

PMP6011
UCC28810/LM3466
Universal Input 45W AC-DC LED Driver Reference
Design



January, 2013

Universal Input 45W AC-DC LED Driver with PFC

1 Introduction

This UCC28810 reference design presents the UCC28810 AC-DC controller driving a multiple string LED output. The 3 separate LED string currents are balanced using an LM3466 on each. The UCC28810 is designed to drive high-brightness light emitting diodes (LEDs) and features a transconductance voltage amplifier for feedback error processing, a simple current reference generator for generating a current command proportional to the input voltage, a current sense (PWM) comparator, PWM logic and a totem pole driver for driving an external FET.

2 Description

This reference design provides a high-brightness LED driver based on the UCC28810 configured as a power factor corrected flyback regulator that drives multiple LED strings with current sharing provided by three LM3466 devices. It is designed to operate with an input voltage in the range of 90VAC to 300VAC with a 120VAC or 230VAC nominal input voltage. This design is set up for a default output current of 1A (333mA each string) with an output voltage range of 30V to 45V or approximately 10 to 15 LEDs depending on the forward voltage of each.

2.1 *Typical Applications*

This converter design describes an application of the UCC28810 coupled with the LM3466 as an LED driver with the specifications listed below. For applications with a different output current range refer to the UCC28810 datasheet.

2.2 *Features*

2.2.1 Protection

This design incorporates multiple protection features. These include output open circuit protection, VDD under-voltage protection, switch current limit, LED string current limit, and thermal protection. Included at the input is line transient protection.

3 Electrical Performance Specifications
Table 1: UCC28810/LM3466 Electrical Performance Specifications

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------------|-----------------------------------------------|------|-------|------|-------|
| Input Characteristics | | | | | |
| Voltage range | | 90 | | 300 | VAC |
| Maximum input current | At 90VAC input voltage | | 625 | | mA |
| Output Characteristics | | | | | |
| Output voltage, VOUT | At IO _{UT} = 1A | 30 | | 45 | V |
| Output load current, IO _{UT} | Total output current | 0.95 | 1 | 1.05 | A |
| Output current regulation | At 120VAC input voltage | | ±5 | | % |
| Output current ripple | Each string | | 230 | | mApp |
| Over-voltage protection level | Output rising | | 60 | | V |
| Systems Characteristics | | | | | |
| Switching frequency | Over the 90VAC to 300VAC input voltage range | 120 | | 300 | kHz |
| Efficiency | Input voltage = 120VAC, Load = 15 LEDs at 45V | | 82.5 | | % |
| Power Factor | Input voltage = 120VAC, Load = 15 LEDs at 45V | | 0.986 | | |
| Efficiency | Input voltage = 230VAC, Load = 15 LEDs at 45V | | 81.6 | | % |
| Power Factor | Input voltage = 230VAC, Load = 15 LEDs at 45V | | 0.988 | | |

4 Schematic

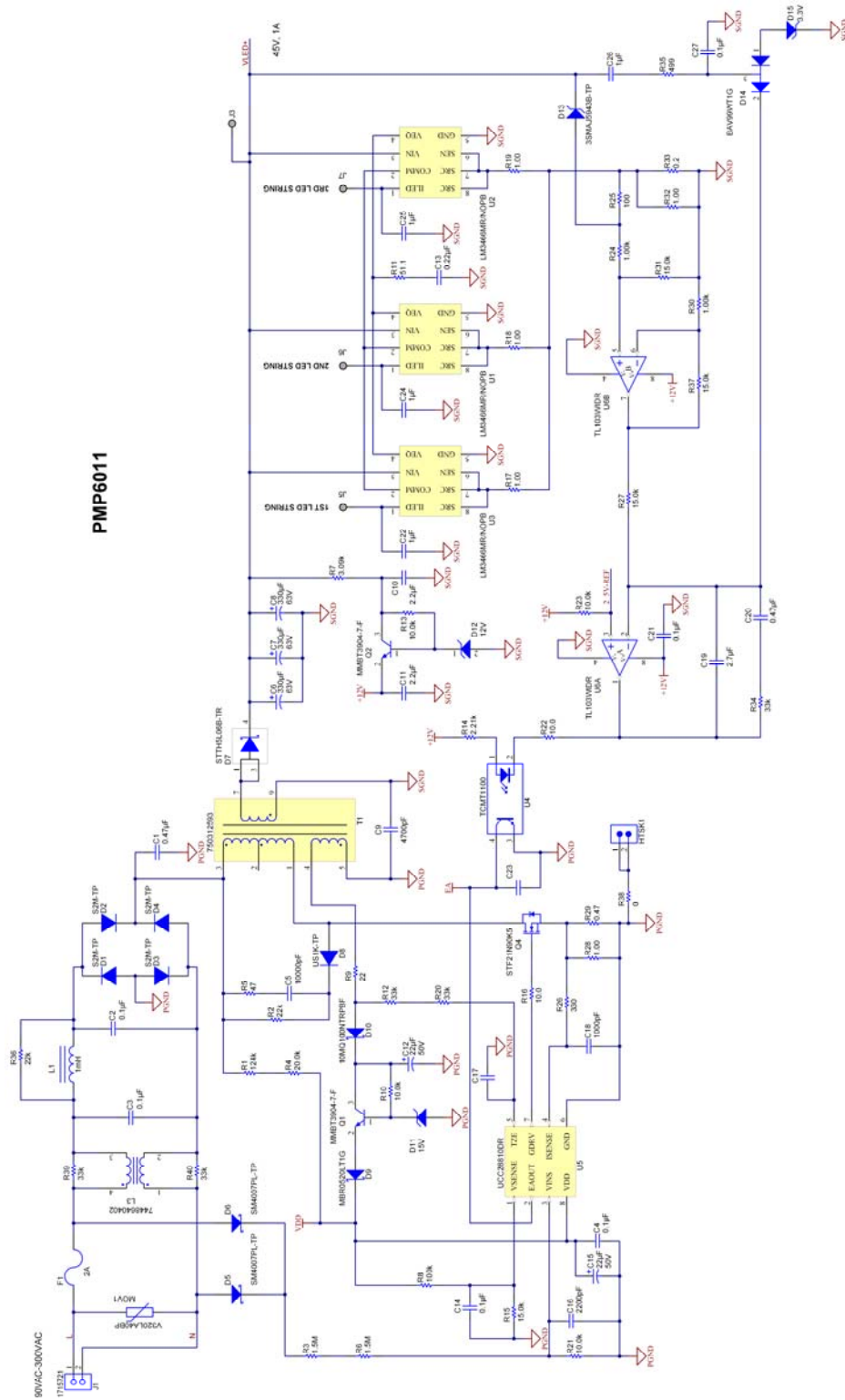


Figure 1: UCC28810/LM3466 Schematic

5 Performance Data and Typical Characteristic Curves

Figures 2 through 11 present typical performance curves for UCC28810/LM3466 design.

5.1 Efficiency

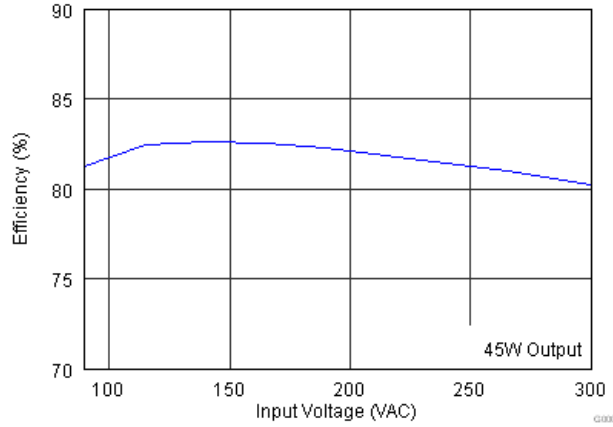


Figure 2: Efficiency

5.2 Line Regulation

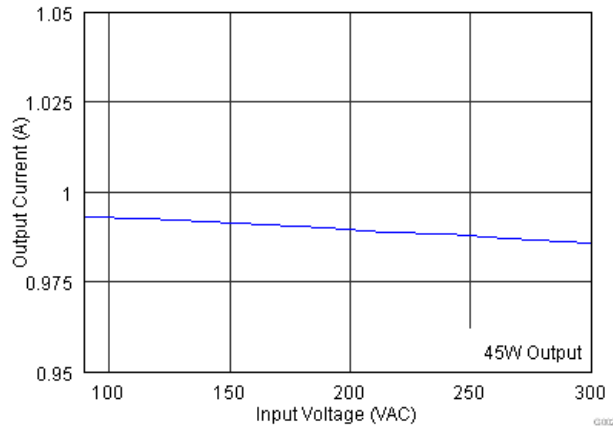


Figure 3: Line Regulation

5.3 Power Factor

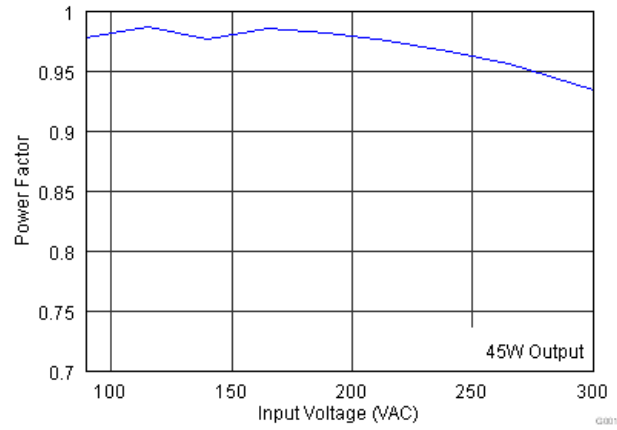


Figure 4: Power Factor

5.4 Scope Shots and EMI Performance

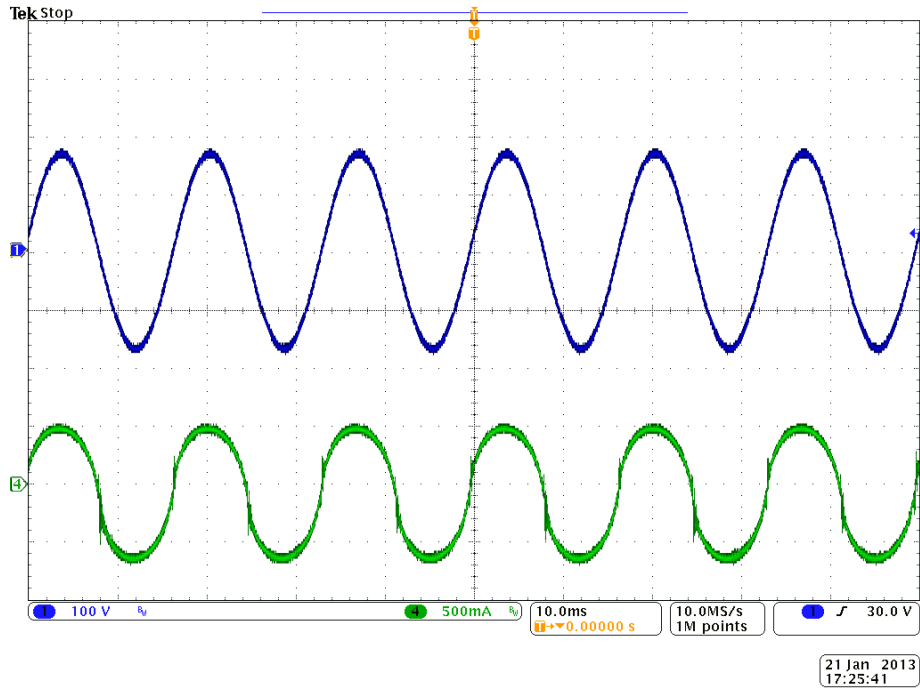


Figure 6: Input Voltage (top) and Input Current (bottom) at 120VAC Input

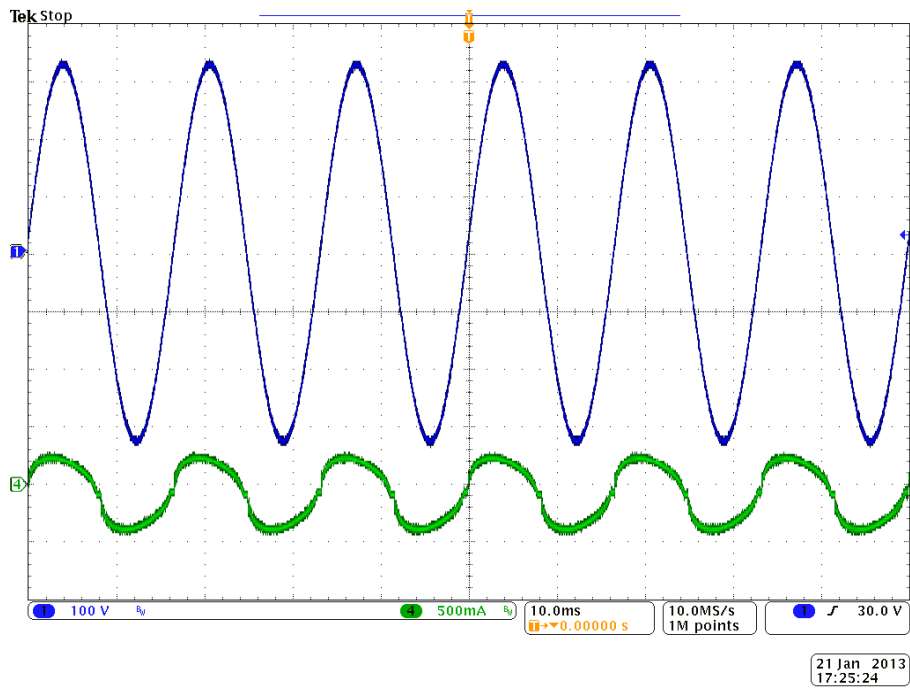


Figure 7: Input Voltage (top) and Input Current (bottom) at 230VAC Input

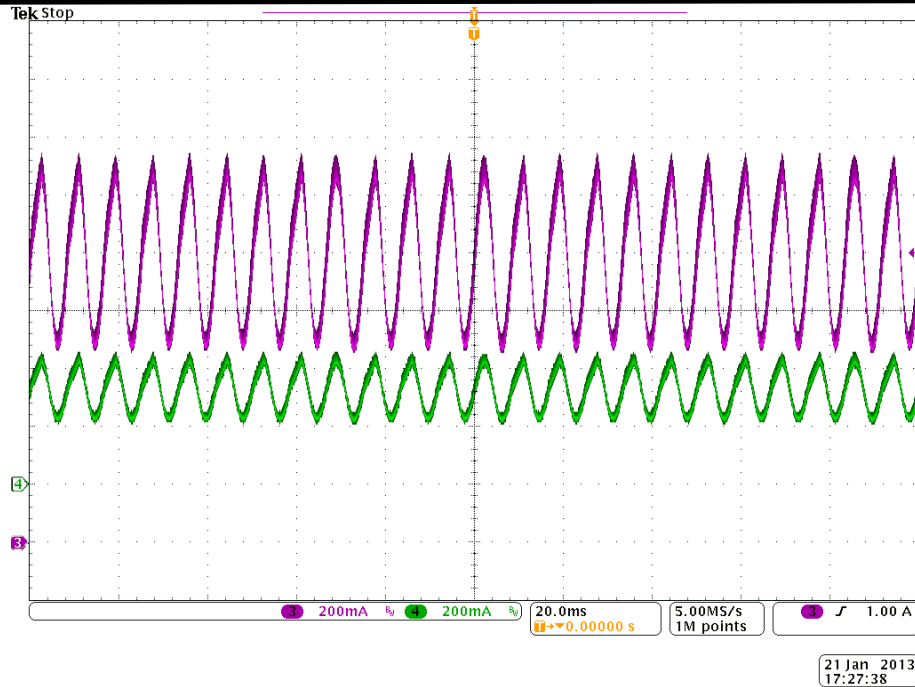


Figure 8: Total Output Current (top) and LED String Current (bottom) at 120VAC Input

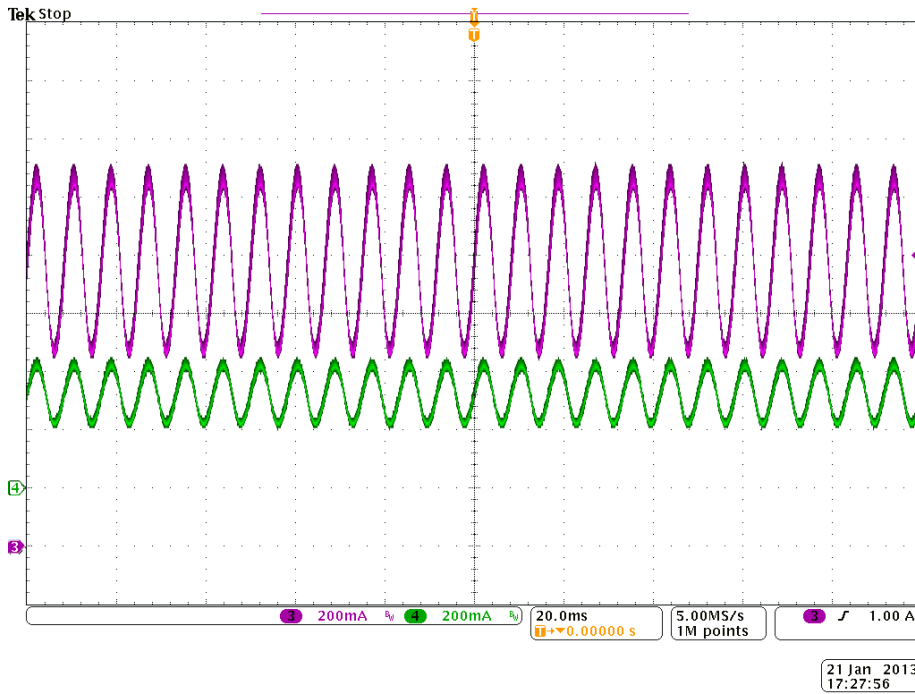
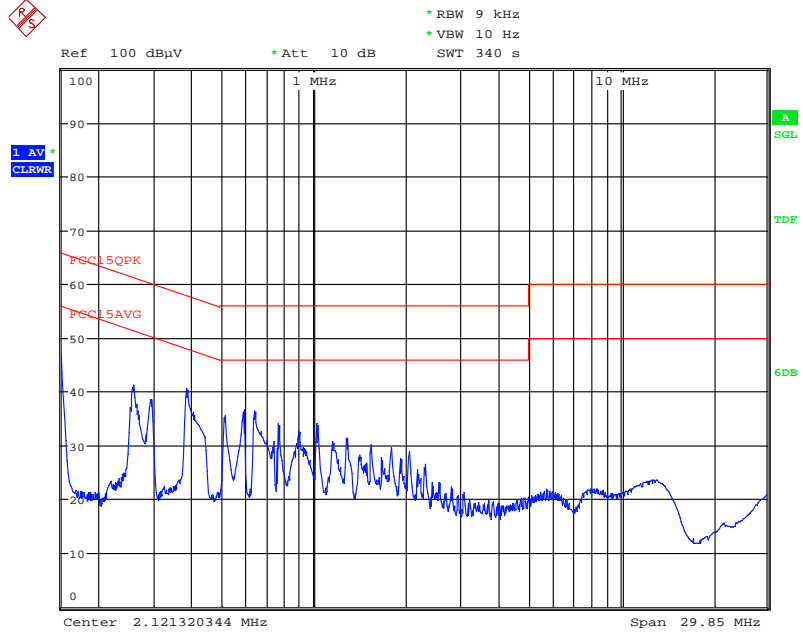
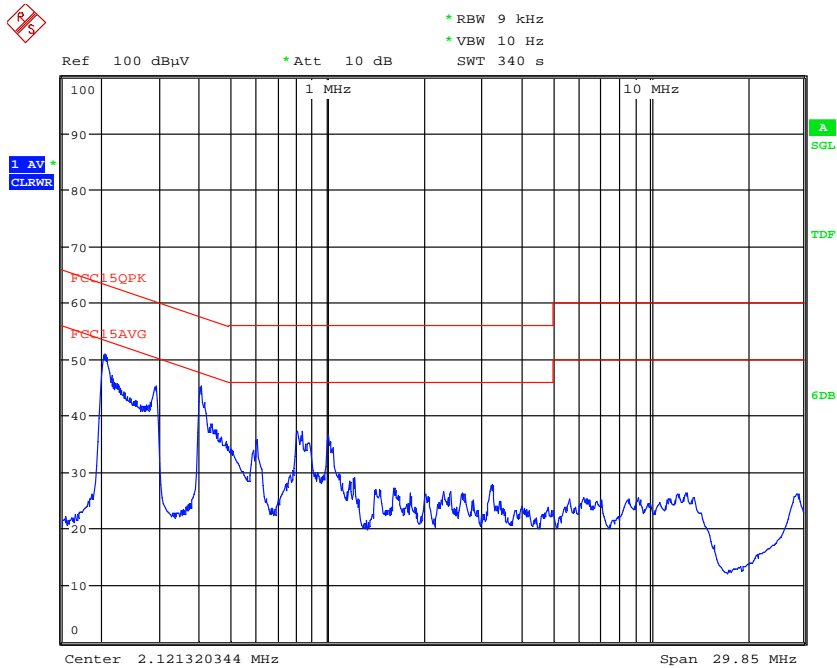


Figure 9: Total Output Current (top) and LED String Current (bottom) at 230VAC Input



Date: 14.JAN.2013 13:08:38

Figure 10: 120VAC Conducted Average EMI Scan



Date: 14.JAN.2013 13:00:03

Figure 11: 230VAC Conducted Average EMI Scan

6 Bill of Materials
Table 2: The UCC28810/LM3466 components list according to the schematic shown in Figure 1

| REFERENCE DESIGNATOR | QTY | VALUE | DESCRIPTION | SIZE | MFR | PART NUMBER |
|----------------------|-----|--------------|--------------------------------------|--------------|-------------------------|----------------------|
| U1, U2, U3 | 3 | | Linear LED Driver | PSOP-8 | TI | LM3466MR |
| U4 | 1 | | Optoisolator | SOP-4 | Vishay | TCMT1100 |
| U5 | 1 | | AC-DC Flyback LED Driver | SOIC-8 | TI | UCC28810DR |
| U6 | 1 | | Dual Op-Amp | SOIC-8 | TI | TL103WIDR |
| C1 | 1 | 0.47 μ F | Capacitor, Film, 630V | 26.5mmx8.5mm | Epcos | B32923C3474M |
| C2, C3 | 2 | 0.1 μ F | Capacitor, Film, 305VAC | 13mmx6mm | Epcos | B32921C3104M |
| C4, C14, C21, C27 | 4 | 0.1 μ F | Capacitor, Ceramic, 16V, X7R | 0603 | AVX | 0603YC104JAT2A |
| C5 | 1 | 0.01 μ F | Capacitor, Ceramic, 500V, X7R | 1206 | AVX | 12067C103KAT2A |
| C6, C7, C8 | 3 | 330 μ F | Capacitor, Aluminum, 63V | 10mmx20mm | Nichicon | UVR1J331MPD |
| C9 | 1 | 4700 pF | Capacitor, Ceramic, 500V, Disc | 16mm | Vishay | VY1472M63Y5UQ63V0 |
| C10 | 1 | 2.2 μ F | Capacitor, Ceramic, 100V, X7R | 1210 | TDK | C3225X7R2A225K230AB |
| C11 | 1 | 2.2 μ F | Capacitor, Ceramic, 50V, X7R | 0805 | TDK | C2012X7R1H225K125A C |
| C12, C15 | 2 | 22 μ F | Capacitor, Aluminum, 50V | 5mmx11mm | Nichicon | UVR1H220MDD |
| C13 | 1 | 0.22 μ F | Capacitor, Ceramic, 16V, X7R | 0805 | AVX | 0805YC224KAT2A |
| C16 | 1 | 2200 pF | Capacitor, Ceramic, 50V, X7R | 0805 | AVX | 08055C222KAT2A |
| C18 | 1 | 1000 pF | Capacitor, Ceramic, 50V, X7R | 0805 | Kemet | C0805C102K5RACTU |
| C19 | 1 | 2.7 μ F | Capacitor, Ceramic, 16V, X7R | 1206 | Kemet | C1206C275K4RACTU |
| C20 | 1 | 0.47 μ F | Capacitor, Ceramic, 50V, X7R | 1206 | TDK | C3216X7R1H474K |
| C22, C24, C25 | 3 | 1 μ F | Capacitor, Ceramic, 25V, X7R | 0603 | MuRata | GRM188R71E105KA12D |
| C26 | 1 | 1 μ F | Capacitor, Ceramic, 25V, X7R | 1206 | AVX | 12063C105KAT2A |
| D1, D2, D3, D4 | 4 | | Diode, 1000V, 2A | SMB | Micro Commercial | S2M-TP |
| D5, D6 | 2 | | Diode, Schottky, 1000V, 1A | Powerlite123 | Micro Commercial | SM4007PL-TP |
| D7 | 1 | | Diode, Schottky, Ultrafast, 600V, 5A | DPAK | ST Micro | STTH5L06B-TR |
| D8 | 1 | | Diode, Fast, 800V, 1A | SMA | Micro Commercial | US1K-TP |
| D9 | 1 | | Diode, Schottky, 20V, 0.5A | SOD-123 | ON Semi | MBR0520LT1G |
| D10 | 1 | | Diode, Schottky, 100V, 1.5A | SMA | International Rectifier | 10MQ100NTRPBF |
| D11 | 1 | | Diode, Zener, 15V, 500mW | SOD-123 | Diodes Inc | MMSZ5245B-7-F |
| D12 | 1 | | Diode, Zener, 12V, 500mW | SOD-123 | Diodes Inc | MMSZ5242B-7-F |
| D13 | 1 | | Diode, Zener, 56V, 3W | SMA | Micro Commercial | 3SMAJ5943B-TP |
| D14 | 1 | | Diode, P-N, 70V, 0.2A | SOT-323 | Fairchild Semi | BAV99WT1G |
| D15 | 1 | | Diode, Zener, 3.3V, 500mW | SOD-123 | ON Semi | MMSZ3V3T1G |
| F1 | 1 | | Fuse, Slow, 2A, 277VAC | 8.35mmx4mm | Bel Fuse Inc | RST 2 |
| HTSK1 | 1 | | Heatsink and Clip for TO-220 | | Ohmite | WA-T220-101E |
| L1 | 1 | 1 mH | Inductor, Shielded, 0.68A | 1278 | Coilcraft | MSS1278T-105KLB |

| | | | | | | |
|-------------------------|---|-----------------|--------------------------------|---------------|-----------------------|-------------------|
| L3 | 1 | 10 mH | Power Line Choke, 0.6A | 21.2mmx21.2mm | Würth | 7448640402 |
| MOV1 | 1 | | Varistor, 320VAC, 150J, Disc | 20mm | Littlefuse Inc | V320LA40BP |
| Q1, Q2 | 2 | | Transistor, NPN, 40V, 0.2A | SOT-23 | Diodes Inc | MMBT3904-7-F |
| Q4 | 1 | | MOSFET, N-Channel, 900V, 18.5A | TO-220FP | ST Micro | STF21N90K5 |
| R1 | 1 | 124 k Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R2 | 1 | 22 k Ω | Resistor, Chip, 1W, 5% | 2512 | Std | |
| R3, R6 | 2 | 100 Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R4 | 1 | 20 k Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R5 | 1 | 47 Ω | Resistor, Chip, 1W, 5% | 2512 | Std | |
| R7 | 1 | 3.09 k Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R8 | 1 | 100 k Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R9 | 1 | 22 Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R10, R13, R21, R23 | 4 | 10 k Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R11 | 1 | 51.1 Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R12, R20, R34 | 3 | 33 k Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R14 | 1 | 2.21 k Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R15, R27, R31, R37 | 4 | 15 k Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R16, R22 | 2 | 10 Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R17, R18, R19, R28, R32 | 4 | 1 Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R24, R30 | 2 | 1 k Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R25 | 1 | 100 Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R26 | 1 | 330 Ω | Resistor, Chip, 1/10W, 1% | 0603 | Std | |
| R29 | 1 | 0.47 Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R33 | 1 | 0.2 Ω | Resistor, Chip, 1/2W, 1% | 1206 | Stackpole Electronics | CSR1206FKR200 |
| R35 | 1 | 499 Ω | Resistor, Chip, 1/8W, 1% | 0805 | Std | |
| R36 | 1 | 22 k Ω | Resistor, Chip, 1/4W, 1% | 1206 | Std | |
| R38 | 1 | 0 Ω | Resistor, Chip, 1/4W, 5% | 1206 | Std | |
| R39, R40 | 2 | 33 k Ω | Resistor, Chip, 1/4W, 5% | 1206 | Std | |
| T1 | 1 | | Transformer | EE-25 | Würth | 750312593 (Rev 3) |
| C17 | | | DNP | | | |
| C23 | | | DNP | | | |

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