ACDC_InnoSwitchEP900V_080817; Rev.1.5; Copyright Power Integrations 2017	***INPUT***	***INFO***	***OUTPUT***	***UNIT***	***InnoSwitch-EP Continuous/Discontinuous Flyback Transformer Design Spreadsheet***
ENTER APPLICATION VARIABLES					*Customer*
VACMIN	*100*		*100*	*V*	*Minimum AC Input Voltage*
VACMAX	*484*		*484*	*V*	*Maximum AC Input Voltage*
fL			*50*	*Hz*	*AC Mains Frequency*
VO	*12.00*		*12.00*	*V*	*Output Voltage (continuous power at the end of the cable)*
IO	*1.00*		*1.00*	*A*	*Power Supply Output Current (corresponding to peak power)*
Power			*12.00*	*W*	*Continuous Output Power, including cable drop compensation*
n			*0.80*		*Efficiency Estimate at output terminals. Use 0.8 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			*2.658*	*mSeconds*	*Bridge Rectifier Conduction Time Estimate*
CIN			*24.00*	*uFarad*	*Input capacitance*
ENTER InnoSwitch-EP VARIABLES					
InnoSwitch-EP	*INN2904*		*INN2904*		*User defined InnoSwitch*
Chose Configuration	*RED*		*Reduced 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			*0.799*	*A*	*Minimum Current Limit*
ILIMITTYP			*0.850*	*A*	*Typical Current Limit*
ILIMITMAX			*0.901*	*A*	*Maximum Current Limit*
fSmin			*93000*	*Hz*	*Minimum Device Switching Frequency*
I^2fmin			*60.69*	*A^2kHz*	*Worst case I2F parameter across the temperature range*
VOR			*76*	*V*	*Reflected Output Voltage (VOR <= 100 V Recommended)*
VDS			*5.00*	*V*	*InnoSwitch on-state Drain to Source Voltage*
KP			*1.473*		*Ripple to Peak Current Ratio at Vmin, assuming ILIMITMIN, and I2FMIN (KP < 6)*
KP_TRANSIENT			*0.524*		*Worst case transient Ripple to Peak Current Ratio. Ensure KP_TRANSIENT > 0.25*
ENTER InnoSwitch-EP PROTECTION VARIABLES					
Line Undervoltage					
BROWN IN			*79.5*	*VRMS*	*Minimum RMS AC Voltage at which the power supply will BROWN-IN (turn-on). The actual value of this voltage may differ slightly from the desired value due to the V-pin resistor's tolerance*
BROWN OUT			*66.9*	*VRMS*	*Typical RMS AC Voltage at which the power supply will BROWN-OUT (turn-off) under conditions of line-undervoltage*
RLS			*8.78*	*MOhms*	*Theoretical V-pin resistor for the desired UV/OV setup*
RLS1/RLS2			*4.42*	*MOhms*	*Standard value of a single 1% resistor, assuming 2 series resistors are used*

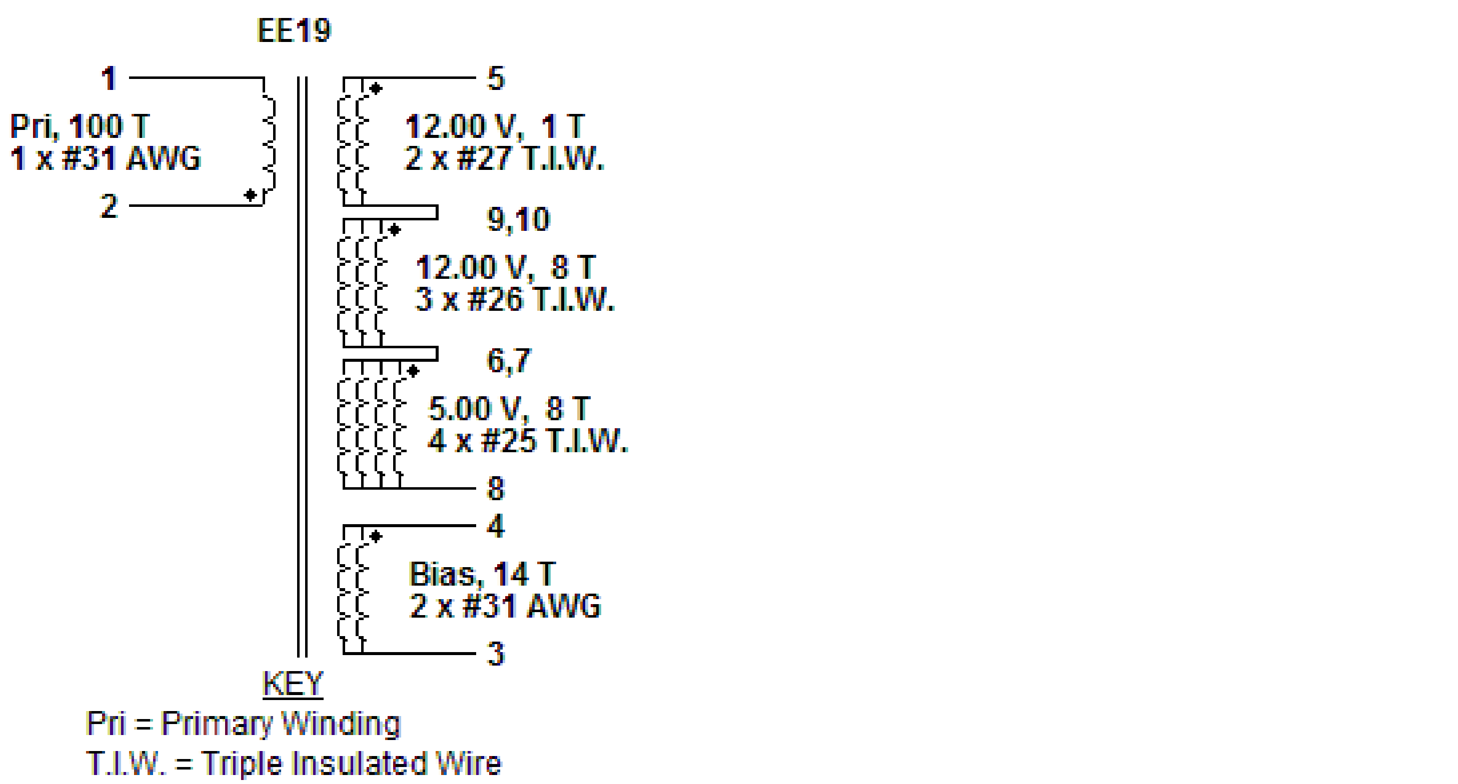
VBROWNIN VARIATION			0.00	%	Variation between the actual and desired brown-in voltage
Line Overvoltage					
BROWN IN			702.2	VRMS	Typical RMS AC voltage at which the power supply will BROWN-IN (turn-on) after a line overvoltage BROWN-OUT (turn-off) event
BROWN OUT			731.5	VRMS	Typical RMS AC voltage at which the power supply will BROWN-OUT (turn-off) under conditions of line-overvoltage
Load Overcurrent					
IOMAX			3.60	A	Load current beyond which the device will enter into overload protection. By default value consists of the sum of all output currents multiplied by 1.2
RIS			0.010	Ohms	Use a 0.01 Ohm, 1-5% resistor having a minimum power rating of 0.126W on the IS pin for load overcurrent protection
ENTER BIAS WINDING VARIABLES					
VB			10.00	V	Bias Winding Voltage
VDB			0.70	V	Bias Winding Diode Forward Voltage Drop
NB			13.22	V	Bias Winding Number of Turns
PIVB			138.71	V	Bias winding peak reverse voltage at VACmax and assuming VB*1.2
ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES					
Core Type	EE19		EE19		Enter Transformer Core
Core			PC40EE19-Z		Enter core part number, if necessary
Bobbin			BE-19-116-CP		Enter bobbin part number, if necessary
AE			0.23	cm^2	Core Effective Cross Sectional Area
LE			3.94	cm	Core Effective Path Length
AL			1250	nH/T^2	Ungapped Core Effective Inductance
BW			9.10	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			16		Number of Secondary Turns
AW			36.40	mm^2	Bobbin window area
DC INPUT VOLTAGE PARAMETERS					
VMIN			102.99	V	Minimum DC Input Voltage
VMAX			684	V	Maximum DC Input Voltage
CURRENT WAVEFORM SHAPE PARAMETERS					
DMAX			0.44		Duty Ratio at full load, minimum primary inductance and minimum input voltage
IAVG			0.14	A	Average Primary Current
IP			0.80	A	Peak Primary Current assuming ILIMITMIN

IR			*0.80*	*A*	*Primary Ripple Current assuming ILIMITMIN, and LPMIN*
IRMS			*0.27*	*A*	*Primary RMS Current, assuming ILIMITMIN, and LPMIN*
TRANSFORMER PRIMARY DESIGN PARAMETERS					
LP			*523*	*uHenry*	*Typical Primary Inductance. +/- 15% to ensure a minimum primary inductance of 444 uH*
LP_TOLERANCE	*15*		*15*	*%*	*Primary inductance tolerance*
NP			*100*		*Primary Winding Number of Turns*
ALG			*52*	*nH/T^2*	*Gapped Core Effective Inductance*
BM			*2847*	*Gauss*	*Maximum Operating Flux Density, BM<3000 is recommended*
BAC			*1423*	*Gauss*	*AC Flux Density for Core Loss Curves (0.5 X Peak to Peak)*
ur			*1704*		*Relative Permeability of Ungapped Core*
LG			*0.53*	*mm*	*Gap Length (Lg > 0.1 mm)*
BWE			*27.3*	*mm*	*Effective Bobbin Width*
OD			*0.27*	*mm*	*Maximum Primary Wire Diameter including insulation*
INS			*0.050*	*mm*	*Estimated Total Insulation Thickness (= 2 * film thickness)*
DIA			*0.223*	*mm*	*Bare conductor diameter*
AWG			*32*	*AWG*	*Primary Wire Gauge (Rounded to next smaller standard AWG value)*
CM			*64*	*Cmils*	*Bare conductor effective area in circular mils*
CMA			*236*	*Cmils/Amp*	*Primary Winding Current Capacity (200 < CMA < 500)*
TRANSFORMER SECONDARY DESIGN PARAMETERS					
Lumped parameters					
ISP			*4.99*	*A*	*Peak Secondary Current, assuming ILIMITMIN*
ISRMS			*1.92*	*A*	*Secondary RMS Current*
IRIPPLE			*1.64*	*A*	*Output Capacitor RMS Ripple Current*
CMS			*385*	*Cmils*	*Secondary Bare Conductor minimum circular mils*
AWGS			*24*	*AWG*	*Secondary Wire Gauge (Rounded up to next larger standard AWG value)*
VOLTAGE STRESS PARAMETERS					
VDRAIN			*810*	*V*	*Maximum Drain Voltage Estimate*
PIVS			*122*	*V*	*Output Rectifier Maximum Peak Inverse Voltage for 1st output, assuming the primary has a Voltage spike 40% above VMAX and VO*1.05*
TRANSFORMER SECONDARY DESIGN PARAMETERS					
1st output					
VO1			*12.00*	*V*	*Main Output Voltage directly after output rectifier*
IO1			*1.00*	*A*	*Output DC Current*

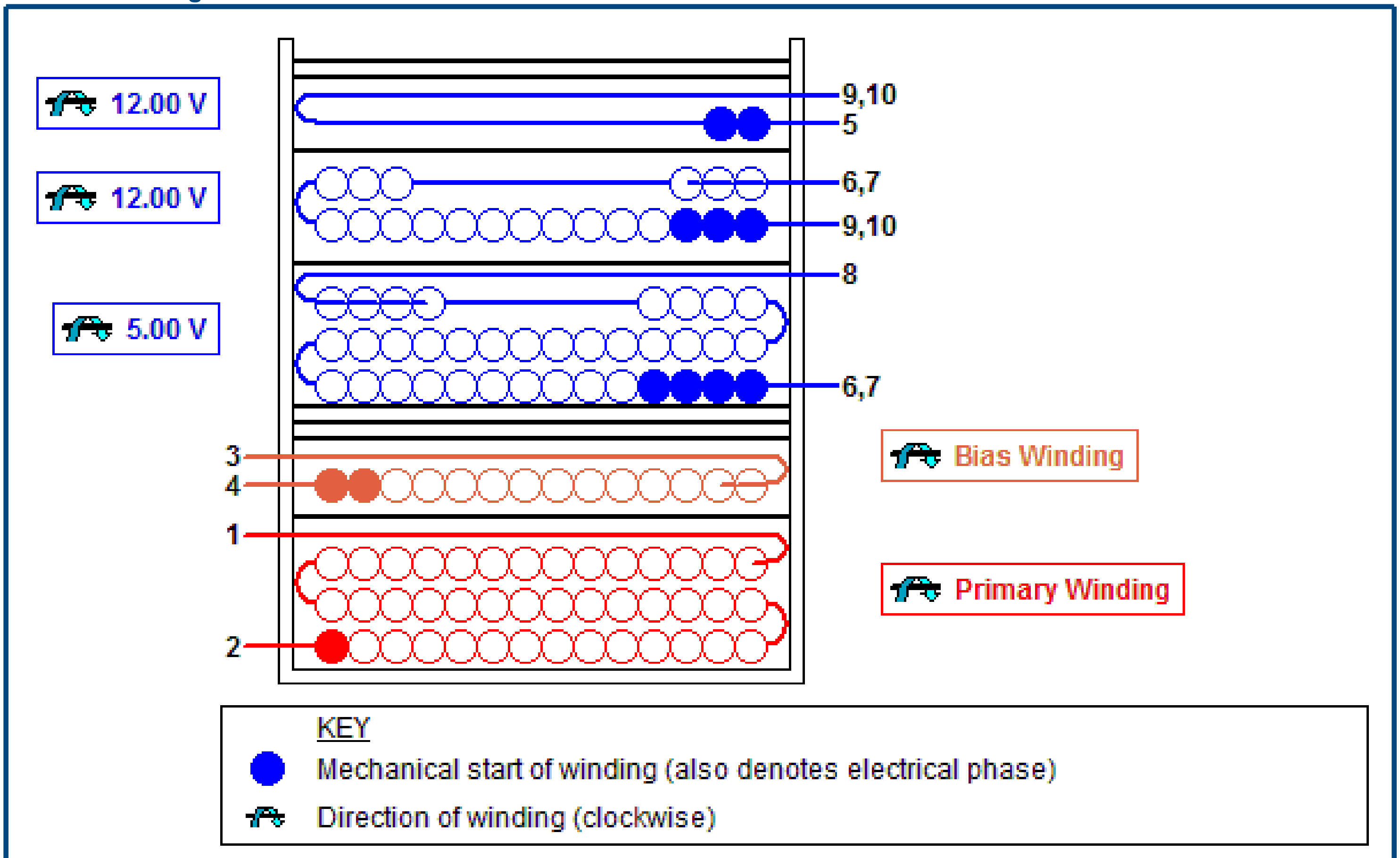
PO1			*12.00*	*W*	*Output Power*
VD1			*0.10*	*V*	*Output Synchronous Rectification FET Forward Voltage Drop*
NS1			*16.00*	*Turns*	*Output Winding Number of Turns*
ISRMS1			*1.92*	*A*	*Output Winding RMS Current*
IRIPPLE1			*1.64*	*A*	*Output Capacitor RMS Ripple Current*
PIVS1			*122*	*V*	*Output Rectifier Maximum Peak Inverse Voltage, assuming the primary has a Voltage spike 40% above VMAX and VO*1.05*
CMS1			*385*	*Cmils*	*Output Winding Bare Conductor minimum circular mils*
AWGS1			*24*	*AWG*	*Wire Gauge (Rounded up to next larger standard AWG value)*
DIAS1			*0.51*	*mm*	*Minimum Bare Conductor Diameter*
ODS1			*0.57*	*mm*	*Maximum Outside Diameter for Triple Insulated Wire*
Recommended MOSFET	*Auto*		*AON7254*		*Recommended SR FET for this output*
RDSON_HOT			*66.00*	*mOhm*	*RDSon at 100C*
VRATED		*Info*	*150*	*V*	*The peak parasitic ring voltage during the SRFET turn-off transition could be very close to the PIV of the SRFET. Verify performance on the bench*
2nd output					
VO2	*5.00*		*5.00*	*V*	*Output Voltage*
IO2	*1.00*		*1.00*	*A*	*Output DC Current*
PO2			*5.00*	*W*	*Output Power*
VD2			*0.70*	*V*	*Output Diode Forward Voltage Drop*
NS2			*8*		*Output Winding Number of Turns*
ISRMS2			*1.92*	*A*	*Output Winding RMS Current*
IRIPPLE2			*1.64*	*A*	*Output Capacitor RMS Ripple Current*
PIVS2			*82*	*V*	*Output Rectifier Maximum Peak Inverse Voltage*
CMS2			*385*	*Cmils*	*Output Winding Bare Conductor minimum circular mils*
AWGS2			*24*	*AWG*	*Wire Gauge (Rounded up to next larger standard AWG value)*
DIAS2			*0.51*	*mm*	*Minimum Bare Conductor Diameter*
ODS2			*1.14*	*mm*	*Maximum Outside Diameter for Triple Insulated Wire*
3rd output					
VO3	*12.00*		*12.00*	*V*	*Output Voltage*
IO3	*1.00*		*1.00*	*A*	*Output DC Current*
PO3			*12.00*	*W*	*Output Power*
VD3			*0.70*	*V*	*Output Diode Forward Voltage Drop*
NS3			*16*		*Output Winding Number of Turns*
ISRMS3			*1.92*	*A*	*Output Winding RMS Current*
IRIPPLE3			*1.64*	*A*	*Output Capacitor RMS Ripple Current*
PIVS3			*166*	*V*	*Output Rectifier Maximum Peak Inverse Voltage*

CMS3			*385*	*Cmils*	*Output Winding Bare Conductor minimum circular mils*
AWGS3			*24*	*AWG*	*Wire Gauge (Rounded up to next larger standard AWG value)*
DIAS3			*0.51*	*mm*	*Minimum Bare Conductor Diameter*
ODS3			*0.57*	*mm*	*Maximum Outside Diameter for Triple Insulated Wire*
Total power					
			29.00	*W*	*Total Power for Multi-output section*
Negative Output			*N/A*		*If negative output exists enter Output number; e.g. If VO2 is negative output, select 2*

Electrical Diagram



Mechanical Diagram



Winding Instruction

Primary Winding

Start on pin(s) 2 and wind 100 turns (x 1 filar) of item [5]. in 3 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. At the end of 2nd layer, continue to wind the next layer from left to right. 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 14 turns (x 2 filar) of item [5]. Winding direction is clockwise. 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) 6,7 and wind 8 turns (x 4 filar) of item [6]. 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) 9,10 and wind 8 turns (x 3 filar) of item [7]. Spread the winding evenly across entire bobbin. Winding direction is clockwise. Finish this winding on pin(s) 6,7.

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

Start on pin(s) 5 and wind 1 turns (x 2 filar) of item [8]. Spread the winding evenly across entire bobbin. Winding direction is clockwise. Finish this winding on pin(s) 9,10.

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. Pins 6 and 7 are electrically shorted to each other on the PCB via a copper trace.
2. Pins 9 and 10 are electrically shorted to each other on the PCB via a copper trace.
3. For non margin wound transformers use triple insulated wire for all secondary windings.

Materials

Item	*Description*
[1]	Core: EE19, 3F3, gapped for ALG of 52 nH/T²
[2]	Bobbin: Generic, 4 pri. + 6 sec.
[3]	Barrier Tape: Polyester film [1 mil (25 µm) base thickness], 9.10 mm wide
[4]	Varnish
[5]	Magnet Wire: 31 AWG, Solderable Double Coated
[6]	Triple Insulated Wire: 25 AWG
[7]	Triple Insulated Wire: 26 AWG
[8]	Triple Insulated Wire: 27 AWG

Electrical Test Specifications

Parameter	*Condition*	*Spec*
Electrical Strength, VAC	**60 Hz 1 second, from pins 1,2,3,4 to pins 5,6,7,8,9,10.**	**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.**	**523**
Tolerance, ±%	**Tolerance of Primary Inductance**	**15.0**
Maximum Primary Leakage, µH	**Measured between Pin 1 to Pin 2, with all other Windings shorted.**	**15.70**

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	**EE19**		Core Type
Core Material	**3F3**		Core Material
Bobbin Reference	**Generic, 4 pri. + 6 sec.**		Bobbin Reference
Bobbin Orientation	**Horizontal**		Bobbin type
Primary Pins	**4**		Number of Primary pins used
Secondary Pins	**6**		Number of Secondary pins used
LP	**523**	μH	Nominal Primary Inductance
ML	**0.00**	mm	Safety Margin on Left Width
MR	**0.00**	mm	Safety Margin on Right Width
LG	**0.529**	mm	Estimated Gap Length
TRF_LOSS	**-1.8243**	W	Total Transformer Losses
FF	**136**	%	Actual Transformer Fit Factor. 100% signifies fully utilized winding window

Bias Variables

Var	Value	Units	Description
NB	**14**		Bias Winding Number of Turns
Wire Size	**31**	AWG	Wire size of Bias windings
Winding Type	**Bifilar (x2)**		Wire type of Bias windings
Layers	**0.82**		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	**100**		Number of Primary Winding Turns in the First Section of Primary
Wire Size	**31**	AWG	Primary Winding - Wire Size
Winding Type	**Single (x1)**		Primary Winding - Number of Parallel Wire Strands
L	**2.93**		Primary Winding - 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	**12.00**	V	Typical Output Voltage
IO	**1.00**	A	Output Current
VOUT_ACTUAL	**12.00**	V	Actual Output Voltage
NS	**8**		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	**1.58**		Secondary Output Winding Layers
Start Pin(s)	**9,10**		Starting pin(s) for Output winding
Termination Pin(s)	**6,7**		Termination pin(s) for Output winding

Output 2

Var	Value	Units	Description

VO	**5.00**	*V*	*Typical Output Voltage*
IO	**1.00**	*A*	*Output Current*
VOUT_ACTUAL	**5.35**	*V*	*Actual Output Voltage*
NS	**8**		*Secondary Number of Turns*
Wire Size	**25**	*AWG*	*Wire size of secondary winding*
Winding Type	**Quadfilar (x4)**		*Output winding number of parallel strands*
L_S_OUT	**2.29**		*Secondary Output Winding Layers*
Start Pin(s)	**6,7**		*Starting pin(s) for Output winding*
Termination Pin(s)	**8**		*Termination pin(s) for Output winding*

Output 3

Var	***Value***	***Units***	***Description***
VO	**12.00**	*V*	*Typical Output Voltage*
IO	**1.00**	*A*	*Output Current*
VOUT_ACTUAL	**12.16**	*V*	*Actual Output Voltage*
NS	**1**		*Secondary Number of Turns*
Wire Size	**27**	*AWG*	*Wire size of secondary winding*
Winding Type	**Bifilar (x2)**		*Output winding number of parallel strands*
L_S_OUT	**0.12**		*Secondary Output Winding Layers*
Start Pin(s)	**5**		*Starting pin(s) for Output winding*
Termination Pin(s)	**9,10**		*Termination pin(s) for Output winding*