

ICL8105 Single-Stage Multi-Mode Flyback Controller with PFC

.dp digital power 2.0

40W Demoboard with Isolated 0-10V Dimming Interface

Application Note

About this document

Scope and purpose

This document contains the complete specification of the 40W LED driver for LED lighting using the Infineon ICL8105 Single-stage multi-mode flyback controller with PFC, a detailed circuit diagram, an entire bill of materials required to build the 40W LED driver and measurement results covering the most important performance.

Intended audience

This document is intended for anyone wishing to design high-performance single-stage digital flyback AC-DC converters for LED lighting based on the ICL8105 controller.

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2 Design Features

- Single-stage flyback with power factor correction (PFC) and high-precision primary side-controlled constant current output. Excellent current accuracy of typ +/-3% across wide line/load to maintain a constant light output
- Excellent line/load regulation over universal input and wide output within +3/-4%
- Wide output voltage range (from 15 V – 45 V)
- Integrated 600 V HV cell for fast startup and maintaining the efficiency across the wide input voltage
- Low Bill Of Materials (BOM)
- Intelligent thermal management
- Quick design and variant handling supported by digital parameter configurability with .dp vision GUI. E.g. Output current setting, protections, temperature handling, startup & shutdown, dimming, power factor correction and operation fine tuning
- The ICL8105 supports isolated 0-10 V dimming without the need for extra ICs. Extended dimming is supported down to 1% of the nominal load. Besides, the dimming curve is adjustable (linear / eye-adapted). Configurable voltage levels ensure that min and max current can always be achieved, making the application robust against dimmer & component tolerances

3 Design Specification

Table 1 lists the design specification for the 40 W LED driver.

Table 1 Design Specification

Parameter	Symbol	Value	Unit
Nominal input voltage	V_{in}	90 – 300	V~
Input overvoltage	$V_{in,OV}$	310	V~
Output power	P_o	40	W
Output voltage	V_{out}	15 – 45	V
Output overvoltage threshold	$V_{out,OV}$	50	V
Output current	$I_{out,set}$	880	mA
Efficiency	η	< 91	%
Power factor		> 0.95	
THD		< 16	%

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Schematic

4 Schematic

Figure 2 shown the complete schematic of this 40 W LED driver

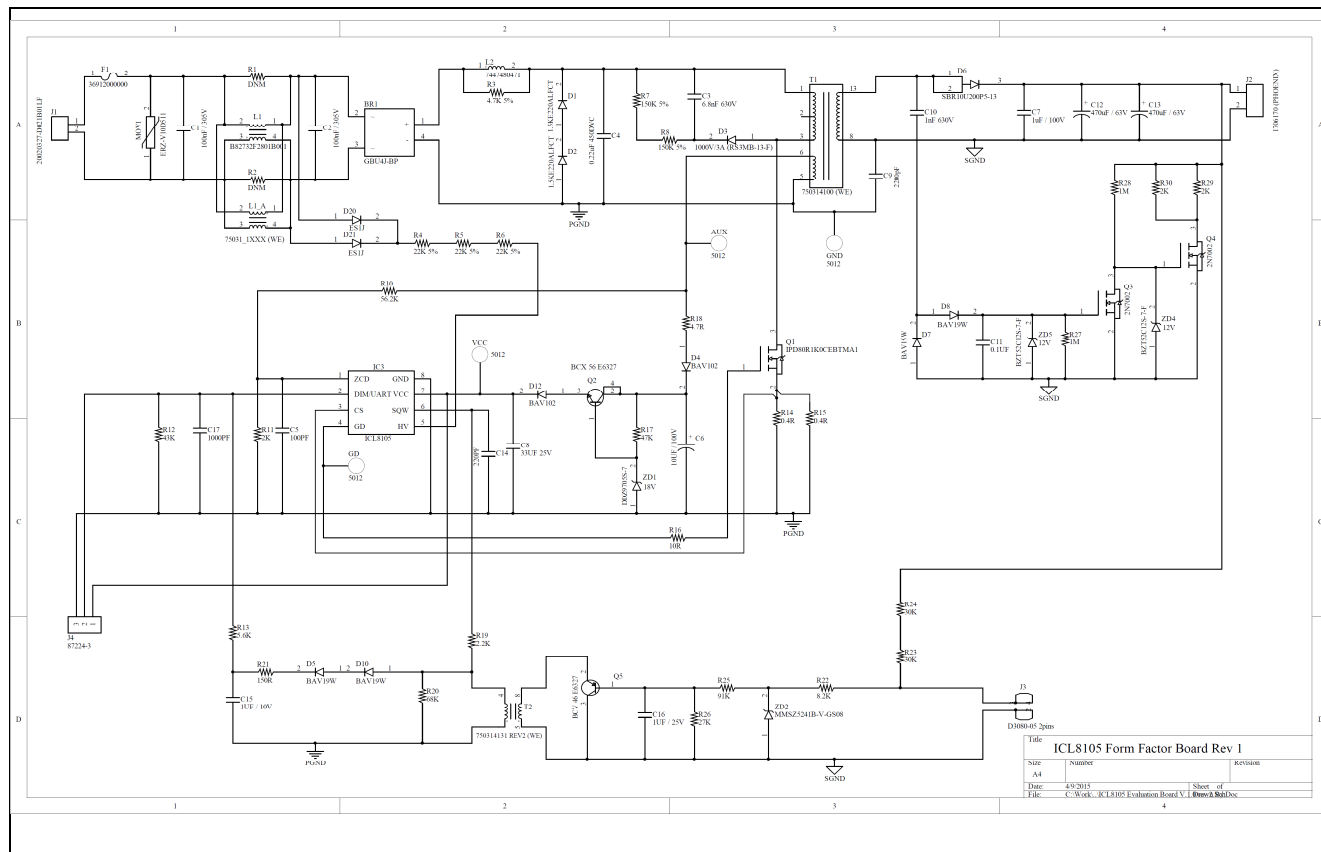


Figure 2 Schematic of the 40W LED driver demoboard

5 PCB Layout

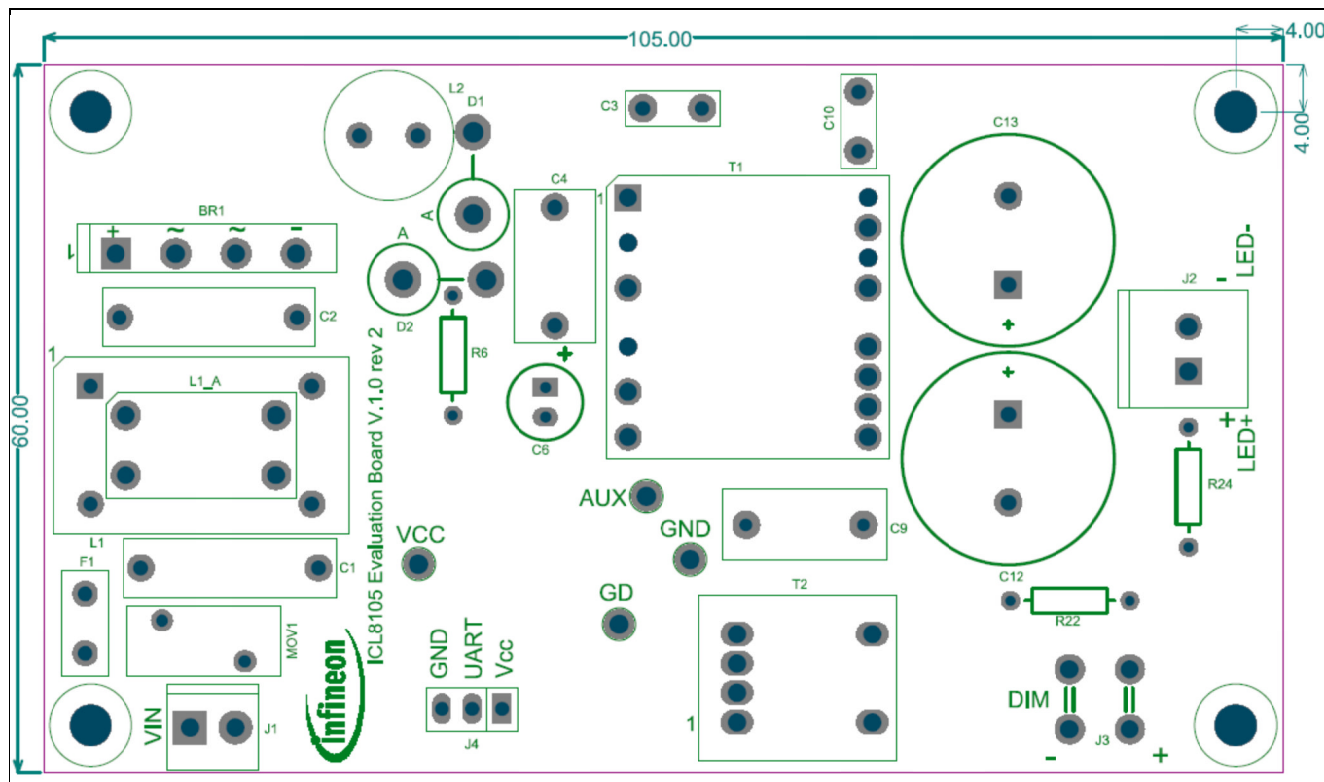


Figure 3 PCB Top

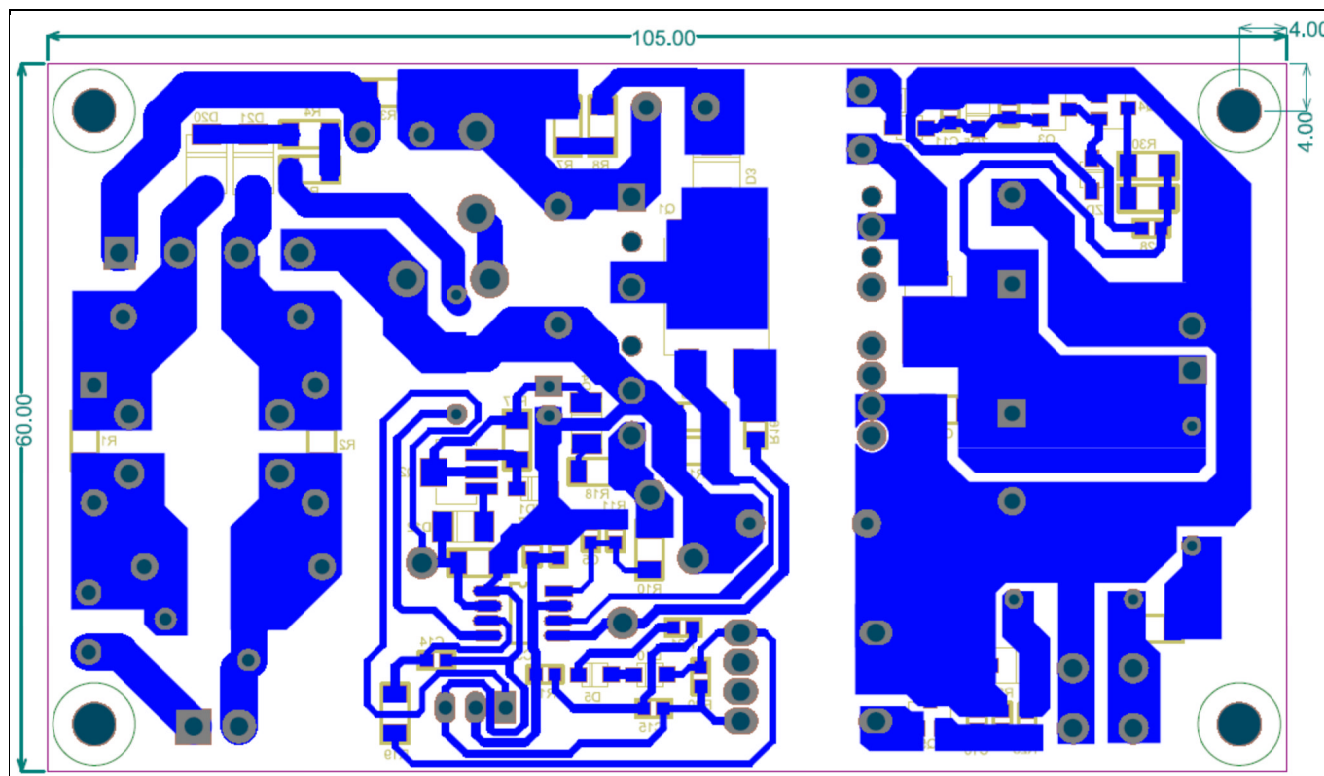


Figure 4 PCB Bottom

6 Performance

In this chapter, the measurement results of the demo board with 6 LEDs (Table 2), 10 LEDs (Table 3) and 16 LEDs (Table 4) are listed for your easy reference.

6.1 $V_{OUT} = 17\text{ V}$

Table 2 Measurement result with 6 LEDs

V_{IN} (VAC)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	Power Factor	THD (%)	η (%)
100	17.59	17.77	0.865	0.994	10.81	87.39
110	17.65	17.77	0.870	0.993	11.69	87.59
120	17.59	17.77	0.868	0.992	12.25	87.69
130	17.58	17.77	0.869	0.991	12.65	87.84
140	17.59	17.77	0.871	0.991	13.21	87.99
150	17.63	17.77	0.872	0.989	13.87	87.89
160	17.65	17.77	0.873	0.989	14.58	87.89
170	17.66	17.77	0.873	0.988	15.09	87.84
180	17.67	17.77	0.872	0.987	15.79	87.69
190	17.69	17.77	0.872	0.986	16.49	87.59
200	17.73	17.77	0.872	0.984	16.45	87.40
210	17.76	17.76	0.873	0.981	15.45	87.30
220	17.76	17.76	0.871	0.975	15.05	87.10
230	17.78	17.76	0.871	0.969	15.13	87.00
240	17.81	17.76	0.871	0.960	14.86	86.86
250	18.08	17.77	0.879	0.952	15.05	86.39
265	18.28	17.78	0.884	0.935	14.89	85.98
277	18.38	17.78	0.886	0.917	14.43	85.71
300	18.51	17.78	0.886	0.880	14.79	85.11

40W Demoboard with Isolated 0-10V Dimming Interface Single-Stage Multi-Mode Flyback Controller with PFC



Performance

6.2 $V_{OUT} = 29\text{ V}$

Table 3 Measurement result with 10 LEDs

V_{IN} (V _{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	Power Factor	THD (%)	η (%)
100	29.03	29.48	0.874	0.997	7.55	88.75
110	28.89	29.47	0.875	0.996	8.27	89.26
120	28.88	29.47	0.877	0.995	8.98	89.49
130	28.86	29.46	0.879	0.995	9.78	89.73
140	28.76	29.45	0.878	0.995	10.15	89.91
150	28.76	29.45	0.879	0.994	10.52	90.01
160	28.75	29.45	0.878	0.994	11.08	89.94
170	28.71	29.44	0.878	0.993	11.73	90.03
180	28.71	29.43	0.877	0.993	11.65	89.90
190	28.79	29.42	0.880	0.993	11.21	89.93
200	28.81	29.42	0.879	0.993	10.98	89.76
210	28.81	29.41	0.879	0.993	10.75	89.73
220	28.82	29.40	0.878	0.993	10.51	89.57
230	28.82	29.40	0.878	0.992	10.25	89.57
240	28.84	29.39	0.877	0.991	9.95	89.37
250	29.11	29.40	0.882	0.989	9.97	89.08
265	29.22	29.40	0.883	0.984	9.68	88.84
277	29.24	29.39	0.883	0.979	9.08	88.75
300	29.36	29.39	0.882	0.963	8.35	88.29

40W Demoboard with Isolated 0-10V Dimming Interface Single-Stage Multi-Mode Flyback Controller with PFC



Performance

6.3 $V_{OUT} = 46\text{ V}$

Table 4 Measurement result with 16 LEDs

V_{IN} (V _{AC})	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	Power Factor	THD (%)	η (%)
100	46.96	46.80	0.891	0.999	5.33	88.80
110	46.47	46.76	0.889	0.998	5.72	89.45
120	46.27	46.75	0.891	0.998	6.09	90.02
130	45.93	46.71	0.889	0.998	6.47	90.41
140	45.97	46.71	0.893	0.997	7.08	90.74
150	45.97	46.70	0.895	0.996	7.95	90.92
160	45.83	46.68	0.893	0.994	8.83	90.96
170	45.65	46.66	0.891	0.995	9.75	91.07
180	45.43	46.64	0.888	0.995	9.92	91.17
190	45.24	46.61	0.884	0.995	9.15	91.08
200	45.16	46.59	0.883	0.995	8.59	91.10
210	45.08	46.58	0.882	0.994	8.15	91.13
220	44.95	46.55	0.878	0.993	7.45	90.93
230	44.86	46.54	0.877	0.994	7.15	90.98
240	45.09	46.54	0.880	0.994	6.95	90.83
250	45.05	46.52	0.878	0.993	6.65	90.66
265	45.03	46.51	0.876	0.992	6.31	90.48
277	45.03	46.49	0.875	0.990	6.25	90.34
300	45.18	46.49	0.875	0.986	6.41	90.04

Performance

6.4 0 – 10 V Dimming

This section provides measurement results for the 0 - 10 V dimming feature. A quadratic curve was configured for this measurement. Using the .dpVision GUI [3] the dimming curve can also be configured to a linear curve. The measurement was done for an input voltage of 230 V, 50 Hz and an output load of 16 LEDs (46 V at maximum current).

Table 5 Output current at different dimming voltages

Vdim (V)	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
Io (A)	0.011	0.011	0.015	0.031	0.045	0.071	0.115	0.151	0.204	0.258
Vdim (V)	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	10.00
Io (A)	0.328	0.401	0.476	0.561	0.651	0.733	0.827	0.877	0.877	0.877

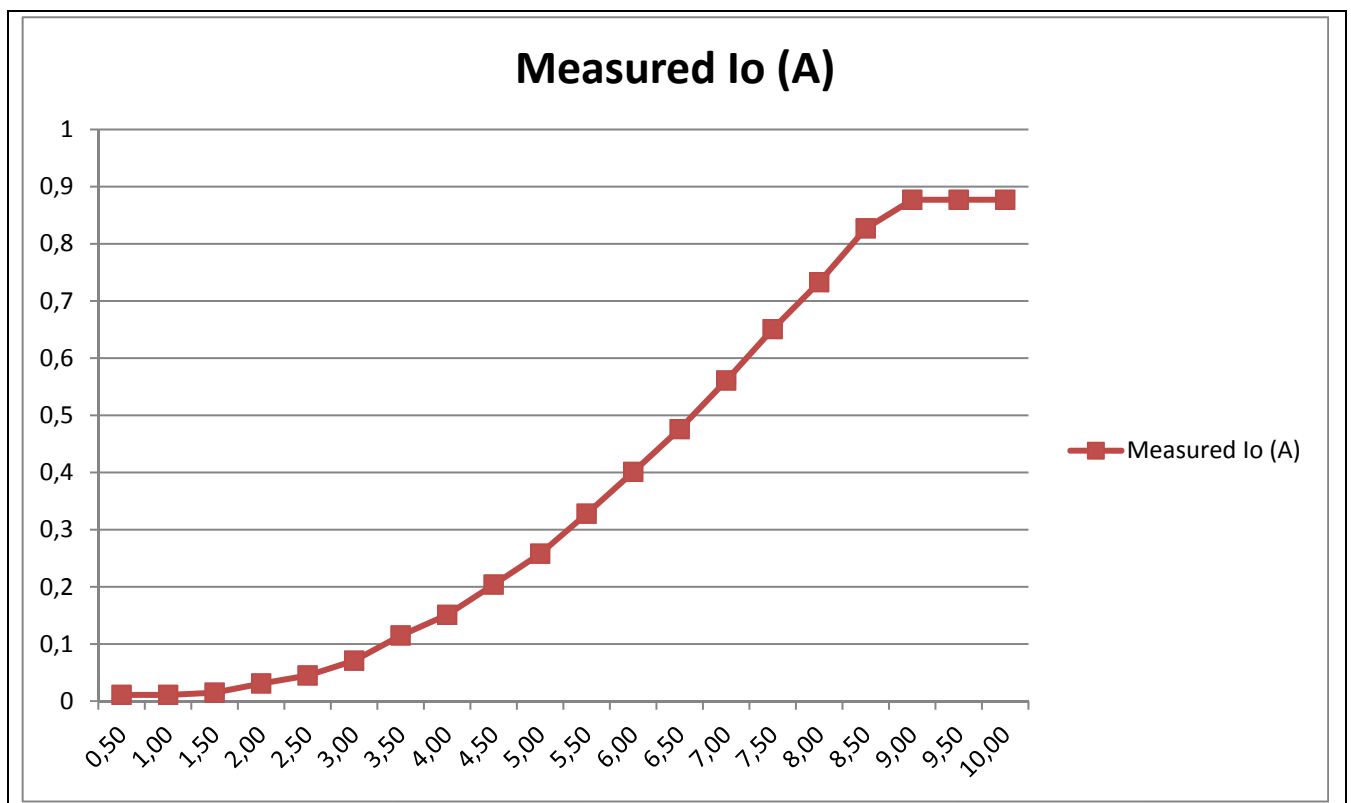


Figure 5 Dimming curve adapted to the sensitivity of the eye

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Bill of Materials

7 Bill of Materials

7.1 Bill of Materials

Table 6 Bill-of-materials

Designator	Value	Part Number	Manuf.	Quantity
BR1	RECT BRIDGE GPP 4A 600V GBU	GBU4J-BP	MICRO COMM.	1
C1, C2	CAP FILM 100nF 305VAC RADIAL	B32922C3104K	EPCOS INC	2
C3	CAP FILM 6800PF 630VDC RADIAL	B32529C8682K289	EPCOS INC	1
C4	CAP FILM 0.22uF 450VDC RADIAL	ECW-F2W224JAQ	Panasonic	1
C5	CAP CER 100pF 50V 10% X7R 0603	C1608X7R1H101M	TDK Corporation	1
C6	CAP ALUM 10uF 100V 20% RADIAL	UPM2A100MED1TD	NICHICON	1
C7	CAP CER 1uF 100V 10% X7R 1206	GRM31CR72A105KA01L	MURATA	1
C8	CAP CER 33uF 25V 10% X5R 1206	C3216X5R1E336M160AC	TDK Corporation	1
C9	CAP CER 2200PF 500V 20% RADIAL	VY1222M47Y5UQ63V0	VISHAY	1
C10	CAP FILM 1000PF 630VDC RADIAL	B32529C8102J	EPCOS	1
C11	CAP CER 0.1uF 50V 10% X7R 0603	GRM188R71H104KA93D	MURATA	1
C12, C13	CAP ALUM 470uF 63V 20% RADIAL	UHE1J471MHD6	NICHICON	2
C14	CAP CER 220PF 50V 10% X7R 0603	GRM188R71H221KA01D	MURATA	1
C15	CAP CER 1uF 10V 10% X7R 0603	GRM188R71A105KA61D	MURATA	1
C16	CAP CER 1uF 25V 10% X7R 0603	C1608X7R1E105K080AB	MURATA	1
C17	CAP CER 1000PF 16V 10% X7R 0603	C0603C102K4RACTU	Kemet	1
D1, D2	DIODE TVS 220V 1500W 5% UNI AXL	1.5KE220A	LITTELFUSE	2
D3	RECT FAST RECOVERY 1000V 3A SMB	RS3MB-13-F	DIODES	1
D4, D12	DIODE SW G-P 200V 250MA SOD80C	BAV102,115	NXP	2
D5, D7, D8, D10	DIODES INC. - BAV19W - DIODE, SS, 100V, 0.2A, SOD123	BAV19W	DIODES INC.	4
D6	DIODE SBR 200V 10A	SBR10U200P5-13	DIODES	1
D20, D21	ES1J - DIODE, FAST, 1A, 600V, SMD	ES1J	FAIRCHILD SEMICONDUCTOR	2
F1	FUSE 300V TL TE5 LL AMMO 2A	36912000000	LITTELFUSE	1
IC3	ICL8105	SP001073464	INFINEON	1
J1	TERM BLOCK 2POS 3.81MM PCB HORIZ	20020327-D021B01LF	FCI	1

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Bill of Materials

Table 6 Bill-of-materials

J2	CONN TERM BLOCK 3.81MM 2POS IDC	1706170	Phoenix Contact	1
J3	1MM UNINSULATED SHORTING PLUG	D3080-05	Harwin Inc	1
J4	CONN HEADER VERT .100 3POS 15AU	87224-3	TE	1
L1	COIL CHOKE 39MH 800MA PIN	B82732F2801B001	EPCOS	1
L2	INDUCTOR 470UH 1.15A RADIAL	7447480471	Würth Electronics	1
MOV1	SUR ABSORBER 10MM 510V 2500A ZNR	ERZ-V10D511	PANASONIC	1
Q1	MOSFET N-CH 800V 5.7A TO252-3	IPD80R1K0CEBTMA1	INFINEON	1
Q2	TRANSISTOR NPN AF 80V SOT-89	BCX 56 E6327	INFINEON	1
Q3, Q4	MOSFET N-CH 60V 300MA SOT-23	2N7002 L6327	INFINEON	2
Q5	TRANS DARL PNP AF 60V SOT-23	BCV 46 E6327	INFINEON	1
R1, R2	OPEN 1206			OPEN
R3	RES 4.7K OHM 1/4W 5% 1206 SMD	ERJ-8GEYJ472V	PANASONIC	1
R4, R5	RES 22K OHM 1/4W 5% 1206 SMD	ERJ-8GEYJ223V	PANASONIC	2
R6	RES 22K OHM 5% AXIAL	CFR-12JB-52-22K	Yageo	1
R7, R8	RES SMD 150K OHM 5% 1/4W 1206	ERJ-8GEYJ154V	PANASONIC	3
R10	RES 56.2K OHM 1/4W 1% 1206 SMD	ERJ-8ENF5622V	PANASONIC	1
R11	RES 2K OHM 1/10W 1% 0603 SMD	ERJ-3EKF2001V	PANASONIC	1
R12	RES 43K OHM 1/10W 1% 0603 SMD	ERJ-3EKF4302V	PANASONIC	1
R13	RES 5.6K OHM 1/10W 1% 0603 SMD	ERJ-3EKF5601V	PANASONIC	1
R14, R15	RES 0.4 OHM 1/4W 1% 1206 SMD	RL1206FR-070R4L	Yageo	2
R16	RES 10 OHM 1/8W 1% 0805 SMD	ERJ-6ENF10R0V	PANASONIC	1
R17	RES 47K OHM 1/4W 5% 1206 SMD	ERJ-8GEYJ473V	PANASONIC	1
R18	RES 4.7 OHM 1/4W 1% 1206 SMD	RC1206FR-074R7L	Yageo	1
R19	RES 2.2K OHM 1/4W 1% 1206 SMD	ERJ-8ENF2201V	PANASONIC	1
R20	RES 68K OHM 1/10W 1% 0603 SMD	ERJ-3EKF6802V	PANASONIC	1
R21	RES 150 OHM 1/10W 1% 0603 SMD	ERJ-3EKF1500V	PANASONIC	1
R22	RES 8.2K OHM 1/4W 5% AXIAL	CFR-25JB-52-8K2	Yageo	1
R23	RES 30K OHM 1/4W 1% 1206 SMD	ERJ-8ENF3002V	PANASONIC	1
R24	RES 30K OHM 1/4W 5% AXIAL	CFR-25JB-52-30K	Yageo	1
R25	RES 91K OHM 1/10W 1% 0603 SMD	ERJ-3EKF9102V	PANASONIC	1
R26	RES 27K OHM 1/10W 1% 0603 SMD	ERJ-3EKF2702V	PANASONIC	1

40W Demoboard with Isolated 0-10V Dimming Interface Single-Stage Multi-Mode Flyback Controller with PFC



Bill of Materials

Table 6 Bill-of-materials

R27, R28	RES 1M OHM 1/10W 5% 0603 SMD	ERJ-3GEYJ105V	PANASONIC	2
R29, R30	RES 2K OHM 1/4W 1% 1206 SMD	ERJ-8GEYJ202V	PANASONIC	2
T1	Transformer PQ20/20 0.54mH	750314100	Würth Electronics	1
T2	Signal Transformer	750314131	Würth Electronics	1
ZD1	DIODE ZENER 18V 200MW SOD323	DDZ9705S-7	DIODES	2
ZD2	MMSZ5241B-V-GS08 - ZENER DIODE 11V	MMSZ5241B-V-GS08	VISHAY	1
ZD4, ZD5	DIODE ZENER 12V 200MW SOD323	BZT52C12S-7-F	DIODES	2
AUX	TEST POINT PC MULTI PURPOSE WHT	5012	Keystone Electronics	1
GD	TEST POINT PC MULTI PURPOSE WHT	5012	Keystone Electronics	1
GND	TEST POINT PC MULTI PURPOSE WHT	5012	Keystone Electronics	1
VCC	TEST POINT PC MULTI PURPOSE WHT	5012	Keystone Electronics	1

40W Demoboard with Isolated 0-10V Dimming Interface Single-Stage Multi-Mode Flyback Controller with PFC

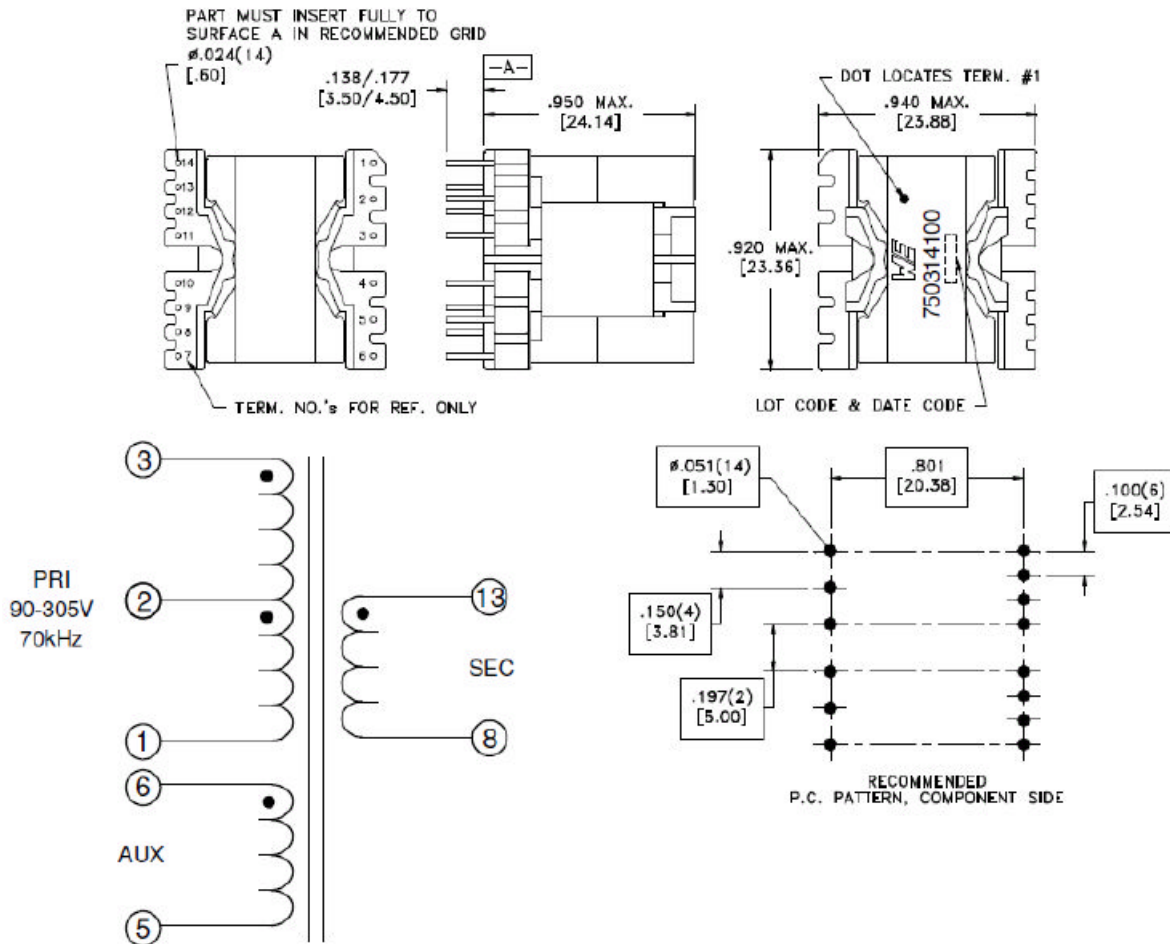


Bill of Materials

7.2 Transformer Specifications

This section provides the transformer design data. The necessary steps to design a transformer based on the design specification can be found in the ICL8105 Design Guide [2]

Main transformer specifications



ELECTRICAL SPECIFICATIONS @ 25 °C unless otherwise noted:

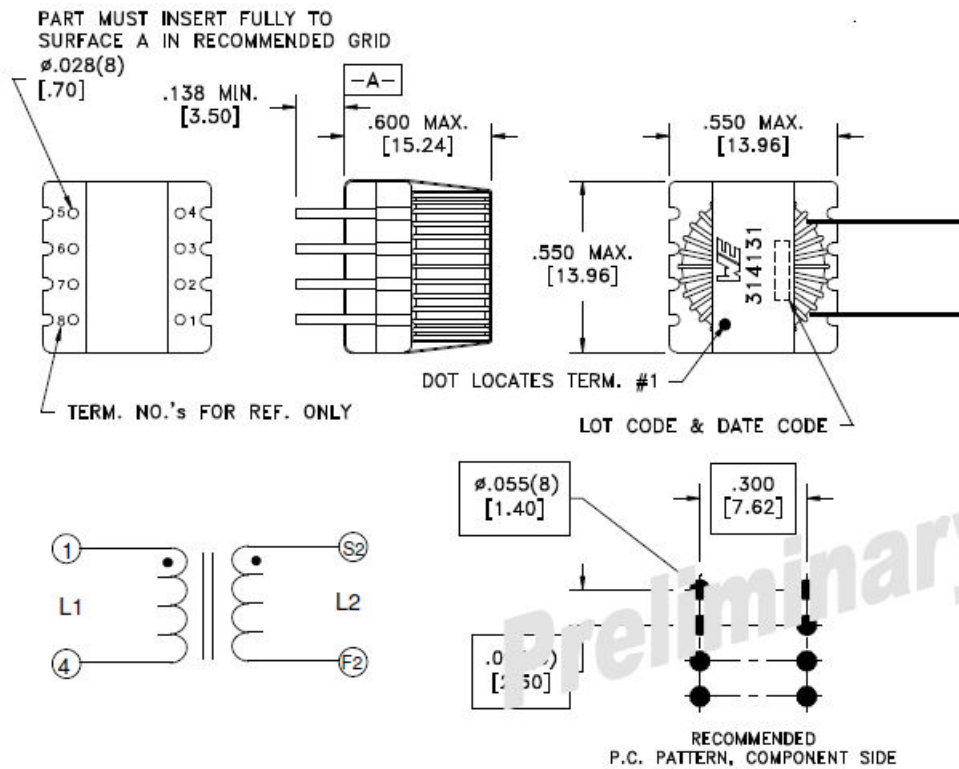
D.C. RESISTANCE (@20 °C):	3-1, 0.770 Ohms $\pm 10\%$. 6-5, 0.300 Ohms $\pm 10\%$. 13-8, 0.067 Ohms $\pm 10\%$.
DIELECTRIC RATING:	1616VAC, 1 minute tested by applying 2020VAC for 1 second between pins 3-13(tie 3+5).
INDUCTANCE:	540.0 μ H $\pm 10\%$, 10kHz, 100mVAC, 0mADC, 3-1, Ls.
SATURATION CURRENT:	3.0A saturating current that causes 20% rolloff from initial inductance.
LEAKAGE INDUCTANCE:	5.0 μ H $\pm 100\%$, 100kHz, 100mVAC, 3-1(5+6,8+13), Ls.
URNS RATIO:	(3-1):(13-8), (3.882):(1.00), $\pm 1\%$. (3-1):(6-5), (3.882):(1.00), $\pm 1\%$.

Dimming transformer specifications

40W Demoboard with Isolated 0-10V Dimming Interface Single-Stage Multi-Mode Flyback Controller with PFC



Bill of Materials



ELECTRICAL SPECIFICATIONS @ 25°C unless otherwise noted:

D.C. RESISTANCE (@20°C):	1-4 , 0.32 Ohms $\pm 10\%$. S2-F2 , 0.52 Ohms $\pm 10\%$.
DIELECTRIC RATING:	3000VAC, 1 minute tested by applying 3750VAC for 1 second between pins 1-S2.
INDUCTANCE:	5.0 mH min, 10kHz, 300mVAC, 0mADC, 1-4, Ls. 5.0 mH min, 10kHz, 300mVAC, 0mADC, S2-F2, Ls.
TURNS RATIO:	(1-4):(S2-F2) , (1):(1.00), $\pm 1\%$.

References

8 References

- [1] ICL8105 Datasheet
- [2] ICL8105 Design Guide
- [3] .dp vision – Basic Mode User Manual
- [4] Power Management Selectionguide:
<http://www.infineon.com/powermanagement-selectionguide>

Revision History

Major changes since the last revision

Page or Reference	Description of change

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