UM10424

SSL2101 120 V (AC) PAR38 flyback reference board

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1. Introduction

WARNING

Lethal voltage and fire ignition hazard

The non-insulated high voltages that are present when operating this product, constitute a risk of electric shock, personal injury, death and/or ignition of fire.

This product is intended for evaluation purposes only. It shall be operated in a designated test area by personnel qualified according to local requirements and labor laws to work with non-insulated mains voltages and high-voltage circuits. This product shall never be operated unattended.

This user manual provides the basic information on the operation and performance of the SSL2101 120 V PAR38 format flyback reference board. This reference board is designed to highlight a compact solution for the driver circuit used in triac-dimmable, PAR38 format , LED integral bulb applications. It provides galvanic isolation from the AC line to the DC output. The design is efficient, cost effective, and compatible with a wide range of mains dimmers. See the *SSL2101 data sheet* or the application note *AN10754, SSL2101 and SSL2102 dimmable mains LED drive for the SSL2101* for more information on the operation of the controller and/or the operation of flyback converters, . These are available for download on the NXP Semiconductors web site (www.nxp.com).

The SSL2101 120 V PAR38 format flyback reference board has been provided to you to demonstrate how to implement an LED-based triac-dimmable light targeted for PAR38 replacement.

NXP has created a cost-effective, reliable solution based on the SSL2101. We are committed to providing engineering and manufacturing support to help you transform this demo into an easily manufacturable, profitable product. If you have any questions, please contact your local sales representative. Additionally, you can contact NXP at www.nxp.com.

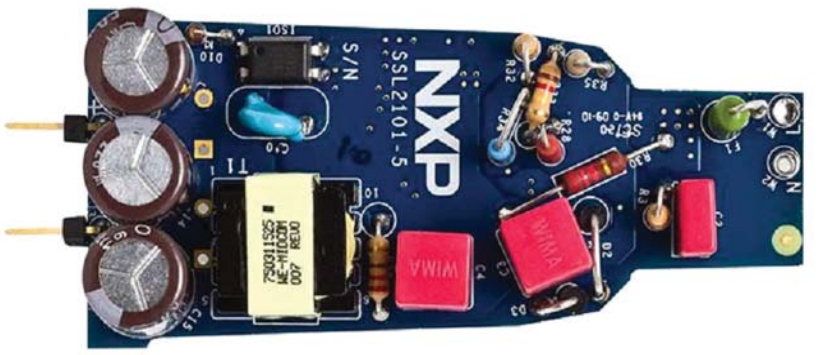

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Fig 1. SSL2101 120 V PAR38 reference board: top side

Table 1. Performance and specifications

Specifications are at T_{amb} = 25 °C

Parameter	Test condition	Min	Typ	Max	Units
input voltage range	60 Hz	90	120	132	V
output voltage		27.5	40	45	V
output current	V_i = 120 V; V_O = 41.3 V	-	350	400	mA
switching frequency		40	60	70	kHz
output current ripple	V_i = 120 V; V_O = 41.3 V; I_o = 350 mA	-	26.7	30	%
input power factor	V_i = 120 V; V_O = 41.3 V;I_o = 350 mA	0.95	0.972	-	
efficiency	V_i = 120 V; V_O = 41.3 V; I_o = 350 mA	80.5	81.3	-	%
output current regulation	line (108 V to 132 V); I_o = 350 mA	-	4.2	5	%
isolation voltage	between primary and secondary	-	2.5	-	kV

2. SSL2101

The SSL2101 is a Switched Mode Power Supply (SMPS) controller IC that can be used in both buck (non-isolated) and flyback (isolated) topologies. The SSL2101 controller has the benefit of valley switching which improves the power supply efficiency. It incorporates an integrated bleeder circuit for triac dimming. In addition, the integrated power MOSFET saves board space and reduces costs. The SSL2101 is a very effective solution for applications with output power up to 14 W. Refer to the *SSL2102 data sheet* for higher wattage applications.

3. Basic description

The reference board is designed to work from a nominal input voltage of 120 V (AC) at 60 Hz with a tolerance of ± 10 % on the voltage. It provides a nominal DC output current of 350 mA when the triac is fully ON. The maximum output voltage, V_{LED}, for the reference board is 45 V. The nominal switching frequency when the triac is fully ON or when the board is connected directly to the 120 V (AC) line is 60 kHz. The reference board operates in Discontinuous Conduction Mode (DCM). The driver is connected to thirteen Cree XPE LEDs. NXP Semiconductors can easily adapt the schematic to match other LED solution up to 14 W.

4. Basic operation

The circuit is divided into four blocks:

- Input block
- Bleeder and damper block
- Feedback block
- power stage block

4.1 Input block

The input block circuitry comprises MOV1, F1, L1, R3, C2, D1, D2, D3, C3, L2 and C4.

The input circuitry provides rectification of the AC line, parallel damping, surge protection, and ElectroMagnetic Interference (EMI) conditioning. The input capacitors (C3, C4) charge and discharge during every 120 Hz cycle, which allows the reference board to have a high Power Factor (PF) with a DCM operation of the SSL2101.

4.2 Bleeder and damper block

A damper reduces the inrush current because of the phase-cut of the mains voltage. It also prevents oscillations that can cause interference with the triac. The circuit can be programmed to allow a minimum amount of hold current to flow in the triac. An external bleeding circuit is used to ensure compatibility with the widest range of dimmers. This circuit supplements the triac's bleeding current, if there is not enough current for the triac to remain on.

4.3 Feedback block

The feedback block comprises R18, R19, R20, R21, R24, D9, Q1, Q2, D10, R22, ISO1 and R12.

The feedback circuitry provides the regulated constant LED current when the triac is fully on. The output current can be adjusted by R24. R19 and D9 form an overvoltage protection circuit on the output. The reference board is designed to limit the output voltage to approximately 44 V (DC). The feedback also provides protection against a short circuit across LED+ and LED−.

4.4 Power stage block (all components not listed in other 3 parts of the circuit)

The Power stage block comprises all components not listed in the other three block of the circuit.

The power stage converts the high voltage input from the input circuitry into a low voltage DC output to power the LEDs. It also controls the output current during dimming by varying the switching frequency and duty cycle of the primary switching MOSFET.

5. Results

5.1 Electrical performance results

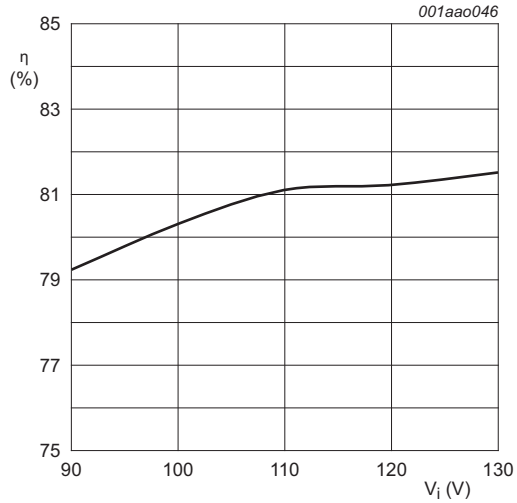

Fig 2. Efficiency as a function of input voltage

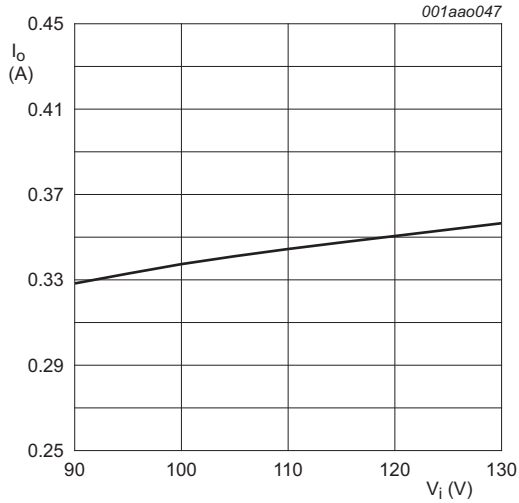

Fig 3. Output current as a function of input voltage

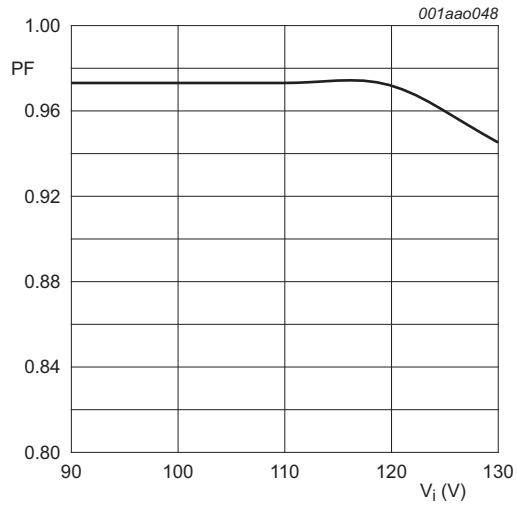

Fig 4. Power factor as a function of input voltage

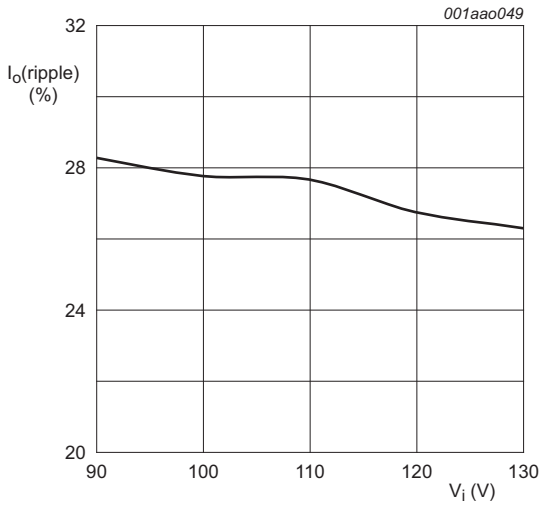

Fig 5. Output current ripple as a function of input voltage

6. Conducted EMI results

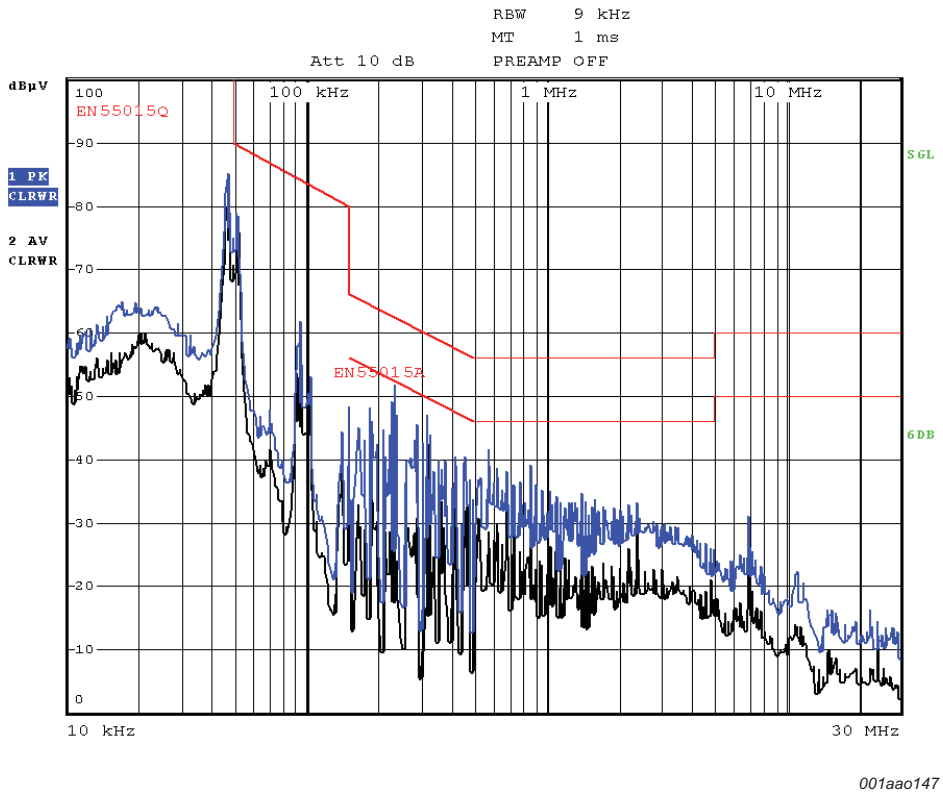

Fig 6. Conducted EMI results

7. SSL2101 120 V (AC) PAR38 flyback application description

7.1 Schematic

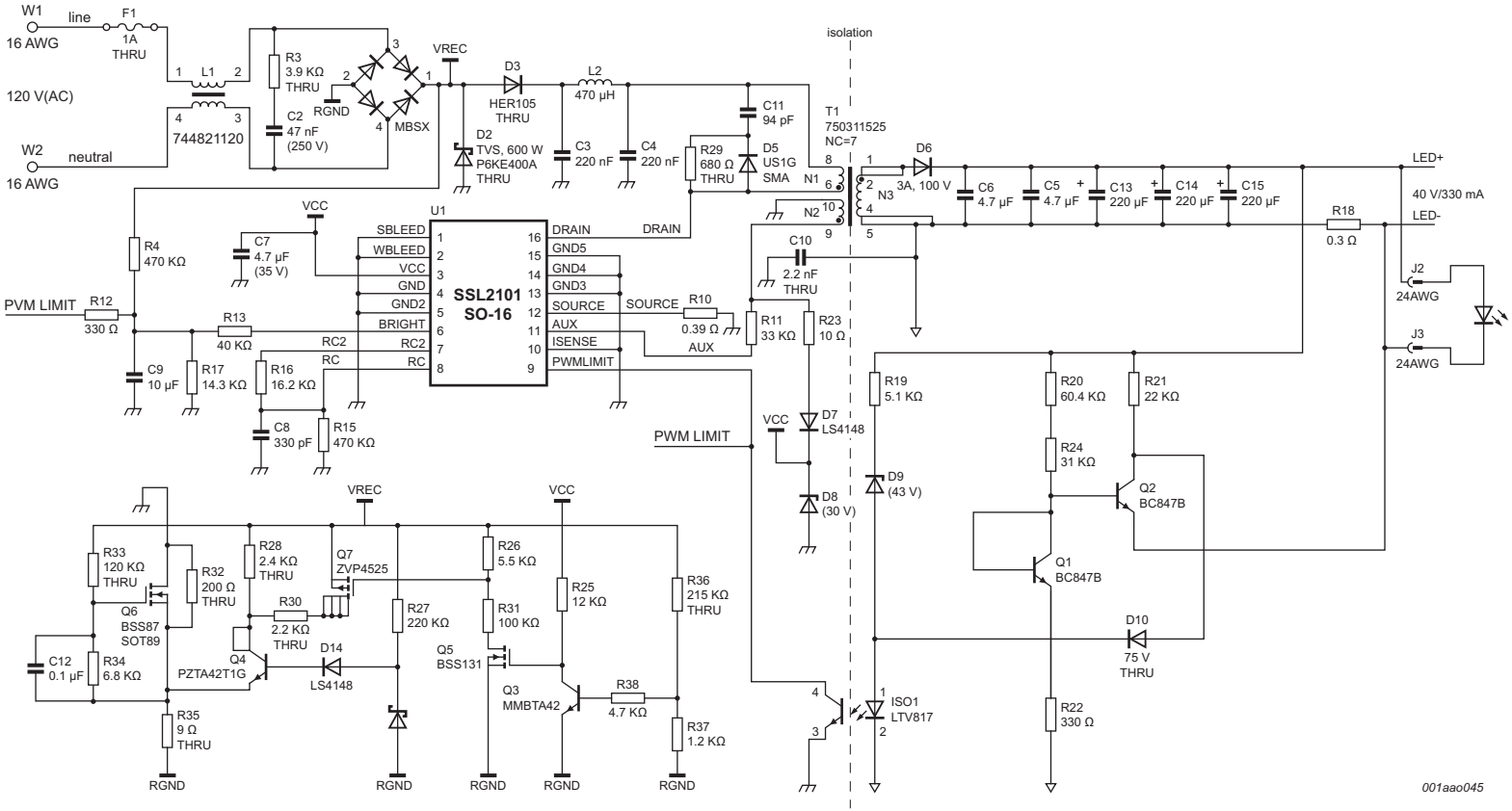

Fig 7. SSL2101 120 V PAR38 flyback application schematic

7.2 Bill Of Materials (BOM)

Table 2. NXP Semiconductors reference design SSL2101 flyback board 120 V (AC), 325 mA

Reference	Quantity	Description	Part number	Manufacturer/Vendor
D1	1	bridge rectifier; MBS-2; 1 %	ERJ-3GEYJ333V	Digikey
C12	1	C0603; 100 nF; 10 %	GRM188R71C104KA01D	Digikey
C8	1	C0603; 330 pF; 5 %	06033A331JAT2A	Mouser
C5	1	C1206; 4.7 μF; 50 V; 10 %	UMK316BJ475KL-T	Digikey
C7	1	C1206; 4.7 μF; 35 V; 20 %	GMK325BJ475MN-T	Digikey
C9	1	C0805; 10 μF; 16 V; 10 %	GRM21BR61C106KE15L	Digikey
C11	1	C1206; 100 pF; 250 V; 5 %	C1608C0G2E101J	Digikey
C2	1	CAP-B32529-3P5X7P2X8MM; 47 nF; 250 V; 10 %	B32529C3473K	Digikey
C10	1	CAP-DEBB-10ODX5X13H; 2.2 nF; 2 kV; 10 %	DEBB33D222KA2B	Digikey
C3; C4	2	CAP-MKP-2-7P2X7P2X13MM; 220 nF; 250 V; 10 %	MKP2 0.22/250/5	Mouser
C13; C14; C15	3	CRAD-10ODX16L; 220 μF; 50 V	UHE1H221MPD	Digikey
D7; D14	2	DIO-LL-34; LS4148	LS4148-GS08	Digikey
D5	1	DIO-SMA; US1G-13-F	US1G-13-F	Digikey
D6	1	DIO-SMA; 2 A; 150 V	STPS2150A	Digikey
D8	1	DIO-SOD80C; 30 V zener; 5 %	BZV55-B30	Mouser
D9	1	DIO-SOD80C; 43 V zener; 5 %	BZV55-B43	Digikey
D13	1	DIO-SOD80C; 2.4 V zener; 5 %	BZV55-B2V4	Digikey
D2	1	DO-15-V; 237 V; 600 W	P6KE250ARL	Digikey
D10	1	DO-35-V; 1N4148	1N4148,113	Mouser
D3	1	DO-41-V; HER105	HER105	Mouser; Taiwan Semiconductor
F1	1	FUSE-0263-V; 1 A; 250 V	0224001.HXP	Digikey
L1	1	IND-744821120; 4.7 mH; 0.5 A	744821120	Würth
L2	1	IND-SDR0805; 470 μH; 0.47 A; 20 %	SDR0805-471KL	Digikey
ISO1	1	OPTO-LTV817	LTV-817	Digikey
R11	1	R0603;33 kΩ; 1 %	ERJ-3GEYJ333V	Digikey
R12	1	R0603; 330 Ω; 1 %	RC0603FR-07330RL	Digikey
R23	1	R0603; 10 Ω; 5 %	ERJ-3GEYJ100V	Digikey
R25	1	R0603; 12 kΩ; 5 %	ERJ-3GEYJ123V	Digikey
R26	1	R0603;5.49 kΩ; 1 %	ERJ-3EKF5491V	Digikey
R34	1	R0603; 6.8 kΩ; 5 %	RMCF 1/16 6.8K 5% R	Digikey
R37	1	R0603; 1.2 kΩ; 1 %	RC0603FR-071K2L	Digikey
R38	1	R0603; 4.7 kΩ; 1 %	RC0603FR-074K7L	Digikey
R10	1	R0805; 0.39 Ω; 1 %	MCR10EZHFLR390	Digikey
R15	1	R0603; 470 kΩ; 1 %	RMCF 1/16 470K 1% R	Digikey
R16	1	R0603; 16.2 kΩ; 1 %	RC0603FR-0716K2L	Digikey
R19	1	R0603; 5.1 kΩ;1 %	RMCF 1/16 5.1K 1% R	Digikey

Table 2. NXP Semiconductors reference design SSL2101 flyback board 120 V (AC), 325 mA

Reference	Quantity	Description	Part number	Manufacturer/Vendor
R17	1	R0603; 4.3 kΩ; 1 %	RMCF 1/16 14.3K 1% R	Digikey
R20	1	R0603; 60.4 kΩ; 1 %	RMCF 1/16 60.4K 1% R	Digikey
R21	1	R0603; 22 kΩ; 1 %	RMCF 1/16 22K 1% R	Digikey
R22	1	R0603; 330 Ω; 1 %	RC0603FR-07330RL	Digikey
R24	1	R0603; 31 kΩ; 1 %	RMCF 1/16 31K 1% R	Digikey
R4	1	R1206; 470 kΩ; 1 %	RC1206FR-07470KL	Digikey
R18	1	R0805; 0.3 Ω; 1 %	CSR 1/4 0.3 1% I	Digikey
R27	1	R1206; 220 kΩ; 5 %	RMCF 1/8 220K 5% R	Digikey
R31	1	R1206; 100 kΩ; 1 %	RC1206FR-07100KL	Digikey
R30	1	RAX-CFR-25; 2.2 kΩ; 1 W; through-hole; 1 %	FMP100JR-52-2K2	Digikey
R3	1	RAX-CFR-25-V; 3.9 kΩ; 1/4 W; through-hole; 5 %	CF 1/8 3.9K 5% R	Digikey
R28	1	RAX-CFR-25-V; 2.4 kW; 1 W; through-hole; 1 %	FMP100JR-52-3K3	Digikey
R32	1	RAX-CFR-25-V; 200 Ω; 0.25 W; through-hole; 5 %	RNF 1/4 T1 200 1% R	Digikey
R33	1	RAX-CFR-25-V; 120 kΩ; through-hole; 5 %	CF 1/4 120K 5% R	Digikey
R35	1	RAX-CFR-25-V; 9.1 Ω; 1/4 W; through-hole; 5 %	ERD-S1TJ9R1V	Digikey
R36	1	RAX-CFR-25-V; 215 kΩ; through-hole; 1 %	RC1206FR-07215KL	Digikey
R29	1	RAX-CFR-50-V; 680 Ω; through-hole; 5 %	CFR-25JR-680R	Digikey
U1	1	SO-16; SSL2101	SSL2101	NXP
Q4	1	SOT223-4; PZTA42T1G	PZTA42,115	Digikey
Q7	1	SOT23-6; ZVP4525	ZVP4525	Digikey
Q1; Q2	2	SOT23_C-BE; BC847B	BC847B+215	Digikey
Q3	1	SOT23_C-BE; MMBTA42	MMBTA42,215	Digikey
Q5	1	SOT23_D-GS; BSS131	BSS131 L6327	Mouser
Q6	1	SOT89-GDS; BSS87	BSS87,115	Digikey
T1	1	XFMR-750311525	750311525	Würth

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9. Contents

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