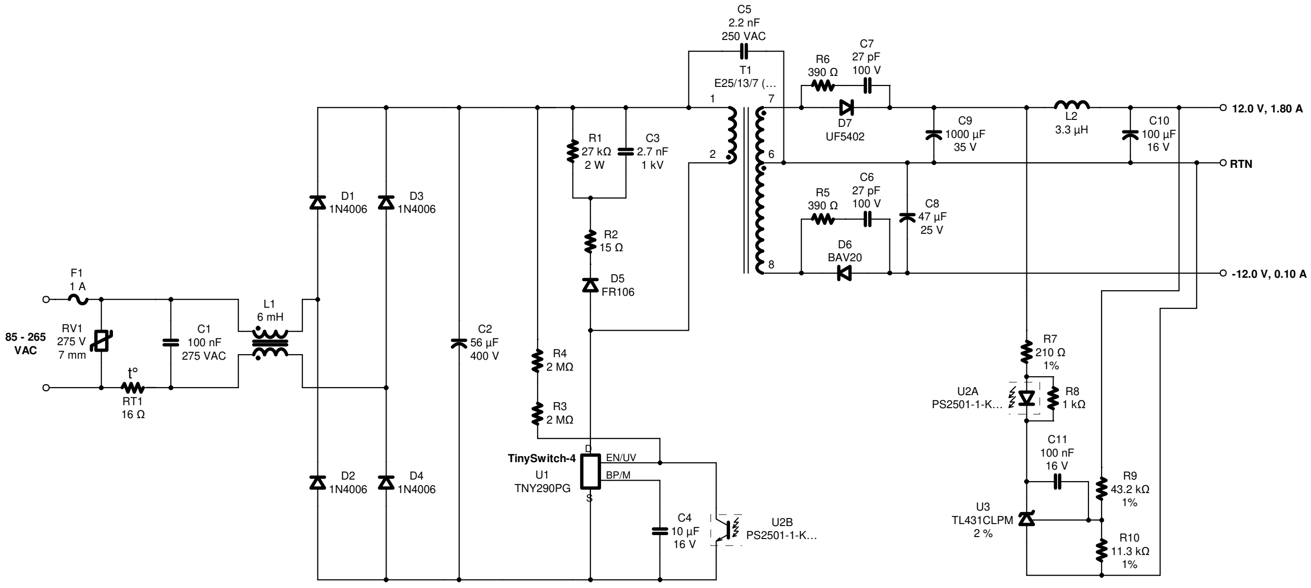


85 - 265 VAC
F1 1 A
RV1 275 V 7 mm
RT1 16 Ω
C1 100 nF 275 VAC
L1 6 mH
D1 1N4006
D2 1N4006
D3 1N4006
D4 1N4006
C2 56 µF 400 V
R4 2 MΩ
R3 2 MΩ
R1 27 kΩ 2 W
C3 2.7 nF 1 kV
R2 15 Ω
D5 FR106
TinySwitch-4
U1 TNY290PG
D
S
EN/UV
BP/M
C4 10 µF 16 V
U2B PS2501-1-K...
C5 2.2 nF 250 VAC
T1 E25/13/7 (...
1
2
7
6
8
R6 390 Ω
C7 27 pF 100 V
D7 UF5402
R5 390 Ω
C6 27 pF 100 V
D6 BAV20
C8 47 µF 25 V
C9 1000 µF 35 V
L2 3.3 µH
C10 100 µF 16 V
12.0 V, 1.80 A
RTN
-12.0 V, 0.10 A
R7 210 Ω 1%
U2A PS2501-1-K...
R8 1 kΩ
C11 100 nF 16 V
U3 TL431CLPM 2 %
R9 43.2 kΩ 1%
R10 11.3 kΩ 1%

## Power Supply Input

| Var | Value | Units | Description |
|---|---|---|---|
| VACMIN | 85 | V | Minimum Input AC Voltage |
| VACMAX | 265 | V | Maximum Input AC Voltage |
| FL | 50 | Hz | Line Frequency |
| TC | 2.70 | ms | Diode Conduction Time |
| Z | 0.50 | | Loss Allocation Factor |
| η | 78.0 | % | Efficiency Estimate |
| VMIN | 82.6 | V | Minimum DC Input Voltage |
| VMAX | 374.8 | V | Maximum DC Input Voltage |

## Input Section

| Var | Value | Units | Description |
|---|---|---|---|
| Fuse | 1.00 | A | Input Fuse Rated Current |
| IAVG | 0.35 | A | Average Diode Bridge Current (DC Input Current) |
| Thermistor | 16.00 | Ω | Input Thermistor |
| MOV_VRATED | 275 | V | MOV Rated Voltage |

## Device Variables

| Var | Value | Units | Description |
|---|---|---|---|
| Device | TNY290PG | | PI Device Name |
| Device Mode | Increased | | Current Limit mode for device |
| PO | 22.80 | W | Total Output Power |
| VDRAIN Estimated | 605.01 | V | Actual Estimated Drain Voltage |
| VDS | 4.57 | V | On state Drain to Source Voltage |
| I2F_MIN | 85.83 | A²kHz | Minimum I2F |
| I2F_MAX | 110.63 | A²kHz | Maximum I2F |
| FS_AT_ILIMMIN | 137183 | Hz | Switching Frequency at Current Limit Minimum |
| KP | 0.41 | | Continuous/Discontinuous Operating Ratio |
| KP_TRANSIENT | 0.29 | | Transient Ripple to Peak Current Ratio |
| ILIMITMIN | 0.79 | A | Minimum Current Limit |
| ILIMITMAX | 0.94 | A | Maximum Current Limit |
| RLS | 2.0 | MΩ | Line sense resistor |
| RLS2 | 2.0 | MΩ | Line sense resistor |
| IRMS | 0.49 | A | Primary RMS Current (at VMIN) |
| P_NO_LOAD | 150 | mW | Estimated No Load Input Power |
| DMAX | 0.57 | | Maximum Duty Cycle |
| RTH_DEVICE | 46.26 | °C/W | PI Device Maximum Thermal Resistance |
| DEV_HSINK_TYPE | 2 Oz (70 µ) Copper PCB | | PI Device Heatsink Type |
| DEV_HSINK_AREA | 262 | mm² | PI Device Heatsink Area |

## Clamp Circuit

| Var | Value | Units | Description |
|---|---|---|---|
| Clamp Type | RCD Clamp | | Clamp Circuit Type |
| VCLAMP | 175 | V | Estimated average clamping voltage |
| Estimated Clamp Loss | 1.04 | W | Clamp Dissipation |

## Transformer Construction Parameters

| Var | Value | Units | Description |
|---|---|---|---|
| Core Type | E25/13/7 (EF25) | | Core Type |

| | | | |
|---|---|---|---|
| Core Material | NC-2H (Nicera) or Equivalent | | Core Material |
| Bobbin Reference | Generic, 5 pri. + 5 sec. | | Bobbin Reference |
| Bobbin Orientation | Vertical | | Bobbin type |
| Primary Pins | 4 | | Number of Primary pins used |
| Secondary Pins | 3 | | Number of Secondary pins used |
| USE_SHIELDS | NO | | Use shield Windings |
| LP_nom | 1041 | µH | Nominal Primary Inductance |
| LP_Tol | 10.0 | % | Primary Inductance Tolerance |
| NP | 64.6 | | Calculated Primary Winding Total Number of Turns |
| NSM | 8 | | Secondary Main Number of Turns |
| CMA | 518 | Cmils/A | Primary Winding Current Capacity |
| VOR | 105.0 | V | Reflected Output Voltage |
| BW | 15.30 | mm | Bobbin Winding Width |
| ML | 0.00 | mm | Safety Margin on Left Width |
| MR | 0.00 | mm | Safety Margin on Right Width |
| FF | 33 | % | Actual Transformer Fit Factor. 100% signifies fully utilized winding window |
| AE | 52.50 | $mm^2$ | Core Cross Sectional Area |
| ALG | 224 | $nH/T^2$ | Gapped Core Effective Inductance |
| BM | 2675 | Gauss | Maximum Flux Density |
| BAC | 453 | Gauss | AC Flux Density for Core Loss |
| LG | 0.256 | mm | Estimated Gap Length |
| L_LKG | 31.24 | µH | Estimated primary leakage inductance |
| LSEC | 15 | nH | Secondary Trace Inductance |

## Primary Winding Section 1

| ***Var*** | ***Value*** | ***Units*** | ***Description*** |
|---|---|---|---|
| NP1 | 65 | | Rounded (Integer) Number of Primary winding turns in the first section of primary |
| Wire Size | 26 | AWG | Wire size of primary winding |
| Winding Type | Single (x1) | | Primary winding number of parallel wire strands |
| L | 1.92 | | Primary Number of Layers |
| DC Copper Loss | 0.10 | W | Primary 1 DC Losses |

## Output 1

| ***Var*** | ***Value*** | ***Units*** | ***Description*** |
|---|---|---|---|
| VO | 12.00 | V | Output Voltage |
| IO | 1.80 | A | Output Current |
| VOUT_ACTUAL | 12.00 | V | Actual Output Voltage |
| NS | 8 | | Secondary Number of Turns |
| Wire Size | 25 | AWG | Wire size of secondary winding |
| Winding Type | Bifilar (x2) | | Output winding number of parallel strands |
| L_S_OUT | 0.68 | | Secondary Output Winding Layers |
| DC Copper Loss | 0.27 | W | Secondary DC Losses |
| VD | 1.00 | V | Output Winding Diode Forward Voltage Drop |
| PIVS | 58 | V | Output Rectifier Maximum Peak Inverse Voltage |
| ISP | 6.05 | A | Peak Secondary Current |
| ISRMS | 3.19 | A | Secondary RMS Current |
| RTH_DIODE | 31.05 | °C/W | Output Diode Maximum Thermal Resistance |
| OD_HSINK_TYPE | 2 Oz (70 µ) Copper PCB | | Output Diode Heatsink Type |

| | | | |
|---|---|---|---|
| OD_HSINK_AREA | 1218 | mm² | Output Diode Heatsink Area |
| CO | 1000 x 1 | µF | Output Capacitor |
| IRIPPLE | 2.63 | A | Output Capacitor RMS Ripple Current |
| Expected Lifetime | 42869 | hr | Expected Lifetime of Output Capacitor |

## Output 2

| *Var* | *Value* | *Units* | *Description* |
|---|---|---|---|
| VO | -12.00 | V | Output Voltage |
| IO | 0.10 | A | Output Current |
| VOUT_ACTUAL | -12.00 | V | Actual Output Voltage |
| NS | 8 | | Secondary Number of Turns |
| Wire Size | 32 | AWG | Wire size of secondary winding |
| Winding Type | Single (x1) | | Output winding number of parallel strands |
| L_S_OUT | 0.21 | | Secondary Output Winding Layers |
| DC Copper Loss | 0.01 | W | Secondary DC Losses |
| VD | 1.00 | V | Output Winding Diode Forward Voltage Drop |
| PIVS | 58 | V | Output Rectifier Maximum Peak Inverse Voltage |
| ISP | 0.34 | A | Peak Secondary Current |
| ISRMS | 0.18 | A | Secondary RMS Current |
| RTH_DIODE | 561.78 | °C/W | Output Diode Maximum Thermal Resistance |
| OD_HSINK_TYPE | 2 Oz (70 µ) Copper PCB | | Output Diode Heatsink Type |
| OD_HSINK_AREA | 52 | mm² | Output Diode Heatsink Area |
| CO | 47 x 1 | µF | Output Capacitor |
| IRIPPLE | 0.15 | A | Output Capacitor RMS Ripple Current |
| Expected Lifetime | 25263 | hr | Expected Lifetime of Output Capacitor |

## Feedback Circuit

| *Var* | *Value* | *Units* | *Description* |
|---|---|---|---|
| DUAL_OUTPUT_FB_FLAG | NO | | Dual Output Feedback regulations use flag |
| SF_FLAG | NO | | Soft Finish Circuits use flag |
| TYPE_3CTRL_FLAG | NO | | Phase Boost Network flag |

**The regulation and tolerances do not account for thermal drifting and component tolerance of the output diode forward voltage drop and voltage drops across the LC post filter. The actual voltage values are estimated at full load only.**

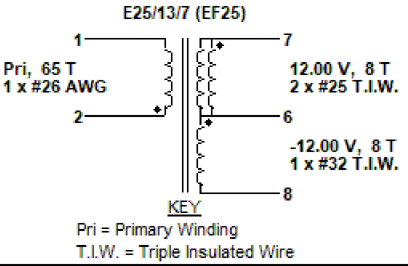
**Please verify cross regulation performance on the bench.**

## Bill Of Materials

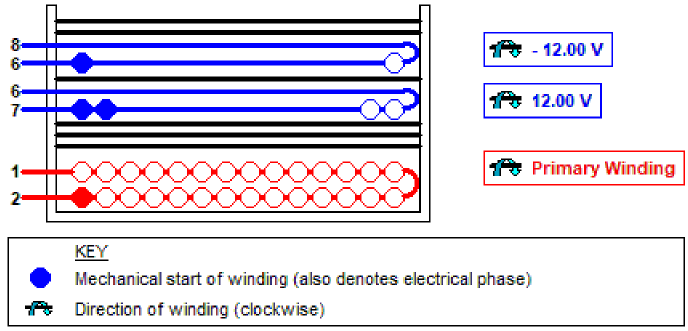
| Item # | Quantity | Part Ref | Value | Description | Mfg | Mfg Part Number |
|---|---|---|---|---|---|---|
| 1 | 1 | C1 | 100 nF | 100 nF, 275 VAC, Film, X Class | Kemet | R46KI310000M1K |
| 2 | 1 | C2 | 56 µF | 56 µF, 400 V, High Voltage Al Electrolytic, (35 mm x 12.5 mm) | United Chemi-Con | EPAG400VB56RM12X35LL |
| 3 | 1 | C3 | 2.7 nF | 2.7 nF, 1 kV, High Voltage Ceramic | Panasonic | ECK-D3A272KBP |
| 4 | 1 | C4 | 10 µF | 10 µF, 16 V, Ceramic, X7R | TDK | C3216X7R1C106K |
| 5 | 1 | C5 | 2.2 nF | 2.2 nF, 250 VAC, Ceramic, Y Class | TDK | CD12-E2GA222MYNS |
| 6 | 2 | C6, C7 | 27 pF | 27 pF, 100 V, Ceramic, C0G | Epcos | B37979N1270J000 |
| 7 | 1 | C8 | 47 µF | 47 µF, 25 V, Electrolytic, Super Low ESR, 300 mΩ, (11 mm x 5 mm) | United Chemi-Con | EKZE250ELL470ME11D |
| 8 | 1 | C9 | 1000 µF | 1000 µF, 35 V, Electrolytic, Super Low ESR, 18 mΩ, (25 mm x 12.5 mm) | United Chemi-Con | EKZE350ELL102MK25S |
| 9 | 1 | C10 | 100 µF | 100 µF, 16 V, Electrolytic, Low ESR, 250 mΩ, (11.5 mm x 6.3 mm) | United Chemi-Con | ELXZ160ELL101MFB5D |
| 10 | 1 | C11 | 100 nF | 100 nF, 16 V, Ceramic, X7R | TDK | C1005X7R1C104K |
| 11 | 4 | D1, D2, D3, D4 | 1N4006 | 800 V, 1 A, Standard Recovery, DO-41 | Vishay | 1N4006 |
| 12 | 1 | D5 | FR106 | 800 V, 1 A, Fast Recovery, 250 ns, DO-41 | Diodes Inc. | FR106 |
| 13 | 1 | D6 | BAV20 | 200 V, 0.2 A, Fast Recovery, 50 ns, DO-35 | Vishay | BAV20 |
| 14 | 1 | D7 | UF5402 | 200 V, 3 A, Ultrafast Recovery, 50 ns, DO-201AD | Vishay | UF5402 |
| 15 | 1 | F1 | 1 A | 250 VAC, 1 A, Radial TR5, Time Lag Fuse | Littelfuse / Wickmann(R) | 37411000410 |
| 16 | 1 | L1 | 6 mH | 6 mH, 1.6 A | Panasonic | ELF18N016 |
| 17 | 1 | L2 | 3.3 µH | 3.3 µH, 2.66 A | Bourns Inc. | RL822-3R3K-RC |
| 18 | 1 | R1 | 27 kΩ | 27 kΩ, 5 %, 2 W, Metal Oxide Film | Generic | |
| 19 | 1 | R2 | 15 Ω | 15 Ω, 5 %, 0.25 W, Carbon Film | Generic | |
| 20 | 2 | R3, R4 | 2 MΩ | 2 MΩ, 5 %, 0.25 W, Carbon Film | Generic | |
| 21 | 2 | R5, R6 | 390 Ω | 390 Ω, 5 %, 0.25 W, Carbon Film | Generic | |
| 22 | 1 | R7 | 210 Ω | 210 Ω, 1 %, 0.125 W, Metal Film | Generic | |
| 23 | 1 | R8 | 1 kΩ | 1 kΩ, 5 %, 0.125 W, Carbon Film | Generic | |
| 24 | 1 | R9 | 43.2 kΩ | 43.2 kΩ, 1 %, 0.125 W, Metal Film | Generic | |
| 25 | 1 | R10 | 11.3 kΩ | 11.3 kΩ, 1 %, 0.125 W, Metal Film | Generic | |
| 26 | 1 | RT1 | 16 Ω | NTC Thermistor 16 Ω, 1.7 A | Thermometrics | CL180 |
| 27 | 1 | RV1 | V275LA4P | 275 V, 23 J, 7 mm, RADIAL, MOV | Littelfuse | V275LA4P |
| 28 | 1 | T1 | E25/13/7 (EF25) | NC-2H (Nicera) or Equivalent Core Material<br>See Transformer Construction's Materials List for complete information | Epcos | B66317-G-X127 |
| 29 | 1 | U1 | TNY290PG | TinySwitch-4, TNY290PG, DIP-8 | Power Integrations | TNY290PG |
| 30 | 1 | U2 | PS2501-1-K-A | Optocoupler PS2501-1-K-A, 80 V, CTR 300 - 600 %, 4-DIP | CEL | PS2501-1-K-A |
| 31 | 1 | U3 | TL431CLPM | 2.495 V, Shunt Regulator IC, 2 %, TO-92 | Texas Instruments | TL431CLPM |

| | | | | | | |
|---|---|---|---|---|---|---|
| 32 | 1 | | | 1218 mm² area on Copper PCB. 2 oz (70 µm) thickness. Heatsink for use with Diode D7. | Custom | |
| 33 | 1 | | | 52 mm² area on Copper PCB. 2 oz (70 µm) thickness. Heatsink for use with Diode D6. | Custom | |
| 34 | 1 | | | 262 mm² area on Copper PCB. 2 oz (70 µm) thickness. Heatsink for use with Device U1. | Custom | |

## Electrical Diagram




## Mechanical Diagram




## Winding Instruction

### Primary Winding

Start on pin(s) 2 and wind 65 turns (x 1 filar) of item [5]. 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.

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

### Secondary Winding

Start on pin(s) 7 and wind 8 turns (x 2 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) 6 and wind 8 turns (x 1 filar) of item [7]. Spread the winding evenly across entire bobbin. Finish this winding on pin(s) 8.

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: E25/13/7 (EF25), NC-2H (Nicera) or Equivalent, gapped for ALG of 224 nH/T²** |
| [2] | **Bobbin: Generic, 5 pri. + 5 sec.** |
| [3] | **Barrier Tape: Polyester film [1 mil (25 µm) base thickness], 15.30 mm wide** |
| [4] | **Varnish** |
| [5] | **Magnet Wire: 26 AWG, Solderable Double Coated** |
| [6] | **Triple Insulated Wire: 25 AWG** |
| [7] | **Triple Insulated Wire: 32 AWG** |

## Electrical Test Specifications

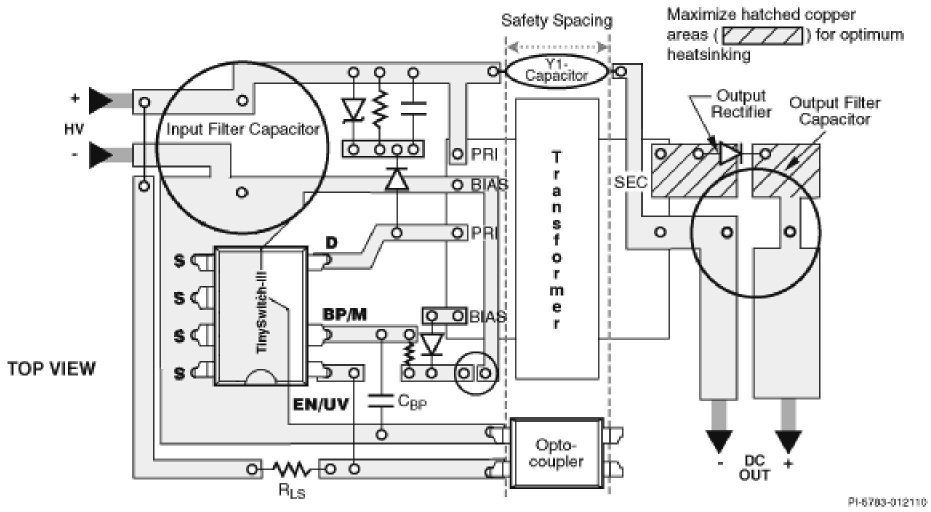
| *Parameter* | *Condition* | *Spec* |
|---|---|---|
| Electrical Strength, VAC | **60 Hz 1 second, from pins 1,2 to pins 6,7,8.** | **3000** |
| Nominal Primary Inductance, µH | **Measured at 1 V pk-pk, typical switching frequency, between pin 1 to pin 2, with all other Windings open.** | **1041** |
| Tolerance, ±% | **Tolerance of Primary Inductance** | **10.0** |
| Maximum Primary Leakage, µH | **Measured between Pin 1 to Pin 2, with all other Windings shorted.** | **31.24** |

**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.**

**The products and applications illustrated herein (including circuits external to the products and transformer construction) may be covered by one or more U.S. and foreign patents or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations' patents may be found at www.power.com.**

# Design Passed (Optimization Done)

# Board Layout Recommendations




*Click on the "Show me" icon to highlight relevant areas on the sample layout.*

| | Description | Show Me |
|---|---|---|
| 1 | Maximize source area for good heat-sinking | |
| 2 | Keep drain trace short | |
| 3 | The BYPASS pin capacitor should be located as close as possible to the BYPASS and SOURCE pins | |
| 4 | Keep noisy traces away from EN/UV pin | |
| 5 | Route bias winding currents back to the bulk cap | |
| 6 | Keep clamp loop short | |
| 7 | Connect Y capacitor to the B+ rail on the primary side for better surge immunity. Keep Y capacitor traces short | |
| 8 | The area of the loop connecting the secondary winding, the output diode and the output filter capacitor should be minimized | |