Title	***Engineering Design Proposal For 17W Single Stage Low THD PFC LED Driver Using LNK416EG***
Specification	Input: 100VAC – 270VAC Output: 38V / 450mA CC EMI:CISPR15 Class B Harmonics : IEC61000 3-2, ITHD <10% Target Surge: IEC61000 4-5 (2KV diff.)
Application	LED Driver
Author/Date/Rev.	SBV/26-03-2013/R1.0

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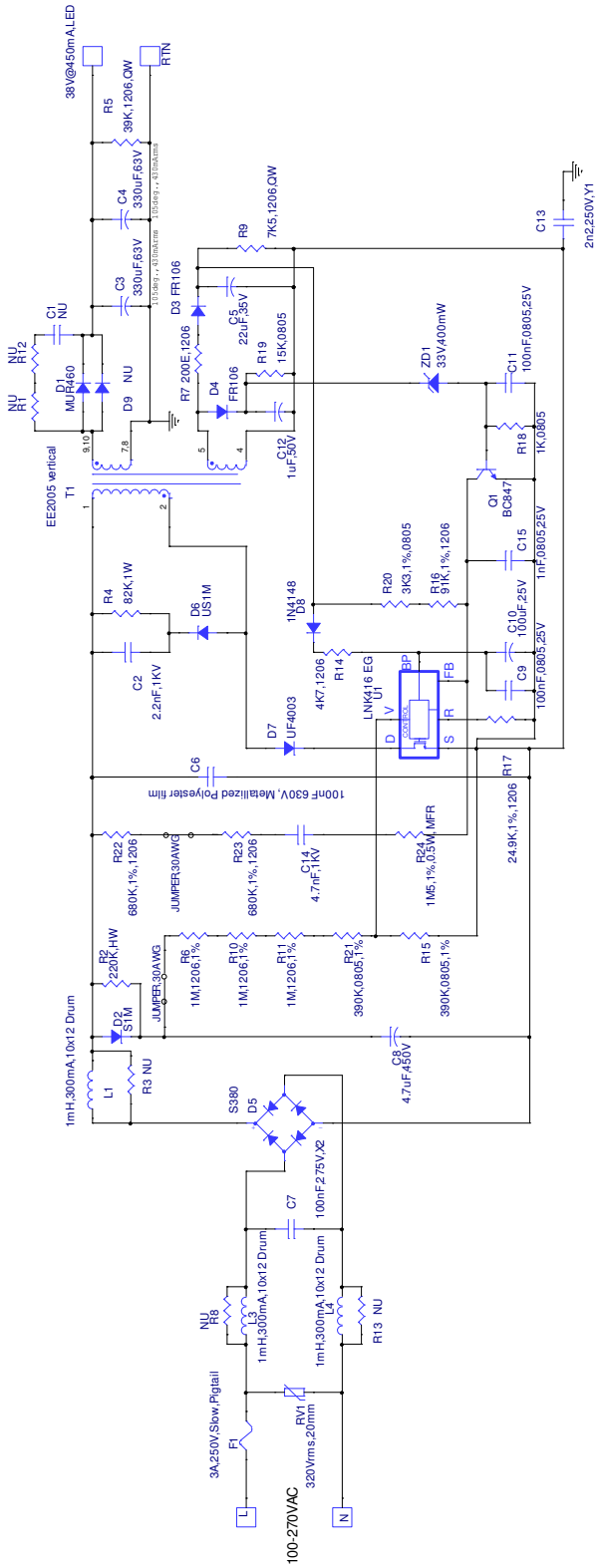
1 Schematic Diagram



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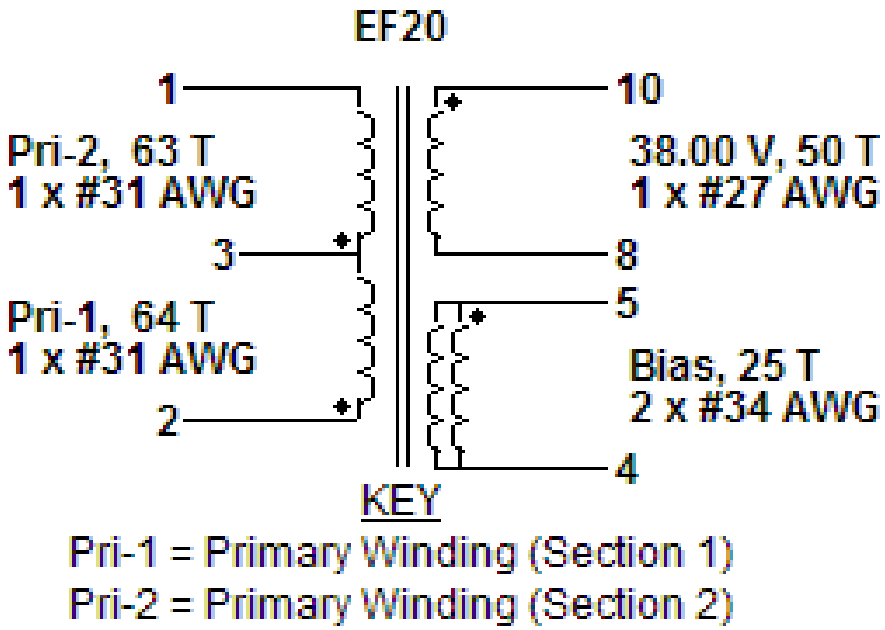
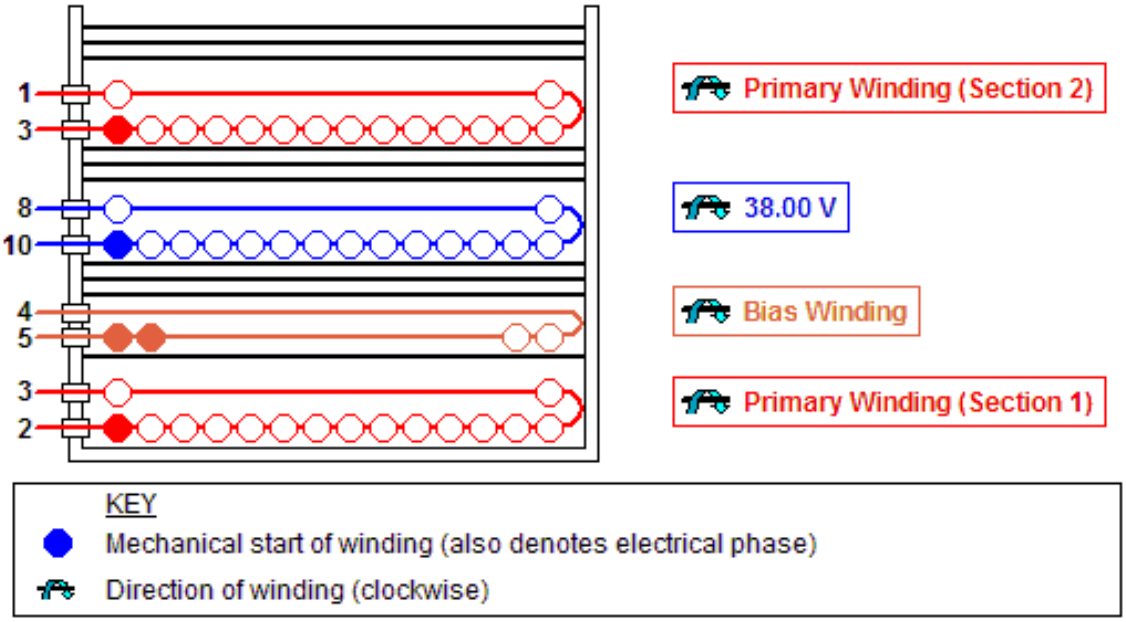
2 Transformer Details

Electrical Diagram



Mechanical Diagram



Winding Instruction

Primary Winding (Section 1)

Start on pin(s) 2 using item [4] at the start leads and wind 64 turns (x 1 filar) of item [7] in 2 layer(s) from left to right. At the end of 1st layer, continue to wind the next layer from right to left. On the final layer, spread the winding evenly across entire bobbin. Finish this winding on pin(s) 3 using item [4] at the finish leads.

Add 1 layer of tape, item [3], for insulation.

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Bias Winding

Start on pin(s) 5 using item [4] at the start leads and wind 25 turns (x 2 filar) of item [8]. Wind in same rotational direction as primary winding. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 4 using item [4] at the finish leads.

Add 3 layers of tape, item [3], for insulation.

Secondary Winding

Start on pin(s) 10 using item [4] at the start leads and wind 50 turns (x 1 filar) of item [9]. Spread the winding evenly across entire bobbin. Wind in same rotational direction as primary winding. Finish this winding on pin(s) 8 using item [4] at the finish leads.

Add 3 layers of tape, item [3], for insulation.

Primary Winding (Section 2)

Start on pin(s) 3 using item [4] at the start leads and wind 63 turns (x 1 filar) of item [7] in 2 layer(s) from left to right. At the end of 1st layer, continue to wind the next layer from right to left. On the final layer, spread the winding evenly across entire bobbin. Finish this winding on pin(s) 1 using item [4] at the finish leads.

Add 3 layers of tape, item [3], for insulation.

Core Assembly

Assemble and secure core halves. Item [1].

Flux-Band

Construct a flux band by wrapping a single shorted turn of item [5] around the outside of windings and core halves with tight tension. Make an electrical connection to pin(s) 1 using wire.

Add 3 layers of tape, item [3], for insulation.

Varnish

Dip varnish uniformly in item [6]. Do not vacuum impregnate.

Comments

Materials

Item	*Description*
[1]	**Core: EF20(EE2005), N87 or CF139 or HP400 or Equivalent, gapped for ALG of 70 nH/T²**
[2]	**Bobbin: Generic, 5 pri. + 5 sec. vertical**
[3]	**Barrier Tape: Polyester film [1 mil (25 µm) base thickness], 12.20 mm wide**
[4]	**Teflon Tubing # 22**
[5]	**Copper Tape: 2 mil thick**
[6]	**Varnish**
[7]	**Magnet Wire: 31 AWG, Solderable Double Coated**
[8]	**Magnet Wire: 34 AWG, Solderable Double Coated**
[9]	**Magnet Wire: 27 AWG, Solderable Double Coated**

Electrical Test Specifications

Parameter	*Condition*	*Spec*
Electrical Strength, VAC	**60 Hz 1 second, from pins 1,2,3,4,5 to pins 8,10.**	**2000**
Nominal Primary Inductance, µH	**Measured at 1 V pk-pk, typical switching frequency, between pin 1 to pin 2, with all other Windings open.**	**1022**
Tolerance, ±%	**Tolerance of Primary Inductance**	**10.0**
Maximum Primary Leakage, µH	**Measured between Pin 1 to Pin 2, with all other Windings shorted.**	**16**

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3 Design Spread Sheet

ACDC_LinkSwitch-PH_101612; Rev.1.9; Copyright Power Integrations 2012	INPUT	INFO	OUTPUT	UNIT	LinkSwitch-PH_101612: Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					
Dimming required	**NO**		**NO**		Select 'YES' option if dimming is required. Otherwise select 'NO'.
VACMIN	90		90	V	Minimum AC Input Voltage
VACMAX	270		270	V	Maximum AC input voltage
fL			50	Hz	AC Mains Frequency
VO	38.00		38	V	Typical output voltage of LED string at full load
VO_MAX			41.80	V	Maximum expected LED string Voltage.
VO_MIN			34.20	V	Minimum expected LED string Voltage.
V_OVP			45.86	V	Over-voltage protection setpoint
IO	0.45		0.45	A	Typical full load LED current
PO			17.1	W	Output Power
n			0.8		
VB	18		18	V	Bias Voltage
ENTER LinkSwitch-PH VARIABLES					
LinkSwitch-PH	**LNK416**		**LNK416**	Universal	115 Doubled/230V
Chosen Device		LNK416			
Current Limit Mode	**FULL**		**FULL**		Select "RED" for reduced Current Limit mode or "FULL" for Full current limit mode
ILIMITMIN			1.48	A	Minimum current limit
ILIMITMAX			1.72	A	Maximum current limit
fS			66000	Hz	Switching Frequency
fSmin			62000	Hz	Minimum Switching Frequency
fSmax			70000	Hz	Maximum Switching Frequency
IV			42.2	uA	V pin current
RV	3.60		3.6	M-ohms	Upper V pin resistor
RV2			1.402	M-ohms	Lower V pin resistor
IFB	174.00		174.0	uA	FB pin current (85 uA < IFB < 210 uA)
RFB1			86.2	k-ohms	FB pin resistor
VDS			10	V	LinkSwitch-PH on-state Drain to Source Voltage
VD			0.50	V	Output Winding Diode Forward Voltage Drop (0.5 V for Schottky and 0.8 V for PN diode)
VDB			0.70	V	Bias Winding Diode Forward Voltage Drop
Key Design Parameters					
KP	0.84		0.84		Ripple to Peak Current Ratio (For PF > 0.9, 0.4 < KP < 0.9)
LP			1136	uH	Primary Inductance
VOR	98.00		98	V	Reflected Output Voltage.
Expected IO (average)			0.45	A	Expected Average Output Current
KP_VACMAX		Info	1.12		!!! Info. PF at high line may be less than 0.9. Decrease KP for higher PF

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TON_MIN		2.01	us	Minimum on time at maximum AC input voltage
PCLAMP		0.15	W	Estimated dissipation in primary clamp

ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES				
Core Type	**EF20**	**EF20**		Transformer core
Custom Core				If using a custom core - Enter part number here
AE		0.335	cm^2	Core Effective Cross Sectional Area
LE		4.49	cm	Core Effective Path Length
AL		1570	nH/T^2	Ungapped Core Effective Inductance
BW		12.2	mm	Bobbin Physical Winding Width
M		0	mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L		3		Number of Primary Layers
NS	50	50		Number of Secondary Turns

DC INPUT VOLTAGE PARAMETERS			
VMIN	127	V	Peak input voltage at VACMIN
VMAX	382	V	Peak input voltage at VACMAX

CURRENT WAVEFORM SHAPE PARAMETERS			
DMAX	0.46		Minimum duty cycle at peak of VACMIN
IAVG	0.23	A	Average Primary Current
IP	1.07	A	Peak Primary Current (calculated at minimum input voltage VACMIN)
IRMS	0.36	A	Primary RMS Current (calculated at minimum input voltage VACMIN)

TRANSFORMER PRIMARY DESIGN PARAMETERS			
LP	1136	uH	Primary Inductance
NP	127		Primary Winding Number of Turns
NB	24		Bias Winding Number of Turns
ALG	70	nH/T^2	Gapped Core Effective Inductance
BM	2848	Gauss	Maximum Flux Density at PO, VMIN (BM<3100)
BP	3437	Gauss	Peak Flux Density (BP<3700)
BAC	1196	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur	1675		Relative Permeability of Ungapped Core
LG	0.57	mm	Gap Length (Lg > 0.1 mm)
BWE	36.6	mm	Effective Bobbin Width
OD	0.29	mm	Maximum Primary Wire Diameter including insulation
INS	0.05	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA	0.24	mm	Bare conductor diameter
AWG	31	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM	81	Cmils	Bare conductor effective area in circular mils
CMA	222	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 600)

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LP_TOL	10		Tolerance of primary inductance

TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)			
Lumped parameters			
ISP	2.72	A	Peak Secondary Current
ISRMS	0.95	A	Secondary RMS Current
IRIPPLE	0.84	A	Output Capacitor RMS Ripple Current
CMS	191	Cmils	Secondary Bare Conductor minimum circular mils
AWGS	27	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS	0.36	mm	Secondary Minimum Bare Conductor Diameter
ODS	0.24	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire

VOLTAGE STRESS PARAMETERS			
VDRAIN	585	V	Estimated Maximum Drain Voltage assuming maximum LED string voltage (Includes Effect of Leakage Inductance)
PIVS	196	V	Output Rectifier Maximum Peak Inverse Voltage (calculated at VOVP, excludes leakage inductance spike)
PIVB	95	V	Bias Rectifier Maximum Peak Inverse Voltage (calculated at VOVP, excludes leakage inductance spike)

FINE TUNING (Enter measured values from prototype)			
V pin Resistor Fine Tuning			
RV1	3.60	M-ohms	Upper V Pin Resistor Value
RV2	1.40	M-ohms	Lower V Pin Resistor Value
VAC1	115.0	V	Test Input Voltage Condition1
VAC2	230.0	V	Test Input Voltage Condition2
IO_VAC1	0.45	A	Measured Output Current at VAC1
IO_VAC2	0.45	A	Measured Output Current at VAC2
RV1 (new)	3.60	M-ohms	New RV1
RV2 (new)	1.40	M-ohms	New RV2
V_OV	293.3	V	Typical AC input voltage at which OV shutdown will be triggered
V_UV	65.4	V	Typical AC input voltage beyond which power supply can startup
FB pin resistor Fine Tuning			
RFB1	86	k-ohms	Upper FB Pin Resistor Value
RFB2	1E+012	k-ohms	Lower FB Pin Resistor Value
VB1	16.2	V	Test Bias Voltage Condition1
VB2	19.8	V	Test Bias Voltage Condition2
IO1	0.45	A	Measured Output Current at Vb1
IO2	0.45	A	Measured Output Current at Vb2
RFB1 (new)	86.2	k-ohms	New RFB1
RFB2(new)	1.00E+12	k-ohms	New RFB2

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Input Current Harmonic Analysis

Harmonic	Max Current (mA)	Limit (mA)	
1st Harmonic			
3rd Harmonic	25.82	1242.74	PASS. 3rd Harmonic current content is lower than the limit
5th Harmonic	13.0	694.47	PASS. 5th Harmonic current content is lower than the limit
7th Harmonic	8.0	365.51	PASS. 7th Harmonic current content is lower than the limit
9th Harmonic	5.53	182.76	PASS. 9th Harmonic current content is lower than the limit
11th Harmonic	4.02	127.93	PASS. 11th Harmonic current content is lower than the limit
13th Harmonic	3.08	108.23	PASS. 13th Harmonic current content is lower than the limit
15th Harmonic	2.40	93.79	PASS. 15th Harmonic current content is lower than the limit
THD	29.7	%	Estimated total Harmonic Distortion (THD)

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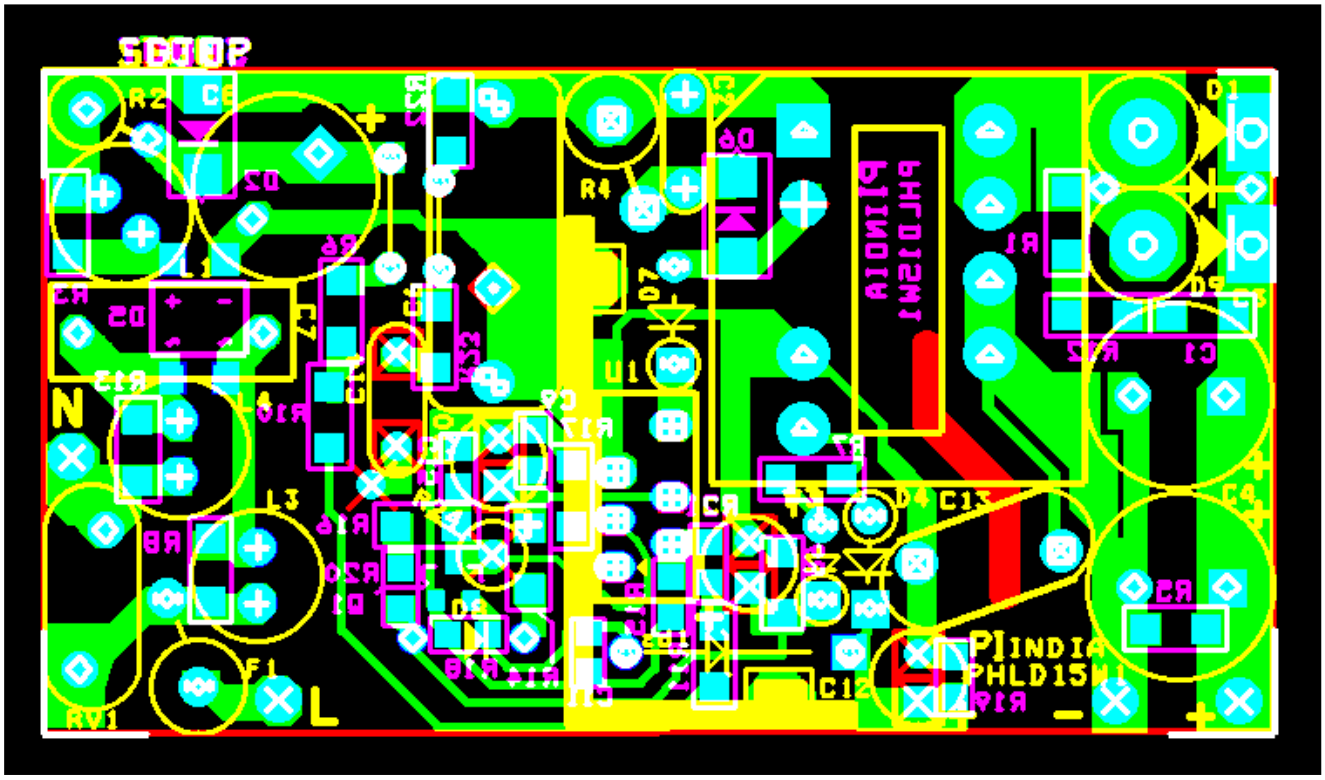
4 PCB Layout guidelines



Note: All three input drum inductors need to be modified to 10x12 size from the present 8x10

PCB name: PHLD15W1 (66x36mm)

Note2: This is a design proposal only, the actual performances and stress parameters of all the components to be tested and verified by building in PCB

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