ON Semiconductor

Design Note – DN05095/D

Fixed Frequency Current Mode Controller for Flyback Converters

Device	Application	Input Voltage	Output Voltage	Output Current	Topology
NCP12400	Adapter	90 - 264 Vac	19 V	3.42 A	Flyback

Table 1. 65W Demo Board Specifications

Output current	3.42	A
Output voltage	19	V
Minimum input voltage	90	V
Maximum input voltage	264	V

Overview

This PWM driver uses a Flyback topology and design operates in both CCM and DCM for generating 19 V and 3.42 A output rating. In CCM operation, it provides good efficiency and lower ripple under higher loading condition. To reduce operation frequency for better light load efficiency from decreasing switching losses under DCM.

Key Features

- No-Load Power Consumption < 75 mW
- Average Efficiency > 88 %
- Frequency Modulation for Softened EMI Signature
- Frequency Foldback then Skip Mode for Maximum Performance in Light Load and Standby Condition
- 10 ms Soft-Start
- Fixed-Frequency Current-Mode Operation

Circuit Description

X2 Capacitor Discharge

This feature saves approximately 16 mW – 25 mW input power depending on the EMI filter X2 capacitors volume and it saves the external components count as well. The discharge feature is ensured via the start-up current source with a dedicated control circuitry for this function.

Current-Mode Control

Cycle by cycle, primary current sensing helps to prevent any significant over current conditions that would cause transformer core saturation and result in power supply failure

Frequency Foldback

This advantage lies in decreasing the switching frequency under light-load conditions. This feature is called frequency foldback and significantly helps to reduce switching losses

High Voltage Sensing

The device features on its HV pin a true ac line monitoring circuitry. It includes a minimum start-up threshold and an auto-recovery brown-out protection; both of them independent of the ripple on the input voltage. It is allowed only to work with an unfiltered, rectified as input to ensure X2 capacitor discharge function as well.

Brown-Out Protection

This function protects the application when the main voltage is too low. When V_{HV} crosses the $V_{HV(start)}$ threshold, the controller can start immediately. When it crosses $V_{HV(stop)}$, it triggers a timer of duration t_{HV}, this ensures that the controller doesn't stop in case of line drop-out

Slope Compensation

In order to avoid the sub-harmonic oscillations during the CCM operation with the duty ratio D higher than 50%, internal slope compensation is applied.

Overpower Compensation

The primary peak current value varies with the value of the input voltage. The reason is the propagation delay between the internal current slope on the input voltage. In order to eliminate this phenomenon, the peak voltage at HV pin is sensed and converted in to a current flowing out of the CS pin.

Fault Protection

The FAULT pin feature allows the additional external OVP and OTP protections. If the pin is between 0.8 V and 2.5 V, the output drive pulses are active. An external NTC can be used to pull in below 0.8 V for OTP and a Zener diode to the bias voltage can be used to detect output OVP condition and shut down the pulses. A decoupled capacitor can be used to filter an induced noise to node where the FAULT pin is connected

Schematic

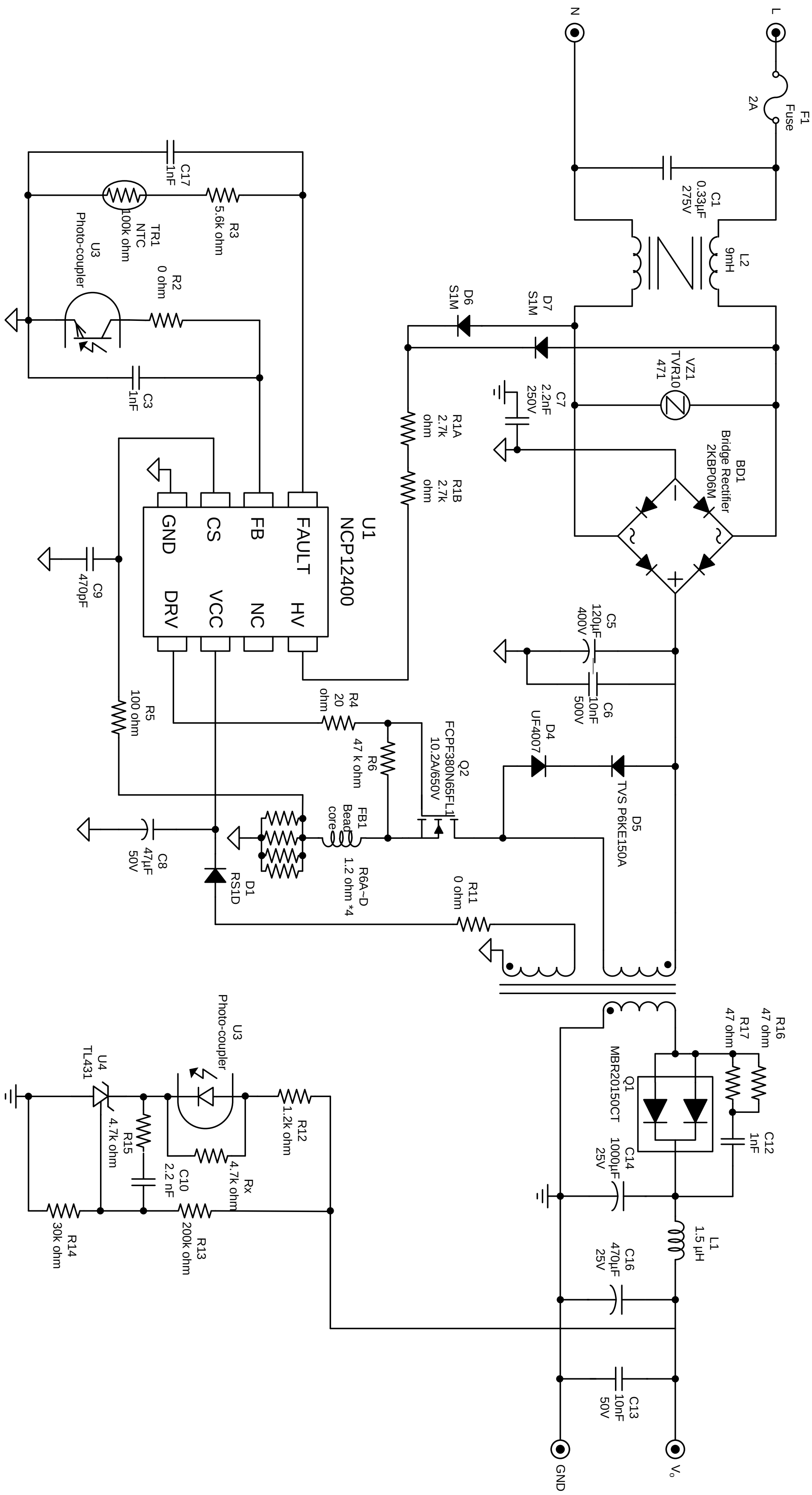

Figure 1. Schematic

Test procedure

Required Equipment:

AC Power Source able to provide universal input voltage (e.g. EXTECH 6800 AC Power Source)…………………………………………………………………………..…. 1pc
Electronic Load able to measure up to maximum loading current (e.g. Chroma 63030) ………………………………………………………………………..……. 1pc
Power Meter able to measure up input wattage (e.g. YOKOGAWA WT210) ... 1pc
Oscilloscope able to measure up waveform (e.g. LeCroy 24Xs-A) ………..…. 1pc

Figure 2. Test setup

Test Procedure:

1. Connect the test setup as shown at Figure 2.
2. Apply an input voltage, V_{IN} = 90 ~ 264 Vac
3. Apply I_{OUT}(load) = 0 ~ 3.42 A
4. Check the value or waveform on equipment
5. Turn off V_{IN}
6. End of the test

Performance Results

Following figures demonstrate the operation of the evaluation board under different operating conditions.

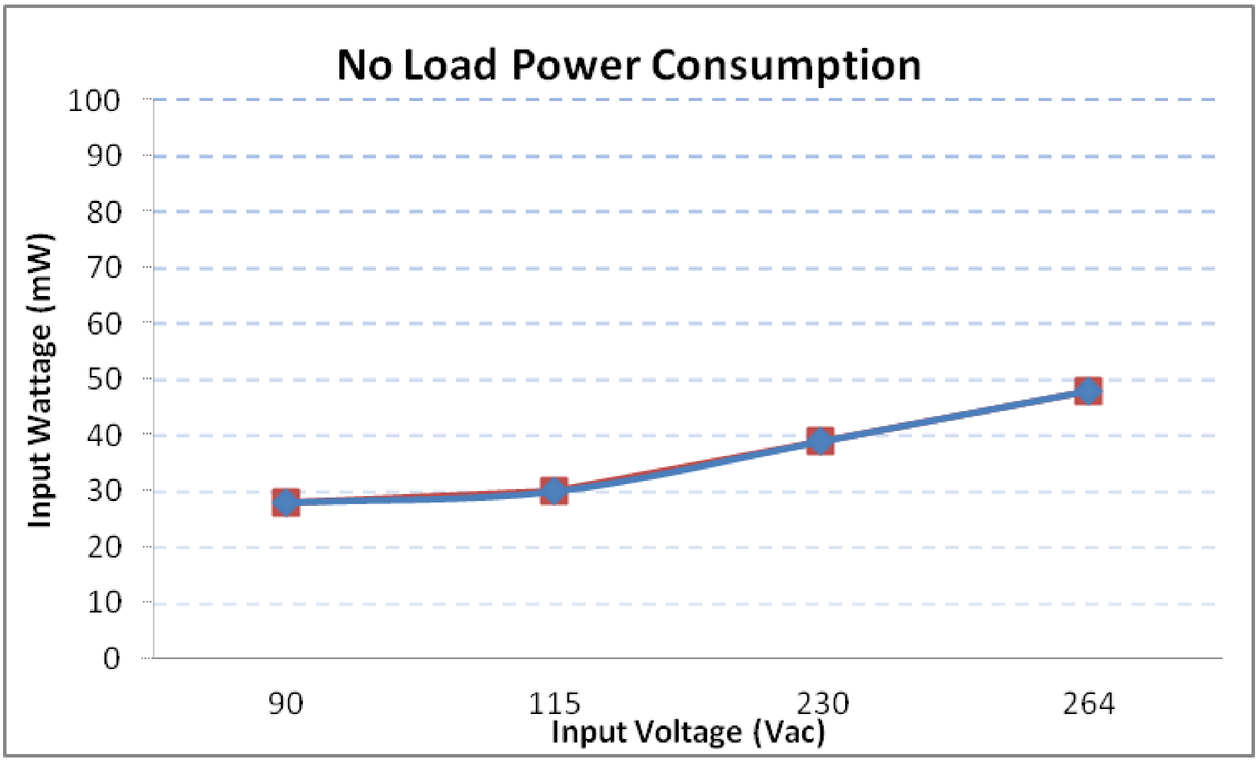

Figure 3. No Load Power Consumption

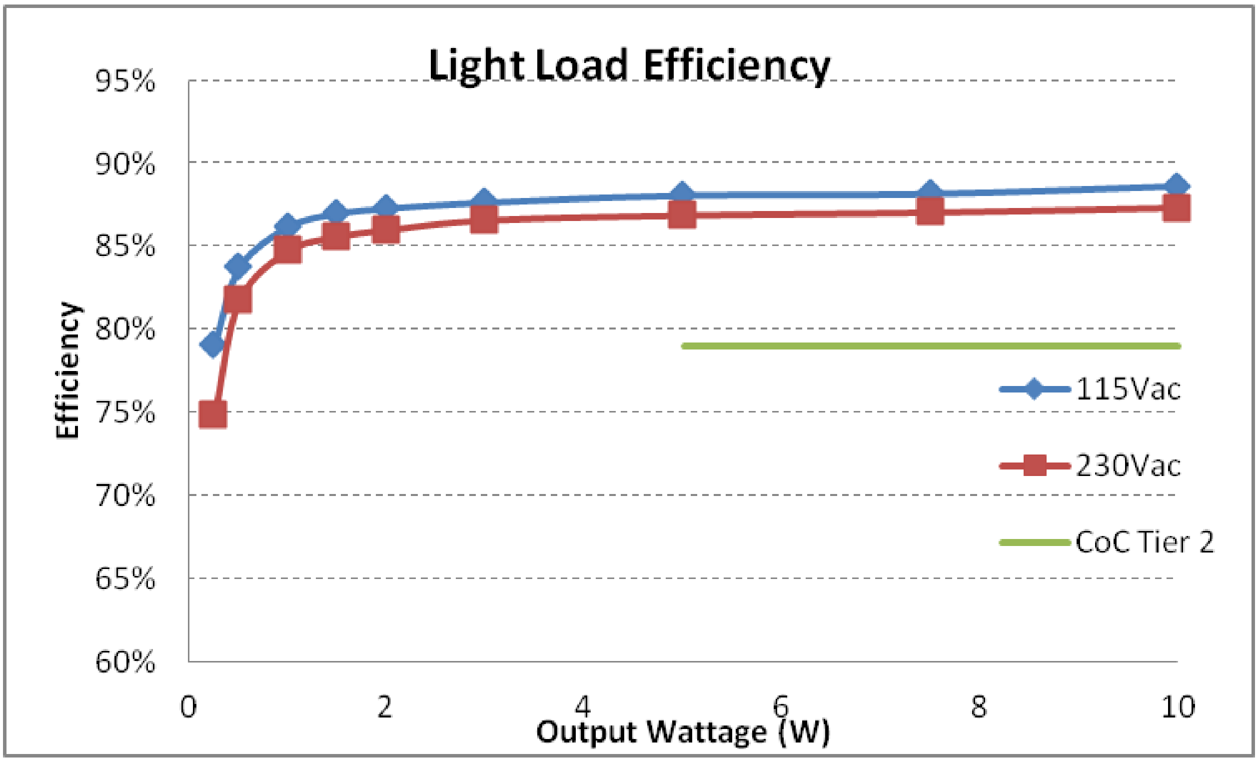

Figure 4. Light Load Efficiency

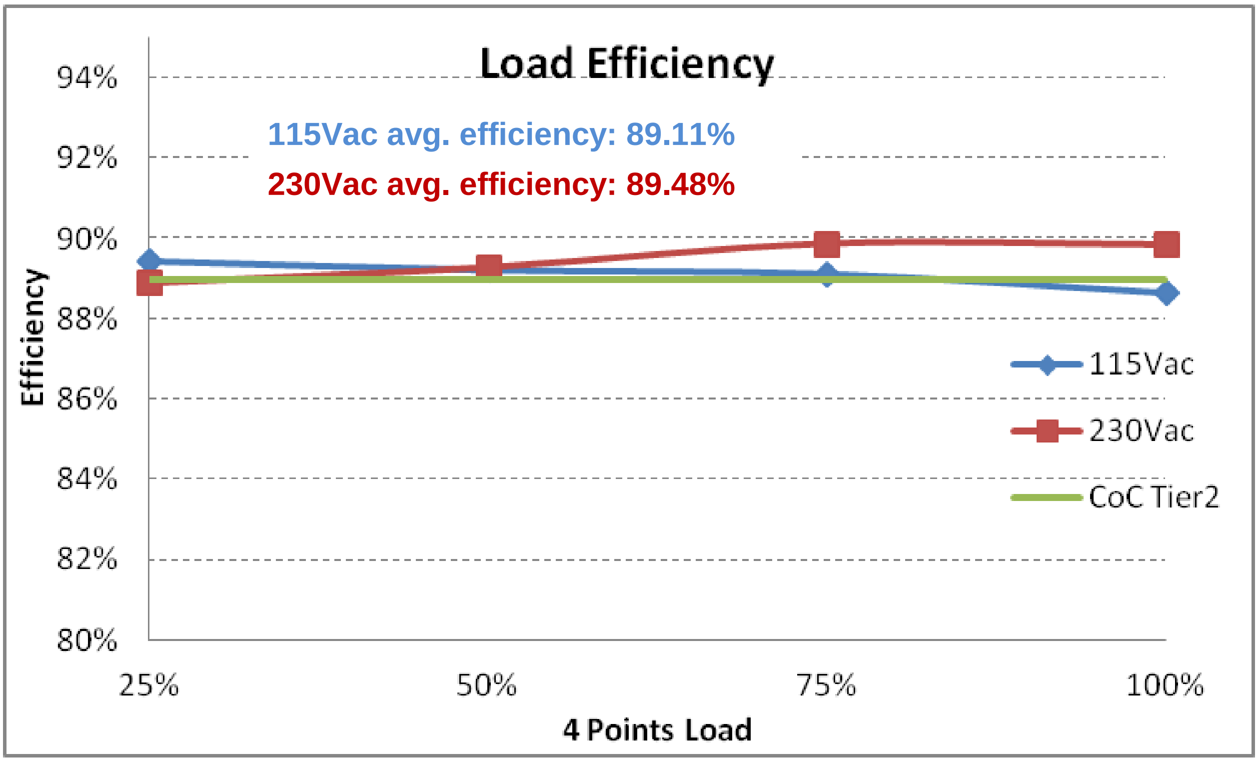

Figure 5. Load Efficiency vs. CoC Tier2

ESD		Surge	
Air	±16.5 kV	L-PE	±4.4 kV
Contact	±8.8 kV	N-PE	±4.4 kV
		L-N	±2 kV

Note1: ESD testing by 230 Vac and max. loading.

Note2: Surge testing by 230 Vac and max. loading.

Figure 6. ESD and Surge Testing

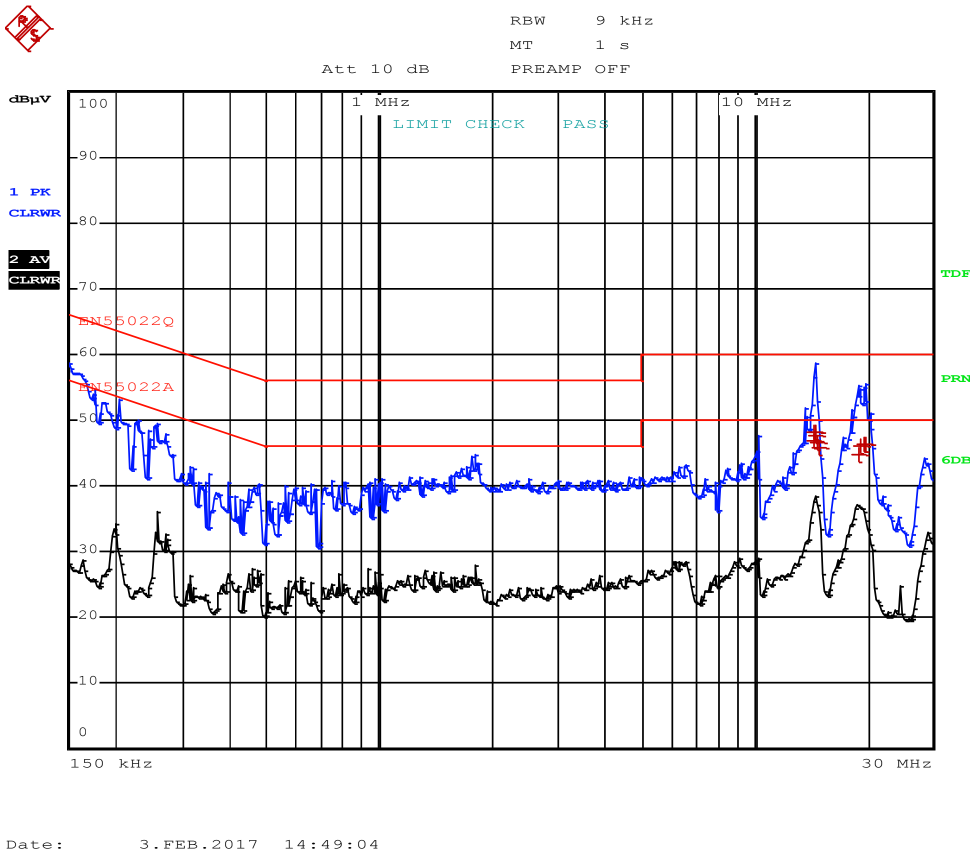

Figure 7. Conducted Emissions Pre-compliance at full load (115 V / 3.42 A)

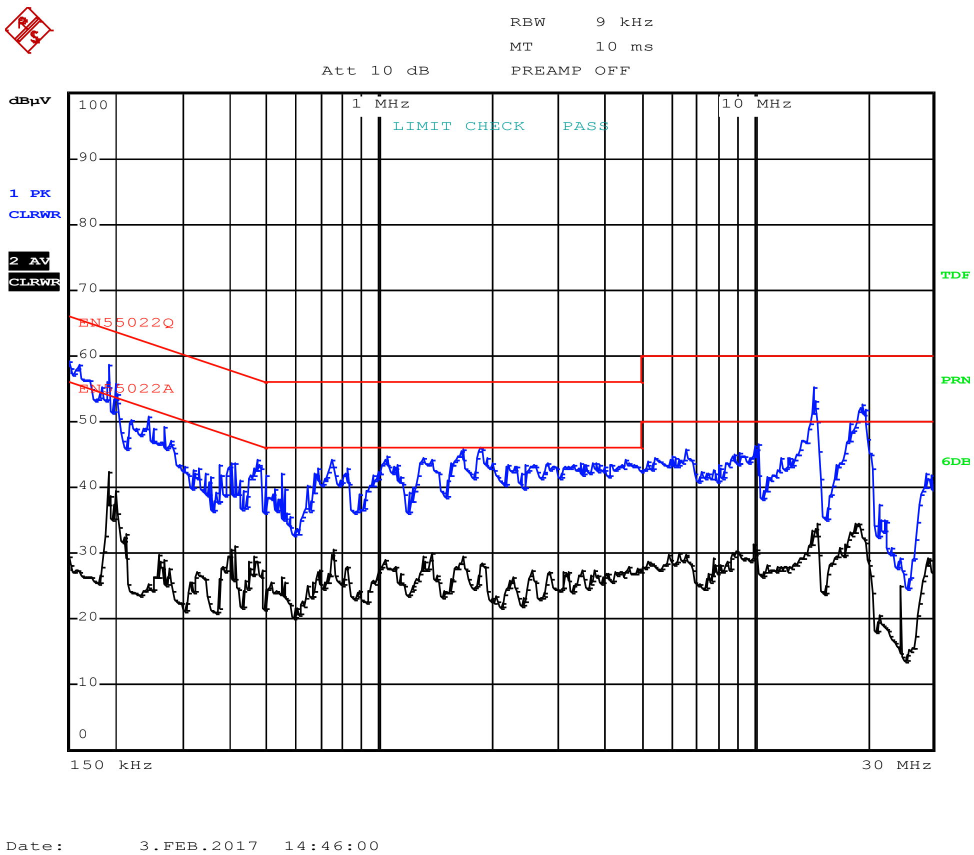

Figure 8. Conducted Emissions Pre-compliance at full load (230 V / 3.42 A)

Results Summary

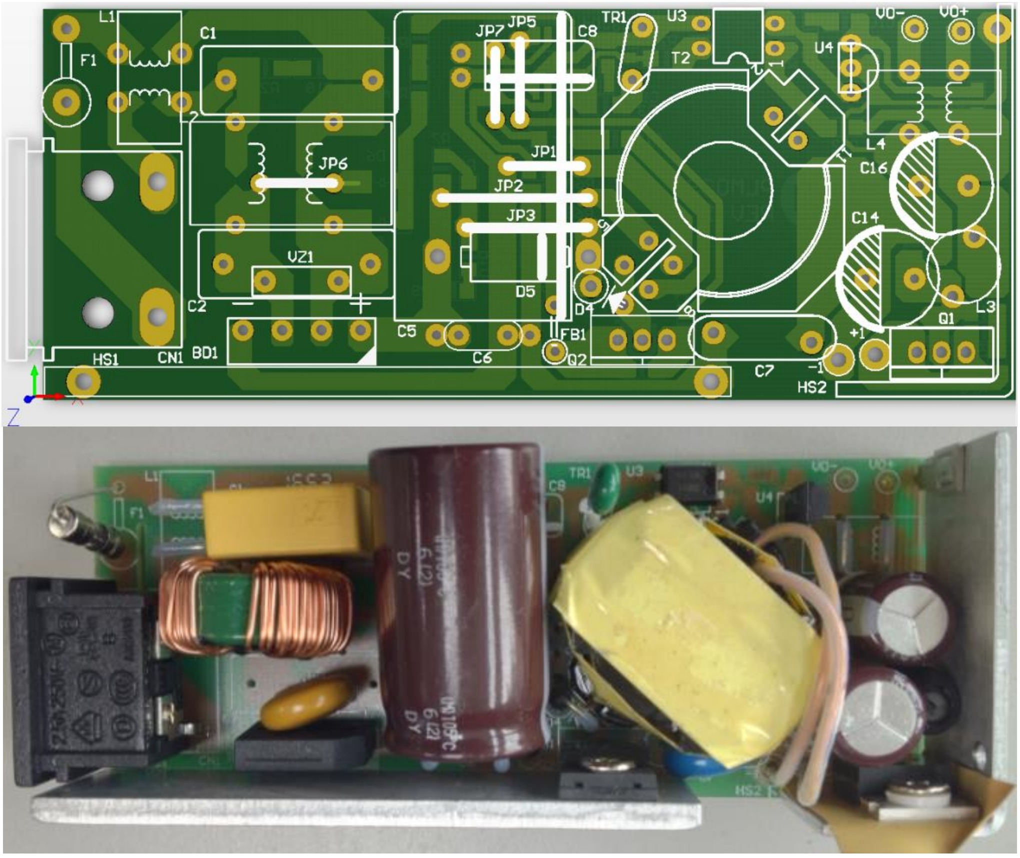

Figure 8. Designed Prototype from the Top side

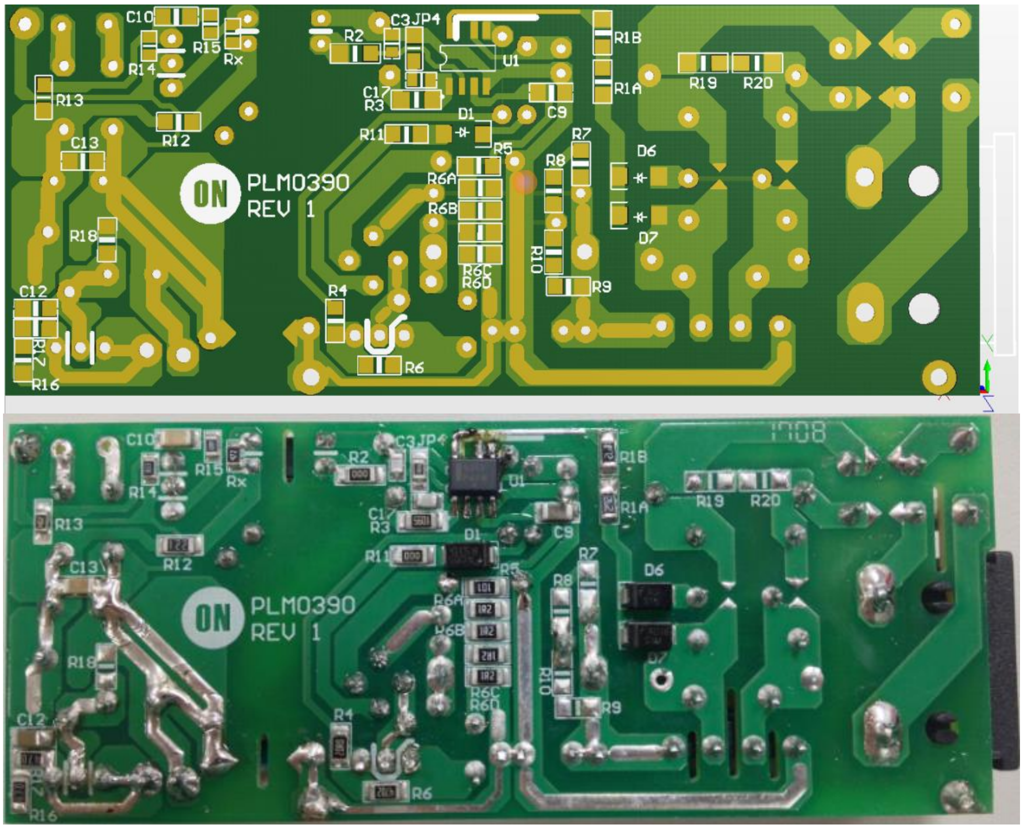

Figure 9. Designed Prototype from the Bottom side

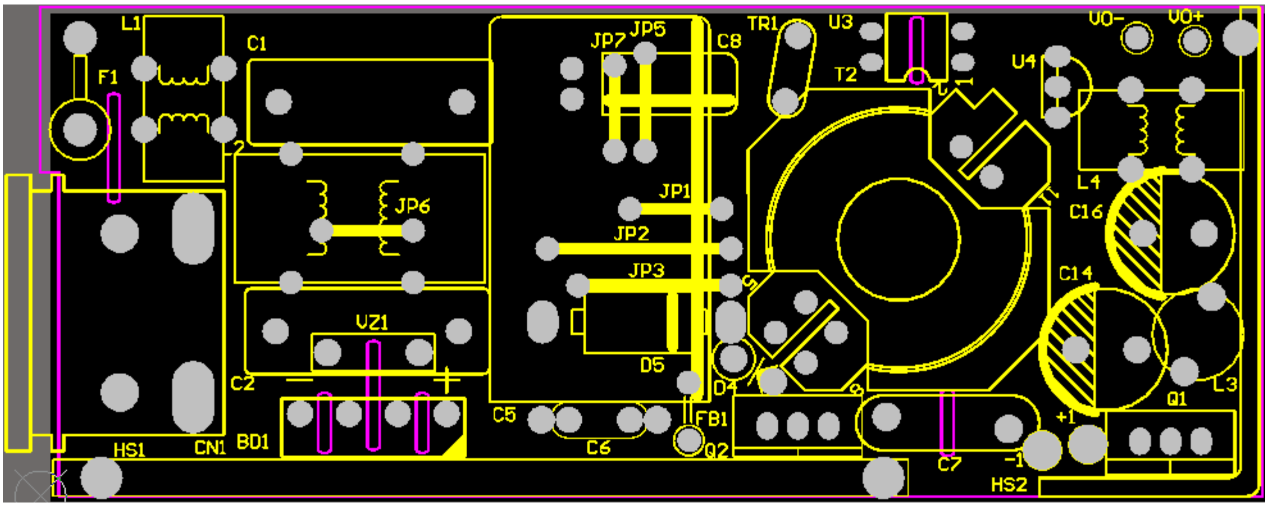

Figure 10. Component Placement on the Top Side (top view)

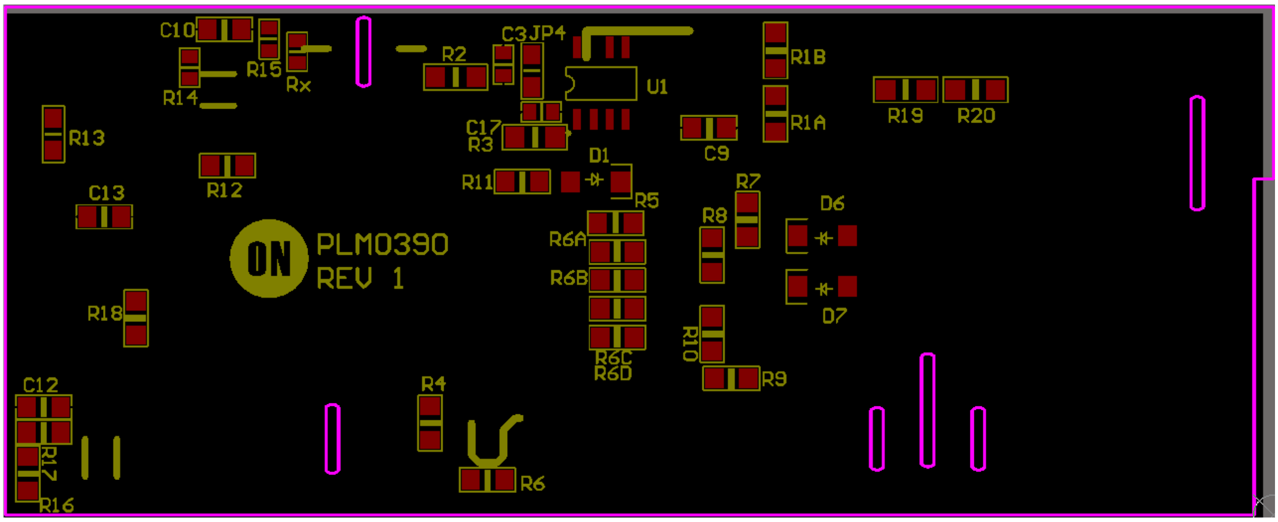

Figure 11. Component Placement on the Bottom Side (bottom view)

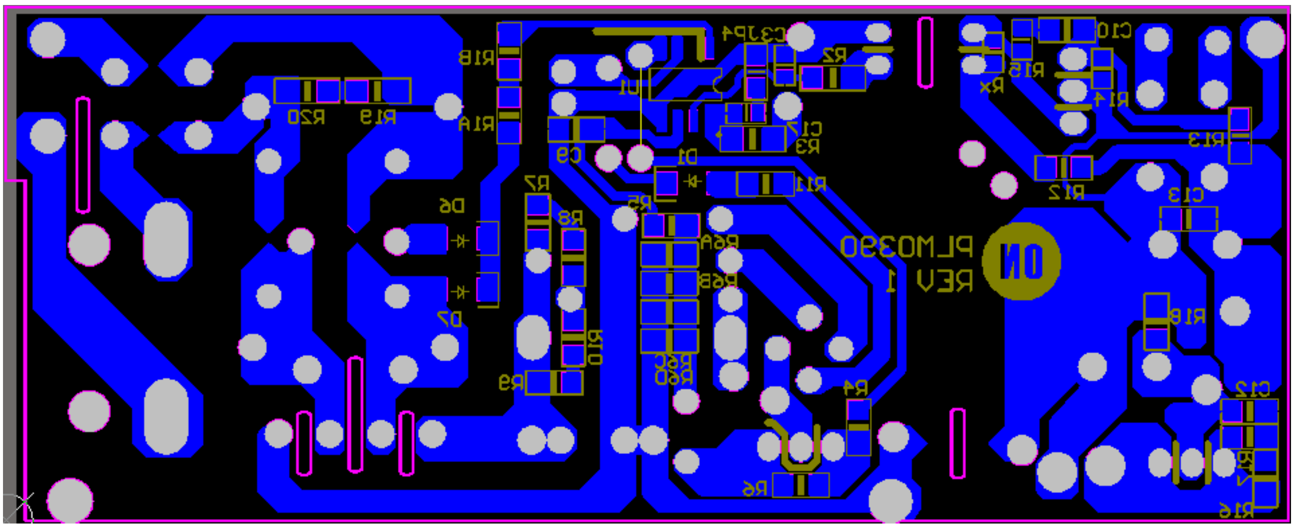

Figure 12. Bottom Side (Bottom view)

Table 4. Bill of materials

Designator	Qty	Description	Value	Toler-ance	Footprint	Manufacturer	Manufacturer Part Number
L1, L4, JP1, JP2, JP5, JP6, JP7	9	Jumper wire	0.8 ψ	-	Through Hole	Taiwan-Resister	
JP4	1	Resistor SMD	0 Ω	5%	R0805	Taiwan-Resister	
R15	1	Resistor SMD	6.8 kΩ	1%	R0805	Taiwan-Resister	
Rx	1	Resistor SMD	4.7 kΩ	5%	R0805	Taiwan-Resister	
R14	1	Resistor SMD	30 kΩ	5%	R0805	Taiwan-Resister	
R13	1	Resistor SMD	200 kΩ	5%	R0805	Taiwan-Resister	
R2, R11	2	Resistor SMD	0 Ω	5%	R1206	Taiwan-Resister	
R6A~D	4	Resistor SMD	1.2 Ω	5%	R1206	Taiwan-Resister	
R4	1	Resistor SMD	20 Ω	5%	R1206	Taiwan-Resister	
R16, R17	2	Resistor SMD	47 Ω	5%	R1206	Taiwan-Resister	
R5	1	Resistor SMD	100 Ω	5%	R1206	Taiwan-Resister	
R12	1	Resistor SMD	1.2 kΩ	5%	R1206	Taiwan-Resister	
R3	1	Resistor SMD	5.6 kΩ	1%	R1206	Taiwan-Resister	
R6	1	Resistor SMD	47 kΩ	5%	R1206	Taiwan-Resister	
R1A, R1B	2	Resistor SMD	2.7 kΩ	5%	R1206	Taiwan-Resister	
TR1	1	Thermistor	5 ψ 100 kΩ	-	Through Hole	SHING CHIN	TTC104
C6	1	Ceramic Capacitor	103 pF 500 V	20%	Radial	Taiwan-Resister	
C3, C17	2	Capacitor SMD	1 nF / 50 V	10%	C0805	Taiwan-Resister	
C12	1	Capacitor SMD	1 nF / 100 V	10%	C1206	Taiwan-Resister	
C13	1	Capacitor SMD	10 nF / 50 V	10%	C1206	Taiwan-Resister	
C9	1	Capacitor SMD	470 pF / 50 V	10%	C1206	Taiwan-Resister	
C10	1	Capacitor SMD	2.2 nF / 50 V	10%	C1206	Taiwan-Resister	
C8	1	Electrolytic Capacitor	47 µF / 50 V	10%	Radial	Jackcon	LHK
C5	1	Electrolytic Capacitor	120 µF / 400 V	10%	Radial	Chemi-com	KMG
C16	1	Electrolytic Capacitor	470 µF / 25 V	10%	Radial	NCC	KMG
C14	1	Electrolytic Capacitor	1000 µF / 25 V	10%	Radial	NCC	KMG
C1	1	X2 Capacitor	0.33 µF / 275 V	10%	Radial	KENJET	
C7	1	Y2 Capacitor	2.2 nF / 250 V	20%	Radial	KENJET	

L3	1	Inductor	1.6 µH	20%	Through Hole	SUMIDA	00777-T053-1R6
L2	1	Choke	9 mH		Through Hole	SUMIDA	I-114
FB1	1	Bead Core	C8B 3.5*3.2*1.0+T	-	Through Hole	BAI HUEI	
D4, C7	2	Bead Core	C8B 3.5*3.2*1.0	-	-	BAI HUEI	
T2	1	Transform er	RM10 510 µH	10%	RM-10	SUMIDA	
D1	1	Diode	RS1D	-	DO-41	Fairchild	
D4	1	Fast Diode	UF4007	-	DO-41	Fairchild	
D6, D7	2	General Diode	S1M	-	SMA	Fairchild	
D5	1	TVS	P6KE150A	-	DO-15	Fairchild	
BD1	1	Bridge Rectifier	2KBP06M	-		Fairchild	
Q1	1	Schottky Diode	MBR20150CT	-	TO-220	Fairchild	
U4	1	Regulator	KA-431	1%	TO-92	Fairchild	
Q2	1	MOSFET	FCPF380N65F L1	-	TO-220	Fairchild	
U3	1	Opto-coupler	FOD817A	-	DIP-4	Fairchild	
F1	1	Fuse	4 A / 250 V	-	Through Hole	SLEETECH	
CN1	1	Inlet	2P 90°	-	Through Hole	RICH BAY	R-201SN90(B06)
U1	1	IC	NCP12400	-	SOIC-8	ON Semiconductor	
VZ1	1	MOV	TVR10 471	-	Through Hole	SHING CHIN	
HS1	1	Heat Sink				Long Teng Feng Industrial	HS MCH0534
HS2	1	Heat Sink				Long Teng Feng Industrial	HS MCH0555

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