

# WEBENCH® Power Architect

## Project Report

Project : 345212/24 : PA\_Project\_402 (modified from 401)  
 Created : 2017-06-09 14:48:35.766  
 Optimize project optFactor=4

### Project Summary

- |                                   |                        |
|-----------------------------------|------------------------|
| 1. Total System Efficiency        | 86.288 %               |
| 2. Total System BOM Count         | 55.0                   |
| 3. Total System Footprint         | 2.459 kmm <sup>2</sup> |
| 4. Total System BOM Cost          | \$0.00                 |
| 5. Total System Power Dissipation | 2.701 W                |

--> Launch WEBENCH Power Architect.

### My Comments

No comments

### Sequencer Flag Table

| Supply   | Sequencer Flag | Load   | Load Name |
|----------|----------------|--------|-----------|
| SUPPLY_2 | 0              | LOAD_1 | LOAD #1   |
| SUPPLY_3 | 0              | LOAD_2 | LOAD #2   |
| SUPPLY_1 | NA             |        |           |

### Power Supplies

| #  | Name     | NSID      | Description  | Vout   | Iout    | Efficiency | Foot-print | Cost   | Design | Page |
|----|----------|-----------|--|--------|---------|------------|------------|--------|--------|------|
| 1. | SUPPLY_1 | UCC28740  | Switcher : Flyback Controller with Opto-coupler Feedback                         | 24.0 V | 0.663 A | 89.9%      | 1696       | \$9.77 | 246    | 14   |
| 2. | SUPPLY_2 | TPS54335A | Switcher : 28V, 3A, Low Iq, Synchronous, monolithic buck converter with Eco-mode | 12 V   | 1.0 A   | 98.2%      | 747        | \$6.85 | 244    | 4    |
| 3. | SUPPLY_3 | LM43603   | Switcher : SIMPLE SWITCHER Buck Regulator  | 5 V    | 1.0 A   | 94.7%      | 349        | \$3.56 | 245    | 9    |

### Power Loads

| #  | Name    | VLoad | Iload | Description   |
|----|---------|-------|-------|---------------|
| 1. | LOAD #1 | 12 V  | 1 A   | VoutRipple=5% |
| 2. | LOAD #2 | 5 V   | 1 A   | VoutRipple=5% |

Project Diagram



## Electrical Procurement BOM

| Manufacturer                    | Part Number          | Description    | Quantity  | Budgetary Price | Footprint (mm <sup>2</sup> ) |
|---------------------------------|----------------------|----------------|-----------|-----------------|------------------------------|
| Panasonic                       | 35SVPF22M            | CAPSMT_62_F61  | 1         | \$0.45          | 74                           |
| Panasonic                       | 35SVPF82M            | CAPSMT_62_E12  | 1         | \$0.64          | 106                          |
| Kemet                           | C0805C104K5RACTU     | 0805           | 2         | \$0.01          | 14                           |
| Yageo America                   | CC0805KRX7R8BB104    | 0805           | 2         | \$0.01          | 14                           |
| Yageo America                   | CC0805KRX7R9BB561    | 0805           | 1         | \$0.01          | 7                            |
| Bourns                          | CD214B-F3600         | SMB            | 1         | \$0.14          | 44                           |
| Samsung Electro-Mechanics       | CL21C200JBANNNC      | 0805           | 1         | \$0.01          | 7                            |
| Vishay-Dale                     | CRCW0402115KFKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW040212K7FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW0402178KFKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW040219K6FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW04021K02FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW04021K30FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW04021K43FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW04021M00FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW0402205KFKED     | 0402           | 2         | \$0.01          | 6                            |
| Vishay-Dale                     | CRCW040224K3FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW0402255KFKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW040238K3FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW04027K15FKED     | 0402           | 1         | \$0.01          | 3                            |
| Vishay-Dale                     | CRCW121810R0FKEK     | 1218           | 1         | \$0.13          | 24                           |
| CUSTOM                          | CUSTOM               | CUSTOM         | 2         | \$0.00          | 0                            |
| Vishay-Semiconductor            | DF10SA               | DF-S           | 1         | \$0.24          | 99                           |
| Panasonic                       | EEUED2G470S          | CAPPR7.5-18X20 | 2         | \$0.71          | 800                          |
| Panasonic                       | ELL-6UH471M          | ELL6UH         | 1         | \$0.30          | 67                           |
| Panasonic                       | ERJ-6ENF1003V        | 0805           | 1         | \$0.01          | 7                            |
| Panasonic                       | ERJ-8RQFR82V         | 1206           | 1         | \$0.03          | 11                           |
| MuRata                          | GRM155R60J225ME15D   | 0402           | 1         | \$0.02          | 3                            |
| MuRata                          | GRM155R60J474KE19D   | 0402           | 1         | \$0.01          | 3                            |
| MuRata                          | GRM155R71H182KA01D   | 0402           | 1         | \$0.01          | 3                            |
| MuRata                          | GRM219C81A475KE34D   | 0805           | 1         | \$0.03          | 7                            |
| MuRata                          | GRM31CR71H475KA12L   | 1206           | 1         | \$0.07          | 11                           |
| MuRata                          | GRM31MR71H105KA88L   | 1206           | 1         | \$0.03          | 11                           |
| MuRata                          | GRM32ER61A476KE20L   | 1210_280       | 1         | \$0.26          | 15                           |
| MuRata                          | GRM32ER61E226KE15L   | 1210           | 3         | \$0.18          | 15                           |
| MuRata                          | GRM32ER71H475KA88L   | 1210           | 1         | \$0.21          | 15                           |
| Coiltronics                     | HC1-100-R            | HC1            | 1         | \$1.32          | 225                          |
| Texas Instruments               | LM43603PWPR          | PWP0016F       | 1         | \$1.85          | 59                           |
| California Eastern Laboratories | PS2811-1             | SSOP-4         | 1         | \$0.41          | 111                          |
| Yageo America                   | RC0603FR-0722RL      | 0603           | 1         | \$0.01          | 5                            |
| Yageo America                   | RC0603FR-07330KL     | 0603           | 1         | \$0.01          | 5                            |
| TDK                             | SLF12565T-101M1R6-PF | SLF12565       | 1         | \$0.70          | 210                          |
| Diodes Inc.                     | SMBJ120A-13-F        | SMB            | 1         | \$0.10          | 44                           |
| STMicroelectronics              | STD16N65M5           | DPAK           | 1         | \$2.23          | 102                          |
| Texas Instruments               | TL431AIDBZR          | DBZ0003A       | 1         | \$0.08          | 14                           |
| Texas Instruments               | TPS54335ADDAR        | R-PDSO-G8      | 1         | \$0.85          | 55                           |
| Texas Instruments               | UCC28740DR           | R-PDSO-G7      | 1         | \$0.37          | 55                           |
| SMC Diode Solutions             | UF4004TA             | DO-41          | 1         | \$0.04          | 43                           |
| <b>Total</b>                    |                      |                | <b>55</b> | <b>\$12.70</b>  | <b>2323.3814</b>             |

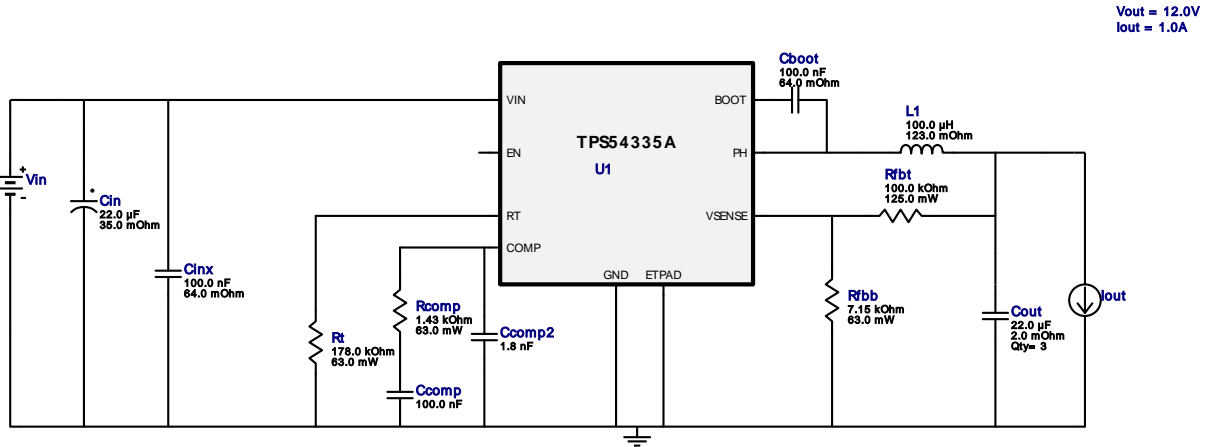


Vout = 12.0V  
Iout = 1.0A

Device = TPS54335ADDAR  
Topology = Buck  
Created = 2017-06-09 14:48:32.960  
BOM Cost = \$2.62  
BOM Count = 14  
Total Pd = 0.49W




## WEBENCH® Design Report

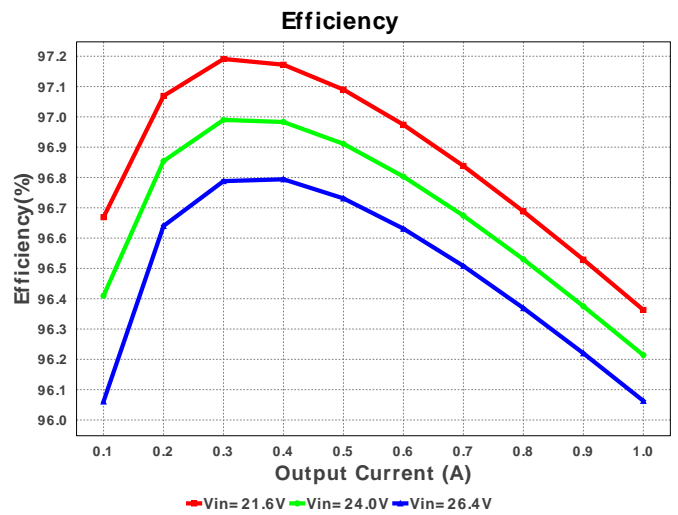
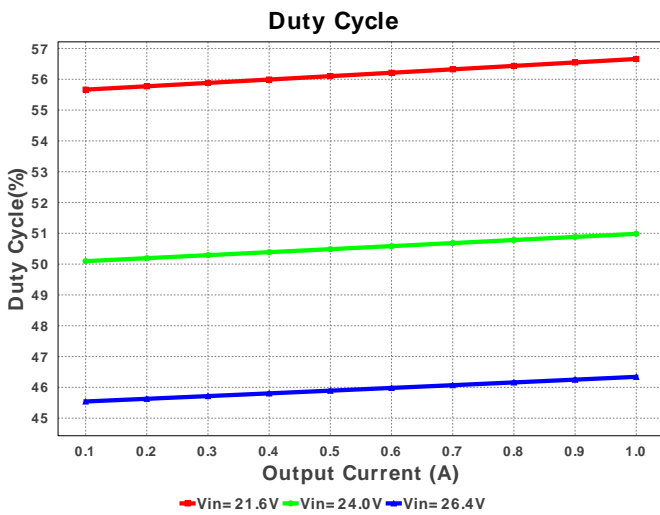
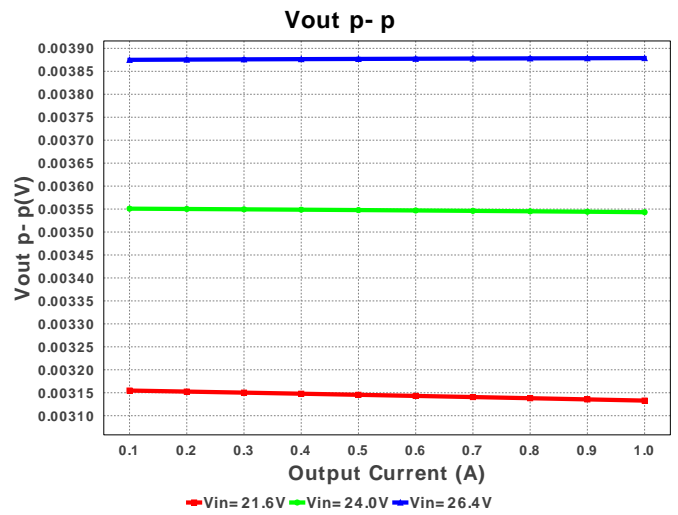
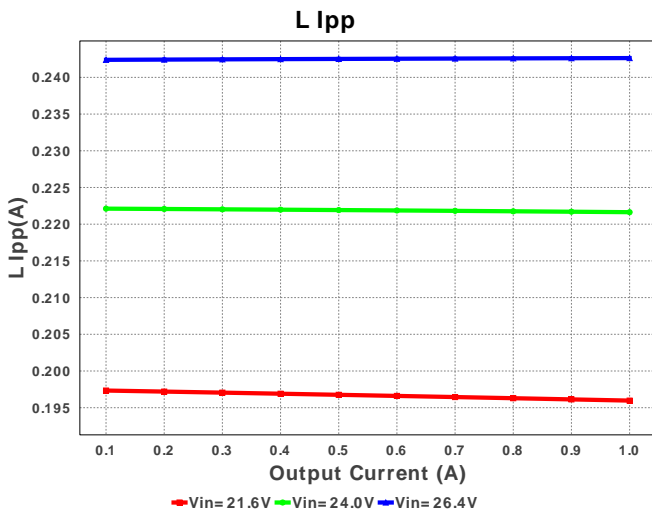
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TPS54335ADDAR 21.6V-26.4V to 12.00V @ 1.0A

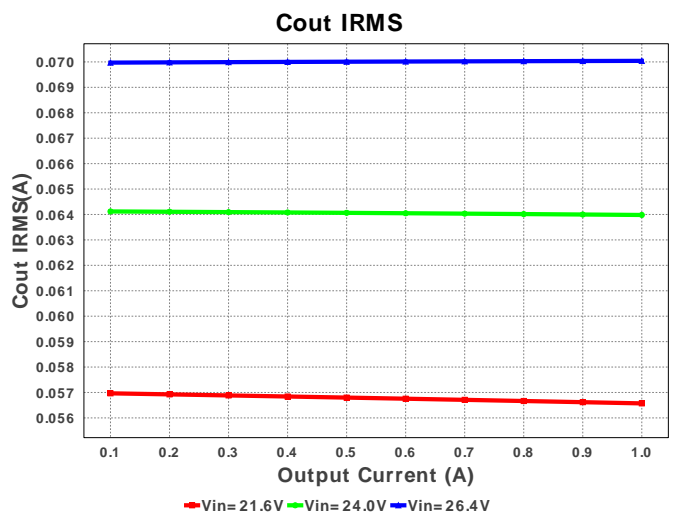
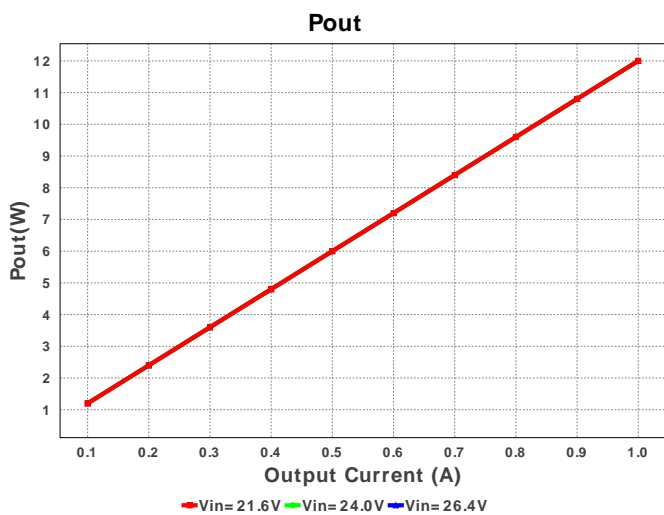
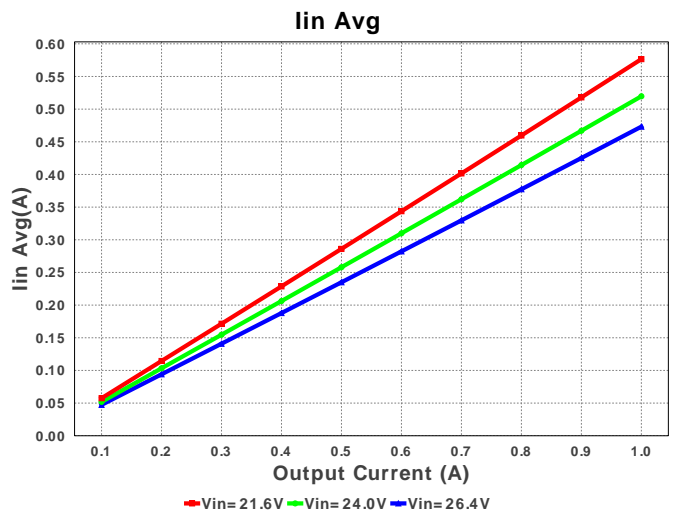
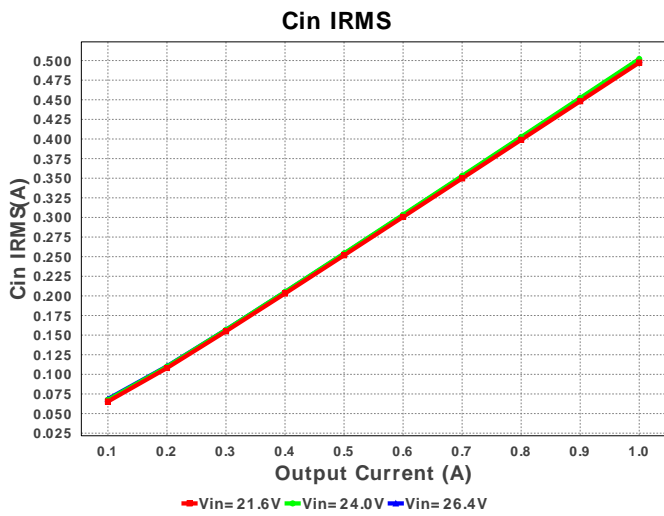
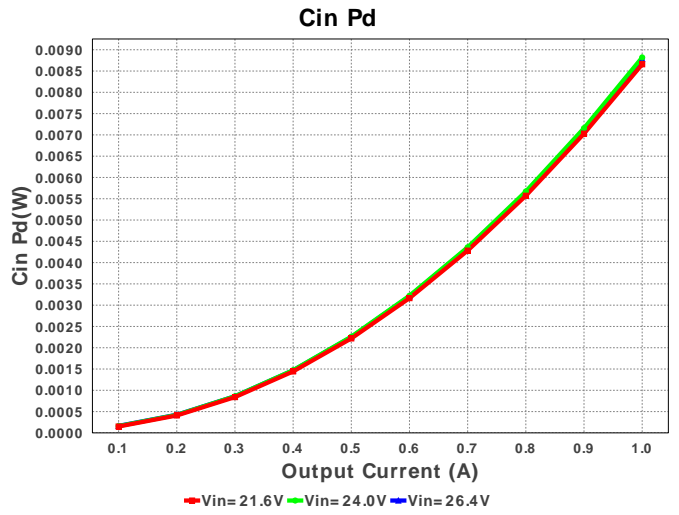
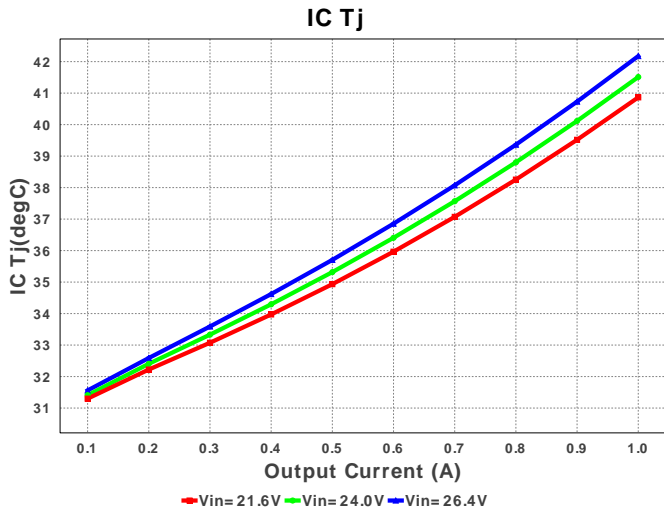


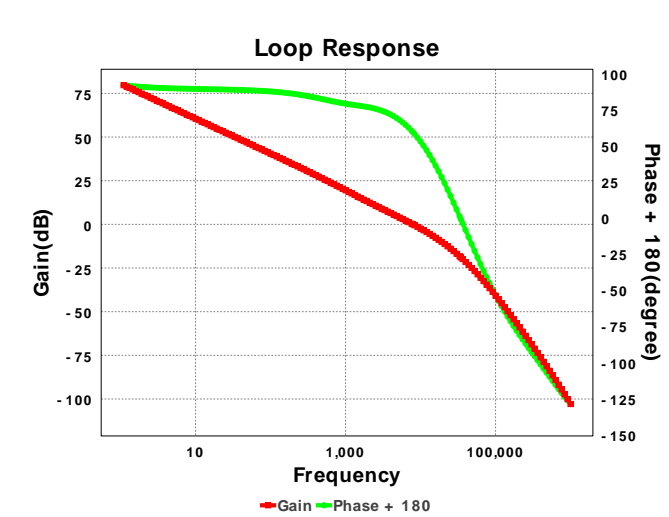
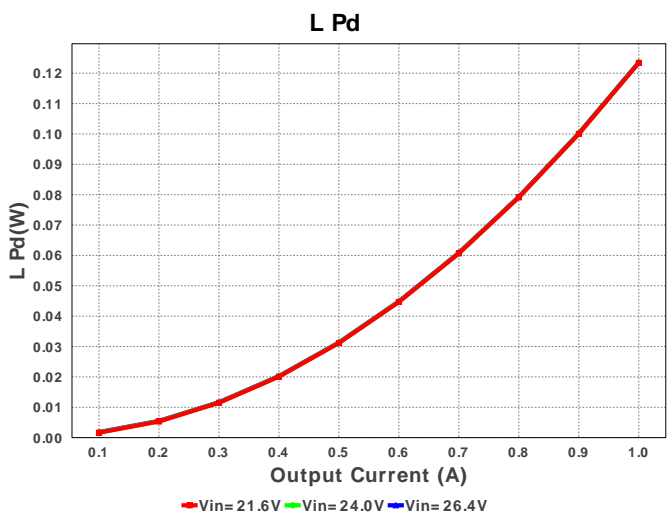
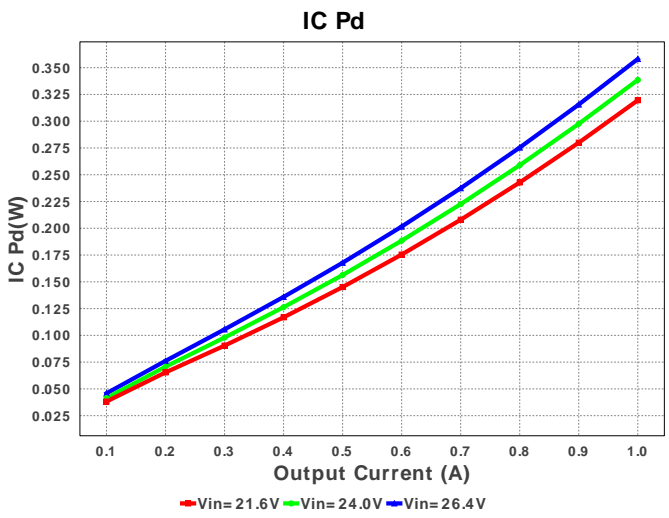
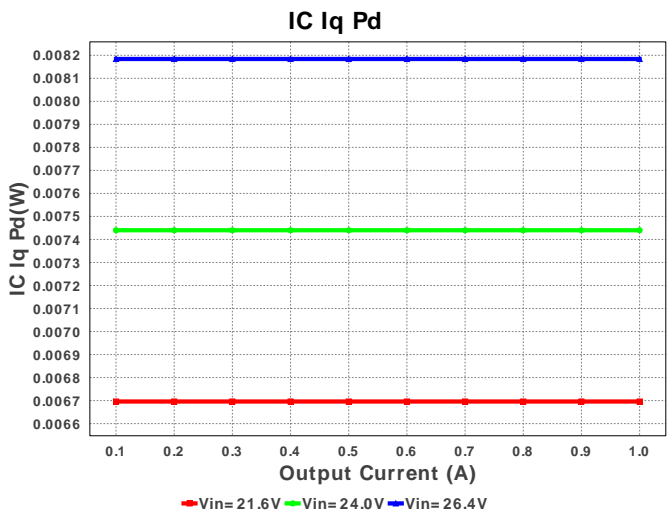
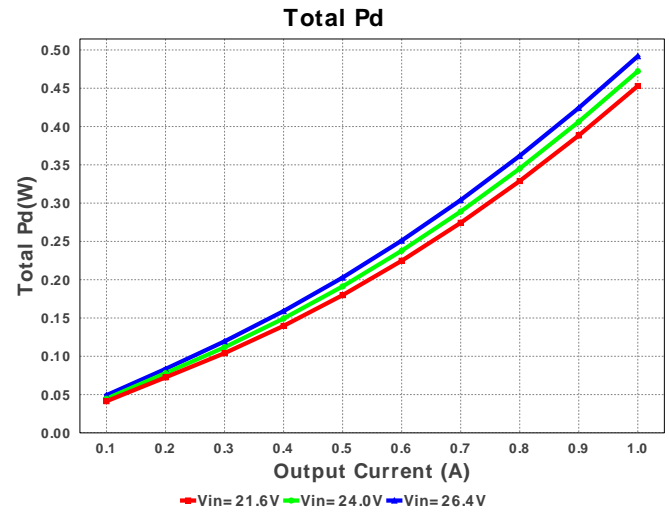
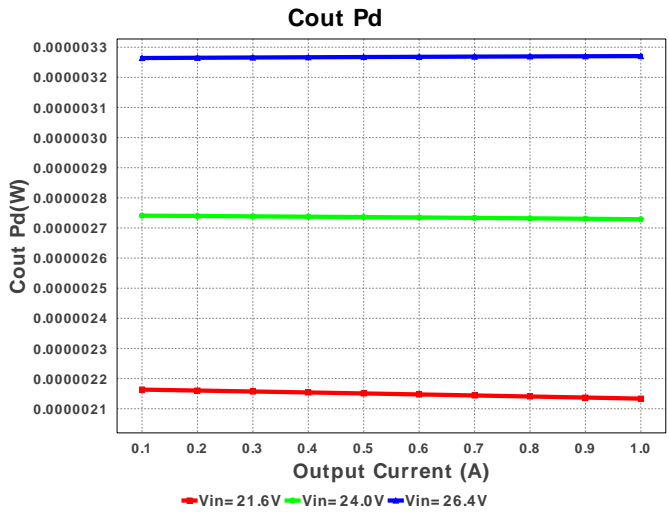
### Electrical BOM

| #  | Name   | Manufacturer  | Part Number                          | Properties   | Qty | Price  | Footprint   |
|----|--------|---------------|--------------------------------------|--|-----|--------|---|
| 1. | Cboot  | Kemet         | C0805C104K5RACTU<br>Series= X7R      | Cap= 100.0 nF<br>ESR= 64.0 mOhm<br>VDC= 50.0 V<br>IRMS= 1.64 A | 1   | \$0.01 | 0805 7 mm <sup>2</sup>  |
| 2. | Ccomp  | Yageo America | CC0805KRX7R8BB104<br>Series= X7R     | Cap= 100.0 nF<br>VDC= 25.0 V<br>IRMS= 0.0 A                    | 1   | \$0.01 | 0805 7 mm <sup>2</sup>  |
| 3. | Ccomp2 | MuRata        | GRM155R71H182KA01D<br>Series= X7R    | Cap= 1.8 nF<br>VDC= 50.0 V<br>IRMS= 0.0 A                      | 1   | \$0.01 | 0402 3 mm <sup>2</sup>  |
| 4. | Cin    | Panasonic     | 35SVPF22M<br>Series= ?               | Cap= 22.0 uF<br>ESR= 35.0 mOhm<br>VDC= 35.0 V<br>IRMS= 2.6 A   | 1   | \$0.45 | <br>CAPSMT_62_F61 74 mm <sup>2</sup> |
| 5. | Cinx   | Kemet         | C0805C104K5RACTU<br>Series= X7R      | Cap= 100.0 nF<br>ESR= 64.0 mOhm<br>VDC= 50.0 V<br>IRMS= 1.64 A | 1   | \$0.01 | 0805 7 mm <sup>2</sup>  |
| 6. | Cout   | MuRata        | GRM32ER61E226KE15L<br>Series= X5R    | Cap= 22.0 uF<br>ESR= 2.0 mOhm<br>VDC= 25.0 V<br>IRMS= 3.67 A   | 3   | \$0.18 | 1210 15 mm <sup>2</sup>   |
| 7. | L1     | TDK           | SLF12565T-101M1R6-PF                 | L= 100.0 uH<br>DCR= 123.0 mOhm                                 | 1   | \$0.70 | <br>SLF12565 210 mm <sup>2</sup>     |
| 8. | Rcomp  | Vishay-Dale   | CRCW04021K43FKED<br>Series= CRCW..e3 | Res= 1.43 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%            | 1   | \$0.01 | 0402 3 mm <sup>2</sup>  |
| 9. | Rfbb   | Vishay-Dale   | CRCW04027K15FKED<br>Series= CRCW..e3 | Res= 7.15 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%            | 1   | \$0.01 | 0402 3 mm <sup>2</sup>  |

| #   | Name | Manufacturer      | Part Number                          | Properties  | Qty | Price  | Footprint  |
|-----|------|-------------------|--------------------------------------|---|-----|--------|--|
| 10. | Rfht | Panasonic         | ERJ-6ENF1003V<br>Series= ERJ-6E      | Res= 100.0 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1   | \$0.01 |  0805 7 mm <sup>2</sup>       |
| 11. | Rt   | Vishay-Dale       | CRCW0402178KFKED<br>Series= CRCW..e3 | Res= 178.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%  | 1   | \$0.01 |  0402 3 mm <sup>2</sup>       |
| 12. | U1   | Texas Instruments | TPS54335ADDAR                        | Switcher  | 1   | \$0.85 |  R-PDSO-G8 55 mm <sup>2</sup> |







### Operating Values

| #   | Name         | Value                 | Category | Description                             |
|-----|--------------|-----------------------|----------|---|
| 1.  | Cin IRMS     | 500.934 mA            | Current  | Input capacitor RMS ripple current      |
| 2.  | Cout IRMS    | 70.041 mA             | Current  | Output capacitor RMS ripple current     |
| 3.  | Iin Avg      | 473.18 mA             | Current  | Average input current                   |
| 4.  | L Ipp        | 242.63 mA             | Current  | Peak-to-peak inductor ripple current    |
| 5.  | BOM Count    | 14                    | General  | Total Design BOM count                  |
| 6.  | FootPrint    | 423.0 mm <sup>2</sup> | General  | Total Foot Print Area of BOM components |
| 7.  | Frequency    | 270.08 kHz            | General  | Switching frequency                     |
| 8.  | IC Tolerance | 12.0 mV               | General  | IC Feedback Tolerance                   |
| 9.  | Mode         | CCM                   | General  | Conduction Mode                         |
| 10. | Pout         | 12.0 W                | General  | Total output power                      |
| 11. | Total BOM    | \$2.62                | General  | Total BOM Cost                          |

| #   | Name                | Value        | Category | Description  |
|-----|---------------------|--------------|----------|--|
| 12. | ICThetaJA Effective | 34.0 degC/W  | Op_Point | Effective IC Junction-to-Ambient Thermal Resistance  |
| 13. | Low Freq Gain       | 79.68 dB     | Op_Point | Gain at 10Hz   |
| 14. | Vout Actual         | 11.989 V     | Op_Point | Vout Actual calculated based on selected voltage divider resistors                         |
| 15. | Vout OP             | 12.0 V       | Op_Point | Operational Output Voltage   |
| 16. | Cross Freq          | 7.894 kHz    | Op_point | Bode plot crossover frequency  |
| 17. | Duty Cycle          | 46.341 %     | Op_point | Duty cycle   |
| 18. | Efficiency          | 96.063 %     | Op_point | Steady state efficiency  |
| 19. | Gain Marg           | -18.975 dB   | Op_point | Bode Plot Gain Margin  |
| 20. | IC Tj               | 42.175 degC  | Op_point | IC junction temperature  |
| 21. | IOUT_OP             | 1.0 A        | Op_point | Iout operating point   |
| 22. | Phase Marg          | 60.232 deg   | Op_point | Bode Plot Phase Margin   |
| 23. | VIN_OP              | 26.4 V       | Op_point | Vin operating point  |
| 24. | Vout p-p            | 3.879 mV     | Op_point | Peak-to-peak output ripple voltage   |
| 25. | Cin Pd              | 8.783 mW     | Power    | Input capacitor power dissipation  |
| 26. | Cout Pd             | 3.27 $\mu$ W | Power    | Output capacitor power dissipation   |
| 27. | IC Iq Pd            | 8.184 mW     | Power    | IC Iq Pd   |
| 28. | IC Pd               | 358.101 mW   | Power    | IC power dissipation   |
| 29. | L Pd                | 123.603 mW   | Power    | Inductor power dissipation   |
| 30. | Total Pd            | 491.808 mW   | Power    | Total Power Dissipation  |
| 31. | Vout Tolerance      | 3.414 %      |          | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |

## Design Inputs

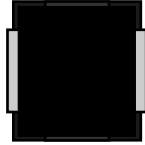




| #  | Name    | Value     | Description            |
|----|---------|-----------|------------------------|
| 1. | Iout    | 1.0       | Maximum Output Current |
| 2. | VinMax  | 26.4      | Maximum input voltage  |
| 3. | VinMin  | 21.6      | Minimum input voltage  |
| 4. | Vout    | 12.0      | Output Voltage         |
| 5. | base_pn | TPS54335A | Base Product Number    |
| 6. | source  | DC        | Input Source Type      |
| 7. | Ta      | 30.0      | Ambient temperature    |

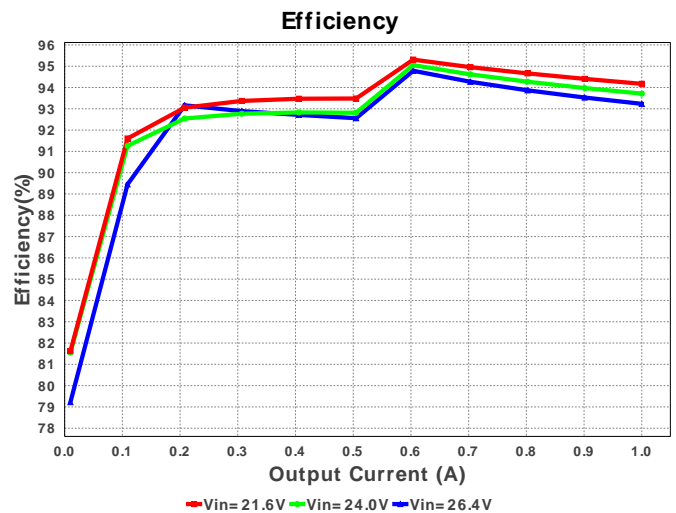
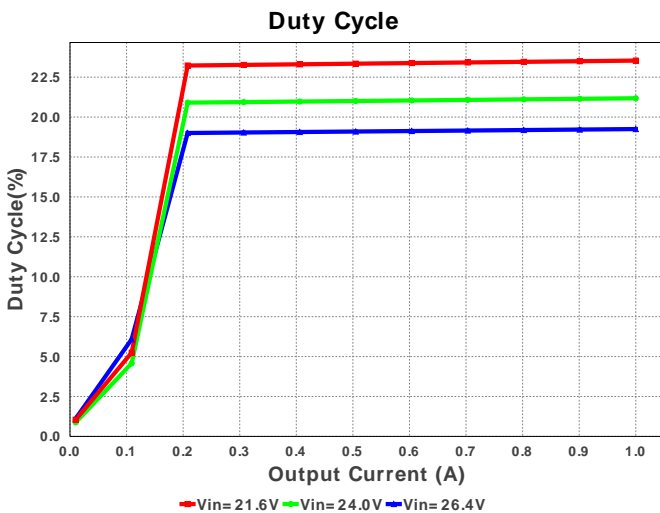
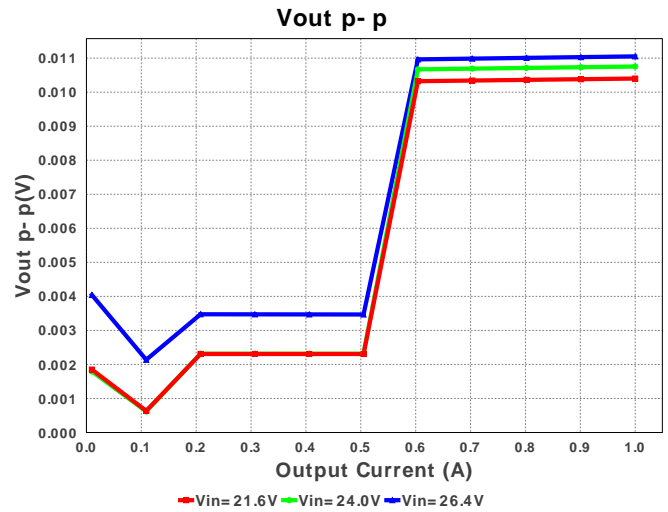
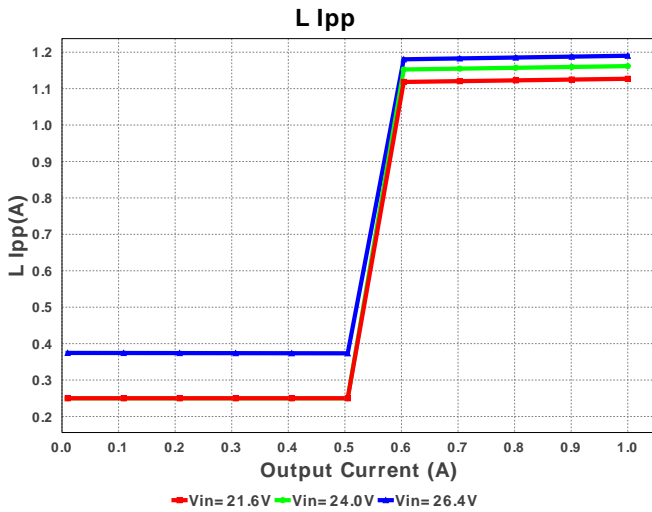
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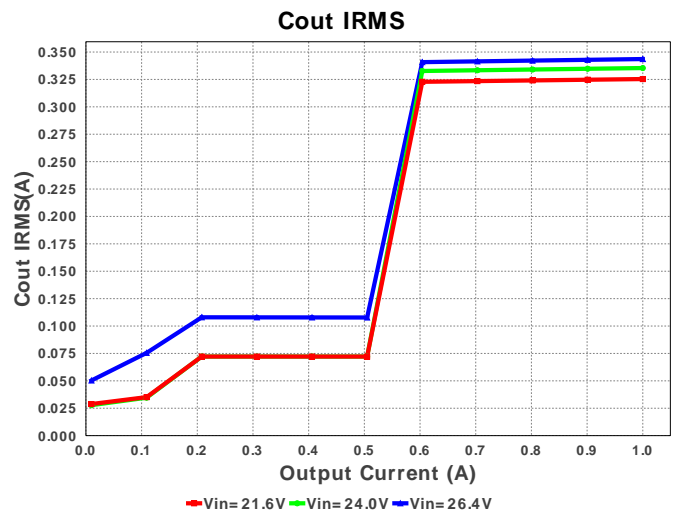
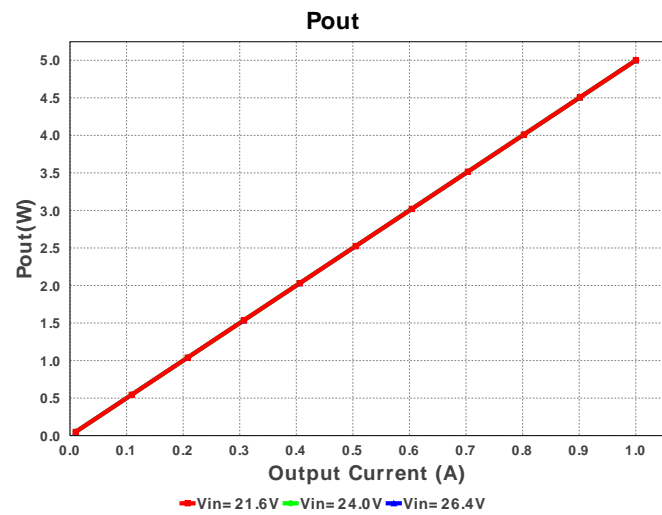
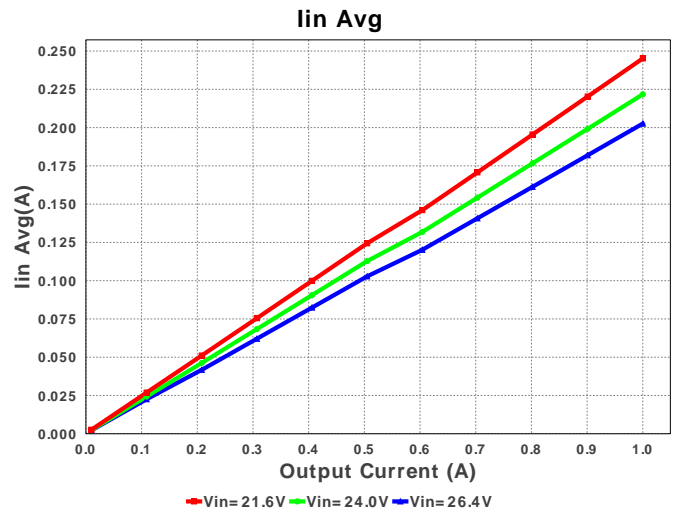
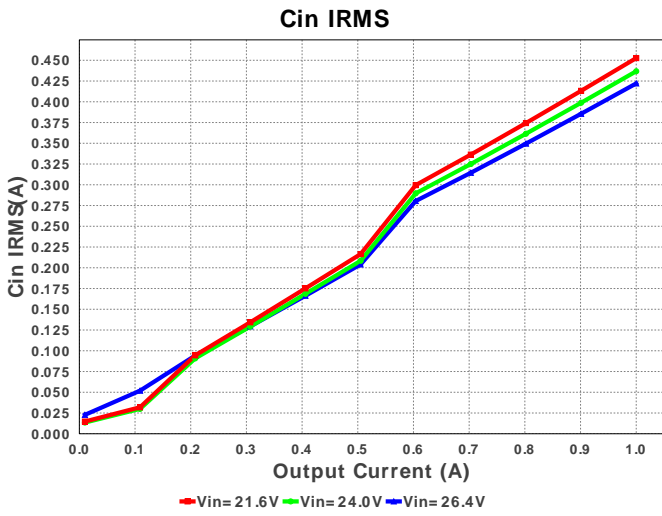
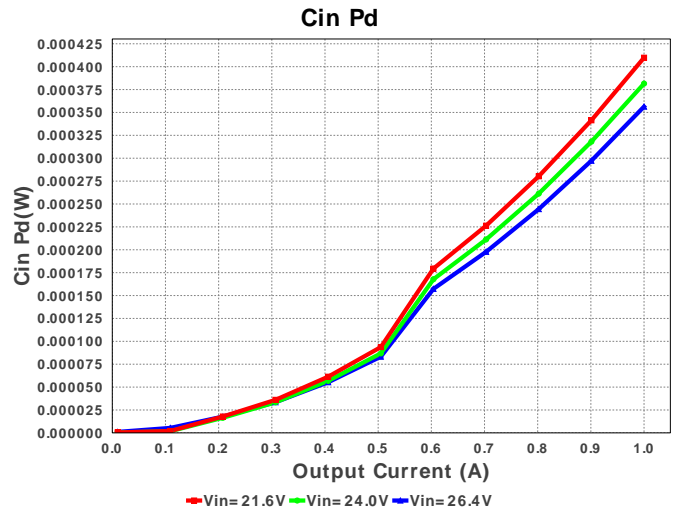
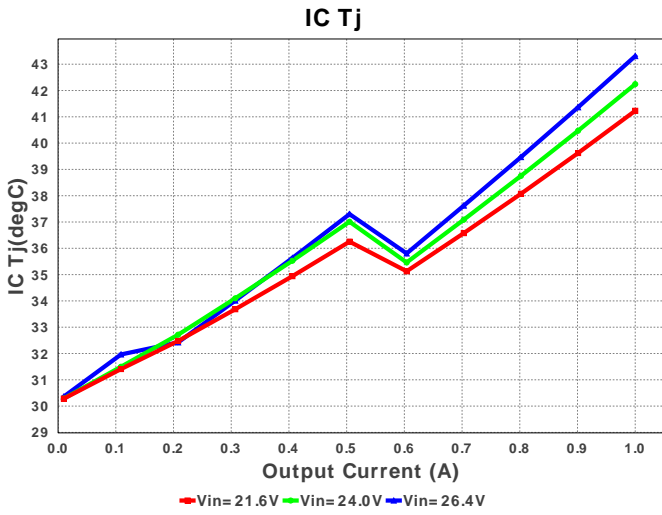
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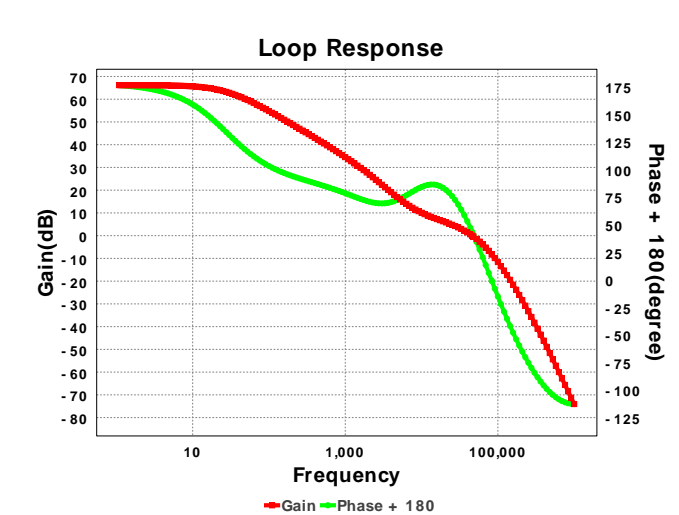
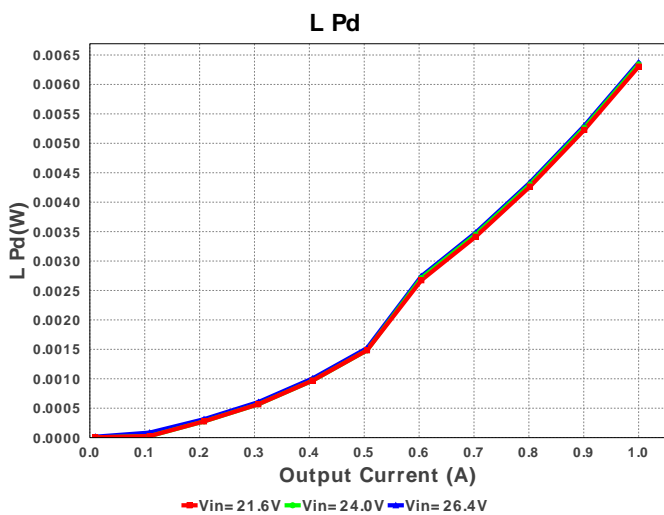
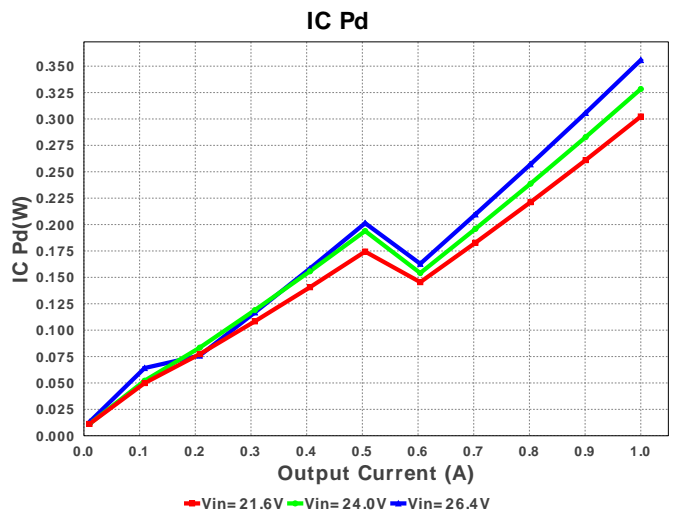
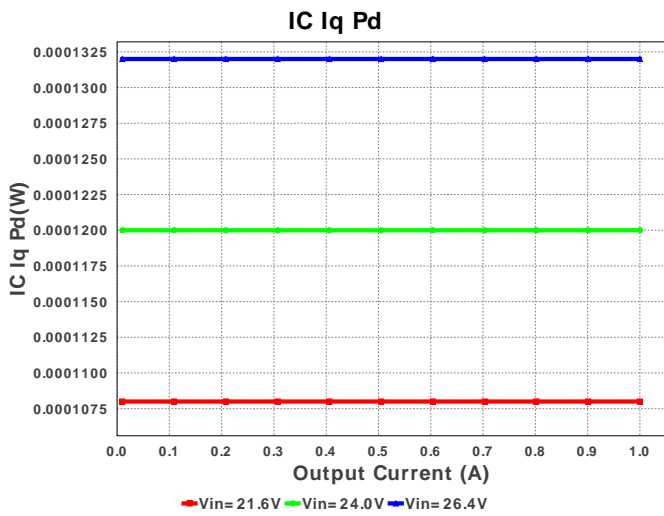
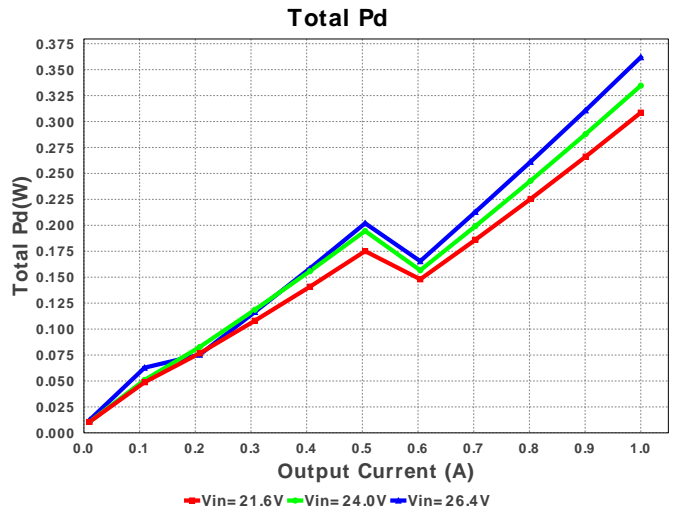
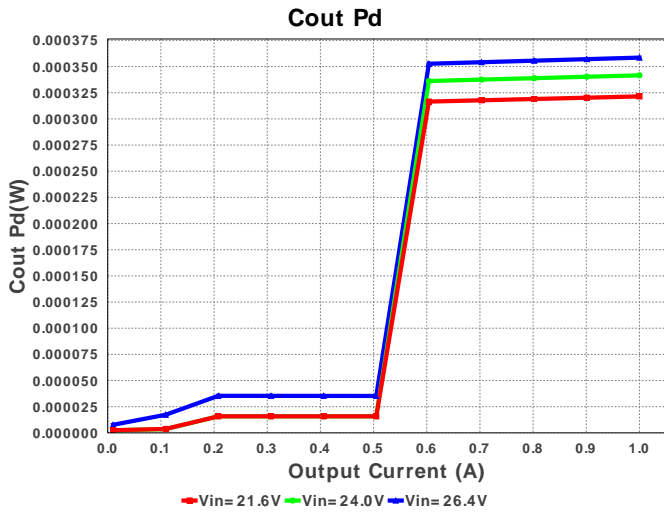


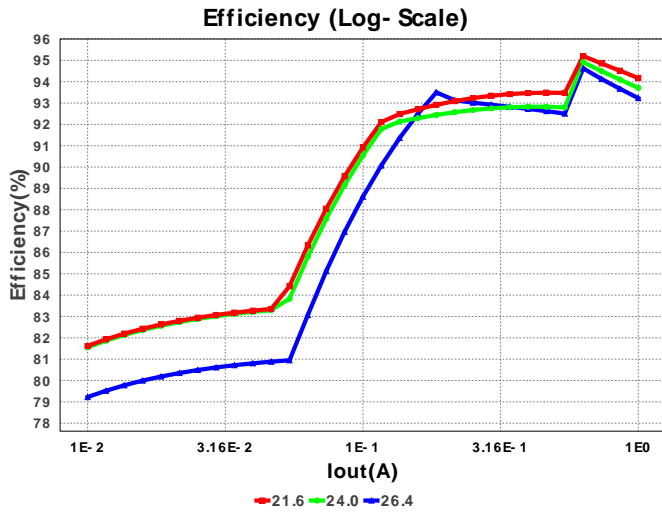


| #   | Name | Manufacturer      | Part Number                          | Properties  | Qty | Price  | Footprint  |
|-----|------|-------------------|--------------------------------------|---|-----|--------|--|
| 8.  | L1   | Coiltronics       | HC1-100-R                            | L= 10.0 $\mu$ H<br>DCR= 5.7 mOhm                      | 1   | \$1.32 | <br>HC1 225 mm <sup>2</sup>     |
| 9.  | Rfbb | Vishay-Dale       | CRCW0402255KFKED<br>Series= CRCW..e3 | Res= 255.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%  | 1   | \$0.01 | <br>0402 3 mm <sup>2</sup>      |
| 10. | Rfbt | Vishay-Dale       | CRCW04021M00FKED<br>Series= CRCW..e3 | Res= 1000.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1   | \$0.01 | <br>0402 3 mm <sup>2</sup>      |
| 11. | Rt   | Vishay-Dale       | CRCW0402115KFKED<br>Series= CRCW..e3 | Res= 115.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%  | 1   | \$0.01 | <br>0402 3 mm <sup>2</sup>      |
| 12. | U1   | Texas Instruments | LM43603PWPR                          | Switcher  | 1   | \$1.85 | <br>PWP0016F 59 mm <sup>2</sup> |









## Operating Values

| #   | Name           | Value                 | Category | Description  |
|-----|----------------|-----------------------|----------|--|
| 1.  | Cin IRMS       | 421.752 mA            | Current  | Input capacitor RMS ripple current   |
| 2.  | Cout IRMS      | 341.392 mA            | Current  | Output capacitor RMS ripple current  |
| 3.  | Iin Avg        | 202.71 mA             | Current  | Average input current  |
| 4.  | L Ipp          | 1.183 A               | Current  | Peak-to-peak inductor ripple current   |
| 5.  | BOM Count      | 12                    | General  | Total Design BOM count   |
| 6.  | FootPrint      | 353.0 mm <sup>2</sup> | General  | Total Foot Print Area of BOM components  |
| 7.  | Frequency      | 350.0 kHz             | General  | Switching frequency  |
| 8.  | Mode           | CCM                   | General  | Conduction Mode  |
| 9.  | Pout           | 5.0 W                 | General  | Total output power   |
| 10. | Total BOM      | \$3.77                | General  | Total BOM Cost   |
| 11. | Low Freq Gain  | 66.178 dB             | Op_Point | Gain at 10Hz   |
| 12. | Vout Actual    | 4.976 V               | Op_Point | Vout Actual calculated based on selected voltage divider resistors                         |
| 13. | Vout OP        | 5.0 V                 | Op_Point | Operational Output Voltage   |
| 14. | Cross Freq     | 46.12 kHz             | Op_point | Bode plot crossover frequency  |
| 15. | Duty Cycle     | 19.249 %              | Op_point | Duty cycle   |
| 16. | Efficiency     | 93.19 %               | Op_point | Steady state efficiency  |
| 17. | Gain Marg      | -8.279 dB             | Op_point | Bode Plot Gain Margin  |
| 18. | IC Tj          | 43.402 degC           | Op_point | IC junction temperature  |
| 19. | ICThetaJA      | 38.9 degC/W           | Op_point | IC junction-to-ambient thermal resistance  |
| 20. | IOUT_OP        | 1.0 A                 | Op_point | Iout operating point   |
| 21. | Phase Marg     | 44.648 deg            | Op_point | Bode Plot Phase Margin   |
| 22. | VIN_OP         | 26.4 V                | Op_point | Vin operating point  |
| 23. | Vout p-p       | 10.917 mV             | Op_point | Peak-to-peak output ripple voltage   |
| 24. | Cin Pd         | 355.75 μW             | Power    | Input capacitor power dissipation  |
| 25. | Cout Pd        | 353.957 μW            | Power    | Output capacitor power dissipation   |
| 26. | IC Iq Pd       | 132.0 μW              | Power    | IC Iq Pd   |
| 27. | IC Pd          | 358.263 mW            | Power    | IC power dissipation   |
| 28. | L Pd           | 6.364 mW              | Power    | Inductor power dissipation   |
| 29. | Total Pd       | 364.44 mW             | Power    | Total Power Dissipation  |
| 30. | Vout Tolerance | 2.615 %               |          | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |

## Design Inputs

| #  | Name    | Value   | Description            |
|----|---------|---------|------------------------|
| 1. | Iout    | 1.0     | Maximum Output Current |
| 2. | VinMax  | 26.4    | Maximum input voltage  |
| 3. | VinMin  | 21.6    | Minimum input voltage  |
| 4. | Vout    | 5.0     | Output Voltage         |
| 5. | base_pn | LM43603 | Base Product Number    |
| 6. | source  | DC      | Input Source Type      |
| 7. | Ta      | 30.0    | Ambient temperature    |

## Design Assistance

1. **LM43603** Product Folder : <http://www.ti.com/product/LM43603> : contains the data sheet and other resources.

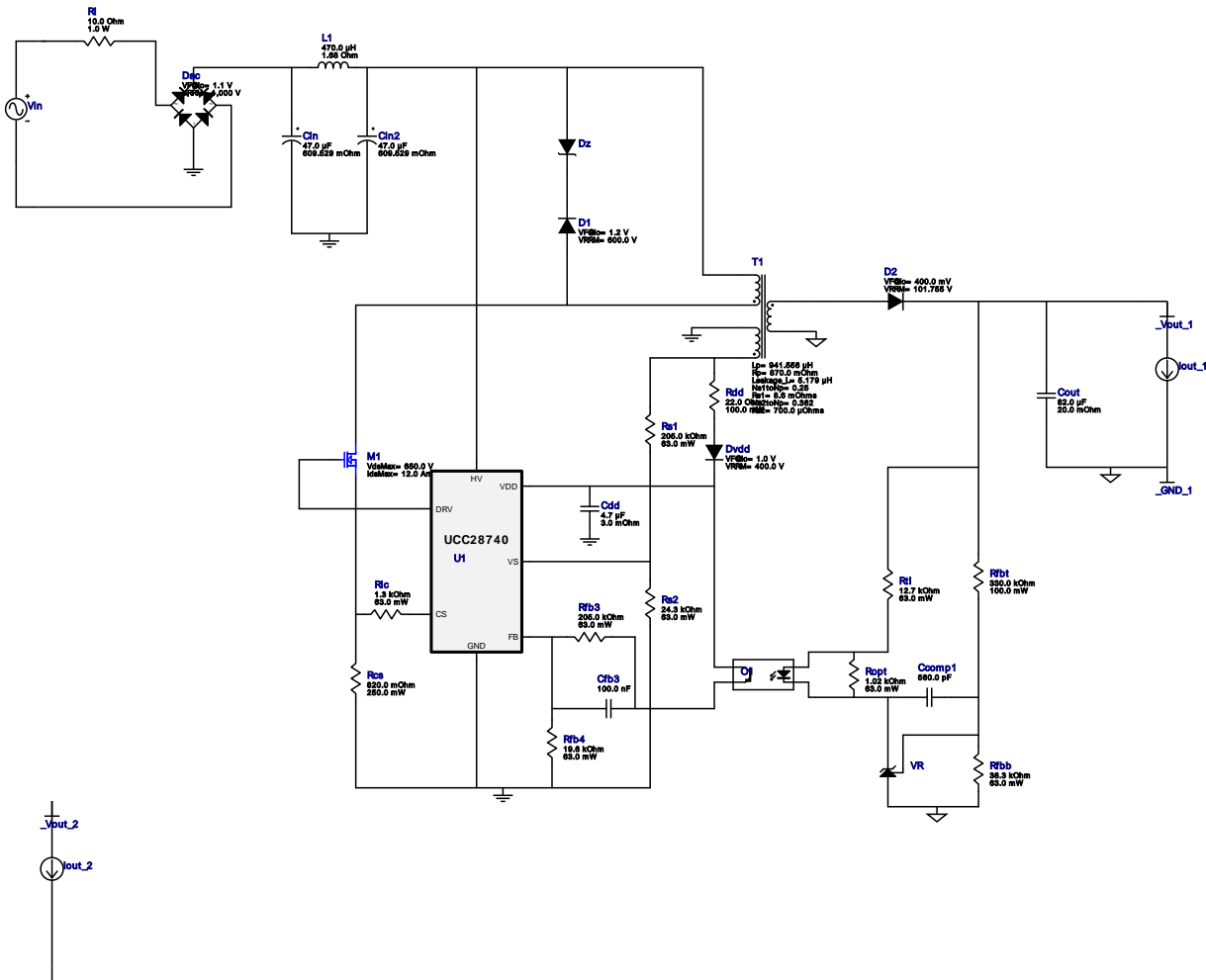


Vout = 24.0V  
Iout = 0.68A

Device = UCC28740DR  
Topology = Flyback  
Created = 2017-06-09 14:48:34.957  
BOM Cost = \$0.00  
BOM Count = 29  
Total Pd = 1.85W

## WEBENCH® Design Report

Design : 345212/246 UCC28740DR  
UCC28740DR 90.0V-240.0V to 24.00V @ 0.67589A



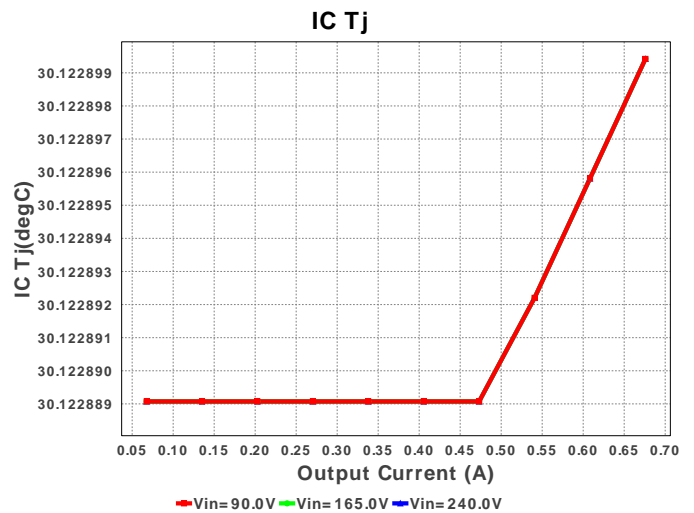
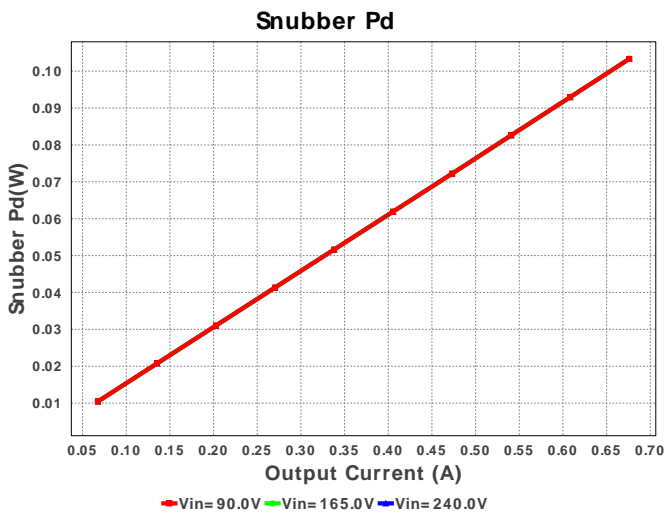
1. R1c, R1l and the feedback resistors for this design are a starting point, but may need adjustment based on the actual transformer used. For more information please click the design assistance button.

### Electrical BOM

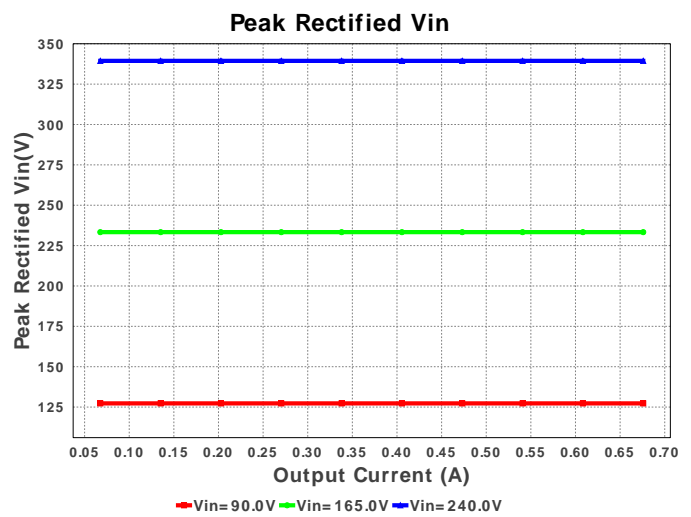
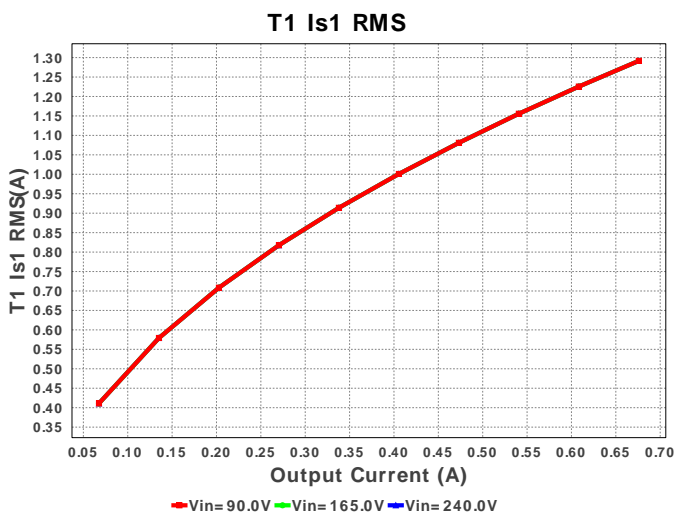
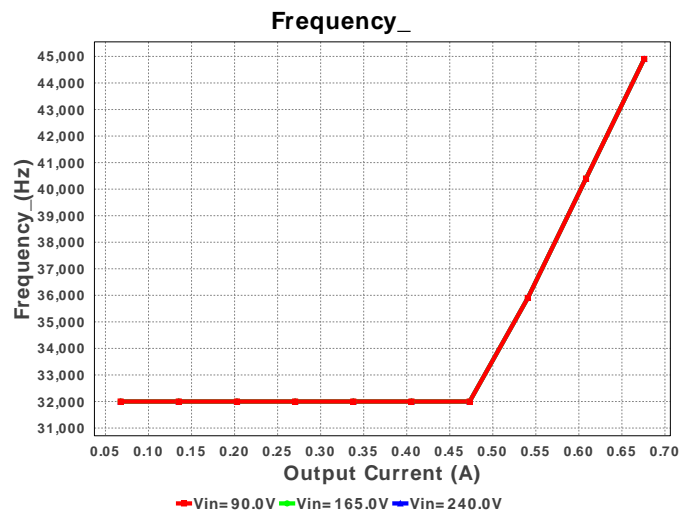
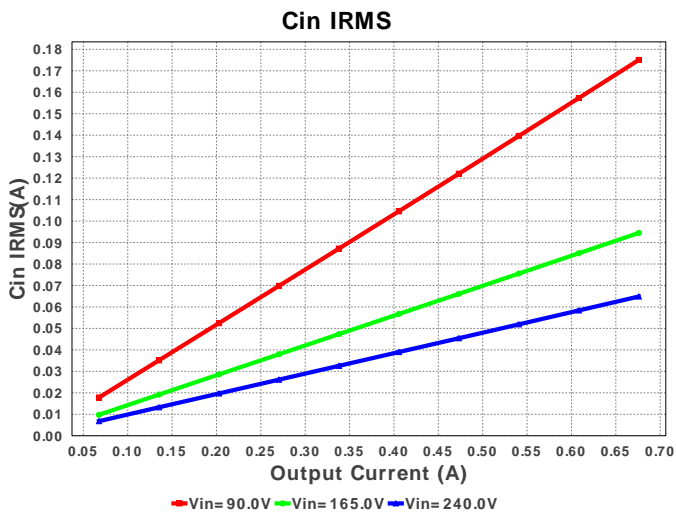
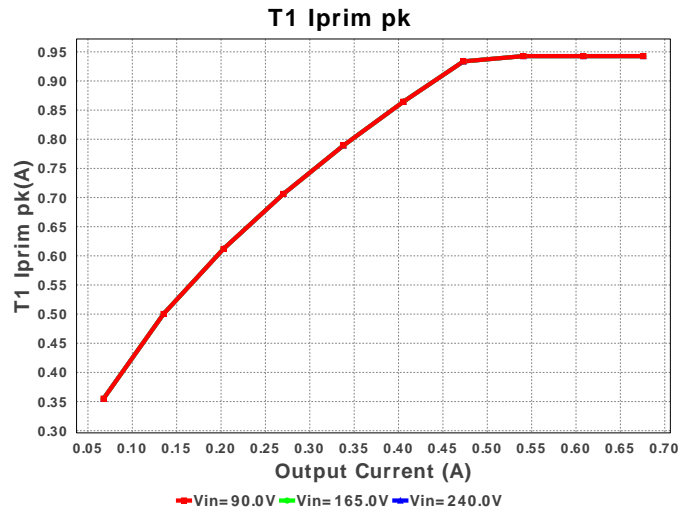
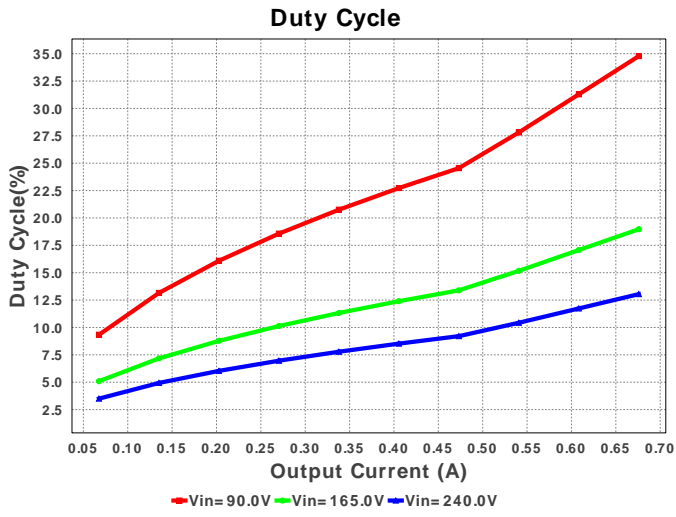
| #  | Name   | Manufacturer  | Part Number                       | Properties  | Qty | Price  | Footprint               |
|----|--------|---------------|-----------------------------------|---|-----|--------|-------------------------|
| 1. | Ccomp1 | Yageo America | CC0805KRX7R9BB561<br>Series= X7R  | Cap= 560.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A                 | 1   | \$0.01 | 0805 7 mm <sup>2</sup>  |
| 2. | Cdd    | MuRata        | GRM31CR71H475KA12L<br>Series= X7R | Cap= 4.7 uF<br>ESR= 3.0 mOhm<br>VDC= 50.0 V<br>IRMS= 4.98 A | 1   | \$0.07 | 1206 11 mm <sup>2</sup> |
| 3. | Cfb3   | Yageo America | CC0805KRX7R8BB104<br>Series= X7R  | Cap= 100.0 nF<br>VDC= 25.0 V<br>IRMS= 0.0 A                 | 1   | \$0.01 | 0805 7 mm <sup>2</sup>  |

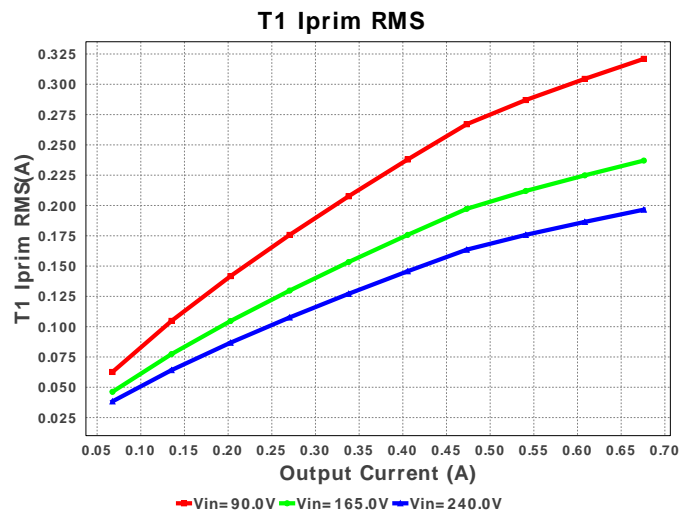
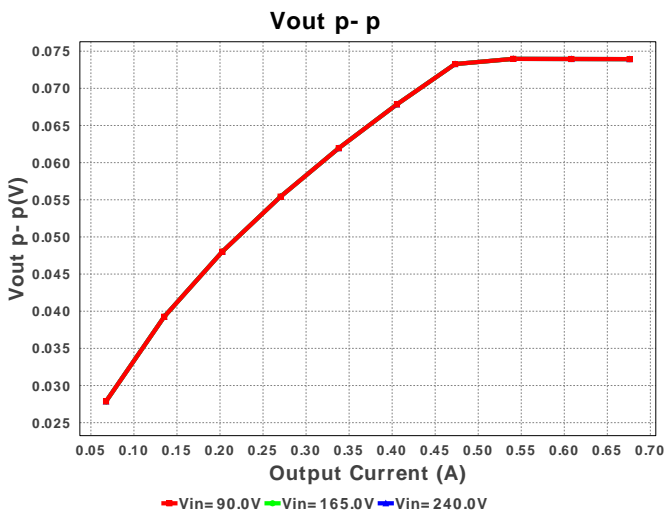
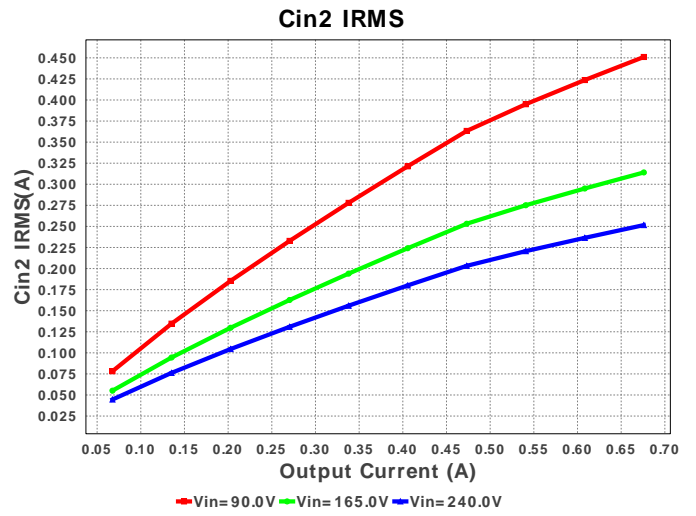
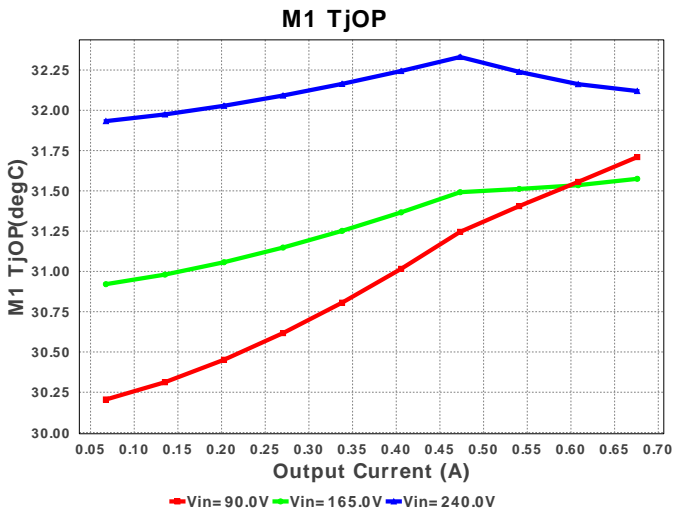
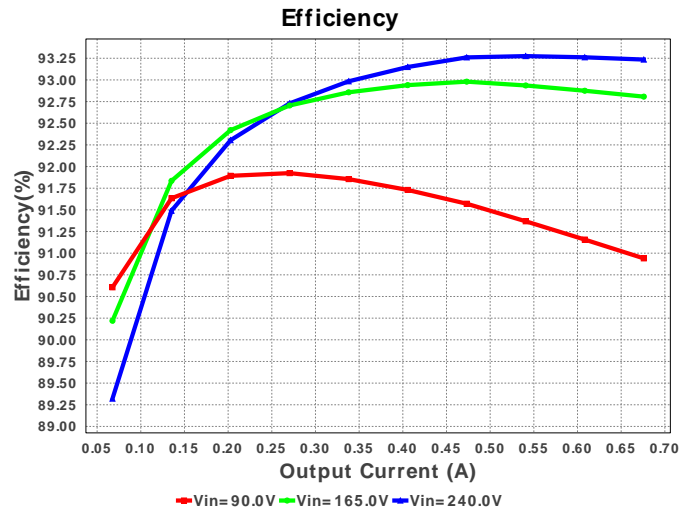
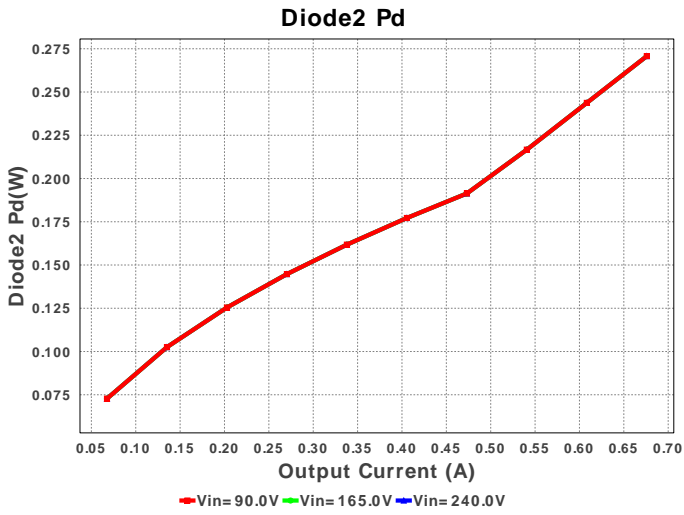
| #   | Name | Manufacturer                    | Part Number                          | Properties   | Qty | Price  | Footprint   |
|-----|------|---------------------------------|--------------------------------------|--|-----|--------|---|
| 4.  | Cin  | Panasonic                       | EEUED2G470S<br>Series= ED            | Cap= 47.0 uF<br>ESR= 609.53 mOhm<br>VDC= 400.0 V<br>IRMS= 840.0 mA | 1   | \$0.71 | <br>CAPPR7.5-18X20 400 mm <sup>2</sup> |
| 5.  | Cin2 | Panasonic                       | EEUED2G470S<br>Series= ED            | Cap= 47.0 uF<br>ESR= 609.53 mOhm<br>VDC= 400.0 V<br>IRMS= 840.0 mA | 1   | \$0.71 | <br>CAPPR7.5-18X20 400 mm <sup>2</sup> |
| 6.  | Cout | Panasonic                       | 35SVPF82M<br>Series= ?               | Cap= 82.0 uF<br>ESR= 20.0 mOhm<br>VDC= 35.0 V<br>IRMS= 4.0 A       | 1   | \$0.64 | <br>CAPSMT_62_E12 106 mm <sup>2</sup>  |
| 7.  | D1   | Bourns                          | CD214B-F3600                         | VF@Io= 1.2 V<br>VRRM= 600.0 V                                      | 1   | \$0.14 | <br>SMB 44 mm <sup>2</sup>             |
| 8.  | D2   | CUSTOM                          | CUSTOM                               | VF@Io= 400.0 mV<br>VRRM= 101.755 V                                 | 1   | NA     | CUSTOM 0 mm <sup>2</sup>  |
| 9.  | Dac  | Vishay-Semiconductor            | DF10SA                               | VF@Io= 1.1 V<br>VRRM= 1,000.0 V                                    | 1   | \$0.24 | <br>DF-S 99 mm <sup>2</sup>           |
| 10. | Dvdd | SMC Diode Solutions             | UF4004TA                             | VF@Io= 1.0 V<br>VRRM= 400.0 V                                      | 1   | \$0.04 | <br>DO-41 43 mm <sup>2</sup>         |
| 11. | Dz   | Diodes Inc.                     | SMBJ120A-13-F                        | Zener  | 1   | \$0.10 | <br>SMB 44 mm <sup>2</sup>           |
| 12. | L1   | Panasonic                       | ELL-6UH471M                          | L= 470.0 uH<br>DCR= 1.68 Ohm                                       | 1   | \$0.30 | <br>ELL6UH 67 mm <sup>2</sup>        |
| 13. | M1   | STMicroelectronics              | STD16N65M5                           | VdsMax= 650.0 V<br>IdsMax= 12.0 Amps                               | 1   | \$2.23 | <br>DPAK 102 mm <sup>2</sup>         |
| 14. | O1   | California Eastern Laboratories | PS2811-1                             | Optocoupler  | 1   | \$0.41 | <br>SSOP-4 111 mm <sup>2</sup>       |
| 15. | Rcs  | Panasonic                       | ERJ-8RQFR82V<br>Series= ERJ-8R       | Res= 820.0 mOhm<br>Power= 250.0 mW<br>Tolerance= 1.0%              | 1   | \$0.03 | <br>1206 11 mm <sup>2</sup>          |
| 16. | Rdd  | Yageo America                   | RC0603FR-0722RL<br>Series= ?         | Res= 22.0 Ohm<br>Power= 100.0 mW<br>Tolerance= 1.0%                | 1   | \$0.01 | <br>0603 5 mm <sup>2</sup>           |
| 17. | Rfb3 | Vishay-Dale                     | CRCW0402205KFKED<br>Series= CRCW..e3 | Res= 205.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%               | 1   | \$0.01 | <br>0402 3 mm <sup>2</sup>           |
| 18. | Rfb4 | Vishay-Dale                     | CRCW040219K6FKED<br>Series= CRCW..e3 | Res= 19.6 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                | 1   | \$0.01 | <br>0402 3 mm <sup>2</sup>           |
| 19. | Rfbb | Vishay-Dale                     | CRCW040238K3FKED<br>Series= CRCW..e3 | Res= 38.3 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                | 1   | \$0.01 | <br>0402 3 mm <sup>2</sup>           |

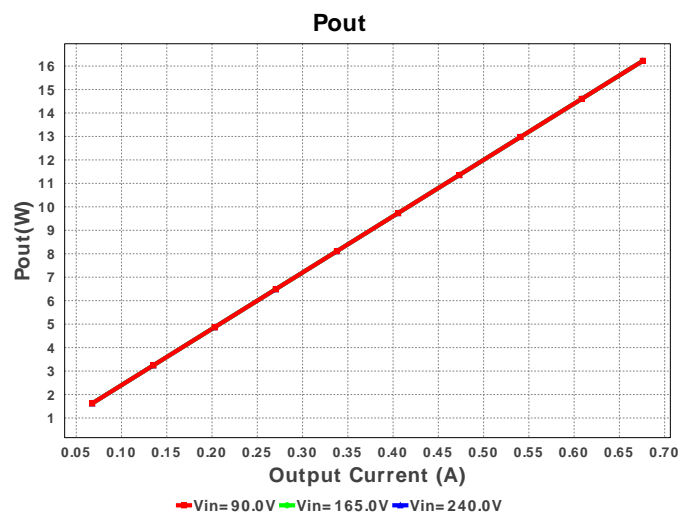
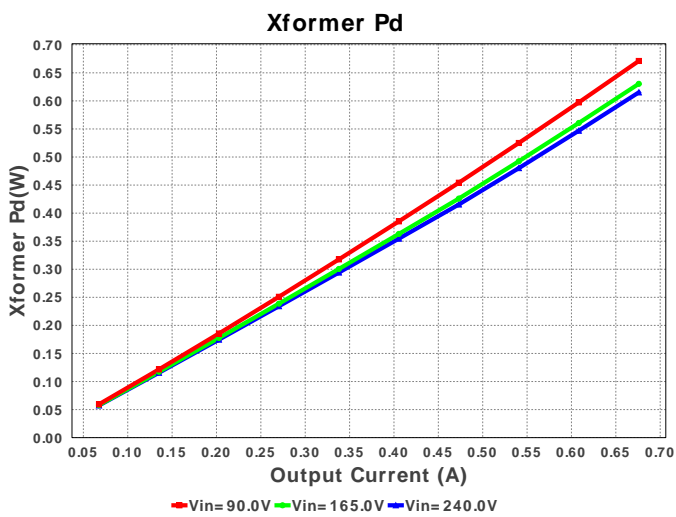
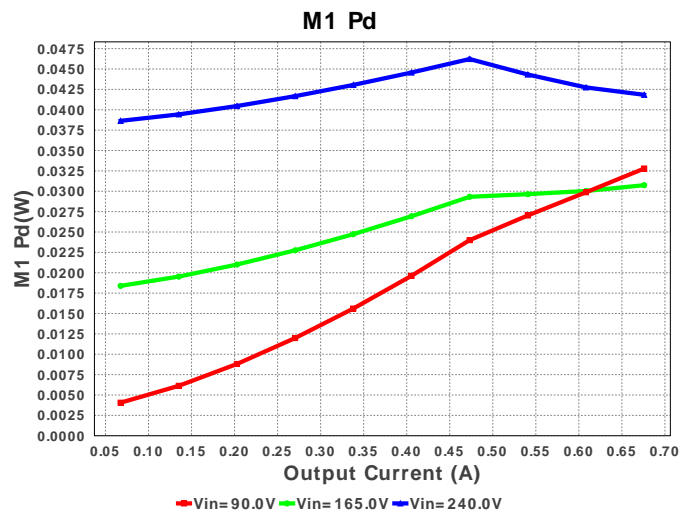
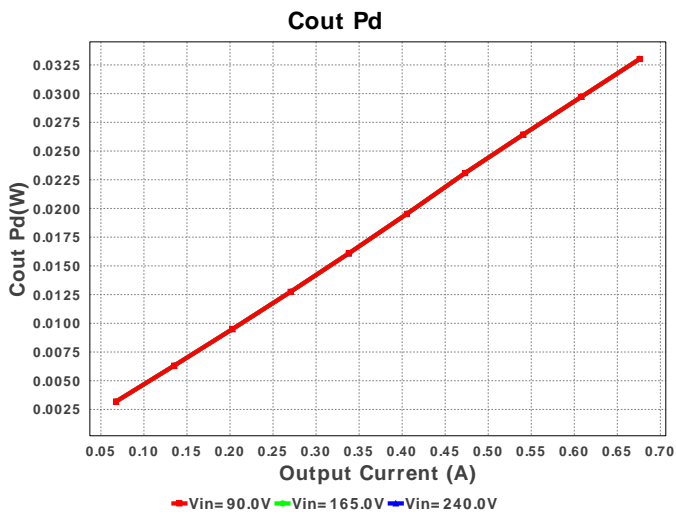
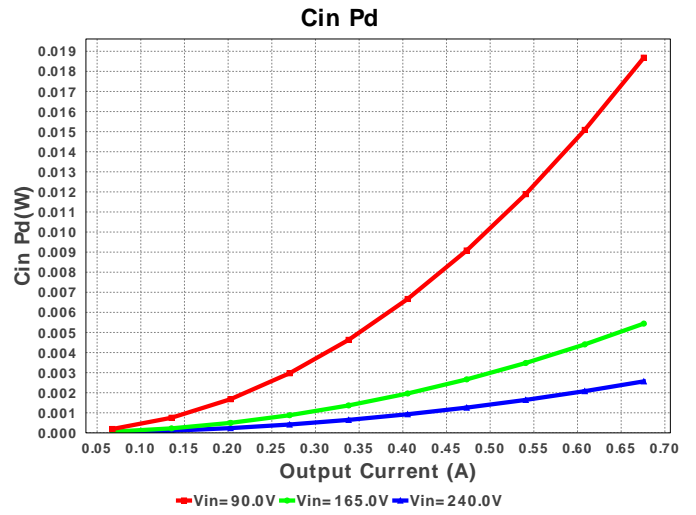
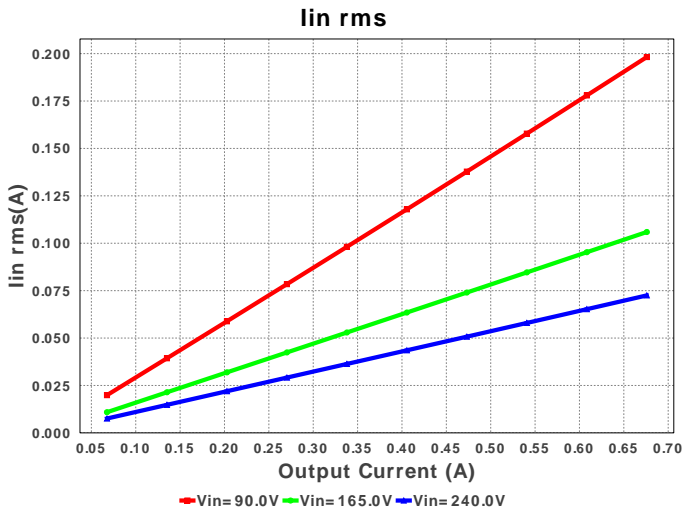
| #   | Name | Manufacturer      | Part Number                          | Properties   | Qty | Price  | Footprint  |
|-----|------|-------------------|--------------------------------------|--|-----|--------|--|
| 20. | Rfbt | Yageo America     | RC0603FR-07330KL<br>Series= ?        | Res= 330.0 kOhm<br>Power= 100.0 mW<br>Tolerance= 1.0%  | 1   | \$0.01 |  0603 5 mm <sup>2</sup>         |
| 21. | RI   | Vishay-Dale       | CRCW121810R0FKEK<br>Series= CRCW..e3 | Res= 10.0 Ohm<br>Power= 1.0 W<br>Tolerance= 1.0%   | 1   | \$0.13 |  1218 24 mm <sup>2</sup>        |
| 22. | Rlc  | Vishay-Dale       | CRCW04021K30FKED<br>Series= CRCW..e3 | Res= 1.3 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%   | 1   | \$0.01 |  0402 3 mm <sup>2</sup>         |
| 23. | Ropt | Vishay-Dale       | CRCW04021K02FKED<br>Series= CRCW..e3 | Res= 1.02 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%  | 1   | \$0.01 |  0402 3 mm <sup>2</sup>         |
| 24. | Rs1  | Vishay-Dale       | CRCW0402205KFKED<br>Series= CRCW..e3 | Res= 205.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%   | 1   | \$0.01 |  0402 3 mm <sup>2</sup>         |
| 25. | Rs2  | Vishay-Dale       | CRCW040224K3FKED<br>Series= CRCW..e3 | Res= 24.3 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%  | 1   | \$0.01 |  0402 3 mm <sup>2</sup>         |
| 26. | Rtl  | 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 mm <sup>2</sup>         |
| 27. | T1   | CUSTOM            | CUSTOM                               | Lp= 941.556 µH<br>Rp= 870.0 mOhm<br>Leakage_L= 5.179 µH<br>Ns1toNp= 0.25<br>Rs1= 8.6 mOhms<br>Ns2toNp= 0.362<br>Rs2= 700.0 µOhms | 1   | NA     | CUSTOM 0 mm <sup>2</sup>   |
| 28. | U1   | Texas Instruments | UCC28740DR                           | Switcher   | 1   | \$0.37 |  R-PDSO-G7 55 mm <sup>2</sup> |
| 29. | VR   | Texas Instruments | TL431AIDBZR                          | Voltage References   | 1   | \$0.08 |  DBZ0003A 14 mm <sup>2</sup>  |

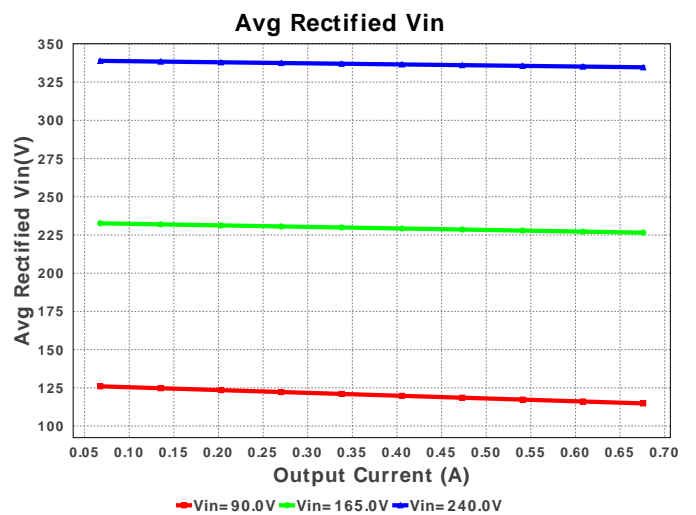
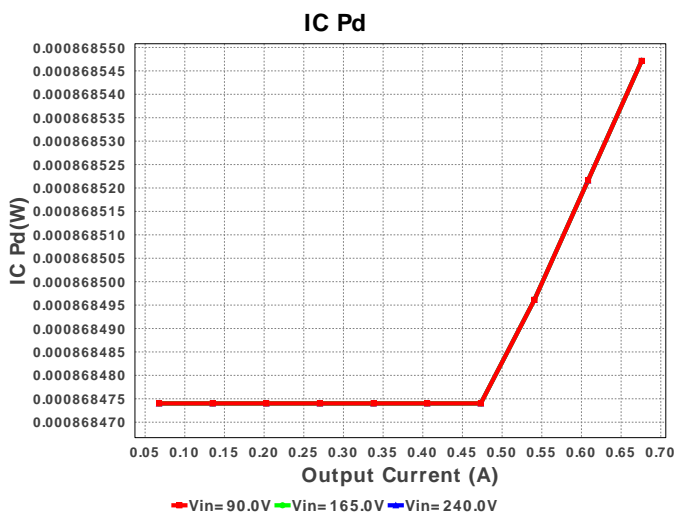
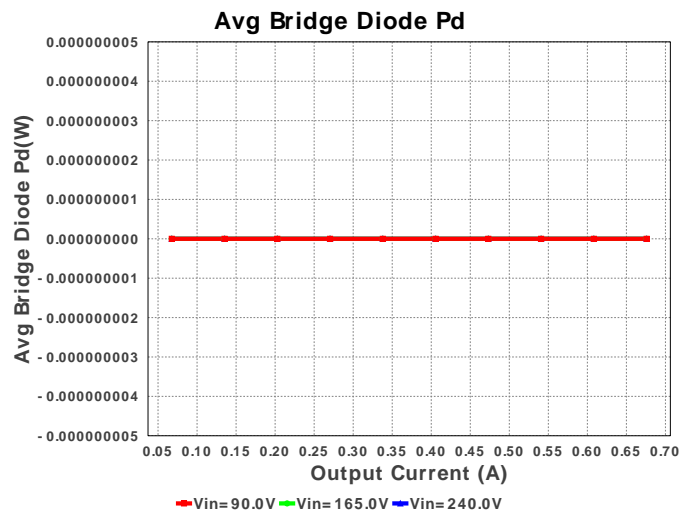
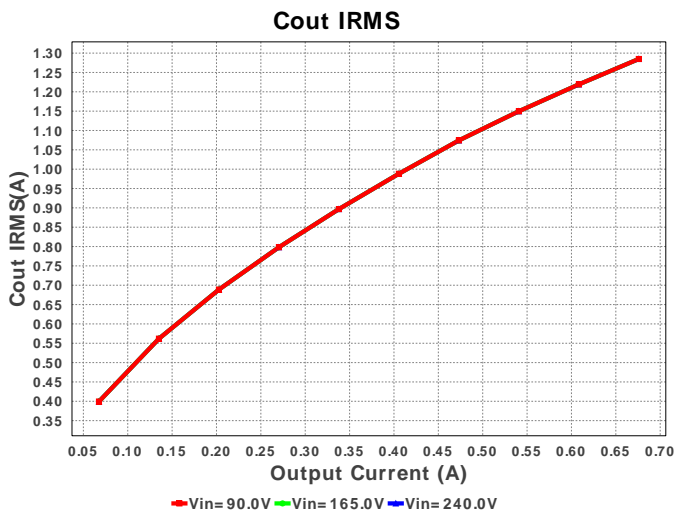
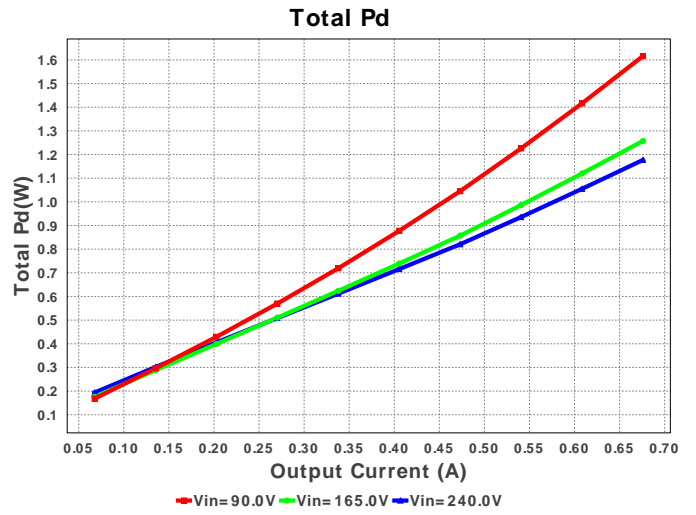
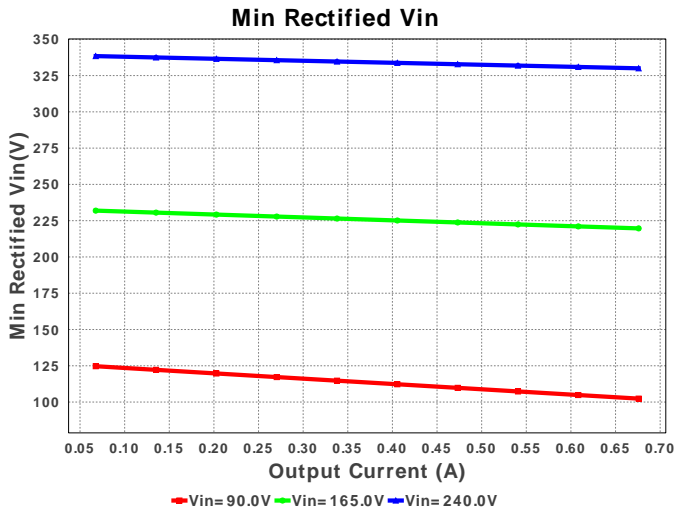


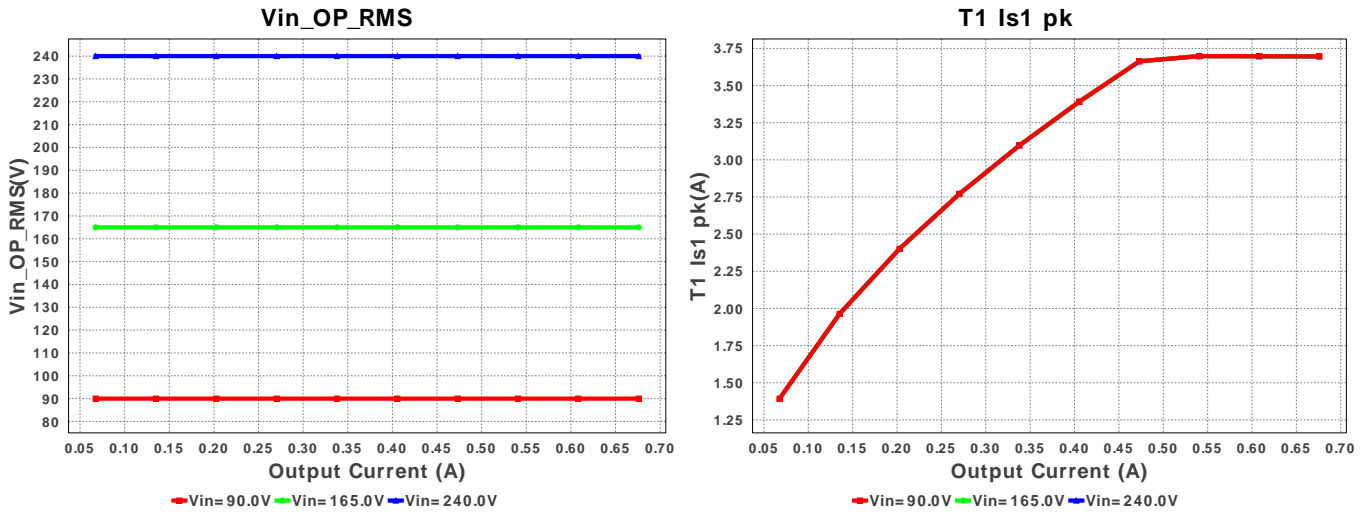












### Operating Values

| #   | Name                | Value                   | Category | Description  |
|-----|---------------------|-------------------------|----------|--|
| 1.  | Cin IRMS            | 178.344 mA              | Current  | Input capacitor RMS ripple current   |
| 2.  | Cin2 IRMS           | 454.3 mA                | Current  | Input Capacitor Cin2 RMS Ripple Current  |
| 3.  | Cout IRMS           | 1.285 A                 | Current  | Output capacitor RMS ripple current  |
| 4.  | Iin rms             | 200.74 mA               | Current  | RMS Input Current  |
| 5.  | T1 Iprim RMS        | 320.979 mA              | Current  | Transformer Primary RMS Current  |
| 6.  | T1 Iprim pk         | 942.683 mA              | Current  | Transformer Primary Peak Current   |
| 7.  | T1 Is1 RMS          | 1.292 A                 | Current  | Transformer Secondary1 RMS Current   |
| 8.  | T1 Is1 pk           | 3.697 A                 | Current  | Transformer Secondary1 Peak Current  |
| 9.  | Avg Rectified Vin   | 114.648 V               | General  | Average Rectified Voltage for the AC Line Period   |
| 10. | BOM Count           | 29                      | General  | Total Design BOM count   |
| 11. | FootPrint           | 1.683 k mm <sup>2</sup> | General  | Total Foot Print Area of BOM components  |
| 12. | Mode                | DCM                     | General  | Conduction Mode  |
| 13. | Pout                | 16.221 W                | General  | Total output power   |
| 14. | Total BOM           | \$0.0                   | General  | Total BOM Cost   |
| 15. | Vout Actual         | 24.04 V                 | Op_Point | Vout Actual calculated based on selected voltage divider resistors                         |
| 16. | Vout OP             | 24.0 V                  | Op_Point | Operational Output Voltage   |
| 17. | Duty Cycle          | 34.781 %                | Op_point | Duty cycle   |
| 18. | Efficiency          | 89.787 %                | Op_point | Steady state efficiency  |
| 19. | Frequency           | 44.903 kHz              | Op_point | Switching frequency  |
| 20. | IC Tj               | 30.123 degC             | Op_point | IC junction temperature  |
| 21. | ICThetaJA           | 141.5 degC/W            | Op_point | IC junction-to-ambient thermal resistance  |
| 22. | IOUT_OP             | 675.89 mA               | Op_point | Iout operating point   |
| 23. | M1 TjOP             | 31.71 degC              | Op_point | M1 MOSFET junction temperature   |
| 24. | Min Rectified Vin   | 102.019 V               | Op_point | Minimum voltage seen at rectified input  |
| 25. | Peak Rectified Vin  | 127.278 V               | Op_point | Peak voltage seen at rectified input   |
| 26. | Vin_OP_RMS          | 90.0 V                  | Op_point | AC Input RMS Voltage   |
| 27. | Vout p-p            | 73.933 mV               | Op_point | Peak-to-peak output ripple voltage   |
| 28. | Avg Bridge Diode Pd | 225.63 mW               | Power    | Average Power Dissipation in the Bridge Diode over the AC Line Period                      |
| 29. | Cin Pd              | 19.387 mW               | Power    | Input capacitor power dissipation  |
| 30. | Cout Pd             | 33.016 mW               | Power    | Output capacitor power dissipation   |
| 31. | Diode2 Pd           | 270.756 mW              | Power    | Diode2 power dissipation   |
| 32. | IC Pd               | 868.547 μW              | Power    | IC power dissipation   |
| 33. | M1 Pd               | 32.786 mW               | Power    | M1 MOSFET total power dissipation  |
| 34. | Snubber Pd          | 103.321 mW              | Power    | Snubber Power Dissipation  |
| 35. | Total Pd            | 1.845 W                 | Power    | Total Power Dissipation  |
| 36. | Xformer Pd          | 671.138 mW              | Power    | Transformer power dissipation  |
| 37. | Vout Tolerance      | 2.136 %                 |          | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |

### Design Inputs

| #  | Name     | Value    | Description            |
|----|----------|----------|------------------------|
| 1. | Iout     | 675.89 m | Maximum Output Current |
| 2. | VinMax   | 240.0    | Maximum input voltage  |
| 3. | VinMin   | 90.0     | Minimum input voltage  |
| 4. | Vout     | 24.0     | Output Voltage         |
| 5. | line_fsw | 60.0     | Light Output in Lumen  |
| 6. | base_pn  | UCC28740 | Base Product Number    |
| 7. | source   | AC       | Input Source Type      |
| 8. | Ta       | 30.0     | Ambient temperature    |

## Design Assistance

1. Application Hints Rlc Rlc provides the function of feed-forward line compensation to eliminate change in IPP due to change in di/dt and the propagation delay of the internal comparator and MOSFET turn-off time. For best results the chosen value may need to be adjusted based on board, FET and transformer parasitics. Rtl Rtl is added to prevent excessive diode current and limit lopt to the maximum value necessary for regulation. The Rtl value may be adjusted for optimal limiting later during the prototype evaluation process. Rfbb & Rfbt The feedback resistors will set the output voltage of the circuit. The values chosen may need to be fine tuned based on the final Transformer turns ratios and the voltage across the output diode at close to zero current. Rfb3 & Cfb3 Rfb3 is necessary to limit the current into FB and to avoid excess draining of Cvdd during this type of transient situation. The value of Rfb3 is chosen to limit the excess lfb and Rfb4 current to an acceptable level when the optocoupler is saturated. Cfb3 helps improve the transient response and is estimated initially by equating the time constant to 1ms. This can later be adjusted for optimal performance during prototype evaluation. Rfb4 Rfb4 speeds up the turnoff time of the optocoupler in the case of a heavy load-step transient condition. This value tends to fall within the range of 10k and 100k. A tradeoff must be made between a lower value for faster transient response and a higher value for lower standby power. Rfb4 also serves to set a minimum bias current for the optocoupler and to drain dark current. Part Description The UCC28740 isolated-flyback controller provides Constant-Voltage (CV) using an optical coupler to improve transient response. Constant-Current (CC) regulation is accomplished through Primary Side Regulation (PSR) techniques. Please see the datasheet for further design guidance. <http://www.ti.com/lit/ds/symlink/ucc28740.pdf>

2. **UCC28740** Product Folder : <http://www.ti.com/product/UCC28740> : contains the data sheet and other resources.

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**You should completely validate and test your design implementation to confirm the system functionality for your application prior to production.**

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