APPLICATION NOTE 4387

Offline LED Driver Reference Design

By: Jim Christensen

Abstract: This application note presents a reference design for a nonisolated LED driver intended to operate directly from a 400V$_{DC}$ input. The design drives a string of 27 WLEDs (white LEDs) or, optionally, 6 amber LEDs at 400mA. The topology is a discontinuous flyback with a transformer. The MAX16801 HB (high brightness) LED controller is featured.

Brief Circuit Description

This reference design is a flyback LED driver for offline environments (400V$_{DC}$). The design can drive 27 WLEDs (white LEDs) at 400mA. With the jumper, J1, installed, the design drives 6 amber LEDs at 400mA. The design uses the MAX16801 HB LED controller and a three-winding transformer (coupled inductor). There is no electrical isolation as the current sense is fed directly into the IC control loop.

The transformer has an 18:6:1 turns ratio. Primary inductance is 800µH with a current rating of 750mA (peak) and a duty cycle always less than 50%.

The frequency of operation is 265kHz and is nonadjustable. Overvoltage protection (nonlatching) is at 120V. The UV detect level is 310V. The turn-on delay time is about 43msec, after which V$_{IN}$ will be about 22V and the IC will begin to drive the external MOSFET. This will, in turn, cause the V$_{IN}$ capacitor to decay until the bootstrap winding can provide support. Because of the high impedance of the LEDs at low voltage, the main secondary load will initially be only the output capacitor. The secondary-to-tertiary turns ratio is 6:1, which means that the bootstrap winding will supply 10V to the IC as soon as 60V develops across the output capacitor. For the 6-LED string option (i.e., with J1 installed), the output capacitor must, obviously, charge to 10.7V before 10V is available to the IC.

The calculated peak current in the primary winding of the inductor is 750mA. Leakage inductance is minimized by a split primary that sandwiches the secondary winding. The primary leakage inductance is measured at less than 5µH. Because of this low value, there is no special provision for dissipating the leakage inductance energy; all leakage energy is dissipated in the MOSFET itself. The transformer temperature rise is less than 30°C.

The switching MOSFET has an isolated tab, which allows the heatsink to be connected to ground. This minimizes the metallic surface area that experiences high-speed voltage transients, and, in turn, minimizes radiated EMI. The MOSFET sees less than a 40°C rise in temperature.

V$_{IN}$:	400V$_{DC}$ ±10%
PWM:	N/A
V$_{LED}$ config.:	27 LEDs (2.8V$_{DC}$ to 4V$_{DC}$) in series (75.6V$_{DC}$ min to 108V$_{DC}$ max); 400mA
	With jumper: 6 LEDs (2V$_{DC}$ to 3V$_{DC}$) in series (12V min to 18V max); 400mA
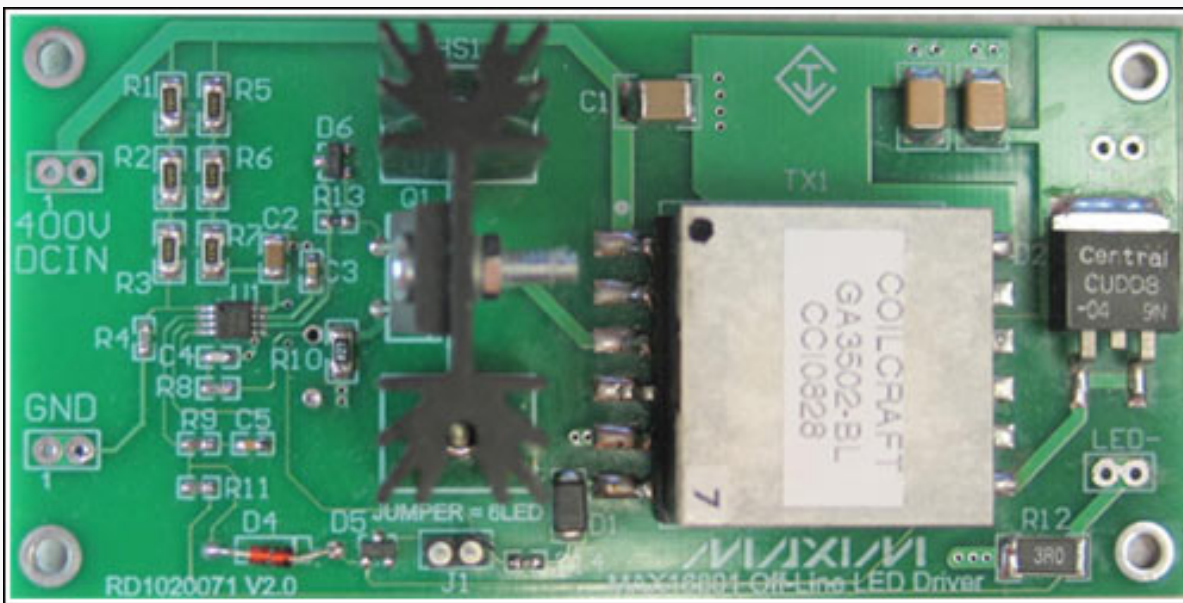
[More detailed image](#) (PDF, 35.6kB)

Figure 1. The LED driver reference design is 1.9in x 3.9in, double sided.
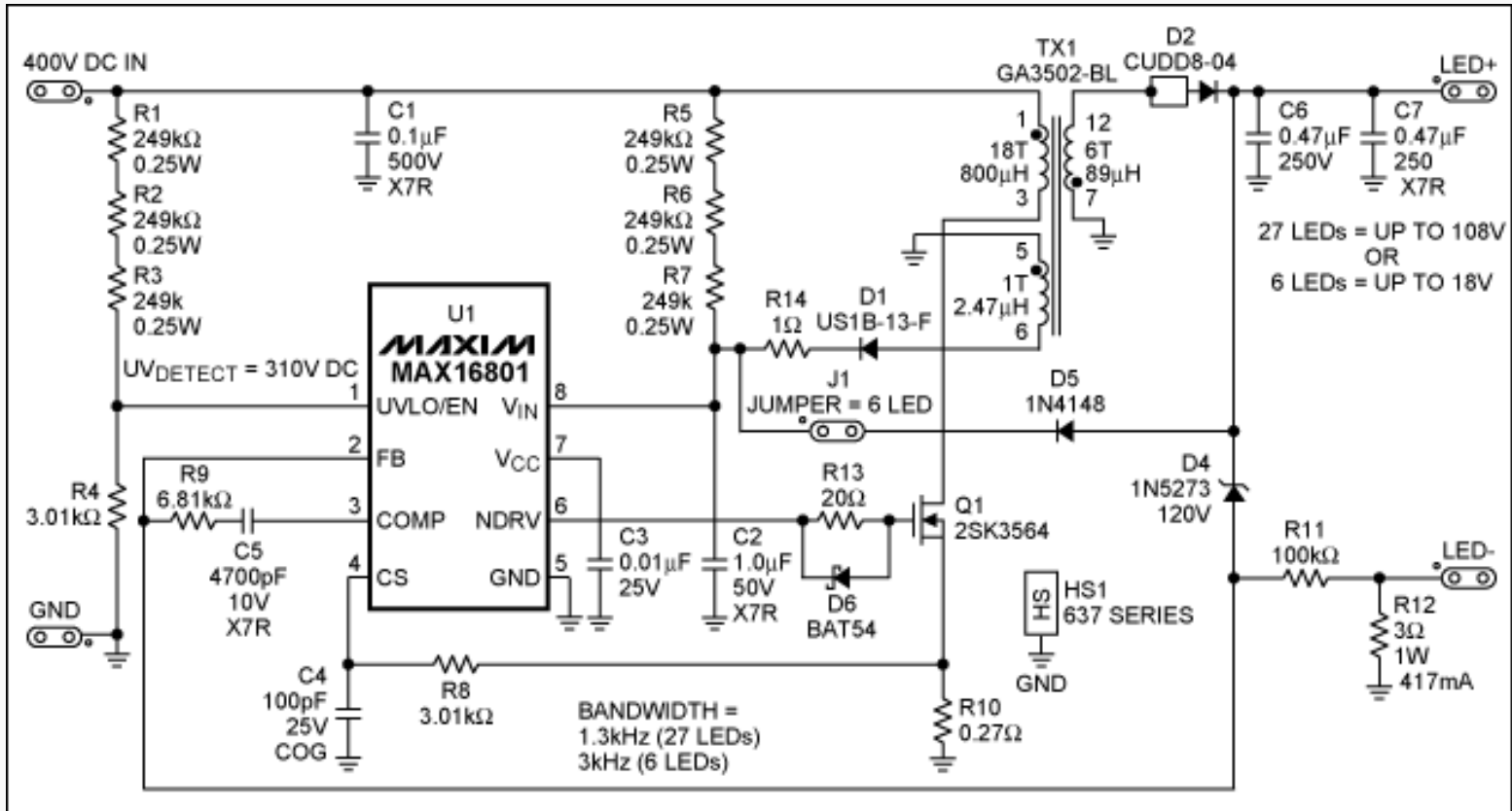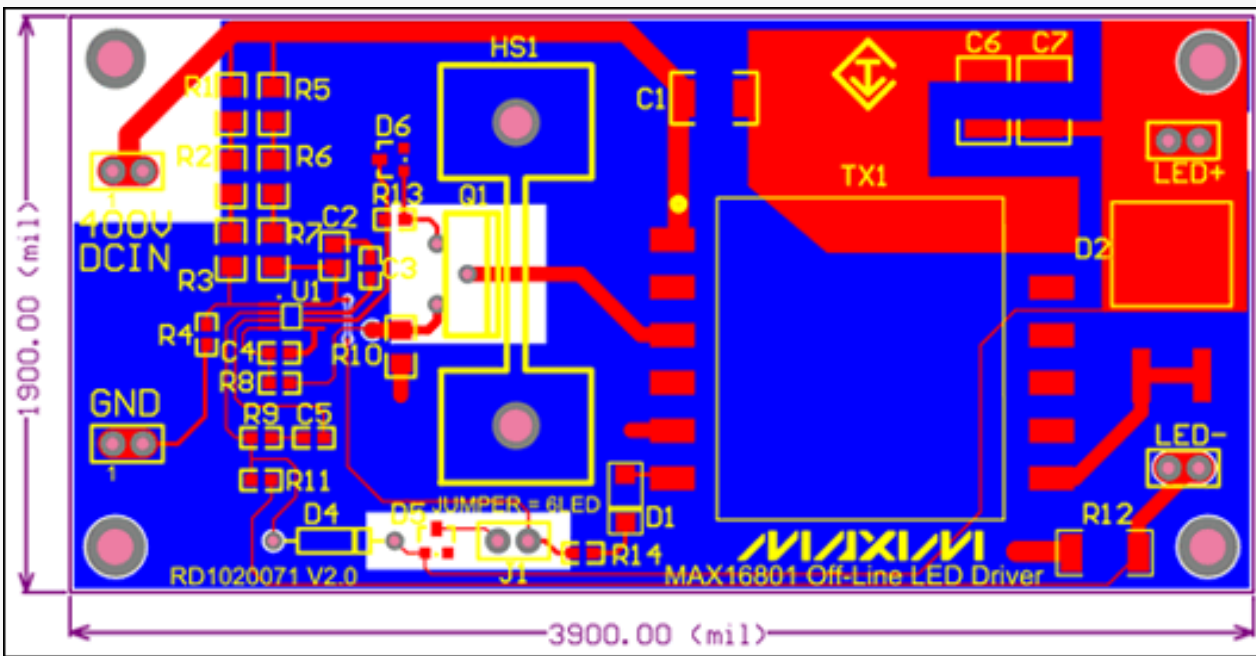

Figure 2. Schematic of the LED driver reference design.

[More detailed image](#) (PDF, 36.88kB)
Figure 3. Board layout of the LED driver.

Coilcraft — TEST DATA SHEET

| Customer: | MAXIM | | Sample Number: | GA3502-BL | | Page 1 |
| Part Number: | | | EWO Number: | 26912 | | |

Parameter	L @ 0 ADC		L @ .75 ADC		DCR	DCR	DCR	DCR		LL	TR	TR		HI POT	HI POT	HI POT
Pins	1-3		1-3		1-2	2-3	5-6	12-7		1-3	5-6	12-7		1,2,3,4,5,6 to 7,12	1,2,3 to 5,6	all pins to core
Min Spec	720		720								0.057	0.342		1500	500	500
Max Spec	880				0.628	0.665	0.146	0.361		6.6	0.061	0.363		1 min.	1 min.	1 min.
Units	µH		µH		Ω	Ω	Ω	Ω		µH				VRMS	VRMS	VRMS
1	806		800		0.572	0.607	0.127	0.331		4.57	0.06	0.351		PASS	PASS	PASS
2	798		796		0.572	0.603	0.127	0.331		4.43	0.059	0.355		PASS	PASS	PASS
3	798		795		0.57	0.605	0.127	0.332		4.43	0.059	0.352		PASS	PASS	PASS
4																
5																
6																
7																
8																
9																
10																
11																
12																
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16																
17																
18																
19																
20																
Average	800.667		797		0.57133	0.605	0.127	0.33133		4.47667	0.05933	0.35267				

Test Instruments Used:

Tester for L	Tester for LL	Tester for C	Tester for DCR	Tester for V/R	Tester for L.B.	Tester for SRF	Q tester
HP4284A	HP4284A	N/A	Keithley 580	VT AT3600	N/A	N/A	N/A

Note: For additional information see product specifications

Comments: _____

TESTED BY: J. PERRY
VALIDATED BY: _____
Form-CW016 Rev. J

[More detailed image](#) (PDF, 88.75kB)
Figure 4. Transformer specifications.

Component list

Source Data From: RD071408JC.PrjPCB
Project: Offline Flyback LED Driver
Variant: None

#	Designator	LibRef	Comment	Footprint	uanti	Notes
1	C1	CAPACITOR - NONPOLARIZED	.1uF, 500V,X7R	1812	1	
2	C2	CAPACITOR - NONPOLARIZED	1.0uF,50V,X7R	0805	1	
3	C3	CAPACITOR - NONPOLARIZED	.01uF, 25V	0603	1	
4	C4	CAPACITOR - NONPOLARIZED	100pF,25V,COG	0603	1	
5	C5	CAPACITOR - NONPOLARIZED	4700pF,10V,X7R	0603	1	
6	C6	CAPACITOR - NONPOLARIZED	.47uF,250V	1812	1	
7	C7	CAPACITOR - NONPOLARIZED	.47uF,250V,X7R	1812	1	
8	D1	DIODE	US1B-13-F	SMA	1	
9	D2	DIODE - D2PAK	CUDD8-04	D2PAK	1	
10	D4	DIODE - ZENER - 2LEAD	1N5273	AXIAL - 400MIL	1	
11	D5	DIODE	1N4148	SOT23-3	1	
12	D6	DIODE - SCHOTTKY	BAT54	SOT23-3	1	
13	HS1	HEAT SINK	637 SERIES	HEAT SINK -- 637 SERIES	1	
14	Q1	MOSFET - N CHANNEL	2SK3564	TO-220 Stand up offset	1	
15	R1, R2, R3, R5, R6, R7	RESISTOR	249K,.25W	1206	6	
16	R4, R8	RESISTOR	3.01K	0603	2	
17	R9	RESISTOR	6.81K	0603	1	
18	R10	RESISTOR	0.27	1206	1	
19	R11	RESISTOR	100K	0603	1	
20	R12	RESISTOR	3, 1W	2512	1	
21	R13	RESISTOR	20.0	0603	1	
22	R14	RESISTOR	1.00	0603	1	
23	TX1	TRANSFORMER - 3 WINDING - NO SH	GA3502-BL	TXFR - COILCRAFT EDF25	1	
24	U1	MAX16801	MAX16801	UMAX8/TDFN8	1	

More detailed image (PDF, 76.43kB)
Figure 5. BOM for the reference design.

Application note 4387: www.maxim-ic.com/an4387

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