Design Example Report

Title	***0.5W Non-Isolated Buck-Boost Converter using the LNK302P***
Specification	Input: 85-265 VAC Output: 0.5W, 40mA Constant current
Application	LED Driver
Author	Power Integrations Applications Department
Document Number	DER-92
Date	August 11, 2005
Revision	1.0

Summary and Features

- Low component count (only 9 components required)
- Low Cost, light weight, compact solution
- No Opto-Coupler required
- Open loop operation
- High efficiency (~70%)
- Meets EN55022 B EMI limits with > 8 dB margin

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Table Of Contents

Important Note:
Although this board is designed to satisfy safety isolation requirements, the engineering prototype has not been agency approved. Therefore, all testing should be performed using an isolation transformer to provide the AC input to the prototype board.

Design Reports contain a power supply design specification, schematic, bill of materials, and transformer documentation. Performance data and typical operation characteristics are included. Typically only a single prototype has been built.

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1 Introduction

This document is an engineering report describing a 0.5 W constant current LED driver power supply utilizing a LNK302P. This power supply is intended as a LED driver that can be used in emergence exit signs and neon light replacements

The document contains the power supply specification, schematic, bill of materials, printed circuit layout, and performance data.

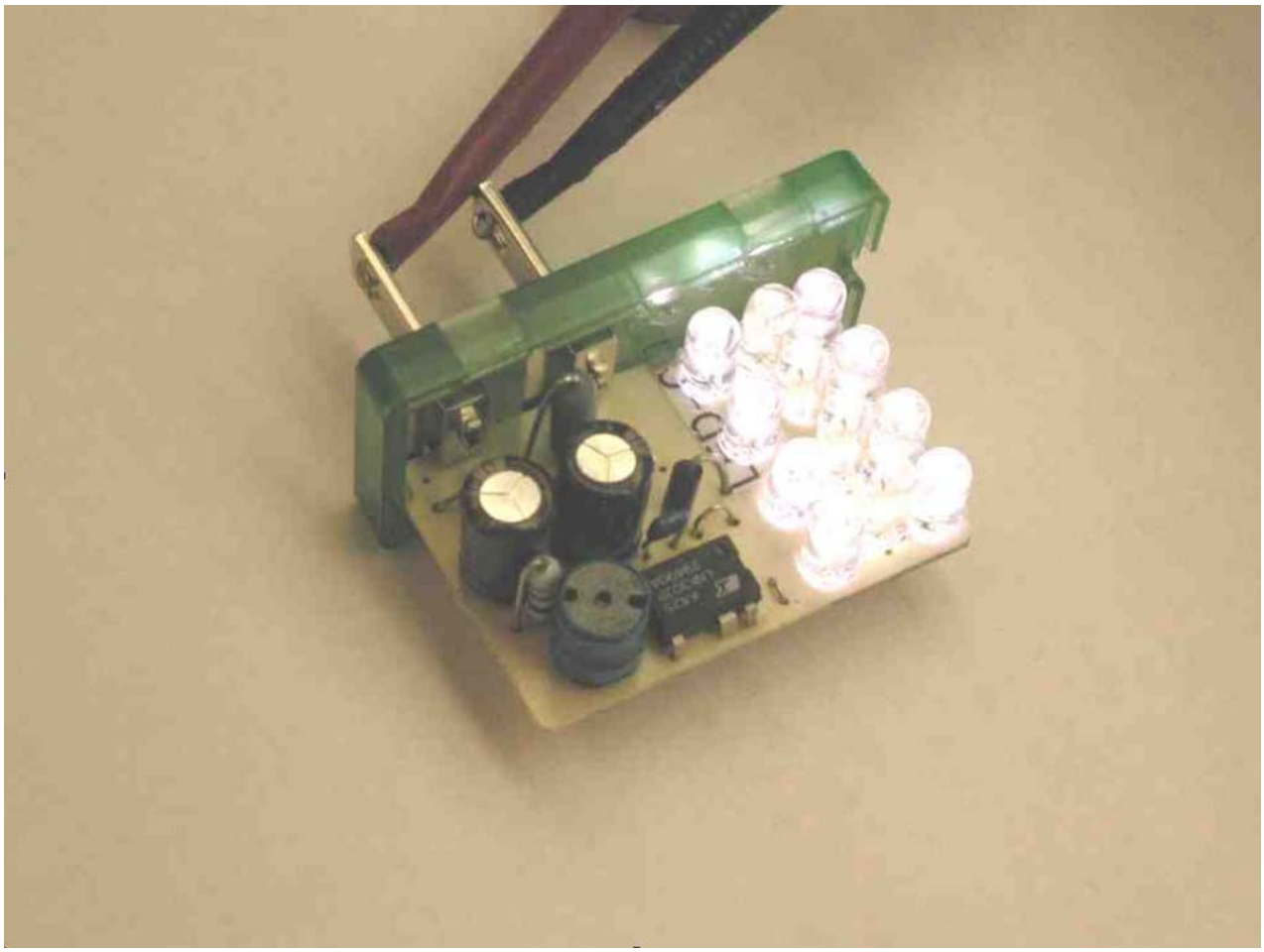

Figure 1 - Populated Circuit Board Photograph

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2 Power Supply Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	85		265	VAC	2 Wire – no P.E.
Frequency	f_{LINE}	47	50/60	64	Hz	
No-load Input Power (230 VAC)			-		W	
Output						
Output Voltage 1	V_{OUT1}		13		V	± 5%
Output Ripple Voltage 1	$V_{RIPPLE1}$				mV	20 MHz bandwidth
Output Current 1	I_{OUT1}		40		mA	
Total Output Power						
Continuous Output Power	P_{OUT}		0.5		W	
Peak Output Power	P_{OUT_PEAK}		0.5		W	
Efficiency						
Full Load	η		70		%	Measured at P_{OUT} 25 °C
Environmental						
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Surge					kV	1.2/50 μs surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω
Surge					kV	100 kHz ring wave, 500 A short circuit current, differential and common mode
Ambient Temperature	T_{AMB}	0	25	50	°C	Free convection, sea level

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3 Schematic

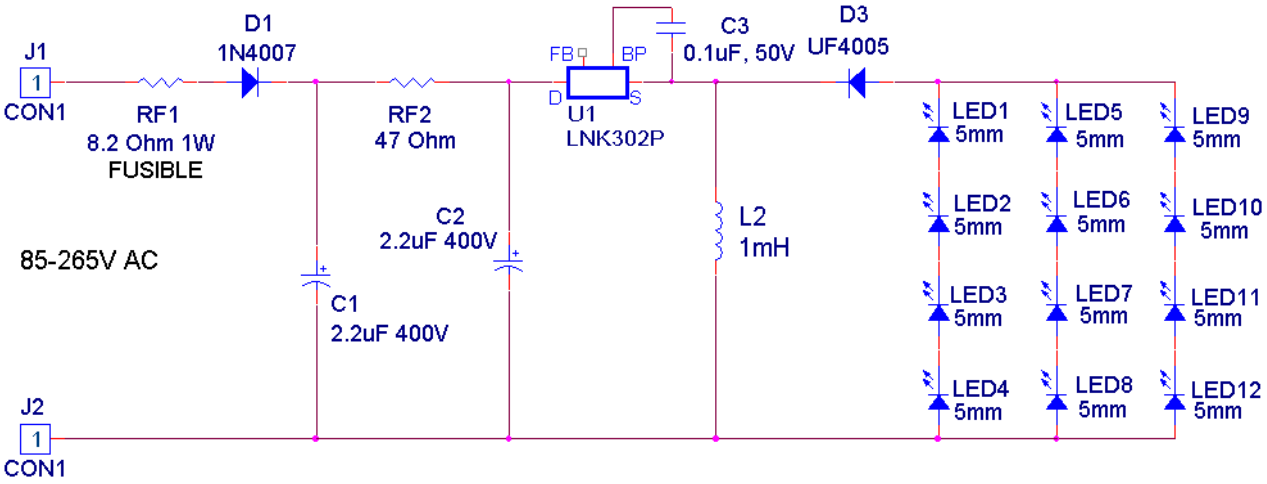

Figure 2 - Schematic

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4 Circuit Description

This is a very simple circuit, which requires as few as 9 components. An additional input diode may be placed on the return leg for EMI and surge withstand capability

4.1 Input EMI Filtering

Resistors RF1, RF2 and capacitors C1 and C2 form the EMI filter. C1 C2 and RF2 are connected to form a low cost resistive π filter and provide excellent differential mode filtering and also serve as the stable DC bus voltage. Resistor RF1 is a fusible flameproof type while RF2 can be only flameproof.

4.2 LinkSwitch-TN

LNK302P is used in open loop mode for this circuit. This particular device in the ***LinkSwitch-TN*** family does not have the auto restart feature, and thus when the feedback pin is left open, the MOSFET switches every cycle until current limit (or duty cycle limit) is reached.

4.3 Output Rectification

Since this circuit operates strictly in the discontinuous conduction mode (DCM) a 75 nS recovery time UF4005 diode is used for output rectification. The buck boost topology also provides benefits of isolating the output from the input in case of Switch failure

4.4 Circuit Operation

This LED driver operates at 66 kHz and energy is provided to the LED's every switching cycle. Since the circuit operates in discontinuous mode, a fixed amount of energy is stored each cycle in L2, then is completely transferred to the load (i.e. the LEDs). The current in the LED is a triangular waveform, whose peak is determined by the fixed and well-controlled current limit of the LNK302. The load current is thus independent of line voltage. As such the need for output filter capacitor is completely eliminated.

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5 PCB Layout

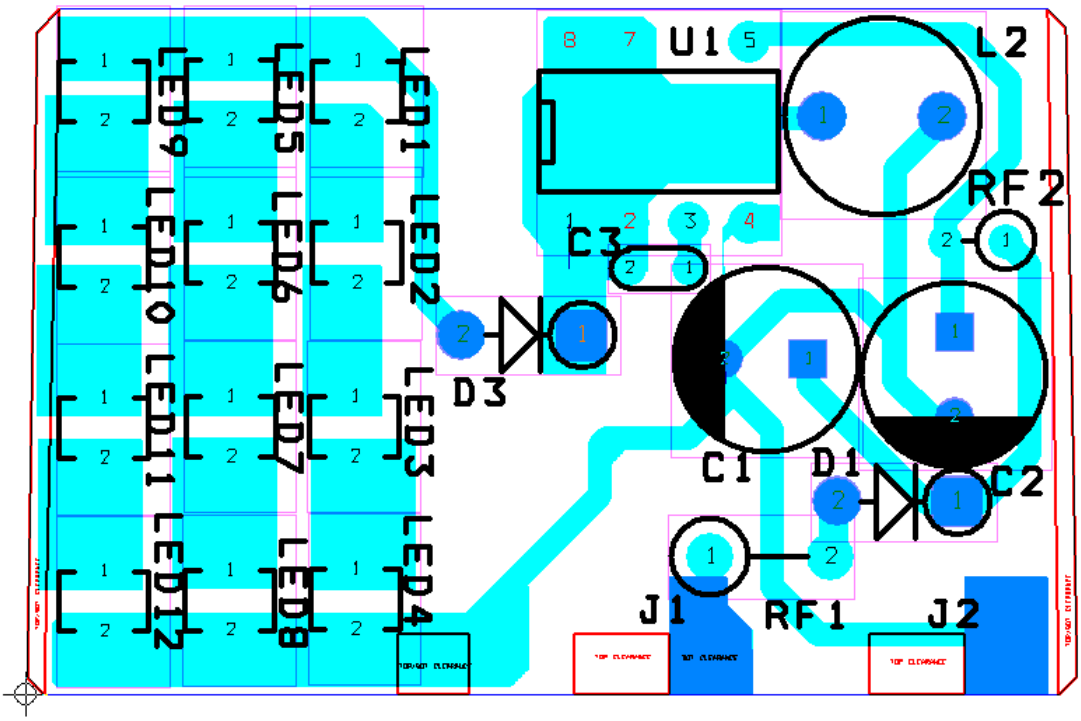

Figure 3 - Printed Circuit Layout

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6 Bill Of Materials

Item	Quantity	Reference	Part	Description	Manufacturer
1	2	C1,C2	2.2 uF	400 V input capacitors	UCC
2	1	C3	0.1 uF, 50 V (ECU-S1H104KBB)	Bypass pin capacitor	Panasonic
3	1	D1	1N4007	Input rectifier diode	Diodes Inc (or Generic)
4	1	D3	UF4005	Output rectifier diode	Gen Semiconductor (or generic)
5	2	J1,J2	CON1	AC Input connector	Generic
6	12	LED1,...12	5mm	Super bright White LED's	OSRAM
7	1	L2	SBC1-102-211	1 mH inductor	Tokin
8	1	RF1	8.2 Ohm 1W	1W, Fusible and Flameproof	VTM
9	1	RF2	47 Ohm, Flameproof	Flameproof	VTM
10	1	U1	LNK302P	LinkSwitch-TN	Power Integrations

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7 Spreadsheet

ACDC_LinkSwitch-TN_BuckBoost_042605; Rev.2.0; Copyright Power Integrations 2004	INPUT	INFO	OUTPUT	UNIT	LinkSwitch-TN_BuckBoost_Rev2-0.xls: LinkSwitch-TN Design Spreadsheet
INPUT VARIABLES					**Customer**
VACMIN	85			Volts	Minimum AC Input Voltage
VACMAX	265			Volts	Maximum AC Input Voltage
FL	50			Hertz	Line Frequency
VO	12.50			Volts	Output Voltage
IO	0.035			Amps	Output Current
EFFICIENCY (User Estimate)	0.75				Overall Efficiency Estimate (Adjust to match Calculated, or enter Measured Efficiency)
EFFICIENCY (Calculated Estimate)			0.65		Calculated % Efficiency Estimate
CIN	4.40		4.40	uF	Input Filter Capacitor
Input Stage Resistance	8.2		8.2	ohms	Input Stage Resistance, Fuse & Filtering
Ambient Temperature			50	deg C	Operating Ambient Temperature (deg Celcius)
Input Rectification Type	H		*H*		Choose H for Half Wave Rectifier and F for Full Wave Rectification
DC INPUT VARIABLES					
VMIN			99.7	Volts	Minimum DC Bus Voltage
VMAX			374.8	Volts	Maximum DC Bus Voltage
LINKSWITCH-TN					
LINKSWITCH-TN			LNK302		Selected LinkSwitch-TN
ILIMIT			0.136	Amps	Typical Current Limit
ILIMIT_MIN			0.136	Amps	Minimum Current Limit
ILIMIT_MAX			0.146	Amps	Maximum Current Limit
FSMIN			66000	Hertz	Minimum Switching Frequency
VDS			12.0	Volts	Maximum On-State Drain To Source Voltage drop
PLOSS_LNK			0.20	Watts	Estimated LinkSwitch-TN losses
DIODE					
VD			0.70	Volts	Freewheeling Diode Forward Voltage Drop
VRR			600	Volts	Recommended PIV rating of Freewheeling Diode
IF			1	Amps	Recommended Diode Continuous Current Rating
TRR			75	ns	Recommended Reverse Recovery Time
Diode Recommendation			**UF4005**		**Suggested Freewheeling Diode**
OUTPUT INDUCTOR					
L_TYP			989.2	uH	Required value of Inductance to deliver Output Power (Includes device and inductor tolerances) Choose next higher standard available value
L			**1000**	**uH**	**Output Inductor, Recommended Standard Value**
L_R			2.0	Ohms	DC Resistance of Inductor
OPERATING MODE			**DCM**		**Discontinuous Conduction Mode (at VMIN)**
KL_TOL			1.15		
K_LOSS			0.833		
ILRMS			0.06	Amps	Estimated RMS inductor current (at VMAX)

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8 Performance Data

All measurements performed at room temperature, 60 Hz input frequency.

8.1 Efficiency

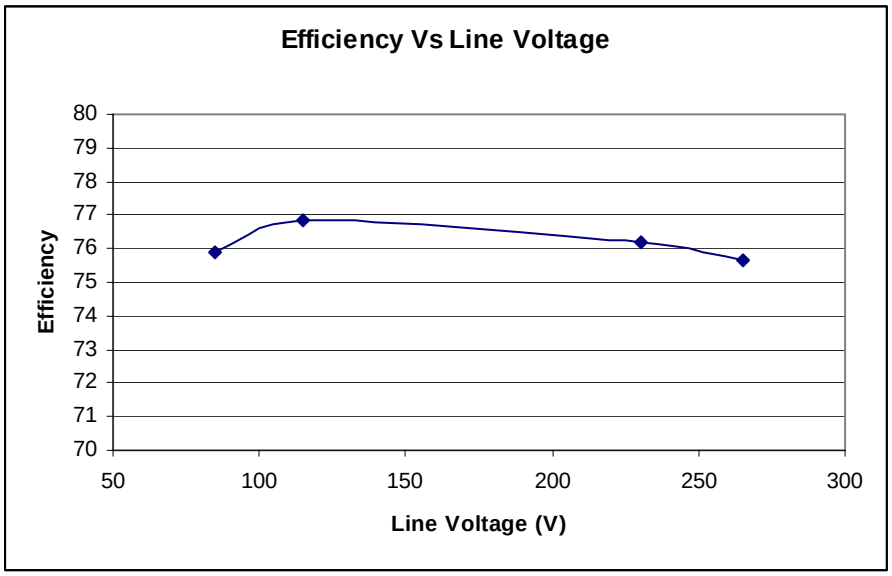

Figure 4 - Efficiency Vs Line Voltage

9 Waveforms

9.1 Drain Voltage and Current, Normal Operation

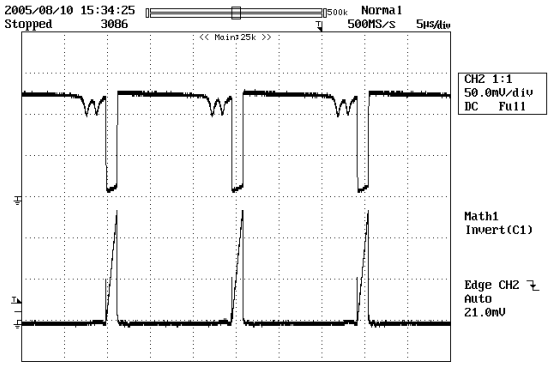

Figure 5 - 85 VAC, Full Load.
Upper: I_{DRAIN}, 50 mA / div
Lower: V_{DRAIN}, 50 V, 5 µs / div

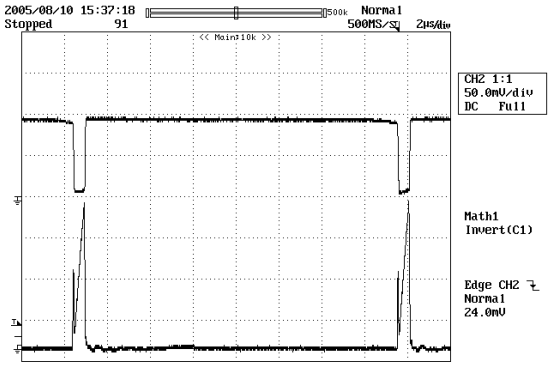

Figure 6 - 265 VAC, Full Load
Upper: I_{DRAIN}, 50 mA / div
Lower: V_{DRAIN}, 200 V / div, 2 µs / div

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9.2 Output Current, Normal operation

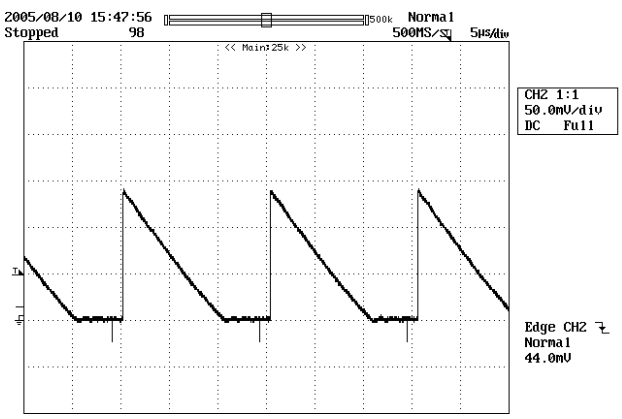

Figure 7 - 115VAC
50 ms / div. 5 µs / div

Figure 8 - Start-up Profile, 230 VAC
50 ms / div. 2 µs / div

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10 Conducted EMI

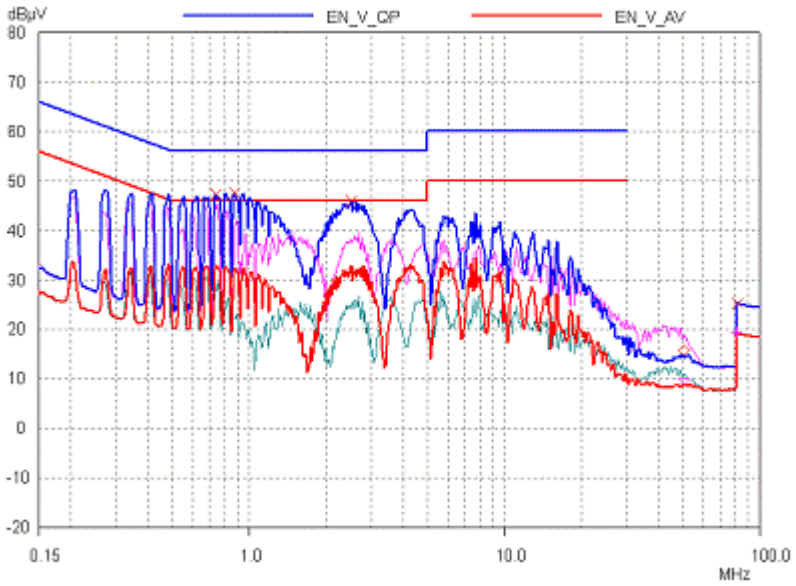

Figure 9 - Conducted EMI, Maximum Steady State Load, foreground shows 230 VAC, background shows 115 VAC, 60 Hz, and EN55022 B Limits.

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11 Revision History

Date	Author	Revision	Description & changes	Reviewed
August 11, 2005	SK	1.0	First Draft	AM / VC

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