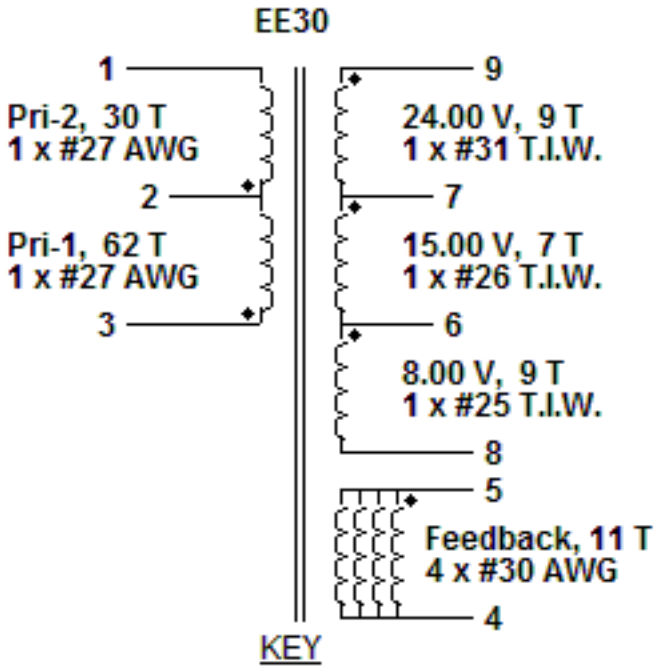
ACDC_LinkSwitch-HP_060623; Rev.2.2; Copyright Power Integrations 2023	INPUT	INFO	OUTPUT	UNIT	ACDC_LinkSwitchHP_060623 Rev 2-2.xls: LinkSwitch-HP Flyback Continuous/Discontinuous Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					Customer
VACMIN	120		120	V	Minimum AC Input Voltage
VACMAX	360		360	V	Maximum AC Input Voltage
fL			50	Hz	AC Mains Frequency
VO	24.00		24.00	V	Output Voltage (main)
PO	15.00		15.00	W	Load Power
n			0.80		Efficiency Estimate
Z			0.50		Loss Allocation Factor
VB			10.00	V	Bias Voltage
tC			3.00	ms	Bridge Rectifier Conduction Time Estimate
CIN			45	uF	Input Filter Capacitor
Package	E/V		E/V		E and V Package Selected
Enclosure	Open Frame		Open Frame		Open Frame type enclosure
Heatsink	Metal		Metal		Metallic heatsink thermally connected to the exposed metal on the E-package
ENTER LinkSwitch-HP VARIABLES					
LinkSwitch-HP	LNK6773E		LNK6773E		Manual Device Selection
ILIMITMIN			0.716	A	Minimum Current limit
ILIMITMAX			0.824	A	Maximum current limit
ILIMITMIN_EXT			0.501	A	External Minimum Current limit
ILIMITMAX_EXT			0.577	A	External Maximum current limit
KI	Auto		0.7		Current limit reduction factor
Rpd			34.80	k-ohm	Program delay Resistor
Cpd			33.0	nF	Program delay Capacitor
Total programmed delay			0.26	sec	Total program delay
fS			132	kHz	LinkSwitch-HP Switching Frequency
fSmin			120	kHz	LinkSwitch-HP Minimum Switching Frequency
fSmax			136	kHz	LinkSwitch-HP Maximum Switching Frequency
KP			0.40		Ripple to Peak Current Ratio (0.4 < KP < 6.0)
VOR	90.00		90.00	V	Reflected Output Voltage
Voltage Sense					
VUVON			165.00	V	Undervoltage turn on
VUVOFF			68.10	V	Undervoltage turn off
VOV			759.23	V	Overvoltage threshold
FMAX_FULL_LOAD			136.00	kHz	Maximum switching frequency at full load
FMIN_FULL_LOAD			120.00	kHz	Minimum switching frequency at full load
TSAMPLE_FULL_LOAD			4.57	us	Minimum available Diode conduction time at full load. This should be greater than 2.5 us
TSAMPLE_LIGHT_LOAD			3.59	us	Minimum available Diode conduction time at light load. This should be greater than 1.4 us
VDS			2.28	V	LinkSwitch-HP on-state Drain to Source Voltage.
VD			0.50	V	Output Winding Diode Forward Voltage Drop
VDB			0.70	V	Bias Winding Diode Forward Voltage Drop

FEEDBACK SENSING SECTION					
RFB1			*78.70*	*k-ohms*	*Feedback divider upper resistor*
RFB2			*17.80*	*k-ohms*	*Feedback divider lowerr resistor*
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Select Core Size	*EE30*		*EE30*		*Manual Core Selected*
Core			*EE30*		*Selected Core*
Custom Core					*Enter name of custom core is applicable*
AE			*1.11*	*cm^2*	*Core Effective Cross Sectional Area*
LE			*5.80*	*cm*	*Core Effective Path Length*
AL			*4690*	*nH/T^2*	*Ungapped Core Effective Inductance*
BW			*13.70*	*mm*	*Bobbin Physical Winding Width*
M			*0.00*	*mm*	*Safety Margin Width (Half the Primary to Secondary Creepage Distance)*
L			*3*		*Number of Primary Layers*
NS	*25*		*25*		*Number of Secondary Turns*
DC INPUT VOLTAGE PARAMETERS					
VMIN	*150*		*150*	*V*	*Minimum DC Input Voltage*
VMAX	*510*		*510*	*V*	*Maximum DC Input Voltage*
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			*0.38*		*Maximum Duty Cycle*
IAVG			*0.13*	*A*	*Average Primary Current*
IP			*0.41*	*A*	*Peak Primary Current*
IR			*0.17*	*A*	*Primary Ripple Current*
IRMS			*0.21*	*A*	*Primary RMS Current*
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP_TYP			*2867*	*uH*	*Typical Primary Inductance*
LP_TOL			*10*	*%*	*Primary inductance Tolerance*
NP			*92*		*Primary Winding Number of Turns*
NB			*11*		*Bias Winding Number of Turns*
ALG			*339*	*nH/T^2*	*Gapped Core Effective Inductance*
BM			*1159*	*Gauss*	*Maximum Flux Density at PO, VMIN (BM<3100)*
BP			*1781*	*Gauss*	*Peak Flux Density (BP<3700)*
BAC			*232*	*Gauss*	*AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)*
ur			*1950*		*Relative Permeability of Ungapped Core*
LG			*0.38*	*mm*	*Gap Length (Lg > 0.1 mm)*
BWE			*41.1*	*mm*	*Effective Bobbin Width*
OD			*0.45*	*mm*	*Maximum Primary Wire Diameter including insulation*
INS			*0.06*	*mm*	*Estimated Total Insulation Thickness (= 2 * film thickness)*
DIA			*0.38*	*mm*	*Bare conductor diameter*
AWG			*27*	*AWG*	*Primary Wire Gauge (Rounded to next smaller standard AWG value)*

CM			203	Cmils	Bare conductor effective area in circular mils
CMA		Warning	990	Cmils/Amp	!!! Info. This is an overdesign. You can decrease CMA (200 < CMA < 500) Decrease L(primary layers),increase NS,smaller Core
TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)					
Lumped parameters					
ISP			1.52	A	Peak Secondary Current
ISRMS			0.97	A	Secondary RMS Current
IO			0.63	A	Power Supply Output Current
IRIPPLE			0.74	A	Output Capacitor RMS Ripple Current
CMS			194	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			0.55	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS			0.09	mm	Maximum Secondary Insulation Wall Thickness
VOLTAGE STRESS PARAMETERS					
VDRAIN			719	V	Peak voltage across drain to source of Linkswitch-HP
PIVS			163	V	Output Rectifier Maximum Peak Inverse Voltage
PIVB			71	V	Bias Rectifier Maximum Peak Inverse Voltage
TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)					
1st output					
VO1	24.00		24.00	V	Output Voltage
IO1	0.25		0.25	A	Output DC Current
PO1			6	W	Output Power
VD1			0.50	V	Output Diode Forward Voltage Drop
NS1			25.00		Output Winding Number of Turns
ISRMS1			0.387	A	Output Winding RMS Current
IRIPPLE1			0.30	A	Output Capacitor RMS Ripple Current
PIVS1			163	V	Output Rectifier Maximum Peak Inverse Voltage
CMS1			77	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			31	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			0.23	mm	Minimum Bare Conductor Diameter
ODS1			0.55	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output					
VO2	15.00		15.00	V	Output Voltage
IO2	0.50		0.50	A	Output DC Current
PO2			7.5	W	Output Power
VD2			0.70	V	Output Diode Forward Voltage Drop
NS2			17.00		Output Winding Number of Turns

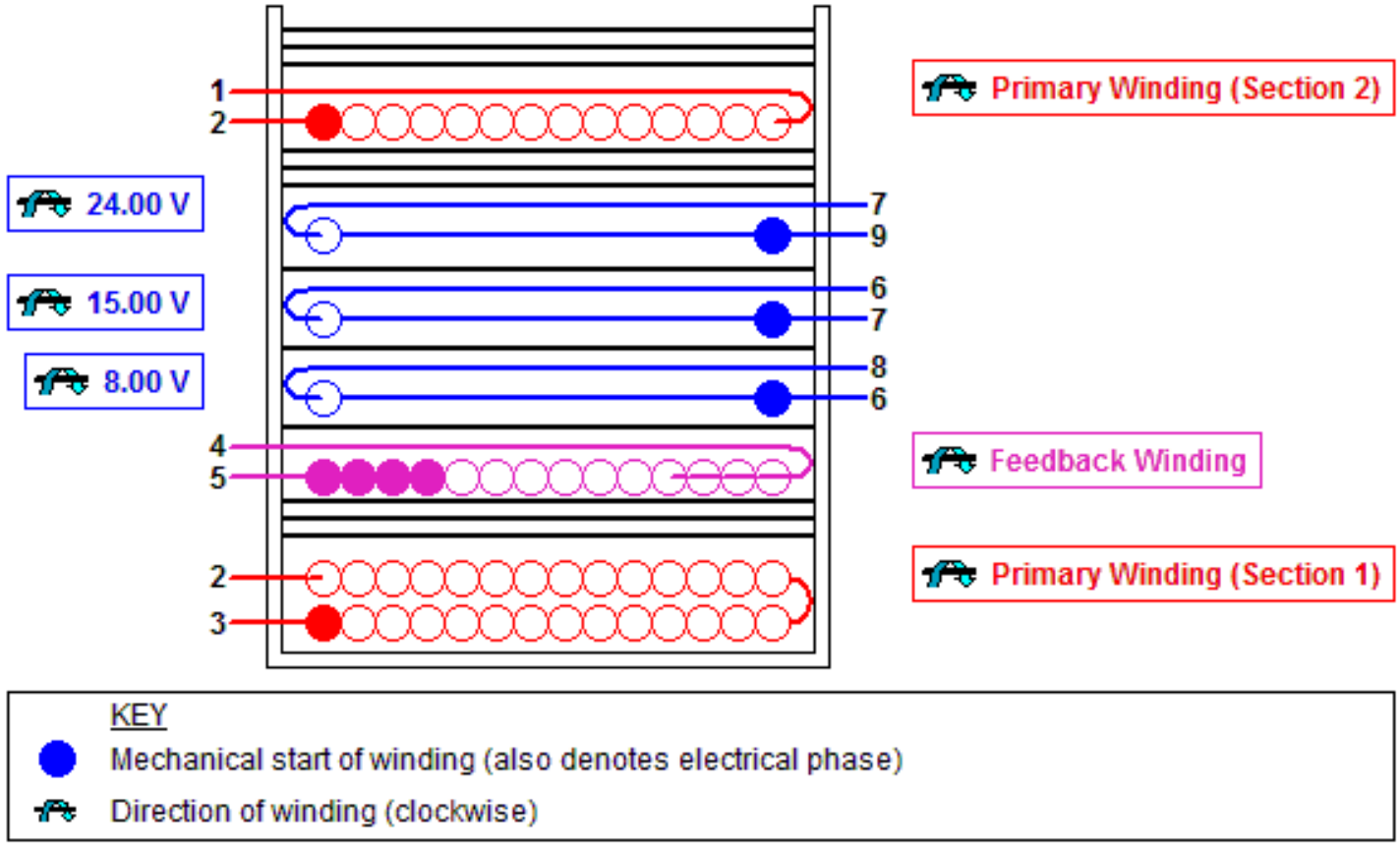
ISRMS2			0.774	A	Output Winding RMS Current
IRIPPLE2			0.59	A	Output Capacitor RMS Ripple Current
PIVS2			109	V	Output Rectifier Maximum Peak Inverse Voltage
CMS2			155	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2			28	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2			0.32	mm	Minimum Bare Conductor Diameter
ODS2			0.81	mm	Maximum Outside Diameter for Triple Insulated Wire
3rd output					
VO3	8.00		8.00	V	Output Voltage
IO3	0.20		0.20	A	Output DC Current
PO3			1.6	W	Output Power
VD3			0.70	V	Output Diode Forward Voltage Drop
NS3			9.00		Output Winding Number of Turns
ISRMS3			0.31	A	Output Winding RMS Current
IRIPPLE3			0.24	A	Output Capacitor RMS Ripple Current
PIVS3			58	V	Output Rectifier Maximum Peak Inverse Voltage
CMS3			62	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3			32	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3			0.20	mm	Minimum Bare Conductor Diameter
ODS3			1.52	mm	Maximum Outside Diameter for Triple Insulated Wire
Total power			15.1	W	!!! Warning: total output power not equal to PO (PO= 15 W)
Negative Output	N/A		N/A		If negative output exists enter Output number; e.g. If VO2 is negative output, select 2

Electrical Diagram



Pri-1 = Primary Winding (Section 1)
Pri-2 = Primary Winding (Section 2)
T.I.W. = Triple Insulated Wire

Mechanical Diagram



Winding Instruction

Primary Winding (Section 1)

Start on pin(s) 3 and wind 62 turns (x 1 filar) of item [5]. in 2 layer(s) from left to right. Winding direction is clockwise. 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) 2.

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

Feedback Winding

Start on any (temp) pin on the secondary side and wind 11 turns (x 4 filar) of item [6]. Winding direction is clockwise. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 4. Move end of wire from temp pin and terminate it on pin 5.

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

Secondary Winding

Start on pin(s) 6 and wind 9 turns (x 1 filar) of item [7]. Spread the winding evenly across entire bobbin. Winding direction is clockwise. Finish this winding on pin(s) 8.

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

Start on pin(s) 7 and wind 7 turns (x 1 filar) of item [8]. Spread the winding evenly across entire bobbin. Winding direction is clockwise. Finish this winding on pin(s) 6.

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

Start on pin(s) 9 and wind 9 turns (x 1 filar) of item [9]. Spread the winding evenly across entire bobbin. Winding direction is clockwise. Finish this winding on pin(s) 7.

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

Primary Winding (Section 2)

Start on pin(s) 2 and wind 30 turns (x 1 filar) of item [5]. in 1 layer(s) from left to right. Winding direction is clockwise. 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.

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

Core Assembly

Assemble and secure core halves. Item [1].

Varnish

Dip varnish uniformly in item [4]. Do not vacuum impregnate.

Comments

1. Use of a grounded flux-band around the core may improve the EMI performance.
2. For non margin wound transformers use triple insulated wire for all secondary windings.

Materials

Item	*Description*
[1]	**Core: EE30, 3F3, gapped for ALG of 339 nH/T²**
[2]	**Bobbin: Generic, 5 pri. + 4 sec.**
[3]	**Barrier Tape: Polyester film [1 mil (25 µm) base thickness], 13.70 mm wide**
[4]	**Varnish**
[5]	**Magnet Wire: 27 AWG (0.35 mm), Solderable Double Coated**
[6]	**Magnet Wire: 30 AWG (0.25 mm), Solderable Double Coated**
[7]	**Triple Insulated Wire: 25 AWG (0.45 mm)**
[8]	**Triple Insulated Wire: 26 AWG (0.4 mm)**
[9]	**Triple Insulated Wire: 31 AWG (0.22 mm)**

Electrical Test Specifications

Parameter	*Condition*	*Spec*
Electrical Strength, VAC	**60 Hz 1 second, from pins 1,2,3,4,5 to pins 6,7,8,9.**	**3000**
Nominal Primary Inductance, µH	**Measured at 1 V pk-pk, typical switching frequency, between pin 1 to pin 3, with all other Windings open.**	**2867**
Tolerance, ±%	**Tolerance of Primary Inductance**	**10.0**

Maximum Primary Leakage, µH	**Measured between Pin 1 to Pin 3, with all other Windings shorted.**	**28.67**

Although the design of the software considered safety guidelines, it is the user's responsibility to ensure that the user's power supply design meets all applicable safety requirements of user's product.

Transformer Construction Parameters

Var	Value	Units	Description
Core Type	EE30		Core Type
Bobbin Reference	Generic, 5 pri. + 4 sec.		Bobbin Reference
Bobbin Orientation	Horizontal		Bobbin type
Primary Pins	5		Number of Primary pins used
Secondary Pins	4		Number of Secondary pins used
LP	2867	µH	Nominal Primary Inductance
ML	0.00	mm	Safety Margin on Left Width
MR	0.00	mm	Safety Margin on Right Width
LG	0.382	mm	Estimated Gap Length

Feedback Winding

Var	Value	Units	Description
NFB	11		Feedback Winding Number of Turns
Wire Size	30	AWG	Wire size of Feedback windings
Winding Type	Quadfilar (x4)		Wire type of Feedback windings
Layers	0.95		Feedback Winding Layers
Start Pin(s)	5		Starting pin(s) for Feedback winding
Termination Pin(s)	4		Termination pin(s) for Feedback winding

Primary Winding Section 1

Var	Value	Units	Description
NP1	62		Number of Primary Winding Turns in the First Section of Primary
Wire Size	27	AWG	Primary Winding - Wire Size
Winding Type	Single (x1)		Primary Winding - Number of Parallel Wire Strands
CMA	982.37	Cmils/A	Primary Winding Current Capacity. See Information section for detail
L	1.85		Primary Winding - Number of Layers
Start Pin(s)	3		Starting pin(s) for first section of primary winding
Termination Pin(s)	2		Termination pin(s) for first section of primary winding

Primary Winding Section 2

Var	Value	Units	Description
NP2	30		Rounded (Integer) Number of Primary winding turns in the second section of primary
Wire Size	27	AWG	Primary Winding - Wire Size
Winding Type	Single (x1)		Primary Winding - Number of Parallel Wire Strands
L2	0.90		Primary Number of Layers in 2nd split winding
Start Pin(s)	2		Starting pin(s) for the second section of primary winding
Termination Pin(s)	1		Termination pin(s) for the second section of primary winding

Output 1

Var	Value	Units	Description

VO	**24.00**	*V*	*Typical Output Voltage*
IO	**0.25**	*A*	*Output Current*
VOUT_ACTUAL	**24.00**	*V*	*Actual Output Voltage*
NS	**9**		*Secondary Number of Turns*
Wire Size	**31**	*AWG*	*Wire size of secondary winding*
Winding Type	**Single (x1)**		*Output winding number of parallel strands*
ISRMS_WINDING	**0.387**	*A*	*Secondary Winding RMS Current*
CMAS	**205**	*Cmils/A*	*Secondary Winding Current Capacity*
L_S_OUT	**0.28**		*Secondary Output Winding Layers*
Start Pin(s)	**9**		*Starting pin(s) for Output winding*
Termination Pin(s)	**7**		*Termination pin(s) for Output winding*

Output 2

Var	*Value*	*Units*	*Description*
VO	**15.00**	*V*	*Typical Output Voltage*
IO	**0.50**	*A*	*Output Current*
VOUT_ACTUAL	**14.98**	*V*	*Actual Output Voltage*
NS	**7**		*Secondary Number of Turns*
Wire Size	**26**	*AWG*	*Wire size of secondary winding*
Winding Type	**Single (x1)**		*Output winding number of parallel strands*
ISRMS_WINDING	**1.161**	*A*	*Secondary Winding RMS Current*
CMAS	**218**	*Cmils/A*	*Secondary Winding Current Capacity*
L_S_OUT	**0.31**		*Secondary Output Winding Layers*
Start Pin(s)	**7**		*Starting pin(s) for Output winding*
Termination Pin(s)	**6**		*Termination pin(s) for Output winding*

Output 3

Var	*Value*	*Units*	*Description*
VO	**8.00**	*V*	*Typical Output Voltage*
IO	**0.20**	*A*	*Output Current*
VOUT_ACTUAL	**8.12**	*V*	*Actual Output Voltage*
NS	**9**		*Secondary Number of Turns*
Wire Size	**25**	*AWG*	*Wire size of secondary winding*
Winding Type	**Single (x1)**		*Output winding number of parallel strands*
ISRMS_WINDING	**1.471**	*A*	*Secondary Winding RMS Current*
CMAS	**218**	*Cmils/A*	*Secondary Winding Current Capacity*
L_S_OUT	**0.43**		*Secondary Output Winding Layers*
Start Pin(s)	**6**		*Starting pin(s) for Output winding*
Termination Pin(s)	**8**		*Termination pin(s) for Output winding*

	Description	Fix	Ref. #
	CMA is high but design will work.	Choose smaller core size, decrease layers (L), VOR, increase secondary turns (NS), KP.	219