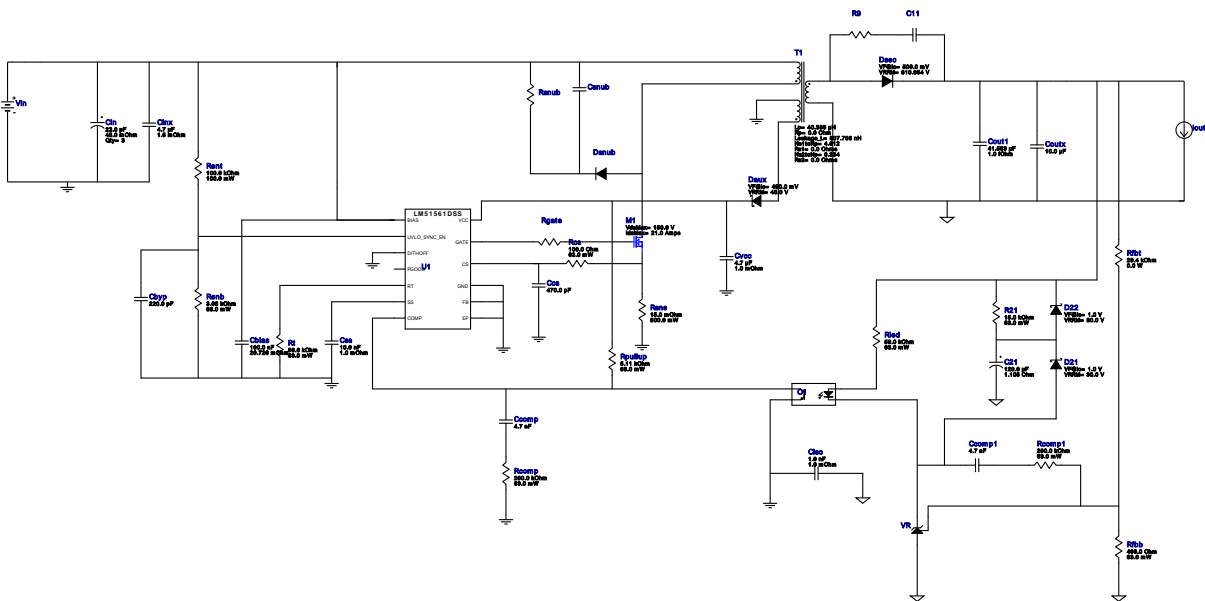


VinMin = 47.0V
VinMax = 53.0V
Vout = 150.0V
Iout = 0.4A

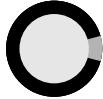





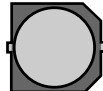

Device = LM51561DSSR
Topology = Flyback
Created = 2023-09-18 18:21:53.424
BOM Cost = NA
BOM Count = 36
Total Pd = 4.61W















WEBENCH[®] Design Report

Design : 2 LM51561DSSR
LM51561DSSR 47V-53V to 150.00V @ 0.4A

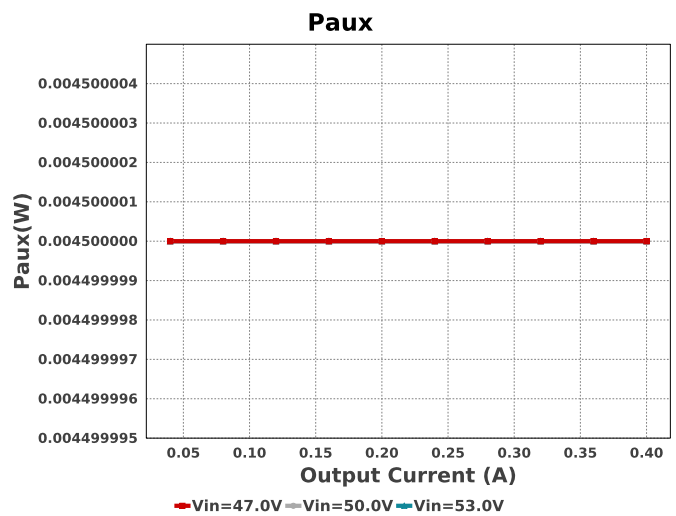
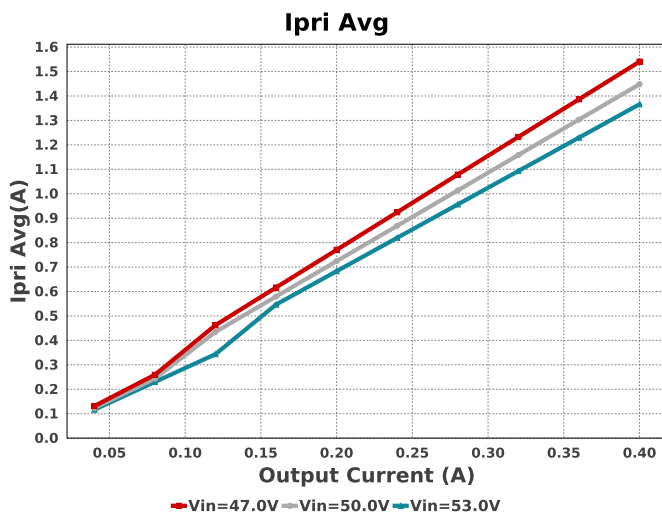
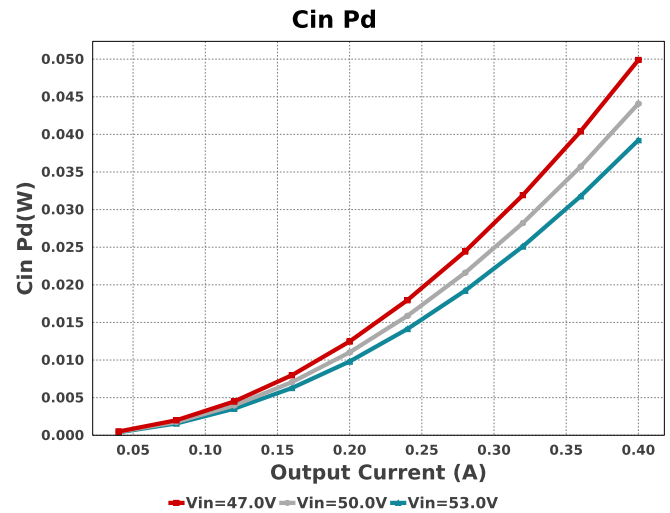
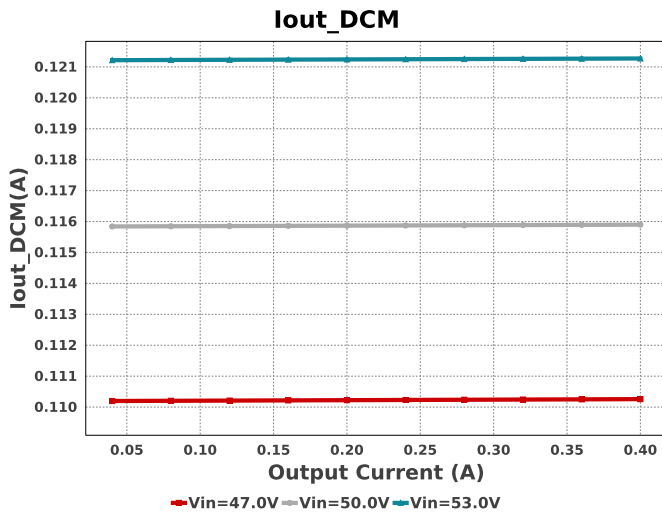


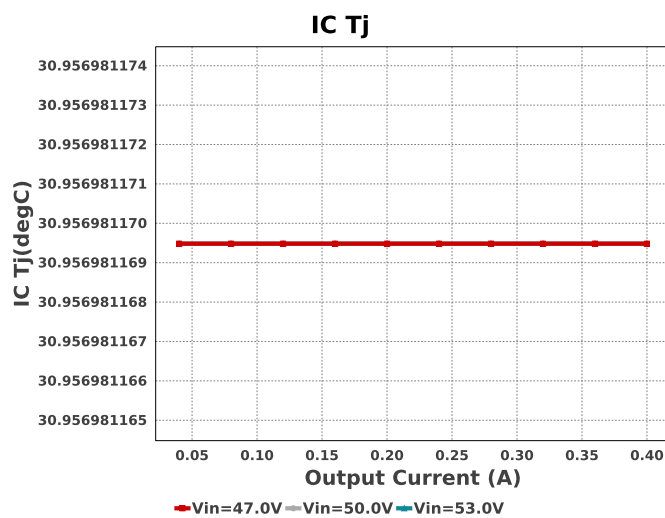
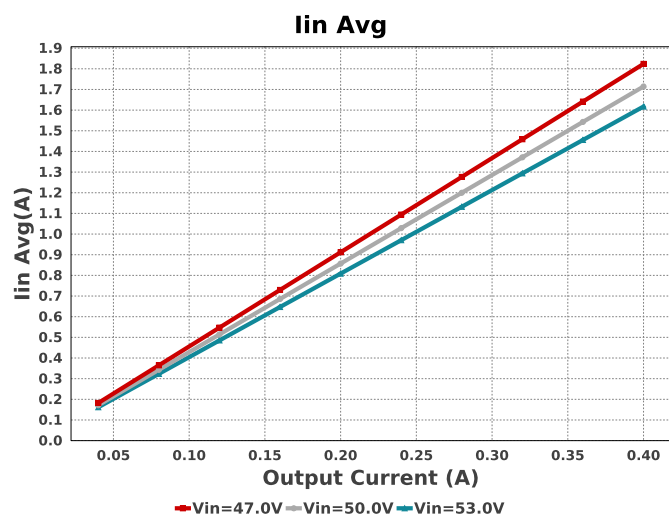
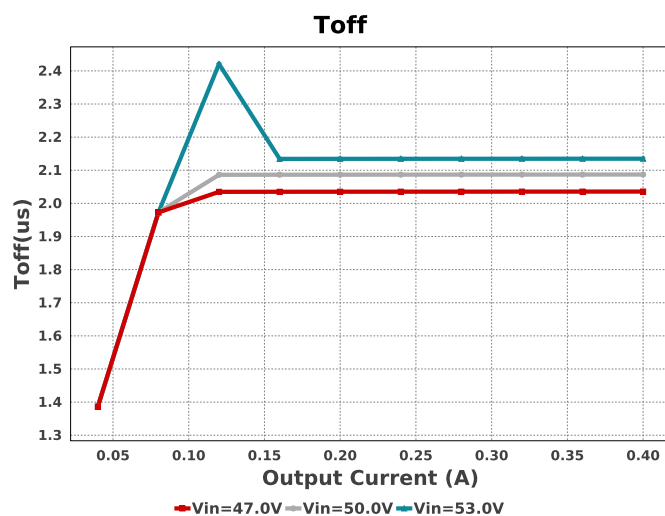
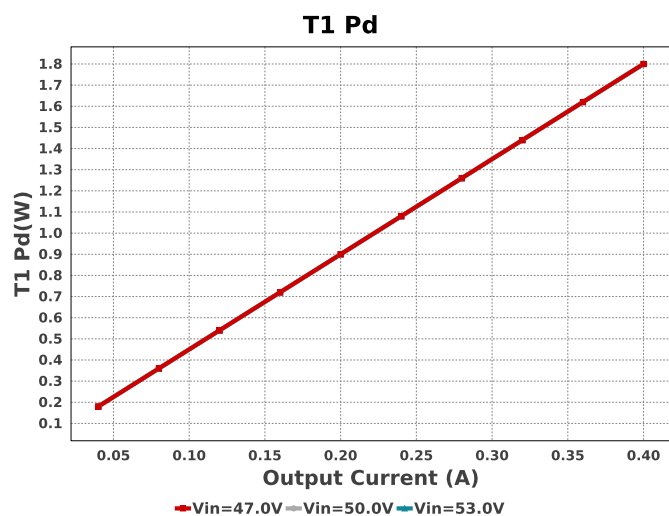
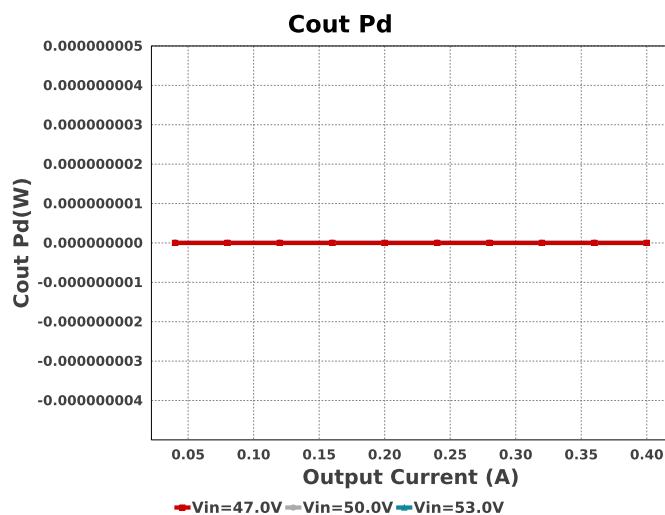
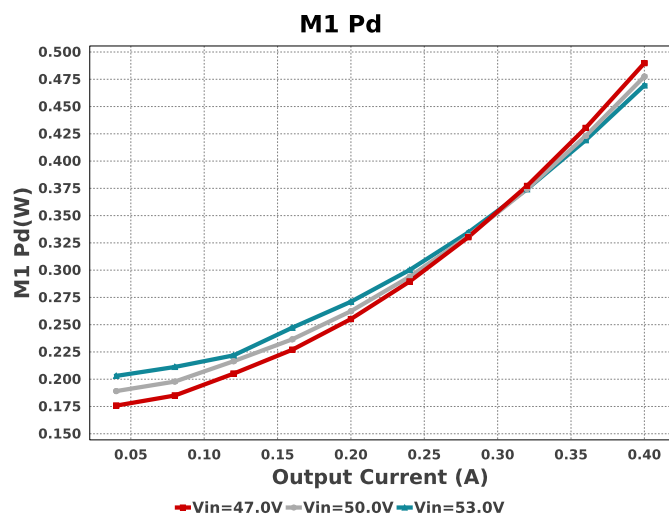
Electrical BOM

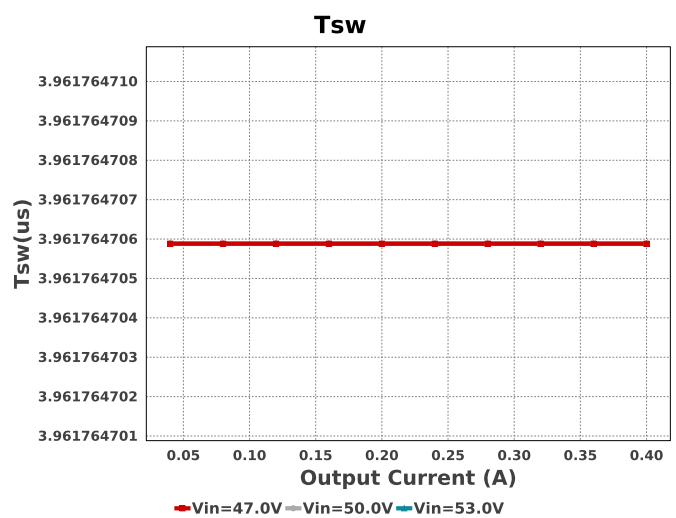
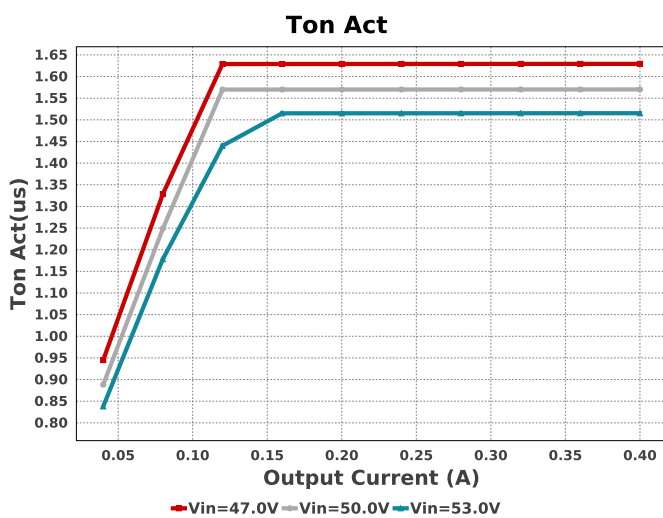
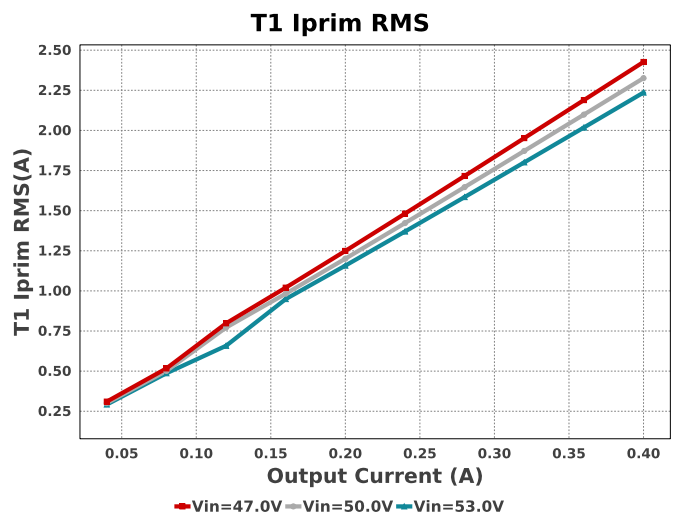
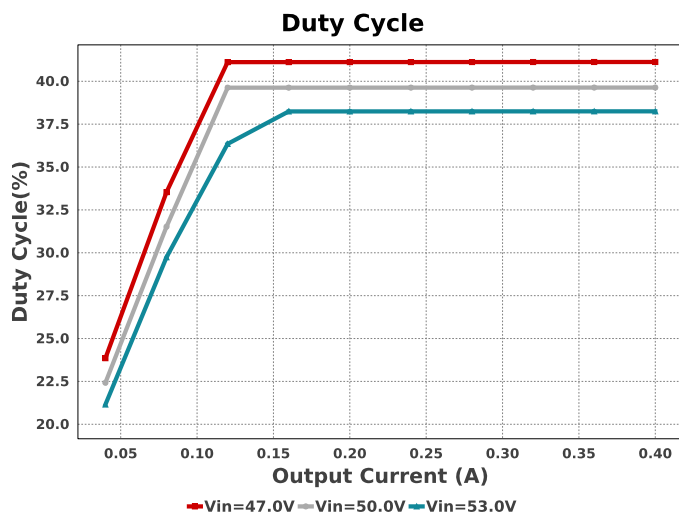
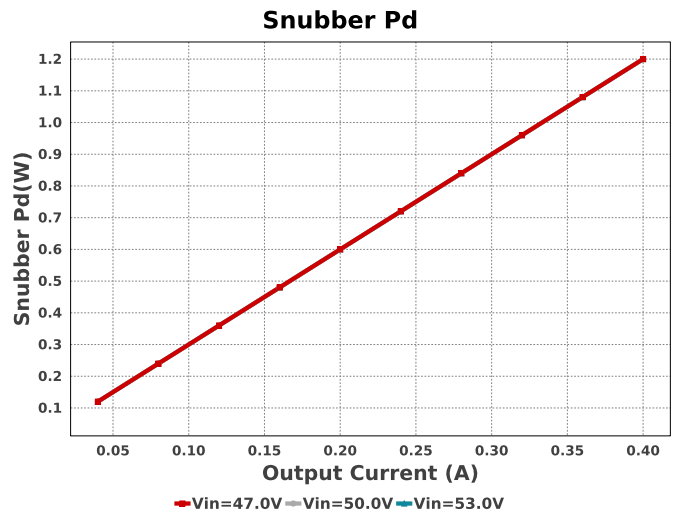
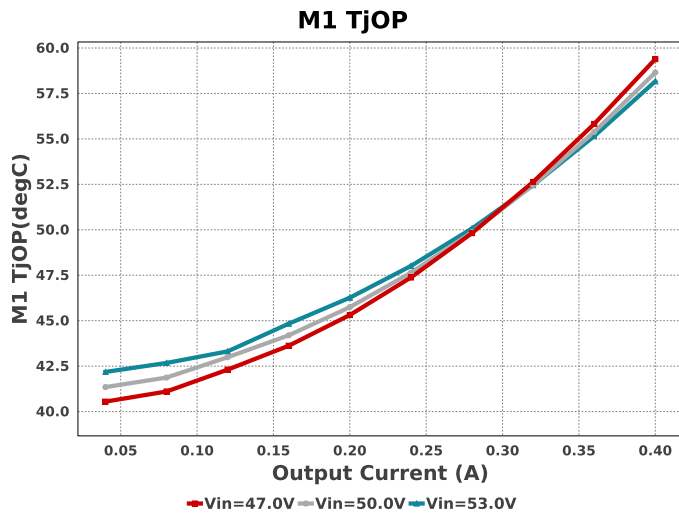
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|--------|---------------------------|---|--|-----|--------|---|
| C21 | Chemi-Con | EKZE500ELL121MH15D Series= KZE | Cap= 120.0 uF ESR= 1.1051 Ohm VDC= 50.0 V IRMS= 950.0 mA | 1 | \$0.21 |  Chemi-Con_800x1500 100 mm ² |
| Cbias | TDK | C2012X7R2A104K125AA Series= X7R | Cap= 100.0 nF ESR= 20.726 mOhm VDC= 100.0 V IRMS= 1.456 A | 1 | \$0.03 |  0805 7 mm ² |
| Cbyp | MuRata | GRM1555C1H221JA01J Series= C0G/NP0 | Cap= 220.0 pF VDC= 5.0 V IRMS= 0.0 A | 1 | \$0.01 |  0402 3 mm ² |
| Ccomp | TDK | CGA4C2C0G1H472J060AA Series= C0G/NP0 | Cap= 4.7 nF VDC= 50.0 V IRMS= 0.0 A | 1 | \$0.04 |  0805 7 mm ² |
| Ccomp1 | TDK | CGA4C2C0G1H472J060AA Series= C0G/NP0 | Cap= 4.7 nF VDC= 50.0 V IRMS= 0.0 A | 1 | \$0.04 |  0805 7 mm ² |
| Ccs | Samsung Electro-Mechanics | CL21C471JBANNNC Series= C0G/NP0 | Cap= 470.0 pF VDC= 50.0 V IRMS= 0.0 A | 1 | \$0.01 |  0805 7 mm ² |
| Cin | Panasonic | EEHZA1K220P Series= ZA | Cap= 22.0 uF ESR= 45.0 mOhm VDC= 80.0 V IRMS= 1.55 A | 3 | \$1.31 |  SM_RADIAL_8MM 113 mm ² |
| Cinx | TDK | C5750X7R2A475M230KA Series= X7R | Cap= 4.7 uF ESR= 1.5 mOhm VDC= 100.0 V IRMS= 5.5 A | 1 | \$0.86 |  2220_280 54 mm ² |

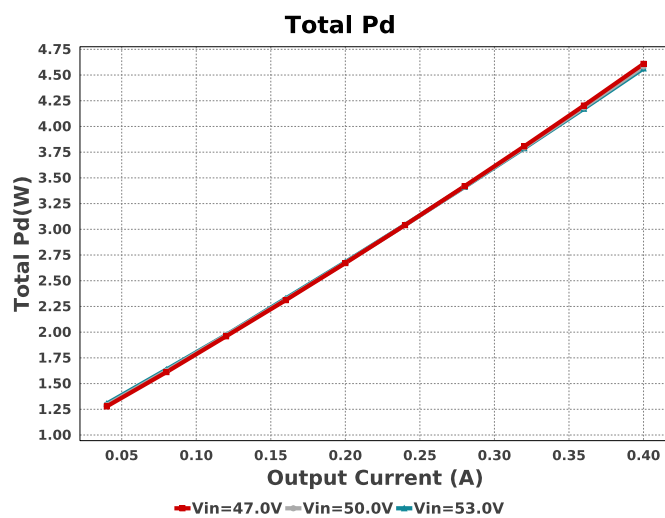
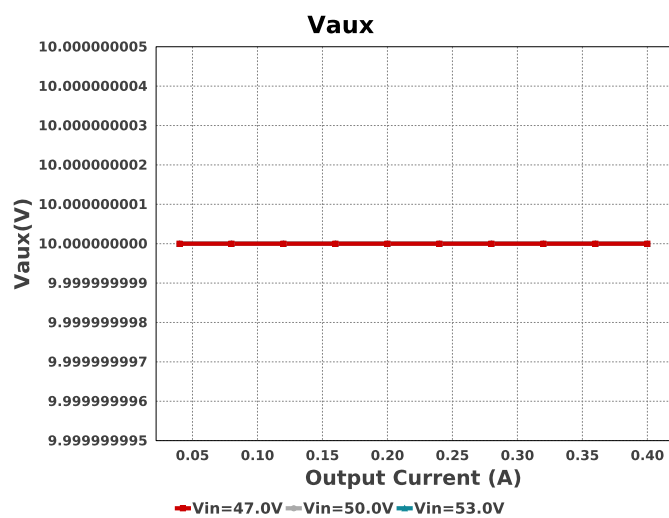
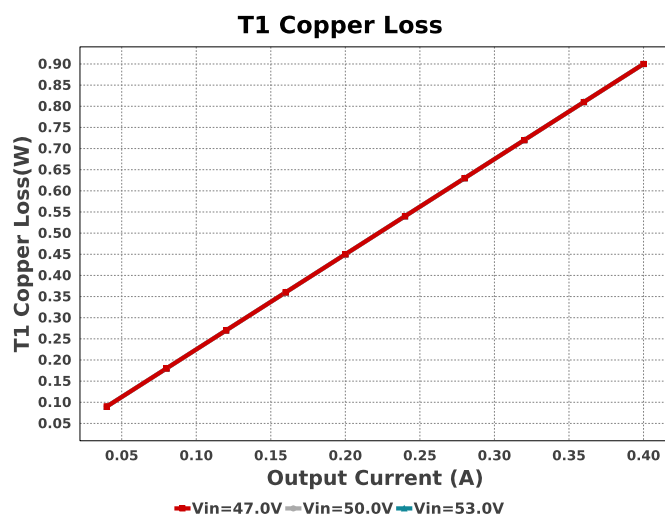
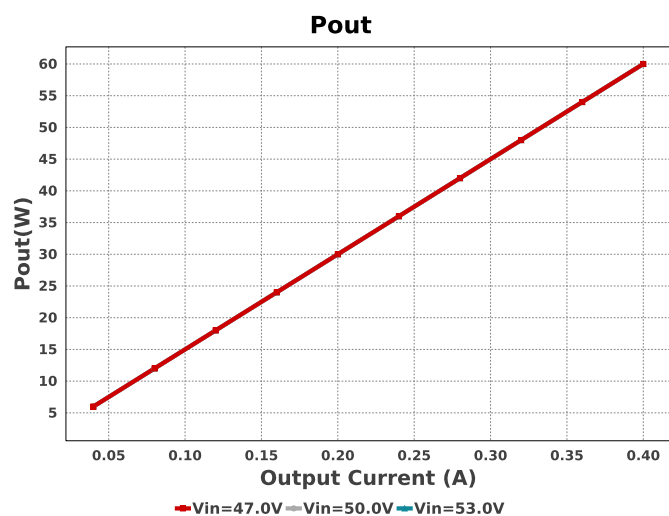
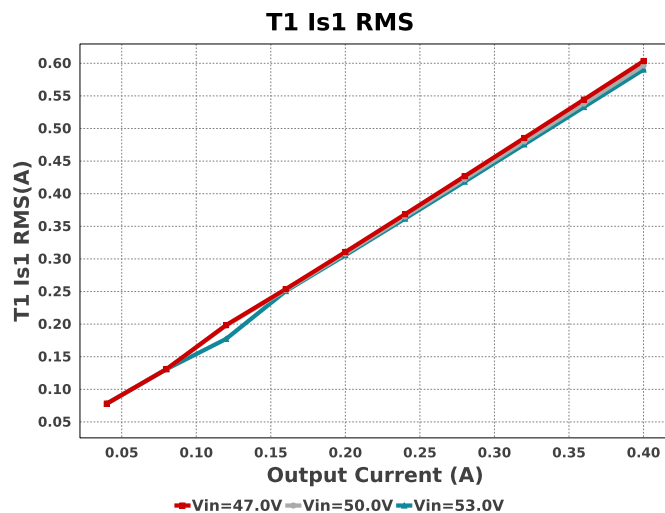
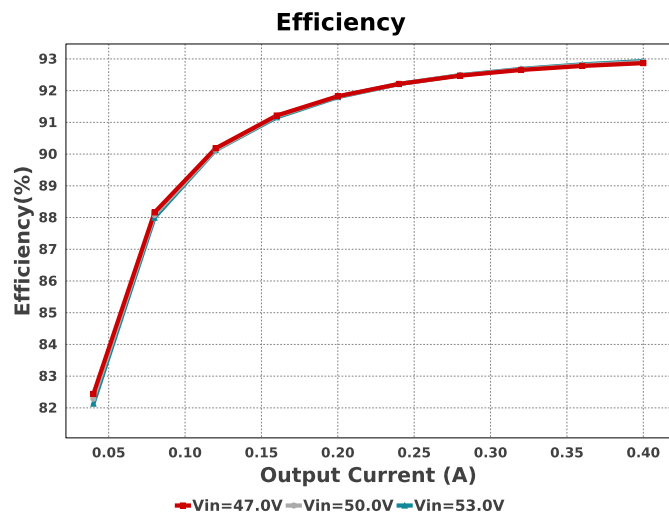
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|--------|-----------------------|--------------------------------------|--|-----|--------|--|
| Ciso | Johanson Technology | 202R18W102KV4E Series= X7R | Cap= 1.0 nF ESR= 1.0 mOhm VDC= 2.0 kV IRMS= 0.0 A | 1 | \$0.06 |  1206_190 11 mm ² |
| Cout1 | CUSTOM | CUSTOM Series= ? | Cap= 41.553 uF ESR= 1.0 fOhm VDC= 300.0 V IRMS= 577.18 mA | 1 | NA | CUSTOM 0 mm ² |
| Coutx | CUSTOM | CUSTOM Series= ? | Cap= 10.0 uF VDC= 375.0 V IRMS= 0.0 A | 1 | NA | CUSTOM 0 mm ² |
| Css | MuRata | GRM155R61A103KA01D Series= X5R | Cap= 10.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A | 1 | \$0.01 |  0402 3 mm ² |
| Cvcc | Taiyo Yuden | TMK212BJ475KG-T Series= X5R | Cap= 4.7 uF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A | 1 | \$0.06 |  0805 7 mm ² |
| D21 | SMC Diode Solutions | BAT54WSTR | VF@Io= 1.0 V VRRM= 30.0 V | 1 | \$0.02 |  SOD-323 9 mm ² |
| D22 | SMC Diode Solutions | BAT54WSTR | VF@Io= 1.0 V VRRM= 30.0 V | 1 | \$0.02 |  SOD-323 9 mm ² |
| Daux | Bourns | CD1005-B0140R | VF@Io= 450.0 mV VRRM= 45.0 V | 1 | \$0.08 |  Diode_1005 7 mm ² |
| Dsec | CUSTOM | CUSTOM | VF@Io= 500.0 mV VRRM= 810.054 V | 1 | NA | CUSTOM 0 mm ² |
| M1 | Infineon Technologies | BSZ520N15NS3 G | VdsMax= 150.0 V IdsMax= 21.0 Amps | 1 | \$0.77 |  PG-TSDSON-8 19 mm ² |
| O1 | Vishay-Semiconductor | TCMT1107 | Optocoupler | 1 | \$0.19 |  SOP-4 44 mm ² |
| R21 | Vishay-Dale | CRCW040215K0FKED Series= CRCW..e3 | Res= 15.0 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |
| Rcomp | Vishay-Dale | CRCW0402200KFKED Series= CRCW..e3 | Res= 200.0 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |
| Rcomp1 | Vishay-Dale | CRCW0402200KFKED Series= CRCW..e3 | Res= 200.0 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |
| Rcs | Vishay-Dale | CRCW0402100RFKED Series= CRCW..e3 | Res= 100.0 Ohm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |
| Renb | Vishay-Dale | CRCW04023K65FKED Series= CRCW..e3 | Res= 3.65 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |
| Rent | Vishay-Dale | CRCW0603100KFKEA Series= CRCW..e3 | Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0603 5 mm ² |
| Rfbb | Vishay-Dale | CRCW0402499RFKED Series= CRCW..e3 | Res= 499.0 Ohm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |
| Rfbt | CUSTOM | CUSTOM Series= ? | Res= 29.4 kOhm Power= 0.0 W Tolerance= 0.0% | 1 | NA | CUSTOM 0 mm ² |
| Rled | Vishay-Dale | CRCW040259K0FKED Series= CRCW..e3 | Res= 59.0 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |

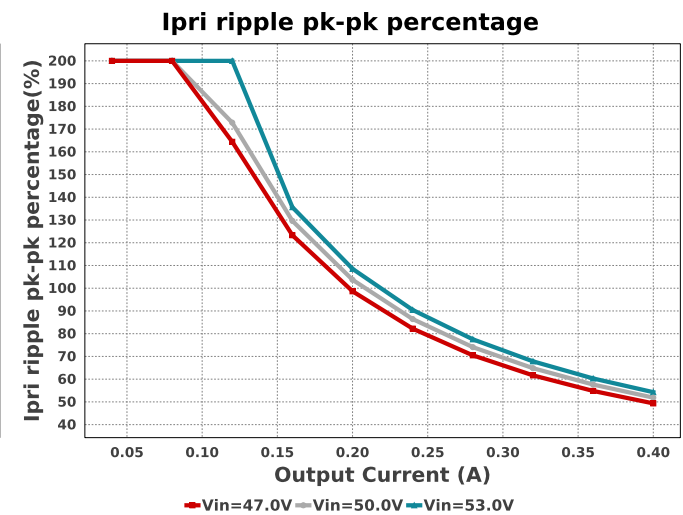
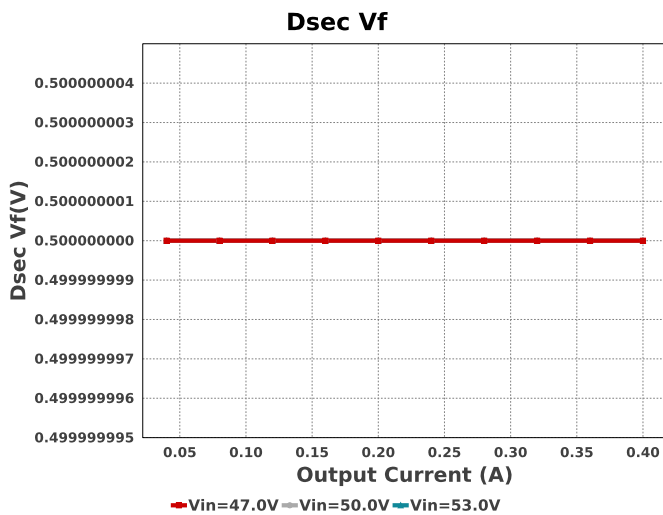
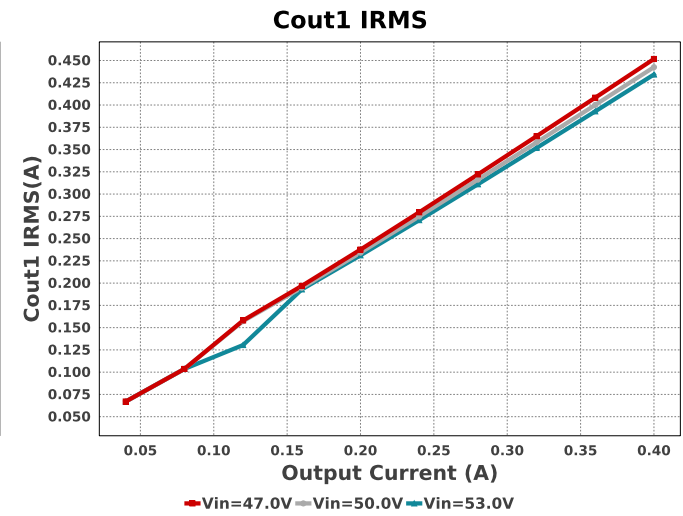
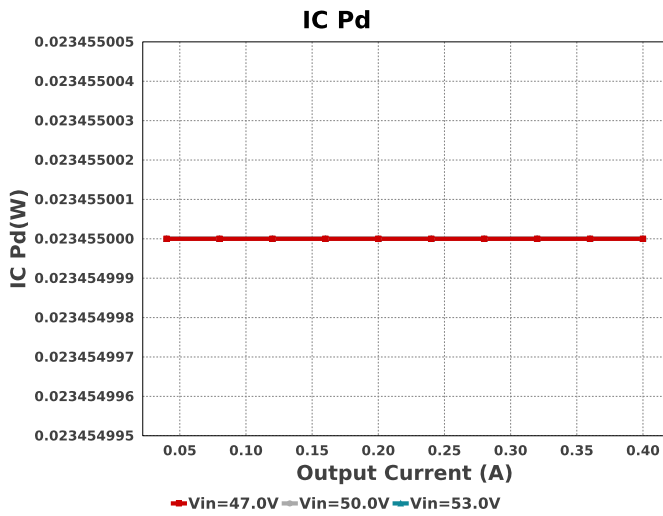
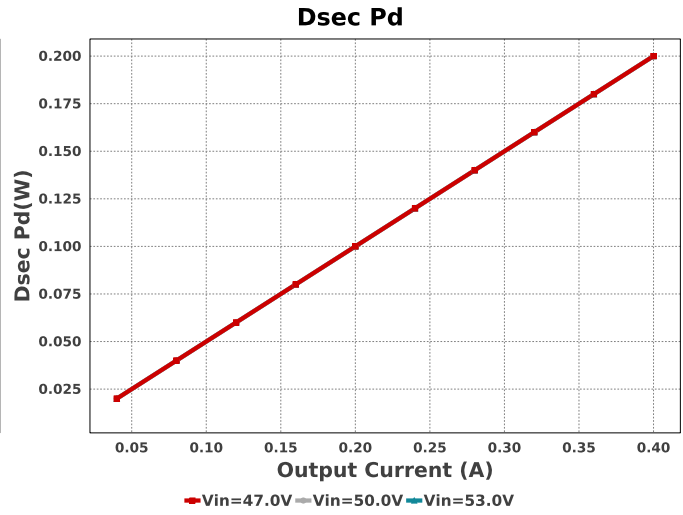
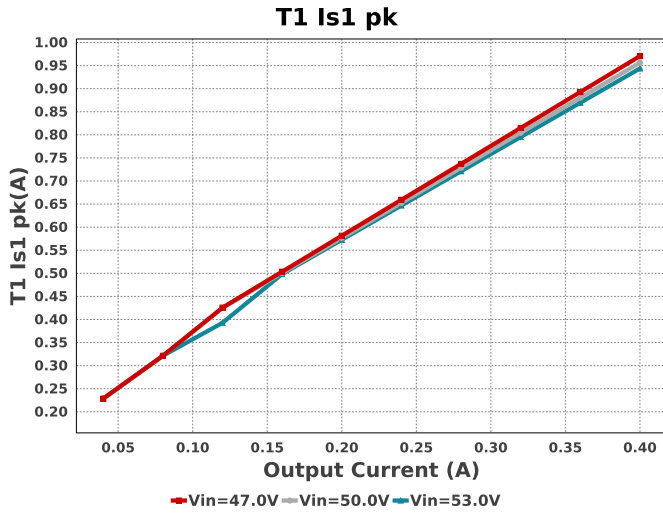
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---------|---------------------------|--------------------------------------|---|-----|--------|--|
| Rpullup | Vishay-Dale | CRCW04025K11FKED Series= CRCW..e3 | Res= 5.11 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm² |
| Rsns | Stackpole Electronics Inc | CSR1206FK15L0 Series= ? | Res= 15.0 mOhm Power= 500.0 mW Tolerance= 1.0% | 1 | \$0.11 |  1206 11 mm² |
| Rt | Yageo | AC0402FR-0786K6L Series= ? | Res= 86.6 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm² |
| T1 | CUSTOM | CUSTOM | Lp= 40.385 µH Rp= 0.0 Ohm Leakage_L= 807.708 nH Ns1toNp= 4.812 Rs1= 0.0 Ohms Ns2toNp= 0.334 Rs2= 0.0 Ohms | 1 | NA | CUSTOM 0 mm² |
| U1 | Texas Instruments | LM51561DSSR | Switcher | 1 | \$0.63 |  DSS0012B 12 mm² |
| VR | Texas Instruments | TL431IDBVR | Voltage References | 1 | \$0.05 |  R-PDSO-G3 16 mm² |

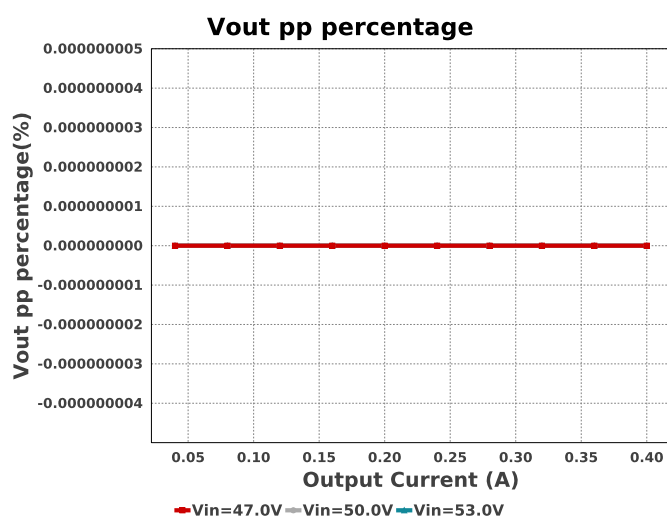
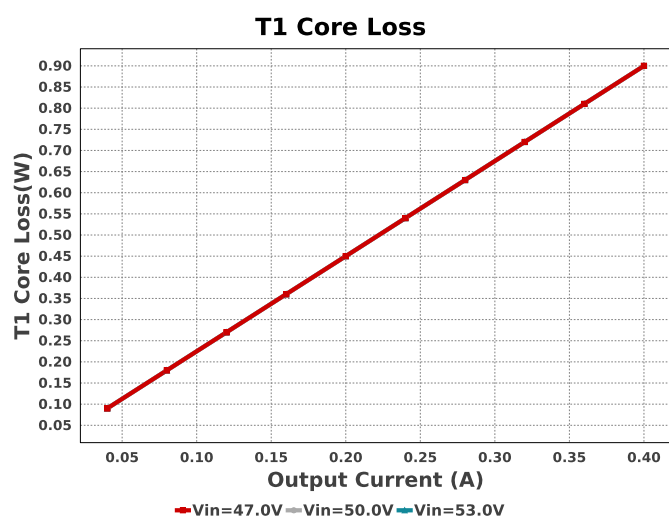
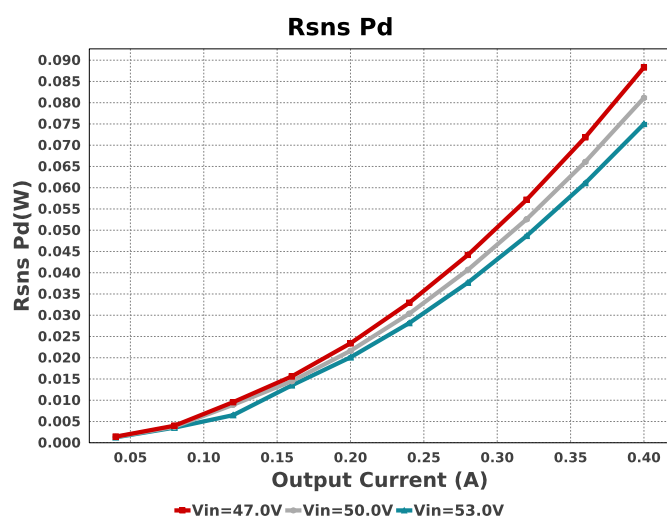
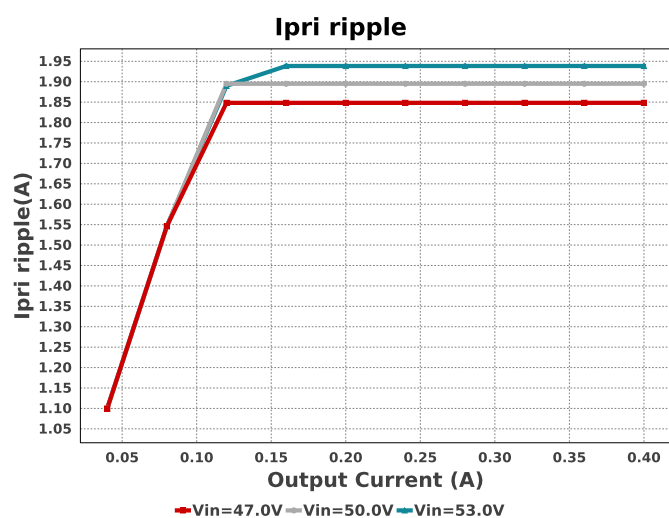
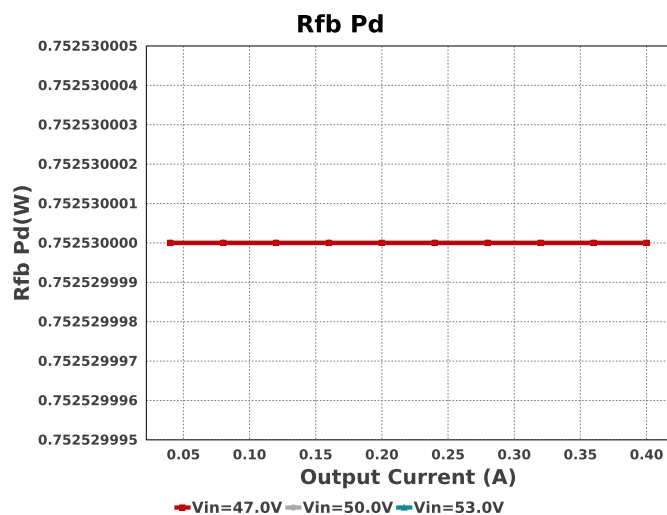
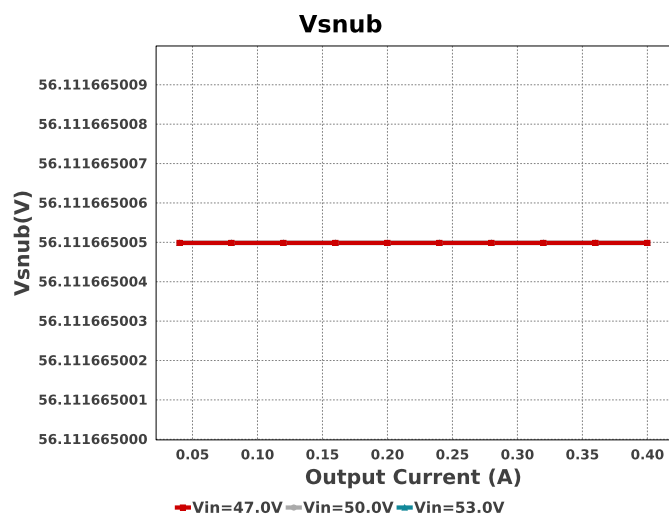


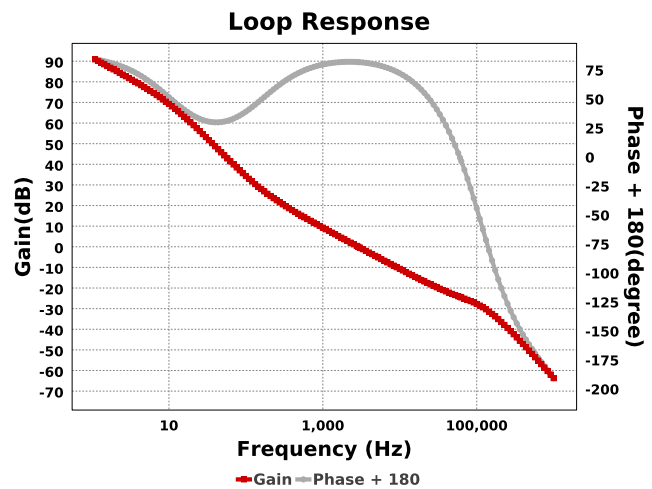
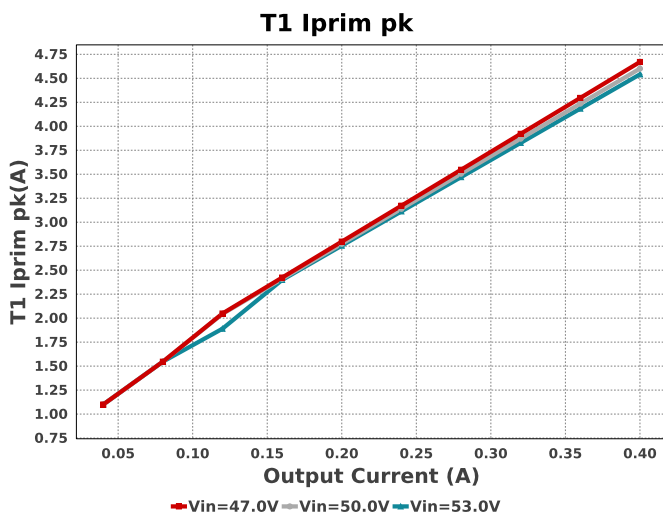
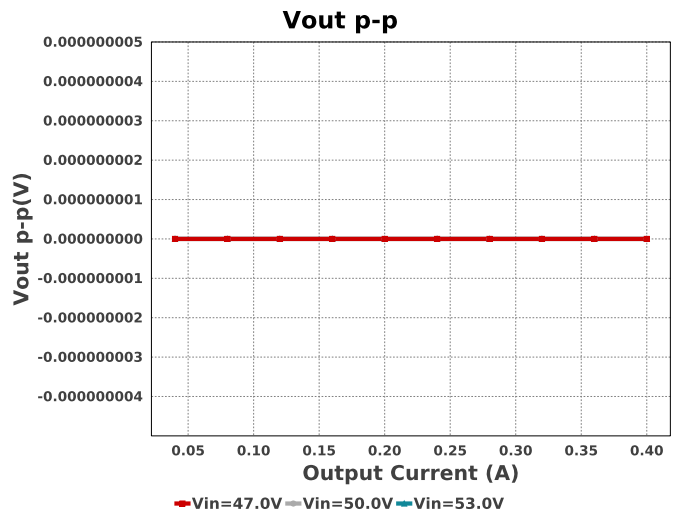
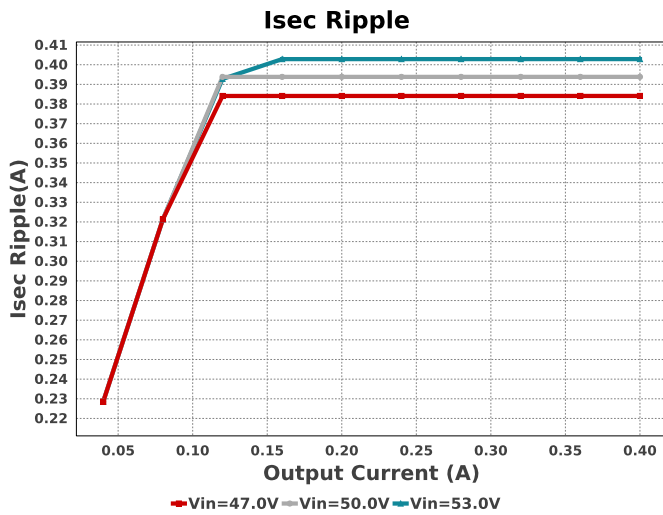












Operating Values

| # | Name | Value | Category | Description |
|-----|---------------------|-------------|--------------------|--|
| 1. | Cin Pd | 49.889 mW | Capacitor | Input capacitor power dissipation |
| 2. | Cout Pd | 0.204 fW | Capacitor | Output capacitor1 power dissipation |
| 3. | Cout1 IRMS | 451.695 mA | Capacitor | Output capacitor1 RMS ripple current |
| 4. | Dsec Pd | 200.0 mW | Diode | Secondary Diode Power Dissipation |
| 5. | Dsec Vf | 500.0 mV | Diode | Effective Forward Voltage Drop at the Operating Current |
| 6. | IC Pd | 23.455 mW | IC | IC power dissipation |
| 7. | IC Tj | 30.957 degC | IC | IC junction temperature |
| 8. | ICThetaJA Effective | 40.8 degC/W | IC | Effective IC Junction-to-Ambient Thermal Resistance |
| 9. | Iin Avg | 1.824 A | IC | Average input current |
| 10. | M1 Pd | 489.83 mW | Mosfet | M1 MOSFET total power dissipation |
| 11. | M1 TjOP | 59.39 degC | Mosfet | M1 MOSFET junction temperature |
| 12. | Cin Pd | 49.889 mW | Power | Input capacitor power dissipation |
| 13. | Cout Pd | 0.204 fW | Power | Output capacitor1 power dissipation |
| 14. | Dsec Pd | 200.0 mW | Power | Secondary Diode Power Dissipation |
| 15. | IC Pd | 23.455 mW | Power | IC power dissipation |
| 16. | M1 Pd | 489.83 mW | Power | M1 MOSFET total power dissipation |
| 17. | Paux | 4.5 mW | Power | Power Dissipation in Raux and Daux |
| 18. | Rfb Pd | 752.53 mW | Power | Rfb Power Dissipation |
| 19. | Rsns Pd | 88.315 mW | Power | Current Limit Sense Resistor Power Dissipation |
| 20. | Snubber Pd | 1.2 W | Power | Approximate Snubber Power Dissipation (Assumed 2% of Output Power) |
| 21. | T1 Copper Loss | 900.0 mW | Power | Transformer Copper Loss Power Dissipation |
| 22. | T1 Core Loss | 900.0 mW | Power | Transformer Core Loss Power Dissipation |
| 23. | T1 Pd | 1.8 W | Power | Estimated Losses in Transformer |
| 24. | Total Pd | 4.609 W | Power | Total Power Dissipation |
| 25. | Rfb Pd | 752.53 mW | Resistor | Rfb Power Dissipation |
| 26. | Rsns Pd | 88.315 mW | Resistor | Current Limit Sense Resistor Power Dissipation |
| 27. | BOM Count | 36 | System | Total Design BOM count |
| 28. | Cross Freq | 2.226 kHz | System Information | Bode plot crossover frequency |

| # | Name | Value | Category | Description |
|-----|------------------------------|-----------------------|--------------------|--|
| 29. | Duty Cycle | 41.126 % | System Information | Duty cycle |
| 30. | Efficiency | 92.867 % | System Information | Steady state efficiency |
| 31. | FootPrint | 798.0 mm ² | System Information | Total Foot Print Area of BOM components |
| 32. | Frequency | 252.413 kHz | System Information | Switching frequency |
| 33. | Gain Marg | -25.568 dB | System Information | Bode Plot Gain Margin |
| 34. | Iout | 400.0 mA | System Information | Iout operating point |
| 35. | Iout_DCM | 110.258 mA | System Information | Approximate Current below which DCM mode of operation will begin |
| 36. | Low Freq Gain | 88.376 dB | System Information | Gain at 1Hz |
| 37. | Mode | CCM | System Information | Conduction Mode |
| 38. | Phase Marg | 82.309 deg | System Information | Bode Plot Phase Margin |
| 39. | Pout | 60.0 W | System Information | Total output power |
| 40. | Toff | 2.036 us | System Information | Approximate Converter Off Time |
| 41. | Ton Act | 1.629 us | System Information | Approximate Converter On Time |
| 42. | Total BOM | NA | System Information | Total BOM Cost |
| 43. | Tsw | 3.962 us | System Information | Switching Time Period |
| 44. | Vin | 47.0 V | System Information | Vin operating point |
| 45. | Vout | 150.0 V | System Information | Operational Output Voltage |
| 46. | Vout Actual | 149.495 V | System Information | Vout Actual calculated based on selected voltage divider resistors |
| 47. | Vout Tolerance | 2.046 % | System Information | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |
| 48. | Vout p-p | 0.384 fV | System Information | Peak-to-peak output ripple voltage |
| 49. | Vout pp percentage | 0.256 f% | System Information | Output Voltage ripple percentage |
| 50. | Vsnub | 56.112 V | System Information | Voltage Across the Snubber |
| 51. | Ipri Avg | 1.541 A | Transformer | Average Current in Primary Winding over the complete Switching Period |
| 52. | Ipri ripple | 1.848 A | Transformer | Ripple Current in the Primary Winding |
| 53. | Ipri ripple pk-pk percentage | 49.342 % | Transformer | Primary Current pk-pk ripple percentage(of Ipri avg during ton only) |
| 54. | Isec Ripple | 384.112 mA | Transformer | Ripple Current in the Secondary Winding |
| 55. | Paux | 4.5 mW | Transformer | Power Dissipation in Raux and Daux |
| 56. | T1 Copper Loss | 900.0 mW | Transformer | Transformer Copper Loss Power Dissipation |
| 57. | T1 Core Loss | 900.0 mW | Transformer | Transformer Core Loss Power Dissipation |
| 58. | T1 Iprim RMS | 2.426 A | Transformer | Transformer Primary RMS Current |
| 59. | T1 Iprim pk | 4.67 A | Transformer | Transformer Primary Peak Current |
| 60. | T1 Is1 RMS | 603.348 mA | Transformer | Transformer Secondary1 RMS Current |
| 61. | T1 Is1 pk | 970.528 mA | Transformer | Transformer Secondary1 Peak Current |
| 62. | T1 Pd | 1.8 W | Transformer | Estimated Losses in Transformer |
| 63. | Vaux | 10.0 V | Transformer | Auxiliary Voltage |

Design Inputs

| Name | Value | Description |
|---------|---------|------------------------|
| Iout | 400.0 m | Maximum Output Current |
| VinMax | 53.0 | Maximum input voltage |
| VinMin | 47.0 | Minimum input voltage |
| VinTyp | 50.0 | Typical input voltage |
| Vout | 150.0 | Output Voltage |
| base_pn | LM51561 | Base Product Number |
| source | DC | Input Source Type |
| Ta | 30.0 | Ambient temperature |

WEBENCH® Assembly

Component Testing

Some published data on components in datasheets such as Capacitor ESR and Inductor DC resistance is based on conservative values that will guarantee that the components always exceed the specification. For design purposes it is usually better to work with typical values. Since this data is not always available it is a good practice to measure the Capacitance and ESR values of C_{in} and C_{out} , and the inductance and DC resistance of $L1$ before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

Soldering Component to Board

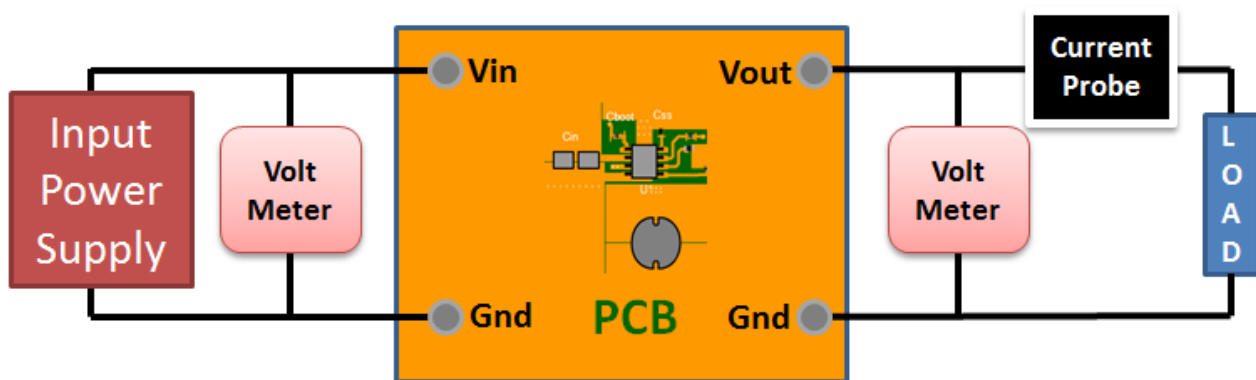
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab down to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 47.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to V_{in} and GND. Connect a digital volt meter and a load if needed to set the minimum load of the design from V_{out} and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between V_{in} and GND, a load is connected between V_{out} and GND and a current meter is connected in series between V_{out} and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.



Design Assistance

1. Master key : 50B143B56528305C1AC00903CE85B6D4[v1]
2. **LM51561** Product Folder : <http://www.ti.com/product/LM51561> : contains the data sheet and other resources.

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