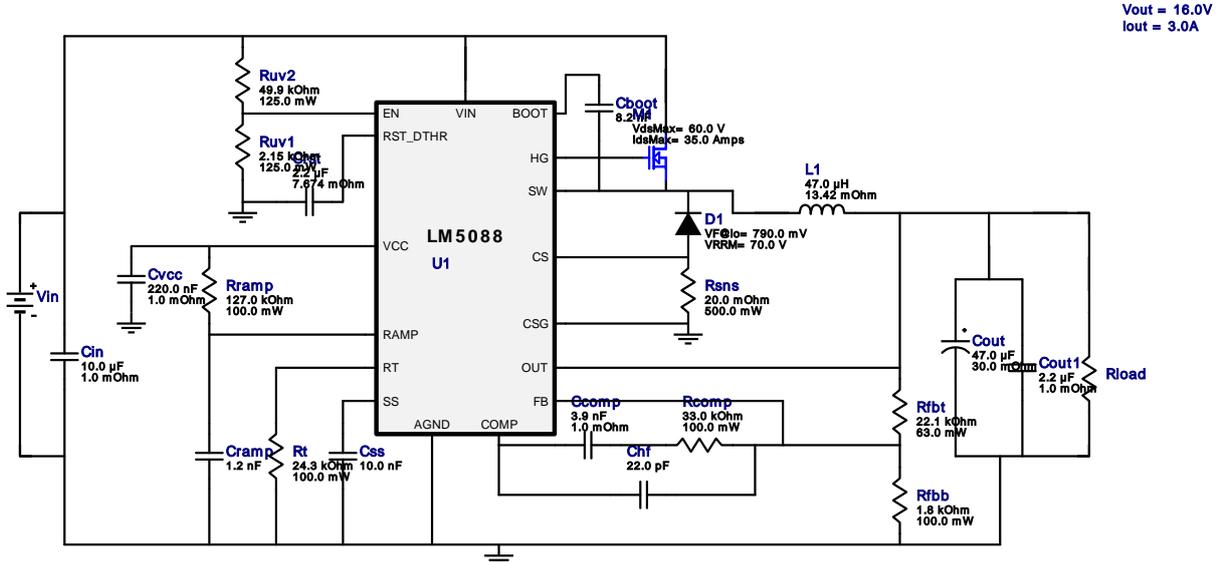
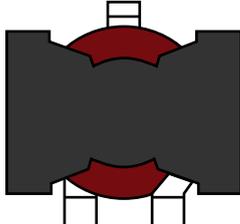
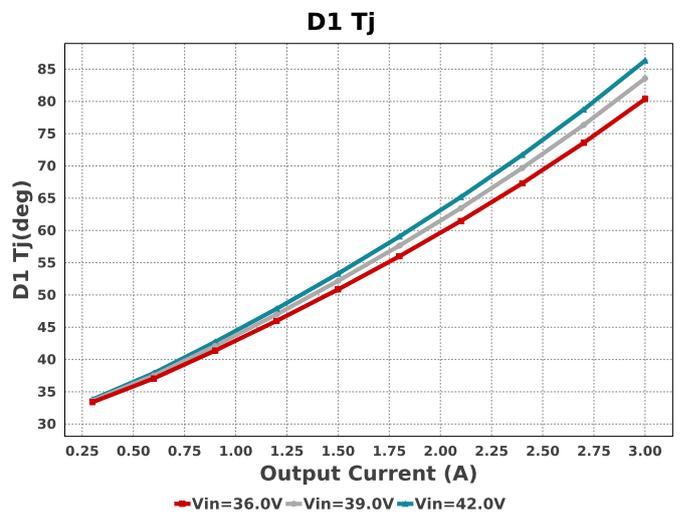
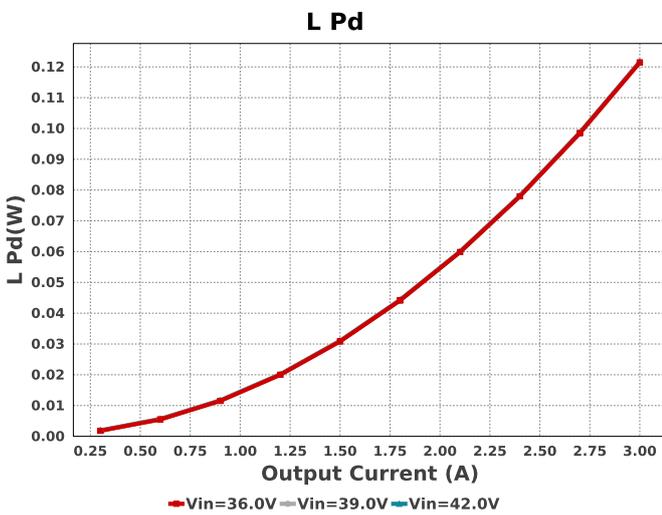
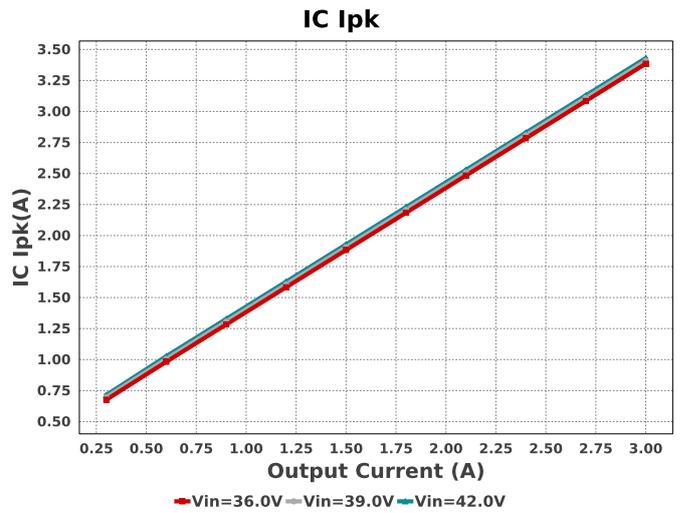
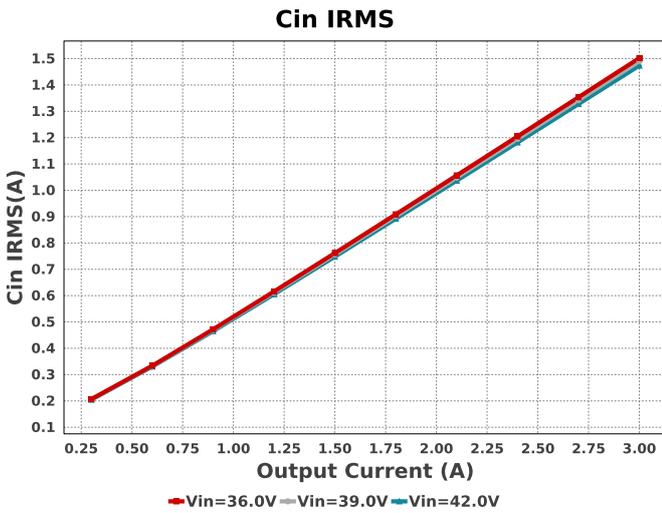
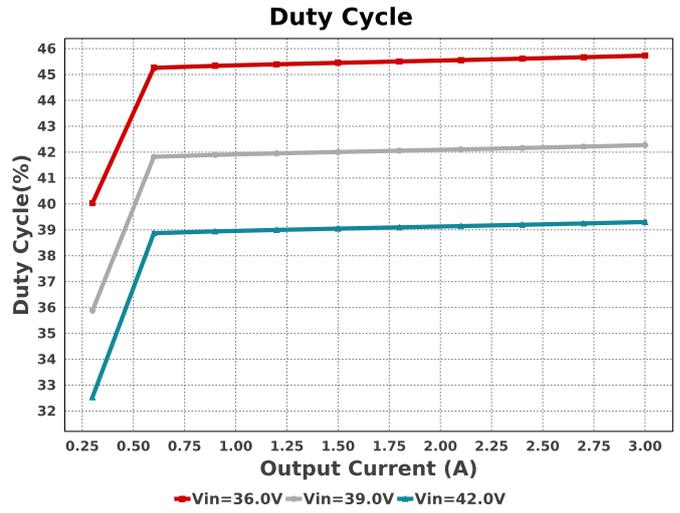
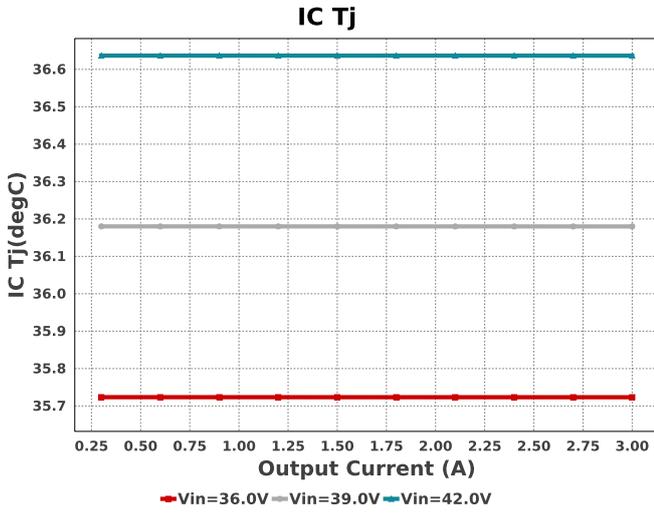


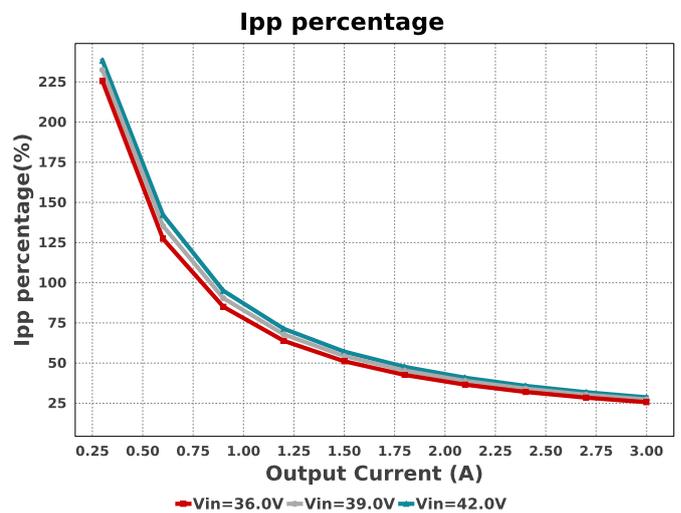
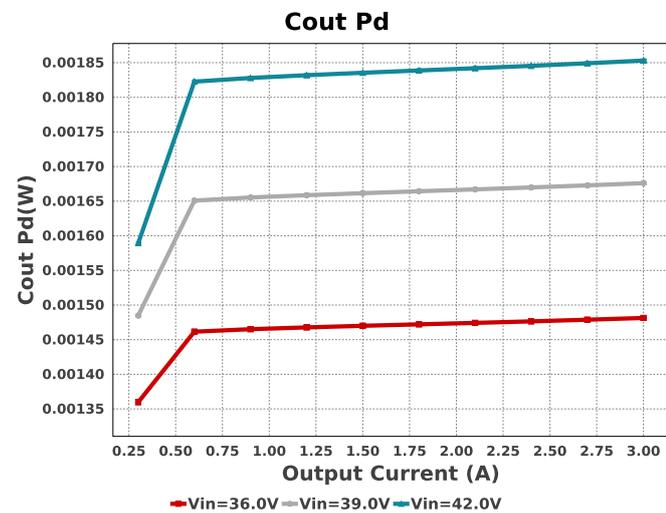
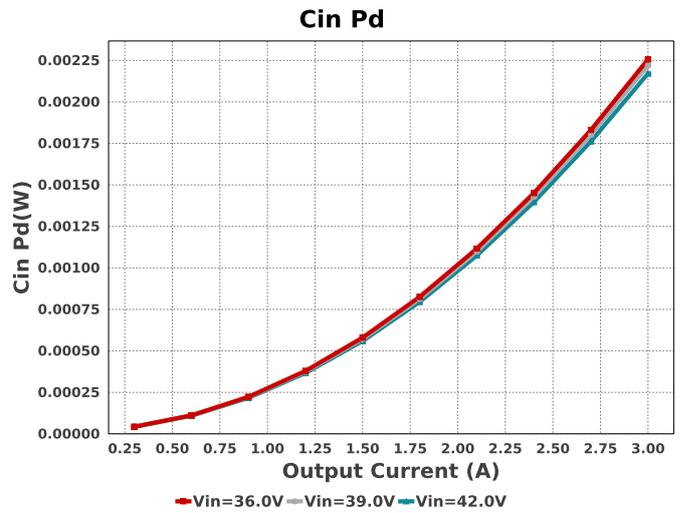
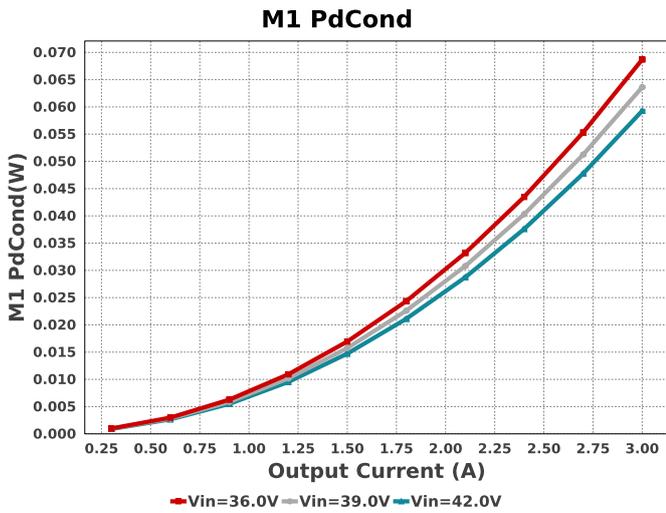
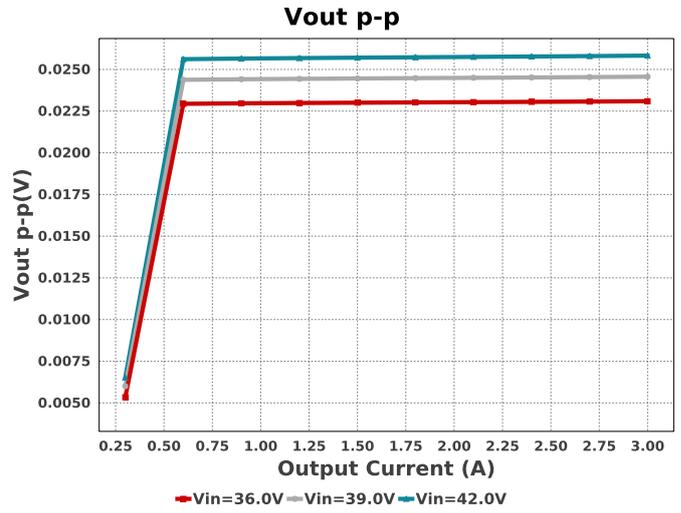
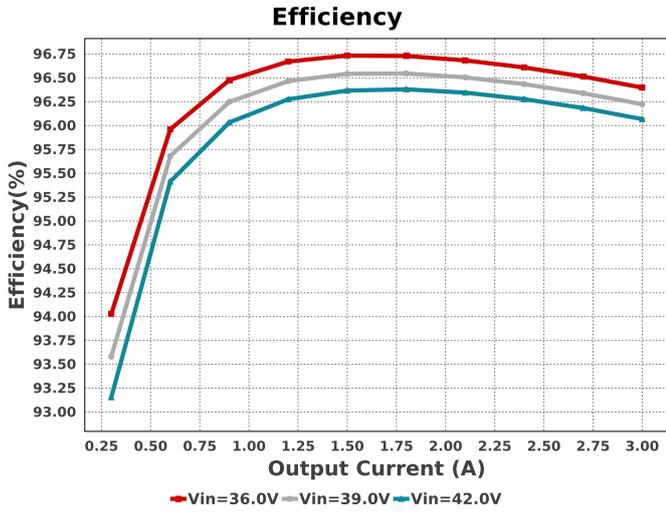
WEBENCH® Design Report

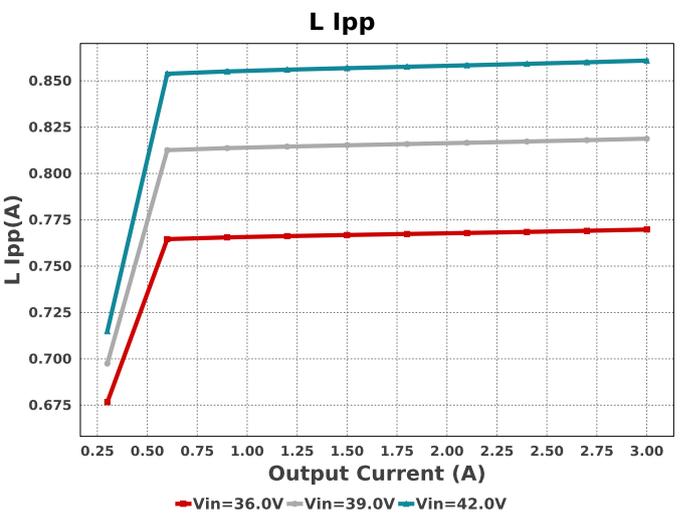
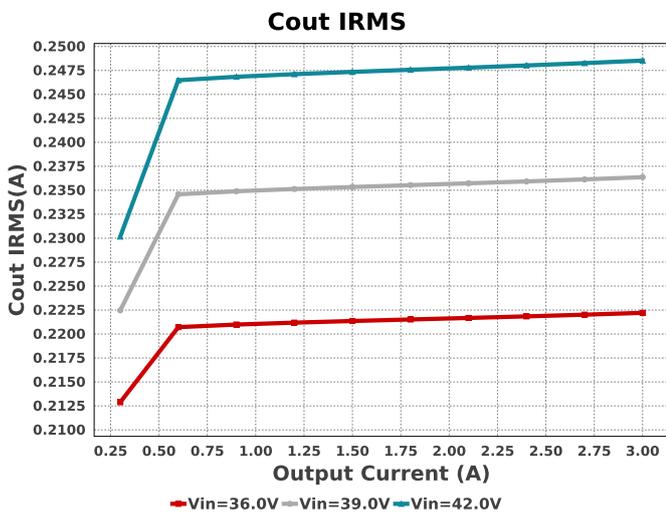
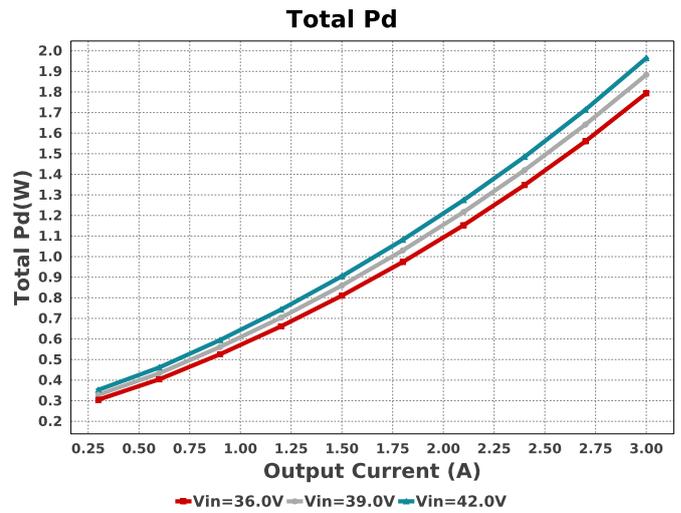
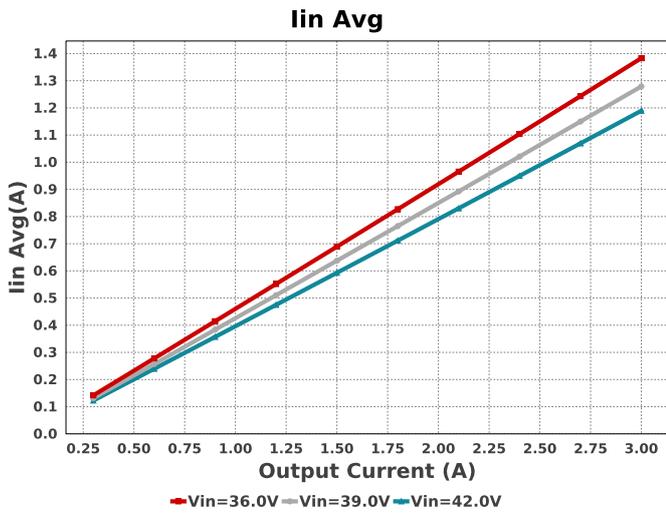
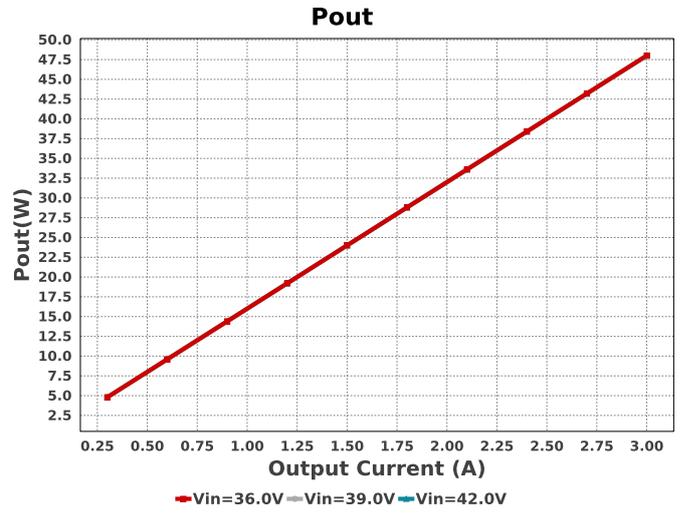
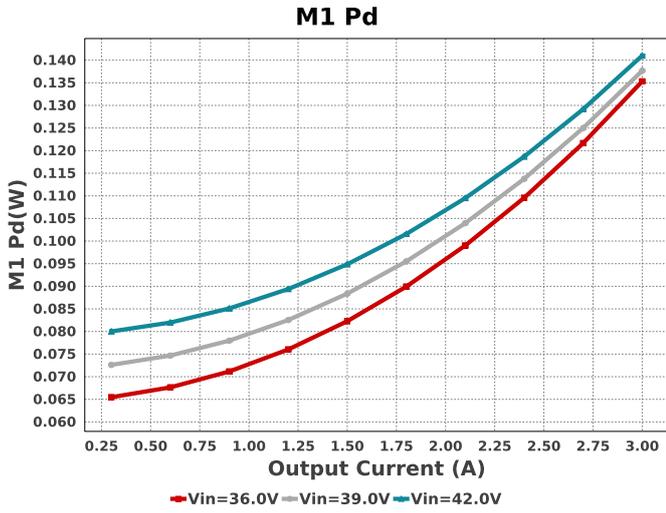
 Design : 211 LM5088MH-2/NOPB
 LM5088MH-2/NOPB 36V-42V to 16.00V @ 3A

Electrical BOM

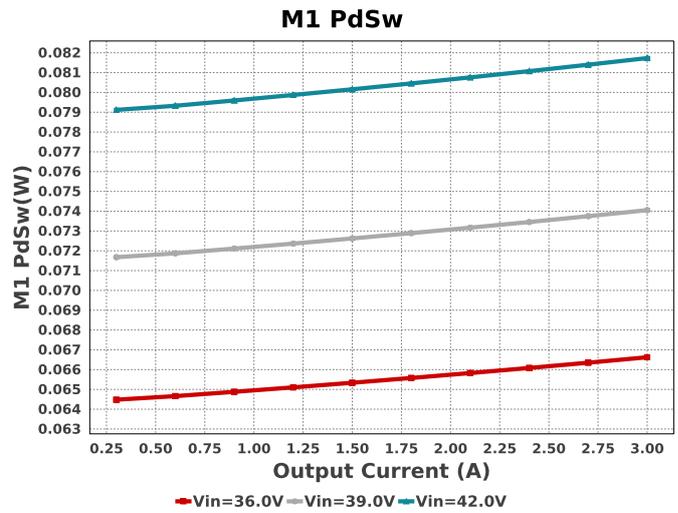
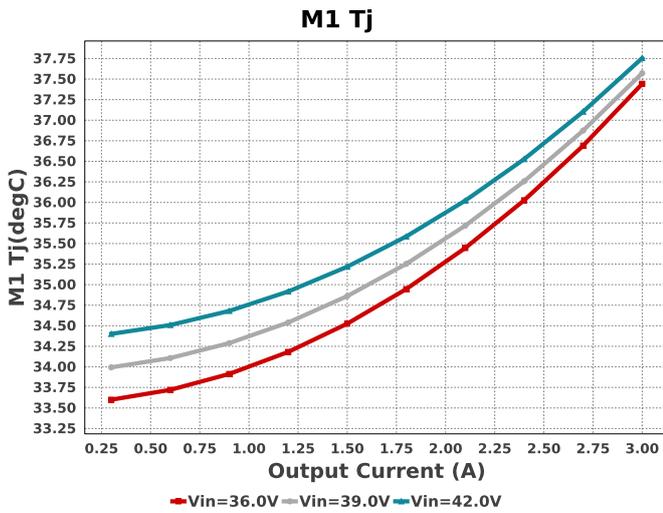
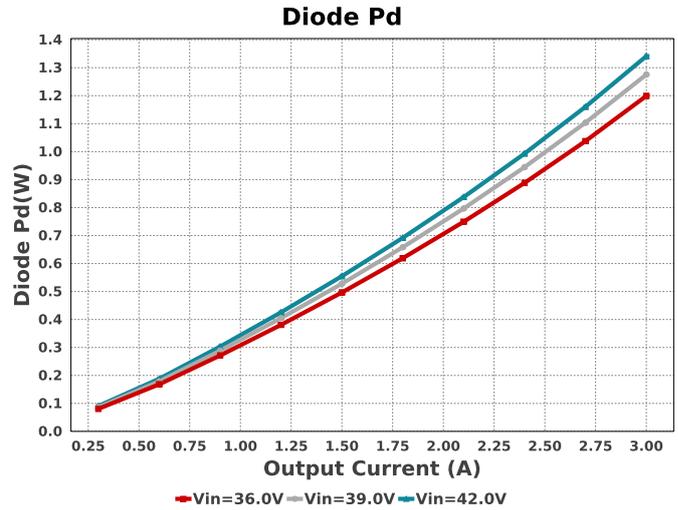
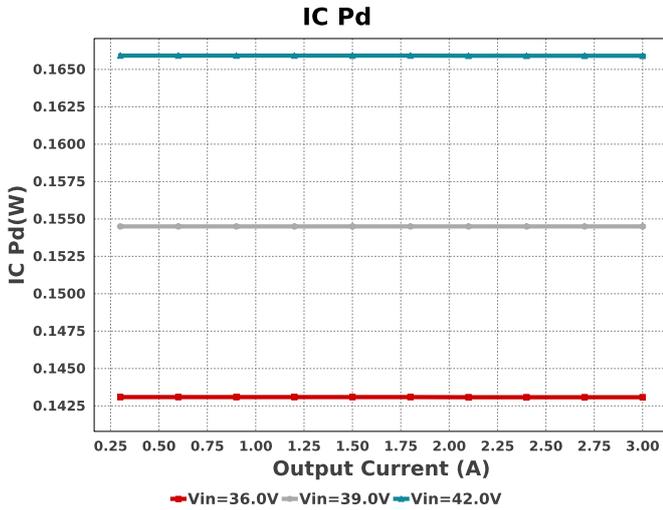
| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|-------|---------------------------|---|--|-----|--------|---|
| Cboot | TDK | CGA3E2C0G1H822J080AA Series= C0G/NP0 | Cap= 8.2 nF VDC= 50.0 V IRMS= 0.0 A | 1 | \$0.05 | 0603 5 mm ² |
| Ccomp | MuRata | GRM188R71E392KA01D Series= X7R | Cap= 3.9 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A | 1 | \$0.01 | 0603 5 mm ² |
| Chf | Samsung Electro-Mechanics | CL10C220JB8NNNC Series= C0G/NP0 | Cap= 22.0 pF VDC= 50.0 V IRMS= 0.0 A | 1 | \$0.01 | 0603 5 mm ² |
| Cin | MuRata | GRM32ER71J106KA12L Series= X7R | Cap= 10.0 uF ESR= 1.0 mOhm VDC= 63.0 V IRMS= 6.0 A | 1 | \$0.30 | 1210_280 15 mm ² |
| Cout | Panasonic | 25SVPF47M Series= SVPF | Cap= 47.0 uF ESR= 30.0 mOhm VDC= 25.0 V IRMS= 2.8 A | 1 | \$0.57 |  CAPSMT_62_F61 74 mm ² |
| Cout1 | Taiyo Yuden | TMK212BJ225KG-T Series= X5R | Cap= 2.2 uF ESR= 1.0 mOhm VDC= 20.0 V IRMS= 0.0 A | 1 | \$0.04 | 0805 7 mm ² |
| Cramp | TDK | CGA3E2C0G1H122J080AA Series= C0G/NP0 | Cap= 1.2 nF VDC= 50.0 V IRMS= 0.0 A | 1 | \$0.03 | 0603 5 mm ² |
| Crst | TDK | C1608X5R1V225K080AC Series= X5R | Cap= 2.2 uF ESR= 7.674 mOhm VDC= 35.0 V IRMS= 1.87823 A | 1 | \$0.04 | 0603 5 mm ² |

| Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|-------|---------------------------|--------------------------------------|--|-----|--------|---|
| Css | Samsung Electro-Mechanics | CL10C103JA8NNNC Series= C0G/NP0 | Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A | 1 | \$0.04 |  0603 5 mm ² |
| Cvcc | Kemet | C0603C224Z4VACTU Series= Y5V | Cap= 220.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A | 1 | \$0.01 |  0603 5 mm ² |
| D1 | Diodes Inc. | B370-13-F | VF@Io= 790.0 mV VRRM= 70.0 V | 1 | \$0.24 |  SMC 83 mm ² |
| L1 | Würth Elektronik | 7443634700 | L= 47.0 µH 13.42 mOhm | 1 | \$4.84 |  WE-HCF_2013 559 mm ² |
| M1 | Texas Instruments | CSD18543Q3A | VdsMax= 60.0 V IdsMax= 35.0 Amps | 1 | \$0.21 |  DNH0008A 18 mm ² |
| Rcomp | Yageo | RC0603FR-0733KL Series= ? | Res= 33.0 kOhm Power= 100.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0603 5 mm ² |
| Rfbb | Yageo | RC0603FR-071K8L Series= ? | Res= 1.8 kOhm Power= 100.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0603 5 mm ² |
| Rfbt | Vishay-Dale | CRCW040222K1FKED Series= CRCW..e3 | Res= 22.1 kOhm Power= 63.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0402 3 mm ² |
| Rramp | Vishay-Dale | CRCW0603127KFKEA Series= CRCW..e3 | Res= 127.0 kOhm Power= 100.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0603 5 mm ² |
| Rsns | Stackpole Electronics Inc | CSR1206FK20L0 Series= ? | Res= 20.0 mOhm Power= 500.0 mW Tolerance= 1.0% | 1 | \$0.10 |  1206 11 mm ² |
| Rt | Vishay-Dale | CRCW060324K3FKEA Series= CRCW..e3 | Res= 24.3 kOhm Power= 100.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0603 5 mm ² |
| Rt | Vishay-Dale | CRCW060324K3FKEA Series= CRCW..e3 | Res= 24.3 kOhm Power= 100.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0603 5 mm ² |
| Ruv1 | Vishay-Dale | CRCW08052K15FKEA Series= CRCW..e3 | Res= 2.15 kOhm Power= 125.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0805 7 mm ² |
| Ruv2 | Vishay-Dale | CRCW080549K9FKEA Series= CRCW..e3 | Res= 49.9 kOhm Power= 125.0 mW Tolerance= 1.0% | 1 | \$0.01 |  0805 7 mm ² |
| U1 | Texas Instruments | LM5088MH-2/NOPB | Switcher | 1 | \$1.71 |  MXA16A 59 mm ² |









Operating Values

| # | Name | Value | Category | Description |
|-----|----------------|-------------|-----------|---|
| 1. | BOM Count | 22 | | Total Design BOM count |
| 2. | Total BOM | \$8.268 | | Total BOM Cost |
| 3. | Cin IRMS | 1.474 A | Capacitor | Input capacitor RMS ripple current |
| 4. | Cin Pd | 2.171 mW | Capacitor | Input capacitor power dissipation |
| 5. | Cout IRMS | 248.529 mA | Capacitor | Output capacitor RMS ripple current |
| 6. | Cout Pd | 1.853 mW | Capacitor | Output capacitor power dissipation |
| 7. | D1 Tj | 86.329 deg | Diode | D1 junction temperature |
| 8. | Diode Pd | 1.341 W | Diode | Diode power dissipation |
| 9. | IC Ipk | 3.43 A | IC | Peak switch current in IC |
| 10. | IC Pd | 165.91 mW | IC | IC power dissipation |
| 11. | IC Tj | 36.637 degC | IC | IC junction temperature |
| 12. | IC Tolerance | 18.0 mV | IC | IC Feedback Tolerance |
| 13. | ICThetaJA | 40.0 degC/W | IC | IC junction-to-ambient thermal resistance |
| 14. | Iin Avg | 1.19 A | IC | Average input current |
| 15. | Ipp percentage | 28.698 % | Inductor | Inductor ripple current percentage (with respect to average inductor current) |
| 16. | L Ipp | 860.93 mA | Inductor | Peak-to-peak inductor ripple current |
| 17. | L Pd | 121.61 mW | Inductor | Inductor power dissipation |
| 18. | M1 Pd | 141.01 mW | Mosfet | M1 MOSFET total power dissipation |
| 19. | M1 PdCond | 59.273 mW | Mosfet | M1 MOSFET conduction losses |
| 20. | M1 PdSw | 81.733 mW | Mosfet | M1 MOSFET switching losses |
| 21. | M1 Tj | 37.755 degC | Mosfet | M1 MOSFET junction temperature |
| 22. | Cin Pd | 2.171 mW | Power | Input capacitor power dissipation |
| 23. | Cout Pd | 1.853 mW | Power | Output capacitor power dissipation |
| 24. | Diode Pd | 1.341 W | Power | Diode power dissipation |
| 25. | IC Pd | 165.91 mW | Power | IC power dissipation |
| 26. | L Pd | 121.61 mW | Power | Inductor power dissipation |
| 27. | M1 Pd | 141.01 mW | Power | M1 MOSFET total power dissipation |
| 28. | M1 PdCond | 59.273 mW | Power | M1 MOSFET conduction losses |
| 29. | M1 PdSw | 81.733 mW | Power | M1 MOSFET switching losses |
| 30. | Total Pd | 1.965 W | Power | Total Power Dissipation |

| # | Name | Value | Category | Description |
|-----|----------------|-----------------------|--------------------|--|
| 31. | Duty Cycle | 39.302 % | System Information | Duty cycle |
| 32. | Efficiency | 96.068 % | System Information | Steady state efficiency |
| 33. | FootPrint | 894.0 mm ² | System Information | Total Foot Print Area of BOM components |
| 34. | Frequency | 251.661 kHz | System Information | Switching frequency |
| 35. | Iout | 3.0 A | System Information | Iout operating point |
| 36. | Mode | CCM | System Information | Conduction Mode |
| 37. | Pout | 48.0 W | System Information | Total output power |
| 38. | Vin | 42.0 V | System Information | Vin operating point |
| 39. | Vout | 16.0 V | System Information | Operational Output Voltage |
| 40. | Vout Actual | 16.265 V | System Information | Vout Actual calculated based on selected voltage divider resistors |
| 41. | Vout Tolerance | 3.365 % | System Information | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |
| 42. | Vout p-p | 25.828 mV | System Information | Peak-to-peak output ripple voltage |

Design Inputs

| Name | Value | Description |
|-----------|---------|-----------------------------|
| Iout | 3.0 | Maximum Output Current |
| SoftStart | 1.0 ms | Soft Start Time (ms) |
| VinMax | 42.0 | Maximum input voltage |
| VinMin | 36.0 | Minimum input voltage |
| Vout | 16.0 | Output Voltage |
| base_pn | LM5088 | Base Product Number |
| source | DC | Input Source Type |
| Ta | 30.0 | Ambient temperature |
| UserFsw | 250.0 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 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

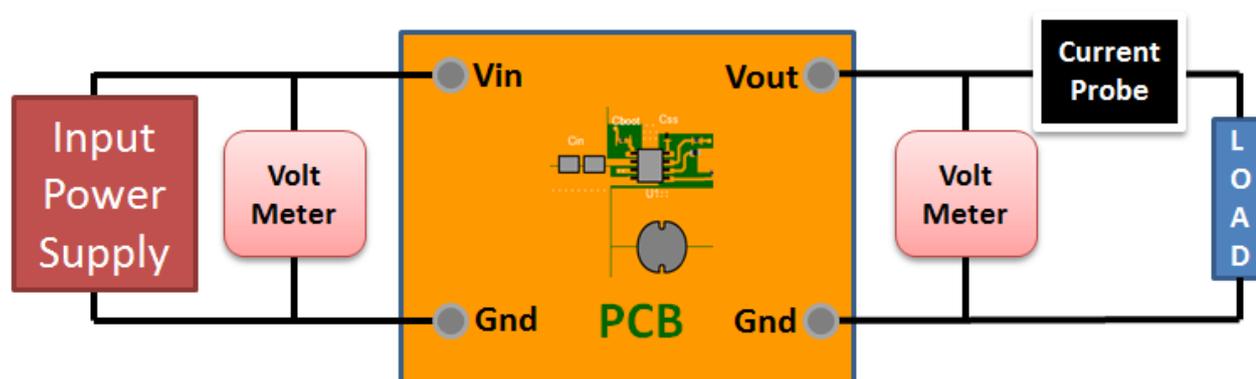
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 36.0V 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 : 9DDFEA0050C8FDF9[v1]
2. **LM5088** Product Folder : <http://www.ti.com/product/LM5088> : contains the data sheet and other resources.

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