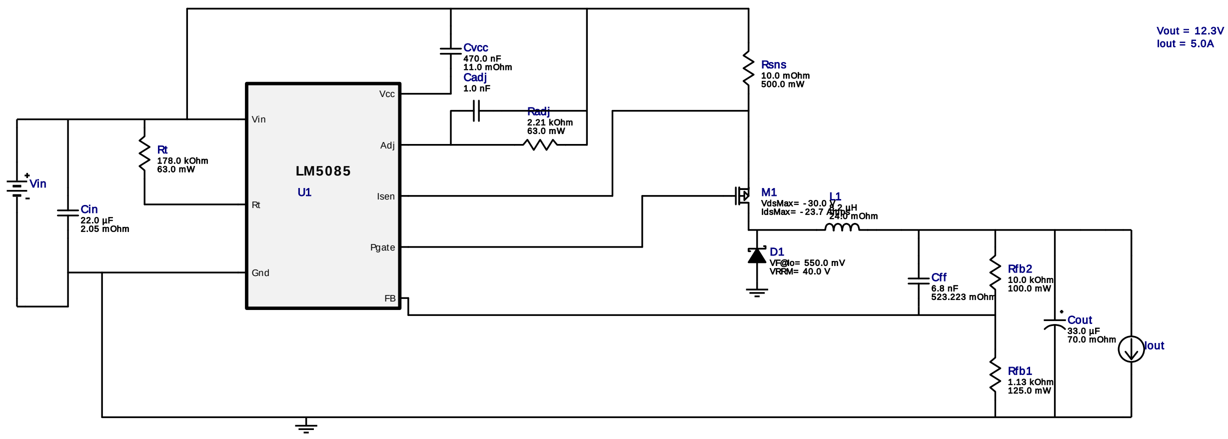
TEXAS INSTRUMENTS

# WEBENCH ® Design Report

VinMin = 14.0V
VinMax = 22.0V
Vout = 12.3V
Iout = 5.0A

Device = LM5085MY/NOPB
Topology = Buck
Created = 2017-09-07 20:10:19.551
BOM Cost = $3.88
BOM Count = 14
Total Pd = 4.51W

Design : 4153829/18 LM5085MY/NOPB
LM5085MY/NOPB 14.0V-22.0V to 12.30V @ 5.0A

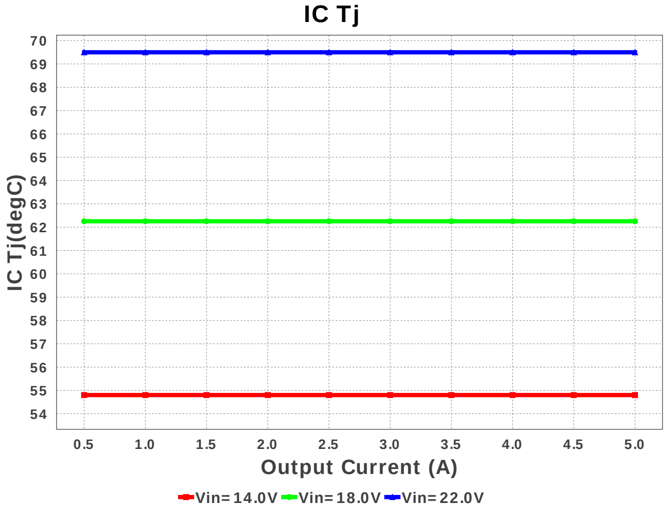



## Electrical BOM

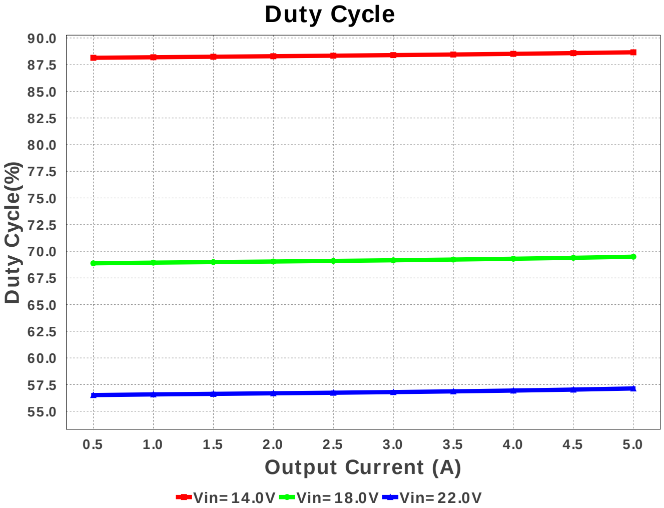
| # | Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|---|
| 1. | Cadj | MuRata | GRM216R71E102KA01D<br>Series= X7R | Cap= 1.0 nF<br>VDC= 25.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0805 7 mm² |
| 2. | Cff | TDK | CGA2B3X7S2A682K050BB<br>Series= X7S | Cap= 6.8 nF<br>ESR= 523.22 mOhm<br>VDC= 100.0 V<br>IRMS= 273.561 mA | 1 | $0.01 | 0402 3 mm² |
| 3. | Cin | TDK | C2012X5R1V226M125AC<br>Series= X5R | Cap= 22.0 uF<br>ESR= 2.05 mOhm<br>VDC= 35.0 V<br>IRMS= 4.5559 A | 1 | $0.33 | 0805 7 mm² |
| 4. | Cout | Panasonic | 16TQC33MYFD<br>Series= TQC | Cap= 33.0 uF<br>ESR= 70.0 mOhm<br>VDC= 16.0 V<br>IRMS= 1.4 A | 1 | $0.76 | 7343-20 59 mm² |
| 5. | Cvcc | AVX | 0805YC474KAT2A<br>Series= X7R | Cap= 470.0 nF<br>ESR= 11.0 mOhm<br>VDC= 16.0 V<br>IRMS= 0.0 A | 1 | $0.02 | 0805 7 mm² |
| 6. | D1 | Diodes Inc. | B540C-13-F | VF@Io= 550.0 mV<br>VRRM= 40.0 V | 1 | $0.19 | SMC 83 mm² |
| 7. | L1 | Coilcraft | XAL6060-822MEB | L= 8.2 µH<br>DCR= 24.0 mOhm | 1 | $0.82 | XAL6060 72 mm² |
| 8. | M1 | Vishay-Siliconix | Si7149DP | VdsMax= -30.0 V<br>IdsMax= -23.7 Amps | 1 | $0.74 | PowerPAK_SO-8 55 mm² |
| 9. | Radj | Vishay-Dale | CRCW04022K21FKED<br>Series= CRCW..e3 | Res= 2.21 kOhm<br>Power= 63.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0402 3 mm² |

| # | Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|---|
| 10. | Rfb1 | Panasonic | ERJ-6ENF1131V<br>Series= ERJ-6E | Res= 1.13 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 $mm^2$ |
| 11. | Rfb2 | Susumu Co Ltd | RR1220P-103-D<br>Series= RR12 | Res= 10.0 kOhm<br>Power= 100.0 mW<br>Tolerance= 0.5% | 1 | $0.01 | 0805 7 $mm^2$ |
| 12. | Rsns | Stackpole Electronics Inc | CSR1206FK10L0<br>Series= ? | Res= 10.0 mOhm<br>Power= 500.0 mW<br>Tolerance= 1.0% | 1 | $0.11 | 1206 11 $mm^2$ |
| 13. | 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 $mm^2$ |
| 14. | U1 | Texas Instruments | LM5085MY/NOPB | Switcher | 1 | $0.85 | MUY08A 24 $mm^2$ |

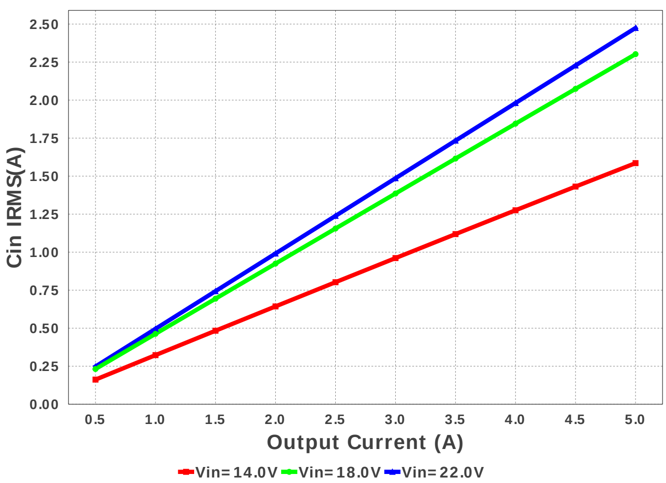
IC Tj



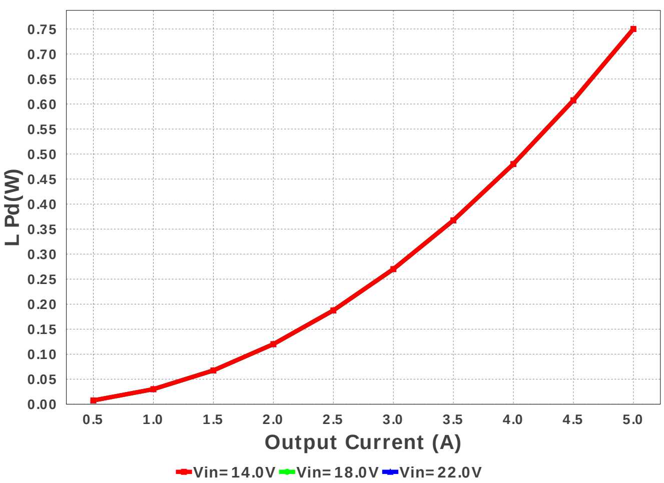

Duty Cycle

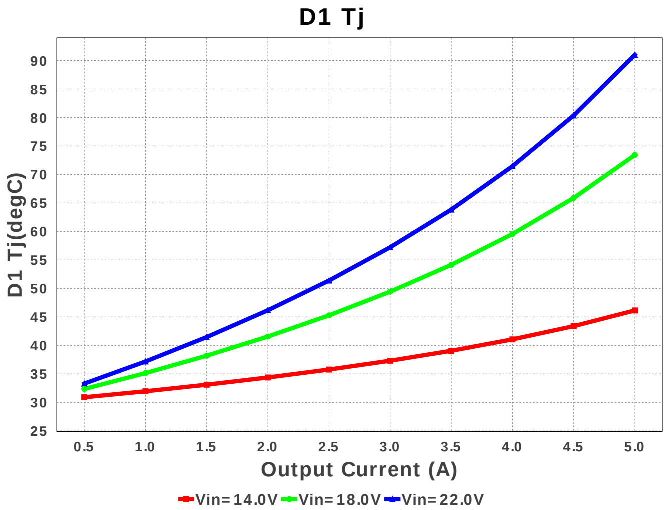


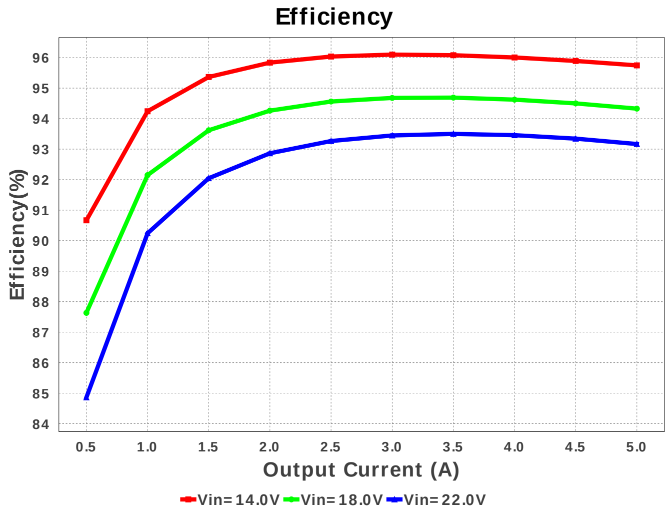

Cin IRMS

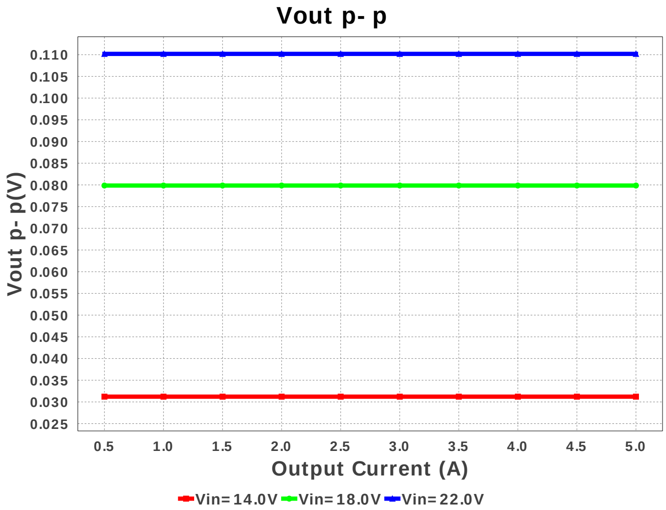


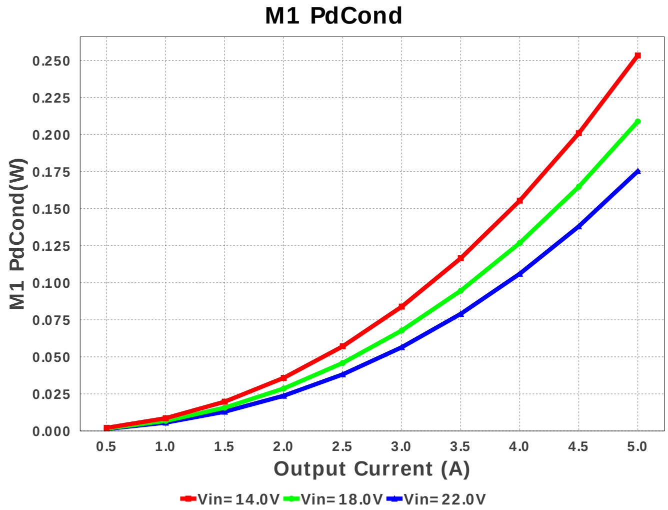

L Pd

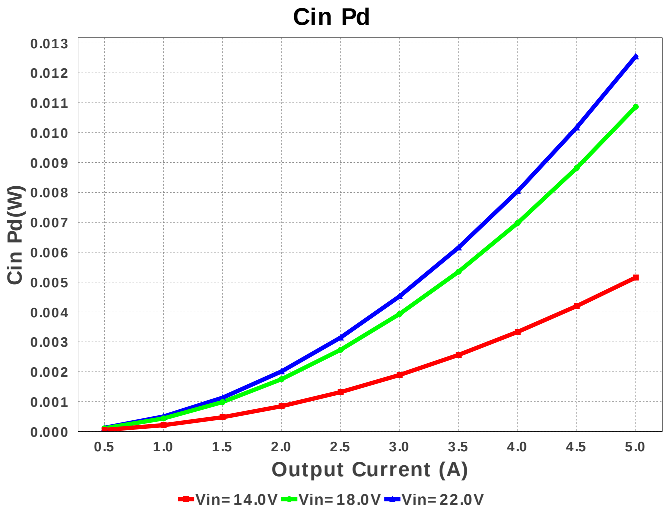


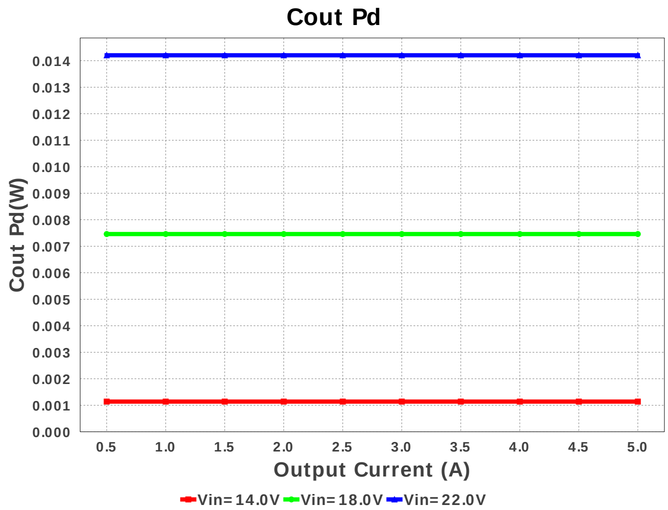

D1 Tj
D1 Tj(degC)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Output Current (A)
Vin=14.0V
Vin=18.0V
Vin=22.0V


Efficiency
Efficiency(%)
96
95
94
93
92
91
90
89
88
87
86
85
84
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Output Current (A)
Vin=14.0V
Vin=18.0V
Vin=22.0V

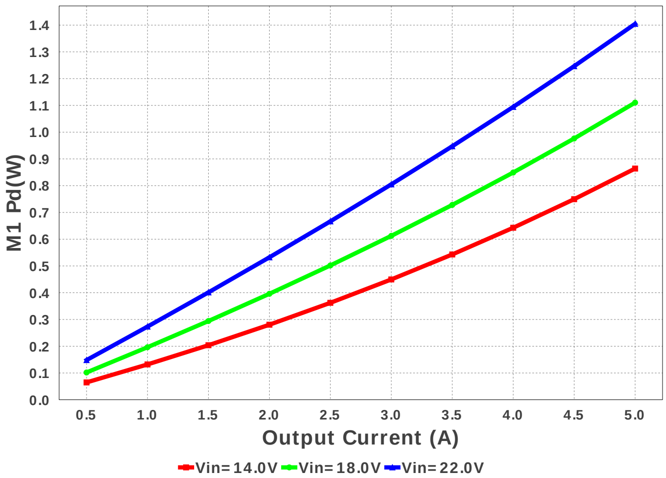

Vout p-p
Vout p-p(V)
0.110
0.105
0.100
0.095
0.090
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Output Current (A)
Vin=14.0V
Vin=18.0V
Vin=22.0V


M1 PdCond
M1 PdCond(W)
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Output Current (A)
Vin=14.0V
Vin=18.0V
Vin=22.0V

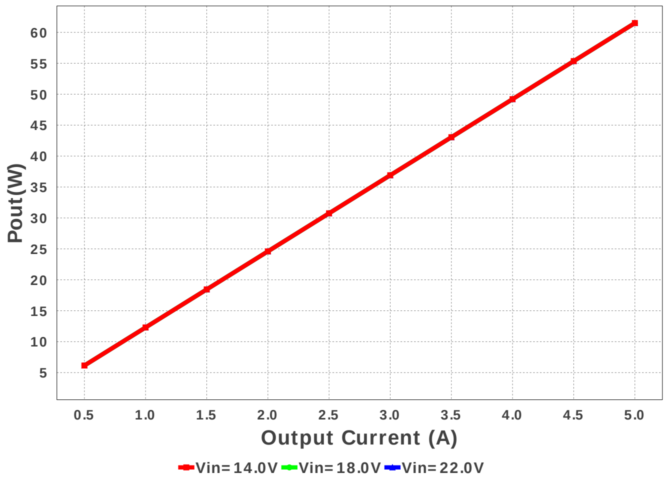

Cin Pd
Cin Pd(W)
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Output Current (A)
Vin=14.0V
Vin=18.0V
Vin=22.0V


Cout Pd
Cout Pd(W)
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Output Current (A)
Vin=14.0V
Vin=18.0V
Vin=22.0V

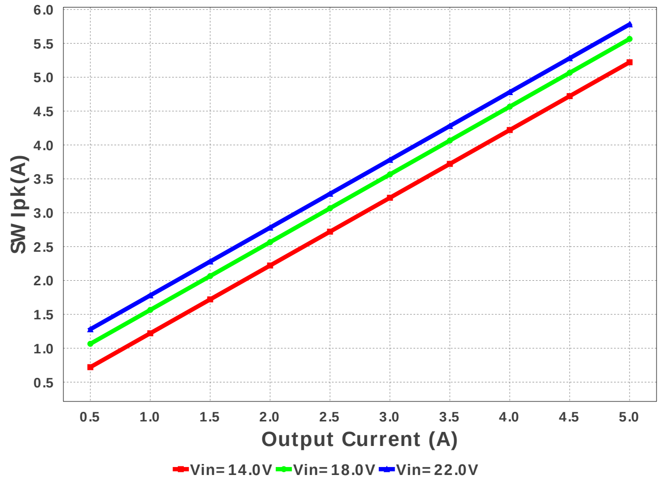
## M1 Pd



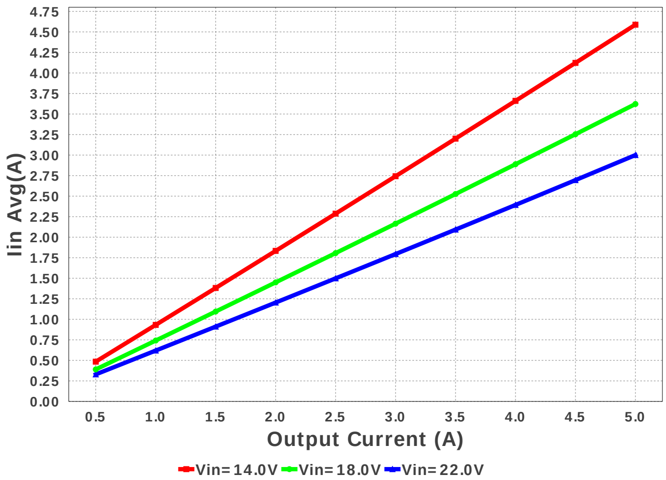

## Pout



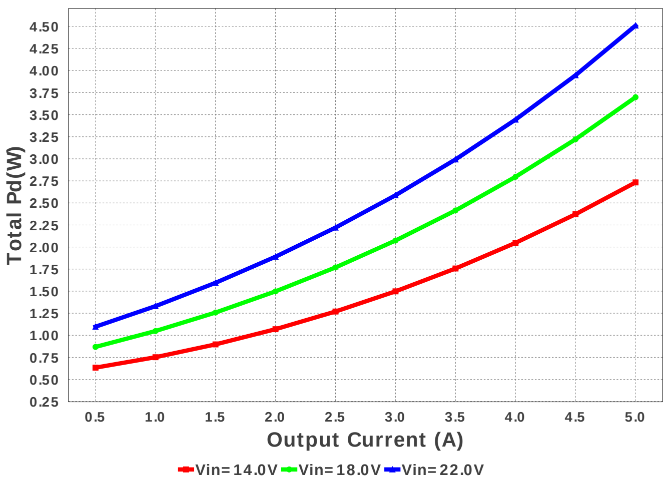

## SW Ipk



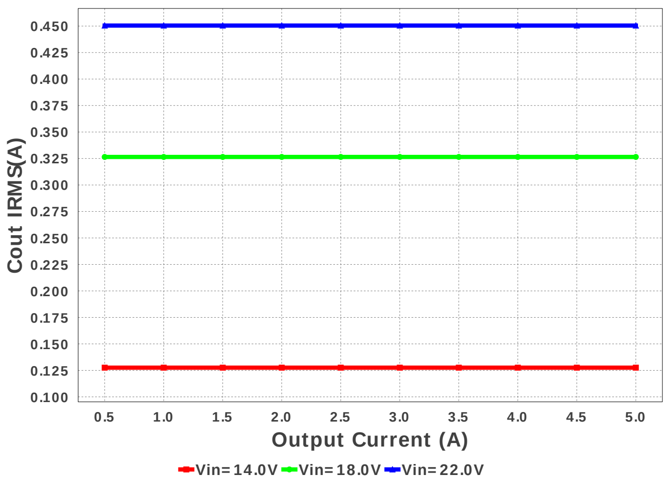

## Iin Avg

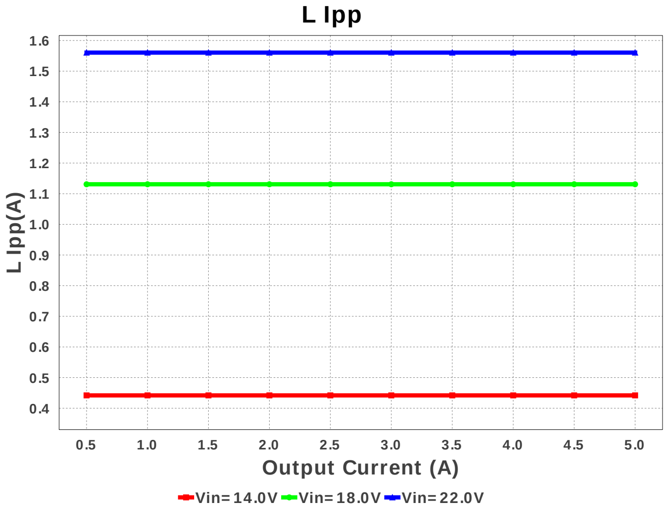


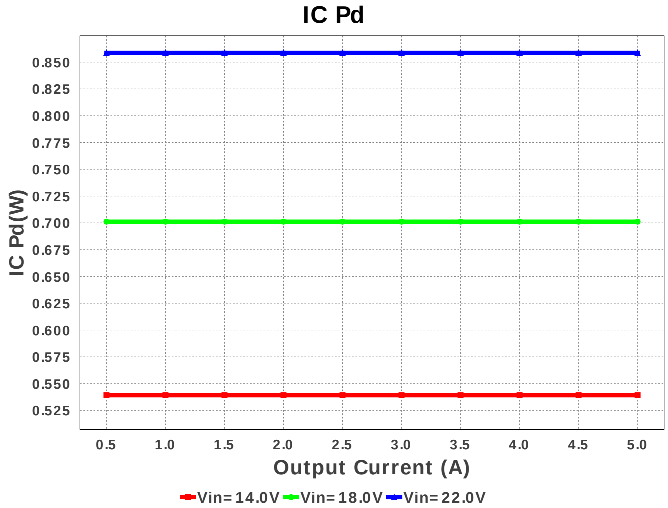

## Total Pd

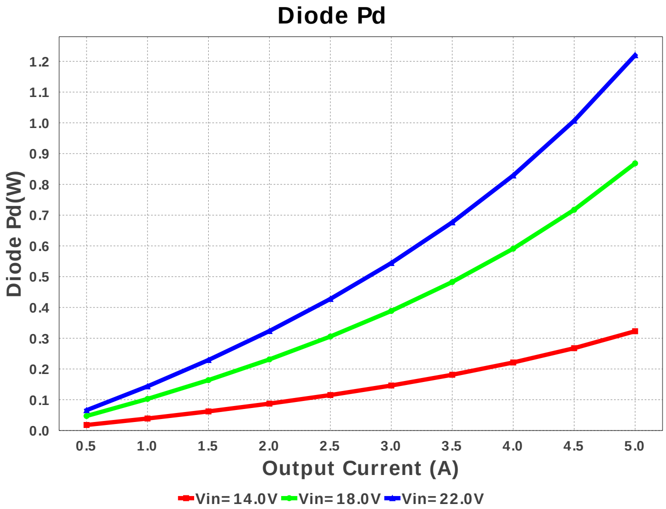


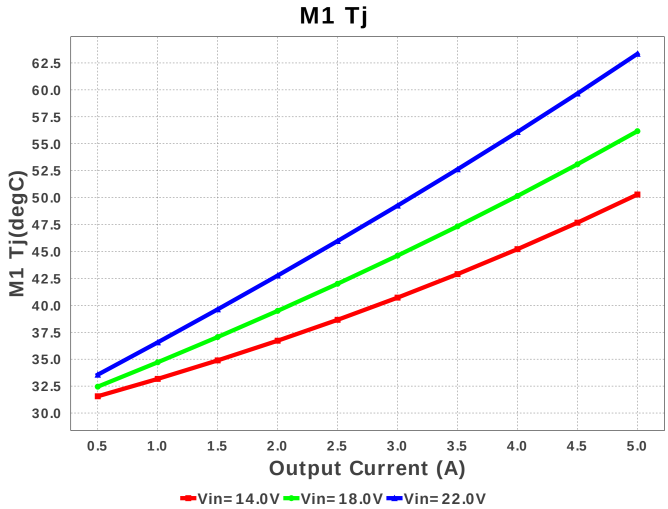

## Cout IRMS

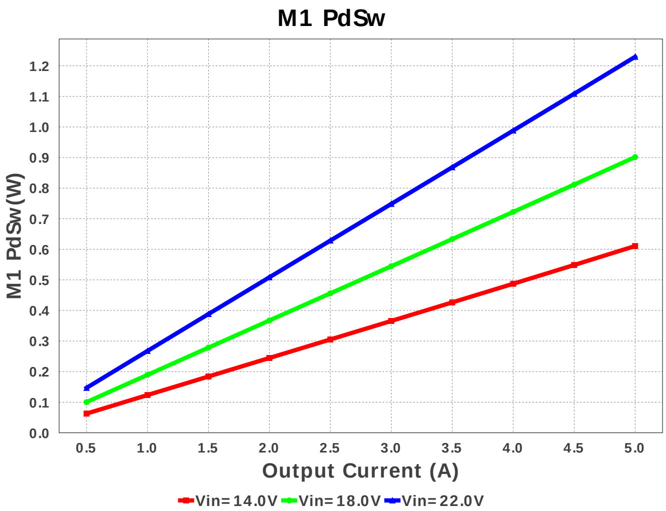





## Operating Values

| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 1. | Cin IRMS | 2.474 A | Current | Input capacitor RMS ripple current |
| 2. | Cout IRMS | 450.469 mA | Current | Output capacitor RMS ripple current |
| 3. | Iin Avg | 3.0 A | Current | Average input current |
| 4. | L Ipp | 1.56 A | Current | Peak-to-peak inductor ripple current |
| 5. | SW Ipk | 5.78 A | Current | Peak switch current |
| 6. | BOM Count | 14 | General | Total Design BOM count |
| 7. | FootPrint | 346.0 $mm^2$ | General | Total Foot Print Area of BOM components |
| 8. | Frequency | 408.345 kHz | General | Switching frequency |
| 9. | IC Tolerance | 25.0 mV | General | IC Feedback Tolerance |
| 10. | Mode | CCM | General | Conduction Mode |
| 11. | Pout | 61.5 W | General | Total output power |

| # | Name | Value | Category | Description |
|---|---|---|---|---|
| 12. | Total BOM | $3.88 | General | Total BOM Cost |
| 13. | D1 Tj | 90.998 degC | Op_Point | D1 junction temperature |
| 14. | Vout Actual | 12.312 V | Op_Point | Vout Actual calculated based on selected voltage divider resistors |
| 15. | Vout OP | 12.3 V | Op_Point | Operational Output Voltage |
| 16. | Duty Cycle | 57.135 % | Op_point | Duty cycle |
| 17. | Efficiency | 93.174 % | Op_point | Steady state efficiency |
| 18. | IC Tj | 69.499 degC | Op_point | IC junction temperature |
| 19. | ICThetaJA | 46.0 degC/W | Op_point | IC junction-to-ambient thermal resistance |
| 20. | IOUT_OP | 5.0 A | Op_point | Iout operating point |
| 21. | M1 Tj | 63.346 degC | Op_point | M1 MOSFET junction temperature |
| 22. | VIN_OP | 22.0 V | Op_point | Vin operating point |
| 23. | Vout p-p | 110.188 mV | Op_point | Peak-to-peak output ripple voltage |
| 24. | Cin Pd | 12.552 mW | Power | Input capacitor power dissipation |
| 25. | Cout Pd | 14.205 mW | Power | Output capacitor power dissipation |
| 26. | Diode Pd | 1.22 W | Power | Diode power dissipation |
| 27. | IC Pd | 858.685 mW | Power | IC power dissipation |
| 28. | L Pd | 750.0 mW | Power | Inductor power dissipation |
| 29. | M1 Pd | 1.4 W | Power | M1 MOSFET total power dissipation |
| 30. | M1 PdCond | 170.755 mW | Power | M1 MOSFET conduction losses |
| 31. | M1 PdSw | 1.229 W | Power | M1 MOSFET switching losses |
| 32. | Total Pd | 4.506 W | Power | Total Power Dissipation |
| 33. | Vout Tolerance | 3.388 % | | Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable |

## Design Inputs

| # | Name | Value | Description |
|---|---|---|---|
| 1. | Iout | 5.0 | Maximum Output Current |
| 2. | VinMax | 22.0 | Maximum input voltage |
| 3. | VinMin | 14.0 | Minimum input voltage |
| 4. | Vout | 12.3 | Output Voltage |
| 5. | base_pn | LM5085 | Texas Instruments Base Part Number |
| 6. | source | DC | Input Source Type |
| 7. | ta | 30.0 | Ambient temperature |

## Design Assistance

1. For a Constant On Time device to be stable, we need to provide a ripple at the feedback comparator. There are various methods to implement the ripple. Depending on the circuit complexity vs. the allowable ripple, we have three options to choose from. The simplest option, 'Low Complexity', would require only a high ESR cap at the output. This means that the BOM count will be small, but the output voltage ripple will be quite large. The 'optimal solution' would require a feed-forward cap in parallel with the upper feedback resistor to AC couple the ripple to the feedback node. This increases the BOM count slightly, but now we have more control over the output voltage ripple. If the output voltage requirement is very tight, then the best option is to go for the 'Low Output Ripple' solution. In this option we can go with very low ESR output caps and have very good control over the output voltage ripple

2. LM5085 Product Folder : http://www.ti.com/product/LM5085 : contains the data sheet and other resources.