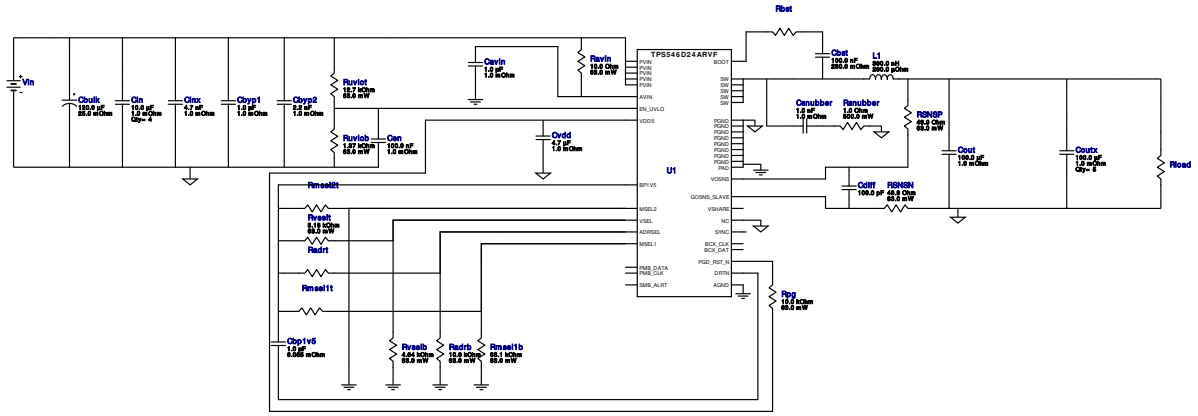
# WEBENCH® Design Report

VinMin = 11.0V
VinMax = 13.0V
Vout = 2.4V
Vout Sch = 2.4V
Iout = 40.0A

Device = TPS546D24ARVFR
Topology = Buck
Created = 2025-09-15 13:40:46.376
BOM Cost = $8.60
BOM Count = 34
Total Pd = 8.11W

Design : 110 TPS546D24ARVFR
TPS546D24ARVFR 11V-13V to 2.40V @ 40A




1. Do not place Rmsel2t, Radrt, Rmsel1t resistors. Place 0 Ohm resistor for Rbst.

## Design Alerts

### TPS546D24A Design

The TPS546D24A is a PMBus(TM) device with key features listed below: PMBus(TM) features marked with * are included in WEBENCH(R) Power Designer. - Adaptive Voltage Scaling (AVS) through VOUT_COMMAND*, - Output voltage and current monitoring, - Thermal Shutdown, - Programmable over current protection, - OCP,OV, UV, OT Levels, - Selectable Internal Compensation*, - Selectable Switching Frequency*, - Turn-On and Turn-Off Delays, - UVLO*, Soft-Start*,OCP* and Soft-Stop. Use the Advanced Options on the left side to set the PMBus(TM) commands. Please refer to the TPS546D24A datasheet and visit http://www.ti.com/pmbus for more information.

## Electrical BOM

| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| Cavin | Taiyo Yuden | TMK212BJ105KG-T<br>Series= X5R | Cap= 1.0 uF<br>ESR= 1.0 mOhm<br>VDC= 25.0 V<br>IRMS= 0.0 A | 1 | $0.03 | 0805 7 mm$^2$ |
| Cbp1v5 | MuRata | GRM188R60J105KA01D<br>Series= X5R | Cap= 1.0 uF<br>ESR= 6.065 mOhm<br>VDC= 6.3 V<br>IRMS= 1.36934 A | 1 | $0.01 | 0603 5 mm$^2$ |
| Cbst | AVX | 08053C104KAT2A<br>Series= X7R | Cap= 100.0 nF<br>ESR= 280.0 mOhm<br>VDC= 25.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0805 7 mm$^2$ |

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| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| Cbulk | Panasonic | 20SVPF120M<br>Series= SVPF | Cap= 120.0 uF<br>ESR= 25.0 mOhm<br>VDC= 20.0 V<br>IRMS= 3.2 A | 1 | $0.57 | <br>CAPSMT_62_F61 74 mm² |
| Cbyp1 | Taiyo Yuden | TMK212BJ105KG-T<br>Series= X5R | Cap= 1.0 uF<br>ESR= 1.0 mOhm<br>VDC= 25.0 V<br>IRMS= 0.0 A | 1 | $0.03 | <br>0805 7 mm² |
| Cbyp2 | MuRata | GRM155R61E222KA01D<br>Series= X5R | Cap= 2.2 nF<br>ESR= 1.0 mOhm<br>VDC= 25.0 V<br>IRMS= 0.0 A | 1 | $0.01 | <br>0402 3 mm² |
| Cdiff | Yageo | CC0201JRNPO8BN101<br>Series= C0G/NP0 | Cap= 100.0 pF<br>VDC= 5.0 V<br>IRMS= 0.0 A | 1 | $0.01 | <br>0201 2 mm² |
| Cen | MuRata | GRM155R71A104KA01D<br>Series= X7R | Cap= 100.0 nF<br>ESR= 1.0 mOhm<br>VDC= 10.0 V<br>IRMS= 0.0 A | 1 | $0.01 | <br>0402 3 mm² |
| Cin | TDK | C3225X7R1H106M250AC<br>Series= X7R | Cap= 10.0 uF<br>ESR= 1.0 mOhm<br>VDC= 50.0 V<br>IRMS= 5.0 A | 4 | $0.27 | <br>1210 15 mm² |
| Cinx | MuRata | GRM155R71E472KA01D<br>Series= X7R | Cap= 4.7 nF<br>ESR= 1.0 mOhm<br>VDC= 25.0 V<br>IRMS= 0.0 A | 1 | $0.01 | <br>0402 3 mm² |
| Cout | MuRata | GRM32EC80J107ME20L<br>Series= X6S | Cap= 100.0 uF<br>ESR= 1.0 mOhm<br>VDC= 6.3 V<br>IRMS= 6.0 A | 1 | $0.17 | <br>1210_270 15 mm² |
| Coutx | MuRata | GRM32EC80J107ME20L<br>Series= X6S | Cap= 100.0 uF<br>ESR= 1.0 mOhm<br>VDC= 6.3 V<br>IRMS= 6.0 A | 5 | $0.17 | <br>1210_270 15 mm² |
| Csnubber | Yageo | CC0805KRX7R9BB102<br>Series= X7R | Cap= 1.0 nF<br>ESR= 1.0 mOhm<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | <br>0805 7 mm² |
| Cvdd | MuRata | GRM155R61A475MEAAD<br>Series= X5R | Cap= 4.7 uF<br>ESR= 1.0 mOhm<br>VDC= 10.0 V<br>IRMS= 0.0 A | 1 | $0.02 | <br>0402_065 3 mm² |
| L1 | Coilcraft | SLC1480-301MLB | L= 300.0 nH<br>200.0 µOhm | 1 | $0.78 | <br>SLC1480 231 mm² |
| RSNSN | Vishay-Dale | CRCW040249R9FKED<br>Series= CRCW..e3 | Res= 49.9 Ohm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | <br>0402 3 mm² |
| RSNSP | Vishay-Dale | CRCW040249R9FKED<br>Series= CRCW..e3 | Res= 49.9 Ohm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | <br>0402 3 mm² |
| Radrb | Vishay-Dale | CRCW040210K0FKED<br>Series= CRCW..e3 | Res= 10.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | <br>0402 3 mm² |
| Ravin | Vishay-Dale | CRCW040210R0FKED<br>Series= CRCW..e3 | Res= 10.0 Ohm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | <br>0402 3 mm² |
| Rmsel1b | Yageo | RC0402FR-0768K1L<br>Series= ? | Res= 68.1 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | <br>0402 3 mm² |

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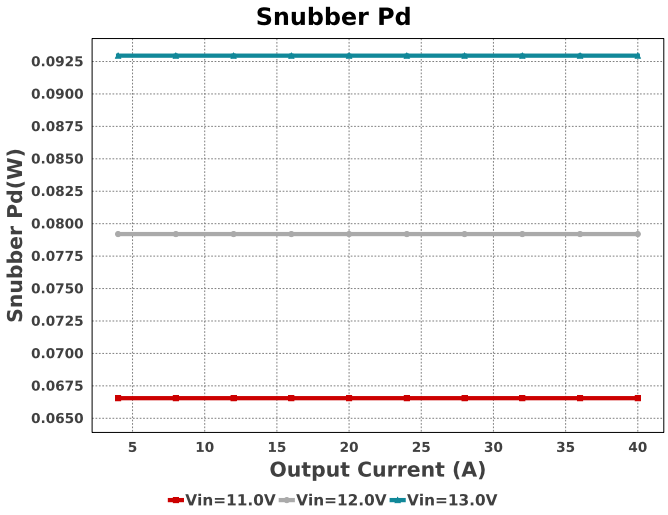
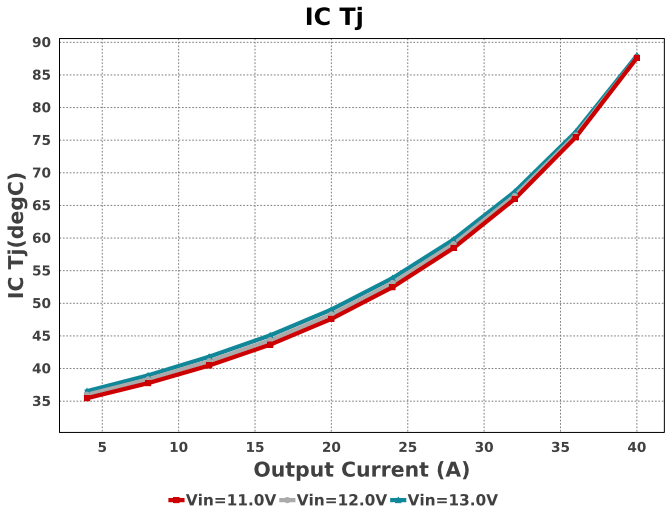
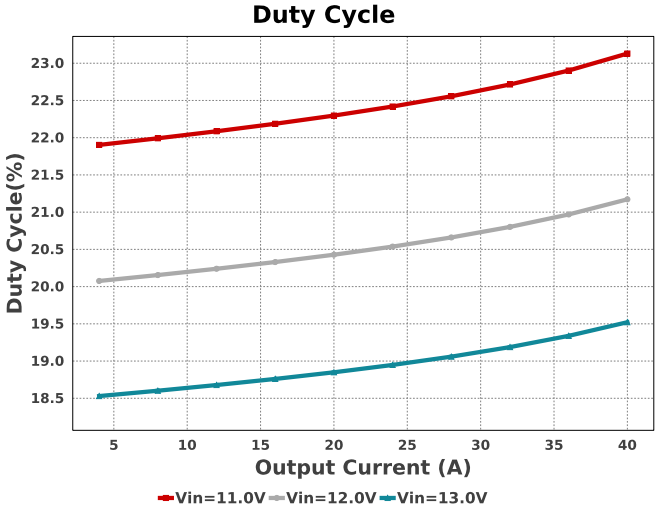
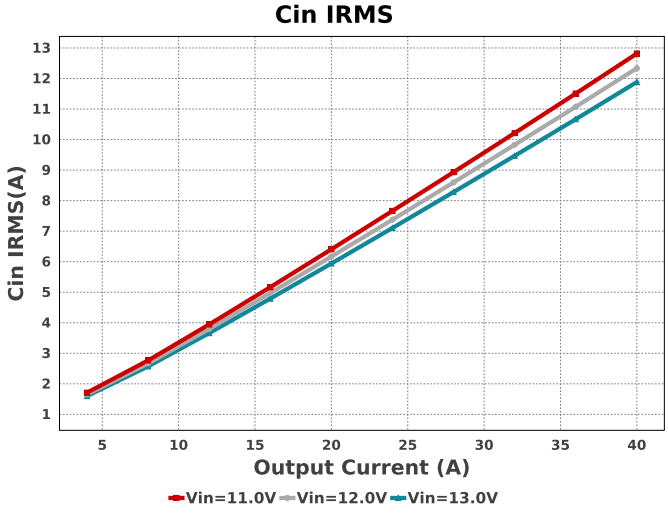
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| Rpg | Vishay-Dale | CRCW040210K0FKED<br>Series= CRCW..e3 | Res= 10.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Rsnubber | Stackpole Electronics Inc | CSR1206FT1R00<br>Series= ? | Res= 1.0 Ohm<br>Power= 500.0 mW<br>Tolerance= 1.0% | 1 | $0.04 | 1206 11 mm² |
| Ruvlob | Vishay-Dale | CRCW04021K37FKED<br>Series= CRCW..e3 | Res= 1.37 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Ruvlot | Vishay-Dale | CRCW040212K7FKED<br>Series= CRCW..e3 | Res= 12.7 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Rvselb | Vishay-Dale | CRCW04024K64FKED<br>Series= CRCW..e3 | Res= 4.64 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| Rvselt | Vishay-Dale | CRCW04023K16FKED<br>Series= CRCW..e3 | Res= 3.16 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |
| U1 | Texas Instruments | TPS546D24ARVFR | Switcher | 1 | $4.86 | RVF0040A 63 mm² |

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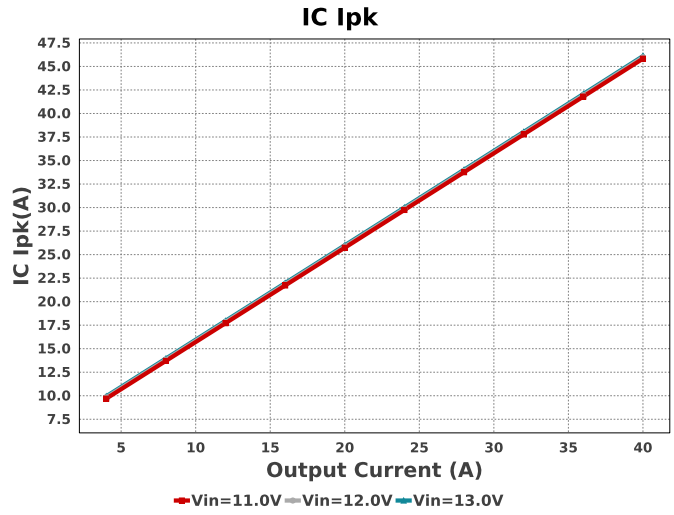


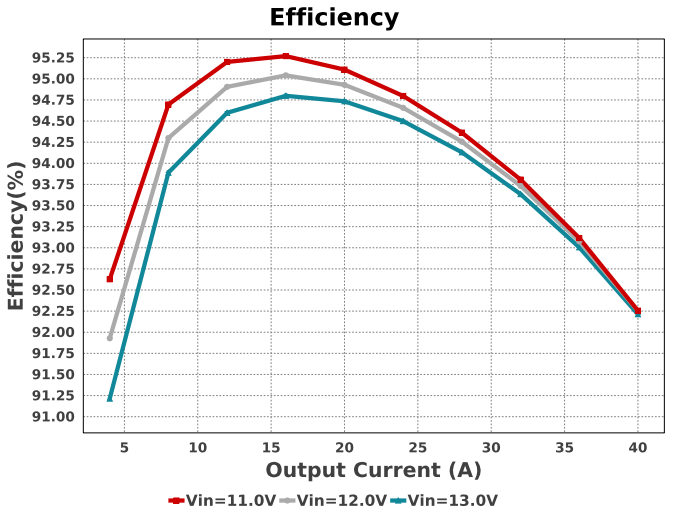


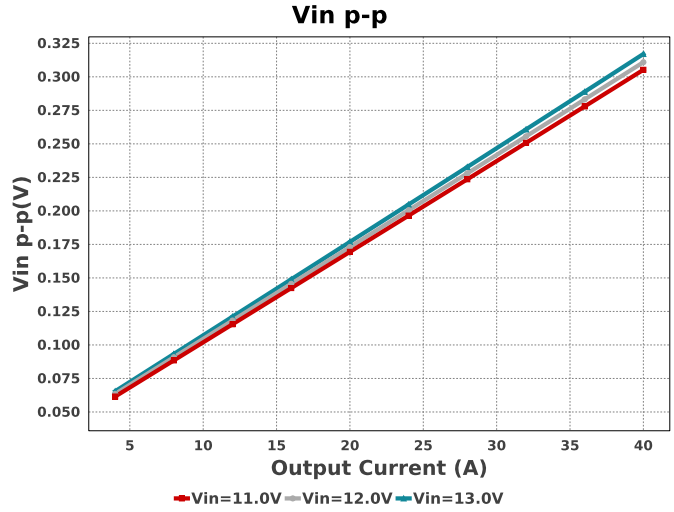


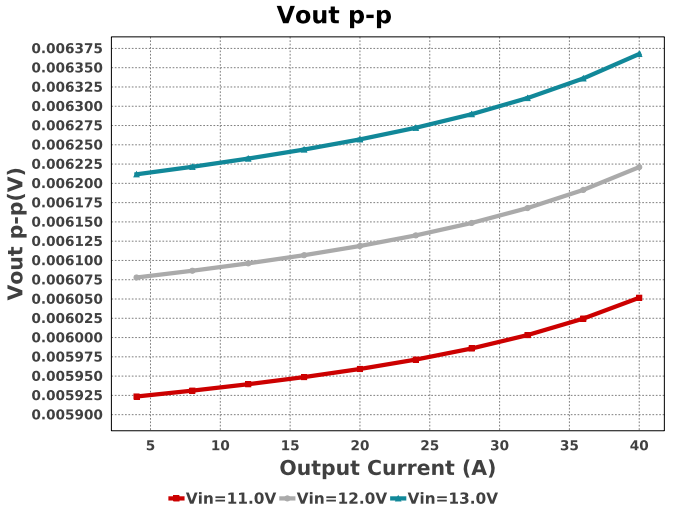


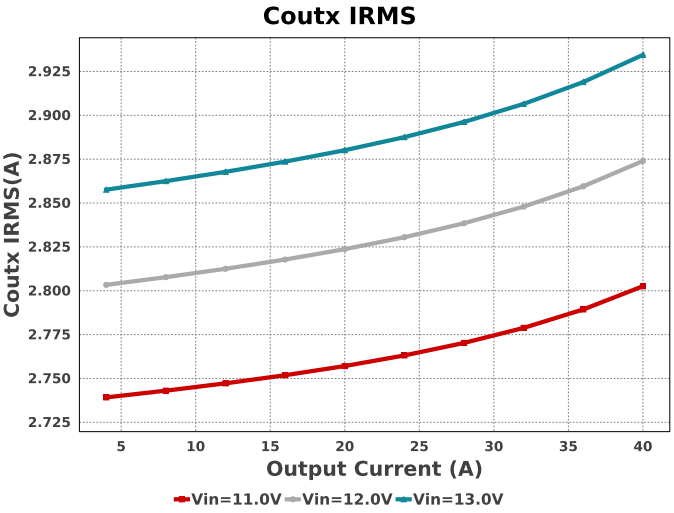


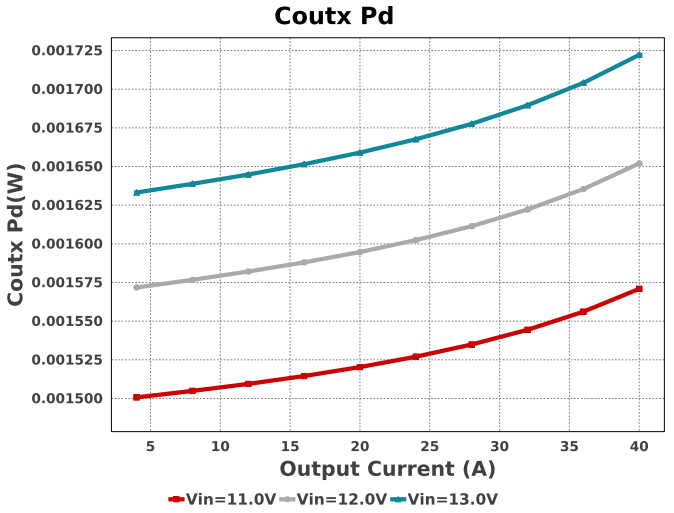


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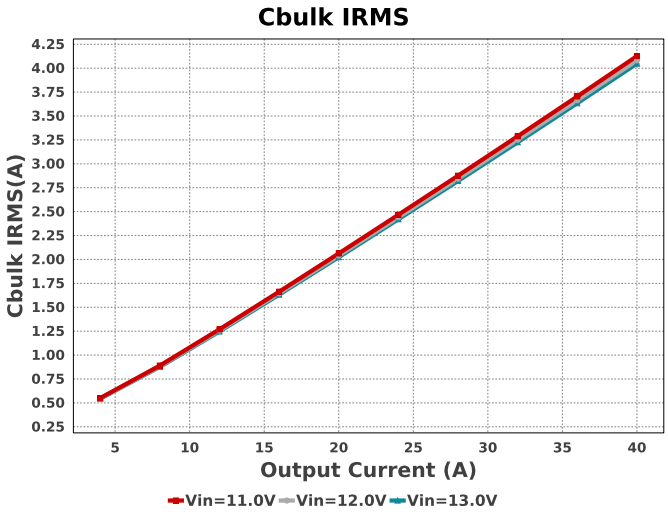


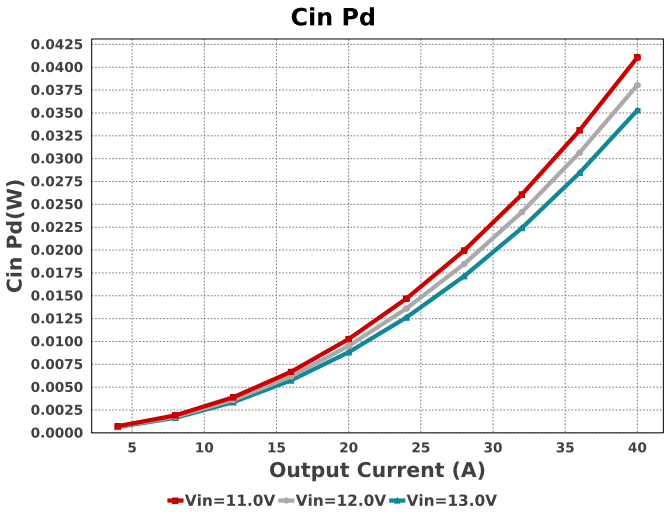


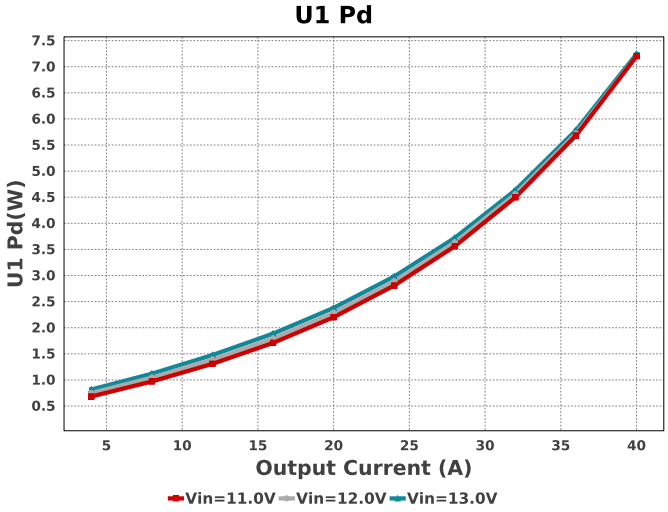


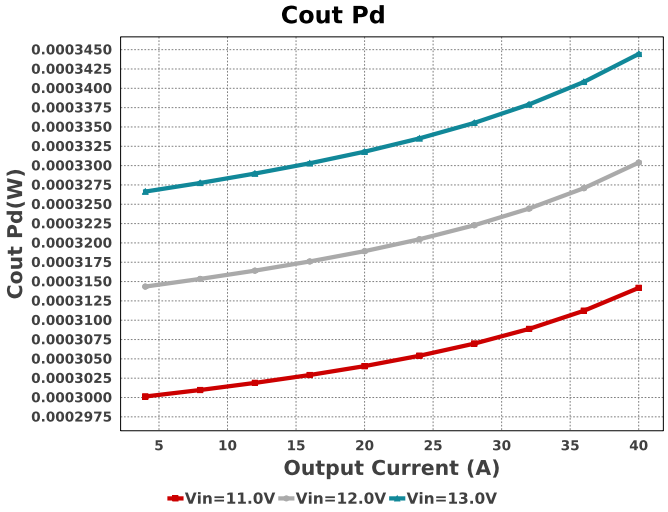


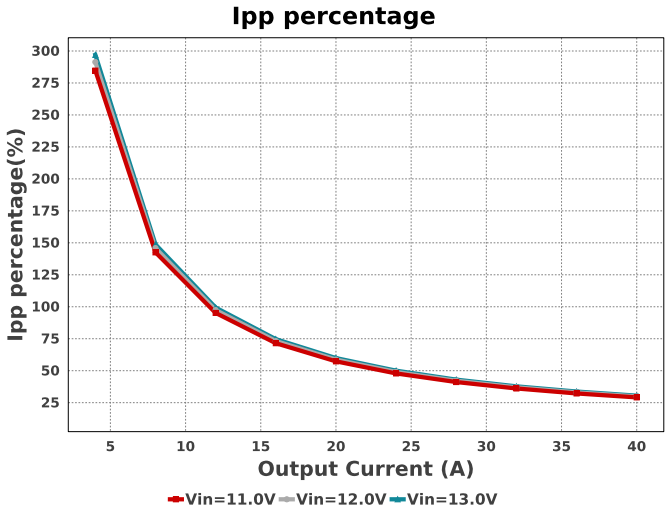


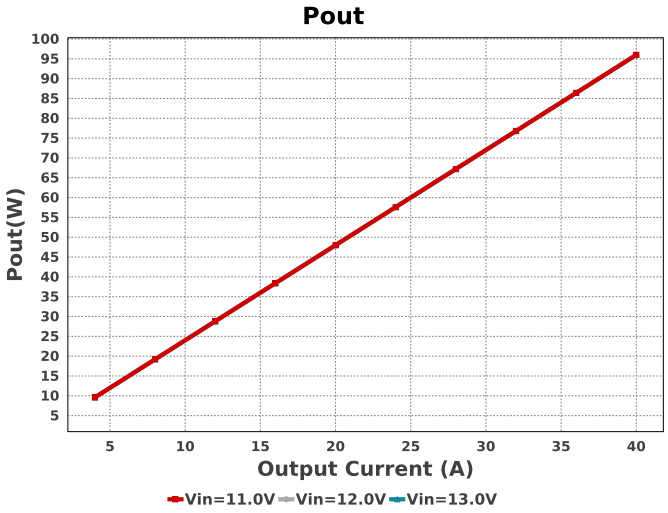


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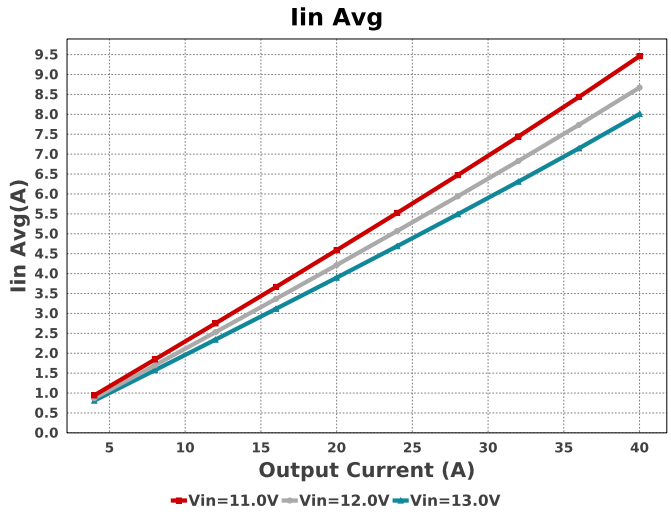


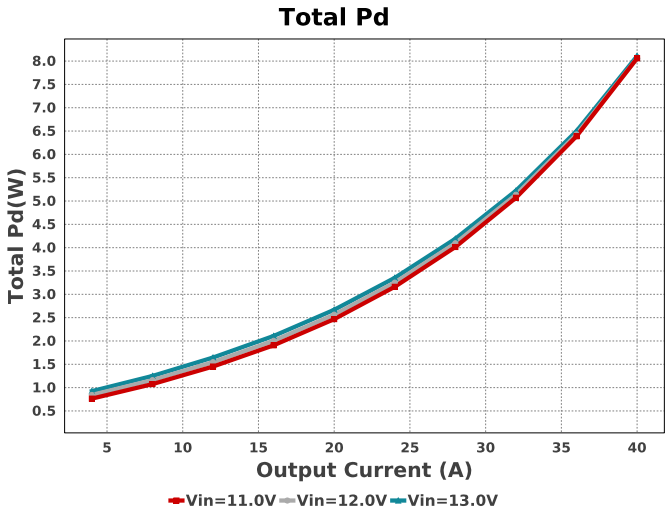


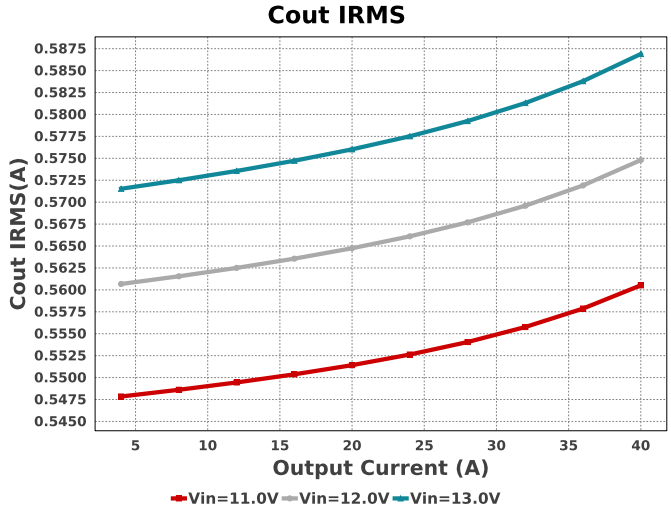


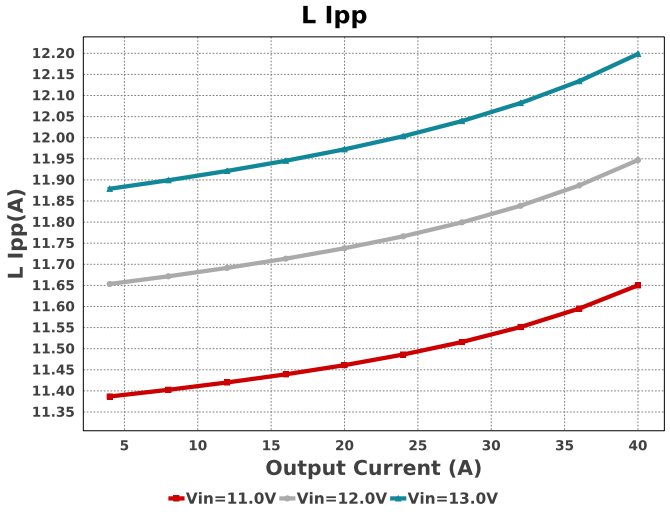


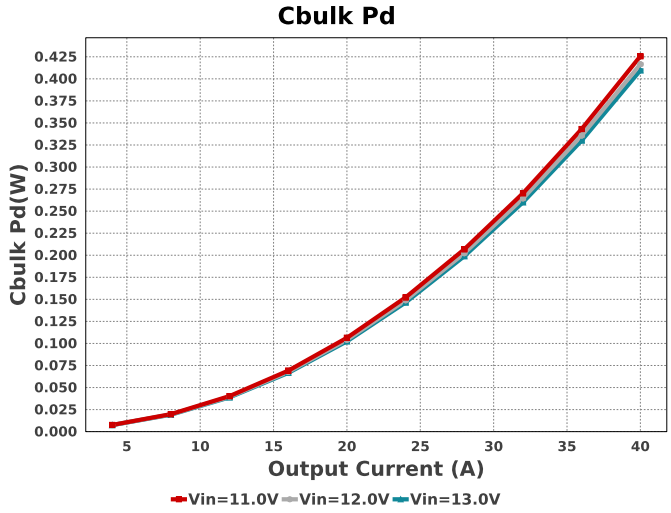


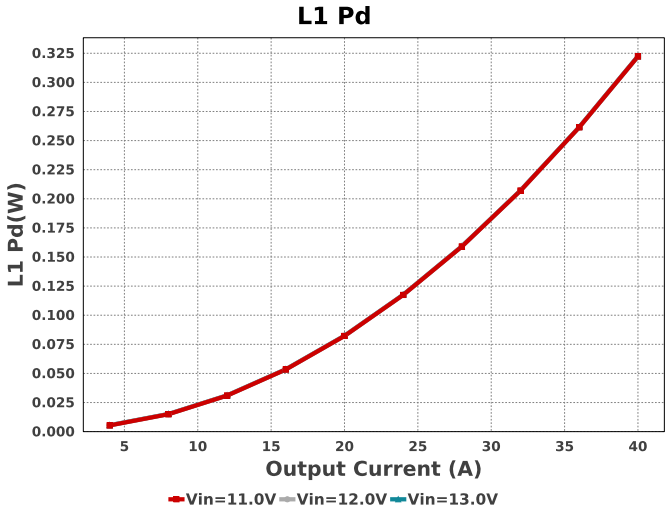


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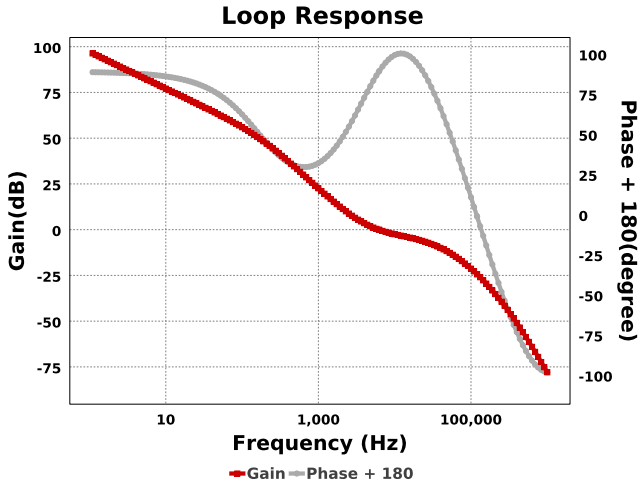


## Operating Values

| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 1. | Cbulk IRMS | 4.048 A | Capacitor | Bulk capacitor RMS ripple current |
| 2. | Cbulk Pd | 409.66 mW | Capacitor | Bulk capacitor power dissipation |
| 3. | Cin IRMS | 11.883 A | Capacitor | Input capacitor RMS ripple current |
| 4. | Cin Pd | 35.3 mW | Capacitor | Input capacitor power dissipation |
| 5. | Cout IRMS | 586.894 mA | Capacitor | Output capacitor RMS ripple current |
| 6. | Cout Pd | 344.44 µW | Capacitor | Output capacitor power dissipation |
| 7. | Coutx IRMS | 2.934 A | Capacitor | Output capacitor_x RMS ripple current |
| 8. | Coutx Pd | 1.722 mW | Capacitor | Output capacitor_x power loss |
| 9. | Fpi | 552.621 kHz | Compensation | Current Loop Pole Frequency |
| 10. | Fpv | 212.207 kHz | Compensation | Voltage Loop Pole Frequency |
| 11. | Fzi | 14.224 kHz | Compensation | Current Loop Zero Frequency |
| 12. | Fzv | 5.305 kHz | Compensation | Voltage Loop Zero Frequency |
| 13. | ILOOP Gain | 6.501 | Compensation | Recommended Current Loop Mid-band Gain |
| 14. | VLOOP Gain | 7.138 | Compensation | Recommended Voltage Loop Mid-band Gain |
| 15. | Zout (Fco) | 56.539 mOhm | Compensation | Output Impedance at Crossover Frequency |
| 16. | Zout (Fsw) | 657.89 µOhm | Compensation | Output Impedance at Switching Frequency |
| 17. | IC Ipk | 46.099 A | IC | Peak switch current in IC |
| 18. | IC Tj | 87.953 degC | IC | IC junction temperature |
| 19. | ICThetaJA Effective | 8.0 degC/W | IC | Effective IC Junction-to-Ambient Thermal Resistance |
| 20. | Iin Avg | 8.008 A | IC | Average input current |
| 21. | U1 Pd | 7.244 W | IC | IC power dissipation |
| 22. | Ipp percentage | 30.496 % | Inductor | Inductor ripple current percentage (with respect to average inductor current) |
| 23. | L Ipp | 12.198 A | Inductor | Peak-to-peak inductor ripple current |
| 24. | L1 Pd | 322.48 mW | Inductor | Inductor power dissipation |
| 25. | CPI | 9.6 pF | PMBus | Selectable compensation parameter through pinstrapping |
| 26. | CPV | 18.75 pF | PMBus | Selectable compensation parameter through pinstrapping |
| 27. | CZI | 372.96 pF | PMBus | Selectable compensation parameter through pinstrapping |
| 28. | CZV | 750.0 pF | PMBus | Selectable compensation parameter through pinstrapping |
| 29. | GMI | 200.0 µS | PMBus | Selectable compensation parameter through pinstrapping |
| 30. | GMV | 50.0 µS | PMBus | Selectable compensation parameter through pinstrapping |
| 31. | PMBus Vout Command | 2.4 | PMBus | PMBus Vout Command |
| 32. | PMBus Vout Scale Loop | 125.0 m | PMBus | PMBus Vout Scale Loop |
| 33. | RVI | 30.0 kOhm | PMBus | Selectable compensation parameter through pinstrapping |
| 34. | RVV | 40.0 kOhm | PMBus | Selectable compensation parameter through pinstrapping |
| 35. | Cbulk Pd | 409.66 mW | Power | Bulk capacitor power dissipation |
| 36. | Cin Pd | 35.3 mW | Power | Input capacitor power dissipation |
| 37. | Cout Pd | 344.44 µW | Power | Output capacitor power dissipation |
| 38. | Coutx Pd | 1.722 mW | Power | Output capacitor_x power loss |
| 39. | L1 Pd | 322.48 mW | Power | Inductor power dissipation |
| 40. | Snubber Pd | 92.95 mW | Power | Snubber Power Dissipation |
| 41. | Total Pd | 8.107 W | Power | Total Power Dissipation |
| 42. | U1 Pd | 7.244 W | Power | IC power dissipation |
| 43. | BOM Count | 34 | System Information | Total Design BOM count |
| 44. | Cross Freq | 6.191 kHz | System Information | Bode plot crossover frequency |
| 45. | Duty Cycle | 19.522 % | System Information | Duty cycle |
| 46. | Efficiency | 92.213 % | System Information | Steady state efficiency |

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| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 47. | FootPrint | 602.0 $mm^2$ | System Information | Total Foot Print Area of BOM components |
| 48. | Frequency | 550.0 kHz | System Information | Switching frequency |
| 49. | Gain Marg | -24.304 dB | System Information | Bode Plot Gain Margin |
| 50. | Iout | 40.0 A | System Information | Iout operating point |
| 51. | Low Freq Gain | 96.308 dB | System Information | Gain at 1Hz |
| 52. | Mode | CCM | System Information | Conduction Mode |
| 53. | Phase Marg | 89.973 deg | System Information | Bode Plot Phase Margin |
| 54. | Pout | 96.0 W | System Information | Total output power |
| 55. | Total BOM | $8.6 | System Information | Total BOM Cost |
| 56. | Vin | 13.0 V | System Information | Vin operating point |
| 57. | Vin p-p | 317.039 mV | System Information | Peak-to-peak input voltage |
| 58. | Vout | 2.4 V | System Information | Operational Output Voltage |
| 59. | Vout Tolerance | 333.33 m% | System Information | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |
| 60. | Vout p-p | 6.368 mV | System Information | Peak-to-peak output ripple voltage |

## Design Inputs

| | Name | Value | Description |
|---|---|---|---|
| | Iout | 40.0 | Maximum Output Current |
| | VinMax | 13.0 | Maximum input voltage |
| | VinMin | 11.0 | Minimum input voltage |
| | Vout | 2.4 | Output Voltage |
| | base_pn | TPS546D24A | Base Product Number |
| | source | DC | Input Source Type |
| | Ta | 30.0 | Ambient temperature |
| 1. | Vout Sch | 2.4 | Output voltage selected |

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# 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 Cin and Cout, 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

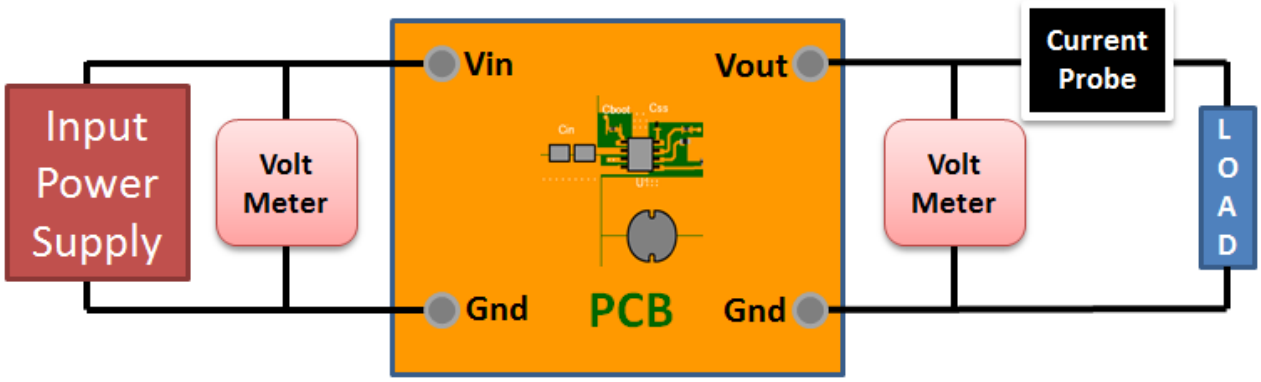
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town 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 11.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout 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 Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout 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 : 4403CD56E2ECE12A[v1]
2. **TPS546D24A** Product Folder : http://www.ti.com/product/TPS546D24A : contains the data sheet and other resources.

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