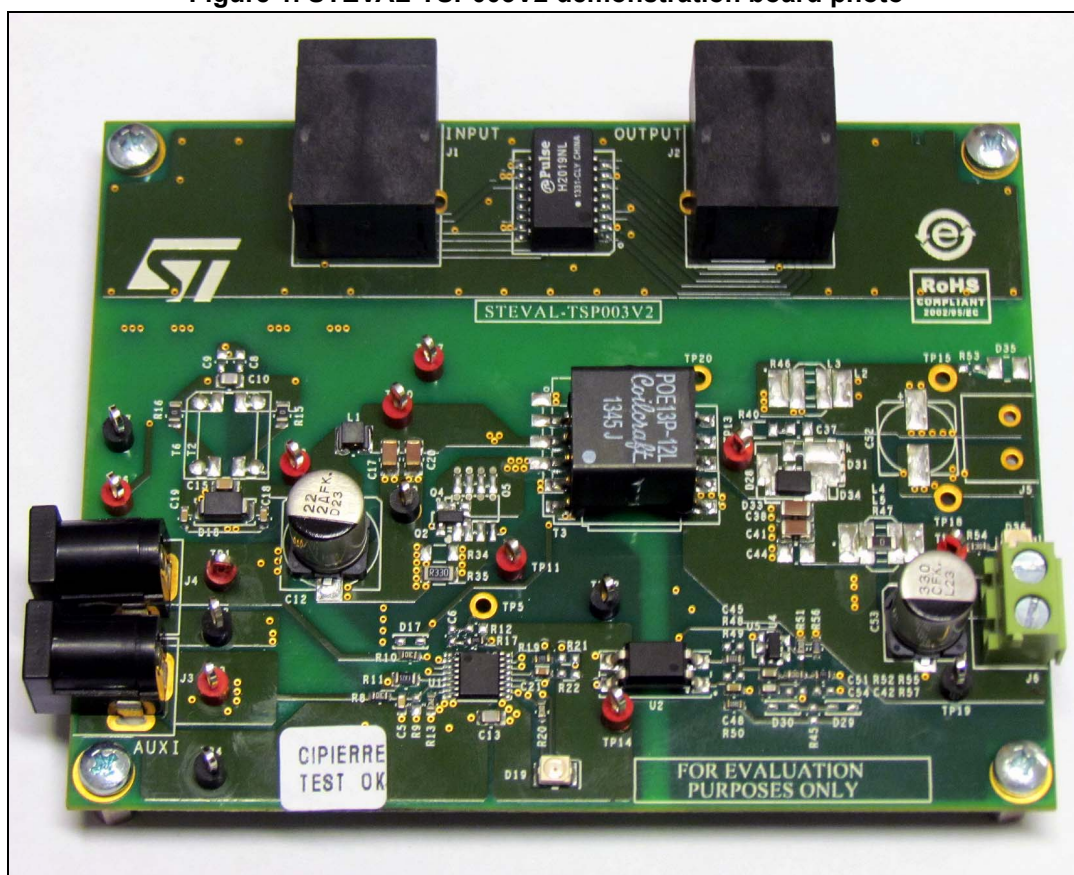
Introduction

This document focuses on a reference design for a simple, low cost 12 V 1 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-TSP003V2 demonstration board photo



Contents

| | | |
|----------|--|-----------|
| 1 | Main characteristics and circuit description | 3 |
| 2 | Electrical diagram and bill of material for 12 V at 1 A | 4 |
| 3 | Measurement results | 9 |
| 3.1 | Efficiency | 9 |
| 3.2 | Output voltage ripple | 11 |
| 3.3 | Startup | 12 |
| 3.4 | Primary side waveforms | 13 |
| 3.5 | Dynamic load | 14 |
| 3.6 | Short-circuit behavior | 15 |
| 4 | Loop compensation | 17 |
| 5 | Support material | 19 |
| 6 | PCB layers | 26 |
| 7 | Revision history | 27 |

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-TSP003V2 |

Table 2. Electrical specification

| Parameter | Specifications |
|---|-------------------------|
| Input voltage supplies VIN [VDC] | From 40 to 60 V at 13 W |
| Output voltage Vout [VDC] | 12 VDC \pm 5% at 1 A |
| Peak-to-peak output ripple | 100 mV |
| Efficiency DC-DC full-load | > 88% |
| Efficiency overall peak | > 85% |
| Transient response $\Delta V_{outpk-pk}$ to 50% load step | < 200 mVpp |
| ΔV in load line case | < 0.5% |
| GLOOP bandwidth | 3.5 kHz |
| GLOOP phase margin at 0 dB | 105 deg. |
| GLOOP dB margin at 0 deg. | -10 dB |

This document details the characteristics and performances of the PM8800A demonstration kit STEVAL-TSP003V2 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, 12 V output voltage with up to 1 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 PM8800 demonstration kit as options on the same PCB. The bill of material (BOM) in [Table 3](#) provides the list of components to be mounted to obtain a 12 V at 1 A demonstration board.

2

Figure 2. Circuit diagram 12 V at 1 A



Table 3. Bill of material 12 V at 1 A

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|-------------------|-------------|---------------|--------------------------|---------|
| 1 | C1 | Ceramic capacitor | 1 nF | C0805 | Several | 100 V |
| 2 | C2 | Ceramic capacitor | 0.1 μ F | 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 μ F | C0805 | Several | 100 V |
| 7 | C12 | Elect. capacitor | 22 μ F | C-POL8-10 | Panasonic EEEFK2A220P | 100 V |
| 8 | C13 | Ceramic capacitor | 1 nF | C0805 | Several | 100 V |
| 9 | C14 | Ceramic capacitor | 0.1 μ F | C0603 | Several | 50 V |
| 10 | C15 | Ceramic capacitor | 0.1 μ F | C0805 | Several | 100 V |
| 11 | C16 | Ceramic capacitor | 10 nF | C0603 | Several | 100 V |
| 12 | C17 | Ceramic capacitor | 1 μ F | 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 μ F | C1206 | Several | 100 V |
| 16 | C21 | Ceramic capacitor | 470 pF | C0603 | Several | 50 V |
| 17 | C22 | Ceramic capacitor | 0.1 μ F | C0603 | Several | 50 V |
| 18 | C23 | Ceramic capacitor | 0.1 μ F | 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 | C28 | Ceramic capacitor | 1 μ F | C0603 | TDK C1608X5R1E105K | 25 V |
| 22 | C29 | Ceramic capacitor | 1 nF | C0805 | Several | 200 V |
| 23 | C30 | Ceramic capacitor | 2.2 nF | C1812 | TDK 4532X7R3D222K | 2 KV |
| 24 | C31 | Ceramic capacitor | 1 nF | C0805 | Several | 200 V |
| 25 | C33 | Ceramic capacitor | 0.1 μ F | C0603 | Several | 50 V |
| 26 | C35 | Ceramic capacitor | 2.2 nF | C1812 | TDK 4532X7R3D222K | 2 KV |
| 27 | C38 | Ceramic capacitor | 22 μ F | C1206 | TDK C3216X5R1E226M | 16 V |
| 28 | C41 | Ceramic capacitor | 22 μ F | C1206 | TDK C3216X5R1E226M | 16 V |
| 29 | C47 | Ceramic capacitor | 22 μ F | C1206 | TDK C3216X5R1E226M | 16 V |
| 30 | C48 | Ceramic capacitor | 1 μ F | C0603 | TDK C1608X5R1E105K | 25 V |
| 31 | C51 | Ceramic capacitor | 22 nF | C0603 | Several | 50 V |
| 32 | C53 | Elect. capacitor | 330 μ F | C-POL8-6_3 | Panasonic EEEFK1C331P | 16 V |
| 33 | C54 | Ceramic capacitor | 100 pF | C0603 | Several | 50 V |

Table 3. Bill of material 12 V at 1 A (continued)

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|-------------------|--------------------------|----------------|--------------------|---------|
| 34 | C56 | Ceramic capacitor | 0.1 μ F | C0603 | Several | 50 V |
| 35 | D3 | Diode bridge | DF01S | DF01S | Diodes | |
| 36 | D5 | Zener diode | BZX84C10 | SOT23 | Several | |
| 37 | D10 | Diode bridge | DF01S | DF01S | Diodes | |
| 38 | D14 | Diode | STTH2R02A | SMA | STMicroelectronics | |
| 39 | D15 | Diode | STTH2R02A | SMA | STMicroelectronics | |
| 40 | D18 | TVS diode | SMAJ58A | SMA | STMicroelectronics | |
| 41 | D19 | LED diode | Green LED | LED-TLGE1100B | Toshiba | |
| 42 | D21 | Diode | BAT46J | SOD323 | STMicroelectronics | |
| 43 | D23 | Diode | BAT46J | SOD323 | STMicroelectronics | |
| 44 | D28 | Schottky diode | PMEG6030EP | SOD128 | NXP | |
| 45 | D36 | LED diode | Green LED | LED-TLGE1100B | Toshiba | |
| 46 | J1 | Connector | RJ45 data and power jack | RJ45-8PIN | Several | |
| 47 | J2 | Connector | RJ45 data jack | RJ45-8PIN | Several | |
| 48 | J3 | Connector | CON3 | P-JACK-RAPC722 | Switchcraft | |
| 49 | J4 | Connector | CON3 | P-JACK-RAPC722 | Switchcraft | |
| 50 | J6 | Connector | MOR-10X10.5-P5-2PIN | MOR-2POLI-508 | Several | |
| 51 | L1 | Inductor | 5.6 μ H | ME3220-562ML | Coilcraft | |
| 52 | Q1 | MOSFET | STS4NF100 | SO8 | STMicroelectronics | |
| 53 | Q2 | MOSFET | FDN86246 | SOT23 | Fairchild | |
| 54 | R1 | Resistor | 15 K Ω | R0805 | Several | |
| 55 | R2 | Resistor | 47 K Ω | R0805 | Several | |
| 56 | R3 | Resistor | 47 K Ω | R0805 | Several | |
| 57 | R4 | Resistor | 470 K Ω | R0805 | Several | |
| 58 | R5 | Resistor | 15 K Ω | R0805 | Several | |
| 59 | R8 | Resistor | 10 k Ω | R0603 | Several | |
| 60 | R10 | Resistor | 10 k Ω | R0603 | Several | |
| 61 | R11 | Resistor | 52.3 Ω - 1% | R0805 | Several | |
| 62 | R13 | Resistor | 22.1 k Ω - 1% | R0603 | Several | |
| 63 | R14 | Resistor | 10 Ω | R0603 | Several | |

Table 3. Bill of material 12 V at 1 A (continued)

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|-------------------|-----------------------|---------------|-----------------------------|---------|
| 64 | R15 | Resistor | 0 Ω | R0805 | Several | |
| 65 | R16 | Resistor | 0 Ω | R0805 | Several | |
| 66 | R17 | Resistor | 124 k Ω - 1% | R0603 | Several | |
| 67 | R19 | Resistor | 510 Ω | R0603 | Several | |
| 68 | R20 | Resistor | 10 k Ω | R0603 | Several | |
| 69 | R23 | Resistor | 0 Ω | R0805 | Several | |
| 70 | R24 | Resistor | 75 Ω | R0805 | Several | |
| 71 | R25 | Resistor | 56 Ω | R0805 | Several | |
| 72 | R27 | Resistor | 75 Ω | R0805 | Several | |
| 73 | R29 | Resistor | 75 Ω | R0805 | Several | |
| 74 | R31 | Resistor | 75 Ω | R0805 | Several | |
| 75 | R32 | Resistor | 100 Ω | R0603 | Several | |
| 76 | R33 | Resistor | 10 k Ω | R0603 | Several | |
| 77 | R35 | Sense resistor | 0.33 Ω - 1% | R1206 | Vishay - RCWE1206R330FKE | |
| 78 | R36 | Resistor | 2.2 K Ω | R0603 | Several | |
| 79 | R37 | Resistor | 0 Ω | R0603 | Several | |
| 80 | R43 | Resistor | 0 Ω | R0805 | Several | |
| 81 | R44 | Resistor | 0 Ω | R1206 | Several | |
| 82 | R47 | Resistor | 0 Ω | R1206 | Several | |
| 83 | R48 | Resistor | 2.2 K Ω | R0603 | Several | |
| 84 | R50 | Resistor | 10 Ω | R0603 | Several | |
| 85 | R51 | Resistor | 10 K Ω - 1% | R0603 | Several | |
| 86 | R52 | Resistor | 100 K Ω - 1% | R0603 | Several | |
| 87 | R54 | Resistor | 10 K Ω | R0603 | Several | |
| 88 | R55 | Resistor | 21 k Ω - 1% | R0603 | Several | |
| 89 | R56 | Resistor | 12.4 k Ω - 1% | R0603 | Several | |
| 90 | T1 | Data transformer | H2019NL / TLA-6T127LF | Pulse-H2019 | Pulse | |
| 91 | T3 | Power transformer | POE13P-12L | POE13P | Coilcraft | |
| 92 | TP1 | Test point | Red | TH-5013 | Keystone | |
| 93 | TP2 | Test point | Black | TH-5013 | Keystone | |
| 94 | TP3 | Test point | Red | TH-5013 | Keystone | |
| 95 | TP4 | Test point | Black | TH-5013 | Keystone | |
| 96 | TP6 | Test point | Red | TH-5013 | Keystone | |

Table 3. Bill of material 12 V at 1 A (continued)

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|-------------------|------------|---------------|--------------------|---------|
| 97 | TP7 | Test point | Black | TH-5013 | Keystone | |
| 98 | TP8 | Test point | Red | TH-5013 | Keystone | |
| 99 | TP9 | Test point | Black | TH-5013 | Keystone | |
| 100 | TP10 | Test point | Red | TH-5013 | Keystone | |
| 101 | TP11 | Test point | Red | TH-5013 | Keystone | |
| 102 | TP12 | Test point | Black | TH-5013 | Keystone | |
| 103 | TP13 | Test point | Red | TH-5013 | Keystone | |
| 104 | TP14 | Test point | Red | TH-5013 | Keystone | |
| 105 | TP16 | Test point | Red | TH-5013 | Keystone | |
| 106 | TP17 | Test point | Red | TH-5013 | Keystone | |
| 107 | TP19 | Test point | Black | TH-5013 | Keystone | |
| 108 | U1 | Controller IC | PM8800A | HTSSOP16 | STMicroelectronics | |
| 109 | U2 | Optocoupler | FOD817A | FOD817 | Fairchild | |
| 110 | U4 | Voltage reference | TS2431AILT | SOT23 | STMicroelectronics | |

3 Measurement results

3.1 Efficiency

Figure 3. Overall and DC/DC efficiency

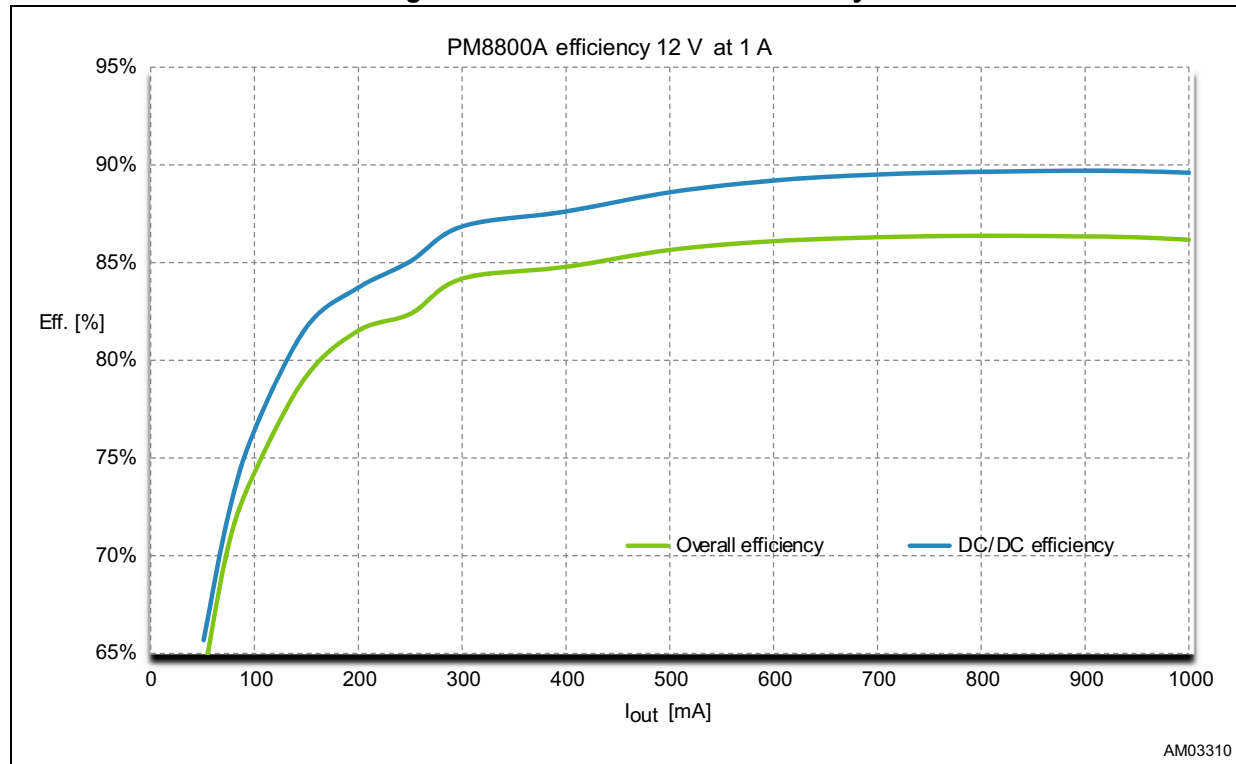


Figure 3 shows overall and DC/DC efficiencies for the converter. Overall efficiency includes all loss from RJ45 to the 12 V output voltage rail. DC/DC efficiency is a figure of merit of the converter standalone, and typically does not include the losses associated to the PoE interface section, that are: the RJ45 connector, data transformer, bridges, power consumption of the I/F section of the PM8800A device.

Figure 4. Efficiency input stage

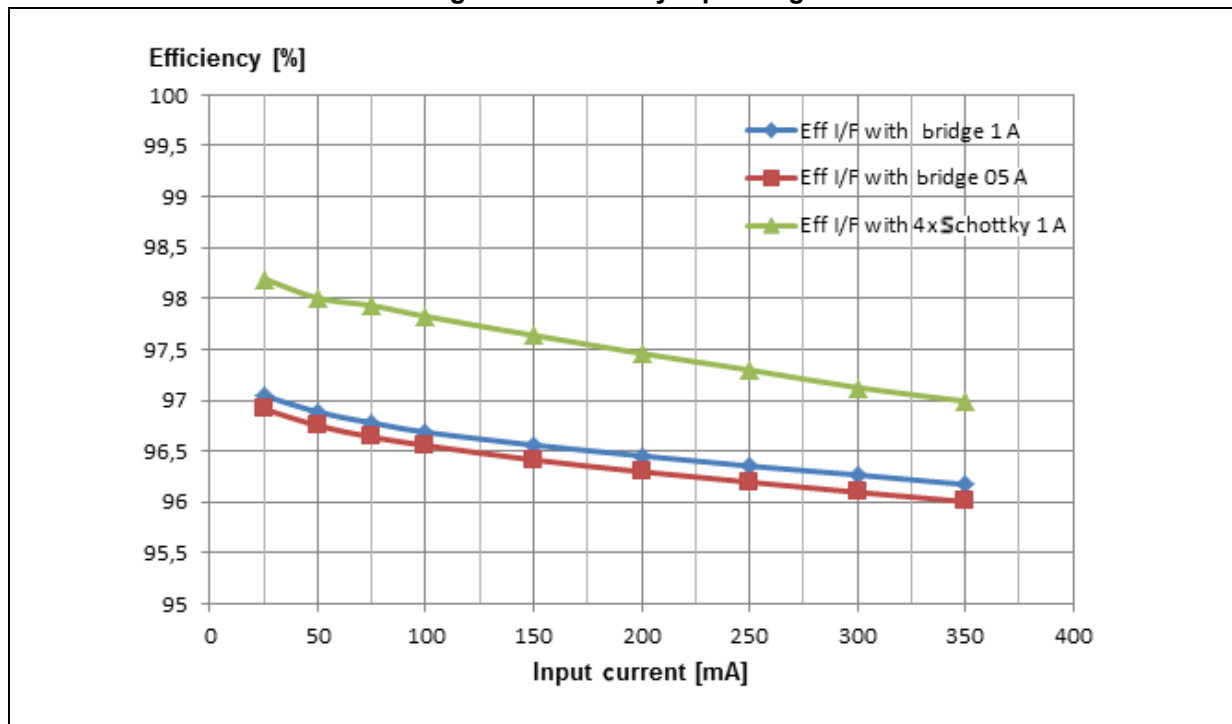


Figure 4 shows the efficiency comparison implementing on board three different setting of bridge rectification. No relevant difference have been highlighted using a standard diode bridge (1 A or 0.5 A). The best efficiency has been captured using a bridge with four discrete 1A Schottky diodes, reaching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

3.2 Output voltage ripple

Figure 5. Ripple 12 V at 1 A

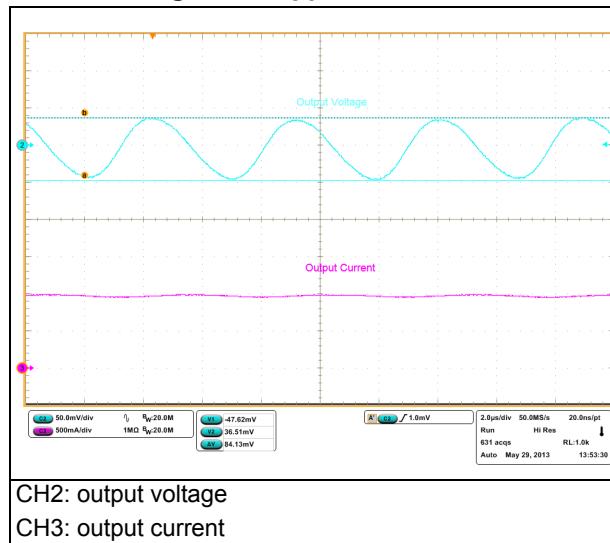
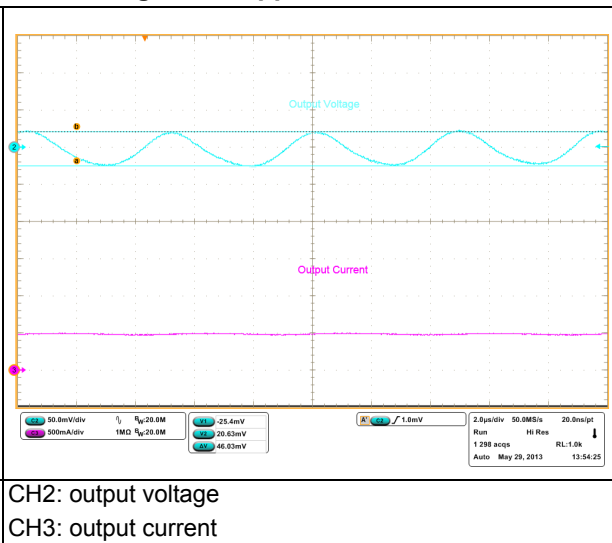


Figure 6. Ripple 12 V at 500 mA



Above measurement are referred at the output voltage ripple (around 85 mV in full load condition) without inductance filter ($R_{47} = 0\Omega$). A ripple voltage comparison has been done replacing the 0Ω resistor with $L_4 = 0.33 \mu\text{H}$ ([Figure 30: Electrical diagram \(general\) on page 19](#)). The output voltage ripple, as shown in [Figure 7](#), it is improved (around 40 mV in full load condition).

Figure 7. Ripple 12 V at 1 A adding L4 filter

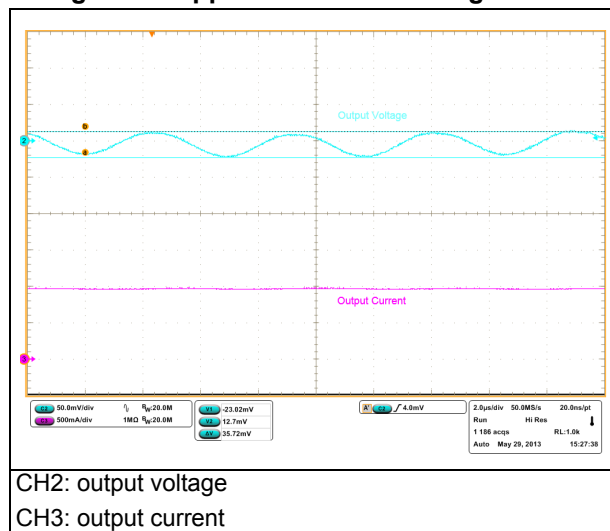
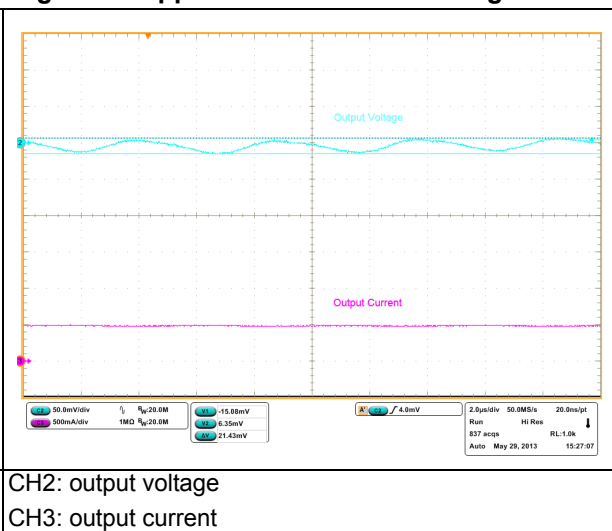
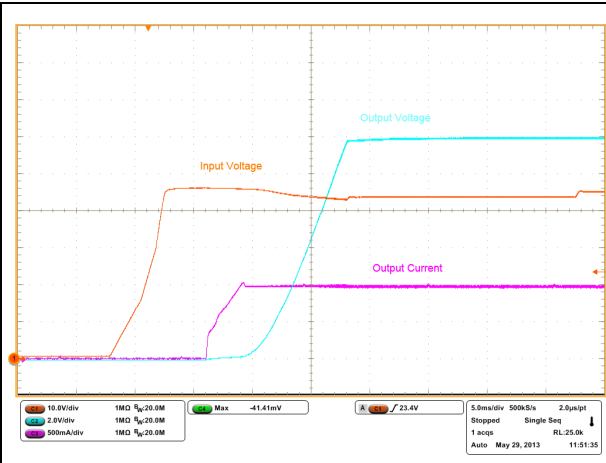


Figure 8. Ripple 12 V at 500 mA adding L4 filter



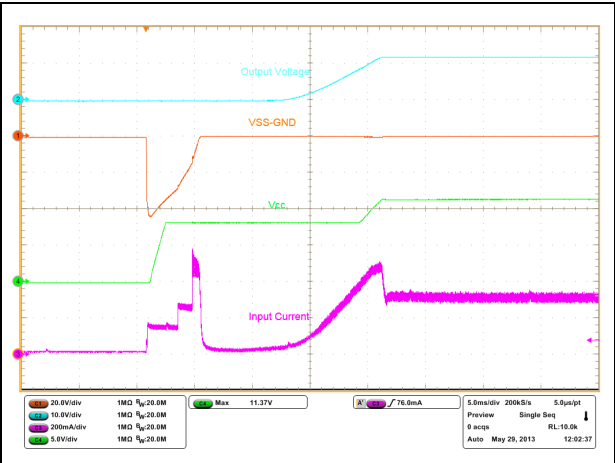
3.3 Startup

Figure 9. Startup - full load



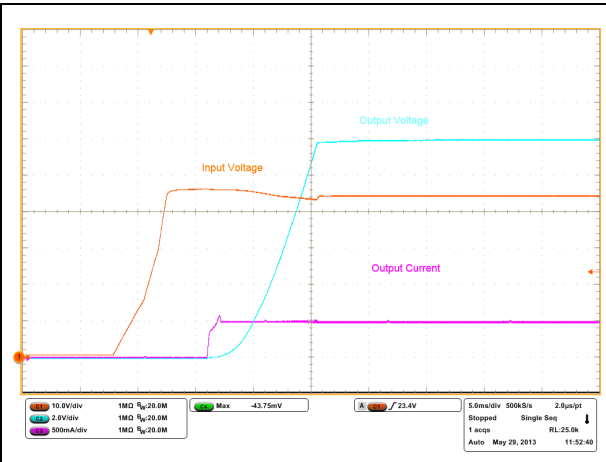
CH1: input voltage
CH2: output voltage
CH3: output current

Figure 10. Startup - full load sequencing



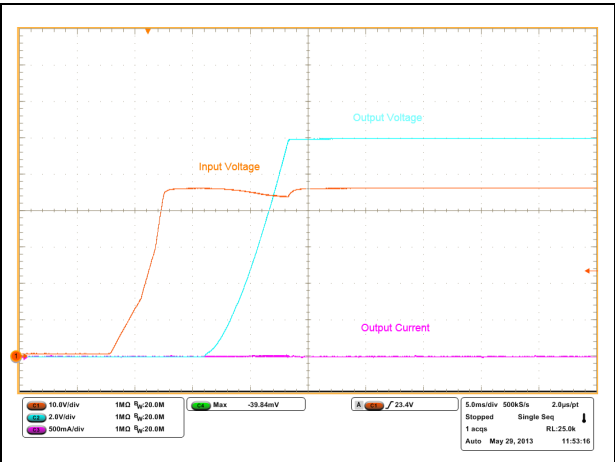
CH1: VSS - GND
CH2: output voltage
CH3: input current
CH4: VCC

Figure 11. Startup - 500 mA



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

Figure 12. Startup - no load



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

3.5 Dynamic load

Figure 17. Dynamic load 1 A - 500 mA

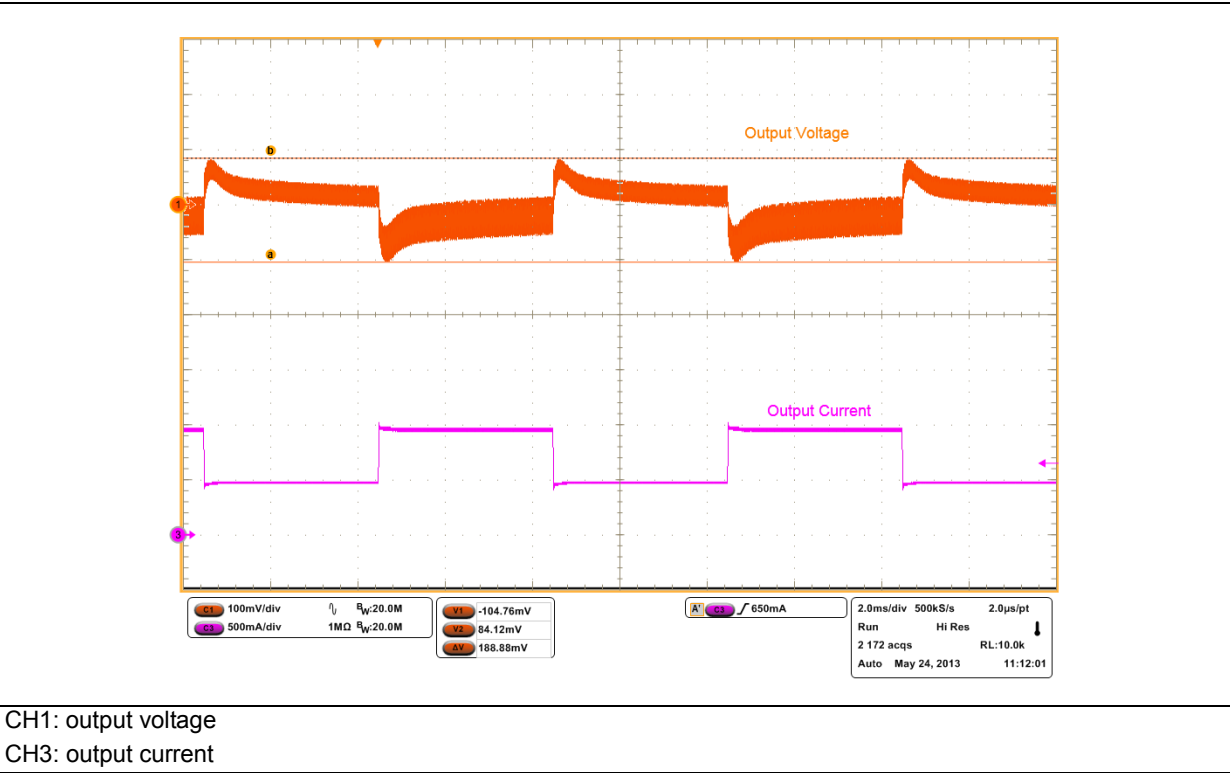


Figure 18. Dynamic load 1 A - 100 mA

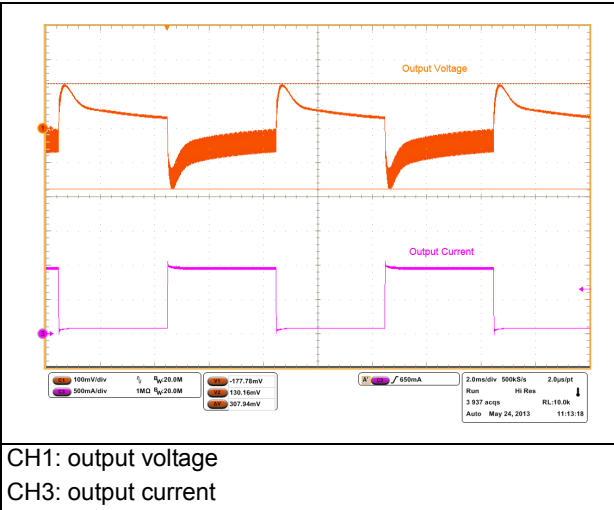
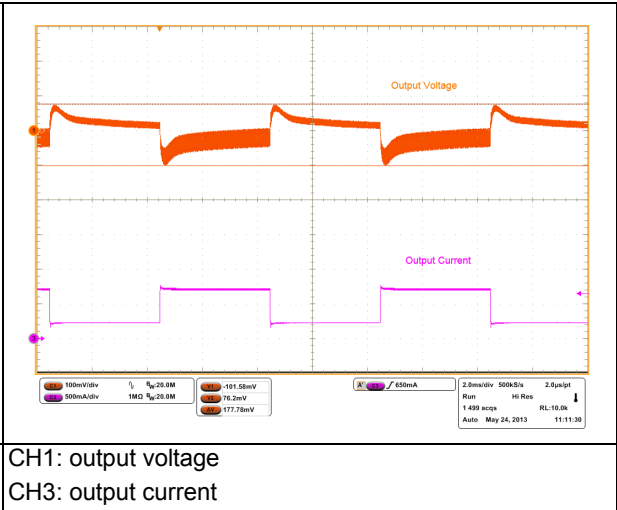
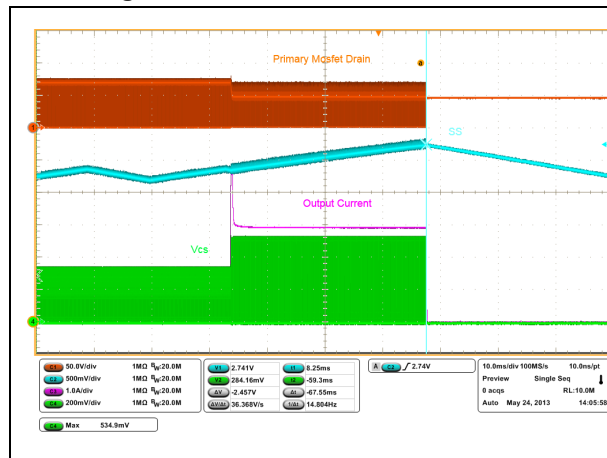


Figure 19. Dynamic load 750 mA - 250 mA



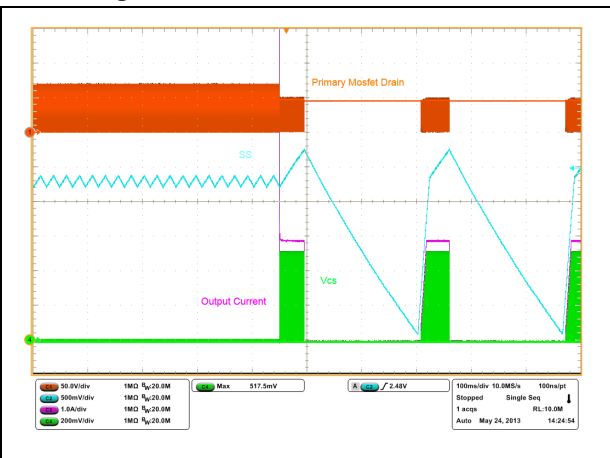
3.6 Short-circuit behavior

Figure 20. OCP detection - full load



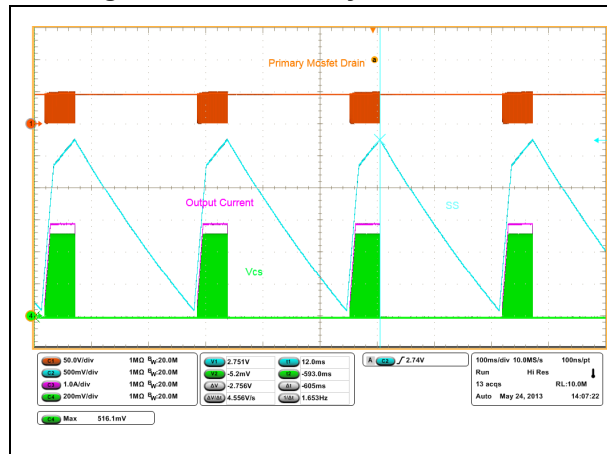
CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 21. OCP detection - no load



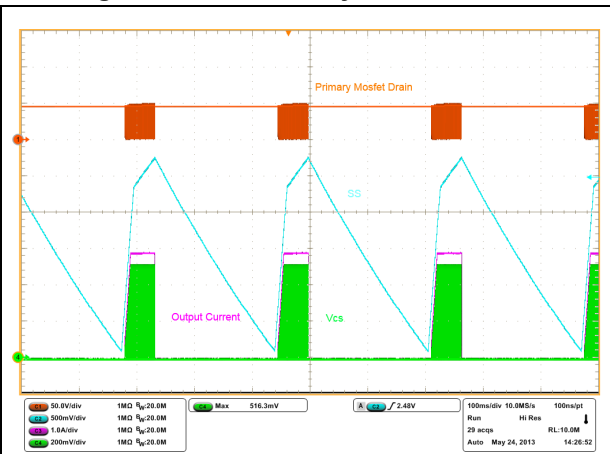
CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 22. OCP steady state - full load



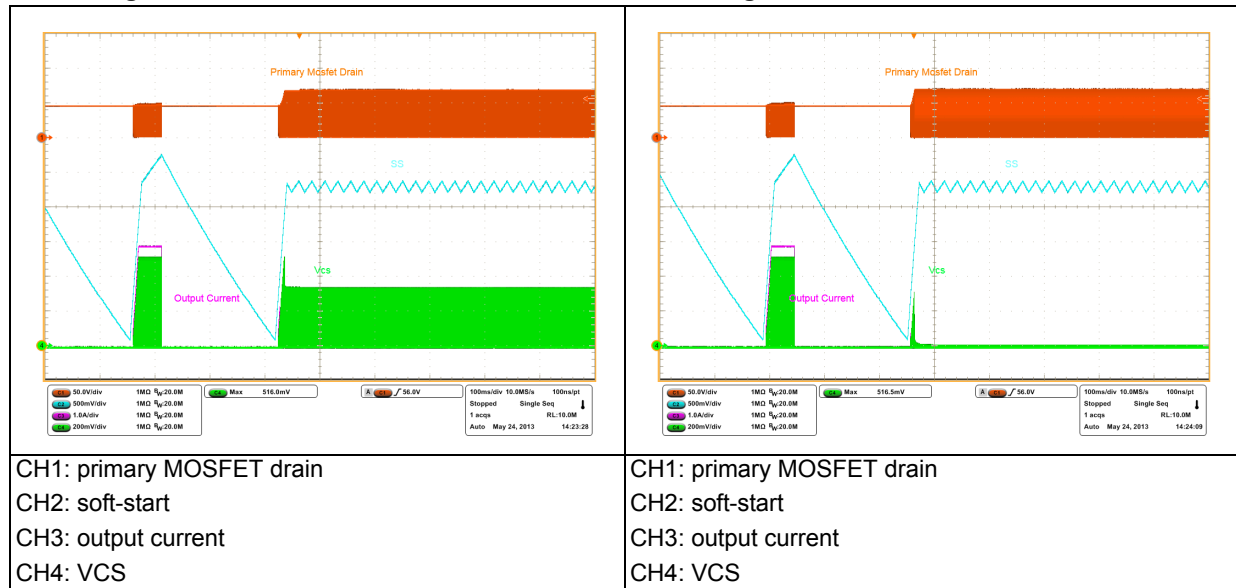
CH1: primary MOSFET drain
CH2: soft-start
CH3: output current
CH4: VCS

Figure 23. OCP steady state - no load



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

Figure 25. OCP removed - no load



4 Loop compensation

Figure 26. Gain loop full load 48 V

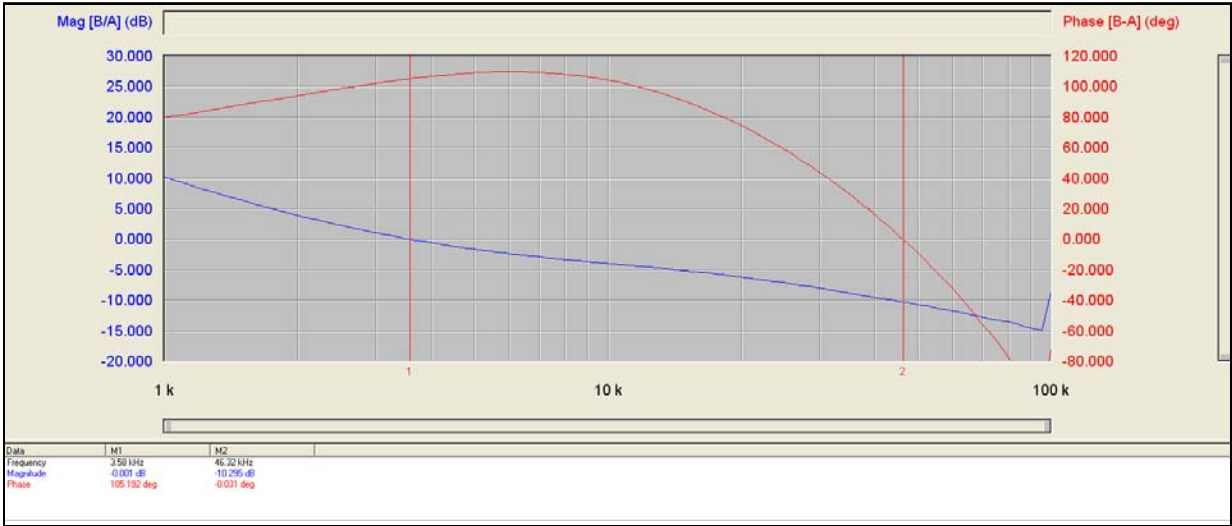


Figure 27. Gain loop half load 48 V

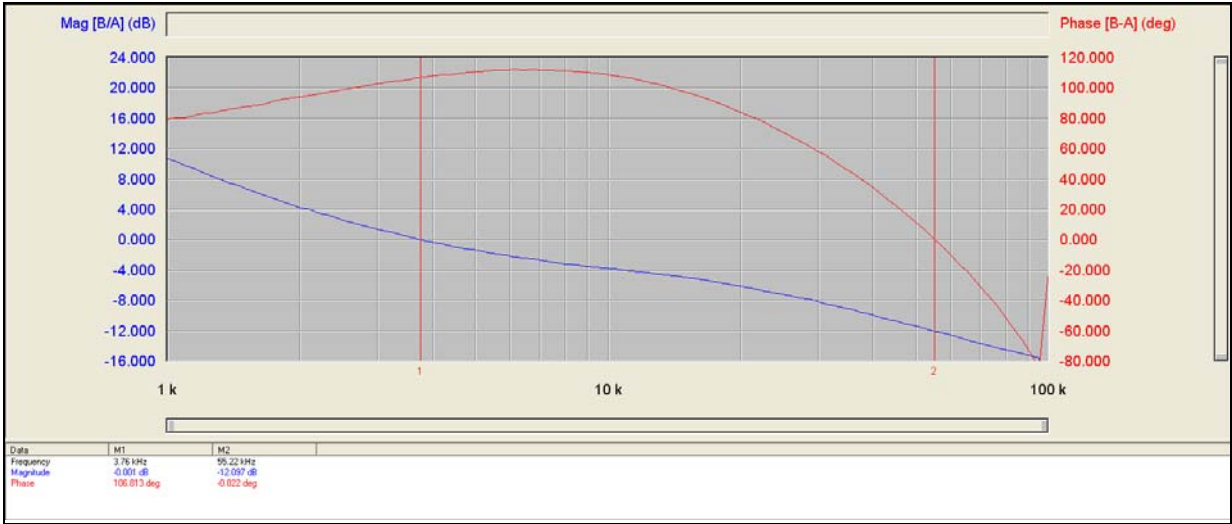


Figure 28. Gain loop full load 40 V

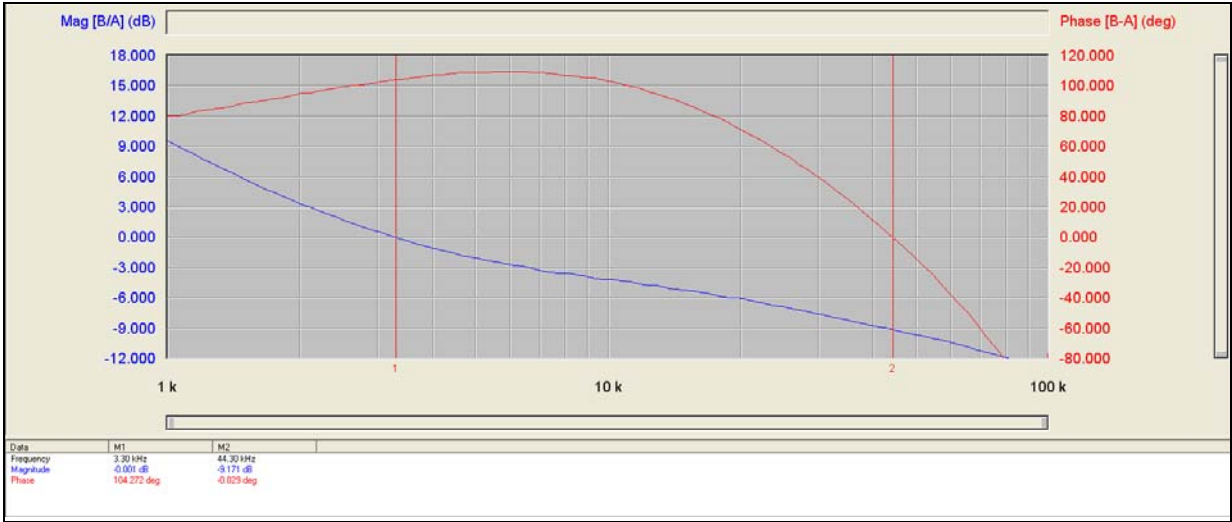


Figure 29. Gain loop full load 60 V

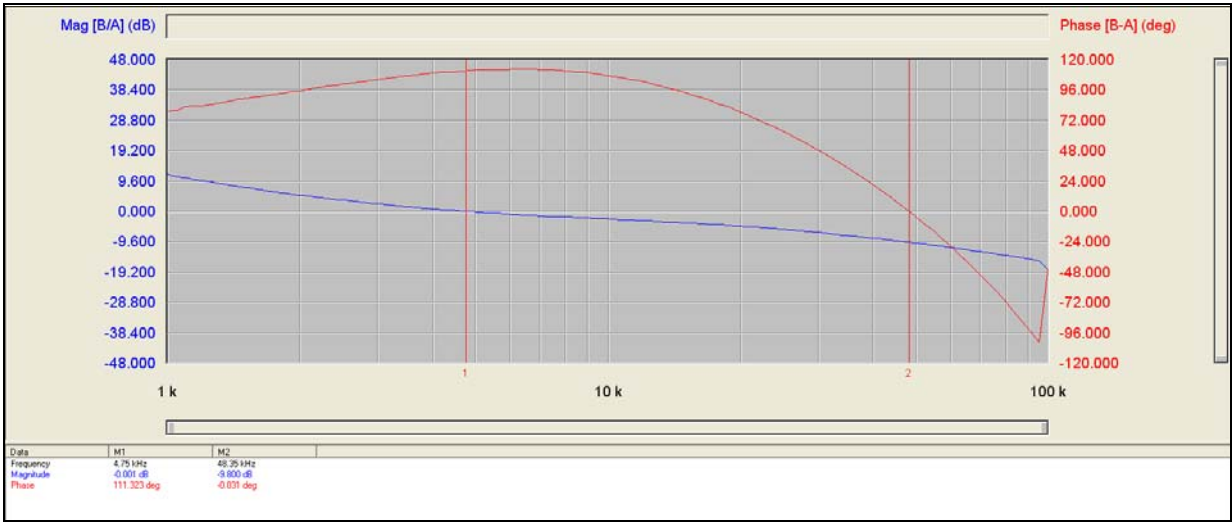


Table 4. Gain loop measurement

| 12 Vout | 48 V 1 A | 40 V 1 A | 60 V 1 A | 48 V 500 mA |
|-----------------------------|----------|----------|----------|-------------|
| BW [kHz] | 3.58 | 3.30 | 4.75 | 3.76 |
| Phase margin [deg.] at 0 db | 105 | 104 | 111 | 106 |
| Gain margin [dB] at 0 deg. | -10 | -9 | -10 | -12 |

5 Support material

Figure 30. Electrical diagram (general)

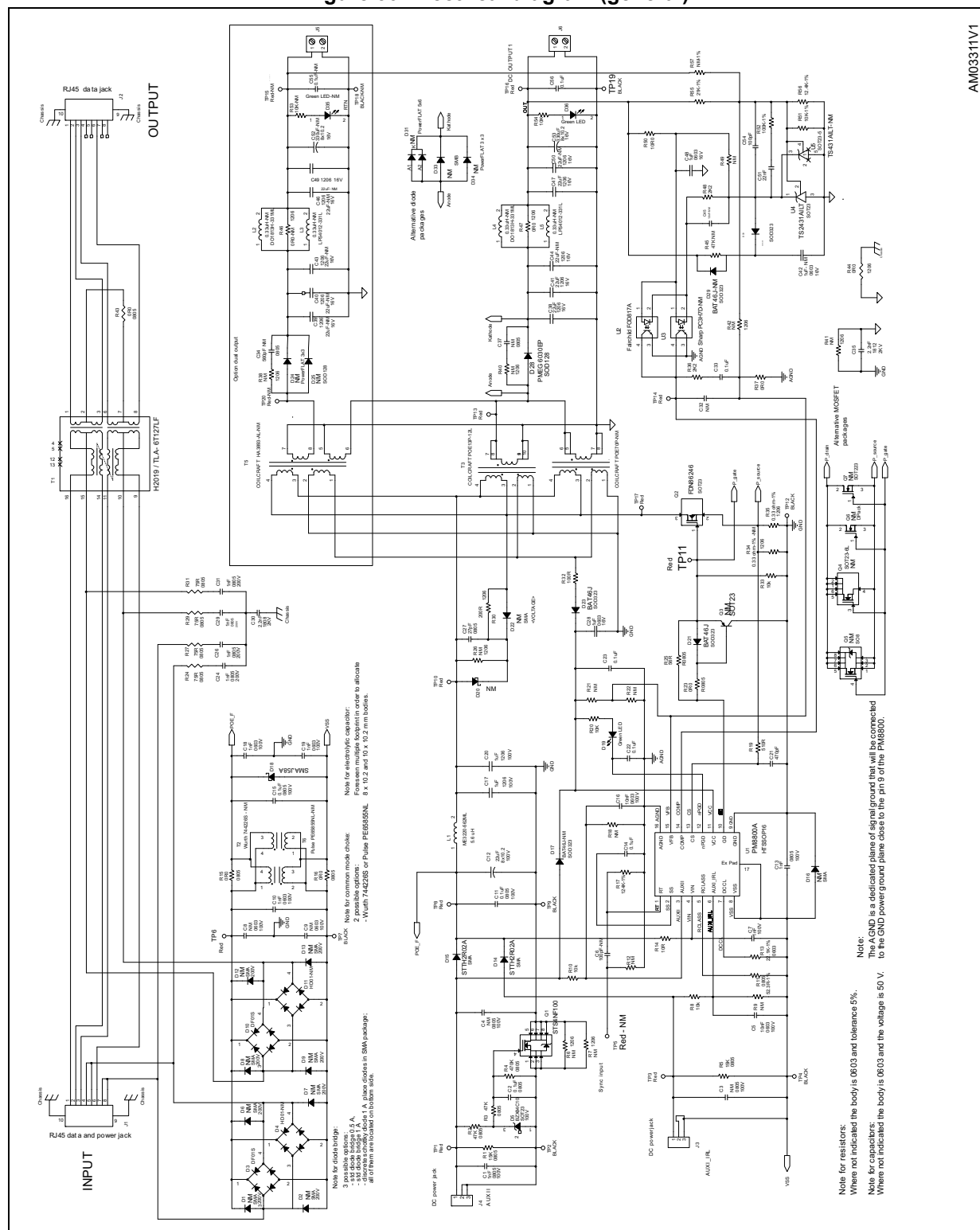


Table 5. Bill of material (general)

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|---------------------|-------------|---------------|--------------------------|---------|
| 1 | C1 | Ceramic capacitor | 1 nF | C0805 | Several | 100 V |
| 2 | C2 | Ceramic capacitor | 0.1 μ F | C0805 | Several | 100 V |
| 3 | C3 | Ceramic capacitor | NM | C0805 | Several | 100 V |
| 4 | C4 | Ceramic capacitor | NM | C0805 | Several | 100 V |
| 5 | C5 | Ceramic capacitor | 10 nF | C0603 | Several | 100 V |
| 6 | C6 | Ceramic capacitor | 100 pF - NM | C0603 | Several | 50 V |
| 7 | C7 | Ceramic capacitor | 1 nF | C0603 | Several | 100 V |
| 8 | C8 | Ceramic capacitor | NM | C0603 | Several | 100 V |
| 9 | C9 | Ceramic capacitor | NM | C0603 | Several | 100 V |
| 10 | C10 | Ceramic capacitor | 1 nF | C0805 | Several | 100 V |
| 11 | C11 | Ceramic capacitor | 0.1 μ F | C0805 | Several | 100 V |
| 12 | C12 | Electrol. capacitor | 22 μ F | C-POL8-10 | Panasonic EEEFK2A220P | 100 V |
| 13 | C13 | Ceramic capacitor | 1 nF | C0805 | Several | 100 V |
| 14 | C14 | Ceramic capacitor | 0.1 μ F | C0603 | Several | 50 V |
| 15 | C15 | Ceramic capacitor | 0.1 μ F | C0805 | Several | 100 V |
| 16 | C16 | Ceramic capacitor | 10 nF | C0603 | Several | 100 V |
| 17 | C17 | Ceramic capacitor | 1 μ F | 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 μ F | C1206 | Several | 100 V |
| 21 | C21 | Ceramic capacitor | 470 pF | C0603 | Several | 50 V |
| 22 | C22 | Ceramic capacitor | 0.1 μ F | C0603 | Several | 50 V |
| 23 | C23 | Ceramic capacitor | 0.1 μ F | 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 | 100 pF - NM | C0805 | Several | 50 V |
| 27 | C28 | Ceramic capacitor | 1 μ F | C0603 | TDK C1608X5R1E105K | 16 V |
| 28 | C29 | Ceramic capacitor | 1 nF | C0805 | Several | 200 V |
| 29 | C30 | Ceramic capacitor | 2.2 nF | C1812 | TDK 4532X7RD222K | 2 KV |
| 30 | C31 | Ceramic capacitor | 1 nF | C0805 | Several | 200 V |
| 31 | C32 | Ceramic capacitor | NM | C0603 | Several | 50 V |
| 32 | C33 | Ceramic capacitor | 0.1 μ F | C0603 | Several | 50 V |
| 33 | C34 | Ceramic capacitor | 560 pF - NM | C0805 | Several | 50 V |
| 34 | C35 | Ceramic capacitor | 2.2 nF | C1812 | TDK 4532X7RD222K | 2 KV |

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

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|---------------------|------------------|---------------|--------------------------|---------|
| 35 | C37 | Ceramic capacitor | 470 pF - NM | C0805 | Several | 50 V |
| 36 | C38 | Ceramic capacitor | 22 μ F | C1206 | TDK C3216X5R1E226M | 16 V |
| 37 | C39 | Ceramic capacitor | 22 μ F - NM | C1206 | TDK C3216X5R1E226M | 16 V |
| 38 | C40 | Ceramic capacitor | 22 μ F - NM | C1206 | TDK C3216X5R1E226M | 16 V |
| 39 | C41 | Ceramic capacitor | 22 μ F | C1206 | TDK C3216X5R1E226M | 16 V |
| 40 | C42 | Ceramic capacitor | 1 μ F - NM | C0603 | Several | 16 V |
| 41 | C43 | Ceramic capacitor | 22 μ F - NM | C1206 | TDK C3216X5R1E226M | 16 V |
| 42 | C44 | Ceramic capacitor | 22 μ F-NM | C1206 | TDK C3216X5R1E226M | 16 V |
| 43 | C45 | Ceramic capacitor | 10 nF-NM | C0603 | Several | 50 V |
| 44 | C46 | Ceramic capacitor | 22 μ F-NM | C1206 | TDK C3216X5R1E226M | 16 V |
| 45 | C47 | Ceramic capacitor | 22 μ F | C1206 | TDK C3216X5R1E226M | 16 V |
| 46 | C48 | Ceramic capacitor | 1 μ F | C0603 | TDK C1608X5R1E105K | 16 V |
| 47 | C49 | Ceramic capacitor | 22 μ F - NM | C1206 | TDK C3216X5R1E226M | 16 V |
| 48 | C50 | Ceramic capacitor | 22 μ F - NM | C1206 | TDK C3216X5R1E226M | 16 V |
| 49 | C51 | Ceramic capacitor | 22 nF | C0603 | Several | 50 V |
| 50 | C52 | Electrol. capacitor | 330 μ F - NM | C-POL8-6_3 | Panasonic EEEFK1C331P | 16 V |
| 51 | C53 | Electrol. capacitor | 330 μ F | C-POL8-6_3 | Panasonic EEEFK1C331P | 16 V |
| 52 | C54 | Ceramic capacitor | 100 pF | C0603 | Several | 50 V |
| 53 | C55 | Ceramic capacitor | 0.1 μ F - NM | C0603 | Several | 50 V |
| 54 | C56 | Ceramic capacitor | 0.1 μ F - NM | C0603 | Several | 50 V |
| 55 | D1 | Diode | NM | SMA | Several | |
| 56 | D2 | Diode | NM | SMA | Several | |
| 57 | D3 | Diode bridge | DF01S | DF01S | Diodes | |
| 58 | D4 | Diode bridge | HD01-NM | HD01 | Diodes | |
| 59 | D5 | Zener diode | BZX84C10 | SOT23 | Several | |
| 60 | D6 | Diode | NM | SMA | Several | |
| 61 | D7 | Diode | NM | SMA | Several | |
| 62 | D8 | Diode | NM | SMA | Several | |
| 63 | D9 | Diode | NM | SMA | Several | |
| 64 | D10 | Diode bridge | DF01S | DF01S | Diodes | |
| 65 | D11 | Diode bridge | HD01 - NM | HD01 | Diodes | |
| 66 | D12 | Diode | NM | SMA | Several | |
| 67 | D13 | Diode | NM | SMA | Several | |

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

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|----------------|---------------------------------------|---------------------|--------------------|---------|
| 68 | D14 | Diode | STTH2R02A | SMA | STMicroelectronics | |
| 69 | D15 | Diode | STTH2R02A | SMA | STMicroelectronics | |
| 70 | D16 | Diode | NM | SMA | Several | |
| 71 | D17 | Diode | BAT46J - NM | SOD323 | STMicroelectronics | |
| 72 | D18 | TVS diode | SMAJ58A | SMA | STMicroelectronics | |
| 73 | D19 | LED diode | Green LED | LED-TLGE1100B | Toshiba | |
| 74 | D20 | Diode | NM | SMA | Several | |
| 75 | D21 | Diode | BAT46J | SOD323 | STMicroelectronics | |
| 76 | D22 | Diode | NM | SMA | Several | |
| 77 | D23 | Diode | BAT46J | SOD323 | STMicroelectronics | |
| 78 | D24 | Diode | NM | PFLAT_3_3X3_3-2-pin | | |
| 79 | D25 | Diode | NM | SOD128 | | |
| 80 | D28 | Schottky diode | PMEG6030P | SOD128 | NXP | |
| 81 | D29 | Diode | BAT46J - NM | SOD323 | STMicroelectronics | |
| 82 | D30 | Diode | BAT46J - NM | SOD323 | STMicroelectronics | |
| 83 | D31 | Diode | NM | PFLAT_6X5-3LEADS | | |
| 84 | D33 | Diode | NM | SMB | | |
| 85 | D34 | Diode | NM | PFLAT_3_3X3_3-2PIN | | |
| 86 | D35 | LED diode | Green LED - NM | 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 | |
| 92 | J5 | Connector | MOR-10 x 10.5 - P5 - 2-pin - NM | MOR-2POLI-508 | Several | |
| 93 | J6 | Connector | MOR-10 x 10.5 - P5 - 2-pin | MOR-2POLI-508 | Several | |
| 94 | L1 | Inductor | 5.6 μ H | ME3220 | Coilcraft | |
| 95 | L2 | Inductor | 0.33 μ H - NM | DO1813H-331ML | Coilcraft | |
| 96 | L3 | Inductor | 0.33 μ H - NM | LPS4012-331L | Coilcraft | |
| 97 | L4 | Inductor | 0.33 μ H - NM | DO1813H-331ML | Coilcraft | |

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

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|-------------|----------------------|---------------|--------------------|---------|
| 98 | L5 | Inductor | 0.33 μ H - NM | LPS4012-331L | Coilcraft | |
| 99 | Q1 | MOSFET | STS4NF100 | SO8 | STMicroelectronics | |
| 100 | Q2 | MOSFET | FDN86246 | SOT23 | Fairchild | |
| 101 | Q3 | Transistor | NM | SOT23 | Several | |
| 102 | Q4 | MOSFET | NM | SOT23-6L | | |
| 103 | Q5 | MOSFET | NM | SO8 | | |
| 104 | Q6 | MOSFET | NM | DPAK | | |
| 105 | Q7 | MOSFET | NM | SOT-223 | | |
| 106 | R1 | Resistor | 15 K Ω | R0805 | Several | |
| 107 | R2 | Resistor | 47 K Ω | R0805 | Several | |
| 108 | R3 | Resistor | 47 K Ω | R0805 | Several | |
| 109 | R4 | Resistor | 470 K Ω | R0805 | Several | |
| 110 | R5 | Resistor | 15 K Ω | R0805 | Several | |
| 111 | R6 | Resistor | NM | R1206 | Several | |
| 112 | R7 | Resistor | NM | R1206 | Several | |
| 113 | R8 | Resistor | 10 k Ω | R0603 | Several | |
| 114 | R9 | Resistor | NM | R0603 | Several | |
| 115 | R10 | Resistor | 10 k Ω | R0603 | Several | |
| 116 | R11 | Resistor | 52.3 Ω - 1% | R0805 | Several | |
| 117 | R12 | Resistor | NM | R0603 | Several | |
| 118 | R13 | Resistor | 22.1 K 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 K Ω - 1% | R0603 | Several | |
| 123 | R18 | Resistor | NM | R0603 | Several | |
| 124 | R19 | Resistor | 100 R Ω | R0603 | Several | |
| 125 | R20 | Resistor | 10 K Ω | R0603 | Several | |
| 126 | R21 | Resistor | NM | R0603 | Several | |
| 127 | R22 | Resistor | NM | 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 | NM | R1206 | Several | |
| 132 | R27 | Resistor | 75 Ω | R0805 | Several | |

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

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|----------------|-------------------------|---------------|--------------------------|---------|
| 133 | R29 | Resistor | 75 Ω | R0805 | Several | |
| 134 | R30 | Resistor | 100 Ω - NM | R1206 | Several | |
| 135 | R31 | Resistor | 75 Ω | R0805 | Several | |
| 136 | R32 | Resistor | 100 Ω | R0603 | Several | |
| 137 | R33 | Resistor | 10 k Ω | R0603 | Several | |
| 138 | R34 | Sense resistor | 0.33 Ω - 1% - NM | R1206 | Vishay - RCWE1206R330FKE | |
| 139 | R35 | Sense resistor | 0.33 Ω - 1% | R1206 | Vishay - RCWE1206R330FKE | |
| 140 | R36 | Resistor | 2.2 K Ω | R0603 | Several | |
| 141 | R37 | Resistor | 0 Ω | R0603 | Several | |
| 142 | R38 | Resistor | NM | R1206 | Several | |
| 143 | R40 | Resistor | NM | R1206 | Several | |
| 144 | R41 | Resistor | NM | R1206 | Several | |
| 145 | R42 | Resistor | NM | R1206 | Several | |
| 146 | R43 | Resistor | 0 Ω | R0805 | Several | |
| 147 | R44 | Resistor | 0 Ω | R1206 | Several | |
| 148 | R45 | Resistor | 47 K Ω - NM | R0603 | Several | |
| 149 | R46 | Resistor | 0 Ω - NM | R1206 | Several | |
| 150 | R47 | Resistor | 0 Ω | R1206 | Several | |
| 151 | R48 | Resistor | 2.2 K Ω | R0603 | Several | |
| 152 | R49 | Resistor | NM | R0603 | Several | |
| 153 | R50 | Resistor | NM | R0603 | Several | |
| 154 | R51 | Resistor | 10 K Ω - 1% | R0603 | Several | |
| 155 | R52 | Resistor | 100 K Ω - 1% | R0603 | Several | |
| 156 | R53 | Resistor | 10 K Ω - NM | R0603 | Several | |
| 157 | R54 | Resistor | 10 K Ω | R0603 | Several | |
| 158 | R55 | Resistor | 21 K Ω - 1% | R0603 | Several | |
| 159 | R56 | Resistor | 12.4 K Ω - 1% | R0603 | Several | |
| 160 | R57 | Resistor | NM - 1% | R0603 | Several | |
| 167 | TP1 | Test point | Red | TH-5013 | Keystone | |
| 168 | TP2 | Test point | Black | TH-5013 | Keystone | |
| 169 | TP3 | Test point | Red | TH-5013 | Keystone | |
| 170 | TP4 | Test point | Black | TH-5013 | Keystone | |
| 171 | TP5 | Test point | Red - NM | TH-5013 | Keystone | |

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

| Item | Reference | Description | Value | PCB footprint | Supplier | Voltage |
|------|-----------|-------------------|---------------------------------|-------------------------|--------------------|---------|
| 172 | TP6 | Test point | Red | TH-5013 | Keystone | |
| 173 | TP7 | Test point | Black | TH-5013 | Keystone | |
| 174 | TP8 | Test point | Red | TH-5013 | Keystone | |
| 175 | TP9 | Test point | Black | TH-5013 | Keystone | |
| 176 | TP10 | Test point | Red | TH-5013 | Keystone | |
| 177 | TP11 | Test point | Red | TH-5013 | Keystone | |
| 178 | TP12 | Test point | Black | TH-5013 | Keystone | |
| 179 | TP13 | Test point | Red | TH-5013 | Keystone | |
| 180 | TP14 | Test point | Red | TH-5013 | Keystone | |
| 181 | TP15 | Test point | Red - NM | TH-5013 | Keystone | |
| 182 | TP16 | Test point | Red | TH-5013 | Keystone | |
| 183 | TP17 | Test point | Red | TH-5013 | Keystone | |
| 184 | TP18 | Test point | Black - NM | TH-5013 | Keystone | |
| 185 | TP19 | Test point | Black | TH-5013 | Keystone | |
| 186 | TP20 | Test point | Red - NM | TH-5013 | Keystone | |
| 161 | T1 | Data transformer | H2019 / TLA-6T127LF | Pulse-H2019 | Pulse | |
| 162 | T2 | CM choke | Würth 744226S - NM | 744226S | Würth | |
| 163 | T3 | Power transformer | COILCRAFT POE13P-12L | POE12L | Coilcraft | |
| 164 | T4 | Power transformer | COILCRAFT POE13P -50L- NM | POE50L | Coilcraft | |
| 165 | T5 | Power transformer | COILCRAFT HA3893-AL - NM | HA3893-AL- COILCRAFT | Coilcraft | |
| 166 | T6 | CM choke | Pulse PE65855NL - NM | PE-65855NL-PULSE | Pulse | |
| 187 | U1 | Controller IC | PM8800A | HTSSOP16 | STMicroelectronics | |
| 188 | U2 | Optocoupler | Fairchild FOD817A | FOD817 | Fairchild | |
| 189 | U3 | Optocoupler | Sharp PC3H7D-NM | PC3H7 | Sharp | |
| 190 | U4 | Voltage reference | TS2431AILT | SOT23 | STMicroelectronics | |
| 191 | U5 | Voltage reference | TS431AILT - NM | SOT23-5L | STMicroelectronics | |

6 PCB layers

Figure 31. PCB layer: top view

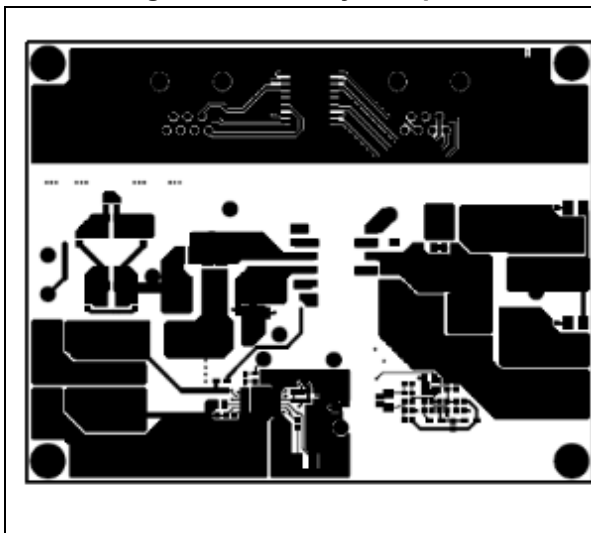


Figure 32. PCB layer: layer 2

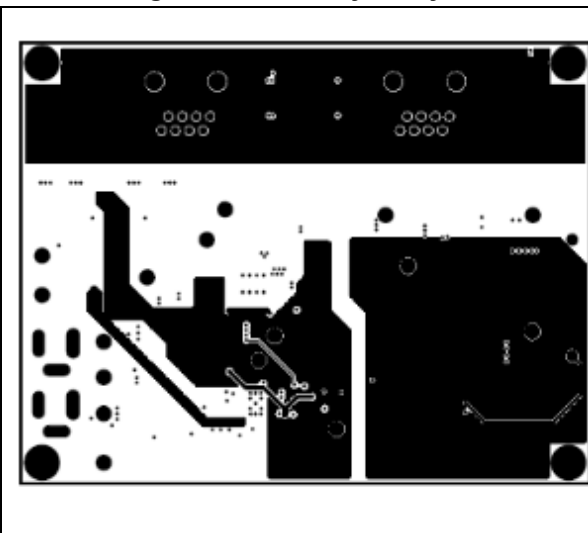


Figure 33. PCB layer: layer 3

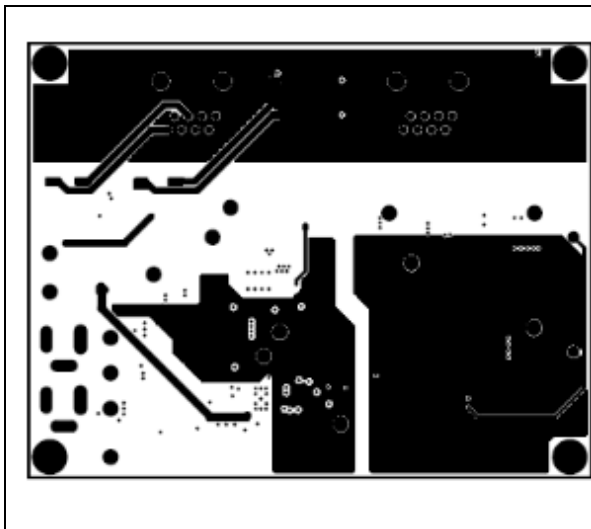


Figure 34. PCB layer: bottom view

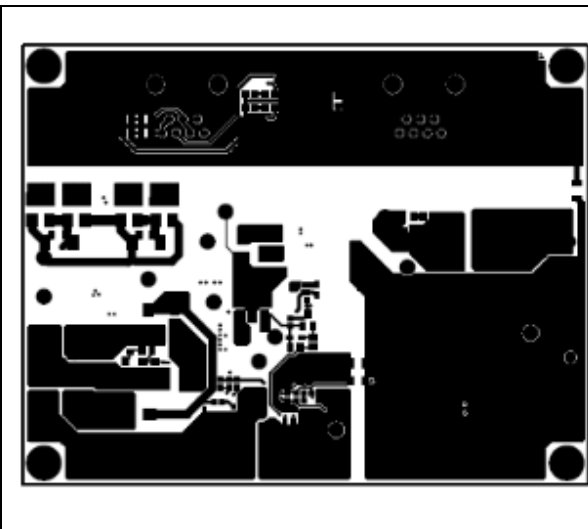
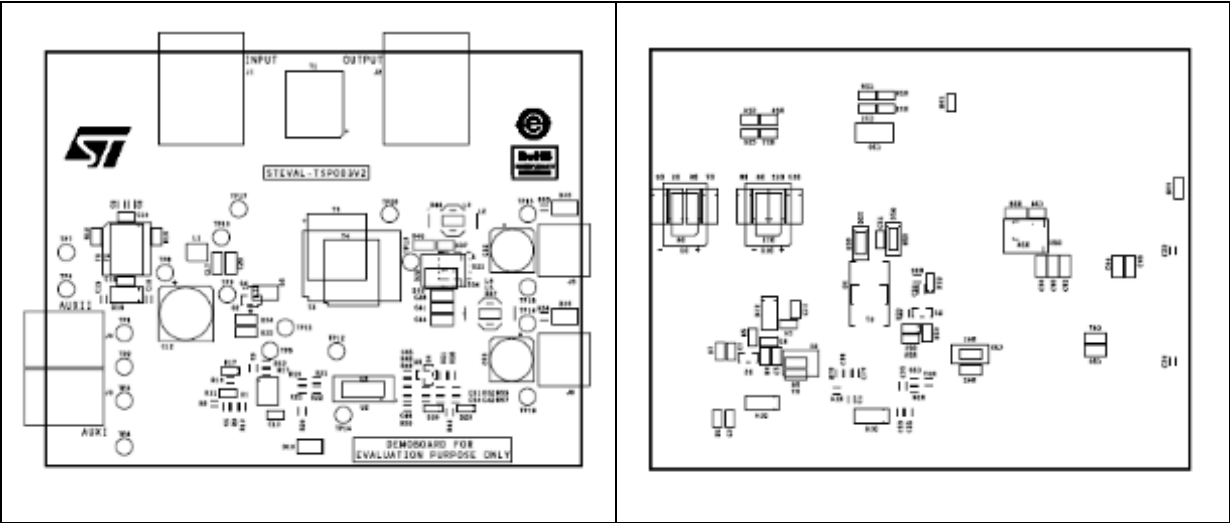


Figure 35. PCB layer: components on top side

Figure 36. PCB layer: components on bottom side



7 Revision history

Table 6. Document revision history

| Date | Revision | Changes |
|-------------|----------|------------------|
| 12-Feb-2014 | 1 | Initial release. |

Please Read Carefully:

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

ST PRODUCTS ARE NOT DESIGNED OR AUTHORIZED FOR USE IN: (A) SAFETY CRITICAL APPLICATIONS SUCH AS LIFE SUPPORTING, ACTIVE IMPLANTED DEVICES OR SYSTEMS WITH PRODUCT FUNCTIONAL SAFETY REQUIREMENTS; (B) AERONAUTIC APPLICATIONS; (C) AUTOMOTIVE APPLICATIONS OR ENVIRONMENTS, AND/OR (D) AEROSPACE APPLICATIONS OR ENVIRONMENTS. WHERE ST PRODUCTS ARE NOT DESIGNED FOR SUCH USE, THE PURCHASER SHALL USE PRODUCTS AT PURCHASER'S SOLE RISK, EVEN IF ST HAS BEEN INFORMED IN WRITING OF SUCH USAGE, UNLESS A PRODUCT IS EXPRESSLY DESIGNATED BY ST AS BEING INTENDED FOR "AUTOMOTIVE, AUTOMOTIVE SAFETY OR MEDICAL" INDUSTRY DOMAINS ACCORDING TO ST PRODUCT DESIGN SPECIFICATIONS. PRODUCTS FORMALLY ESCC, QML OR JAN QUALIFIED ARE DEEMED SUITABLE FOR USE IN AEROSPACE BY THE CORRESPONDING GOVERNMENTAL AGENCY.

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2014 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Philippines - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

www.st.com