ACDC_TOPSwitchHX_032514; Rev.1.12; Copyright Power Integrations 2014	INPUT	INFO	OUTPUT	UNIT	TOP_HX_032514: TOPSwitch-HX Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					Design title
VACMIN	180			Volts	Minimum AC Input Voltage
VACMAX	476			Volts	Maximum AC Input Voltage
fL	50			Hertz	AC Mains Frequency
VO	5.00			Volts	Output Voltage (main)
PO_AVG	61.00			Watts	Average Output Power
PO_PEAK			61.00	Watts	Peak Output Power
n	0.80			%/100	Efficiency Estimate
Z	0.50				Loss Allocation Factor
VB	15			Volts	Bias Voltage
tC	3.00			mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	90.0		90.0	uFarads	Input Filter Capacitor
ENTER TOPSWITCH-HX VARIABLES					
TOPSwitch-HX	TOP258YN			Universal / Peak	115 Doubled/230V
Chosen Device		TOP258YN	Power Out	148 W / 148 W	195W
KI	0.46				External Ilimit reduction factor (KI=1.0 for default ILIMIT, KI <1.0 for lower ILIMIT)
ILIMITMIN_EXT			1.84	Amps	Use 1% resistor in setting external ILIMIT
ILIMITMAX_EXT			2.116	Amps	Use 1% resistor in setting external ILIMIT
Frequency (F)=132kHz, (H)=66kHz	H		H		Select 'H' for Half frequency - 66kHz, or 'F' for Full frequency - 132kHz
fS			66000	Hertz	TOPSwitch-HX Switching Frequency: Choose between 132 kHz and 66 kHz
fSmin			59400	Hertz	TOPSwitch-HX Minimum Switching Frequency
fSmax			72600	Hertz	TOPSwitch-HX Maximum Switching Frequency
High Line Operating Mode			FF		Full Frequency, Jitter enabled
VOR	110.00			Volts	Reflected Output Voltage
VDS			10.00	Volts	TOPSwitch on-state Drain to Source Voltage
VD	0.50			Volts	Output Winding Diode Forward Voltage Drop
VDB	0.70			Volts	Bias Winding Diode Forward Voltage Drop
KP	0.70				Ripple to Peak Current Ratio (0.3 < KRP < 1.0 : 1.0< KDP<6.0)
PROTECTION FEATURES					
LINE SENSING					
VUV_STARTUP			201.07	Volts	Minimum DC Bus Voltage at which the power supply will start-up
VOV_SHUTDOWN			1050	Volts	Typical DC Bus Voltage at which power supply will shut-down (Max)
RLS			9.4	M-ohms	Use two standard, 4.7 M-Ohm, 5% resistors in series for line sense functionality.
OUTPUT OVERVOLTAGE					
VZ			27	Volts	Zener Diode rated voltage for Output Overvoltage shutdown protection

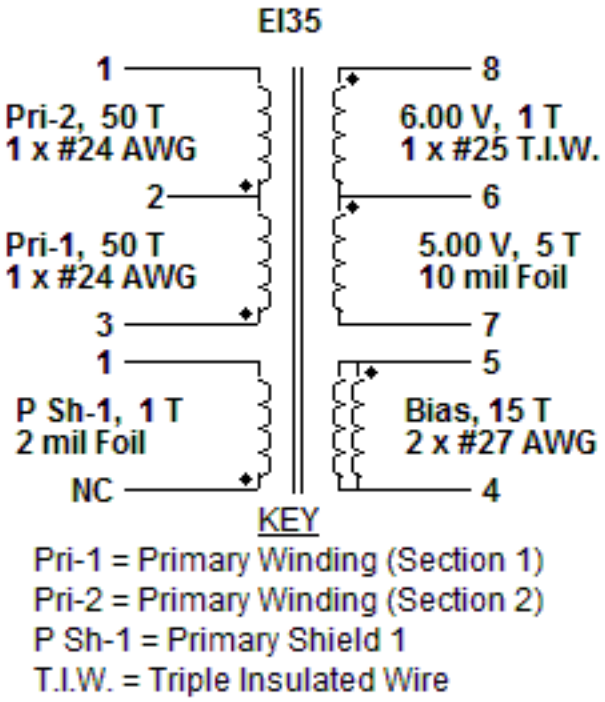
RZ			5.1	k-ohms	Output OVP resistor. For latching shutdown use 20 ohm resistor instead
OVERLOAD POWER LIMITING					
Overload Current Ratio at VMAX			1.20		Enter the desired margin to current limit at VMAX. A value of 1.2 indicates that the current limit should be 20% higher than peak primary current at VMAX
Overload Current Ratio at VMIN			1.20		Margin to current limit at low line.
ILIMIT_EXT_VMIN			1.53	A	Peak primary Current at VMIN
ILIMIT_EXT_VMAX			1.40	A	Peak Primary Current at VMAX
RIL			13.16	k-ohms	Current limit/Power Limiting resistor.
RPL			N/A	M-ohms	Resistor not required. Use RIL resistor only
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	EI35		EI35		Core Type
Custom Core Part Number (Optional)					If custom core used - Enter part number here
Bobbin		EI35_BOBBIN		P/N:	BE-35-1112CPL
AE			1.0140	cm^2	Core Effective Cross Sectional Area
LE			6.7100	cm	Core Effective Path Length
AL			3800.0	nH/T^2	Ungapped Core Effective Inductance
BW			15.7	mm	Bobbin Physical Winding Width
M	0.00			mm	Safety Margin Width (Half the Primary to Secondary Creepage Distance)
L	3.00				Number of Primary Layers
NS	5		5		Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS					
VMIN			230	Volts	Minimum DC Input Voltage
VMAX			673	Volts	Maximum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.33		Maximum Duty Cycle (calculated at PO_PEAK)
IAVG			0.33	Amps	Average Primary Current (calculated at average output power)
IP			1.53	Amps	Peak Primary Current (calculated at Peak output power)
IR			1.07	Amps	Primary Ripple Current (calculated at average output power)
IRMS			0.60	Amps	Primary RMS Current (calculated at average output power)
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			1205	uHenries	Primary Inductance
LP Tolerance			10		Tolerance of Primary Inductance
NP			100		Primary Winding Number of Turns
NB			14		Bias Winding Number of Turns
ALG			121	nH/T^2	Gapped Core Effective Inductance

BM			1819	Gauss	Maximum Flux Density at PO, VMIN (BM<3000)
BP			2767	Gauss	Peak Flux Density (BP<4200) at ILIMITMAX and LP_MAX. Note: Recommended values for adapters and external power supplies <=3600 Gauss
BAC			637	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			2001		Relative Permeability of Ungapped Core
LG			1.02	mm	Gap Length (Lg > 0.1 mm)
BWE			47.1	mm	Effective Bobbin Width
OD			0.47	mm	Maximum Primary Wire Diameter including insulation
INS			0.06	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.41	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			338	Cmils/Amp	Primary Winding Current Capacity (200 < CMA < 500)
Primary Current Density (J)			5.88	Amps/mm^2	Primary Winding Current density (3.8 < J < 9.75)
TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT)					
Lumped parameters					
ISP			30.60	Amps	Peak Secondary Current
ISRMS			17.01	Amps	Secondary RMS Current
IO_PEAK			12.20	Amps	Secondary Peak Output Current
IO			12.20	Amps	Average Power Supply Output Current
IRIPPLE			11.85	Amps	Output Capacitor RMS Ripple Current
CMS			3401	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			14	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
DIAS			1.63	mm	Secondary Minimum Bare Conductor Diameter
ODS			3.14	mm	Secondary Maximum Outside Diameter for Triple Insulated Wire
INSS			0.76	mm	Maximum Secondary Insulation Wall Thickness
VOLTAGE STRESS PARAMETERS					
VDRAIN		Warning	891	Volts	!!! REDUCE DRAIN VOLTAGE Vdrain<680, reduce VACMAX, reduce VOR
PIVS			39	Volts	Output Rectifier Maximum Peak Inverse Voltage
PIVB			111	Volts	Bias Rectifier Maximum Peak Inverse Voltage
TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)					
1st output					
VO1			5.00	Volts	Output Voltage

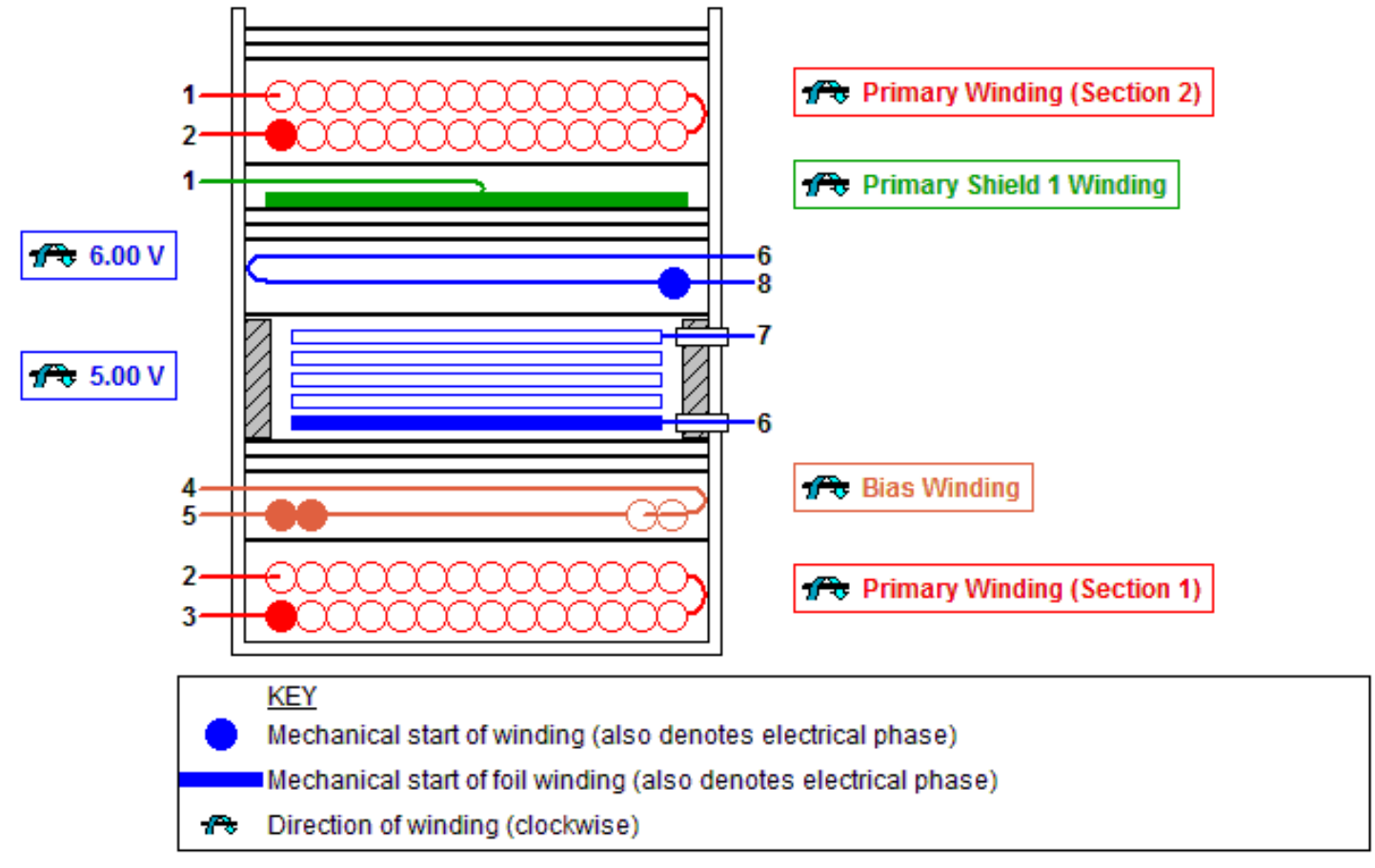
IO1_AVG	11.00		11.00	Amps	Average DC Output Current
PO1_AVG			55	Watts	Average Output Power
VD1			0.50	Volts	Output Diode Forward Voltage Drop
NS1			5.00		Output Winding Number of Turns
ISRMS1			15.334	Amps	Output Winding RMS Current
IRIPPLE1			10.68	Amps	Output Capacitor RMS Ripple Current
PIVS1			39	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS1			3067	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			15	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			1.45	mm	Minimum Bare Conductor Diameter
ODS1			3.14	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output					
VO2	6.00			Volts	Output Voltage
IO2_AVG	1.00			Amps	Average DC Output Current
PO2_AVG			6	Watts	Average Output Power
VD2			0.70	Volts	Output Diode Forward Voltage Drop
NS2			6.09		Output Winding Number of Turns
ISRMS2			1.394	Amps	Output Winding RMS Current
IRIPPLE2			0.97	Amps	Output Capacitor RMS Ripple Current
PIVS2			47	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS2			279	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2			25	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2			0.46	mm	Minimum Bare Conductor Diameter
ODS2			2.58	mm	Maximum Outside Diameter for Triple Insulated Wire
3rd output					
VO3				Volts	Output Voltage
IO3_AVG				Amps	Average DC Output Current
PO3_AVG			0	Watts	Average Output Power
VD3			0.70	Volts	Output Diode Forward Voltage Drop
NS3			0.64		Output Winding Number of Turns
ISRMS3			0	Amps	Output Winding RMS Current
IRIPPLE3			0.00	Amps	Output Capacitor RMS Ripple Current
PIVS3			4	Volts	Output Rectifier Maximum Peak Inverse Voltage
CMS3			0	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS3			N/A	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS3			N/A	mm	Minimum Bare Conductor Diameter
ODS3			N/A	mm	Maximum Outside Diameter for Triple Insulated Wire

Total Continuous Output Power			*61*	*Watts*	*Total Continuous Output Power*
Negative Output	*N/A*		*N/A*		*If negative output exists enter Output number; e.g.: If VO2 is negative output, enter 2*

Electrical Diagram



Mechanical Diagram



Winding Instruction

Primary Winding (Section 1)

Start on pin(s) 3 and wind 50 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 1 layer of tape, item [3], for insulation.

Bias Winding

Start on pin(s) 5 and wind 15 turns (x 2 filar) of item [6]. Winding direction is clockwise. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 4.

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

Secondary Winding

Use 3 mm margin (item [8]) on the left side and 3 mm margin on the right side (to meet safety). Start on pin(s) 6 and wind 5 turns of item [7]. Winding direction is clockwise. Finish this winding on pin(s) 7.

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

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

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

Primary Shield 1 Winding

Leaving the start of this winding unconnected, wind 1 turn of item [10]. Winding direction is clockwise. Finish this winding on pin(s) 1.

Add 1 layer of tape, item [3], to secure the winding in place.

Primary Winding (Section 2)

Start on pin(s) 2 and wind 50 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) 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: EI35, PC44, gapped for ALG of 121 nH/T²**
[2]	**Bobbin: Generic, 5 pri. + 3 sec.**
[3]	**Barrier Tape: Polyester film [1 mil (25 µm) base thickness], 15.70 mm wide**
[4]	**Varnish**
[5]	**Magnet Wire: 24 AWG, Solderable Double Coated**
[6]	**Magnet Wire: 27 AWG, Solderable Double Coated**
[7]	**Copper Foil: 10 mil thick, 9.70 mm wide, covered with 1 layer of lapped tape. Terminations to foil: 2 x 23 AWG magnet wire with sleeving**
[8]	**Tape: Polyester web 3 mm wide**
[9]	**Triple Insulated Wire: 25 AWG**
[10]	**Copper Foil: 2 mil thick, 15.70 mm wide, covered with 1 layer of lapped tape. Terminations to foil: 1 x 24 AWG magnet wire**

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.**	**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.**	**1205**
Tolerance, ±%	**Tolerance of Primary Inductance**	**10.0**
Maximum Primary Leakage, µH	**Measured between Pin 1 to Pin 3, with all other Windings shorted.**	**30.13**

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	**EI35**		Core Type
Core Material	**PC44**		Core Material
Bobbin Reference	**Generic, 5 pri. + 3 sec.**		Bobbin Reference
Bobbin Orientation	**Horizontal**		Bobbin type
Primary Pins	**5**		Number of Primary pins used
Secondary Pins	**3**		Number of Secondary pins used
LP	**1205**	µH	Nominal Primary Inductance
ML	**0.00**	mm	Safety Margin on Left Width
MR	**0.00**	mm	Safety Margin on Right Width
LG	**1.024**	mm	Estimated Gap Length

Bias Variables

Var	Value	Units	Description
NB	**15**		Bias Winding Number of Turns
Wire Size	**27**	AWG	Wire size of Bias windings
Winding Type	**Bifilar (x2)**		Wire type of Bias windings
Layers	**0.78**		Bias Winding Layers
Start Pin(s)	**5**		Starting pin(s) for Bias winding
Termination Pin(s)	**4**		Termination pin(s) for Bias winding

Primary Winding Section 1

Var	Value	Units	Description
NP1	**50**		Number of Primary Winding Turns in the First Section of Primary
Wire Size	**24**	AWG	Primary Winding - Wire Size
Winding Type	**Single (x1)**		Primary Winding - Number of Parallel Wire Strands
L	**1.80**		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	**50**		Rounded (Integer) Number of Primary winding turns in the second section of primary
Wire Size	**24**	AWG	Primary Winding - Wire Size
Winding Type	**Single (x1)**		Primary Winding - Number of Parallel Wire Strands
L2	**1.80**		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

Primary Shield 1

Var	Value	Units	Description
SH_N	**1**		Number of winding turns in shield winding
Foil Thickness	**2**	mil	Wire size of Shield winding
Winding Type	**Foil**		Shield winding number of parallel strands
SH_L	**1.00**		Shield Winding Layers
Start Pin(s)	**NC**		Starting pin(s) for Shield Winding

Termination Pin(s)	**1**		*Termination pin(s) for Shield Winding*

Output 1

Var	*Value*	*Units*	*Description*
VO	**5.00**	*V*	*Typical Output Voltage*
IO	**11.00**	*A*	*Output Current*
VOUT_ACTUAL	**5.00**	*V*	*Actual Output Voltage*
NS	**5**		*Secondary Number of Turns*
Foil Thickness	**10**	*mil*	*Wire size of secondary winding*
Winding Type	**Foil**		*Output winding number of parallel strands*
L_S_OUT	**5.00**		*Secondary Output Winding Layers*
Start Pin(s)	**6**		*Starting pin(s) for Output winding*
Termination Pin(s)	**7**		*Termination pin(s) for Output winding*

Output 2

Var	*Value*	*Units*	*Description*
VO	**6.00**	*V*	*Typical Output Voltage*
IO	**1.00**	*A*	*Output Current*
VOUT_ACTUAL	**5.90**	*V*	*Actual Output Voltage*
NS	**1**		*Secondary Number of Turns*
Wire Size	**25**	*AWG*	*Wire size of secondary winding*
Winding Type	**Single (x1)**		*Output winding number of parallel strands*
L_S_OUT	**0.04**		*Secondary Output Winding Layers*
Start Pin(s)	**8**		*Starting pin(s) for Output winding*
Termination Pin(s)	**6**		*Termination pin(s) for Output winding*