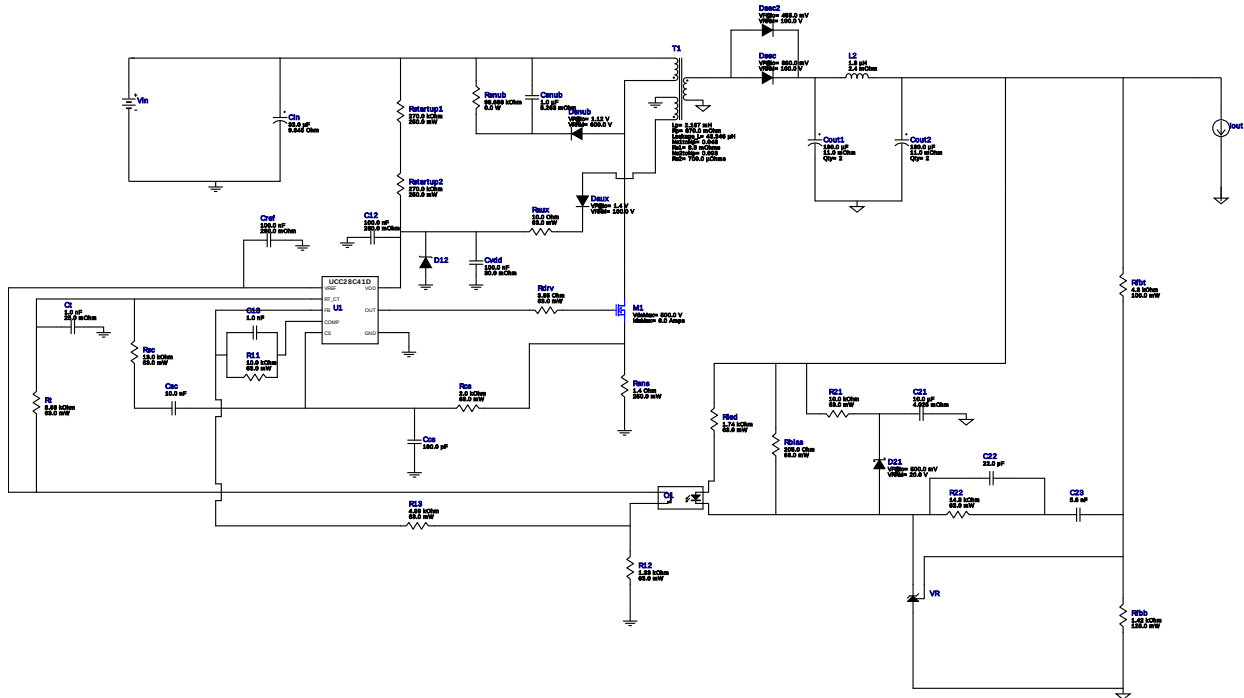


## WEBENCH® Design Report

Design : 4766773/6 UCC28C41DR  
UCC28C41DR 180.0V-250.0V to 5.00V @ 4.0A



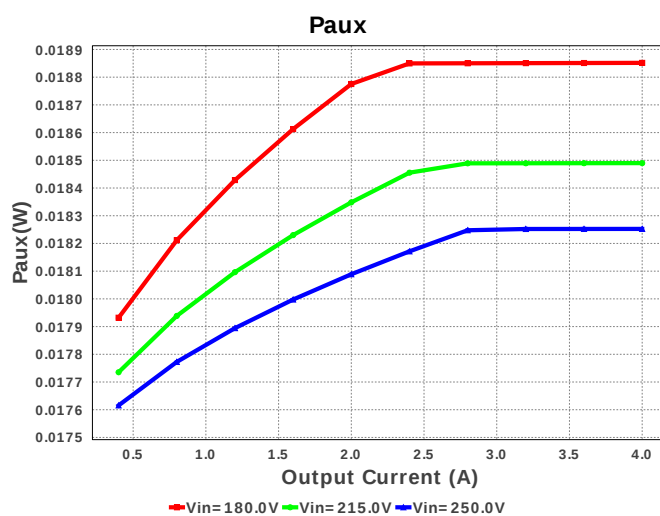
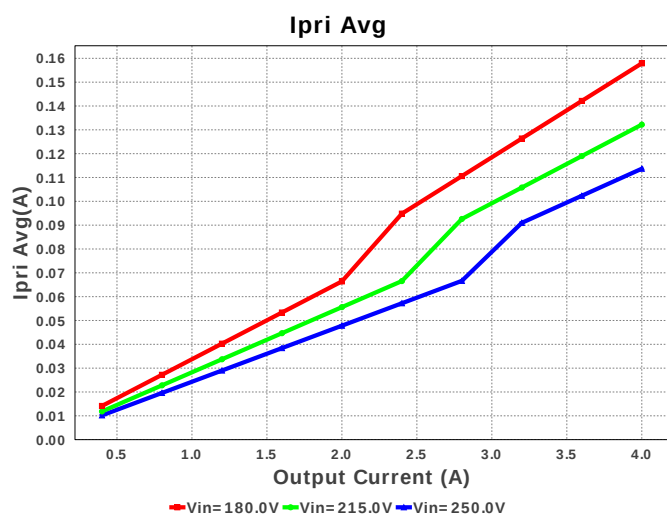
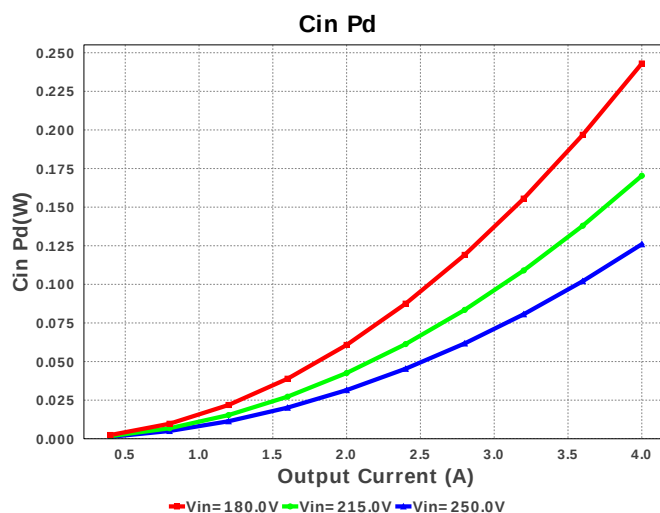
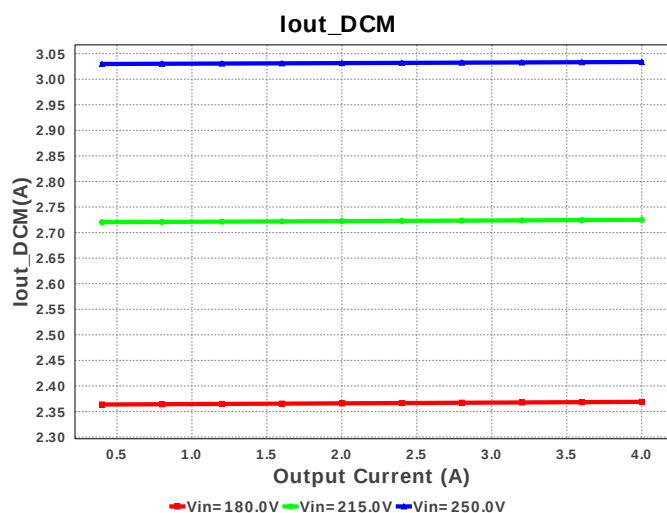
## Electrical BOM

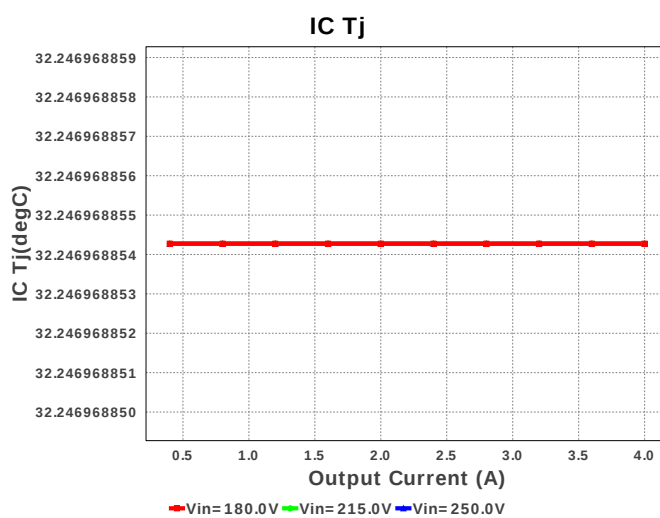
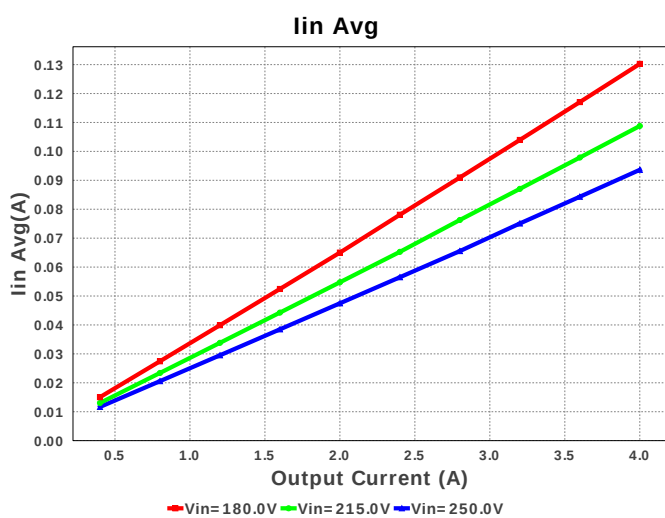
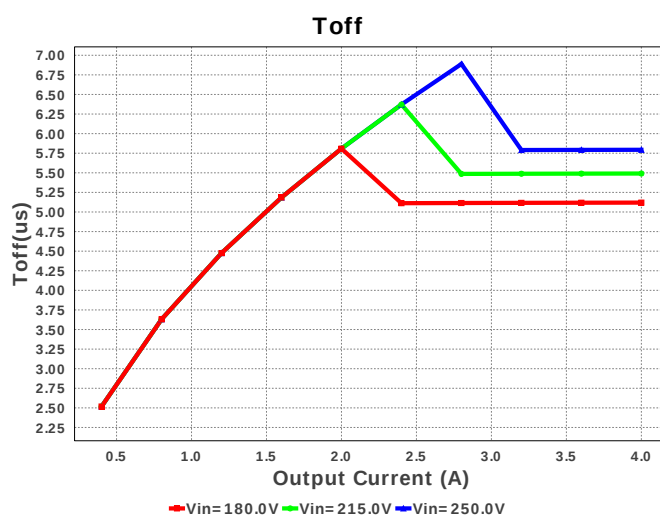
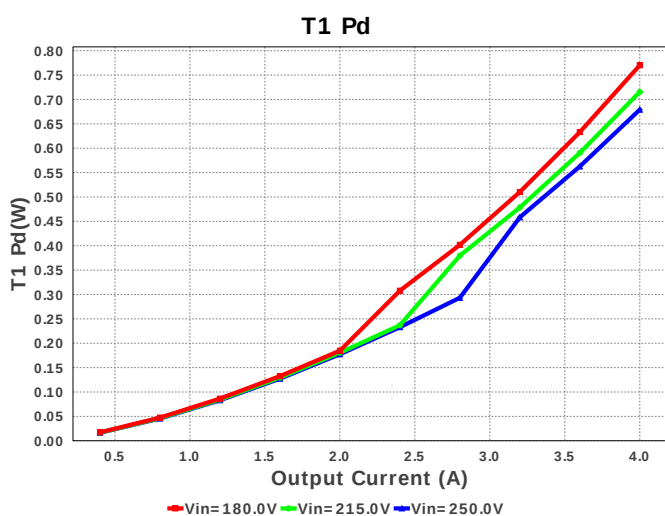
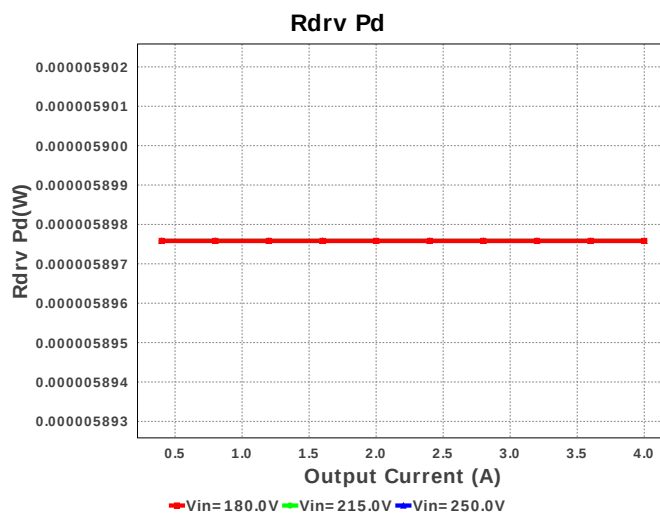
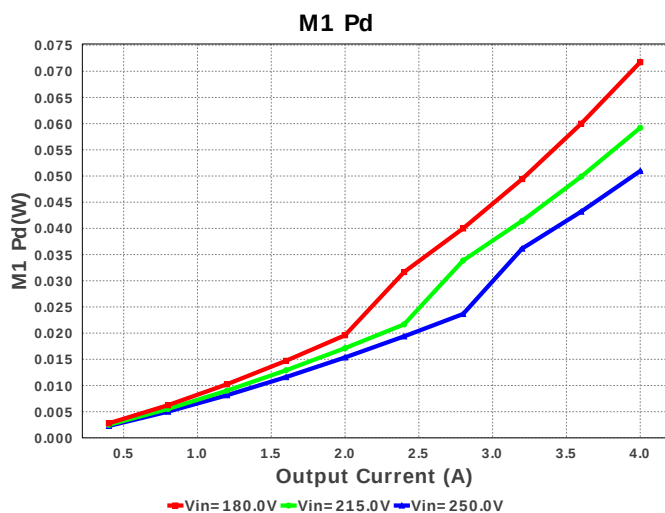
| #  | Name  | Manufacturer              | Part Number                         | Properties                                                       | Qty | Price  | Footprint                                                                                                                 |
|----|-------|---------------------------|-------------------------------------|------------------------------------------------------------------|-----|--------|---------------------------------------------------------------------------------------------------------------------------|
| 1. | C12   | 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 <sup>2</sup>                                                                                                    |
| 2. | C13   | Samsung Electro-Mechanics | CL21C102JBCNFNC<br>Series= C0G/NP0  | Cap= 1.0 nF<br>VDC= 50.0 V<br>IRMS= 0.0 A                        | 1   | \$0.01 | 0805 7 mm <sup>2</sup>                                                                                                    |
| 3. | C21   | MuRata                    | GRM21BR61A106KE19L<br>Series= X5R   | Cap= 10.0 uF<br>ESR= 4.025 mOhm<br>VDC= 10.0 V<br>IRMS= 2.445 A  | 1   | \$0.03 | 0805 7 mm <sup>2</sup>                                                                                                    |
| 4. | C22   | Kemet                     | C0805C220K3GACTU<br>Series= C0G/NP0 | Cap= 22.0 pF<br>VDC= 25.0 V<br>IRMS= 0.0 A                       | 1   | \$0.01 | 0805 7 mm <sup>2</sup>                                                                                                    |
| 5. | C23   | Yageo America             | CC0805KRX7R9BB562<br>Series= X7R    | Cap= 5.6 nF<br>VDC= 50.0 V<br>IRMS= 0.0 A                        | 1   | \$0.01 | 0805 7 mm <sup>2</sup>                                                                                                    |
| 6. | Ccs   | Kemet                     | C0805C181K5GACTU<br>Series= C0G/NP0 | Cap= 180.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A                      | 1   | \$0.01 | 0805 7 mm <sup>2</sup>                                                                                                    |
| 7. | Cin   | Nichicon                  | UCS2W330MHD6<br>Series= 2234        | Cap= 33.0 uF<br>ESR= 9.645 Ohm<br>VDC= 450.0 V<br>IRMS= 490.0 mA | 1   | \$0.58 | UCS_1800x2000 0 mm <sup>2</sup>                                                                                           |
| 8. | Cout1 | Panasonic                 | 16SVPE180M<br>Series= SVPE          | Cap= 180.0 uF<br>ESR= 11.0 mOhm<br>VDC= 16.0 V<br>IRMS= 4.46 A   | 2   | \$0.49 | <br>CAPSMT_62_C10 74 mm <sup>2</sup> |

| #   | Name  | Manufacturer            | Part Number                          | Properties                                                     | Qty | Price  | Footprint                                                                                                   |
|-----|-------|-------------------------|--------------------------------------|----------------------------------------------------------------|-----|--------|-------------------------------------------------------------------------------------------------------------|
| 9.  | Cout2 | Panasonic               | 16SVPE180M<br>Series= SVPE           | Cap= 180.0 uF<br>ESR= 11.0 mOhm<br>VDC= 16.0 V<br>IRMS= 4.46 A | 2   | \$0.49 | <br>CAPSMT_62_C10 74 mm² |
| 10. | Cref  | 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 | <br>0805 7 mm²           |
| 11. | Csc   | MuRata                  | GRM216R71H103KA01D<br>Series= X7R    | Cap= 10.0 nF<br>VDC= 50.0 V<br>IRMS= 0.0 A                     | 1   | \$0.01 | <br>0805 7 mm²           |
| 12. | Csnub | TDK                     | C5750X6S2W105K<br>Series= X6S        | Cap= 1.0 uF<br>ESR= 5.263 mOhm<br>VDC= 400.0 V<br>IRMS= 0.0 A  | 1   | \$1.19 | <br>2220 54 mm²          |
| 13. | Ct    | Kemet                   | C0805C102J5GACTU<br>Series= C0G/NP0  | Cap= 1.0 nF<br>ESR= 25.0 mOhm<br>VDC= 50.0 V<br>IRMS= 1.71 A   | 1   | \$0.01 | <br>0805 7 mm²           |
| 14. | Cvdd  | MuRata                  | GRM188R71C104KA01D<br>Series= X7R    | Cap= 100.0 nF<br>ESR= 30.0 mOhm<br>VDC= 16.0 V<br>IRMS= 1.7 A  | 1   | \$0.01 | <br>0603 5 mm²           |
| 15. | D12   | Diodes Inc.             | MMSZ5248B-7-F                        | Zener                                                          | 1   | \$0.04 | <br>SOD-123 13 mm²       |
| 16. | D21   | Diodes Inc.             | B220-13-F                            | VF@Io= 500.0 mV<br>VRRM= 20.0 V                                | 1   | \$0.08 | <br>SMB 44 mm²           |
| 17. | Daux  | NXP Semiconductor       | BAS316,115                           | VF@Io= 1.4 V<br>VRRM= 100.0 V                                  | 1   | \$0.02 | <br>SOD-323 9 mm²      |
| 18. | Dsec  | Vishay-Semiconductor    | SS10PH10-M3/86A                      | VF@Io= 880.0 mV<br>VRRM= 100.0 V                               | 1   | \$0.29 | <br>TO-277A 56 mm²     |
| 19. | Dsec2 | STMicroelectronics      | STPS20M100SG-TR                      | VF@Io= 455.0 mV<br>VRRM= 100.0 V                               | 1   | \$1.33 | <br>DDPAK 210 mm²      |
| 20. | Dsnub | Bourns                  | CD214C-F3600                         | VF@Io= 1.12 V<br>VRRM= 600.0 V                                 | 1   | \$0.18 | <br>SMC 83 mm²         |
| 21. | L2    | Coilcraft               | SER1360-182KLB                       | L= 1.8 uH<br>DCR= 2.4 mOhm                                     | 1   | \$0.72 | <br>SER1360 225 mm²    |
| 22. | M1    | Fairchild Semiconductor | FDD6N50TM                            | VdsMax= 500.0 V<br>IdsMax= 6.0 Amps                            | 1   | \$0.47 | <br>DPAK 102 mm²       |
| 23. | O1    | Vishay-Semiconductor    | TCMT1109                             | Optocoupler                                                    | 1   | \$0.21 | <br>SOP-4 44 mm²       |
| 24. | R11   | 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         |
| 25. | R12   | Vishay-Dale             | CRCW04021K33FKED<br>Series= CRCW..e3 | Res= 1.33 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%            | 1   | \$0.01 | <br>0402 3 mm²         |

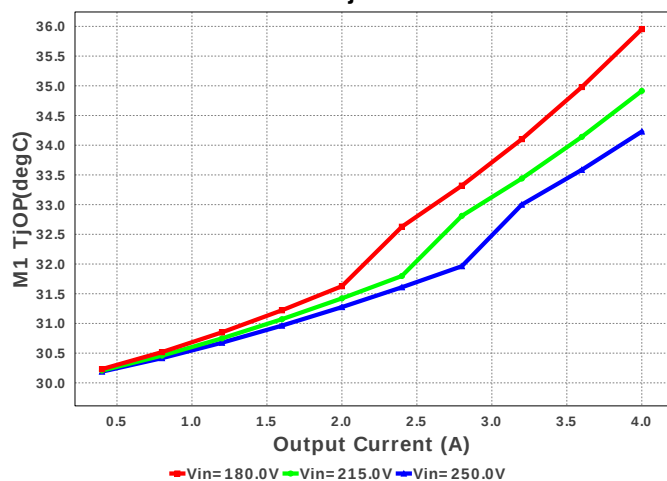
| #   | Name      | Manufacturer      | Part Number                          | Properties                                                                                                                          | Qty | Price  | Footprint                                                                                           |
|-----|-----------|-------------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|-----|--------|-----------------------------------------------------------------------------------------------------|
| 26. | R13       | Vishay-Dale       | CRCW04024K99FKED<br>Series= CRCW..e3 | Res= 4.99 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                 | 1   | \$0.01 |  0402 3 mm²      |
| 27. | R21       | 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      |
| 28. | R22       | Vishay-Dale       | CRCW040214K3FKED<br>Series= CRCW..e3 | Res= 14.3 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                 | 1   | \$0.01 |  0402 3 mm²      |
| 29. | Raux      | Vishay-Dale       | CRCW040210R0FKED<br>Series= CRCW..e3 | Res= 10.0 Ohm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                  | 1   | \$0.01 |  0402 3 mm²      |
| 30. | Rbias     | Vishay-Dale       | CRCW0402205RFKED<br>Series= CRCW..e3 | Res= 205.0 Ohm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                 | 1   | \$0.01 |  0402 3 mm²      |
| 31. | Rcs       | Vishay-Dale       | CRCW04022K00FKED<br>Series= CRCW..e3 | Res= 2.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                  | 1   | \$0.01 |  0402 3 mm²      |
| 32. | Rdrv      | Vishay-Dale       | CRCW04023R65FKED<br>Series= CRCW..e3 | Res= 3.65 Ohm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                  | 1   | \$0.01 |  0402 3 mm²      |
| 33. | Rfbb      | Yageo America     | RT0805BRD071K42L<br>Series= RT0805   | Res= 1.42 kOhm<br>Power= 125.0 mW<br>Tolerance= 0.1%                                                                                | 1   | \$0.05 |  0805 7 mm²      |
| 34. | Rfbt      | Yageo America     | RC0603FR-074K3L<br>Series= ?         | Res= 4.3 kOhm<br>Power= 100.0 mW<br>Tolerance= 1.0%                                                                                 | 1   | \$0.01 |  0603 5 mm²      |
| 35. | Rled      | Vishay-Dale       | CRCW04021K74FKED<br>Series= CRCW..e3 | Res= 1.74 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                 | 1   | \$0.01 |  0402 3 mm²      |
| 36. | Rsc       | Vishay-Dale       | CRCW040213K0FKED<br>Series= CRCW..e3 | Res= 13.0 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                 | 1   | \$0.01 |  0402 3 mm²    |
| 37. | Rsns      | Vishay-Dale       | CRCW12061R40FKEA<br>Series= CRCW..e3 | Res= 1.4 Ohm<br>Power= 250.0 mW<br>Tolerance= 1.0%                                                                                  | 1   | \$0.01 |  1206 11 mm²   |
| 38. | Rsnu      | CUSTOM            | CUSTOM<br>Series= ?                  | Res= 98.668 kOhm<br>Power= 0.0 W<br>Tolerance= 0.0%                                                                                 | 1   | NA     | CUSTOM 0 mm²                                                                                        |
| 39. | Rstartup1 | Yageo America     | RC1206FR-07270KL<br>Series= ?        | Res= 270.0 kOhm<br>Power= 250.0 mW<br>Tolerance= 1.0%                                                                               | 1   | \$0.01 |  1206 11 mm²   |
| 40. | Rstartup2 | Yageo America     | RC1206FR-07270KL<br>Series= ?        | Res= 270.0 kOhm<br>Power= 250.0 mW<br>Tolerance= 1.0%                                                                               | 1   | \$0.01 |  1206 11 mm²   |
| 41. | Rt        | Vishay-Dale       | CRCW04028K66FKED<br>Series= CRCW..e3 | Res= 8.66 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0%                                                                                 | 1   | \$0.01 |  0402 3 mm²    |
| 42. | T1        | CUSTOM            | CUSTOM                               | Lp= 2.167 mH<br>Rp= 870.0 mOhm<br>Leakage_L= 43.346<br>μH<br>Ns1toNp= 0.048<br>Rs1= 8.6 mOhms<br>Ns2toNp= 0.093<br>Rs2= 700.0 μOhms | 1   | NA     | CUSTOM 0 mm²                                                                                        |
| 43. | U1        | Texas Instruments | UCC28C41DR                           | Switcher                                                                                                                            | 1   | \$0.75 |  D0008A 57 mm² |

| #   | Name | Manufacturer      | Part Number    | Properties         | Qty | Price  | Footprint                                                                                                           |
|-----|------|-------------------|----------------|--------------------|-----|--------|---------------------------------------------------------------------------------------------------------------------|
| 44. | VR   | Texas Instruments | LMV431CM5/NOPB | Voltage References | 1   | \$0.16 | <br>R-PDSO-G3 16 mm <sup>2</sup> |

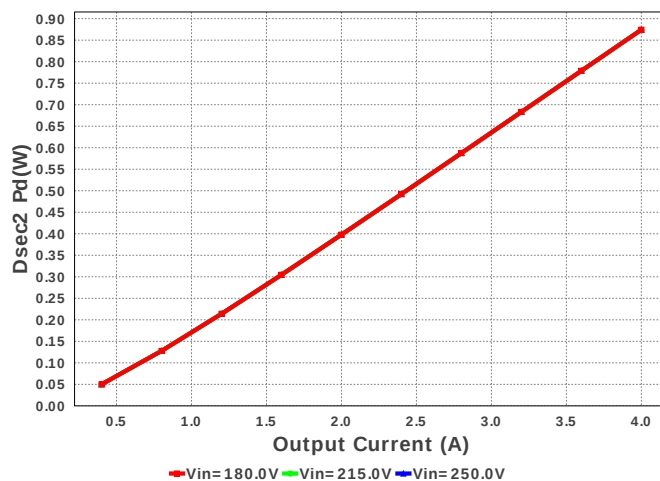




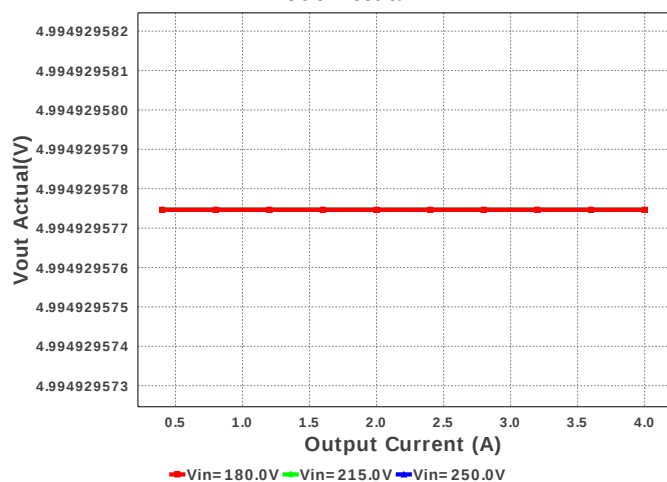
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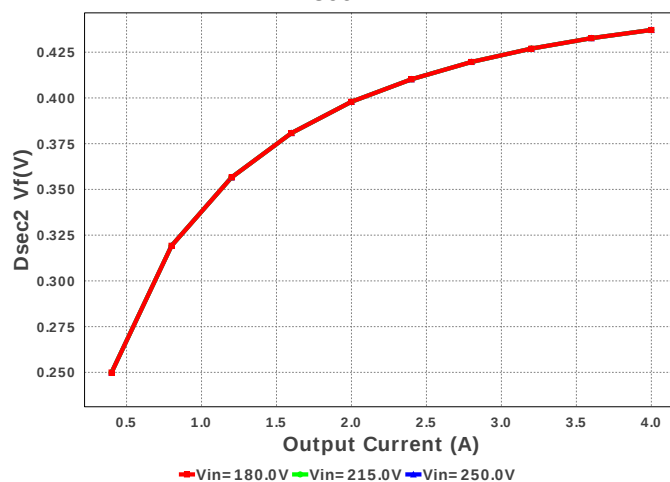
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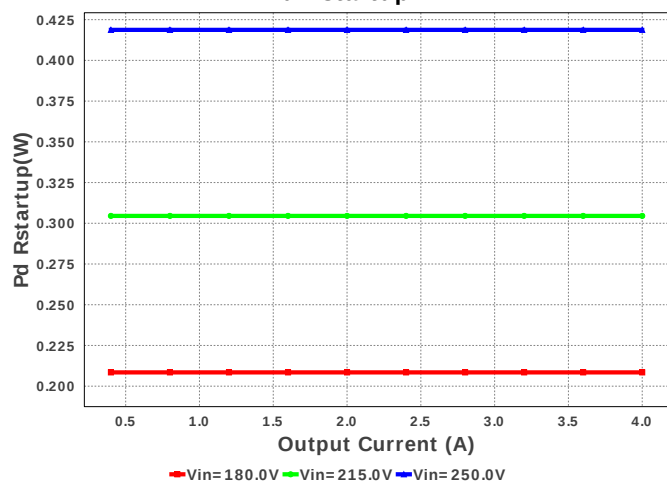
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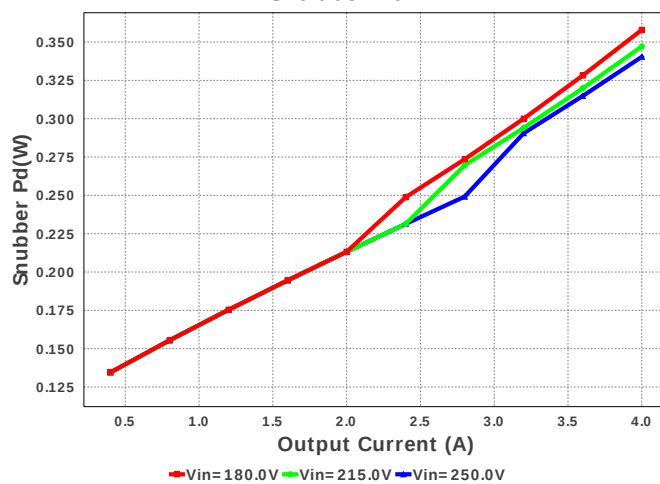
Dsec2 Vf

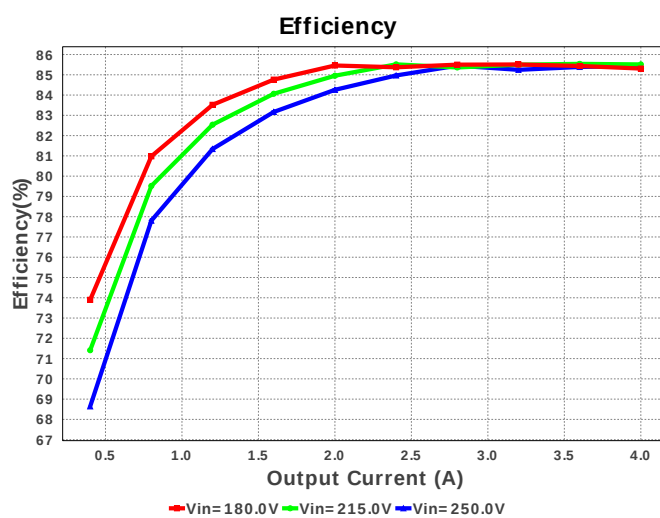
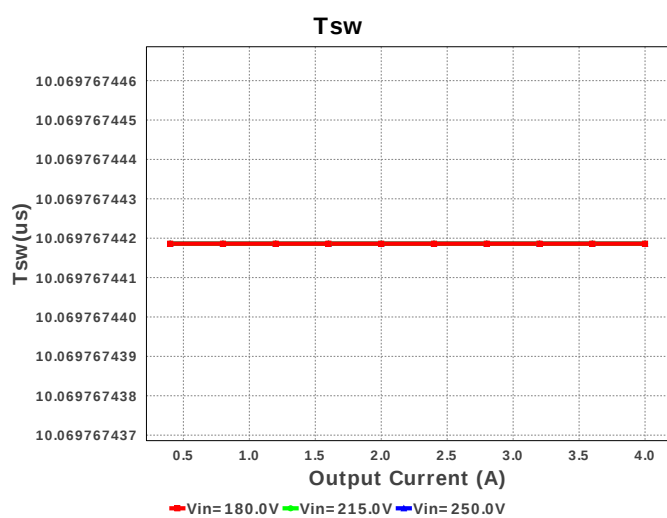
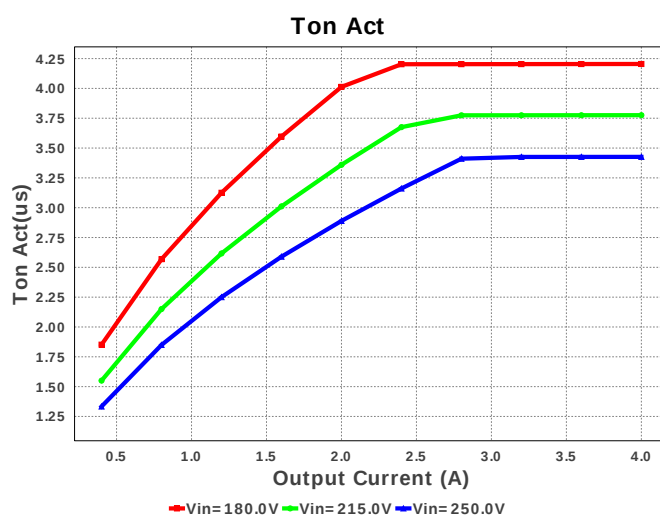
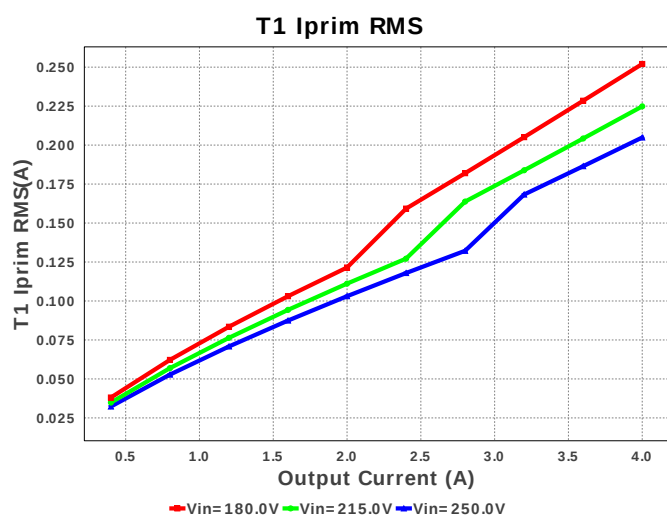
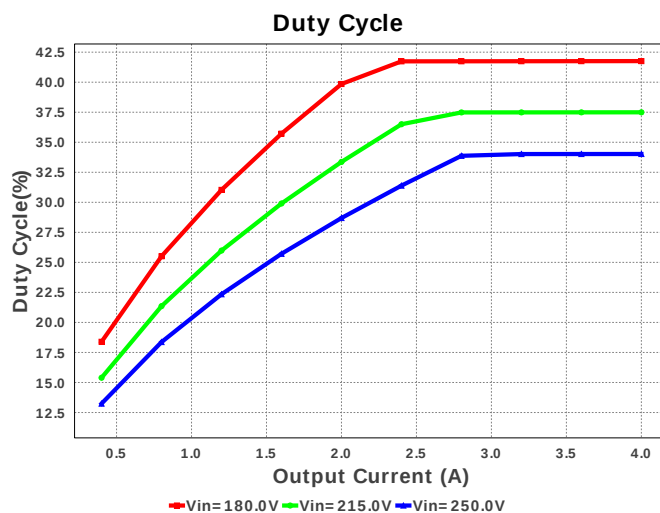
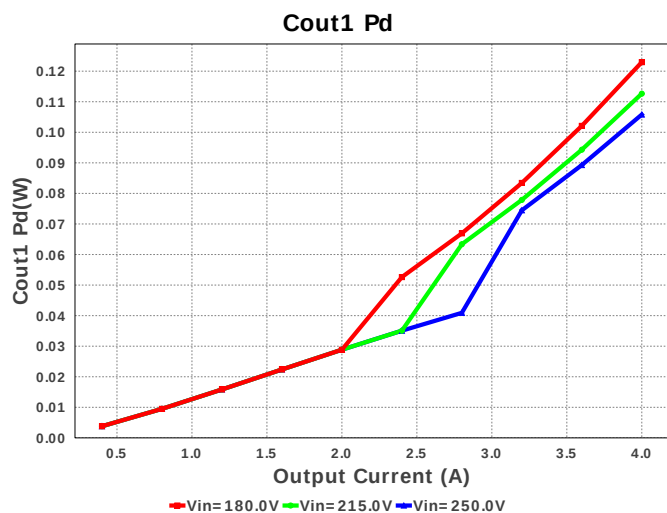


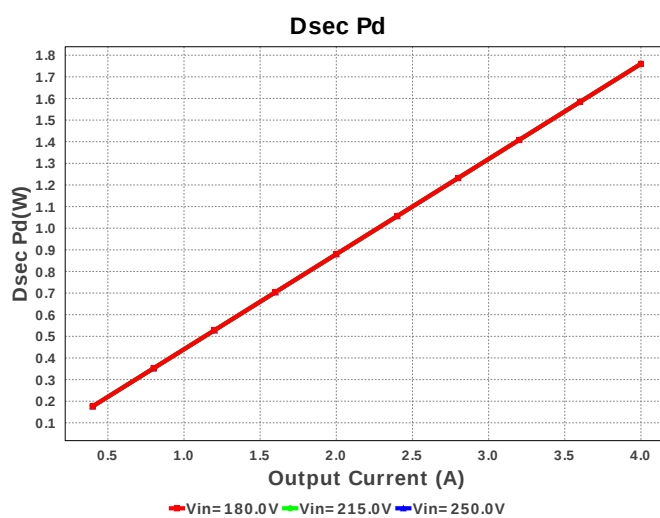
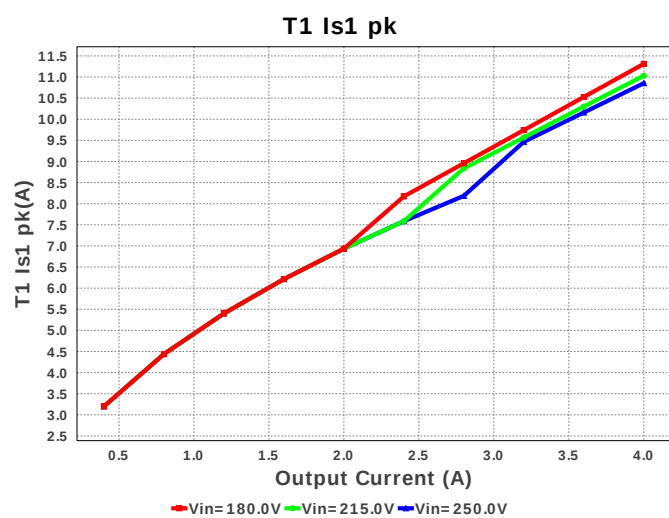
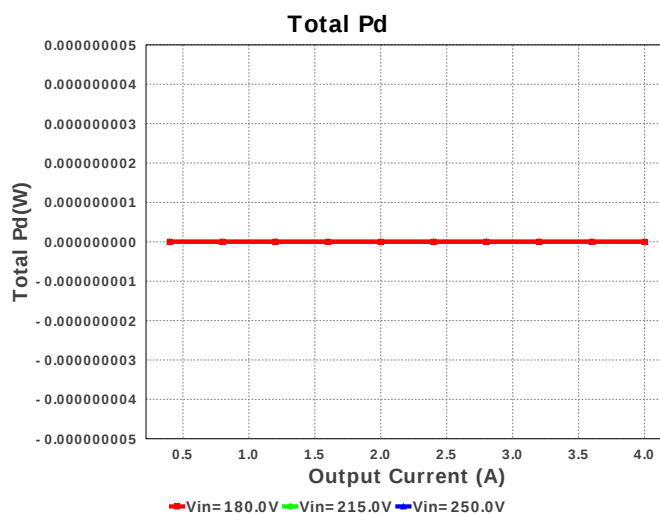
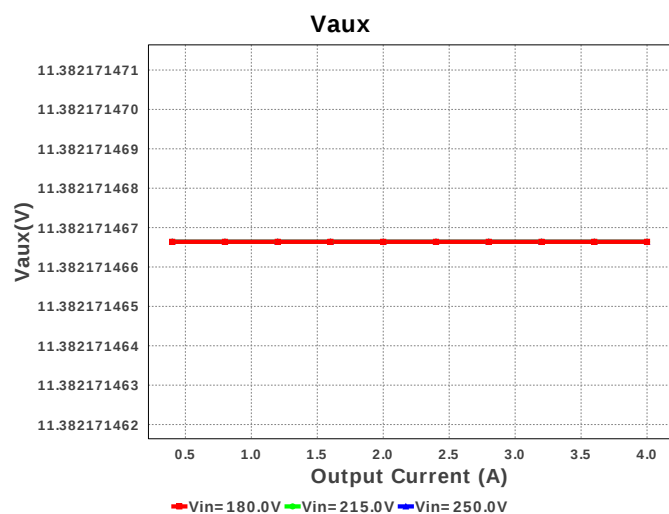
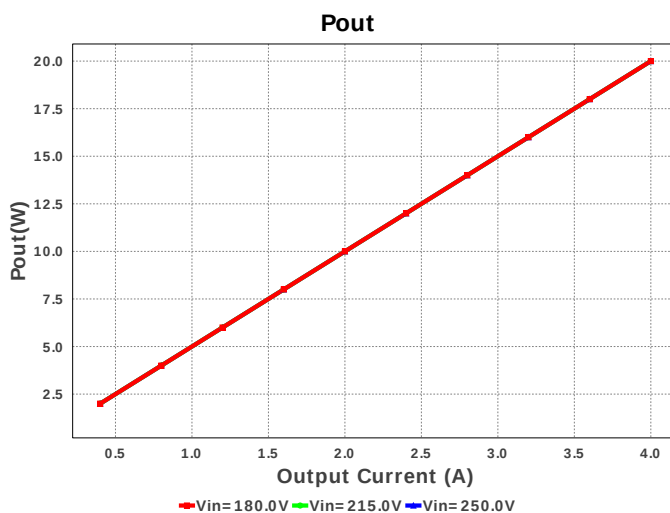
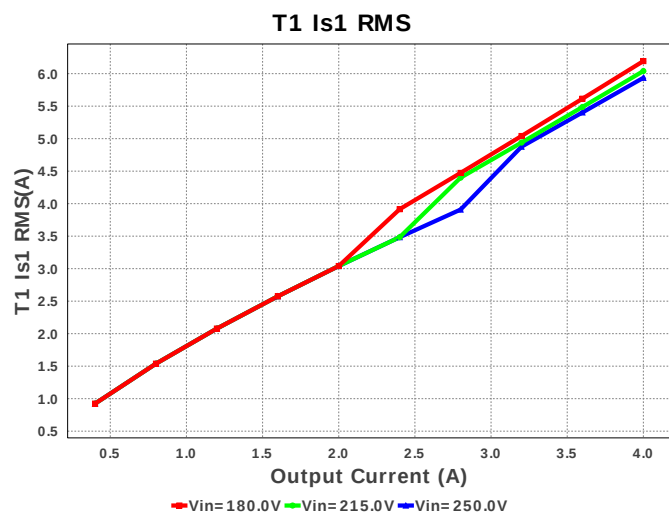
Pd Rstartup

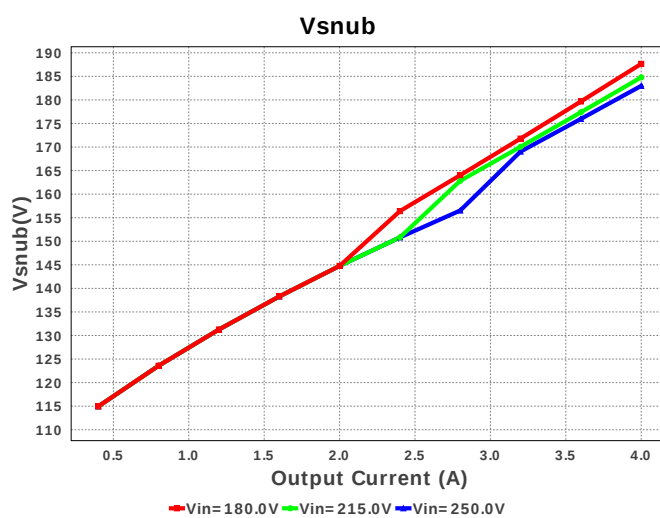
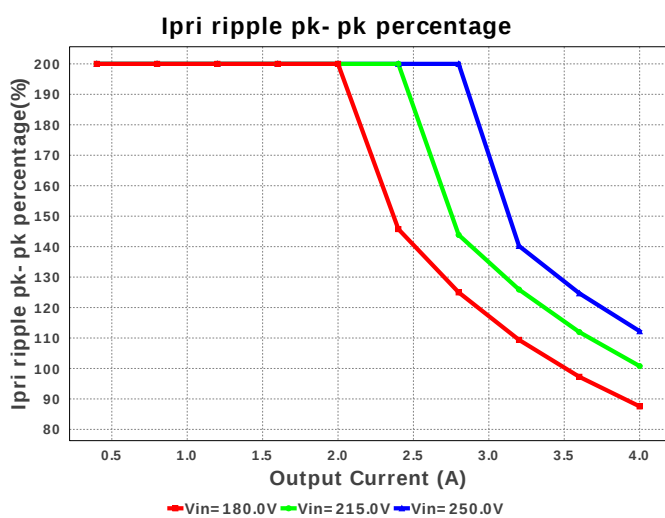
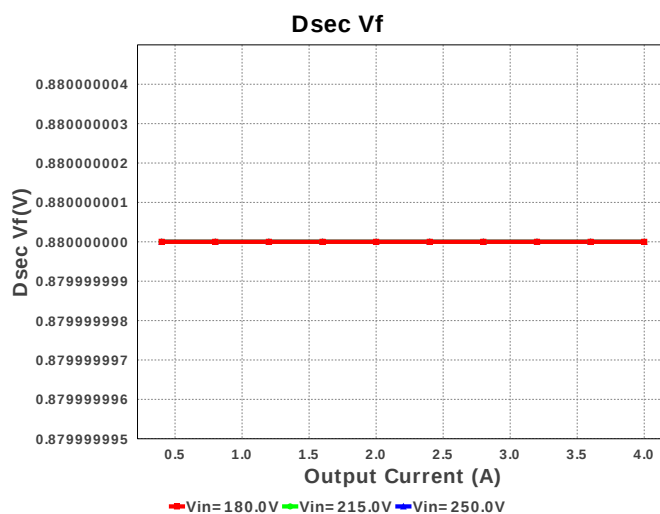
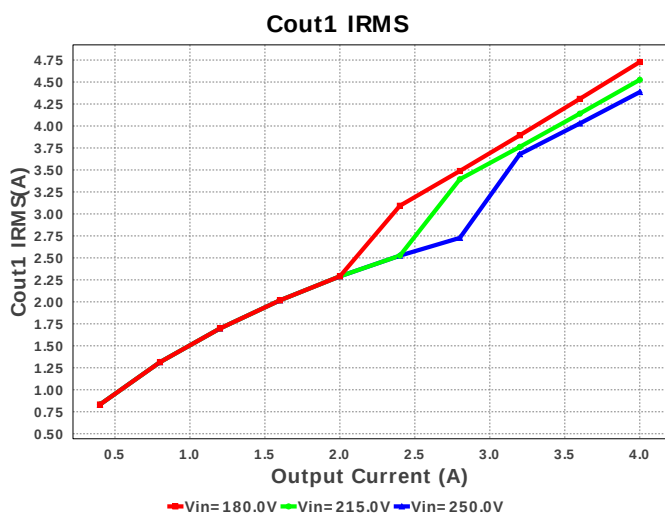
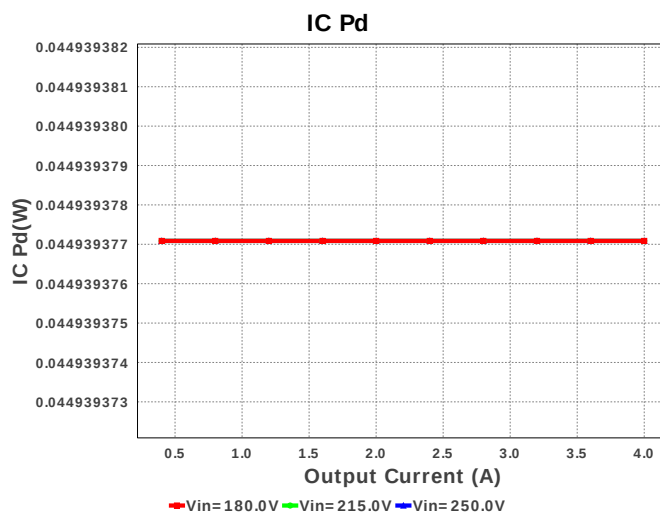
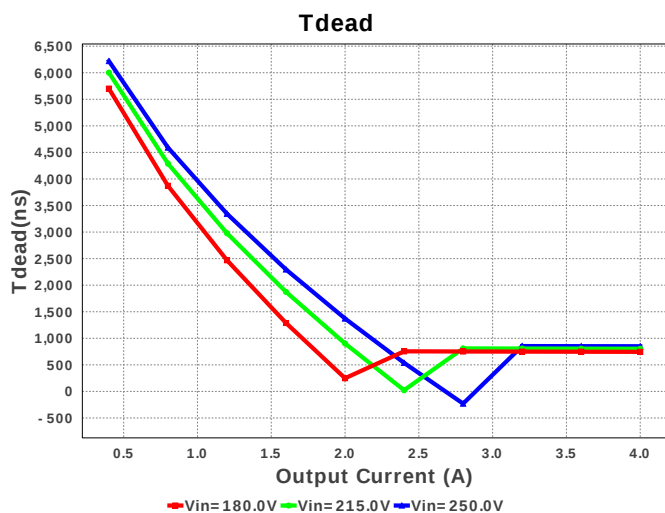


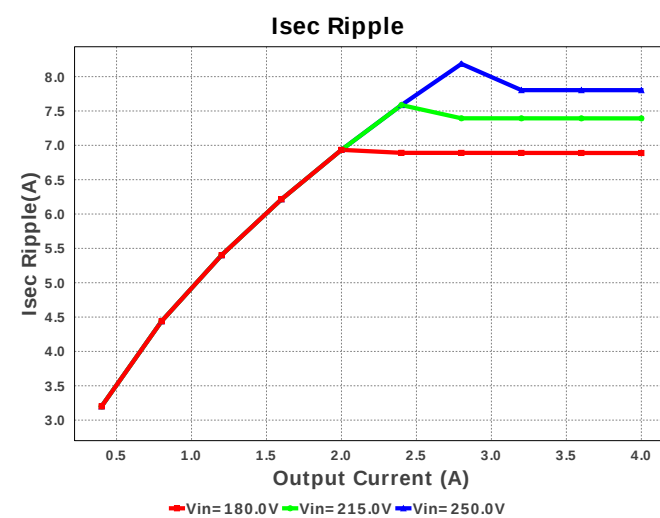
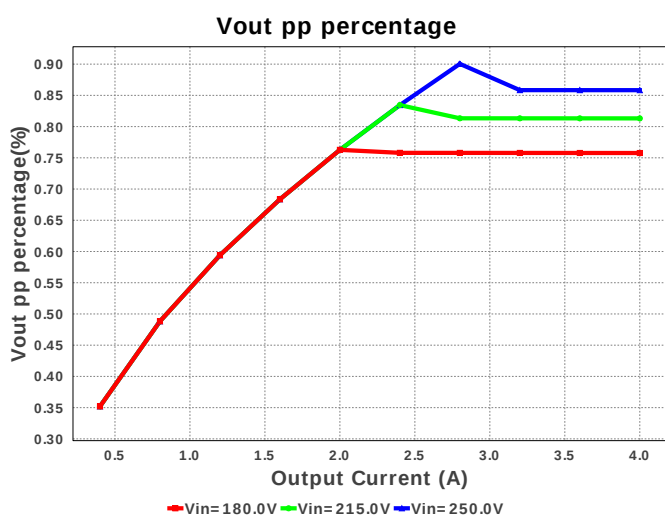
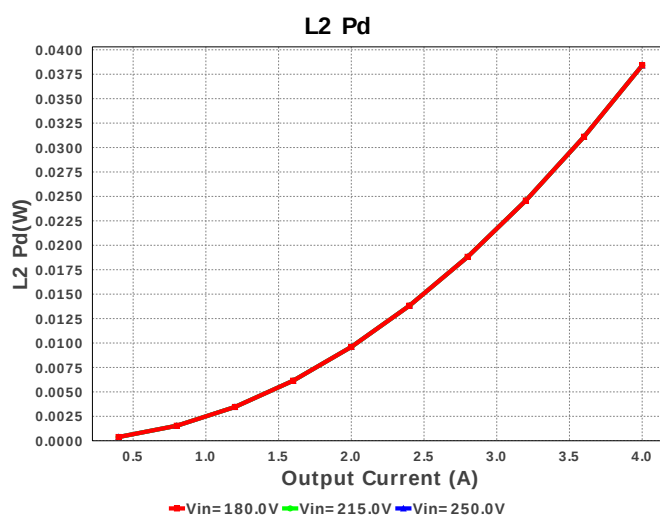
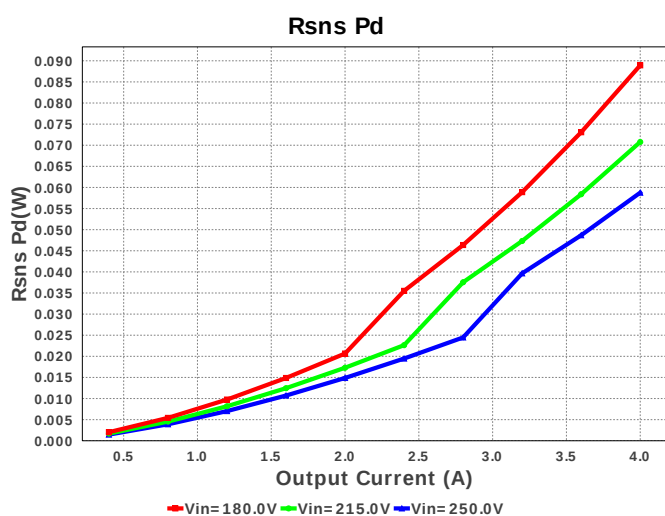
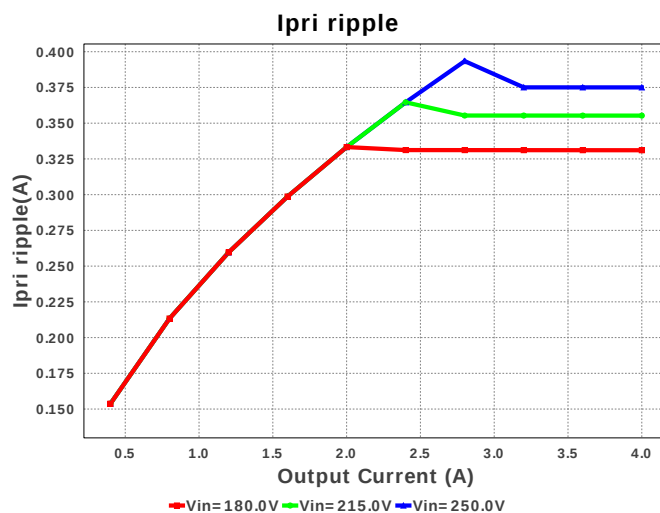
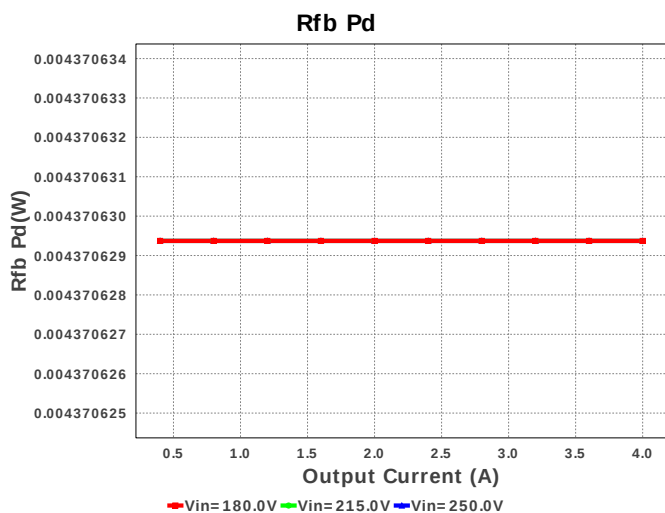
Snubber Pd

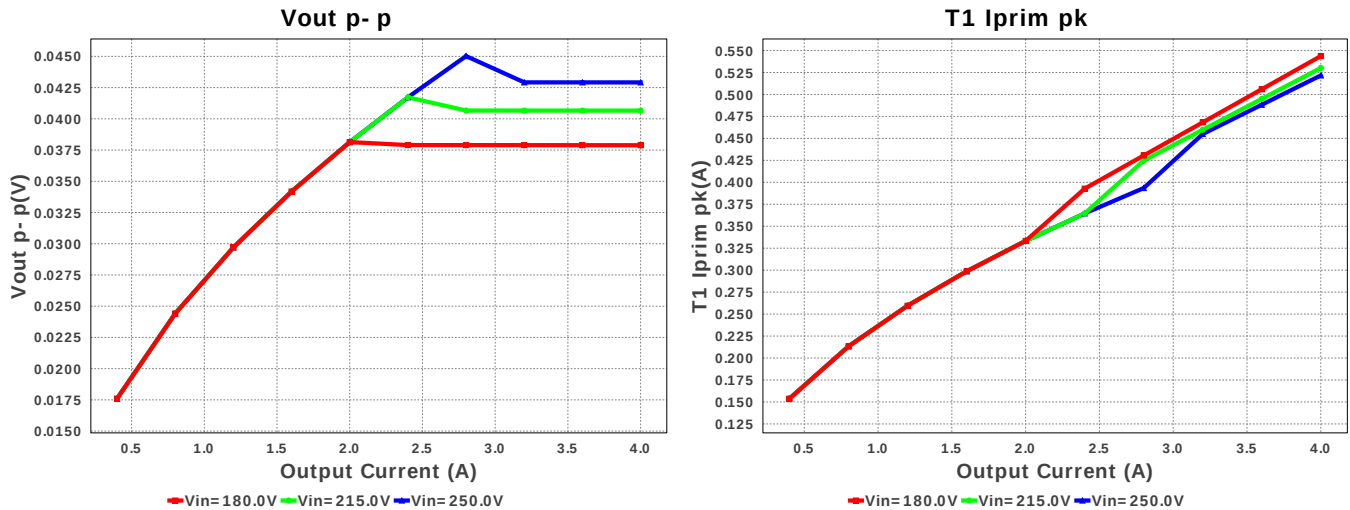












## Operating Values

| #   | Name                         | Value                   | Category | Description                                                           |
|-----|------------------------------|-------------------------|----------|-----------------------------------------------------------------------|
| 1.  | Cout1 IRMS                   | 4.728 A                 | Current  | Output capacitor1 RMS ripple current                                  |
| 2.  | Iin Avg                      | 130.248 mA              | Current  | Average input current                                                 |
| 3.  | Iout_DCM                     | 2.369 A                 | Current  | Approximate Current below which DCM mode of operation will begin      |
| 4.  | Ipri Avg                     | 157.896 mA              | Current  | Average Current in Primary Winding over the complete Switching Period |
| 5.  | Ipri ripple                  | 331.066 mA              | Current  | Ripple Current in the Primary Winding                                 |
| 6.  | Ipri ripple pk-pk percentage | 87.553 %                | Current  | Primary Current pk-pk ripple percentage(of Ipri avg during ton only)  |
| 7.  | Isec Ripple                  | 6.888 A                 | Current  | Ripple Current in the Secondary Winding                               |
| 8.  | T1 Iprim RMS                 | 252.031 mA              | Current  | Transformer Primary RMS Current                                       |
| 9.  | T1 Iprim pk                  | 543.666 mA              | Current  | Transformer Primary Peak Current                                      |
| 10. | T1 Is1 RMS                   | 6.193 A                 | Current  | Transformer Secondary1 RMS Current                                    |
| 11. | T1 Is1 pk                    | 11.311 A                | Current  | Transformer Secondary1 Peak Current                                   |
| 12. | BOM Count                    | 46                      | General  | Total Design BOM count                                                |
| 13. | Daux trr                     | 4.0 ns                  | General  | Auxiliary Diode Reverse Recovery Time                                 |
| 14. | Dsec Vf                      | 880.0 mV                | General  | Effective Forward Voltage Drop at the Operating Current               |
| 15. | Dsec trr                     | 0.0 ns                  | General  | Output Diode Reverse Recovery Time                                    |
| 16. | Dsec2 Vf                     | 437.139 mV              | General  | Effective Forward Voltage Drop at the Operating Current               |
| 17. | Dsnub trr                    | 30.0 ns                 | General  | Snubber Diode Reverse Recovery Time                                   |
| 18. | FootPrint                    | 1.398 k mm <sup>2</sup> | General  | Total Foot Print Area of BOM components                               |
| 19. | Frequency                    | 99.307 kHz              | General  | Switching frequency                                                   |
| 20. | Mode                         | CCM                     | General  | Conduction Mode                                                       |
| 21. | Pout                         | 20.0 W                  | General  | Total output power                                                    |
| 22. | Tdead                        | 745.241 ns              | General  | Approximate Dead Time of the Regulator                                |
| 23. | Toff                         | 5.12 us                 | General  | Approximate Converter Off Time                                        |
| 24. | Ton Act                      | 4.205 us                | General  | Approximate Converter On Time                                         |
| 25. | Total BOM                    | \$0.0                   | General  | Total BOM Cost                                                        |
| 26. | Tsw                          | 10.07 us                | General  | Switching Time Period                                                 |
| 27. | Vaux                         | 11.382 V                | General  | Auxiliary Voltage                                                     |
| 28. | Vsnub                        | 187.652 V               | General  | Voltage Across the Snubber                                            |
| 29. | Vout Actual                  | 4.995 V                 | Op_Point | Vout Actual calculated based on selected voltage divider resistors    |
| 30. | Vout OP                      | 5.0 V                   | Op_Point | Operational Output Voltage                                            |
| 31. | Duty Cycle                   | 41.757 %                | Op_point | Duty cycle                                                            |
| 32. | Efficiency                   | 85.307 %                | Op_point | Steady state efficiency                                               |
| 33. | IC Tj                        | 32.247 degC             | Op_point | IC junction temperature                                               |
| 34. | ICThetaJA                    | 50.0 degC/W             | Op_point | IC junction-to-ambient thermal resistance                             |
| 35. | IOUT_OP                      | 4.0 A                   | Op_point | Iout operating point                                                  |
| 36. | M1 TjOP                      | 35.954 degC             | Op_point | M1 MOSFET junction temperature                                        |
| 37. | Vout p-p                     | 37.885 mV               | Op_point | Peak-to-peak output ripple voltage                                    |
| 38. | Cin Pd                       | 243.008 mW              | Power    | Input capacitor power dissipation                                     |
| 39. | Cout1 Pd                     | 122.944 mW              | Power    | Output capacitor1 power dissipation                                   |
| 40. | Dsec Pd                      | 1.76 W                  | Power    | Secondary Diode Power Dissipation                                     |
| 41. | Dsec2 Pd                     | 874.277 mW              | Power    | Secondary Diode Power Dissipation                                     |
| 42. | IC Pd                        | 44.939 mW               | Power    | IC power dissipation                                                  |
| 43. | L2 Pd                        | 38.4 mW                 | Power    | Average Power Dissipation in the Inductor Over the AC Line Period     |
| 44. | M1 Pd                        | 17.739 mW               | Power    | M1 MOSFET total power dissipation                                     |
| 45. | Paux                         | 18.852 mW               | Power    | Power Dissipation in Raux and Daux                                    |
| 46. | Pd Rstartup                  | 208.463 mW              | Power    | Power Dissipation in Rstartup1 and Rstartup2                          |
| 47. | Rdrv Pd                      | 5.898 μW                | Power    | Power Dissipation in Gate Drive Resistor                              |
| 48. | Rfb Pd                       | 4.371 mW                | Power    | Rfb Power Dissipation                                                 |
| 49. | Rsns Pd                      | 88.928 mW               | Power    | Current Limit Sense Resistor Power Dissipation                        |
| 50. | Snubber Pd                   | 357.938 mW              | Power    | Snubber Power Dissipation                                             |

| #   | Name               | Value      | Category | Description                                                                                |
|-----|--------------------|------------|----------|--------------------------------------------------------------------------------------------|
| 51. | T1 Pd              | 770.203 mW | Power    | Estimated Losses in Transformer                                                            |
| 52. | Total Pd           | 0.0 W      | Power    | Total Power Dissipation                                                                    |
| 53. | Vout Tolerance     | 1.478 %    |          | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |
| 54. | Vout pp percentage | 757.694 m% |          | Output Voltage ripple percentage                                                           |

## Design Inputs

| #  | Name    | Value    | Description            |
|----|---------|----------|------------------------|
| 1. | Iout    | 4.0      | Maximum Output Current |
| 2. | VinMax  | 250.0    | Maximum input voltage  |
| 3. | VinMin  | 180.0    | Minimum input voltage  |
| 4. | Vout    | 5.0      | Output Voltage         |
| 5. | base_pn | UCC28C41 | Base Product Number    |
| 6. | source  | DC       | Input Source Type      |
| 7. | Ta      | 30.0     | Ambient temperature    |

## Design Assistance

1. **UCC28C41** Product Folder : <http://www.ti.com/product/UCC28C41> : contains the data sheet and other resources.

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