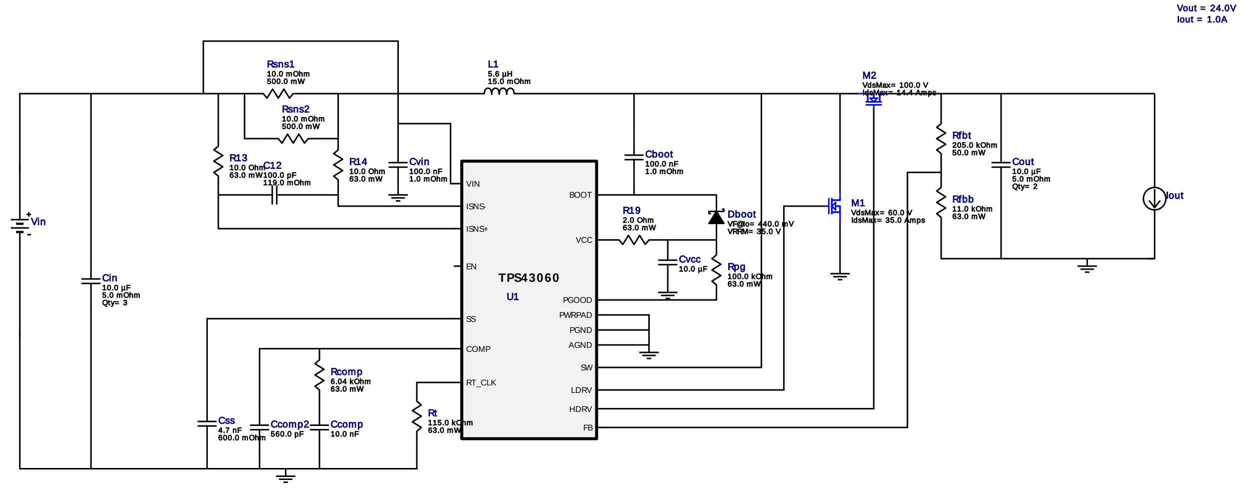
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 6.0V
VinMax = 10.0V
Vout = 24.0V
Iout = 1.0A

Device = TPS43060RTER
Topology = Boost
Created = 2020-09-14 19:02:05.162
BOM Cost = $3.36
BOM Count = 27
Total Pd = 2.75W

Design : 414 TPS43060RTER
TPS43060RTER 6V-10V to 24.00V @ 1A

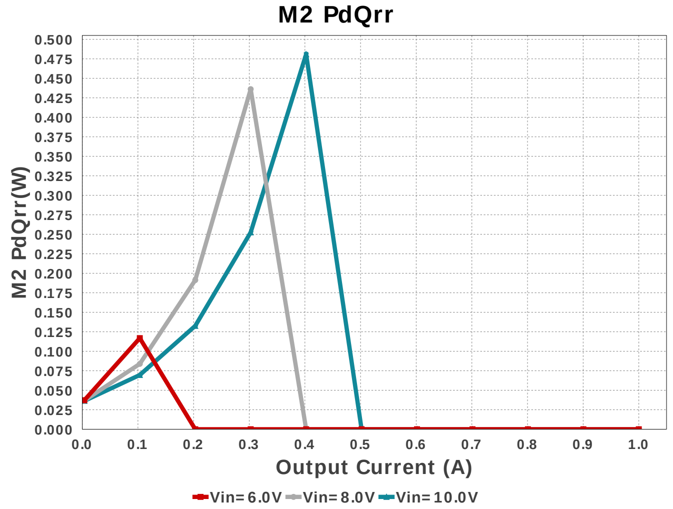


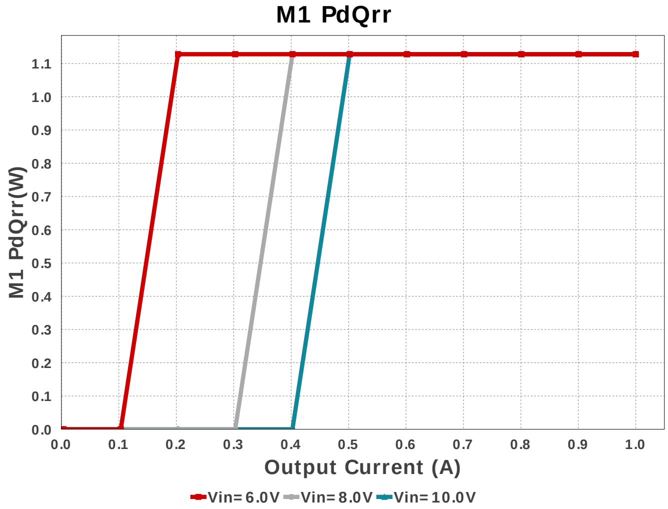
1. The pulse skip mode in the device has not been modeled. Efficiency and operational parameters of the model in pulse skip mode is not valid.

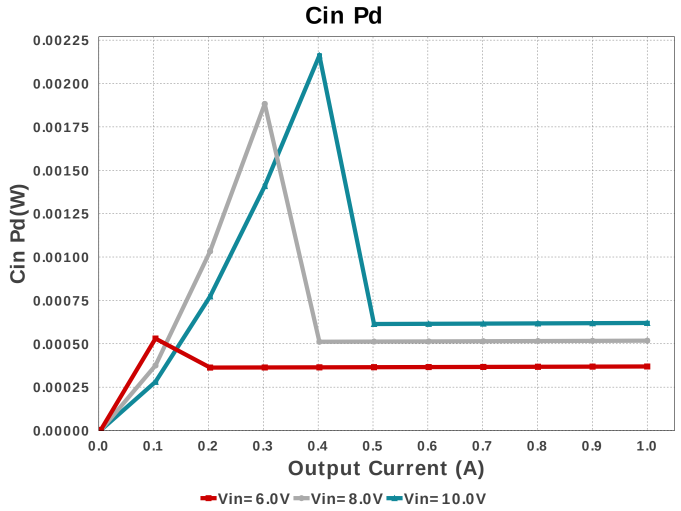
Electrical BOM

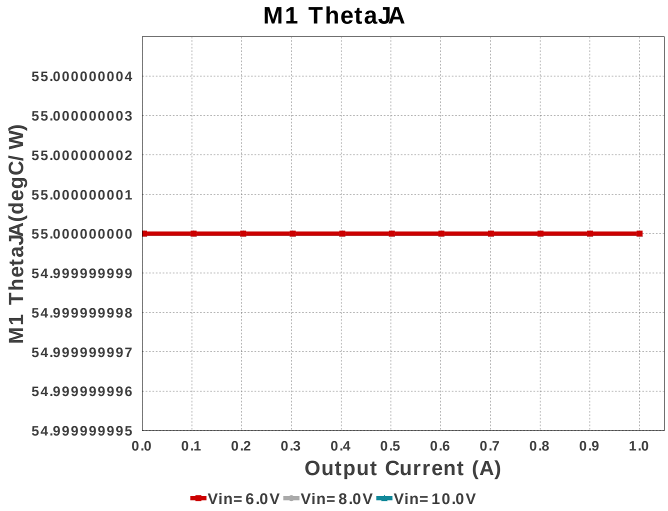
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C12	AVX	06035A101JAT2A Series= C0G/NP0	Cap= 100.0 pF ESR= 119.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Cboot	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp	TDK	CGA4C2C0G1H103J060AA Series= C0G/NP0	Cap= 10.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm^2
Ccomp2	MuRata	GRM1555C1H561JA01J Series= C0G/NP0	Cap= 560.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	Samsung Electro-Mechanics	CL32B106KBJNNWE Series= X7R	Cap= 10.0 uF ESR= 5.0 mOhm VDC= 50.0 V IRMS= 0.0 A	3	$0.17	1210_270 15 mm^2
Cout	Samsung Electro-Mechanics	CL32B106KBJNNWE Series= X7R	Cap= 10.0 uF ESR= 5.0 mOhm VDC= 50.0 V IRMS= 0.0 A	2	$0.17	1210_270 15 mm^2
Css	MuRata	GRM188R71E472KA01D Series= X7R	Cap= 4.7 nF ESR= 600.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Cvcc	Taiyo Yuden	EMK107BBJ106MA-T Series= X5R	Cap= 10.0 uF VDC= 16.0 V IRMS= 0.0 A	1	$0.07	0603 5 mm^2
Cvin	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2

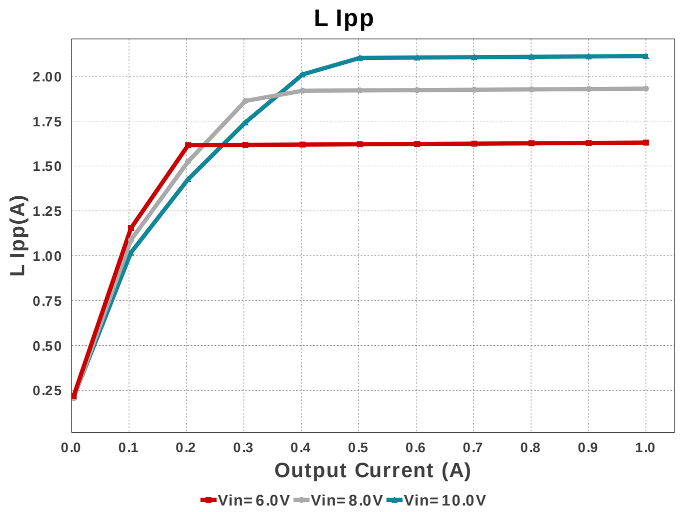
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Dboot	Bourns	CD0603-B0130L	VF@Io= 440.0 mV VRRM= 35.0 V	1	$0.09	Diode_0603 5 mm²
L1	Bourns	SDR1307-5R6ML	L= 5.6 µH 15.0 mOhm	1	$0.42	SDR1307 226 mm²
M1	Texas Instruments	CSD18543Q3A	VdsMax= 60.0 V IdsMax= 35.0 Amps	1	$0.25	DNH0008A 18 mm²
M2	Texas Instruments	CSD19538Q2	VdsMax= 100.0 V IdsMax= 14.4 Amps	1	$0.15	DQK0006C 9 mm²
R13	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R14	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R19	Vishay-Dale	CRCW04022R00FKED Series= CRCW..e3	Res= 2.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcomp	Vishay-Dale	CRCW04026K04FKED Series= CRCW..e3	Res= 6.04 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Vishay-Dale	CRCW040211K0FKED Series= CRCW..e3	Res= 11.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Yageo	RC0201FR-07205KL Series= ?	Res= 205.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rpg	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsns1	Stackpole Electronics Inc	CSR1206FK10L0 Series= ?	Res= 10.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.12	1206 11 mm²
Rsns2	Stackpole Electronics Inc	CSR1206FK10L0 Series= ?	Res= 10.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.12	1206 11 mm²
Rt	Vishay-Dale	CRCW0402115KFKED Series= CRCW..e3	Res= 115.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	TPS43060RTER	Switcher	1	$1.10	S-PVQFN-N16 17 mm²

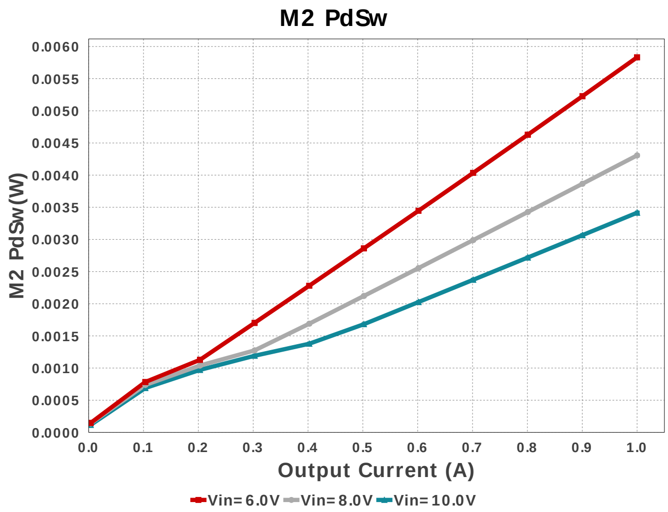

M2 PdQrr
M2 PdQrr(W)
0.000
0.025
0.050
0.075
0.100
0.125
0.150
0.175
0.200
0.225
0.250
0.275
0.300
0.325
0.350
0.375
0.400
0.425
0.450
0.475
0.500
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

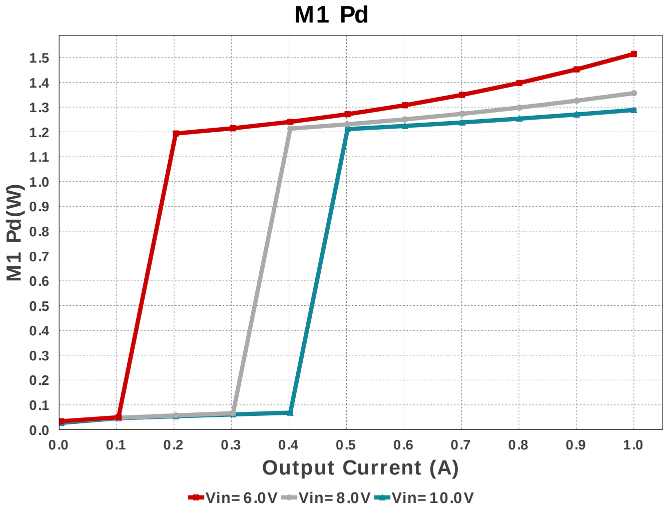

M1 PdQrr
M1 PdQrr(W)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

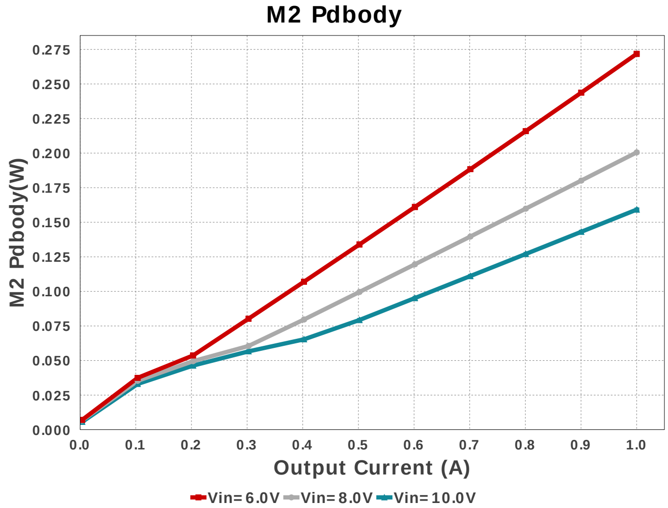

Cin Pd
Cin Pd(W)
0.00000
0.00025
0.00050
0.00075
0.00100
0.00125
0.00150
0.00175
0.00200
0.00225
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

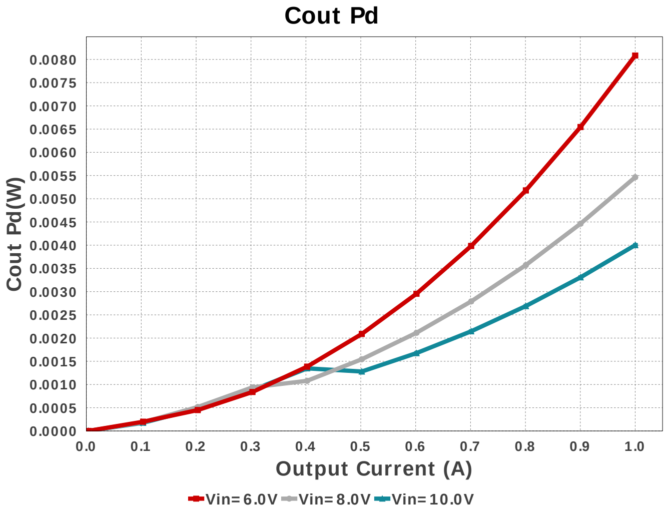

M1 ThetaJA
M1 ThetaJA(degC/W)
54.999999995
54.999999996
54.999999997
54.999999998
54.999999999
55.000000000
55.000000001
55.000000002
55.000000003
55.000000004
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

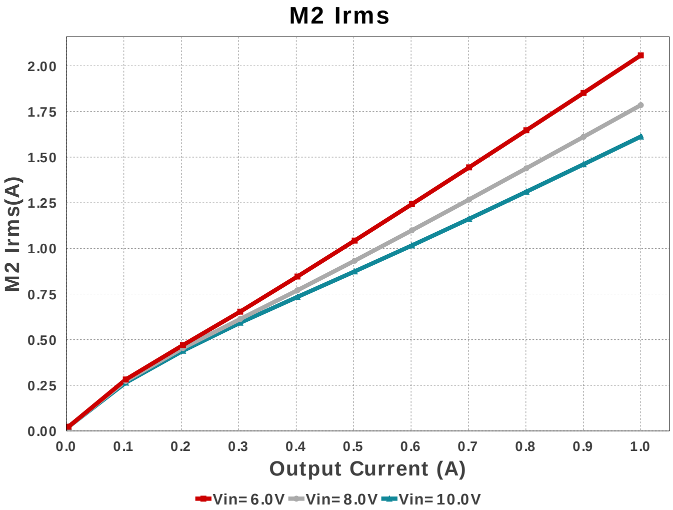

L Ipp
L Ipp(A)
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

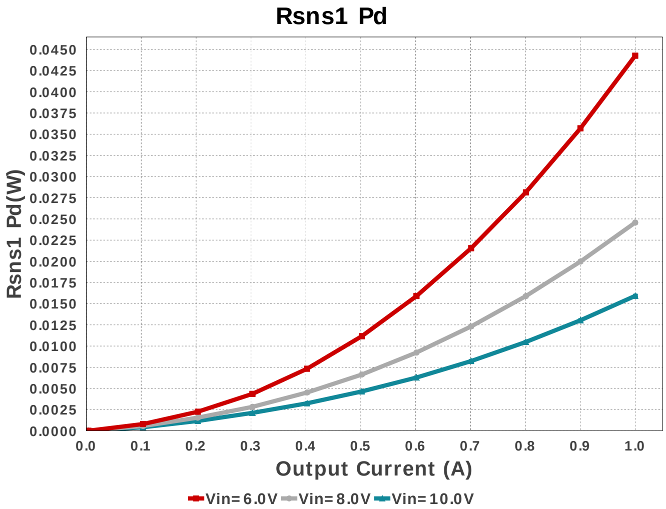

M2 PdSw
M2 PdSw(W)
0.0000
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
0.0035
0.0040
0.0045
0.0050
0.0055
0.0060
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

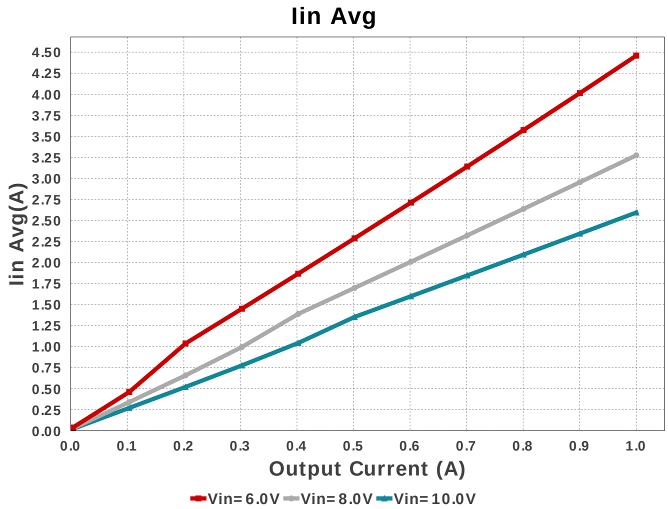

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

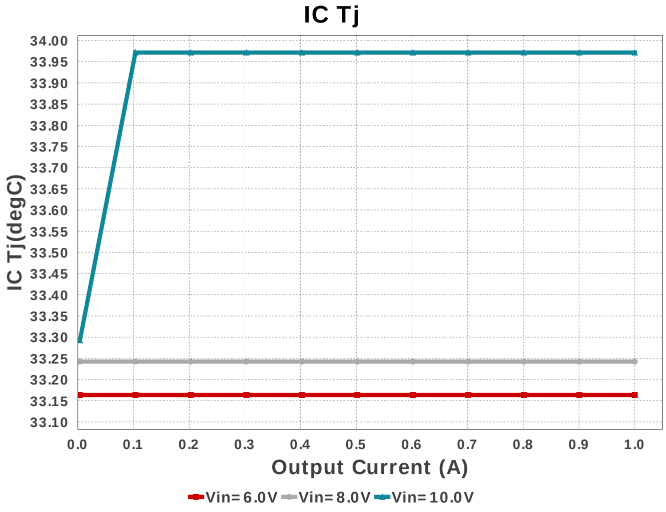

M2 Pdbody
M2 Pdbody(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

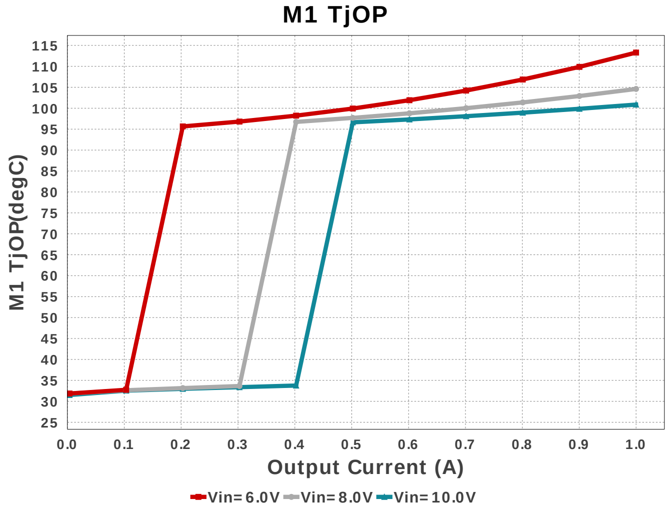

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

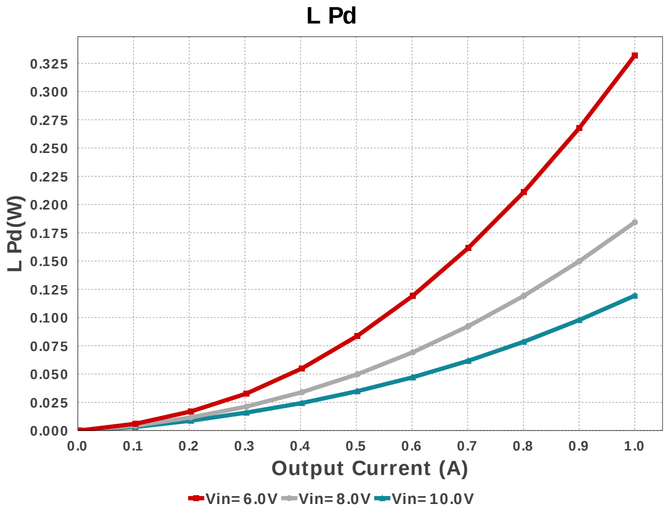

M2 Irms
M2 Irms(A)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

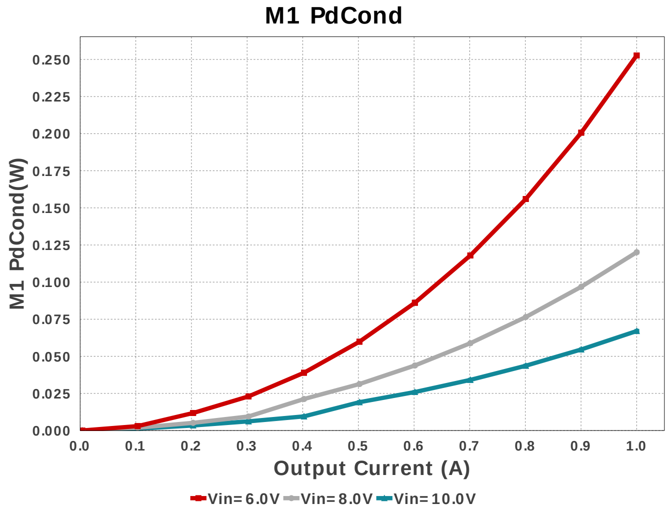

Rsns1 Pd
Rsns1 Pd(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

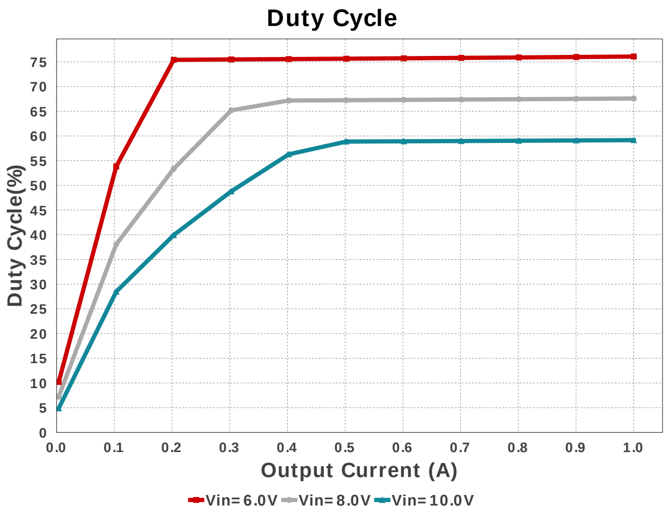

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

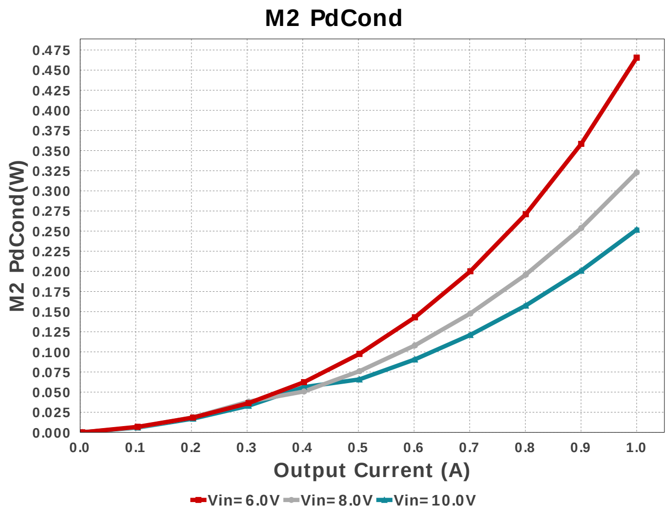

IC Tj
IC Tj(degC)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

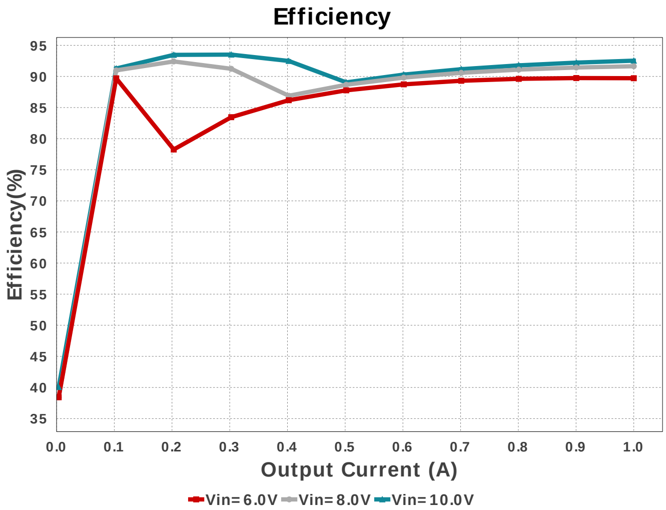

M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

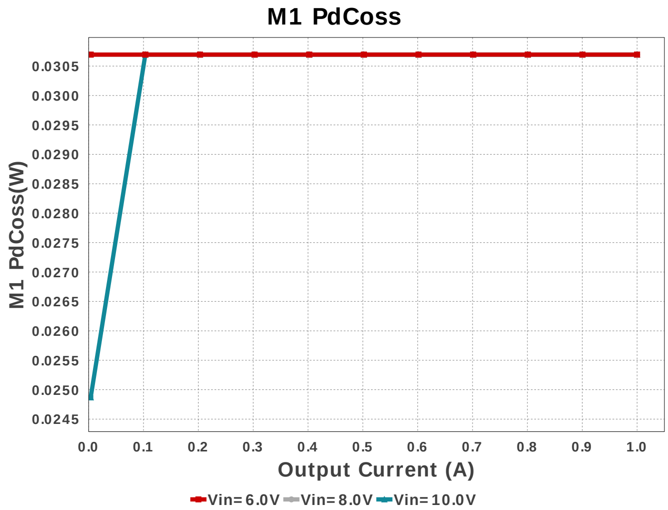

L Pd
L Pd(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

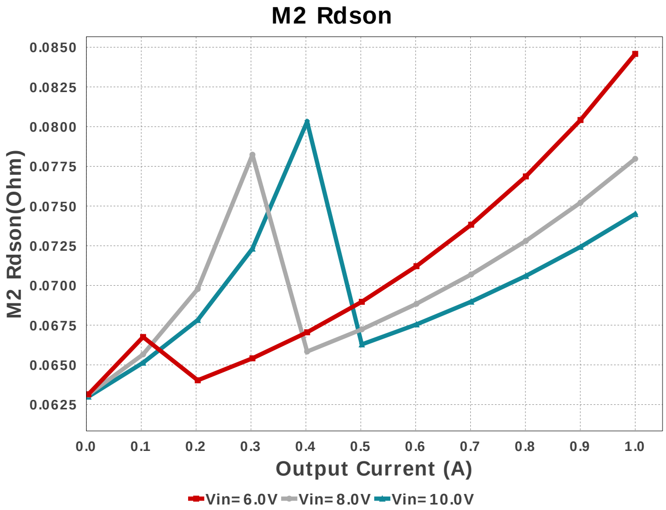

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

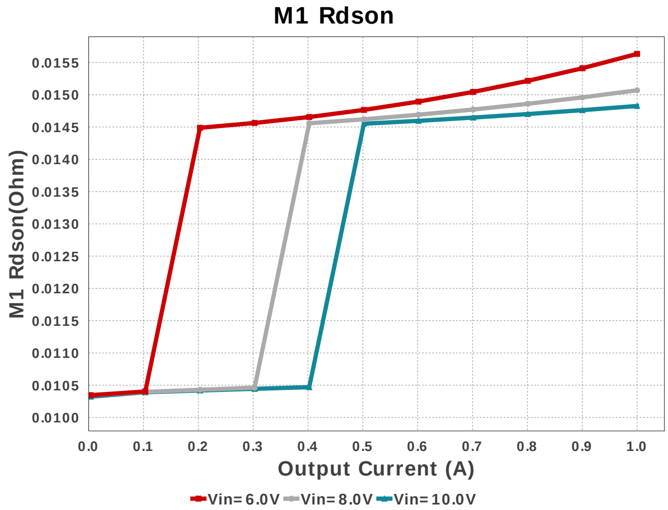

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

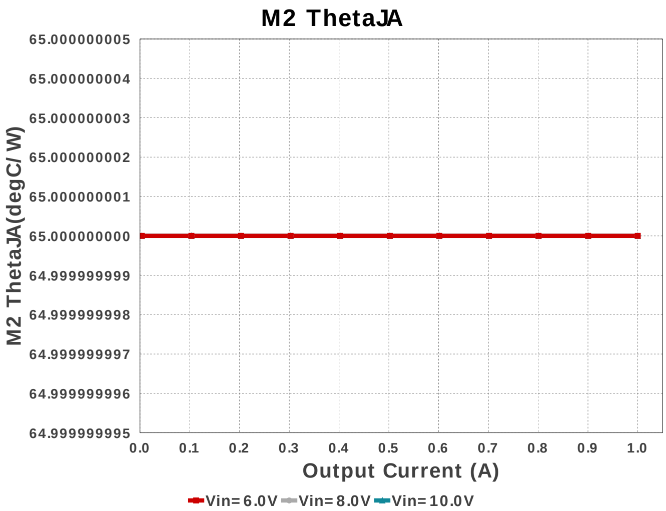

M2 PdCond
M2 PdCond(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

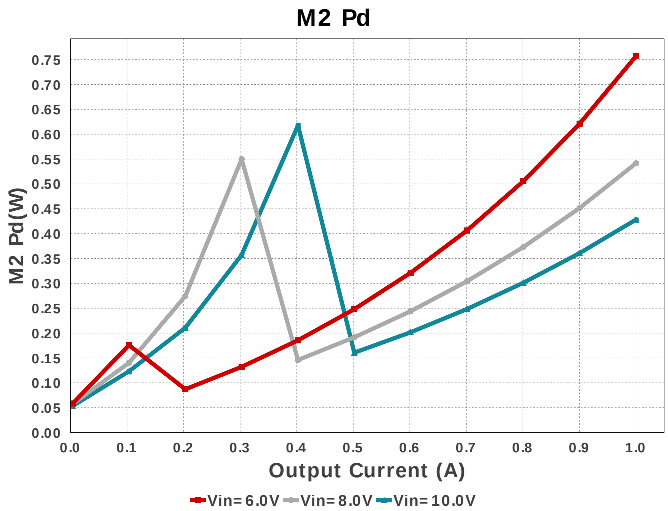

Efficiency
Efficiency(%)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

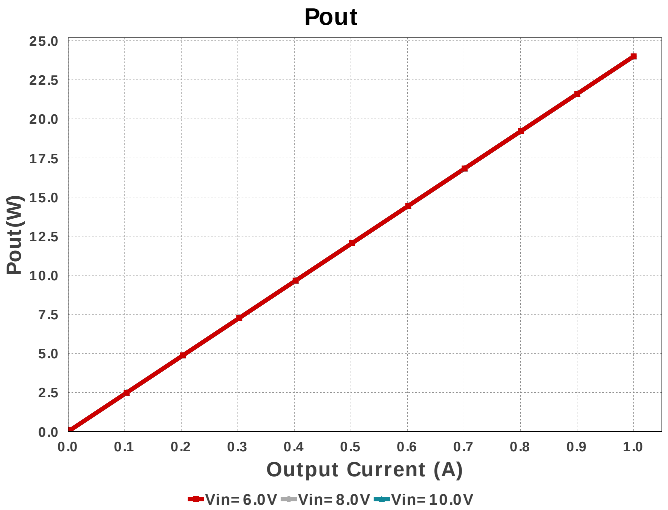

M1 PdCoss
M1 PdCoss(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

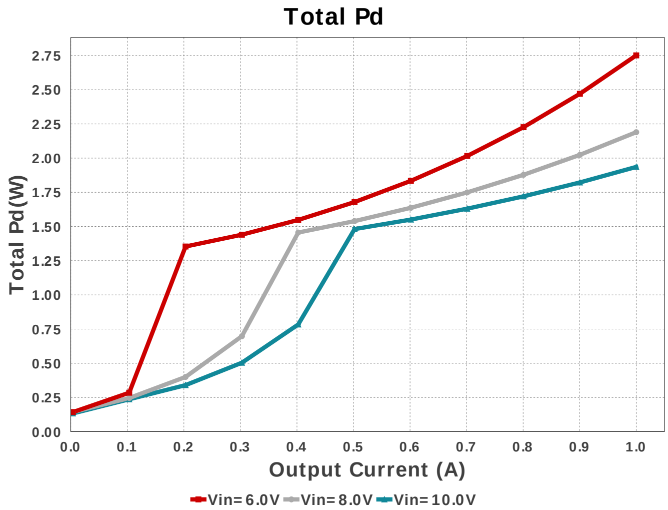

M2 Rdson
M2 Rdson(Ohm)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

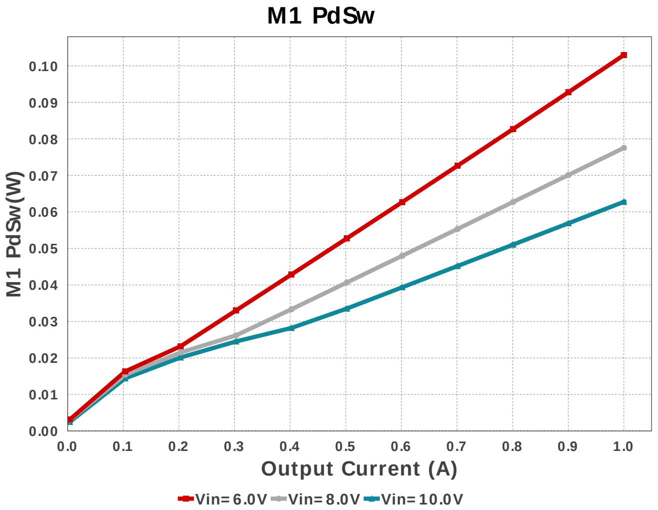

M1 Rdson
M1 Rdson(Ohm)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

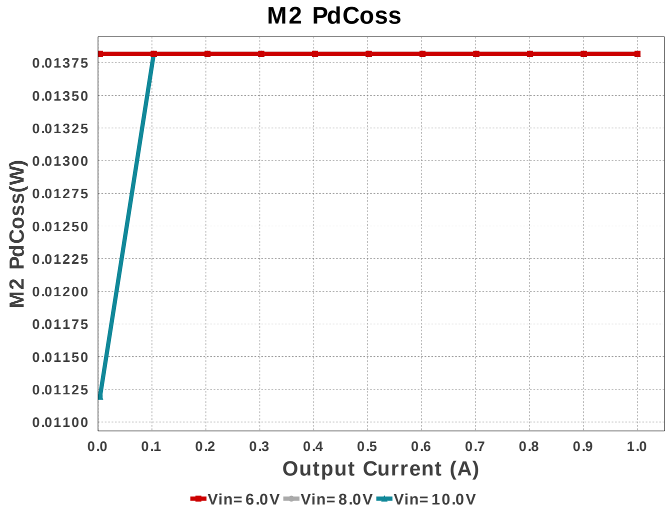

M2 ThetaJA
M2 ThetaJA(degC/W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

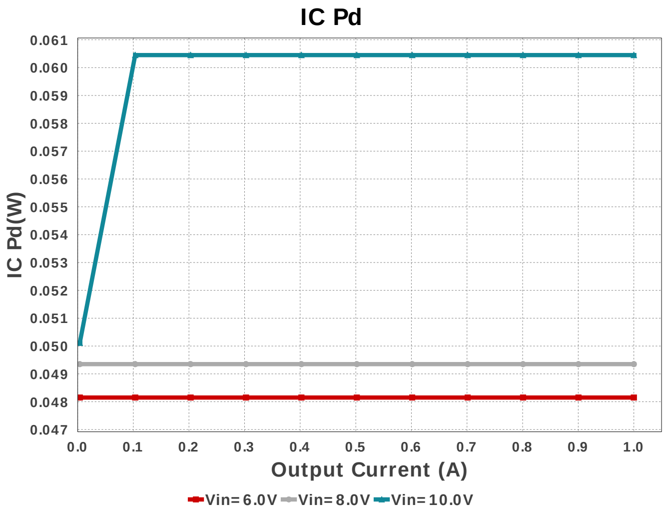

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

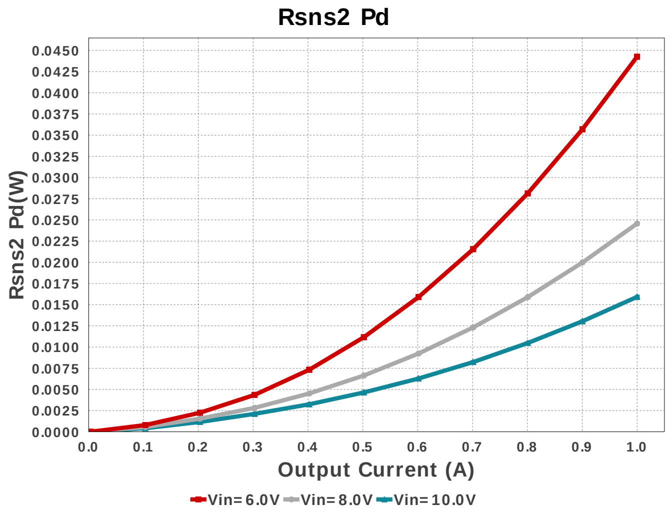

Pout
Pout(W)
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

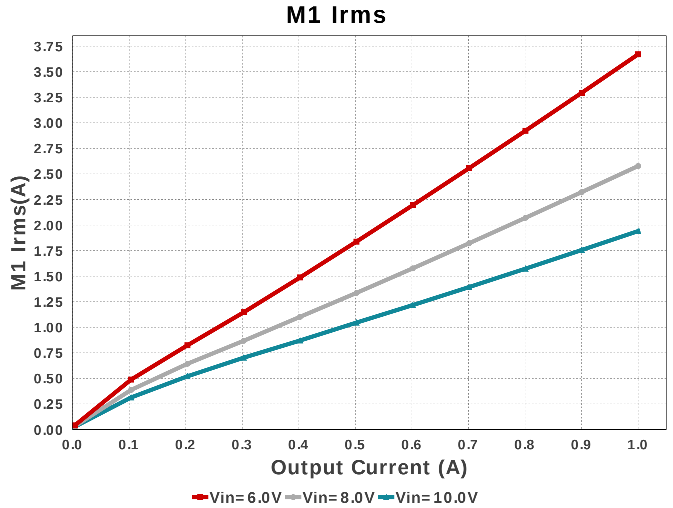

Total Pd
Total Pd(W)
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

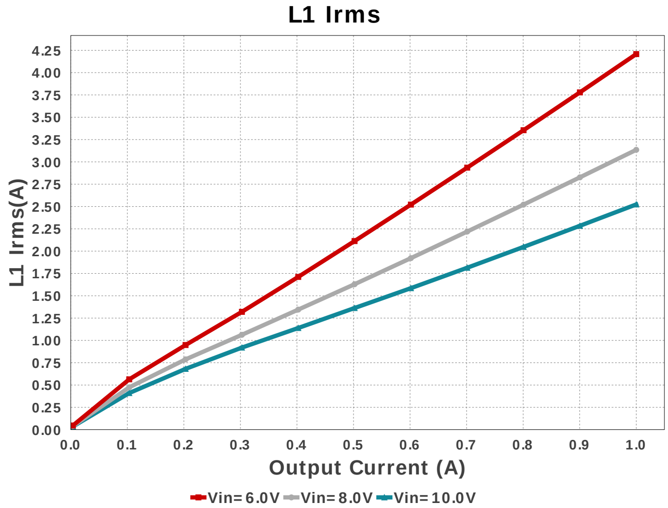

M1 PdSw
M1 PdSw(W)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

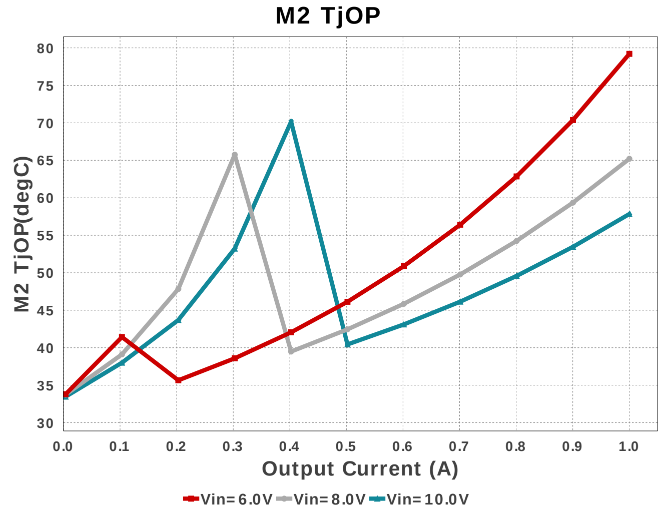

M2 PdCoss
M2 PdCoss(W)
0.01375
0.01350
0.01325
0.01300
0.01275
0.01250
0.01225
0.01200
0.01175
0.01150
0.01125
0.01100
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

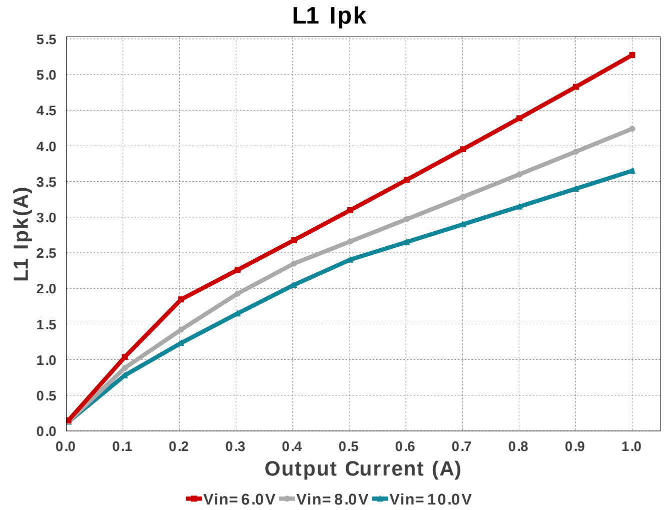

IC Pd
IC Pd(W)
0.061
0.060
0.059
0.058
0.057
0.056
0.055
0.054
0.053
0.052
0.051
0.050
0.049
0.048
0.047
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

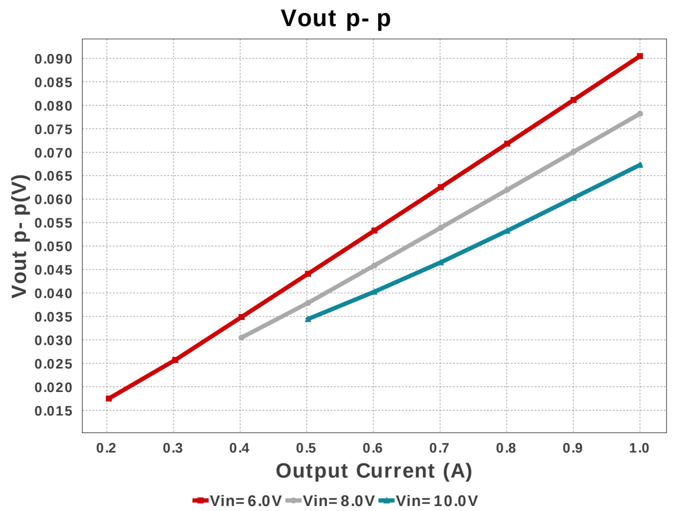

Rsns2 Pd
Rsns2 Pd(W)
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

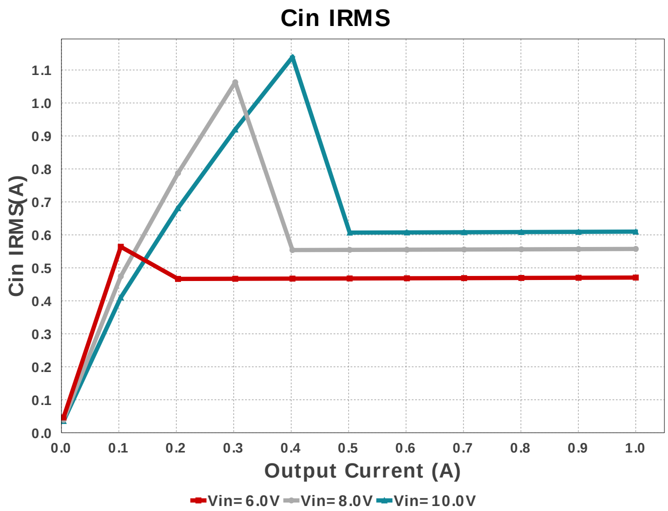

M1 Irms
M1 Irms(A)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V

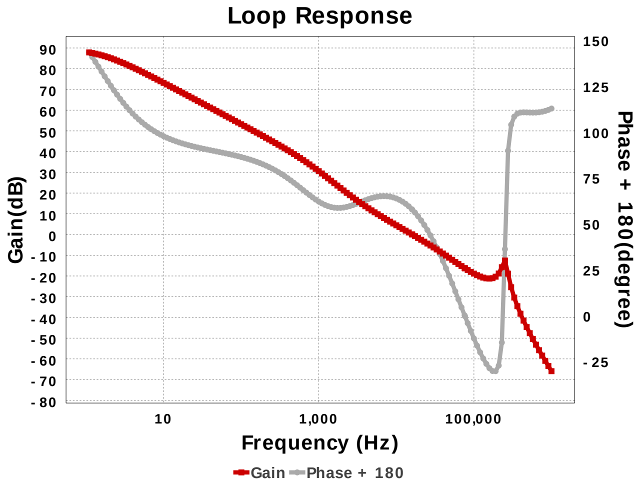

L1 Irms
L1 Irms(A)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V


M2 TjOP
M2 TjOP(degC)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V


L1 Ipk
L1 Ipk(A)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V


Vout p-p
Vout p-p(V)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V


Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=6.0V Vin=8.0V Vin=10.0V



Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	470.642 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	369.17 µW	Capacitor	Input capacitor power dissipation
3.	Cout Pd	8.085 mW	Capacitor	Output capacitor power dissipation
4.	IC Pd	48.15 mW	IC	IC power dissipation
5.	IC Tj	33.163 degC	IC	IC junction temperature
6.	ICThetaJA	65.7 degC/W	IC	IC junction-to-ambient thermal resistance
7.	Iin Avg	4.458 A	IC	Average input current
8.	L Ipp	1.63 A	Inductor	Peak-to-peak inductor ripple current
9.	L Pd	331.94 mW	Inductor	Inductor power dissipation
10.	L1 Ipk	5.274 A	Inductor	Inductor peak current
11.	L1 Irms	4.208 A	Inductor	Inductor ripple current
12.	M1 Irms	3.67 A	Mosfet	MOSFET RMS ripple current
13.	M1 Pd	1.514 W	Mosfet	MOSFET power dissipation
14.	M1 PdCond	252.69 mW	Mosfet	M1 MOSFET conduction losses
15.	M1 PdCoss	30.695 mW	Mosfet	M1 MOSFET Coss Losses
16.	M1 PdQrr	1.128 W	Mosfet	M1 MOSFET switching losses
17.	M1 PdSw	102.95 mW	Mosfet	M1 MOSFET switching losses
18.	M1 Rdson	15.634 mOhm	Mosfet	Drain-Source On-resistance
19.	M1 ThetaJA	55.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
20.	M1 TjOP	113.29 degC	Mosfet	M1 MOSFET junction temperature
21.	M2 Irms	2.058 A	Mosfet	MOSFET RMS ripple current
22.	M2 Pd	756.88 mW	Mosfet	MOSFET power dissipation
23.	M2 PdCond	465.46 mW	Mosfet	M2 MOSFET conduction losses
24.	M2 PdCoss	13.817 mW	Mosfet	M2 MOSFET Coss Losses
25.	M2 PdSw	5.832 mW	Mosfet	M2 MOSFET switching losses
26.	M2 Pdbody	271.77 mW	Mosfet	Power dissipation through lower FET
27.	M2 Rdson	84.581 mOhm	Mosfet	Drain-Source On-resistance
28.	M2 ThetaJA	65.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
29.	M2 TjOP	79.197 degC	Mosfet	MOSFET junction temperature
30.	Cin Pd	369.17 µW	Power	Input capacitor power dissipation
31.	Cout Pd	8.085 mW	Power	Output capacitor power dissipation
32.	IC Pd	48.15 mW	Power	IC power dissipation
33.	L Pd	331.94 mW	Power	Inductor power dissipation
34.	M1 Pd	1.514 W	Power	MOSFET power dissipation
35.	M1 PdCond	252.69 mW	Power	M1 MOSFET conduction losses
36.	M1 PdCoss	30.695 mW	Power	M1 MOSFET Coss Losses
37.	M1 PdQrr	1.128 W	Power	M1 MOSFET switching losses
38.	M1 PdSw	102.95 mW	Power	M1 MOSFET switching losses
39.	M2 Pd	756.88 mW	Power	MOSFET power dissipation
40.	M2 PdCond	465.46 mW	Power	M2 MOSFET conduction losses
41.	M2 PdCoss	13.817 mW	Power	M2 MOSFET Coss Losses
42.	M2 PdQrr	0.0 W	Power	Synchronous Boost High Side Reverse Recovery
43.	M2 PdSw	5.832 mW	Power	M2 MOSFET switching losses
44.	M2 Pdbody	271.77 mW	Power	Power dissipation through lower FET
45.	Rsns1 Pd	44.258 mW	Power	Rsns1 Power Dissipation
46.	Rsns2 Pd	44.258 mW	Power	Rsns2 Power Dissipation
47.	Total Pd	2.751 W	Power	Total Power Dissipation
48.	Rsns1 Pd	44.258 mW	Resistor	Rsns1 Power Dissipation
49.	Rsns2 Pd	44.258 mW	Resistor	Rsns2 Power Dissipation
50.	BOM Count	27	System Information	Total Design BOM count

#	Name	Value	Category	Description
51.	Cross Freq	9.922 kHz	System Information	Bode plot crossover frequency
52.	Duty Cycle	76.083 %	System Information	Duty cycle
53.	Efficiency	89.716 %	System Information	Steady state efficiency
54.	FootPrint	424.0 mm^2	System Information	Total Foot Print Area of BOM components
55.	Frequency	500.0 kHz	System Information	Switching frequency
56.	Gain Marg	-12.158 dB	System Information	Bode Plot Gain Margin
57.	Iout	1.0 A	System Information	Iout operating point
58.	Low Freq Gain	84.883 dB	System Information	Gain at 1Hz
59.	Mode	CCM	System Information	Conduction Mode
60.	Phase Marg	54.212 deg	System Information	Bode Plot Phase Margin
61.	Pout	24.0 W	System Information	Total output power
62.	Total BOM	$3.36	System Information	Total BOM Cost
63.	Vin	6.0 V	System Information	Vin operating point
64.	Vout	24.0 V	System Information	Operational Output Voltage
65.	Vout Actual	23.956 V	System Information	Vout Actual calculated based on selected voltage divider resistors
66.	Vout Tolerance	4.006 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
67.	Vout p-p	90.494 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
SoftStart	1.01 ms	Soft Start Time (ms)
VinMax	10.0	Maximum input voltage
VinMin	6.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	TPS43060	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	500.0 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 Cin and Cout, and the inductance and DC resistance of L1 before assembly of the board. Any large discrepancies in values should be electrically simulated in WEBENCH to check for instabilities and thermally simulated in WebTHERM to make sure critical temperatures are not exceeded.

Soldering Component to Board

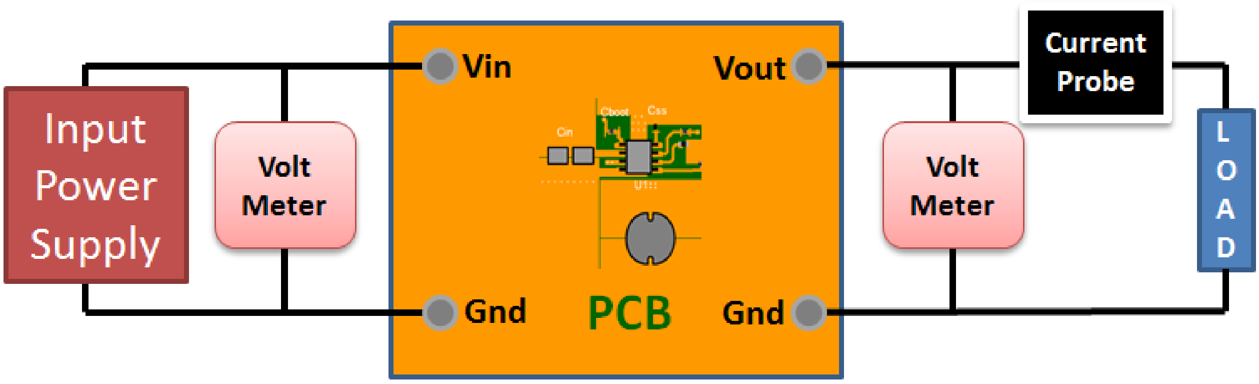
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. To solder the tab town to the board place the iron down on the board while resting against the tab, heating both surfaces simultaneously. Apply light pressure to the top of the plastic case until the solder flows around the part and the part is flush with the PCB. If the solder is not flowing around the board you may need a higher wattage iron (generally 25W to 30W is enough).

Initial Startup of Circuit

It is best to initially power up the board by setting the input supply voltage to the lowest operating input voltage 6.0V and set the input supply's current limit to zero. With the input supply off connect up the input supply to Vin and GND. Connect a digital volt meter and a load if needed to set the minimum Iout of the design from Vout and GND. Turn on the input supply and slowly turn up the current limit on the input supply. If the voltage starts to rise on the input supply continue increasing the input supply current limit while watching the output voltage. If the current increases on the input supply, but the voltage remains near zero, then there may be a short or a component misplaced on the board. Power down the board and visually inspect for solder bridges and recheck the diode and capacitor polarities. Once the power supply circuit is operational then more extensive testing may include full load testing, transient load and line tests to compare with simulation results.

Load Testing

The setup is the same as the initial startup, except that an additional digital voltmeter is connected between Vin and GND, a load is connected between Vout and GND and a current meter is connected in series between Vout and the load. The load must be able to handle at least rated output power + 50% (7.5 watts for this design). Ideally the load is supplied in the form of a variable load test unit. It can also be done in the form of suitably large power resistors. When using an oscilloscope to measure waveforms on the prototype board, the ground leads of the oscilloscope probes should be as short as possible and the area of the loop formed by the ground lead should be kept to a minimum. This will help reduce ground lead inductance and eliminate EMI noise that is not actually present in the circuit.



Design Assistance

1. Feature Highlights: Low Quiescent Current Boost Controller, Wide Vin Range 4.5V to 38V Vin, 58V Vout, 7.5V Gate Drive optimized for standard MOSFET Thresholds Thermal Shutdown

2. Master key : 37D9365D5834ED3F[v1]

3. **TPS43060** Product Folder : http://www.ti.com/product/TPS43060 : contains the data sheet and other resources.

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