

## Description

The AS044 Energy Meter Power supply is a 10W Isolated multi-channel AC-DC Flyback converter which has a special requirement to pass the magnetic tampering using Iron dust core. The design is made to operate at 450V AC, and it has capacitor saver function which will help in reducing the BOM and increase the reliability.

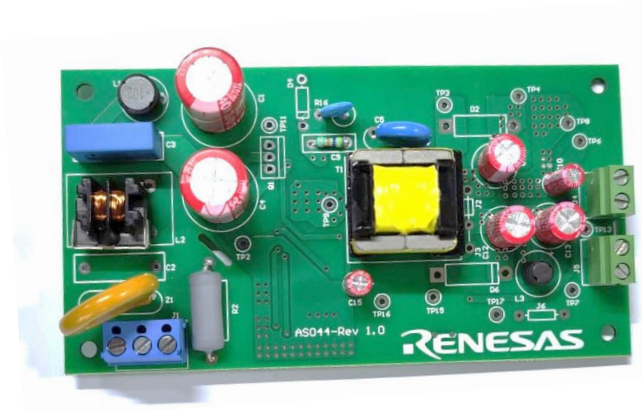
## Kit Contents

- AS044 Energy Meter Power Supply Board

## Features

- Flyback AC-DC supply to withstand 450V AC with avalanche rated 900V, 13ohm integrated Mosfet.
- Iron dust core to pass 0.5T Magnetic tampering as per IEC standard.
- Capacitor Saver feature to save the BOM Cost and improve reliability.
- Isolated dual channel outputs which have 4KV isolation between Primary and all secondary outputs.
- Configurable overload timer of the device allows 100msec peak demand of 2A.
- Pulse frequency Modulation (PFM) for light load implementation, PWM changes from 50KHz to 3KHz.

## Evaluation Board



**Figure 1. AS044 Energy Meter Power Supply Board**

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## AS044 Overview

The block diagram below highlights the main parts of the system:

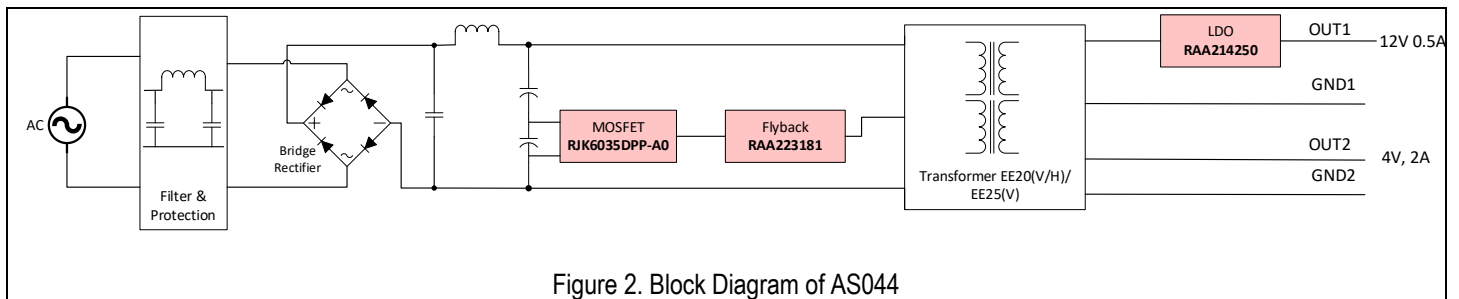


Figure 2. Block Diagram of AS044

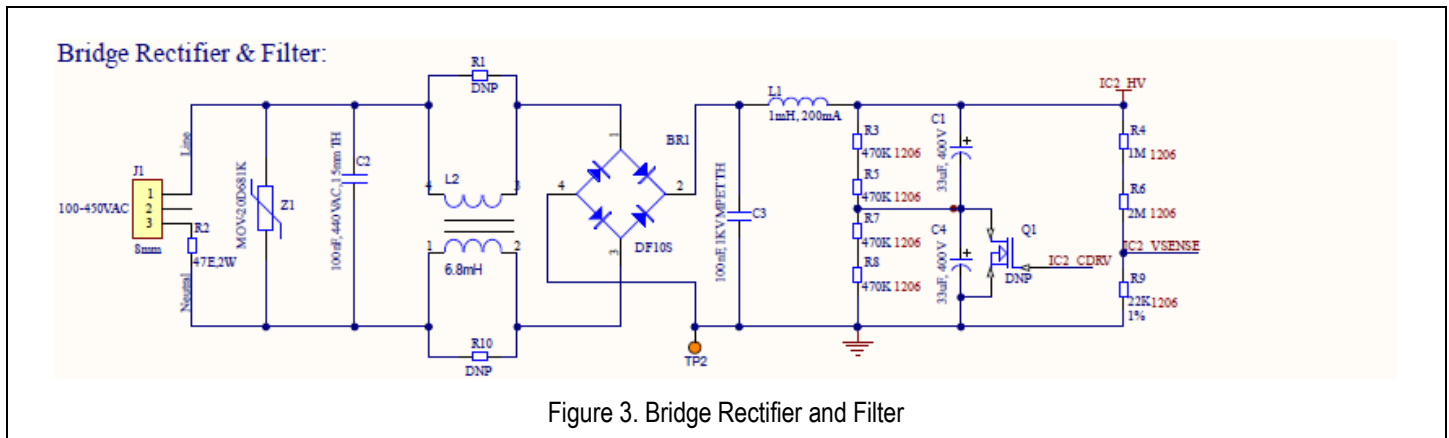
The building blocks of the AS044 and their functionality are listed below:

1. [RAA214250](#): The RAA214250 is a low-dropout linear voltage regulator that operates from 2.5V to 20V and provide up to 500mA of output current with a typical dropout of 269mV. The output voltage is adjustable with external feedback resistors anywhere from 1.224V to 18V.
2. [RAA223181](#): The RAA223181 is an off-line Flyback regulator with a 900V integrated MOSFET, designed for high input voltage and high reliability application of smart meter power supplies and other general isolated power supplies.
3. [RJK6035DPP-A0](#): MOSFETs suitable for switching (motor drive, etc.) and load switch applications. Low on-resistance, high-speed switching, and high-robustness.

## Hardware Overview

The following block diagrams have specific applications explained below.

**Bridge Rectifier and Filter:** The mains AC line input with the Diode Bridge, Storage Capacitor(s), EMI-reduction Choke as well as safety and protection components like Fuse or Fusible Resistor, MOV and X-Capacitor. The input surge section consists of 510V MOV (Metal Oxide Varistor). MOV is used to protect the circuit from high voltage spikes. The LC filter helps by filtering the HV peak of the incoming surge event. Line filter design can be improved to increase the system surge rating. Common mode choke coils are suited for noise suppression on lines with large current flows, such as AC/DC power supply lines. The Bridge rectifier DF10S is used to convert AC to DC supply. The obtained DC output is filtered and is fed to RAA223181 Flyback converter.



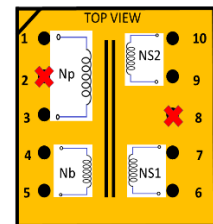
**Input Capacitor Saving Feature:** Meters are required to be always safe at two types of input overvoltage (transient kV+ as lighting surge; continuous OV of 2-3 times of nominal AC input as wrong wiring). Power meters need 2+ stacked 450V capacitors to protect from any extended OV event. Renesas CAPsaver™ replaces one 450V capacitor with a lower cost MOSFET. Example shown saves from two 450V 47µF capacitors & two 2512 balancing resistors to one 450V 22µF capacitor and one 500V 10ohm MOSFET (>\$0.2 savings). For the meters that must always work at full load at any OV events, this feature can be disabled.

**Output LDO:** The RAA214250 is a low-dropout linear voltage regulator that operates from 2.5V to 20V and provides up to 500mA of output current with a typical dropout of 269mV. The output voltage is adjustable with external feedback resistors anywhere from 1.224V to 18V. RAA214250 is connected to 18V from transformer to provide an output of 12V, 0.5A.

**Flyback Operation:** The RAA223181 is an off-line Flyback regulator with a 900V integrated MOSFET, designed for high input voltage and high reliability application of smart meter power supplies and other general isolated power supplies. The Energy Meter Power supply board, featuring the RAA223181 900V regulator, is a dual output 8W universal input flyback evaluation board; it provides a low-cost high performance isolated AC/DC solution from a universal input of 85VAC to 450VAC to both a 12V output and a 4V output for smart meter applications. The board operates in DCM with constant frequency at 50kHz in normal operation and uses valley switching to reduce switching losses and EMI noises. The board has built-in protections of overload, short-circuit, input brownout, VCC UV, VCC OV, VIN UV, peak current limit, primary short, and over-temperature protections. With a low-cost input EMI filter, the board is pre-compliant with EN55022/CISPR 22 Class B conducted EMI limits, and it has the 4kV surge capability according to IEC61000-4-5 standard.

Transformer Details:

CORE TYPE:	EE2005S
CORE MATERIAL:	Iron Dust Core - KE16-26
MARGIN TAPE:	0
AL	78nH
FLUX BAND	
VACUUM IMPREGNATION	NO, DIP VARNISH
PRIMARY INDUCTANCE:	1500 uH + 10%
LEAKAGE INDUCTANCE:	50uH
TAPE LAYER BETN P&S:	3L OF 2 mil
TAPE LAYER BETN S&S:	3L OF 2 mil
BOBBIN TYPE:	VERTICAL
BOBBIN PIN:	10 PIN



SI. No.	WIRE GAUGE & TYPE	VOLTAGE	CURRENTS	TURNS / LAYERS	NO OF STRAND	START PIN	FINISH PIN	WDG DICTION
W1	TIW 0.35mm/ SEC2	15V	0.2	24T/ ONE	2	10	9	Spread Full Layer
W2	0.35mmX1 / BIAS WDG	15V	0.006	28T/ ONE	1	5	4	Spread Full Layer
W3	UEW 0.15mmX1/ PRI_MAIN	700V	0.3	141T/TWO	1	3	1	Spread Full Layer
W4	TIW 0.35mmX2/SEC1	4V	2.1	10T/ONE	2	6	7	Spread Full Layer

Flyback:

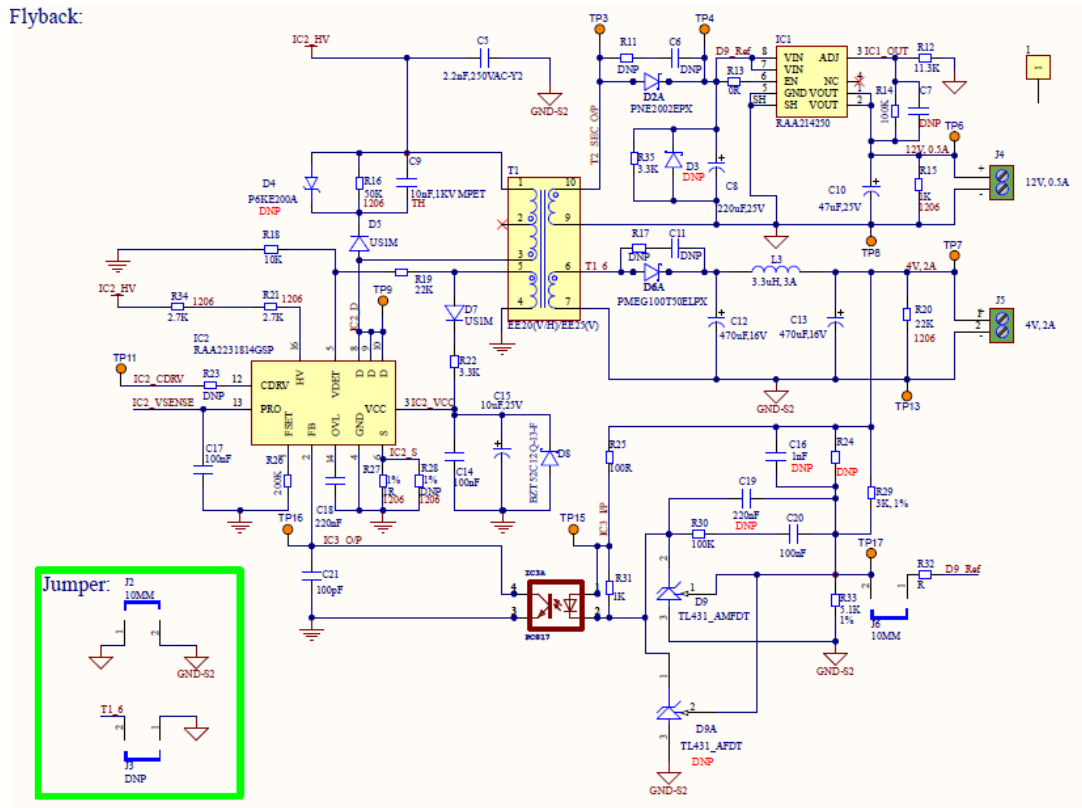


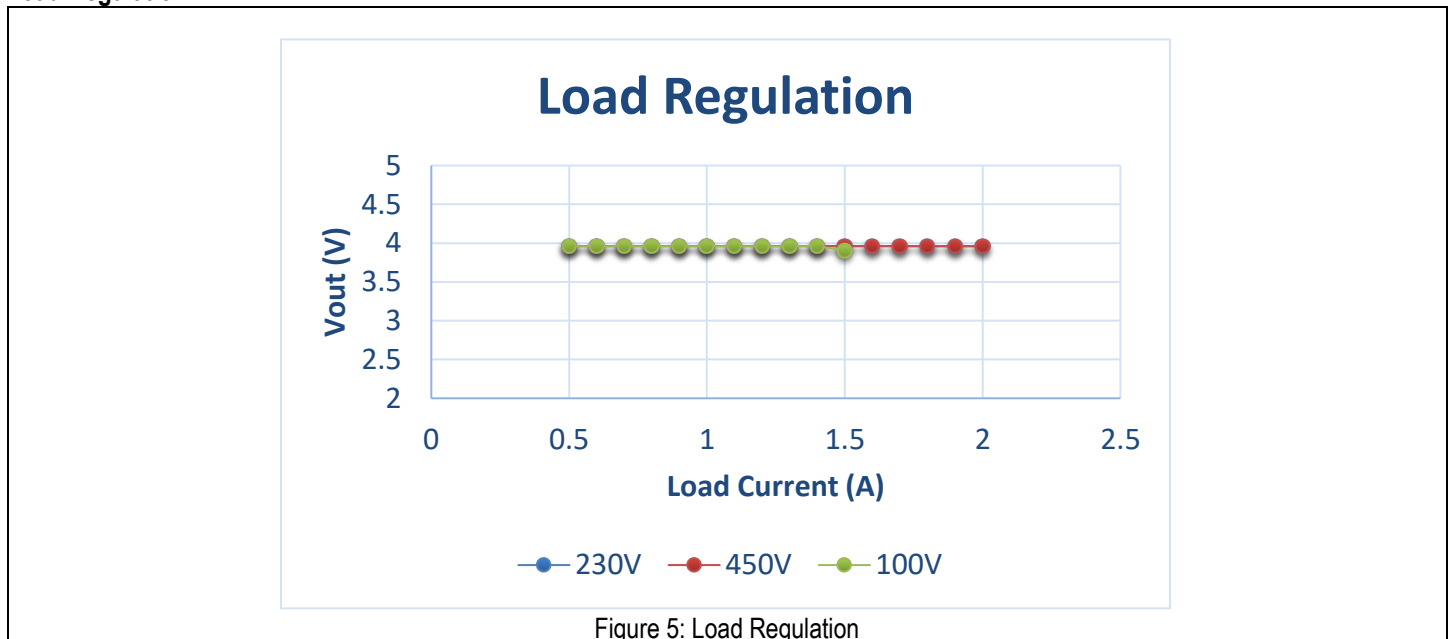
Figure 4: Flyback Circuit

## Test Data and Steps

**Table 1. Specification of AS044 Board**

Sl. No	Description	Min	Typ	Max	Remarks
1	Input Voltage Range (Vin Ac)	100Vac	230Vac	450Vac	Vac
2	Line Frequency	47	50	53	HZ
3	Vout1		4V		
4	Iout1	250mA	1000mA	2000mA	mA
5	Vout2	9.8V	12V	12.04V	V
6	Iout1			250mA	mA
7	Efficiency			59%	
8	CE				As per CISPER 22
9	SURGE - IMPULSE				10KV Surge- Impulse
10	EFT				
11	SURGE				>6KV
12	MAGNETIC TAMPER	Iron Dust Core			Target 0.5T
13	Transformer	EE20			Used Iron Dust core to provide Magnetic Immunity to the SMPS design.
14	PCB DIMESION				127 X 65 MM
15	Ambient Temperature	0		55	Free Convection

### Load Regulation:



Line Regulation:

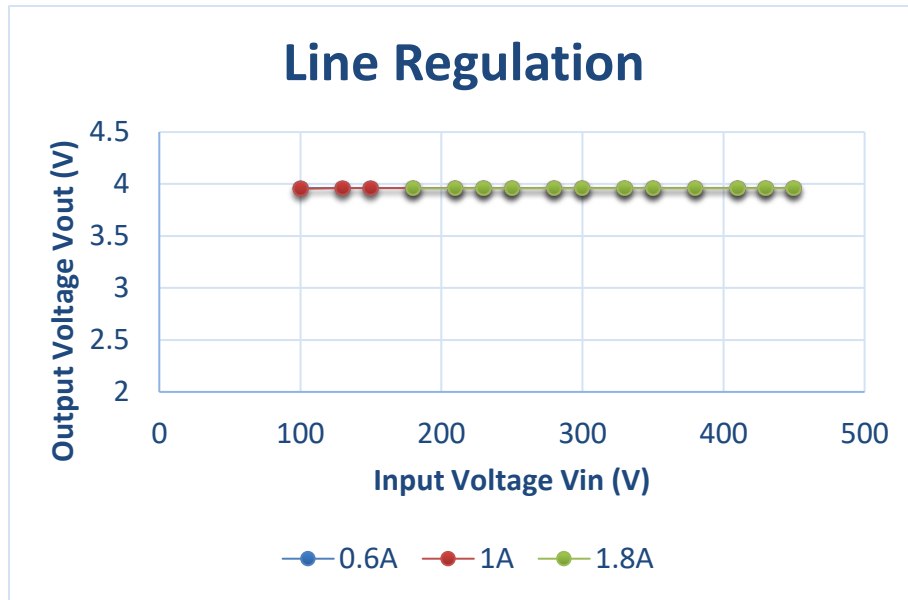


Figure 6: Line Regulation

Efficiency:

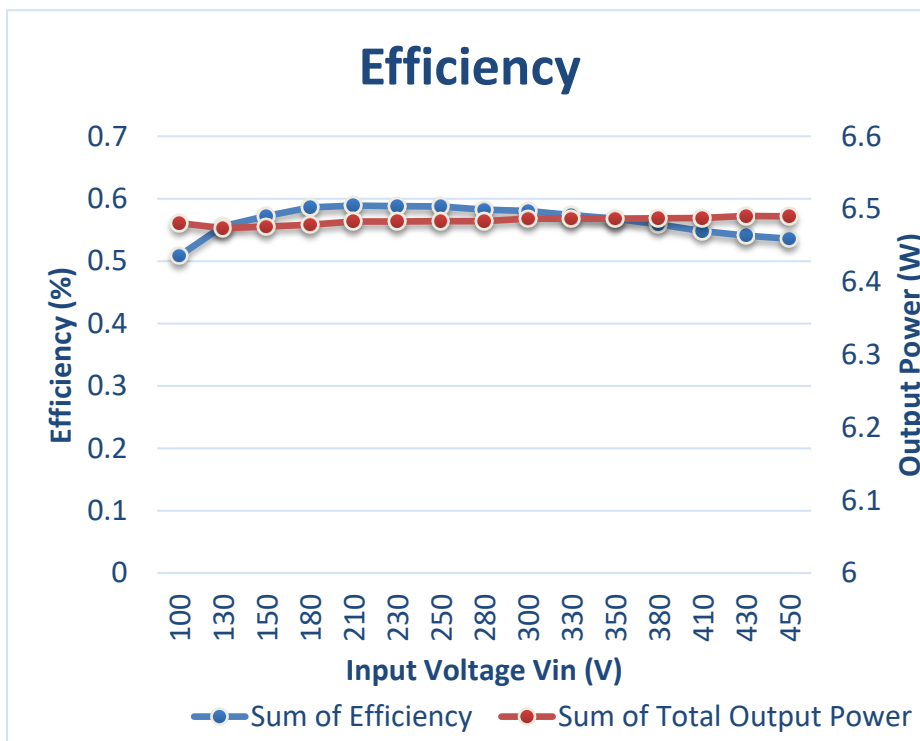


Figure 7: Efficiency Plot



Efficiency at 230V:

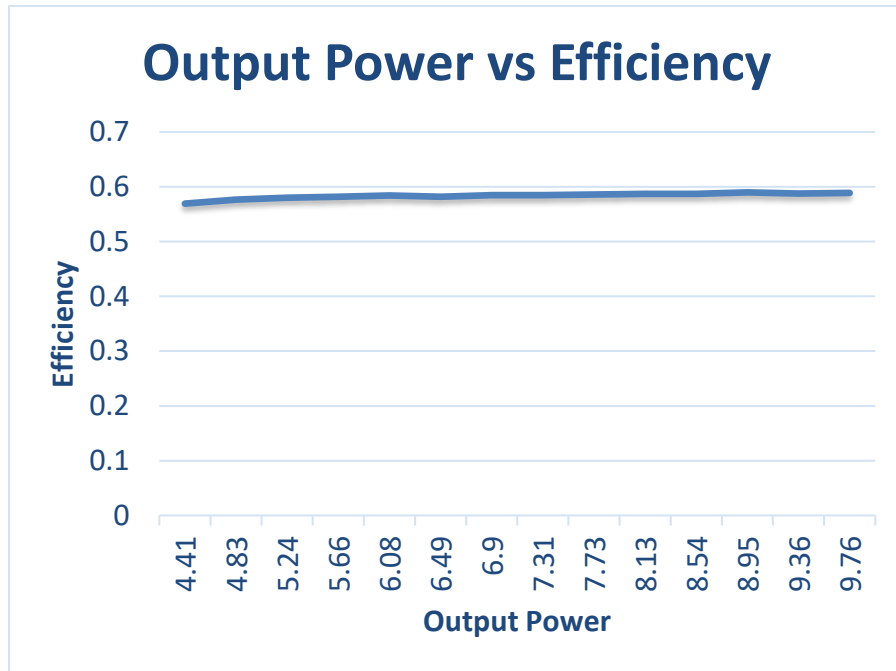


Figure 8: Output Power Vs Efficiency Plot

Voltage Ripple Waveforms:

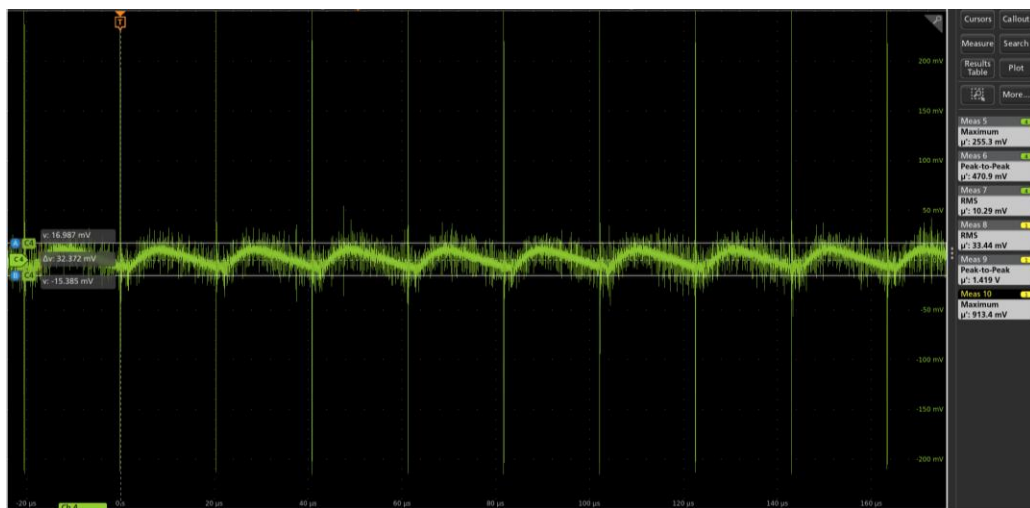
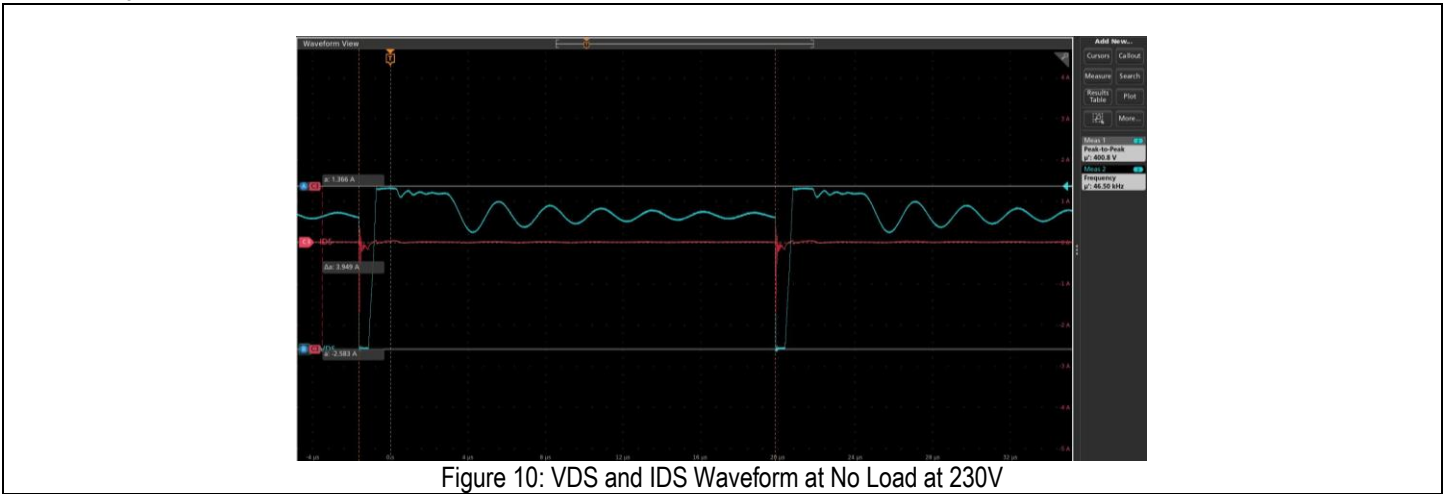


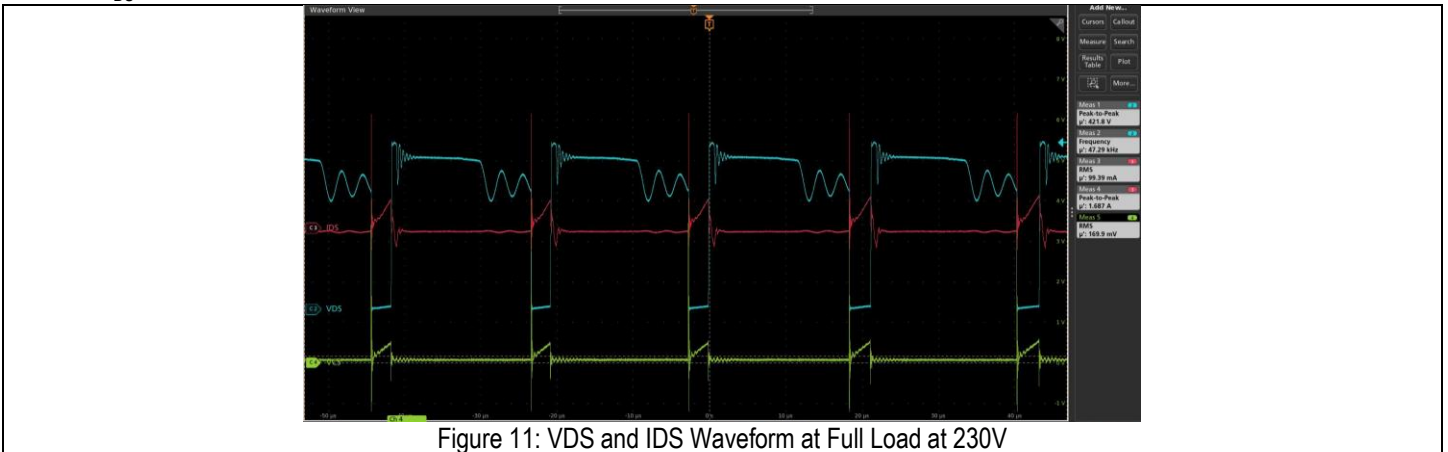
Figure 9: Ripple Voltage Waveform at 230V

**V<sub>DS</sub> and I<sub>DS</sub> Waveforms at different Waveforms:**

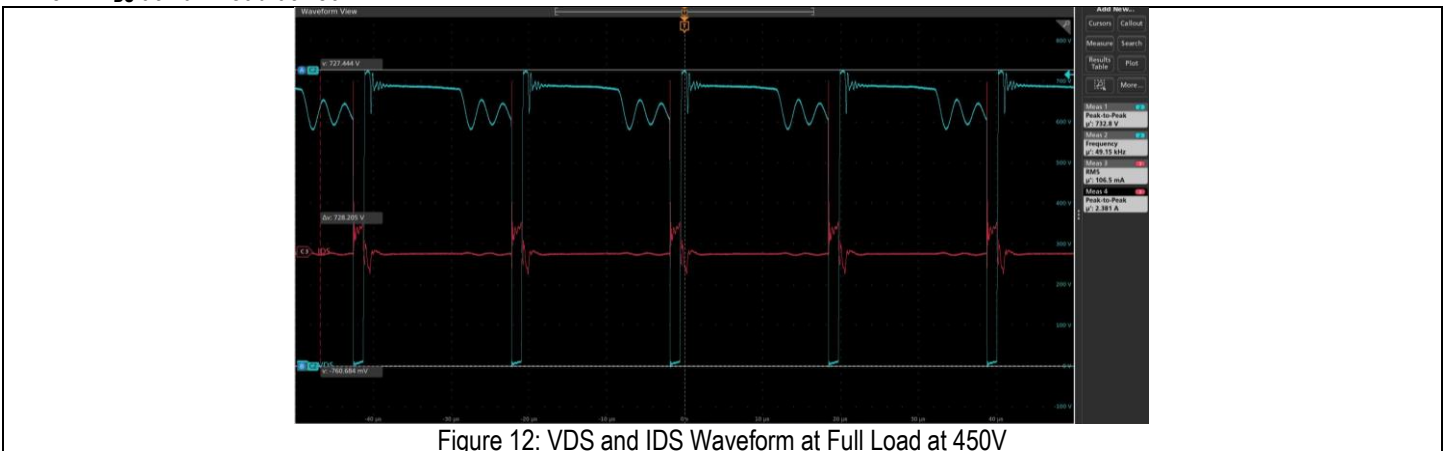
**1. V<sub>DS</sub> at No Load at 230V**



**2. V<sub>DS</sub> at Full Load at 230V**



**3. V<sub>DS</sub> at Full Load at 450V**



### Test Setup:

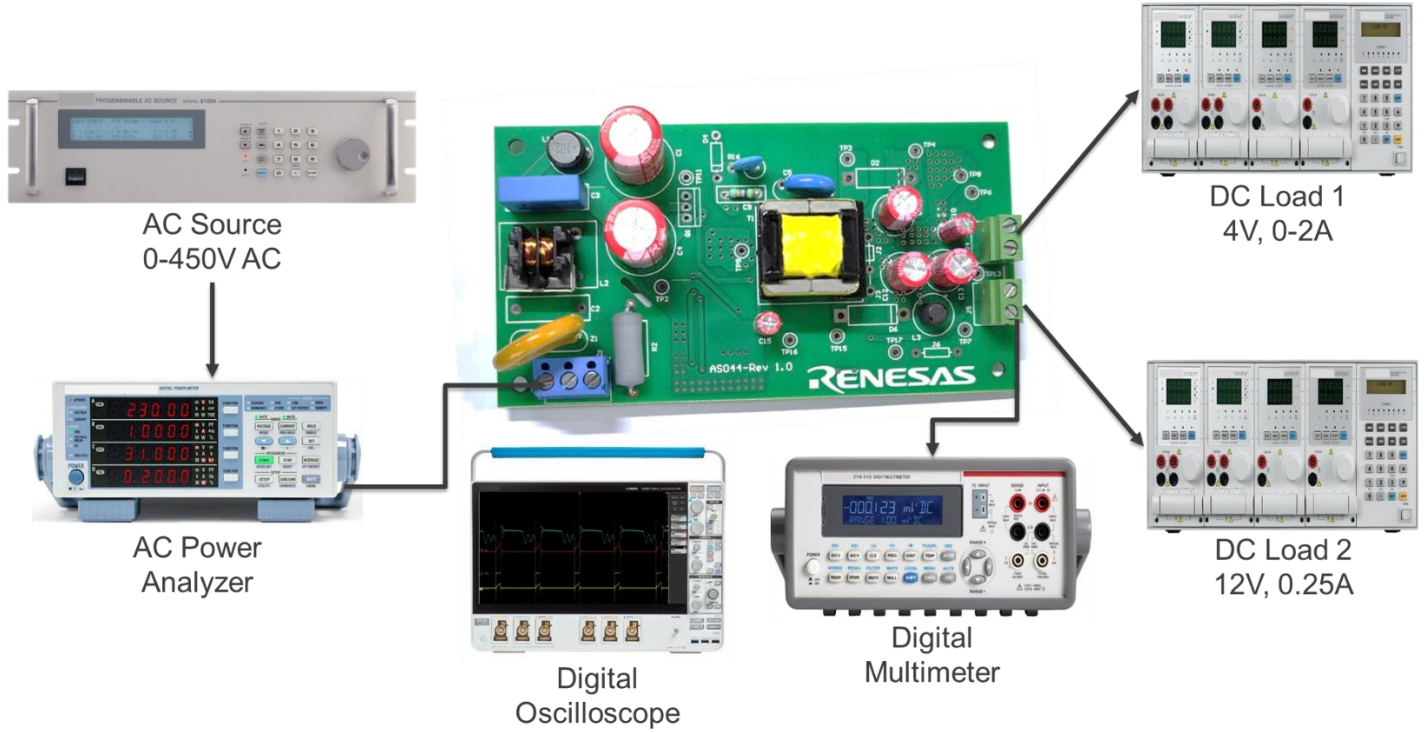


Figure 13. Evaluation Kit Details

# AS044 Application Schematic

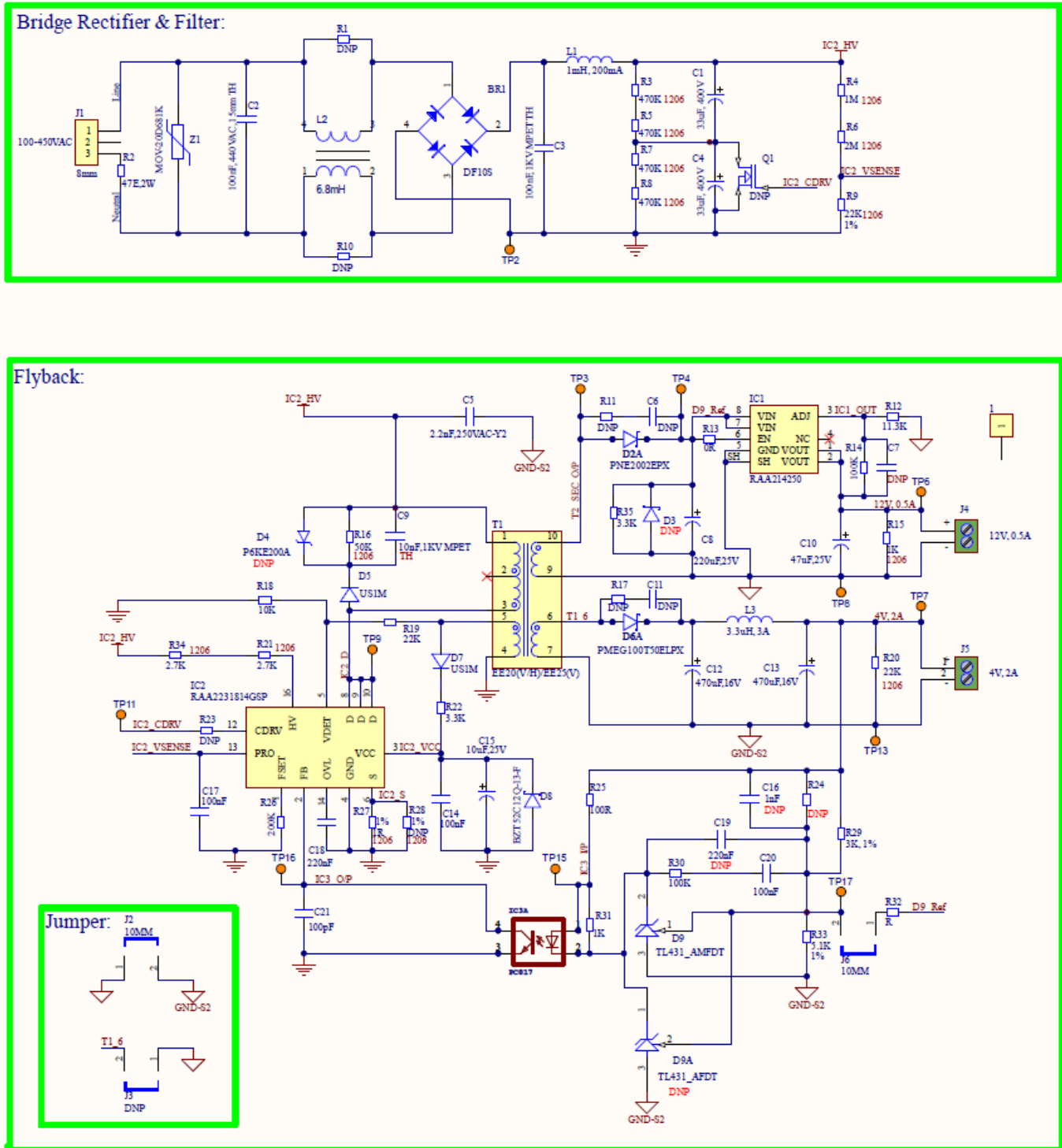


Figure 14. Schematic

## Bill of Materials (BOM)

**Table 1. AS044 BOM**

Quantity	Designator	Description	Manufacturer	Manufacturer Part #
1	BR1	Bridge Rectifier Single Phase Standard 1 kV Surface Mount DF-S	Diodes Incorporated	DF10S
2	C1, C4	33 $\mu$ F 400 V Aluminium Electrolytic Capacitors Radial, Can 2000 Hrs @ 105°C	Würth Elektronik	860021378014
2	C2, C3	0.1 $\mu$ F Film Capacitor 310V Polypropylene (PP), Metallized Radial., 0.1 $\mu$ F Film Capacitor 310V Polypropylene (PP), Metallized Radial	Würth Elektronik	890334023023CS
1	C5	2200 pF $\pm$ 20% 440VAC Ceramic Capacitor Y5U (E) Radial, Disc	Vishay	AY2222M35Y5US63L7
3	C6, C7, C11	0.1 $\mu$ F $\pm$ 10% 25V Ceramic Capacitor X7R 0805 (2012 Metric)	Würth Elektronik	885012207072
1	C8	220 $\mu$ F 25 V Aluminium Electrolytic Capacitors Radial, Can 2000 Hrs @ 105°C	Würth Elektronik	860020474012
1	C9	10000 pF Film Capacitor - 1000V (1kV) Polyester, Metallized Radial	Würth Elektronik	890493422002CS
1	C10	Aluminium Electrolytic Capacitors - Radial Ledged WCAP-ATG5 47 $\mu$ F 25V 20% Radial	Würth Elektronik	860020472006
2	C12, C13	CAP 470 $\mu$ F, ELE TH 25V	Würth Elektronik	860020474014
3	C14, C17, C20	0.1 $\mu$ F $\pm$ 10% 25V Ceramic Capacitor X7R 0805 (2012 Metric)	Würth Elektronik	885012207072
1	C15	Aluminium Electrolytic Capacitors - Radial Ledged WCAP-ATG5 10 $\mu$ F 25V 20% Radial	Würth Elektronik	860020472003
1	C16	1000 pF $\pm$ 10% 25V Ceramic Capacitor X7R 0805 (2012 Metric)	Würth Elektronik	885012207060
2	C18, C21	100 pF $\pm$ 10% 25V Ceramic Capacitor X7R 0805 (2012 Metric)	Würth Elektronik	885012207054
1	C19	100 pF $\pm$ 10% 25V Ceramic Capacitor X7R 0805 (2012 Metric)	Würth Elektronik	885012207054
1	D2	Rectifiers PNE20020EP/SOD128/FlatPower	Nexperia	PNE20020EPX
1	D3	Zener Diodes 500mW 20V	Diodes Incorporated	BZT52C20-13-F
1	D4	TVS DIODE 171VWM 274VC DO15	SMC Diode Solutions	P6KE200A
2	D5, D7	Diode ULTRAFast RECOVERY RECTIFIER SMA, 1A Surface Mount	Taiwan Semiconductor Corporation	US1M
1	D6	Schottky Diodes & Rectifiers PMEG60T50ELP/SOD128/FlatPower	Nexperia	PMEG100T50ELPX
1	D8	Zener Diode 12 V 370 mW $\pm$ 5.42% Surface Mount SOD-123	Diodes Incorporated	BZT52C12Q-13-F
1	D9	TL431CDBVR	Nexperia	TL431AMFDT,215
1	IC1	20V, 500MA LDO, 8L SOIC, 2500 PC	Renesas Electronics	RAA2142504GSP#HA0
1	IC2	900V FLY-BACK REGULATOR, 13-LD S	Renesas Electronics	RAA2231814GSP#HA0
1	IC3	Optoisolator Transistor Output - 1 Channel 4-DIP	CT Micro	CT817ASL
1	J1	3 Position Wire to Board Terminal Block Horizontal with Board 0.197" (5.00mm) Through Hole	Würth Elektronik	691101710003
1	J2	10mm pitch, 2POS jumper.		
1	J3	CONN HEADER VERT 2POS 2.54MM	Sullins	PBC02SAAN
2	J4, J5	2 Position Wire to Board Terminal Block Horizontal with Board 0.197" (5.00mm) Through Hole	Würth Elektronik	691137710002
1	L1	1 mH Unshielded Drum Core, Wirewound Inductor 290 mA 60 $\Omega$ Max Radial, Vertical Cylinder	Würth Elektronik	744741102

1	L2	8.2 mH @ 10 kHz 2 Line Common Mode Choke Through Hole 500mA DCR 1.3Ohm	Würth Elektronik	744861082
1	L3	3.3 µH Unshielded Drum Core, Wirewound Inductor 4.7 A 25mOhm Max Radial, Vertical Cylinder	Würth Elektronik	7447462033
1	Q1	N-Channel 600V, 6A- - Through Hole TO-220FP	Renesas Electronics	RJK6035DPP-A0#T2
6	R1, R10, R11, R17, R24, R32	RES 0R OHM 1% 1/8W 0805	YAGEO	RC0805JR-100RL
1	R2	Resistor: wire-wound; THT; 47Ω; 2W; ±5%; Ø3.5x10mm; 300ppm/°C; axial	Vishay	Z34081831000J6DC10
4	R3, R5, R7, R8	RES 470K OHM 1% 1/4W 1206	YAGEO	RC1206FR-07470KL
1	R4	RES 1M OHM 1% 1/4W 1206	YAGEO	RC1206FR-071ML
1	R6	RES 2M OHM 1% 1/4W 1206	YAGEO	RC1206FR-072ML
2	R9, R20	RES 22K OHM 1% 1/4W 1206	YAGEO	RC1206FR-0722KL
1	R12	RES 11.3K OHM 1% 1/8W 0805	YAGEO	RC0805FR-0711K3L
1	R13	RES 0R OHM 1% 1/8W 0805	YAGEO	RC0805JR-100RL
1	R14	RES 100K OHM 1% 1/8W 0805	YAGEO	RC0805FR-07100KL
1	R15	Chip Resistor, 1 KOhm, +/- 1%, 0.25 W, -55 to 155 degC, 1206 (3216 Metric)	YAGEO	RC1206FR-071KL
1	R16	RES 49.9K OHM 1% 1/4W 1206	YAGEO	RC1206FR-0749K9L
1	R18	Chip Resistor, 10 KOhm, +/- 1%, 125 mW, -55 to 155 degC, 0805 (2012 Metric)	YAGEO	RC0805FR-0710KL
1	R19	RES 22K OHM 1% 1/8W 0805	YAGEO	RC0805FR-0722KL
2	R21, R34	2.7 kOhms ±1% 0.25W, 1/4W Chip Resistor 1206 (3216 Metric) Moisture Resistant Thick Film	YAGEO	RC1206FR-072K7L
1	R22	RES 3.3K OHM 1% 1/8W 0805	YAGEO	RC0805FR-073K3L
1	R23	RES 10 R 1% 1/8W 0805	YAGEO	RC0805FR-0710RL
1	R25	RES 100 R 1% 1/8W 0805	YAGEO	RC0805FR-07100RL
1	R26	RES 200K OHM 1% 1/8W 0805	YAGEO	RC0805FR-07200KL
1	R27	RES 1 OHM 1% 1/4W 1206	YAGEO	RC1206FR-071RL
1	R28	RES 1 OHM 1% 1/4W 1206	YAGEO	RC1206FR-071RL
1	R29	RES 3K OHM 1% 1/8W 0805	YAGEO	RC0805FR-073KL
1	R30	RES 20K OHM 1% 1/8W 0805	YAGEO	RC0805FR-1320KL
1	R31	Chip Resistor, 1 KOhm, +/- 1%, 0.125 W, -55 to 155 degC, 0805 (2013 Metric)	YAGEO	RC0805FR-071KL
1	R33	RES 5.1K OHM 1% 1/8W 0805	YAGEO	RC0805FR-075K1L
1	T1	TR		
17	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17	Test Point, Orange, Height 4.6 mm, Tail Length 3 mm, 1-Pin THD, RoHS	Keystone	5003
1	Z1	680 V 6.5 kA Varistor 1 Circuit Through Hole Disc 20mm	Würth Elektronik	820524211B

## Board Layout

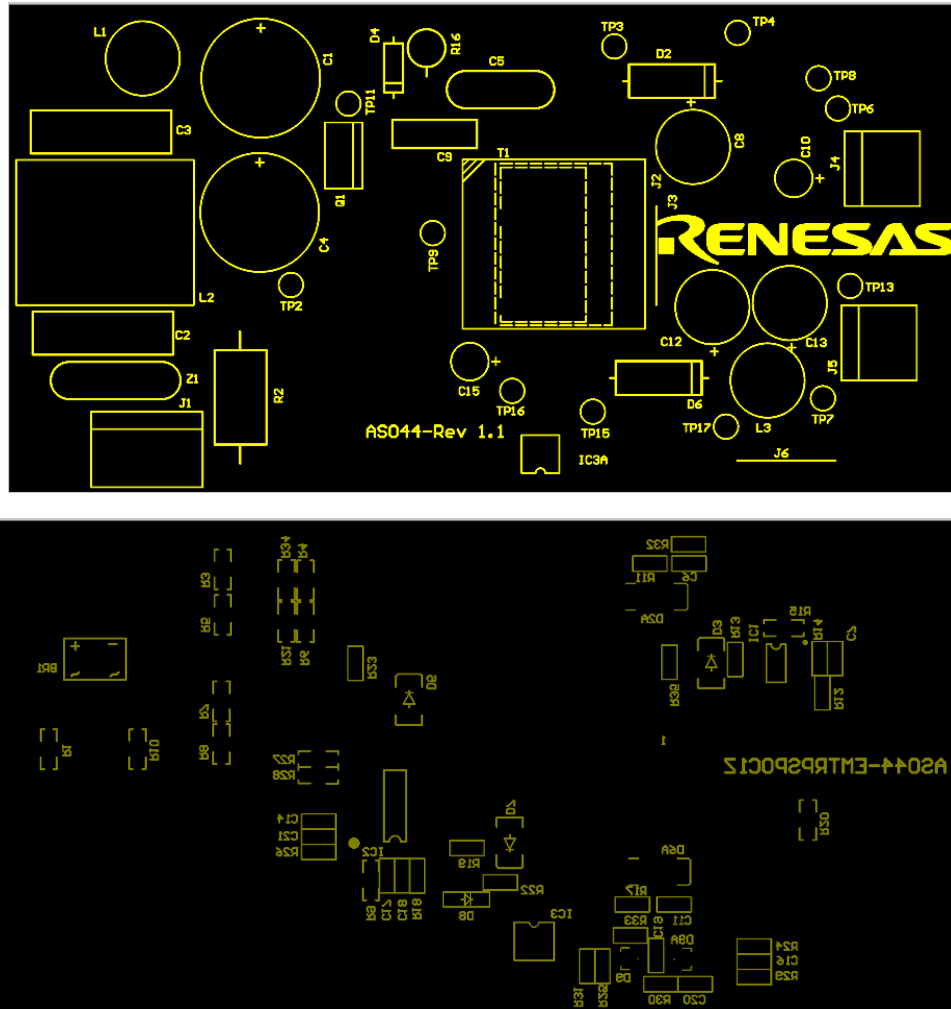


Figure 15. Silkscreen Top and Silkscreen Bottom

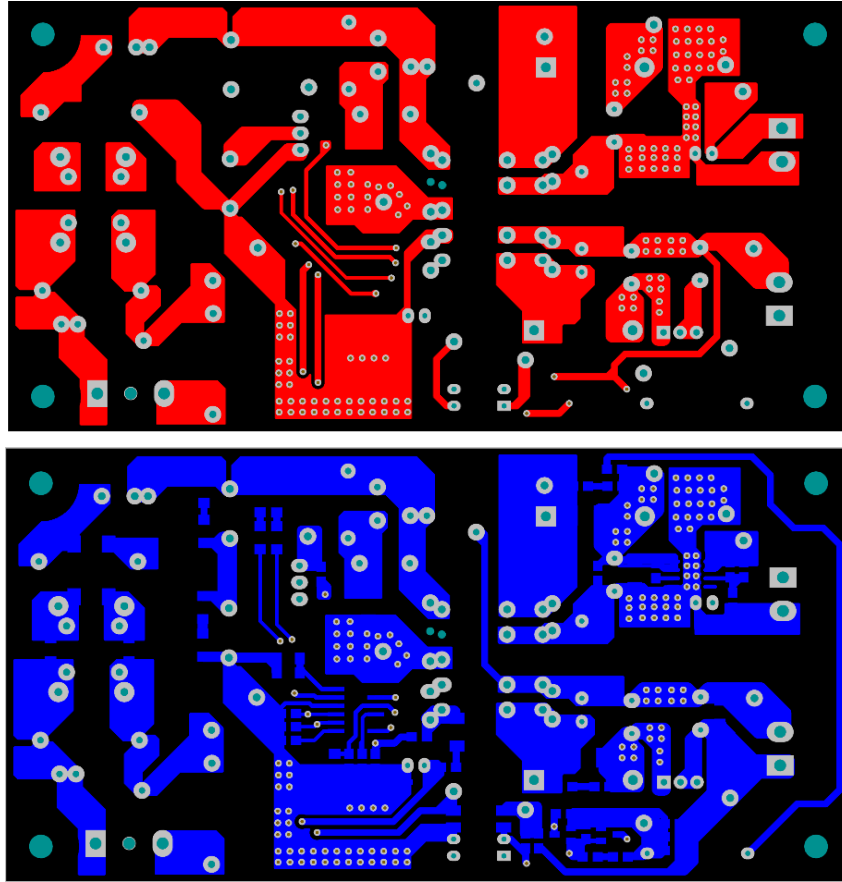


Figure 16. Copper Top and Copper Bottom