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SSL3401DB1174 7 W mains dimmable MR16/12 V driver for GU5.3 22 mm

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Revision history

Rev	Date	Description
v. 1.1	20131114	updated issue
Modifications:		• The information about component U5 in Table 7 "Bill of material" has been updated.
v. 1	20131023	first issue

Contact information

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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.
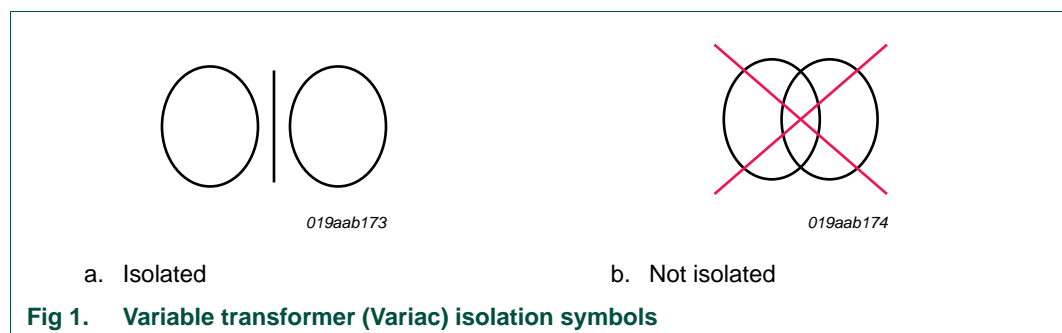

The SSL3401HN 7 W LED driver is a solution for a dimmable MR16/12 V application connected to an electronic transformer. It is dimmable with both leading edge (Triac) dimmers and trailing edge (transistor) dimmers. It generates 5.4 W output power when using a 27 V LED voltage load. The 27 V LED voltage is the voltage measured at ambient temperatures and at a 200 mA LED current.

The design provides an example of how to make a driver that is suitable for small form factor LED retrofit lamps.

The device controls the application to run in hysteretic boost mode. A filtered Pulse Width Modulation (PWM) signal is generated to control the analog LED current source of the application. This mode ensures an accurate LED current with low ripple.

2. Safety warnings

The board must be connected to 12 V transformer. Touching the board during operation must be avoided at all times. An isolated housing is obligatory when used in uncontrolled, non-laboratory environments. The secondary circuit with LED connection has galvanic isolation using the 12 V electronic transformer. Thus galvanic isolation of the mains phase using a variable transformer is always recommended. The symbols shown in Figure 1 indicate these devices.

019aab173   *019aab174*

a. Isolated   b. Not isolated

Fig 1.   Variable transformer (Variac) isolation symbols

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3. Restrictions

Connect the SSL3401HN 7 W dimmable MR16/12 V demo board to a transformer that generates a peak output voltage < 30 V.

The evaluation board can drive an LED voltage of 33 V (measured LED voltage at functional current value) when the electrolytic capacitor CBUS1 (see Figure 9.) is changed to a 50 V capability and the LED current is adjusted to keep the application working within the same power range.

Pay attention to the 5 V LDO (U6) dissipation and temperature when increasing the LED voltage.

## 4. Connecting and configuring the board

The board is designed for 12 V (AC) transformer connected to a 230 V/120 V (AC), 50 Hz/60 Hz mains source. It is designed to work with multiple high-power LEDs with a total working voltage of between 24 V and 30 V.

Connect the board as shown in Figure 2.

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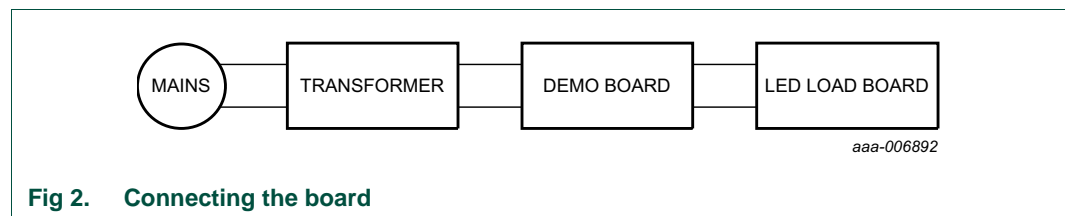
Fig 2.   Connecting the board

The physical connection in shown in Figure 3.

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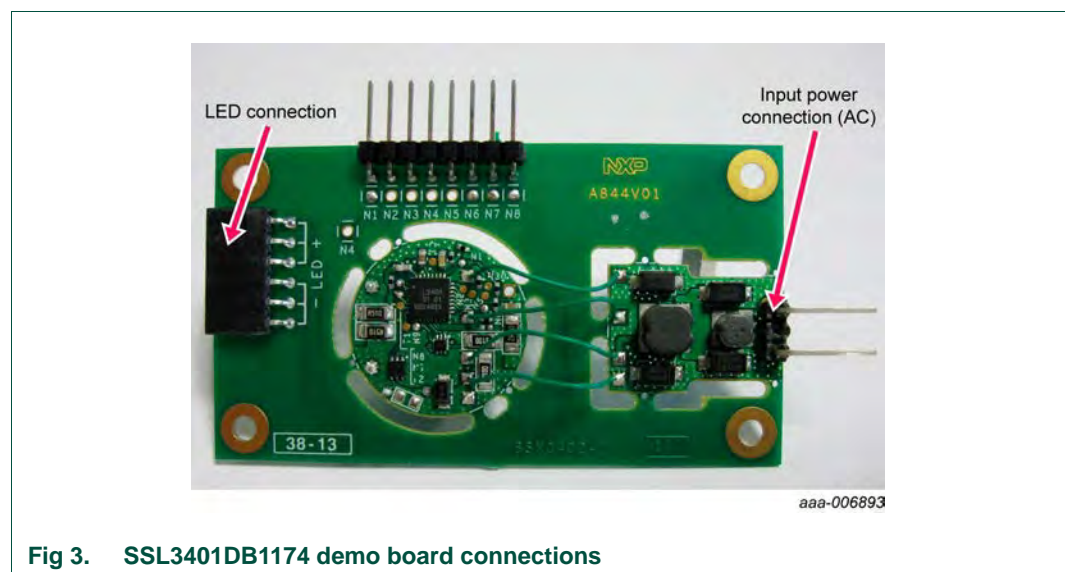
Fig 3.   SSL3401DB1174 demo board connections

5. Specification

Table 1 gives the specifications for the SSL3401 7 W application tested with an OSRAM HTM 70 electronic transformer unless otherwise specified.

Table 1.   Specifications

Parameter	Values	Comments
AC line input voltage	11 V (AC; RMS); ±15 %	electronic transformer connected to 230 V mains voltage
maximum input voltage	30 V	
input power of system (excluding electronic transformer)	7.1 W	board supplied by electronic transformer
output voltage (LED voltage)	minimum 24 V; typical 27 V; maximum 30 V	
efficiency of system (excluding electronic transformer	typical: 73 %	at T_{amb} = 25 °C; board supplied by electronic transformer
	typical: 75 %	at a PCB temperature of 100 °C; board supplied by electronic transformer
power factor	> 0.9	
Total Harmonic Distortion (THD)	< 15 %	
output current (LED current)	nominal: 200 mA	adjustable modifying some resistor values
LED current ripple	< ±10 %	
dimming range	100 % to 5 %	measured on LED current
board dimensions	diameter = 22 mm	

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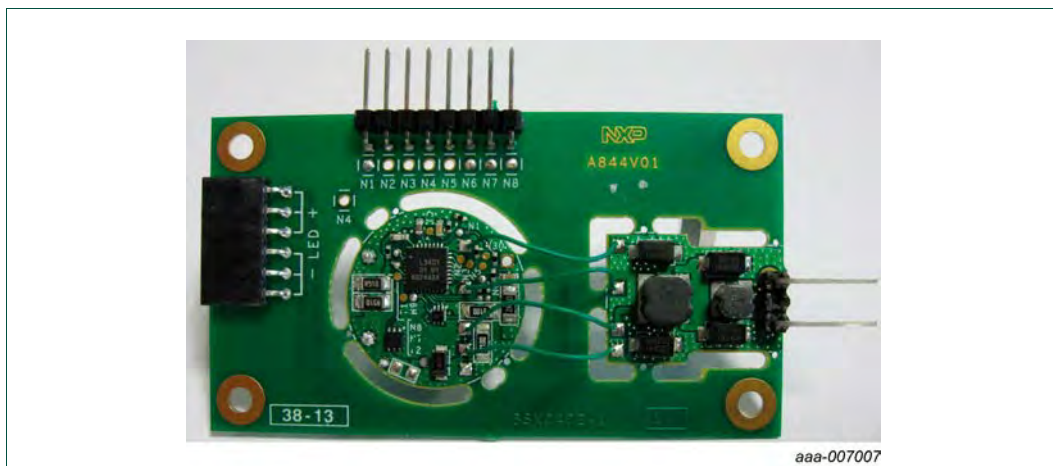
6. Board photographs
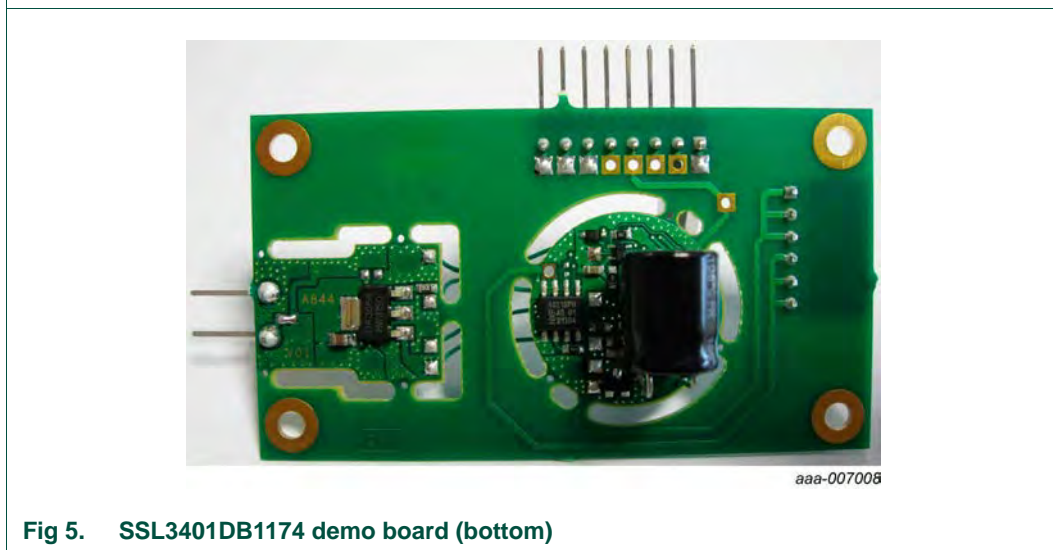

Fig 4. SSL3401DB1174 demo board (top)

Fig 5. SSL3401DB1174 demo board (bottom)

7. Dimmers and transformers compatibility

The demo board has been tested with several electronic transformers and dimmers, as listed in Table 2 to Table 4.

Table 2. **Dimmers compatibility test result at V$_{mains}$ = 230 V**

Electronic transformer	Clipsal 32E450UDM	Clipsal 32E450LM	Clipsal 32E450TM	Legrand cat 400L	Legrand cat 400T
Tridonic Speedy TE-0070 C101	OK[1]	OK[2]	OK[2]	not OK	OK[2]
Tridonic Atco VIPER 60VA (220-240V) (EU/AU)	OK[1]	not OK	not OK	does not start	OK[1]
ET-Redback 60VA/230-240Vac	OK	not OK	OK	OK	OK
Tridonic Possum 60VA	OK	OK[2]	not OK	OK	OK
Actec MIni60	OK	OK	OK	OK	OK
Magnetic transformer	not tested	OK	not tested	OK[1]	not tested

[1] Tested with two lamps.

[2] Tested with three lamps.

Table 3. **Dimmers compatibility test result at V$_{mains}$ = 230 V**

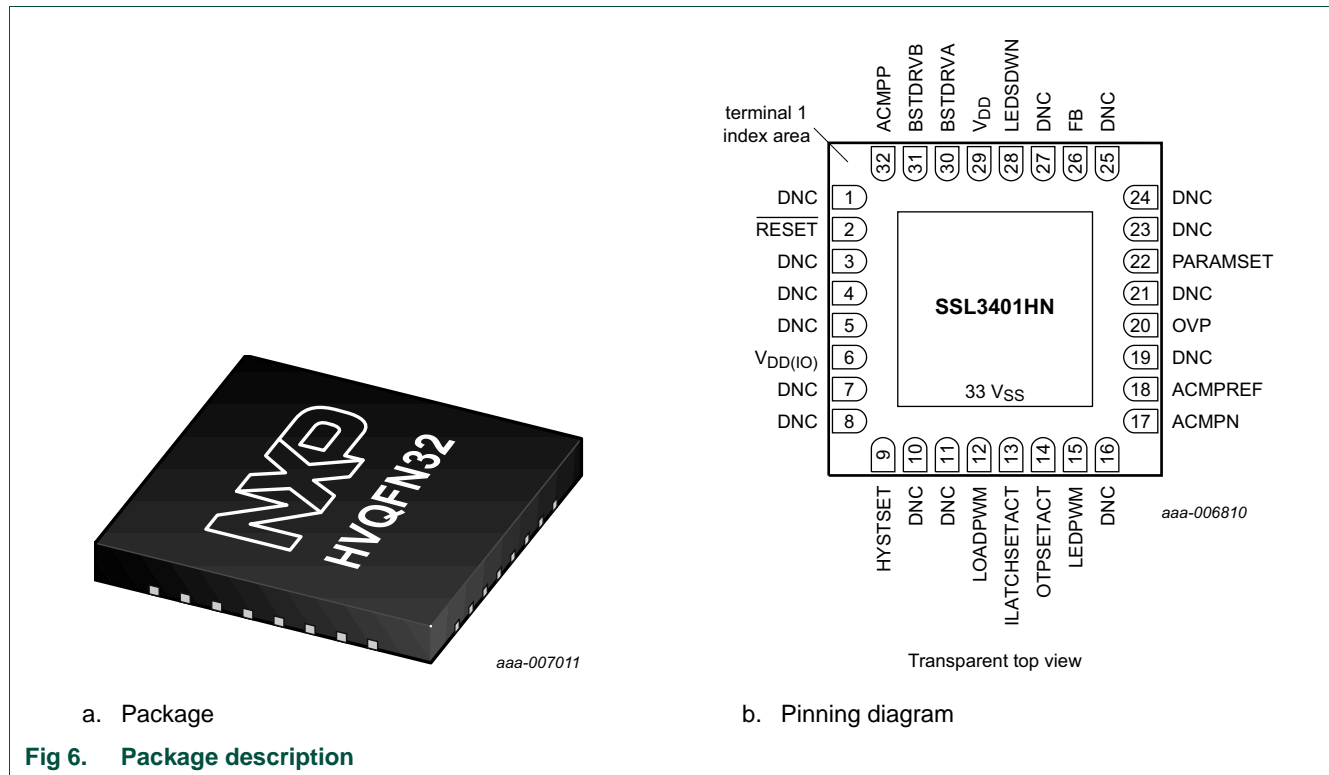| Electronic transformer	PEHA Tronic 433 HAB	Busch Universal 6591U	Siemens 5TC8284	Berker 2873 (RL)	GIRA 1184 00/100	Busch 6513 U-102 (RC)
Magnetic transformer	not tested	OK	not tested	OK	not tested	not tested
OSRAM HTM70/230-240	OK	OK	OK	OK[1]	OK	OK
Philips ET-S60	OK[1]	OK[1]	not OK	OK[2]	OK[1]	OK[1]
Philips Primaline 70 230-240V	OK	OK	OK	OK	OK	OK

[1] Tested with two lamps.

[2] Tested with three lamps.

Table 4. **Dimmers compatibility test result at V$_{mains}$ = 120 V**

Electronic transformer	Lutron SPSELV 600 WH (trailing edge)[1]
CB+L CV90098	OK
Lightech LET 151 R 150W	OK
LighTech LET 60	OK
Hatch VS12-60WD	OK

[1] Tested with one lamp.

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8. IC description

a. Package

b. Pinning diagram

Fig 6. **Package description**

Table 5. **Pin descriptions**

Symbol	Pin	Description
DNC	1	do not connect
$\overline{RESET}$	2	reset if LOW
DNC	3	do not connect
DNC	4	do not connect
DNC	5	do not connect
$V_{DD(IO)}$	6	3.3 V I/O supply voltage
DNC	7	do not connect
DNC	8	do not connect
HYSTSET	9	comparator hysteresis level setting (high hysteresis level if pin is left open or set HIGH, low hysteresis level if pin is set LOW)
DNC	10	do not connect
DNC	11	do not connect
LOADPWM	12	output load control (input pin at reset)
ILATCHSETACT	13	input latching current setting control
OTPSETACT	14	overtemperature setting control
LEDPWM	15	LED current control (input pin at reset)
DNC	16	do not connect
ACMPN	17	analog comparator negative input
ACMPREF	18	analog comparator reference voltage

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Table 5. **Pin descriptions** *…continued*

Symbol	Pin	Description
DNC	19	do not connect
OVP	20	overvoltage protection sensing input
DNC	21	do not connect
PARAMSET	22	input latching current and OTP setting input
DNC	23	do not connect
DNC	24	do not connect
DNC	25	do not connect
FB	26	feedback loop input voltage
DNC	27	do not connect
LEDSDWN	28	LED current deep dimming control
V_{DD}	29	3.3 V supply voltage
BSTDRVA	30	power MOSFET driver output
BSTDRVB	31	power MOSFET driver output
ACMPP	32	analog comparator positive input
V_{SS}	33	die pad ground terminal

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9. Functional description

9.1 Latching current and OTP configuration

The application can be configured for different latching currents or independently for different OTP temperature protection values. The resistor ratio RSET1/RSET2 determines the OTP threshold.

By default the resistor values are:

- RSET1= 47 kΩ
- RSET2 = 51 kΩ

Table 6 describes the OTP temperature threshold value versus the RSET1 resistance value when the RSET2 value is 51 kΩ.

Table 6.   OTP temperature threshold versus RSET1

RSET1 value (kΩ)	OTP threshold (°C)
open	120
562	107.5
287	110
187	112.5
133	115
100	117.5
68.1	122.5
48.7	125
33	127.5
21.5	130

Figure 7 shows the input current of the application when the latching current is disabled, resistor RSET3 is not connected (see Section 9.2).

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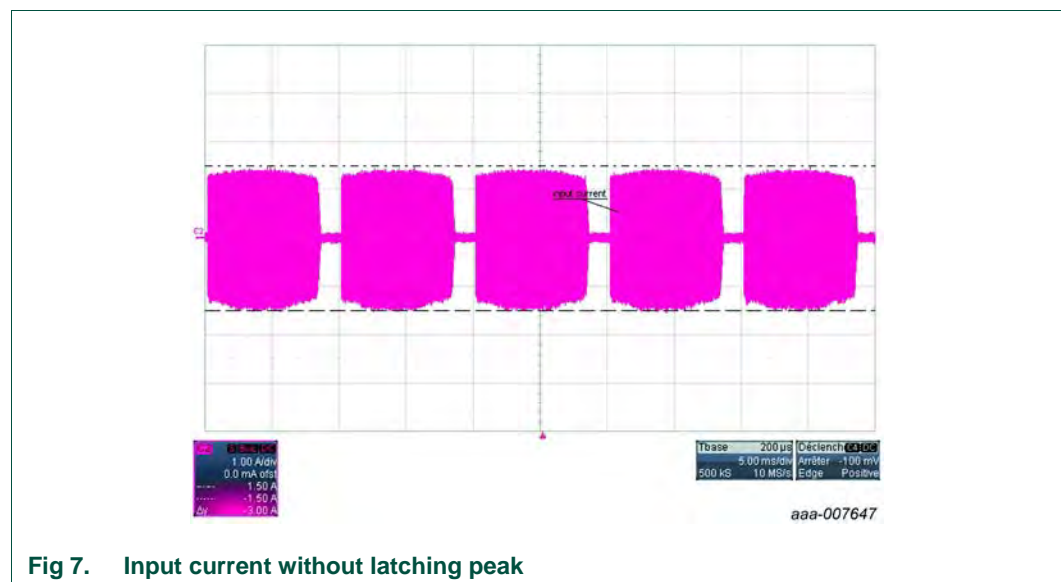
Fig 7.   Input current without latching peak

9.2 Adding the latched current

The demo board has been built without added latched current, contrary to the IC functionality. This functionality is disabled when RSET3 is not connected (see Figure 9).

To allow control of the latched current, choose an RSET3 following the information given in the data sheet. The added latched current value is linked to the resistor ratio of RSET2 and RSET3 (see Figure 9).

Remark: When adding latched current, boost inductor and EMI filter inductor must have a saturation current rating above 3 A.

Remark: Make sure that the maximum allowed transformer power is not exceeded when the latched current is enabled and multiple boards are connected to each transformer.
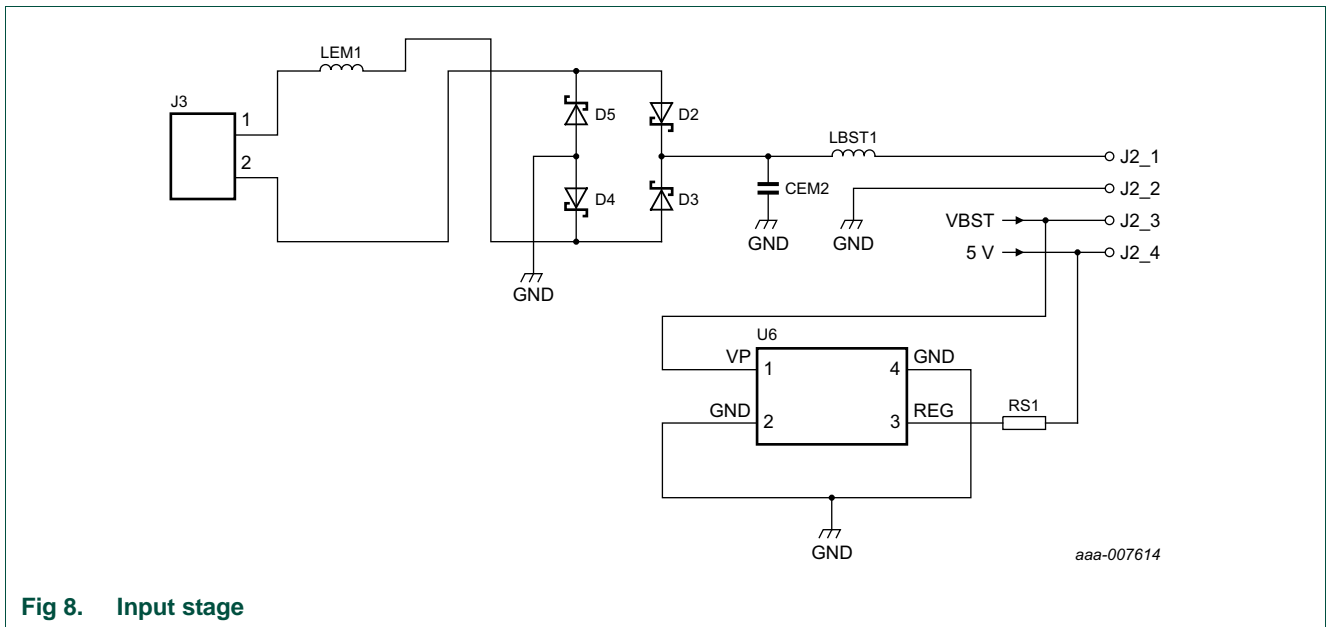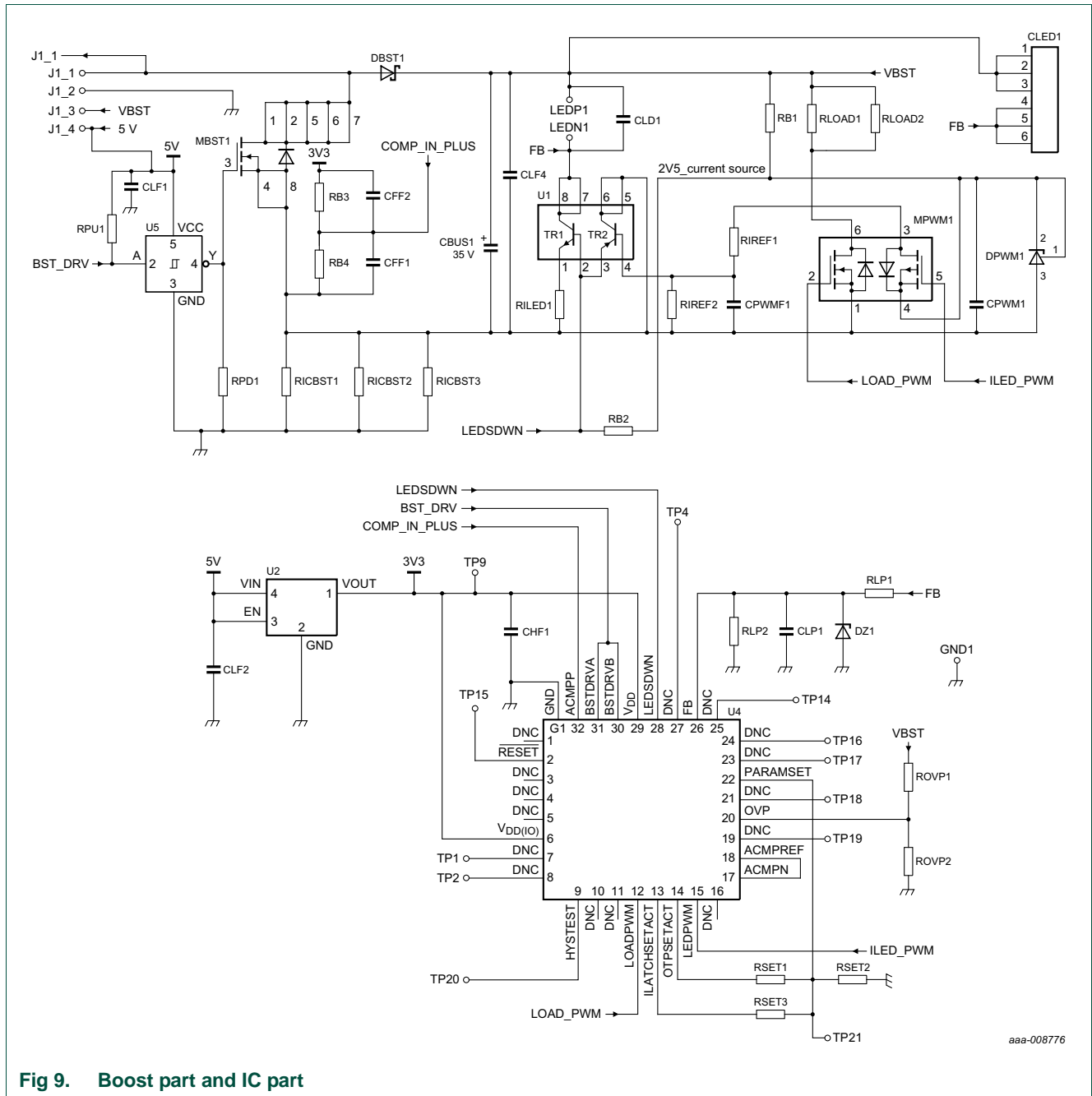
10. Board schematic

Fig 8. Input stage

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Fig 9.   Boost part and IC part

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11. Bill Of Material (BOM)

Table 7.   Bill of material

Reference	Description and values	Part number	Manufacturer
CBUS1	capacitor; 330 μF; 35 V; 10 mm × 12.5 mm	EEUFR1V331U	Panasonic
CEM2	capacitor; 1 μF; 50 V; 125 °C; 10 %; X7R; 0805	GRM21BR71H105KA12L	Murata
CFF1; CFF2	capacitor; 33 pF; 50 V; 125 °C; 5 %; 0603	GRM1885C1H330JA01D	Murata
CLD1; CLF1; CPWMF1	capacitor; 100 nF; 50 V; 125 °C; 10 %; 0603	GRM188R71H104KA93D	Murata
CHF1; CLF2; CPWM1	capacitor; 1 μF; 16 V; 125 °C; 10 %; X7R; 0603	0603YC105KAT2A	AVX
CLF4	capacitor; not connected; 0805	-	-
CLP1	capacitor; 33 nF; 50 V; 125 °C; 5 %; 0603	06035C333JAT2A	AVX
D2; D3; D4; D5	diode; rectifier; 60 V; 3 A; 150 °C; SMA	B360A-13-F	Diodes Incorporated
DBST1	diode; rectifier; 60 V; 1 A; 150 °C; SMA	SS19L	Taiwan Semiconductor
DPWM1	shunt regulator; 2.5 V; 0.5 %; SOT23	TL431BMFDT	NXP Semiconductors
DZ1	Zener diode; 3.3 V; 0.5 W; SOD323	TDZ3V3J	NXP Semiconductors
LBST1	inductor; 15 μH; 2.3 A; 125 °C; 20 %; 6 mm	SRN6045-150M	Bourns
LEM1	inductor; 4.7 μF; 1.7 A; 125 °C; 20 %; 4.5 mm	SDR0403-4R7ML	Bourns
MBST1	N MOSFET; 60 V; 12 A; 150 °C; DFN2020-6	PMPB40SNA	NXP Semiconductors
MH1; MH2; MH3; MH4	strut; M3 × 25 mm	301 3150 400 50	Ex-ACME
MPWM1	N/P MOSFET; 60 V; 330 mA; 50 V; 170 mA; 150 °C; SOT366	NX1029X	NXP Semiconductors
RB1	resistor; 9.1 kΩ; 150 V; 155 °C; 1 %; 0805	CRCW08059K10FKEA	Vishay
RB2	resistor; 698 Ω; 75 V; 155 °C; 100 mW; 1 %; 0603	CRCW0603698RFKEA	Vishay
RB3; RB4	resistor; 220 kΩ; 50 V; 155 °C; 1 %; 0603	CRCW0603220KFKEA	Vishay
RICBST1	resistor; 1 Ω; leaded 7 mm × 2.5 mm	MRS25000C1008FCT00	Vishay
RICBST2; RICBST3	resistor; 0.51 Ω; 1 %; 0.5 W; 1206	CRM1206-FX-R510ELF	Bourns
RILED1	resistor; 2 Ω; 250 mW; 100 ppm; 125 °C; 1 %; 1206	ERJ6BQF2R0V	Panasonic
RIREF1	resistor; 24 kΩ; 50 V; 100 ppm; 155 °C; 1 %; 0603	MC 0.063W 0603 1% 24K	Multicomp
RIREF2	resistor; 6.65 kΩ; 100 ppm; 125 °C; 1 %; 0603	CRCW06036K65FKEA	Vishay
RLOAD1; RLOAD2	resistor; 910 Ω; 330 mW; 200 ppm; 125 °C; 5 %; 1206	ERJP08F9100V	Panasonic
RLP1	resistor; 15 kΩ; 100 ppm; 125 °C; 1 %; 0603	CPF0603B15KE1	TE Connectivity
RLP2	resistor; 5.1 kΩ; 100 ppm; 125 °C; 1 %; 0603	CRCW06035K10FKEA	Vishay
ROVP1	resistor; 100 kΩ; 100 ppm; 155 °C; 1 %; 0402	CPF0402B100KE1	TE Connectivity
ROVP2	resistor; 4.99 kΩ; 60 V; 50 ppm; 125 °C; 1 %; 0603	CPF0603F4K99C1	TE Connectivity
RPU1; RPD1	resistor; 10 kΩ; 75 V; 100 ppm; 125 °C; 1 %; 0603	CRCW060310K0FKEA	Vishay
RS1	resistor; 0.5 Ω; 100 ppm; 155 °C; 1 %; 0603	LRCS0603-0R5FT5	Welwyn Components

Table 7. **Bill of material** *…continued*

Reference	Description and values	Part number	Manufacturer
RSET1	resistor; 48.7 kΩ; 100 ppm; 155 °C; 1 %; 0402	CRCW040248K7FKED	Vishay
RSET2	resistor; 51 kΩ; 60 V; 50 ppm; 155 °C; 1 %; 0402	CRCW040251K0FKED	Vishay
RSET3	resistor; not connected; 0402	-	-
U1	IC; NPN/PNP; 20 V; 6.3 A; 800 mW; SOT96-1	PBSS4021SPN	NXP Semiconductors
U2	IC; 3.3 V regulator; 150 mA; 3 %; DFN1010C-4	LD6805K/33H	NXP Semiconductors
U4	IC; driver; HVQFN33	SSL3401HN	NXP Semiconductors
U5	IC; single inverter buffer; 5 V; 24 mA; TSSOP5	74LVC1G14GW-Q100	NXP Semiconductors
U6	IC; 5 V regulator; 100 mA; 5 %; SOT223	TDA3664/N1	NXP Semiconductors

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