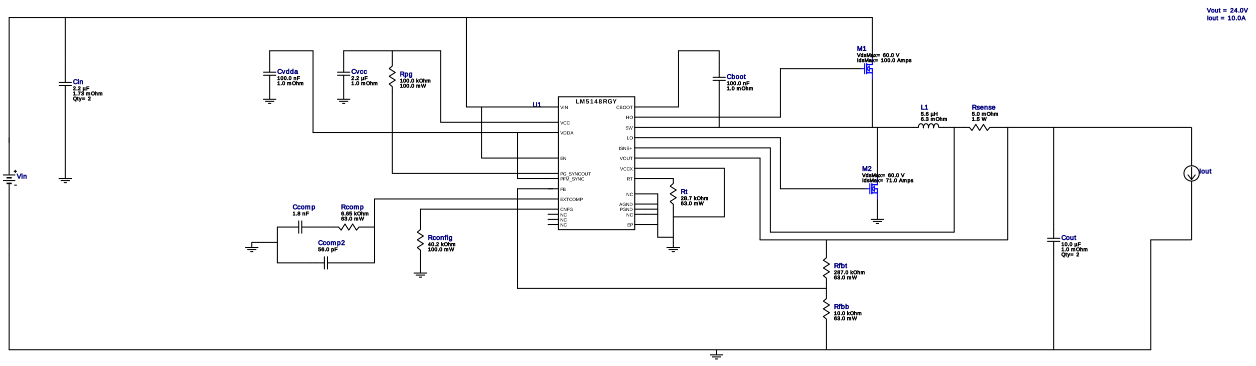
TEXAS INSTRUMENTS

# WEBENCH ® Design Report

VinMin = 40.0V
VinMax = 48.0V
Vout = 24.0V
Iout = 10.0A

Device = LM5148RGYR
Topology = Buck
Created = 2025-04-21 06:49:45.845
BOM Cost = $5.40
BOM Count = 20
Total Pd = 5.86W

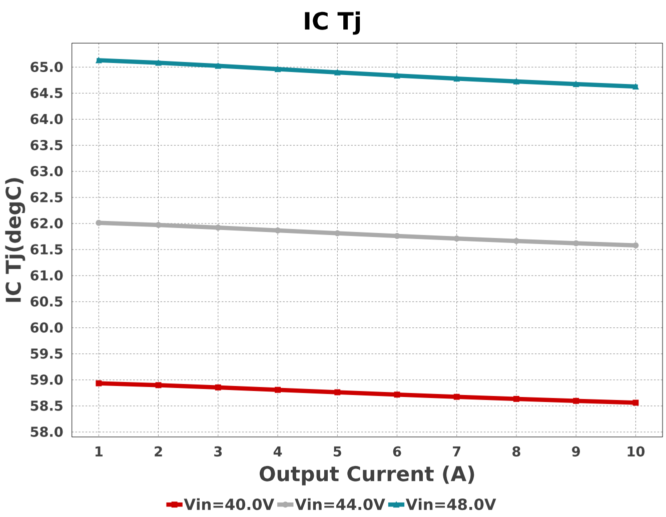
Design : 8 LM5148RGYR
LM5148RGYR 40V-48V to 24.00V @ 10A

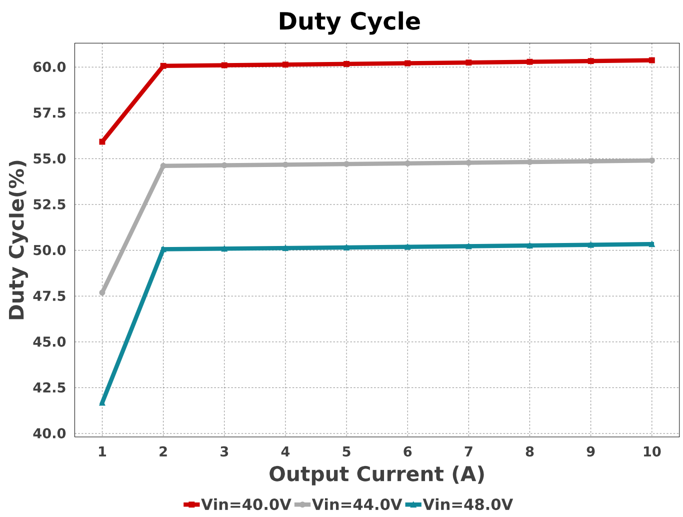


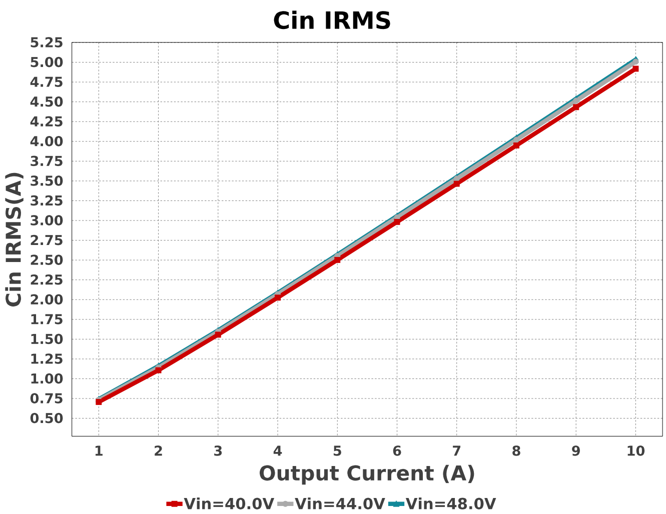
## Electrical BOM

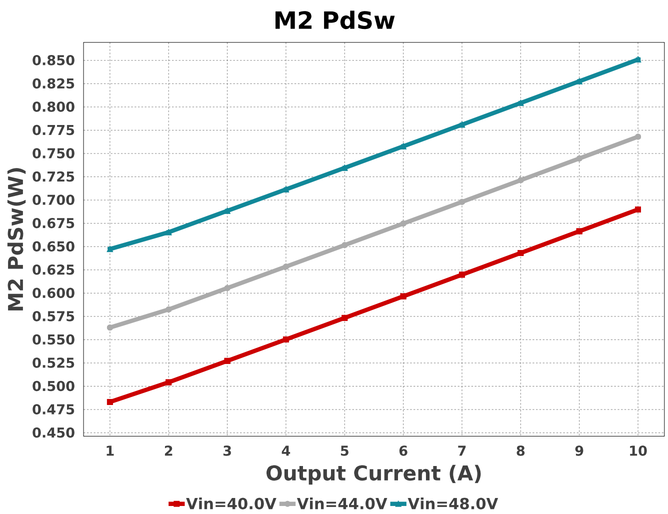
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| Cboot | MuRata | GRM155R71A104KA01D<br>Series= X7R | Cap= 100.0 nF<br>ESR= 1.0 mOhm<br>VDC= 10.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 $mm^2$ |
| Ccomp | MuRata | GRM1885C1H182JA01J<br>Series= C0G/NP0 | Cap= 1.8 nF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.02 | 0603 5 $mm^2$ |
| Ccomp2 | Taiyo Yuden | UMK105CG560JVHF<br>Series= C0G/NP0 | Cap= 56.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 $mm^2$ |
| Cin | TDK | C3225X7R2A225K230AB<br>Series= X7R | Cap= 2.2 uF<br>ESR= 1.73 mOhm<br>VDC= 100.0 V<br>IRMS= 5.5932 A | 2 | $0.21 | 1210_250 15 $mm^2$ |
| Cout | TDK | C3225X7R1H106M250AC<br>Series= X7R | Cap= 10.0 uF<br>ESR= 1.0 mOhm<br>VDC= 50.0 V<br>IRMS= 5.0 A | 2 | $0.27 | 1210 15 $mm^2$ |
| Cvcc | TDK | C1005X5R1V225K050BC<br>Series= X5R | Cap= 2.2 uF<br>ESR= 1.0 mOhm<br>VDC= 35.0 V<br>IRMS= 0.0 A | 1 | $0.06 | 0402_065 3 $mm^2$ |
| Cvdda | 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 | 0402 3 $mm^2$ |
| L1 | Coilcraft | XAL1010-562MEB | L= 5.6 µH<br>6.3 mOhm | 1 | $1.71 | XAL1010 160 $mm^2$ |
| M1 | Texas Instruments | CSD18540Q5B | VdsMax= 60.0 V<br>IdsMax= 100.0 Amps | 1 | $0.75 | DNK0008A 56 $mm^2$ |
| M2 | ON Semiconductor | NTMFS5C670NLT1G | VdsMax= 60.0 V<br>IdsMax= 71.0 Amps | 1 | $1.02 | SO-8FL 58 $mm^2$ |

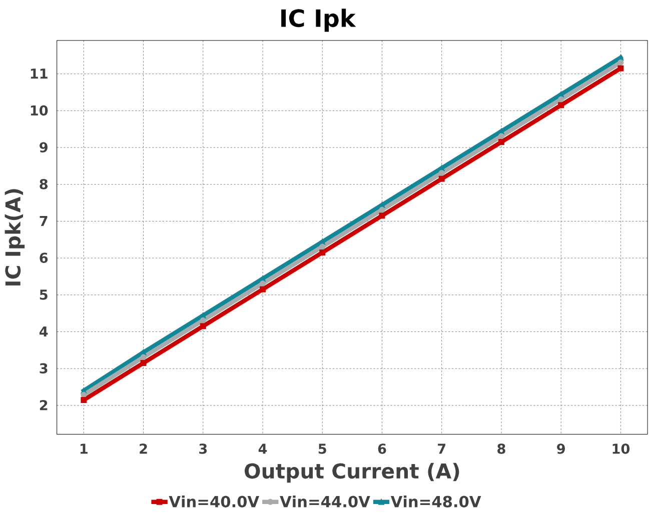
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|
| Rcomp | Vishay-Dale | CRCW04026K65FKED<br>Series= CRCW..e3 | Res= 6.65 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm$^2$ |
| Rconfig | Vishay-Dale | CRCW060340K2FKEA<br>Series= CRCW..e3 | Res= 40.2 kOhm<br>Power= 100.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0603 5 mm$^2$ |
| Rfbb | Vishay-Dale | CRCW040210K0FKED<br>Series= CRCW..e3 | Res= 10.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm$^2$ |
| Rfbt | Vishay-Dale | CRCW0402287KFKED<br>Series= CRCW..e3 | Res= 287.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm$^2$ |
| Rpg | Vishay-Dale | CRCW0603100KFKEA<br>Series= CRCW..e3 | Res= 100.0 kOhm<br>Power= 100.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0603 5 mm$^2$ |
| Rsense | Stackpole Electronics Inc | CSNL2010FT5L00<br>Series= ? | Res= 5.0 mOhm<br>Power= 1.5 W<br>Tolerance= 1.0% | 1 | $0.19 | 2010 32 mm$^2$ |
| Rt | Yageo | AC0402FR-0728K7L<br>Series= ? | Res= 28.7 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm$^2$ |
| U1 | Texas Instruments | LM5148RGYR | Switcher | 1 | $0.60 | RGY0024F 43 mm$^2$ |

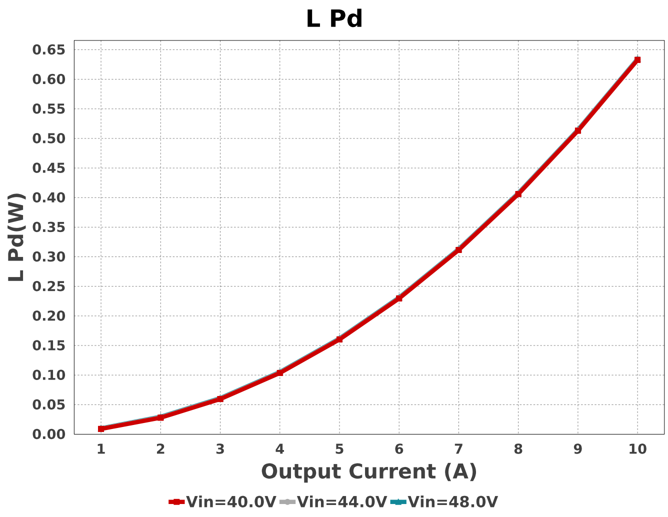


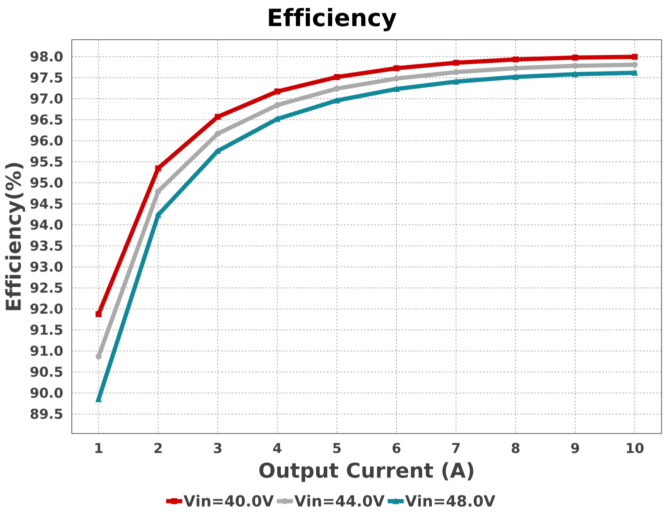



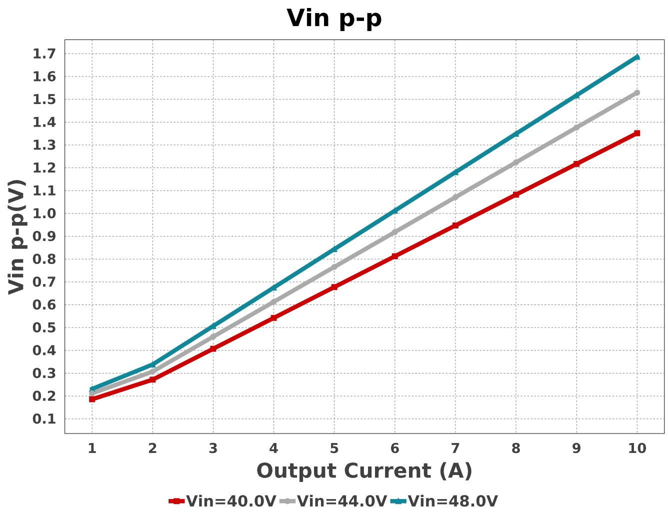



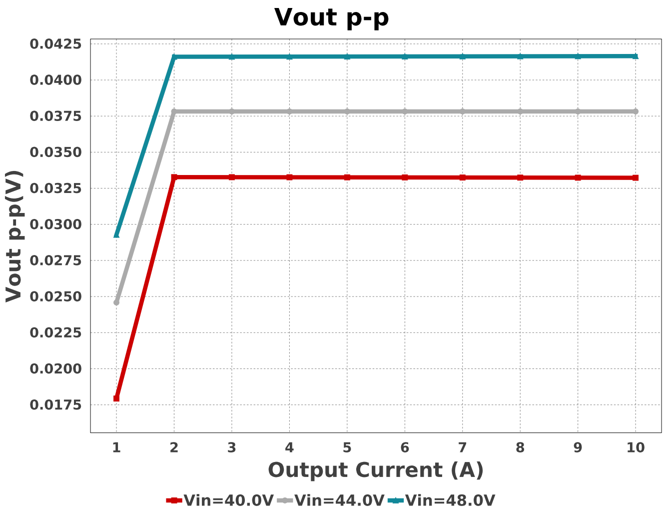



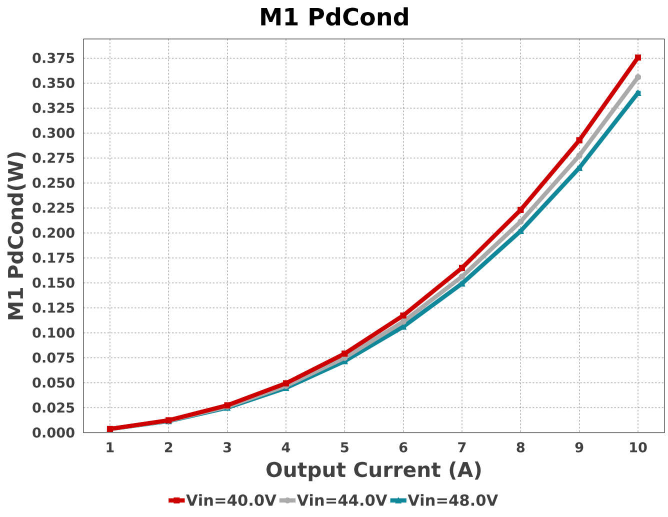

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=40.0V Vin=44.0V Vin=48.0V


L Pd
L Pd(W)
Output Current (A)
Vin=40.0V Vin=44.0V Vin=48.0V

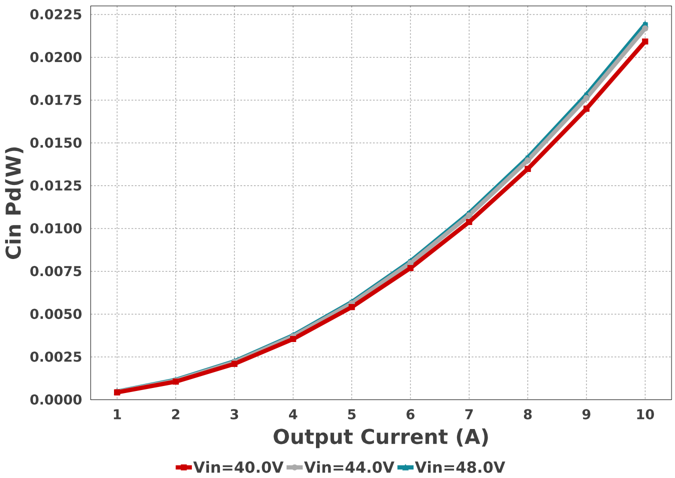

Efficiency
Efficiency(%)
Output Current (A)
Vin=40.0V Vin=44.0V Vin=48.0V


Vin p-p
Vin p-p(V)
Output Current (A)
Vin=40.0V Vin=44.0V Vin=48.0V

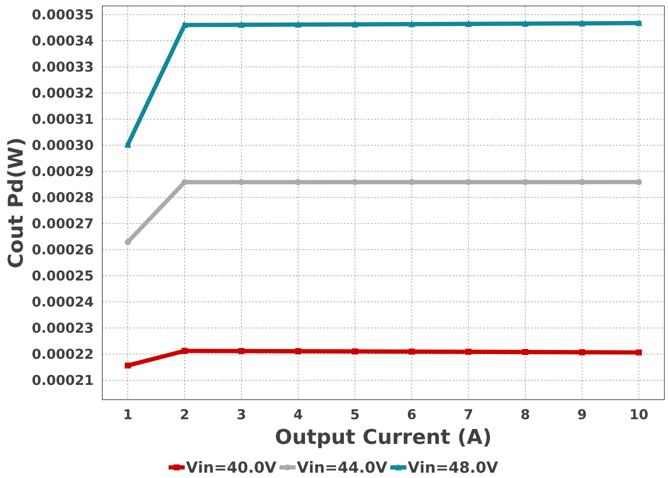

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=40.0V Vin=44.0V Vin=48.0V


M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=40.0V Vin=44.0V Vin=48.0V

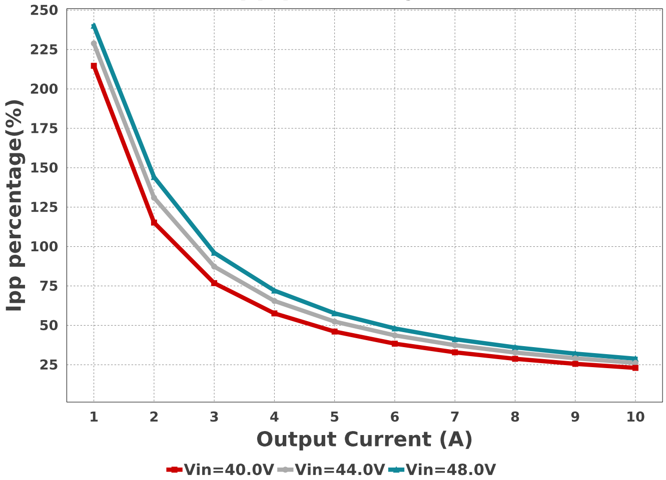
Cin Pd



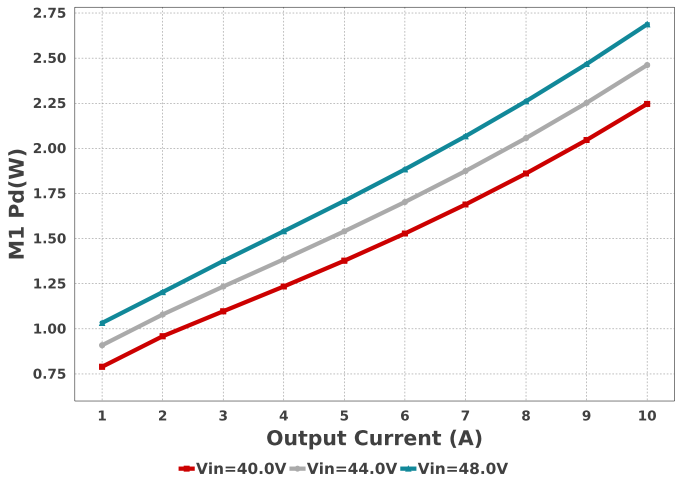

Cout Pd



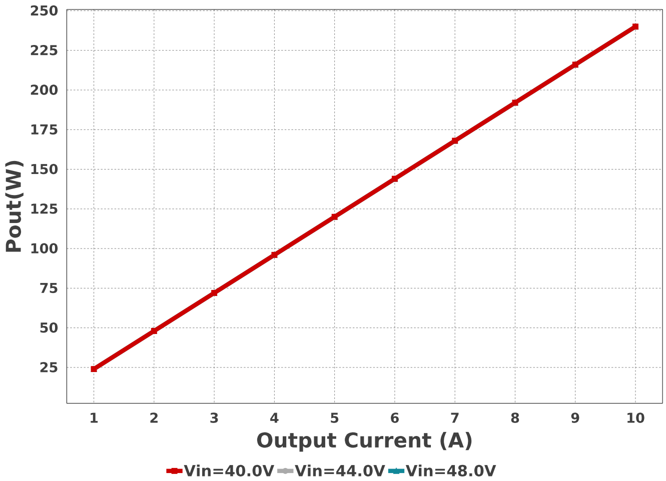

Ipp percentage



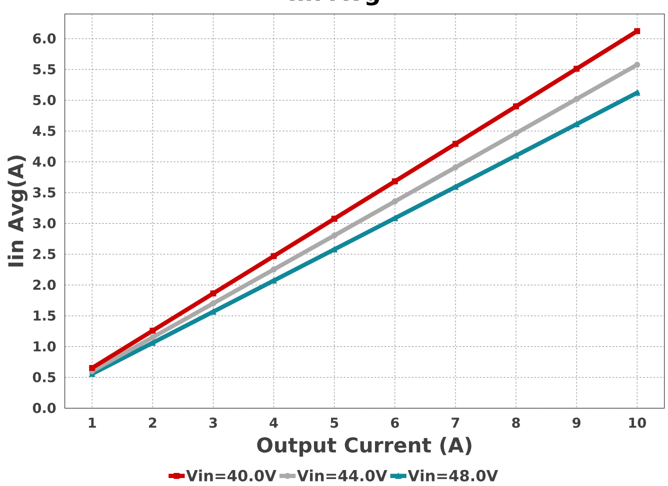

M1 Pd

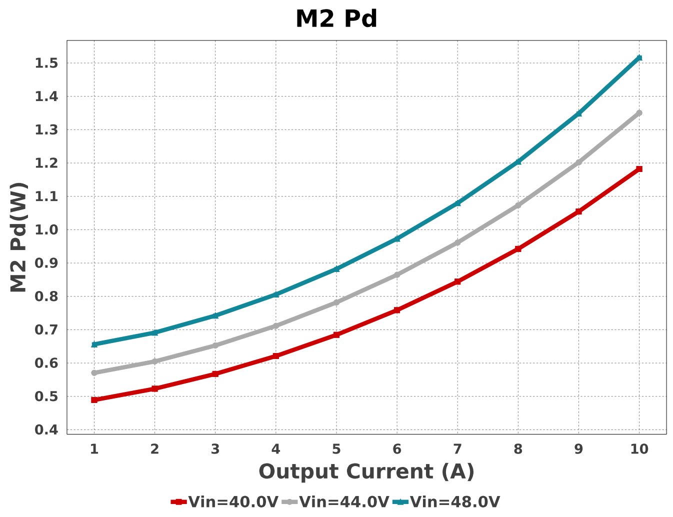


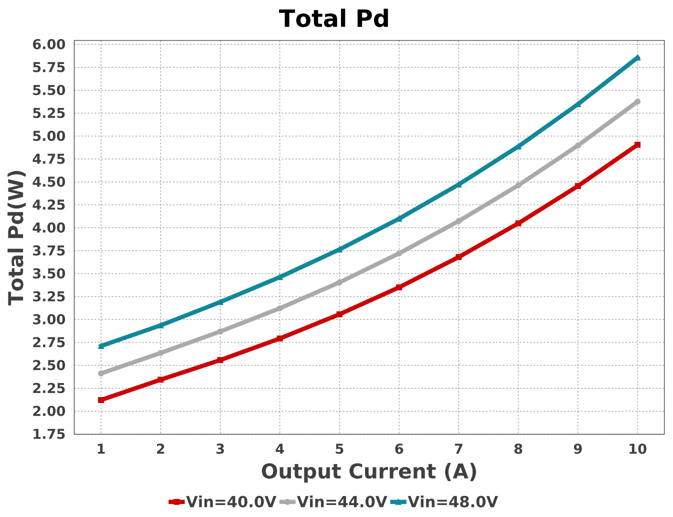

Pout

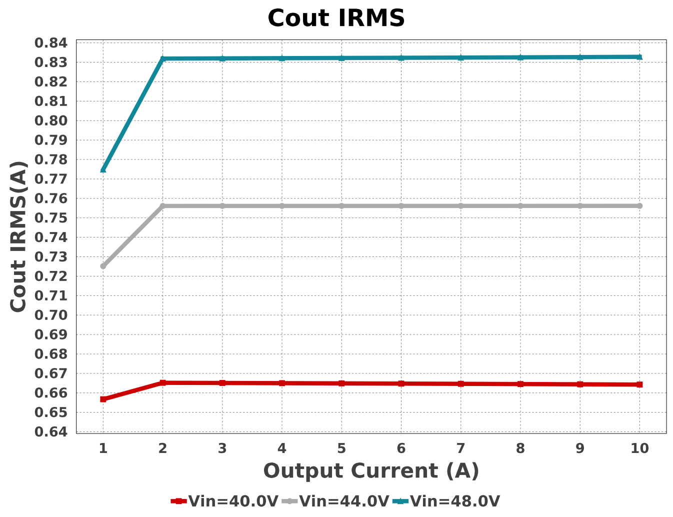


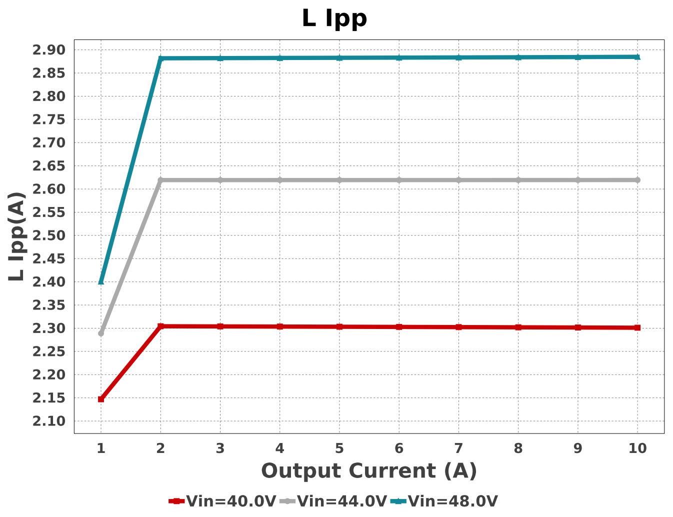

Iin Avg

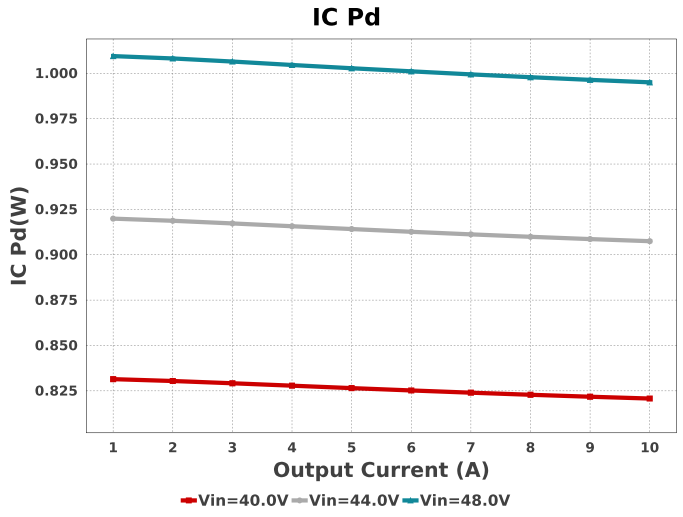


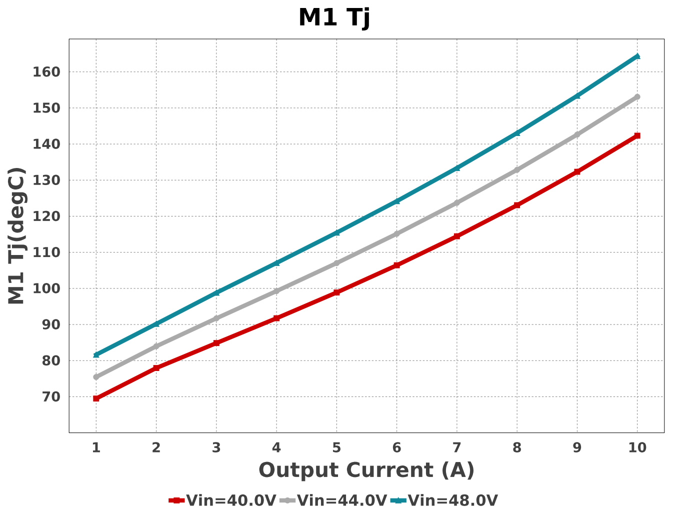

M2 Pd
M2 Pd(W)
Output Current (A)
1.5 1.4 1.3 1.2 1.1 1.0 0.9 0.8 0.7 0.6 0.5 0.4
1 2 3 4 5 6 7 8 9 10
Vin=40.0V Vin=44.0V Vin=48.0V

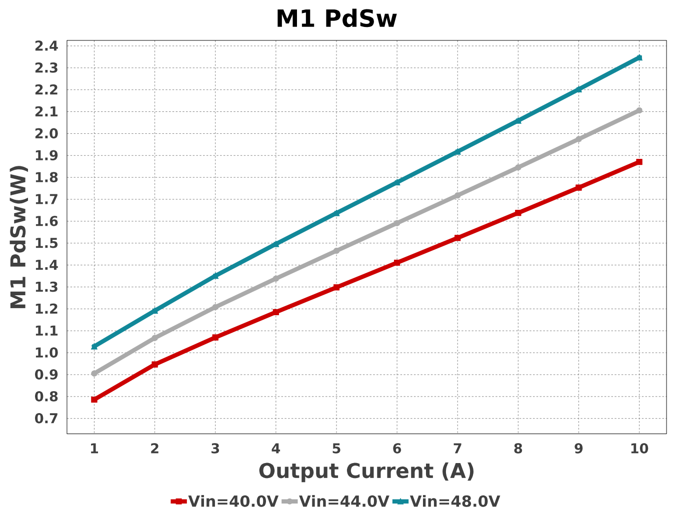

Total Pd
Total Pd(W)
Output Current (A)
6.00 5.75 5.50 5.25 5.00 4.75 4.50 4.25 4.00 3.75 3.50 3.25 3.00 2.75 2.50 2.25 2.00 1.75
1 2 3 4 5 6 7 8 9 10
Vin=40.0V Vin=44.0V Vin=48.0V

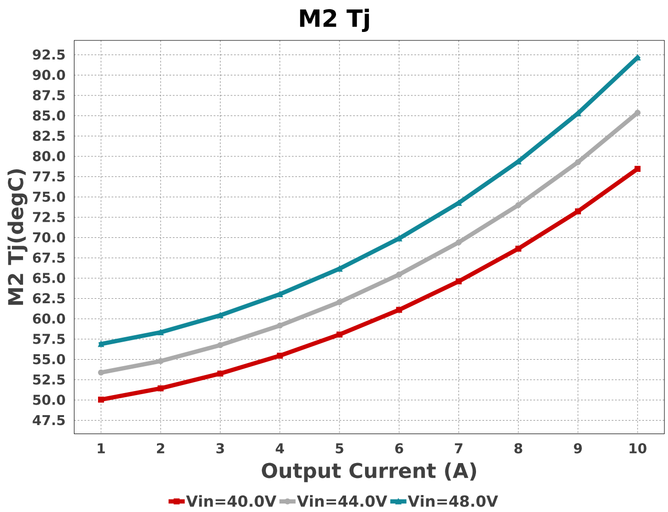

Cout IRMS
Cout IRMS(A)
Output Current (A)
0.84 0.83 0.82 0.81 0.80 0.79 0.78 0.77 0.76 0.75 0.74 0.73 0.72 0.71 0.70 0.69 0.68 0.67 0.66 0.65 0.64
1 2 3 4 5 6 7 8 9 10
Vin=40.0V Vin=44.0V Vin=48.0V

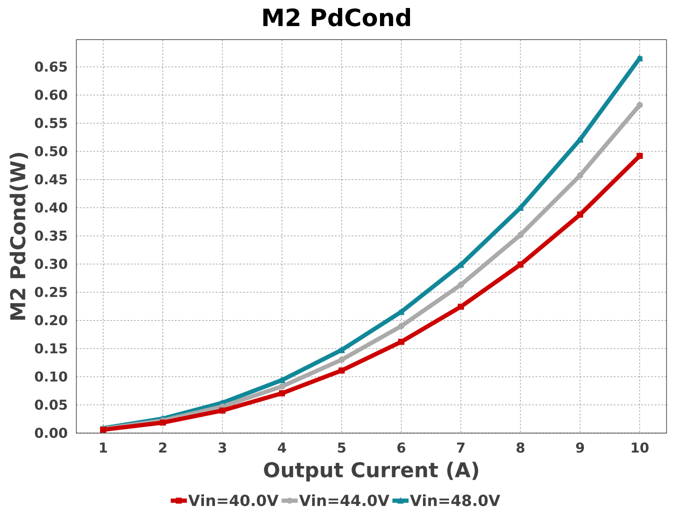

L Ipp
L Ipp(A)
Output Current (A)
2.90 2.85 2.80 2.75 2.70 2.65 2.60 2.55 2.50 2.45 2.40 2.35 2.30 2.25 2.20 2.15 2.10
1 2 3 4 5 6 7 8 9 10
Vin=40.0V Vin=44.0V Vin=48.0V

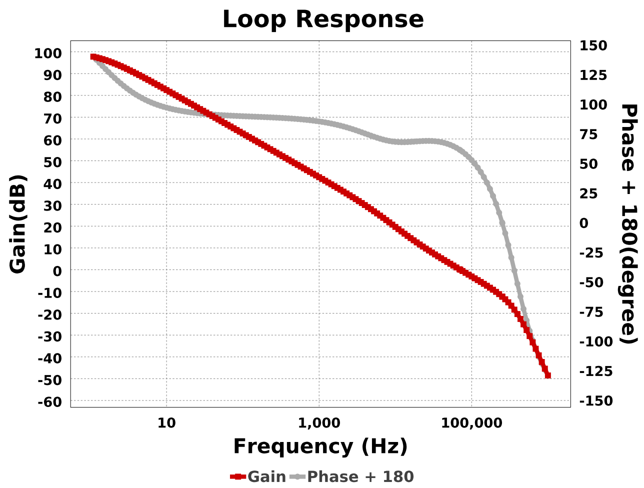

IC Pd
IC Pd(W)
Output Current (A)
1.000 0.975 0.950 0.925 0.900 0.875 0.850 0.825
1 2 3 4 5 6 7 8 9 10
Vin=40.0V Vin=44.0V Vin=48.0V

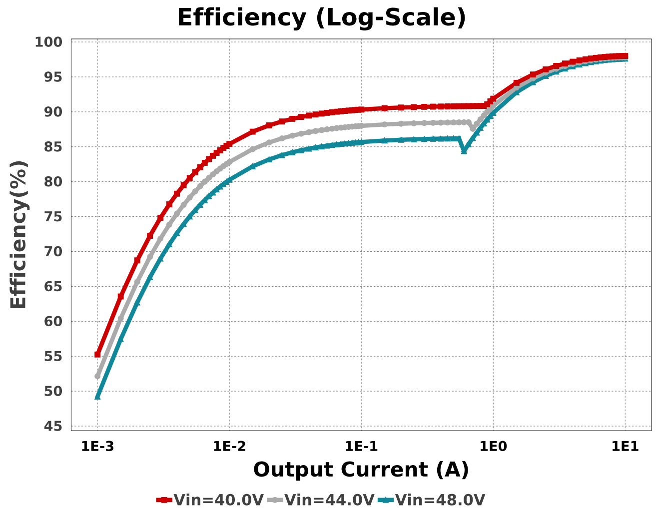

M1 Tj
M1 Tj(degC)
Output Current (A)
160 150 140 130 120 110 100 90 80 70
1 2 3 4 5 6 7 8 9 10
Vin=40.0V Vin=44.0V Vin=48.0V




## Operating Values

| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 1. | Cin IRMS | 5.035 A | Capacitor | Input capacitor RMS ripple current |
| 2. | Cin Pd | 21.926 mW | Capacitor | Input capacitor power dissipation |
| 3. | Cout IRMS | 832.798 mA | Capacitor | Output capacitor RMS ripple current |
| 4. | Cout Pd | 346.78 µW | Capacitor | Output capacitor power dissipation |
| 5. | IC Ipk | 11.442 A | IC | Peak switch current in IC |
| 6. | IC Pd | 995.04 mW | IC | IC power dissipation |
| 7. | IC Tj | 64.627 degC | IC | IC junction temperature |
| 8. | IC Tolerance | 10.0 mV | IC | IC Feedback Tolerance |
| 9. | ICThetaJA Effective | 34.8 degC/W | IC | Effective IC Junction-to-Ambient Thermal Resistance |
| 10. | Iin Avg | 5.122 A | IC | Average input current |

| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 11. | Ipp percentage | 28.849 % | Inductor | Inductor ripple current percentage (with respect to average inductor current) |
| 12. | L Ipp | 2.885 A | Inductor | Peak-to-peak inductor ripple current |
| 13. | L Pd | 634.37 mW | Inductor | Inductor power dissipation |
| 14. | M1 Pd | 2.687 W | Mosfet | M1 MOSFET total power dissipation |
| 15. | M1 PdCond | 340.19 mW | Mosfet | M1 MOSFET conduction losses |
| 16. | M1 PdSw | 2.347 W | Mosfet | M1 MOSFET switching losses |
| 17. | M1 Tj | 164.36 degC | Mosfet | M1 MOSFET junction temperature |
| 18. | M2 Pd | 1.516 W | Mosfet | M2 MOSFET total power dissipation |
| 19. | M2 PdCond | 665.32 mW | Mosfet | M2 MOSFET conduction losses |
| 20. | M2 PdSw | 850.95 mW | Mosfet | M2 MOSFET switching losses |
| 21. | M2 Tj | 92.167 degC | Mosfet | M2 MOSFET junction temperature |
| 22. | Cin Pd | 21.926 mW | Power | Input capacitor power dissipation |
| 23. | Cout Pd | 346.78 µW | Power | Output capacitor power dissipation |
| 24. | IC Pd | 995.04 mW | Power | IC power dissipation |
| 25. | L Pd | 634.37 mW | Power | Inductor power dissipation |
| 26. | M1 Pd | 2.687 W | Power | M1 MOSFET total power dissipation |
| 27. | M1 PdCond | 340.19 mW | Power | M1 MOSFET conduction losses |
| 28. | M1 PdSw | 2.347 W | Power | M1 MOSFET switching losses |
| 29. | M2 Pd | 1.516 W | Power | M2 MOSFET total power dissipation |
| 30. | M2 PdCond | 665.32 mW | Power | M2 MOSFET conduction losses |
| 31. | M2 PdSw | 850.95 mW | Power | M2 MOSFET switching losses |
| 32. | Total Pd | 5.856 W | Power | Total Power Dissipation |
| 33. | BOM Count | 20 | System Information | Total Design BOM count |
| 34. | Cross Freq | 71.047 kHz | System Information | Bode plot crossover frequency |
| 35. | Duty Cycle | 50.339 % | System Information | Duty cycle |
| 36. | Efficiency | 97.618 % | System Information | Steady state efficiency |
| 37. | FootPrint | 445.0 $mm^2$ | System Information | Total Foot Print Area of BOM components |
| 38. | Frequency | 743.771 kHz | System Information | Switching frequency |
| 39. | Gain Marg | -12.401 dB | System Information | Bode Plot Gain Margin |
| 40. | Iout | 10.0 A | System Information | Iout operating point |
| 41. | Iout transient step used for Cout calculations | 5.0 A | System Information | Custom Transient current step requirement that was used for Cout selection (A). |
| 42. | Low Freq Gain | 97.776 dB | System Information | Gain at 1Hz |
| 43. | Mode | CCM | System Information | Conduction Mode |
| 44. | Overshoot Value | 250.512 mV | System Information | Theoretical Vout Overshoot Value |
| 45. | Phase Marg | 61.634 deg | System Information | Bode Plot Phase Margin |
| 46. | Pout | 240.0 W | System Information | Total output power |
| 47. | Total BOM | $5.4 | System Information | Total BOM Cost |
| 48. | Undershoot Value | 539.21 mV | System Information | Theoretical Vout Undershoot Value |
| 49. | Vin | 48.0 V | System Information | Vin operating point |
| 50. | Vin p-p | 1.686 V | System Information | Peak-to-peak input voltage |
| 51. | Vout | 24.0 V | System Information | Operational Output Voltage |
| 52. | Vout Actual | 23.76 V | System Information | Vout Actual calculated based on selected voltage divider resistors |
| 53. | Vout Ripple requirement used for Cout calculations | 1.0 % | System Information | Custom maximum output ripple requirement that was used for Cout selection(% of Vout). |
| 54. | Vout Tolerance | 3.227 % | System Information | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |
| 55. | Vout p-p | 41.656 mV | System Information | Peak-to-peak output ripple voltage |
| 56. | Vout transient requirement used for Cout calculations | 3.0 % | System Information | Custom Transient voltage change requirement that was used for Cout selection (% of Vout). |

## Design Inputs

| Name | Value | Description |
|---|---|---|
| Iout | 10.0 | Maximum Output Current |
| VinMax | 48.0 | Maximum input voltage |
| VinMin | 40.0 | Minimum input voltage |
| Vout | 24.0 | Output Voltage |
| base_pn | LM5148 | Base Product Number |
| source | DC | Input Source Type |
| Ta | 30.0 | Ambient temperature |
| UserFsw | 743.771 k | Customer Selected Frequency |

# 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

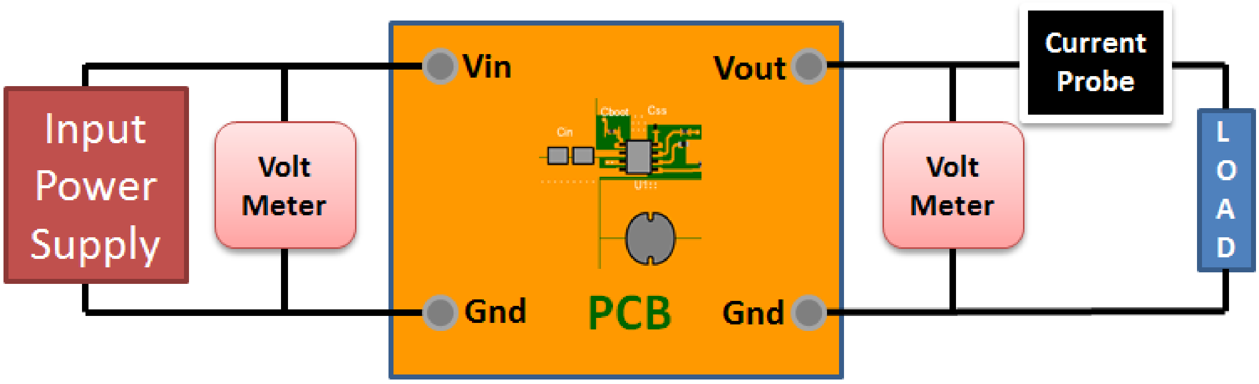
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 40.0V 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 : 256B1E9865B5AAD2[v1]

2. **LM5148** Product Folder : http://www.ti.com/product/LM5148 : contains the data sheet and other resources.