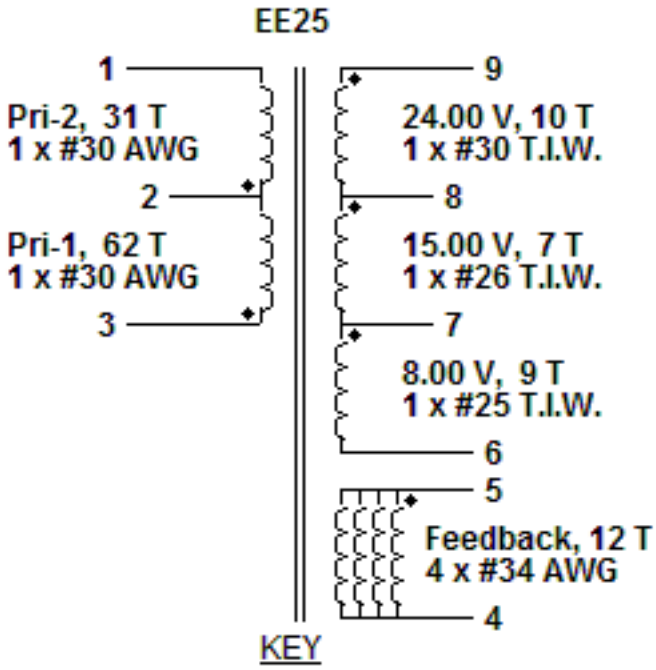
| ACDC_LinkSwitch-HP_060623; Rev.2.2; Copyright Power Integrations 2023 | INPUT | INFO | OUTPUT | UNIT | ACDC_LinkSwitchHP_060623 Rev 2-2.xls: LinkSwitch-HP Flyback Continuous/Discontinuous Transformer Design Spreadsheet |
|---|---|---|---|---|---|
| ENTER APPLICATION VARIABLES | | | | | Customer |
| VACMIN | | | 85 | V | Minimum AC Input Voltage |
| VACMAX | | | 265 | V | Maximum AC Input Voltage |
| fL | | | 50 | Hz | AC Mains Frequency |
| VO | 15.00 | | 15.00 | V | Output Voltage (main) |
| PO | 15.10 | | 15.10 | 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 | | | 0.573 | A | External Minimum Current limit |
| ILIMITMAX_EXT | | | 0.659 | A | External Maximum current limit |
| KI | Auto | | 0.8 | | Current limit reduction factor |
| Rpd | | | 52.30 | k-ohm | Program delay Resistor |
| Cpd | 4.7 | | 4.7 | nF | Program delay Capacitor |
| Total programmed delay | | | 0.05 | 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 | 0.45 | | 0.45 | | Ripple to Peak Current Ratio (0.4 < KP < 6.0) |
| VOR | 90.00 | | 90.00 | V | Reflected Output Voltage |
| Voltage Sense | | | | | |
| VUVON | 112.00 | | 112.00 | V | Undervoltage turn on |
| VUVOFF | | | 46.15 | V | Undervoltage turn off |
| VOV | | | 503.48 | 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 | | | 4.00 | us | Minimum available Diode conduction time at full load. This should be greater than 2.5 us |
| TSAMPLE_LIGHT_LOAD | | | 2.74 | us | Minimum available Diode conduction time at light load. This should be greater than 1.4 us |
| VDS | | | 2.60 | V | LinkSwitch-HP on-state Drain to Source Voltage. |
| VD | | | 0.50 | V | Output  Winding Diode Forward Voltage Drop |
| VDB | 1.00 | | 1.00 | V | Bias Winding Diode Forward Voltage Drop |
| | | | | | |
| | | | | | |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| FEEDBACK SENSING SECTION | | | | | |
| RFB1 | | | 56.20 | k-ohms | Feedback divider upper resistor |
| RFB2 | | | 11.80 | k-ohms | Feedback divider lowerr resistor |
| | | | | | |
| | | | | | |
| ENTER TRANSFORMER CORE/CONSTRUCTION VARIABLES | | | | | |
| Select Core Size | EE25 | | EE25 | | Manual Core Selected |
| Core | | | EE25 | | Selected Core |
| Custom Core | | | | | Enter name of custom core is applicable |
| AE | | | 0.41 | cm^2 | Core Effective Cross Sectional Area |
| LE | | | 4.70 | cm | Core Effective Path Length |
| AL | | | 2140 | nH/T^2 | Ungapped Core Effective Inductance |
| BW | | | 9.80 | mm | Bobbin Physical Winding Width |
| M | | | 0.00 | mm | Safety Margin Width (Half the Primary to Secondary Creepage Distance) |
| L | 3 | | 3 | | Number of Primary Layers |
| NS | 16 | | 16 | | Number of Secondary Turns |
| | | | | | |
| | | | | | |
| DC INPUT VOLTAGE PARAMETERS | | | | | |
| VMIN | 110 | | 110 | V | Minimum DC Input Voltage |
| VMAX | 510 | | 510 | V | Maximum DC Input Voltage |
| | | | | | |
| | | | | | |
| CURRENT WAVEFORM SHAPE PARAMETERS | | | | | |
| DMAX | | | 0.46 | | Maximum Duty Cycle |
| IAVG | | | 0.17 | A | Average Primary Current |
| IP | | | 0.49 | A | Peak Primary Current |
| IR | | | 0.22 | A | Primary Ripple Current |
| IRMS | | | 0.26 | A | Primary RMS Current |
| | | | | | |
| | | | | | |
| TRANSFORMER PRIMARY DESIGN PARAMETERS | | | | | |
| LP_TYP | | | 1912 | uH | Typical Primary Inductance |
| LP_TOL | 10 | | 10 | % | Primary inductance Tolerance |
| NP | | | 93 | | Primary Winding Number of Turns |
| NB | | | 12 | | Bias Winding Number of Turns |
| ALG | | | 221 | nH/T^2 | Gapped Core Effective Inductance |
| BM | | | 2436 | Gauss | Maximum Flux Density at PO, VMIN (BM<3100) |
| BP | | | 3637 | Gauss | Peak Flux Density (BP<3700) |
| BAC | | | 548 | Gauss | AC Flux Density for Core Loss Curves (0.5 X Peak to Peak) |
| ur | | | 1952 | | Relative Permeability of Ungapped Core |
| LG | | | 0.21 | mm | Gap Length (Lg > 0.1 mm) |
| BWE | | | 29.4 | mm | Effective Bobbin Width |
| OD | | | 0.32 | mm | Maximum Primary Wire Diameter including insulation |
| INS | | | 0.05 | mm | Estimated Total Insulation Thickness (= 2 * film thickness) |
| DIA | | | 0.26 | mm | Bare conductor diameter |
| AWG | | | 30 | AWG | Primary Wire Gauge (Rounded to next smaller standard AWG value) |

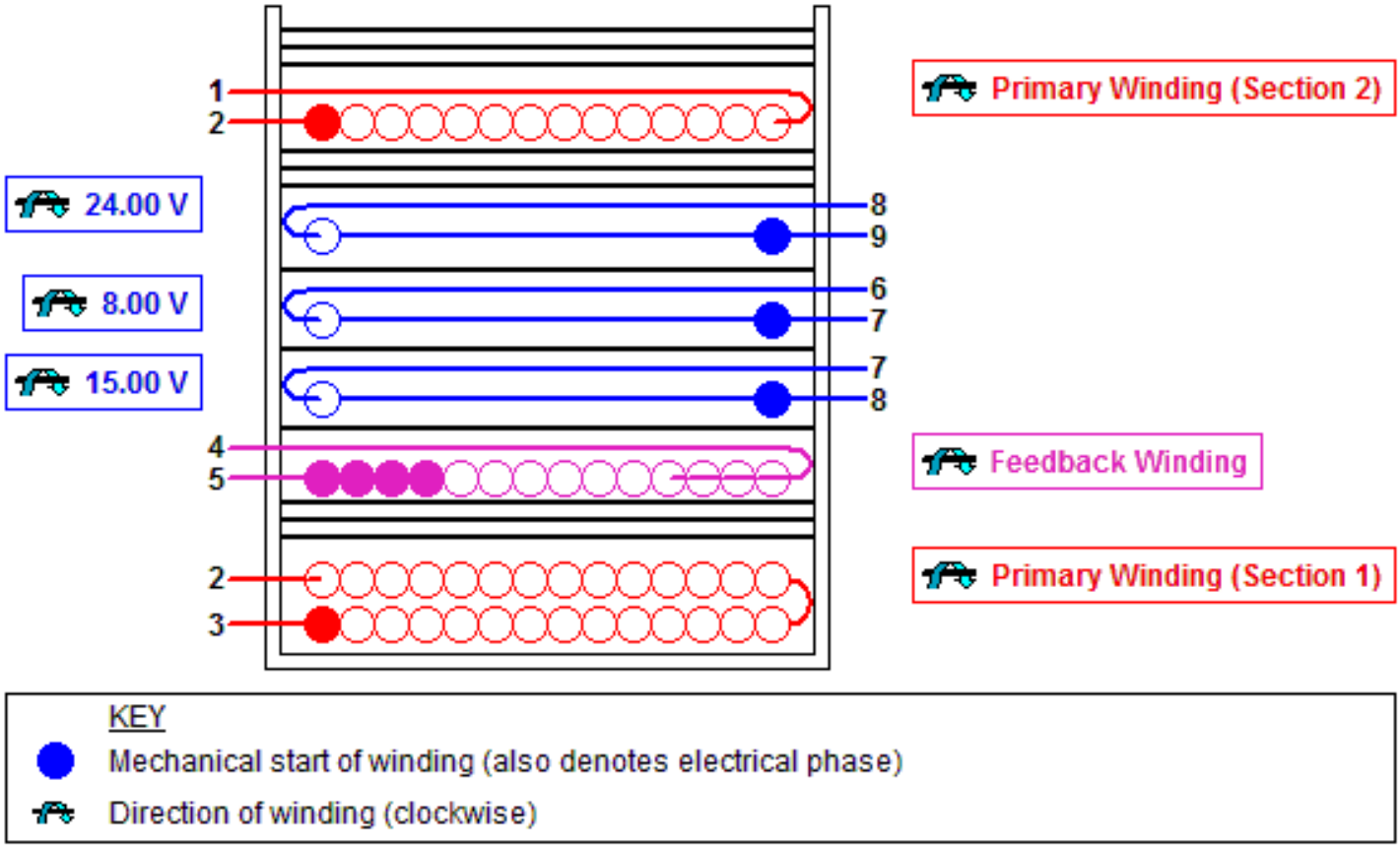
| | | | | | |
|---|---|---|---|---|---|
| CM | | | 102 | Cmils | Bare conductor effective area in circular mils |
| CMA | | | 394 | Cmils/Amp | Primary Winding Current Capacity (200 < CMA < 500) |
| | | | | | |
| | | | | | |
| | | | | | |
| TRANSFORMER SECONDARY DESIGN PARAMETERS (SINGLE OUTPUT EQUIVALENT) | | | | | |
| Lumped parameters | | | | | |
| ISP | | | 2.82 | A | Peak Secondary Current |
| ISRMS | | | 1.64 | A | Secondary RMS Current |
| IO | | | 1.01 | A | Power Supply Output Current |
| IRIPPLE | | | 1.29 | A | Output Capacitor RMS Ripple Current |
| CMS | | | 327 | Cmils | Secondary Bare Conductor minimum circular mils |
| AWGS | | | 24 | AWG | Secondary Wire Gauge (Rounded up to next larger standard AWG value) |
| DIAS | | | 0.51 | mm | Secondary Minimum Bare Conductor Diameter |
| ODS | | | 0.61 | mm | Secondary Maximum Outside Diameter for Triple Insulated Wire |
| INSS | | | 0.05 | mm | Maximum Secondary Insulation Wall Thickness |
| | | | | | |
| | | | | | |
| VOLTAGE STRESS PARAMETERS | | | | | |
| VDRAIN | | | 719 | V | Peak voltage across drain to source of Linkswitch-HP |
| PIVS | | | 103 | V | Output Rectifier Maximum Peak Inverse Voltage |
| PIVB | | | 76 | V | Bias Rectifier Maximum Peak Inverse Voltage |
| | | | | | |
| | | | | | |
| TRANSFORMER SECONDARY DESIGN PARAMETERS (MULTIPLE OUTPUTS) | | | | | |
| 1st output | | | | | |
| VO1 | 15.00 | | 15.00 | V | Output Voltage |
| IO1 | 0.50 | | 0.50 | A | Output DC Current |
| PO1 | | | 7.5 | W | Output Power |
| VD1 | 0.90 | | 0.90 | V | Output Diode Forward Voltage Drop |
| NS1 | | | 17.00 | | Output Winding Number of Turns |
| ISRMS1 | | | 0.813 | A | Output Winding RMS Current |
| IRIPPLE1 | | | 0.64 | A | Output Capacitor RMS Ripple Current |
| PIVS1 | | | 108 | V | Output Rectifier Maximum Peak Inverse Voltage |
| CMS1 | | | 163 | Cmils | Output Winding Bare Conductor minimum circular mils |
| AWGS1 | | | 27 | AWG | Wire Gauge (Rounded up to next larger standard AWG value) |
| DIAS1 | | | 0.36 | mm | Minimum Bare Conductor Diameter |
| ODS1 | | | 0.58 | mm | Maximum Outside Diameter for Triple Insulated Wire |
| | | | | | |
| | | | | | |
| 2nd output | | | | | |
| VO2 | 8.00 | | 8.00 | V | Output Voltage |
| IO2 | 0.20 | | 0.20 | A | Output DC Current |
| PO2 | | | 1.6 | W | Output Power |
| VD2 | 0.90 | | 0.90 | V | Output Diode Forward Voltage Drop |
| NS2 | | | 10.00 | | Output Winding Number of Turns |
| ISRMS2 | | | 0.325 | A | Output Winding RMS Current |

| | | | | | |
|---|---|---|---|---|---|
| IRIPPLE2 | | | 0.26 | A | Output Capacitor RMS Ripple Current |
| PIVS2 | | | 63 | V | Output Rectifier Maximum Peak Inverse Voltage |
| CMS2 | | | 65 | 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 | | | 0.98 | mm | Maximum Outside Diameter for Triple Insulated Wire |
| | | | | | |
| | | | | | |
| 3rd output | | | | | |
| VO3 | 24.00 | | 24.00 | V | Output Voltage |
| IO3 | 0.25 | | 0.25 | A | Output DC Current |
| PO3 | | | 6 | W | Output Power |
| VD3 | 1.30 | | 1.30 | V | Output Diode Forward Voltage Drop |
| NS3 | | | 27.00 | | Output Winding Number of Turns |
| ISRMS3 | | | 0.406 | A | Output Winding RMS Current |
| IRIPPLE3 | | | 0.32 | A | Output Capacitor RMS Ripple Current |
| PIVS3 | | | 172 | V | Output Rectifier Maximum Peak Inverse Voltage |
| CMS3 | | | 81 | Cmils | Output Winding Bare Conductor minimum circular mils |
| AWGS3 | | | 30 | AWG | Wire Gauge (Rounded up to next larger standard AWG value) |
| DIAS3 | | | 0.26 | mm | Minimum Bare Conductor Diameter |
| ODS3 | | | 0.36 | mm | Maximum Outside Diameter for Triple Insulated Wire |
| | | | | | |
| Total power | | | 15.1 | W | Total Power for Multi-output section |
| | | | | | |
| Negative Output | N/A | | 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 (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 12 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) 8 and wind 7 turns (x 1 filar) of item [7]. Spread the winding evenly across entire bobbin. Winding direction is clockwise. Finish this winding on pin(s) 7.*

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

*Start on pin(s) 7 and wind 9 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 10 turns (x 1 filar) of item [9]. Spread the winding evenly across entire bobbin. Winding direction is clockwise. Finish this winding on pin(s) 8.*

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

**Primary Winding (Section 2)**

*Start on pin(s) 2 and wind 31 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: EE25, , gapped for ALG of 221 nH/T²** |
| **[2]** | **Bobbin: Generic, 5 pri. + 4 sec.** |
| **[3]** | **Barrier Tape: Polyester film [1 mil (25 µm) base thickness], 9.80 mm wide** |
| **[4]** | **Varnish** |
| **[5]** | **Magnet Wire: 30 AWG (0.25 mm), Solderable Double Coated** |
| **[6]** | **Magnet Wire: 34 AWG (0.16 mm), Solderable Double Coated** |
| **[7]** | **Triple Insulated Wire: 26 AWG (0.4 mm)** |
| **[8]** | **Triple Insulated Wire: 25 AWG (0.45 mm)** |
| **[9]** | **Triple Insulated Wire: 30 AWG (0.25 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.** | **1912** |
| *Tolerance, ±%* | **Tolerance of Primary Inductance** | **10.0** |
| *Maximum Primary Leakage, µH* | **Measured between Pin 1 to Pin 3, with all other Windings shorted.** | **19.12** |

*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 | EE25 | | 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 | 1912 | µH | Nominal Primary Inductance |
| ML | 0.00 | mm | Safety Margin on Left Width |
| MR | 0.00 | mm | Safety Margin on Right Width |
| LG | 0.209 | mm | Estimated Gap Length |

## Feedback Winding

| Var | Value | Units | Description |
|---|---|---|---|
| NFB | 12 | | Feedback Winding Number of Turns |
| Wire Size | 34 | AWG | Wire size of Feedback windings |
| Winding Type | Quadfilar (x4) | | Wire type of Feedback windings |
| Layers | 0.93 | | 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 | 30 | AWG | Primary Winding - Wire Size |
| Winding Type | Single (x1) | | Primary Winding - Number of Parallel Wire Strands |
| CMA | 388.09 | Cmils/A | Primary Winding Current Capacity |
| L | 1.86 | | 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 | 31 | | Rounded (Integer) Number of Primary winding turns in the second section of primary |
| Wire Size | 30 | AWG | Primary Winding - Wire Size |
| Winding Type | Single (x1) | | Primary Winding - Number of Parallel Wire Strands |
| L2 | 0.93 | | 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* | **15.00** | *V* | *Typical Output Voltage* |
| *IO* | **0.50** | *A* | *Output Current* |
| *VOUT_ACTUAL* | **14.60** | *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* | **1.219** | *A* | *Secondary Winding RMS Current* |
| *CMAS* | **207** | *Cmils/A* | *Secondary Winding Current Capacity* |
| *L_S_OUT* | **0.43** | | *Secondary Output Winding Layers* |
| *Start Pin(s)* | **8** | | *Starting pin(s) for Output winding* |
| *Termination Pin(s)* | **7** | | *Termination pin(s) for Output winding* |

## Output 2

| *Var* | *Value* | *Units* | *Description* |
|---|---|---|---|
| *VO* | **8.00** | *V* | *Typical Output Voltage* |
| *IO* | **0.20** | *A* | *Output Current* |
| *VOUT_ACTUAL* | **7.82** | *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* | **1.544** | *A* | *Secondary Winding RMS Current* |
| *CMAS* | **208** | *Cmils/A* | *Secondary Winding Current Capacity* |
| *L_S_OUT* | **0.60** | | *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* | **24.00** | *V* | *Typical Output Voltage* |
| *IO* | **0.25** | *A* | *Output Current* |
| *VOUT_ACTUAL* | **23.89** | *V* | *Actual Output Voltage* |
| *NS* | **10** | | *Secondary Number of Turns* |
| *Wire Size* | **30** | *AWG* | *Wire size of secondary winding* |
| *Winding Type* | **Single (x1)** | | *Output winding number of parallel strands* |
| *ISRMS_WINDING* | **0.406** | *A* | *Secondary Winding RMS Current* |
| *CMAS* | **246** | *Cmils/A* | *Secondary Winding Current Capacity* |
| *L_S_OUT* | **0.46** | | *Secondary Output Winding Layers* |
| *Start Pin(s)* | **9** | | *Starting pin(s) for Output winding* |
| *Termination Pin(s)* | **8** | | *Termination pin(s) for Output winding* |