ACDC_TinySwitch-4_032514; Rev.1.1; Copyright Power Integrations 2014	INPUT	INFO	OUTPUT	UNIT	ACDC_TinySwitch-4_032514_Rev1-1.xls; TinySwitch-4 Continuous/Discontinuous Flyback Transformer Design Spreadsheet
ENTER APPLICATION VARIABLES					Customer
VACMIN	195		195	Volts	Minimum AC Input Voltage
VACMAX	265		265	Volts	Maximum AC Input Voltage
fL	50		50	Hertz	AC Mains Frequency
VO	6.00		6.00	Volts	Output Voltage (at continuous power)
IO	2.50		2.50	Amps	Power Supply Output Current (corresponding to peak power)
Power			15.00	Watts	Continuous Output Power
n			0.70		Efficiency Estimate at output terminals. Under 0.7 if no better data available
Z			0.50		Z Factor. Ratio of secondary side losses to the total losses in the power supply. Use 0.5 if no better data available
tC			3.00	mSeconds	Bridge Rectifier Conduction Time Estimate
CIN	18.00		18.00	uFarads	Input Capacitance
ENTER TinySwitch-4 VARIABLES					
TinySwitch-4	**TNY287D**		**TNY287D**		User-defined TinySwitch-4
Chose Configuration	**STD**		Standard Current Limit		Enter "RED" for reduced current limit (sealed adapters), "STD" for standard current limit or "INC" for increased current limit (peak or higher power applications)
ILIMITMIN			0.419	Amps	Minimum Current Limit
ILIMITTYP			0.450	Amps	Typical Current Limit
ILIMITMAX			0.491	Amps	Maximum Current Limit
fSmin			124000	Hertz	Minimum Device Switching Frequency
I^2fmin			24.057	A^2kHz	I^2f (product of current limit squared and frequency is trimmed for tighter tolerance)
VOR			120.00	Volts	Reflected Output Voltage (VOR < 135 V Recommended)
VDS			10.00	Volts	TinySwitch-4 on-state Drain to Source Voltage
VD			0.50	Volts	Output Winding Diode Forward Voltage Drop
KP			0.90		Ripple to Peak Current Ratio (KP < 6)
KP_TRANSIENT			0.55		Transient Ripple to Peak Current Ratio. Ensure KP_TRANSIENT > 0.25
ENTER BIAS WINDING VARIABLES					
VB			22.00	Volts	Bias Winding Voltage
VDB			0.70	Volts	Bias Winding Diode Forward Voltage Drop
NB			10.15		Bias Winding Number of Turns
VZOV			28.00	Volts	Over Voltage Protection zener diode voltage.
UVLO VARIABLES					
V_UV_TARGET			268.06	Volts	Target DC under-voltage threshold, above which the power supply with start
V_UV_ACTUAL			277.20	Volts	Typical DC start-up voltage based on standard value of RUV_ACTUAL
RUV_IDEAL			10.63	Mohms	Calculated value for UV Lockout resistor
RUV_ACTUAL			11.00	Mohms	Closest standard value of resistor to RUV_IDEAL
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	**EF25**		**EF25**		Enter Transformer Core
Core		EF25		P/N:	PC40EF25-Z
Custom core				P/N:	EF25_BOBBIN
AE			0.52	cm^2	Core Effective Cross Sectional Area
LE			5.78	cm	Core Effective Path Length
AL			2000.00	nH/T^2	Ungapped Core Effective Inductance
BW			15.60	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			3		Number of Secondary Turns
DC INPUT VOLTAGE PARAMETERS					
VMIN			243.69	Volts	Minimum DC Input Voltage
VMAX			374.77	Volts	Maximum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.34		Duty Ratio at full load, minimum primary inductance and minimum input voltage
IAVG			0.09	Amps	Average Primary Current
IP			0.42	Amps	Minimum Peak Primary Current

IR			0.38	Amps	Primary Ripple Current
IRMS			0.17	Amps	Primary RMS Current
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			1721	uHenries	Typical Primary Inductance. +/- 10% to ensure a minimum primary inductance of 1549 uH
LP_TOLERANCE			10	%	Primary inductance tolerance
NP			55		Primary Winding Number of Turns
ALG			561	nH/T^2	Gapped Core Effective Inductance
BM			2946	Gauss	Maximum Operating Flux Density, BM<3100 is recommended
BAC			1323	Gauss	AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)
ur			1776		Relative Permeability of Ungapped Core
LG		Warning	0.08	mm	!!! INCREASE GAP>>0.1. Increase NS, increase VOR,bigger Core
BWE			46.8	mm	Effective Bobbin Width
OD			0.85	mm	Maximum Primary Wire Diameter including insulation
INS			0.08	mm	Estimated Total Insulation Thickness (= 2 * film thickness)
DIA			0.77	mm	Bare conductor diameter
AWG			21	AWG	Primary Wire Gauge (Rounded to next smaller standard AWG value)
CM			813	Cmils	Bare conductor effective area in circular mils
CMA		Info	4667	Cmils/Amp	CAN DECREASE CMA < 500 (decrease L(primary layers),increase NS,use smaller Core)
TRANSFORMER SECONDARY DESIGN PARAMETERS					
Lumped parameters					
ISP			7.74	Amps	Peak Secondary Current
ISRMS			4.49	Amps	Secondary RMS Current
IRIPPLE			3.73	Amps	Output Capacitor RMS Ripple Current
CMS			897	Cmils	Secondary Bare Conductor minimum circular mils
AWGS			20	AWG	Secondary Wire Gauge (Rounded up to next larger standard AWG value)
VOLTAGE STRESS PARAMETERS					
VDRAIN			647	Volts	Maximum Drain Voltage Estimate (Assumes 20% zener clamp tolerance and an additional 10% temperature tolerance)
PIVS			26	Volts	Output Rectifier Maximum Peak Inverse Voltage
TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS)					
1st output					
VO1	6.00		6.00	Volts	Main Output Voltage (if unused, defaults to single output design)
IO1	1.80		1.80	Amps	Output DC Current
PO1			10.80	Watts	Output Power
VD1			0.50	Volts	Output Diode Forward Voltage Drop
NS1			3.00		Output Winding Number of Turns
ISRMS1			3.230	Amps	Output Winding RMS Current
IRIPPLE1			2.68	Amps	Output Capacitor RMS Ripple Current
PIVS1			26	Volts	Output Rectifier Maximum Peak Inverse Voltage
Recommended Diodes			SB520		Recommended Diodes for this output
CMS1			646	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS1			22	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS1			0.65	mm	Minimum Bare Conductor Diameter
ODS1			5.20	mm	Maximum Outside Diameter for Triple Insulated Wire
2nd output					
VO2	20.00			Volts	Output Voltage
IO2	0.20			Amps	Output DC Current
PO2			4.00	Watts	Output Power
VD2			0.70	Volts	Output Diode Forward Voltage Drop
NS2			9.55		Output Winding Number of Turns
ISRMS2			0.359	Amps	Output Winding RMS Current
IRIPPLE2			0.30	Amps	Output Capacitor RMS Ripple Current
PIVS2			85	Volts	Output Rectifier Maximum Peak Inverse Voltage
Recommended Diode			1N5817, SB120		Recommended Diodes for this output
CMS2			72	Cmils	Output Winding Bare Conductor minimum circular mils
AWGS2			31	AWG	Wire Gauge (Rounded up to next larger standard AWG value)
DIAS2			0.23	mm	Minimum Bare Conductor Diameter
ODS2			1.63	mm	Maximum Outside Diameter for Triple Insulated Wire
3rd output					

VO3				Volts	Output Voltage
IO3				Amps	Output DC Current
PO3			0.00	Watts	Output Power
VD3			0.70	Volts	Output Diode Forward Voltage Drop
NS3			0.32		Output Winding Number of Turns
ISRMS3			0.000	Amps	Output Winding RMS Current
IRIPPLE3			0.00	Amps	Output Capacitor RMS Ripple Current
PIVS3			2	Volts	Output Rectifier Maximum Peak Inverse Voltage
Recommended Diode					Recommended Diodes for this output
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 power			14.8	Watts	Total Output Power
Negative Output	N/A		N/A		If negative output exists enter Output number; eg: If VO2 is negative output, enter 2

Transformer Construction Parameters

Var	Value	Units	Description
Core Type	EF25		Core Type
Core Material	NC-2H (Nicera) or Equivalent		Core Material
Bobbin Reference	Generic, 4 pri. + 3 sec.		Bobbin Reference
Bobbin Orientation	Horizontal		Bobbin type
Primary Pins	4		Number of Primary pins used
Secondary Pins	3		Number of Secondary pins used
LP	1721	µH	Nominal Primary Inductance
ML	0.00	mm	Safety Margin on Left Width
MR	0.00	mm	Safety Margin on Right Width
LG	0.083	mm	Estimated Gap Length

Bias Variables

Var	Value	Units	Description
NB	11		Bias Winding Number of Turns
Wire Size	26	AWG	Wire size of Bias windings
Winding Type	Bifilar (x2)		Wire type of Bias windings
Layers	0.64		Bias Winding Layers
Start Pin(s)	4		Starting pin(s) for Bias winding
Termination Pin(s)	3		Termination pin(s) for Bias winding

Primary Winding Section 1

Var	Value	Units	Description
NP1	55		Rounded (Integer) Number of Primary winding turns in the first section of primary
Wire Size	26	AWG	Wire size of primary winding
Winding Type	Trifilar (x3)		Primary winding number of parallel wire strands
L	4.78		Primary Number of Layers
Start Pin(s)	2		Starting pin(s) for first section of primary winding
Termination Pin(s)	1		Termination pin(s) for first section of primary winding

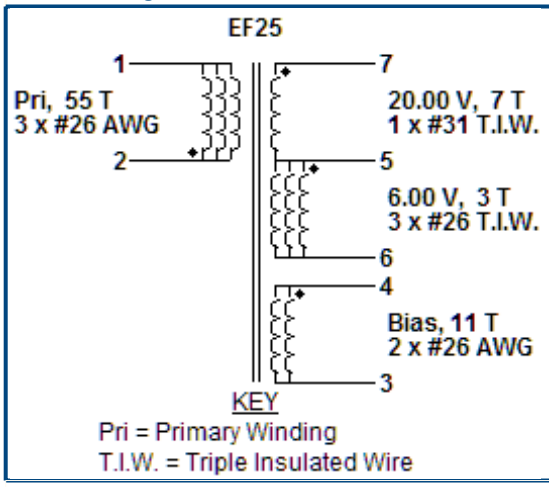
Output 1

Var	Value	Units	Description
VO	6.00	V	Output Voltage
IO	1.80	A	Output Current
VOUT_ACTUAL	6.00	V	Actual Output Voltage
NS	3		Secondary Number of Turns
Wire Size	26	AWG	Wire size of secondary winding
Winding Type	Trifilar (x3)		Output winding number of parallel strands
L_S_OUT	0.35		Secondary Output Winding Layers
Start Pin(s)	5		Starting pin(s) for Output winding
Termination Pin(s)	6		Termination pin(s) for Output winding

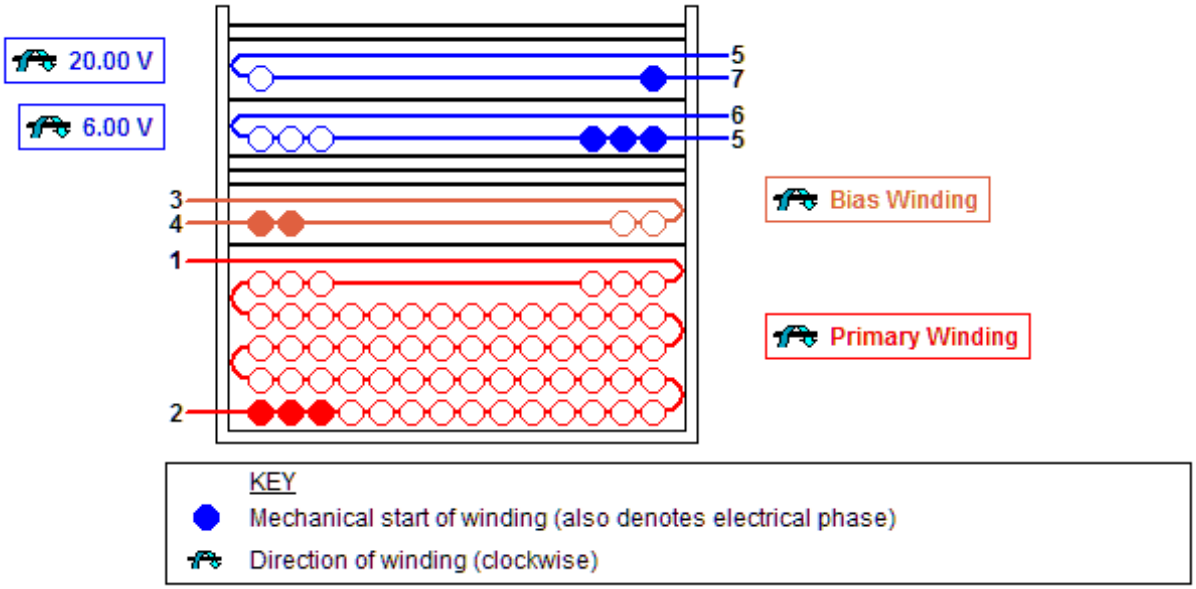
Output 2

Var	Value	Units	Description
VO	20.00	V	Output Voltage
IO	0.20	A	Output Current
VOUT_ACTUAL	20.97	V	Actual Output Voltage
NS	7		Secondary Number of Turns
Wire Size	31	AWG	Wire size of secondary winding
Winding Type	Single (x1)		Output winding number of parallel strands
L_S_OUT	0.19		Secondary Output Winding Layers
Start Pin(s)	7		Starting pin(s) for Output winding
Termination Pin(s)	5		Termination pin(s) for Output winding

Electrical Diagram



Mechanical Diagram



Winding Instruction

Primary Winding

Start on pin(s) 2 and wind 55 turns (x 3 filar) of item [5]. in 5 layer(s) from left to right. At the end of 1st layer, continue to wind the next layer from right to left. At the end of 2nd layer, continue to wind the next layer from left to right. Continue the same way as in previous 2 layers. On the final layer, spread the winding evenly across entire bobbin. Finish this winding on pin(s) 1.

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

Bias Winding

Start on pin(s) 4 and wind 11 turns (x 2 filar) of item [5]. Wind in same rotational direction as primary winding. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 3.

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

Secondary Winding

Start on pin(s) 5 and wind 3 turns (x 3 filar) of item [6]. Spread the winding evenly across entire bobbin. Wind in same rotational direction as primary winding. Finish this winding on pin(s) 6.

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

Start on pin(s) 7 and wind 7 turns (x 1 filar) of item [7]. Spread the winding evenly across entire bobbin. Wind in same rotational direction as primary winding. Finish this winding on pin(s) 5.

Add 2 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

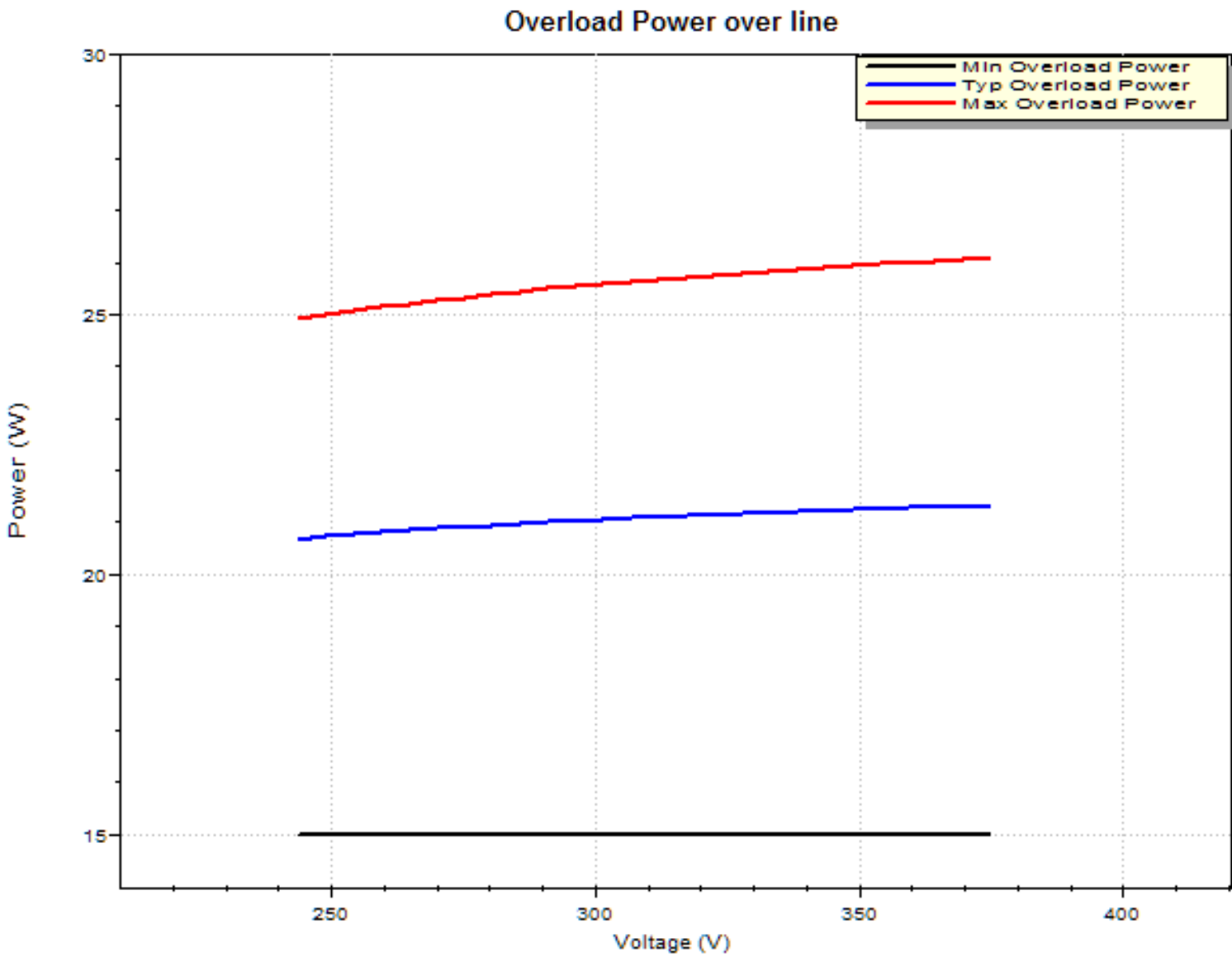
1. For non margin wound transformers use triple insulated wire for all secondary windings.

Materials

Item	*Description*
[1]	Core: EF25, NC-2H (Nicera) or Equivalent, gapped for ALG of 561 nH/T²
[2]	Bobbin: Generic, 4 pri. + 3 sec.
[3]	Barrier Tape: Polyester film [1 mil (25 µm) base thickness], 15.60 mm wide
[4]	Varnish
[5]	Magnet Wire: 26 AWG, Solderable Double Coated
[6]	Triple Insulated Wire: 26 AWG
[7]	Triple Insulated Wire: 31 AWG

Electrical Test Specifications

Parameter	*Condition*	*Spec*
Electrical Strength, VAC	**60 Hz 1 second, from pins 1,2,3,4 to pins 5,6,7.**	**3000**
Nominal Primary Inductance, µH	**Measured at 1 V pk-pk, typical switching frequency, between pin 1 to pin 2, with all other Windings open.**	**1721**
Tolerance, ±%	**Tolerance of Primary Inductance**	**10.0**
Maximum Primary Leakage, µH	**Measured between Pin 1 to Pin 2, with all other Windings shorted.**	**51.64**


Overload Power over line
Min Overload Power
Typ Overload Power
Max Overload Power
30
25
20
15
Power (W)
250
300
350
400
Voltage (V)