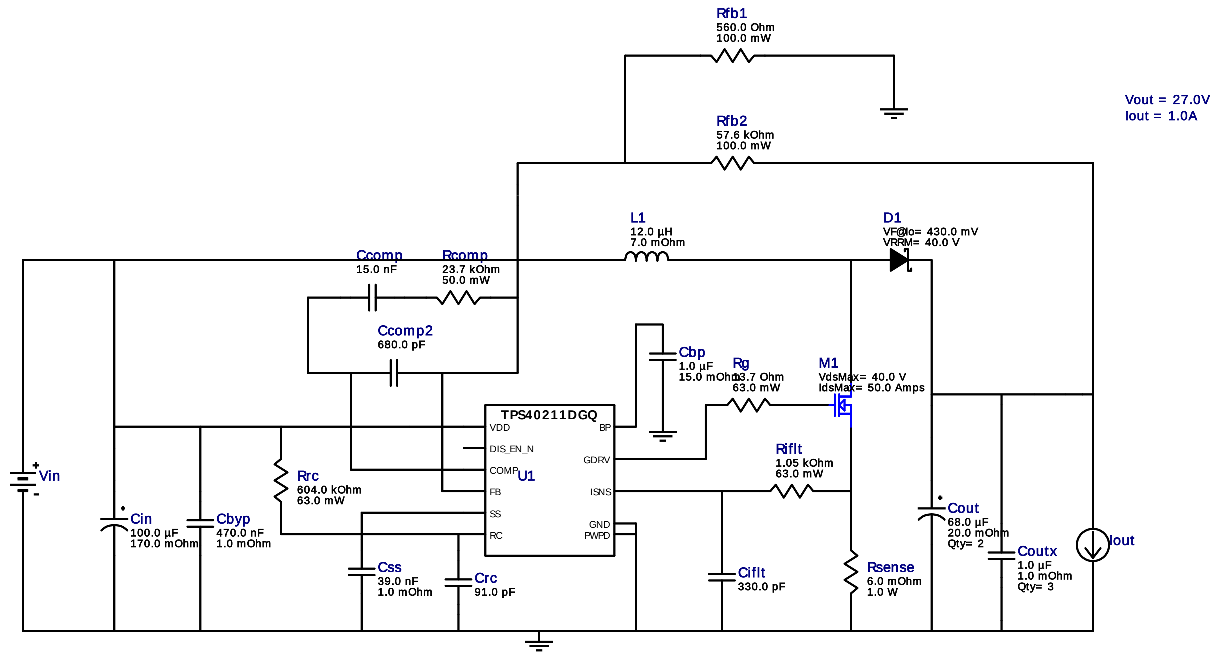
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 4.5V
VinMax = 5.5V
Vout = 27.0V
Iout = 1.0A

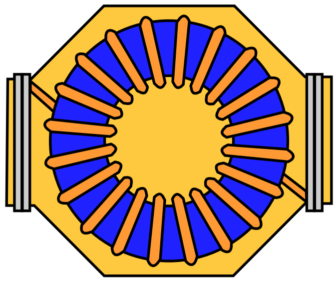
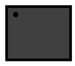
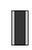
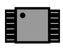
Device = TPS40211DGQR
Topology = Boost
Created = 2019-06-20 11:11:38.107
BOM Cost = $5.08
BOM Count = 24
Total Pd = 2.7W

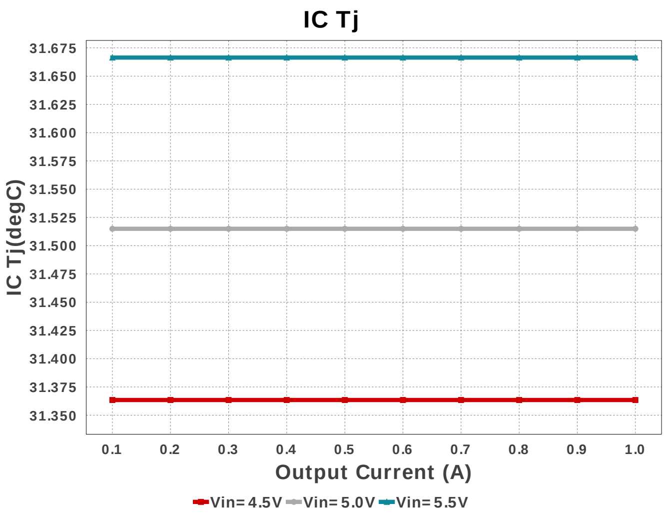
Design : 10 TPS40211DGQR
TPS40211DGQR 4.5V-5.5V to 27.00V @ 1A

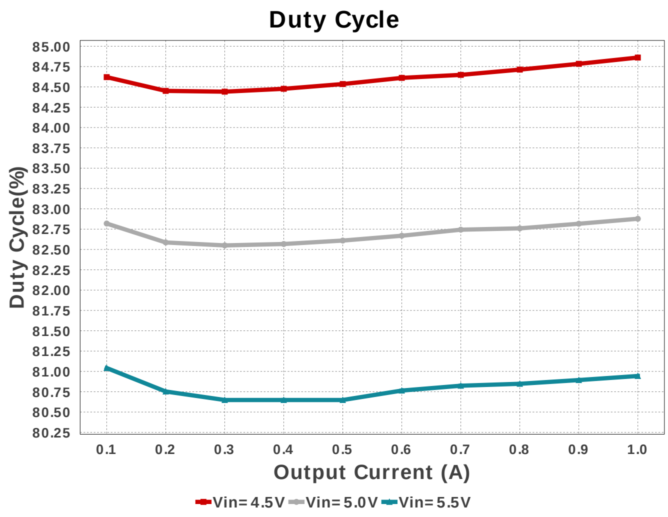


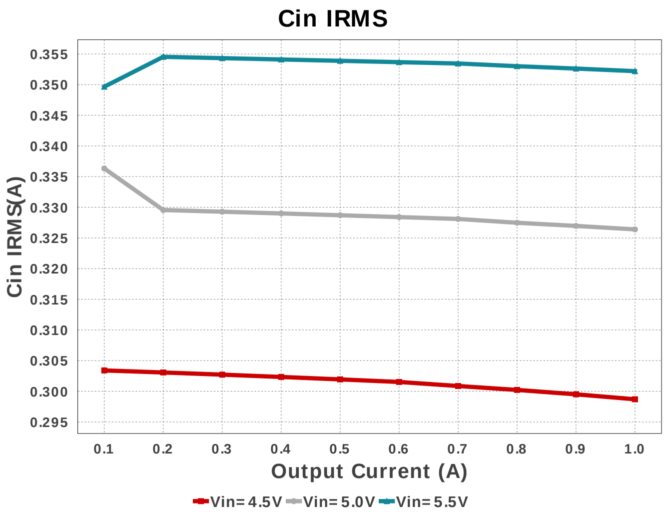
Electrical BOM

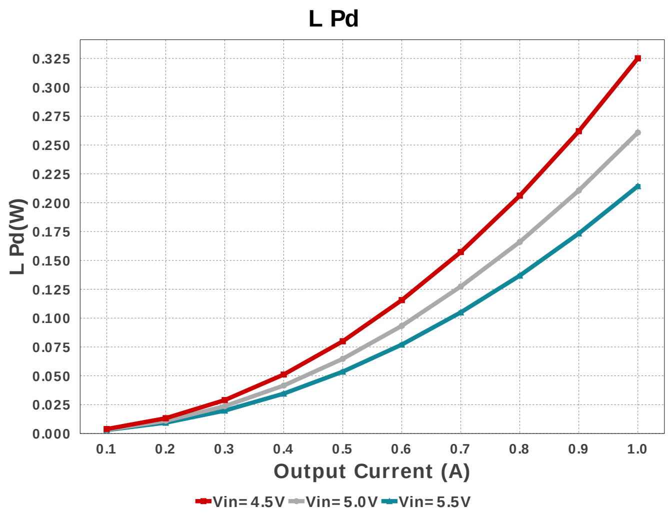
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbp	Kemet	C0805C105K4RACTU Series= X7R	Cap= 1.0 uF ESR= 15.0 mOhm VDC= 16.0 V IRMS= 8.19 A	1	$0.02	0805 7 mm^2
Cbyp	MuRata	GRM155R60J474KE19D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	$0.02	0402 3 mm^2
Ccomp	TDK	CGA4F2C0G1H153J085AA Series= C0G/NP0	Cap= 15.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.07	0805 7 mm^2
Ccomp2	Samsung Electro-Mechanics	CL05C681JB5NNNC Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ciflt	Samsung Electro-Mechanics	CL21C331JBANNNC Series= C0G/NP0	Cap= 330.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	Nichicon	UUD1V101MNL1GS Series= uD	Cap= 100.0 uF ESR= 170.0 mOhm VDC= 35.0 V IRMS= 450.0 mA	1	$0.21	SM_RADIAL_8MM 113 mm^2
Cout	Panasonic	50SVPF68M Series= SVPF	Cap= 68.0 uF ESR= 20.0 mOhm VDC= 50.0 V IRMS= 4.3 A	2	$0.95	CAPSMT_62_F12 151 mm^2

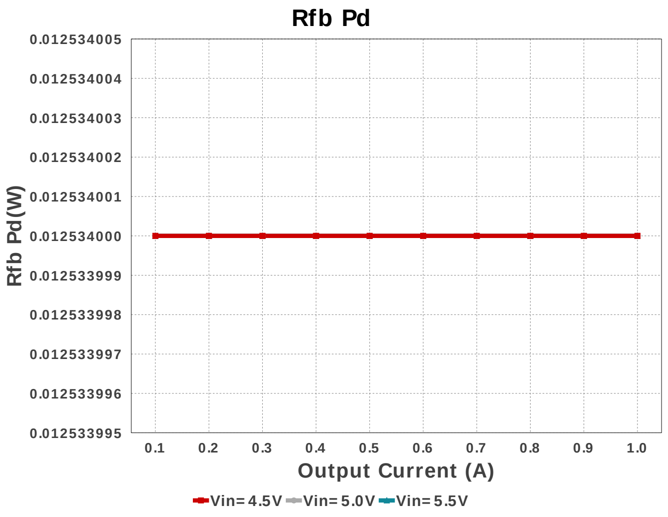
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Coutx	Taiyo Yuden	GMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	3	$0.05	0805 7 mm^2
Crc	Samsung Electro-Mechanics	CL21C910JBANNNC Series= C0G/NP0	Cap= 91.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Css	MuRata	GRM155R71A393KA01D Series= X7R	Cap= 39.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
D1	ON Semiconductor	MBRS2040LT3G	VF@Io= 430.0 mV VRRM= 40.0 V	1	$0.10	 SMB 44 mm^2
L1	Bourns	PM2110-120K-RC	L= 12.0 µH 7.0 mOhm	1	$1.37	 PM2110 890 mm^2
M1	Texas Instruments	CSD18504Q5A	VdsMax= 40.0 V IdsMax= 50.0 Amps	1	$0.33	 TRANS_NexFET_Q5A 55 mm^2
Rcomp	Yageo	RC0201FR-0723K7L Series= ?	Res= 23.7 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rfb1	Yageo	RC0603FR-07560RL Series= ?	Res= 560.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfb2	Yageo	RC0603FR-0757K6L Series= ?	Res= 57.6 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rg	Vishay-Dale	CRCW040213R7FKED Series= CRCW..e3	Res= 13.7 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Riflt	Vishay-Dale	CRCW04021K05FKED Series= CRCW..e3	Res= 1.05 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rrc	Vishay-Dale	CRCW0402604KFKED Series= CRCW..e3	Res= 604.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rsense	Susumu Co Ltd	PRL1632-R006-F-T1 Series= PRL1632	Res= 6.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	$0.20	 0612 11 mm^2
U1	Texas Instruments	TPS40211DGQR	Switcher	1	$0.61	 DGQ0010D_NV_N 24 mm^2

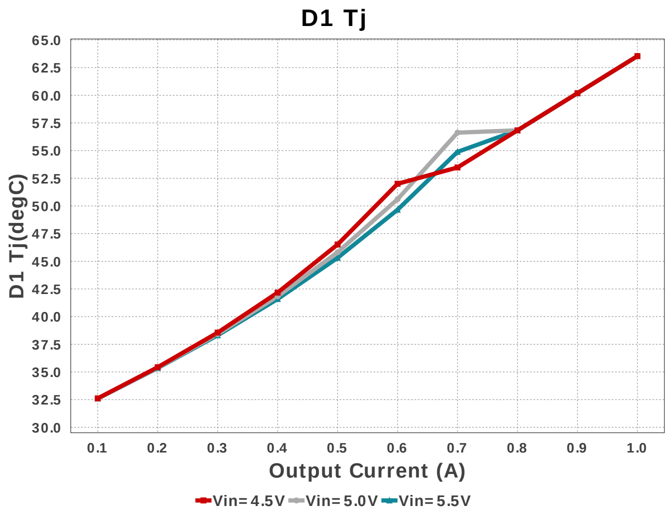

IC Tj
IC Tj(degC)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

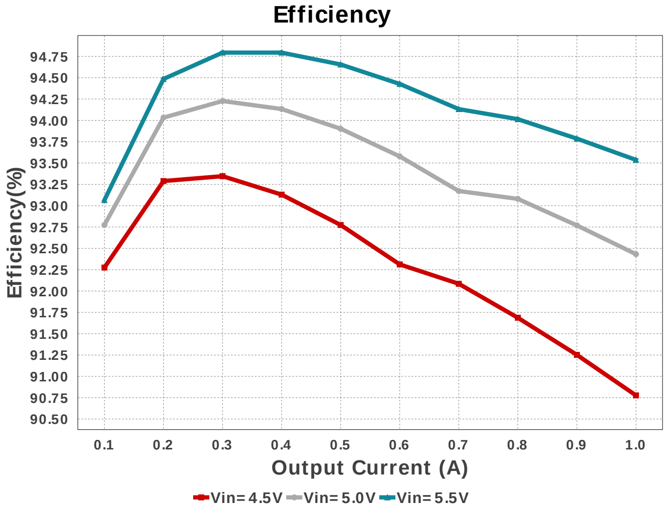

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

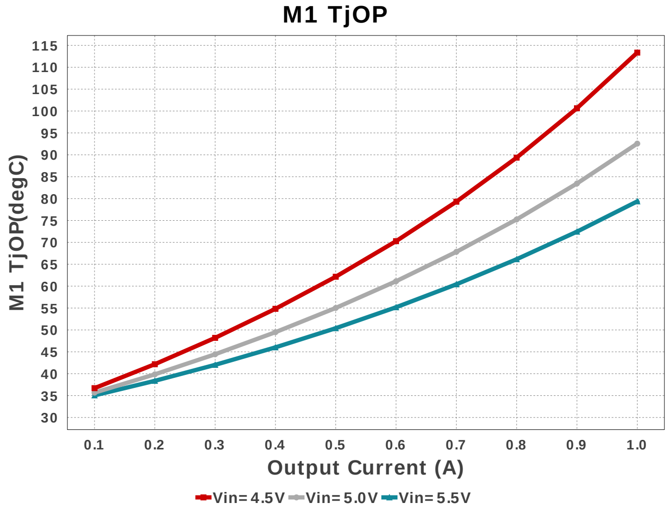

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

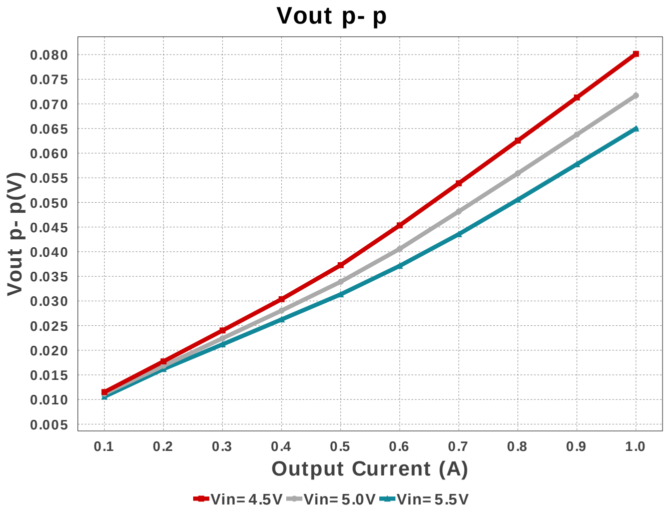

L Pd
L Pd(W)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

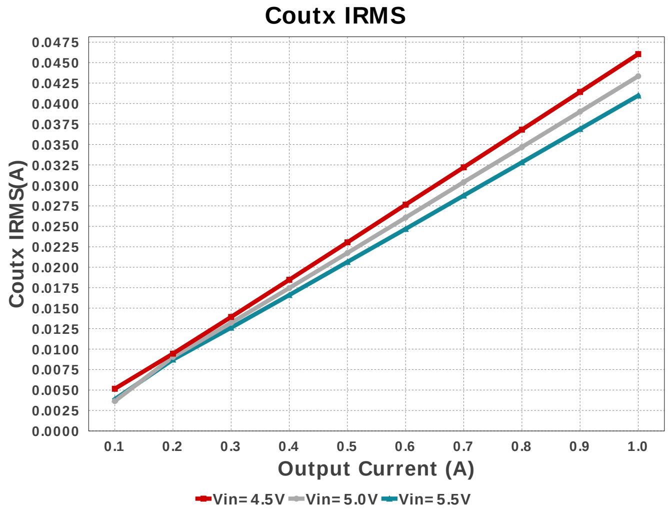

Rfb Pd
Rfb Pd(W)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

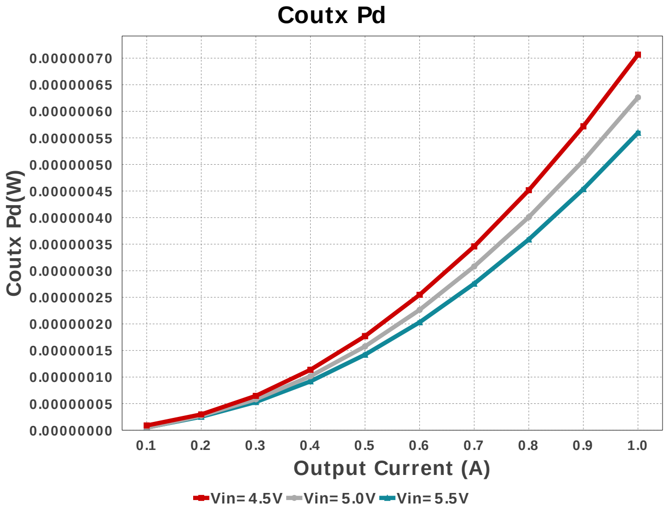

D1 Tj
D1 Tj(degC)
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

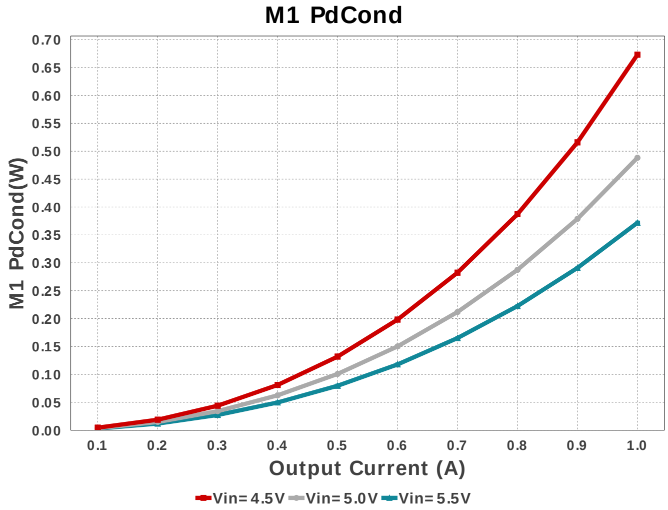

Efficiency
Efficiency(%)
94.75
94.50
94.25
94.00
93.75
93.50
93.25
93.00
92.75
92.50
92.25
92.00
91.75
91.50
91.25
91.00
90.75
90.50
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

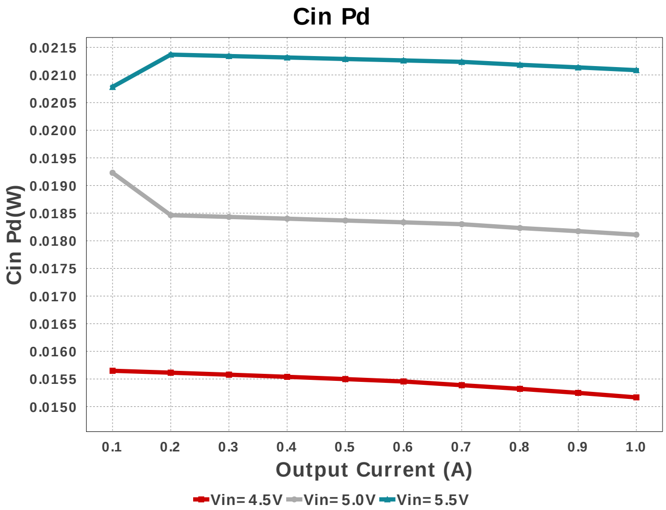

M1 TjOP
M1 TjOP(degC)
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

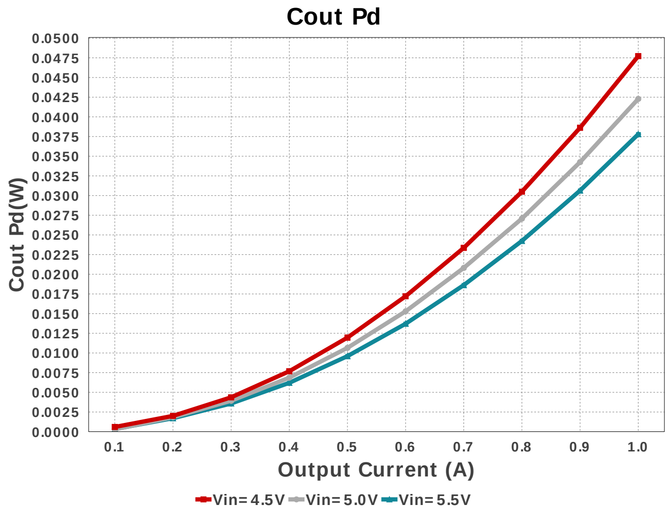

Vout p- p
Vout p- p(V)
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

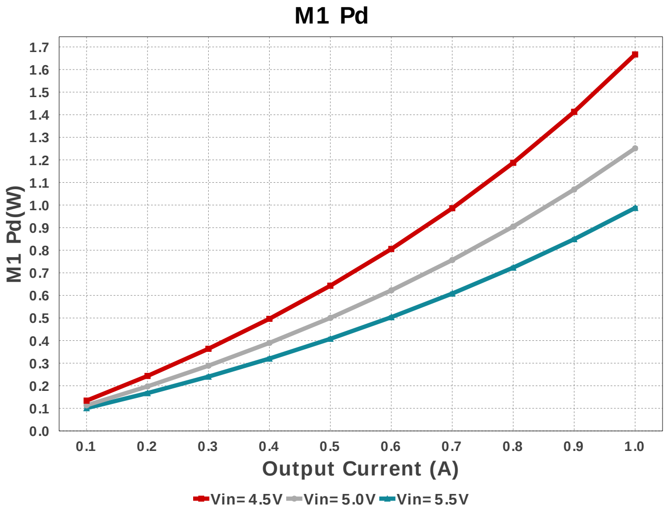

Coutx IRMS
Coutx IRMS(A)
0.0475
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

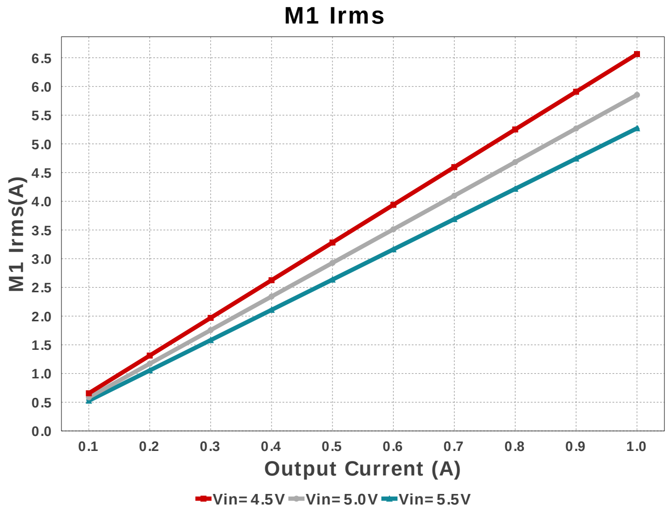

Coutx Pd
Coutx Pd(W)
0.00000070
0.00000065
0.00000060
0.00000055
0.00000050
0.00000045
0.00000040
0.00000035
0.00000030
0.00000025
0.00000020
0.00000015
0.00000010
0.00000005
0.00000000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

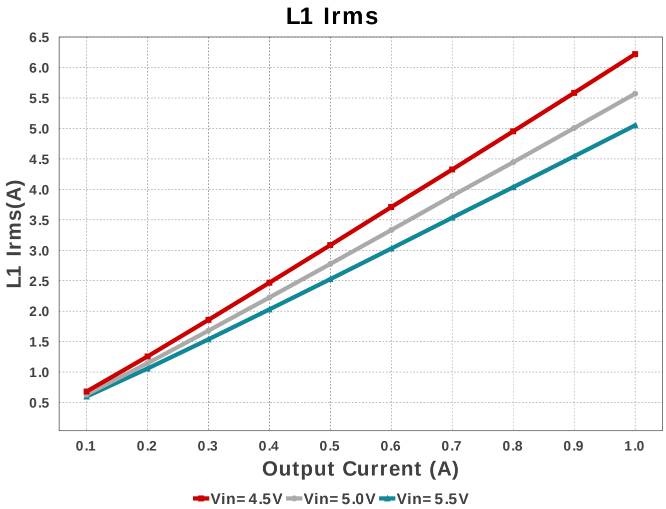

M1 PdCond
M1 PdCond(W)
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 4.5V Vin= 5.0V Vin= 5.5V

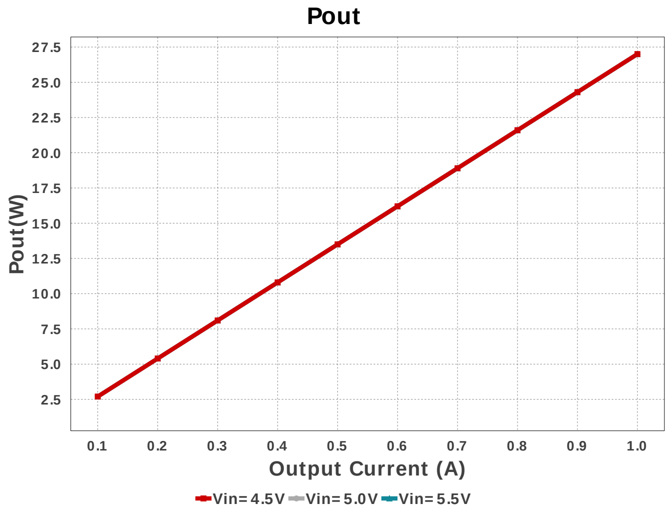

Cin Pd
Cin Pd(W)
0.0215
0.0210
0.0205
0.0200
0.0195
0.0190
0.0185
0.0180
0.0175
0.0170
0.0165
0.0160
0.0155
0.0150
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=4.5V
Vin=5.0V
Vin=5.5V

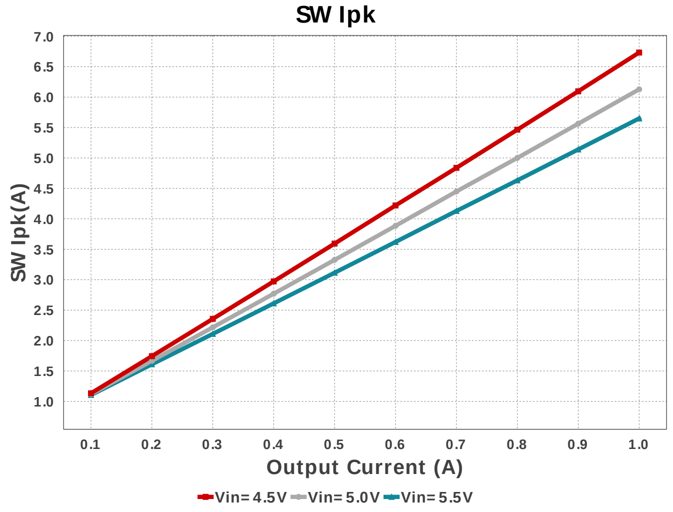

Cout Pd
Cout Pd(W)
0.0500
0.0475
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=4.5V
Vin=5.0V
Vin=5.5V

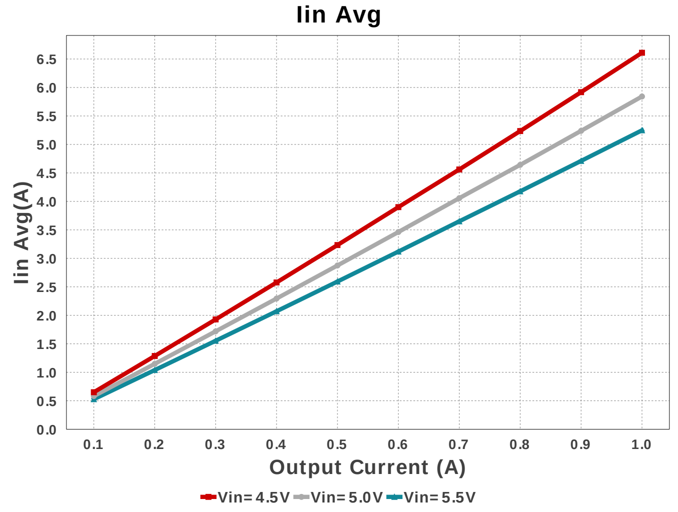

M1 Pd
M1 Pd(W)
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=4.5V
Vin=5.0V
Vin=5.5V

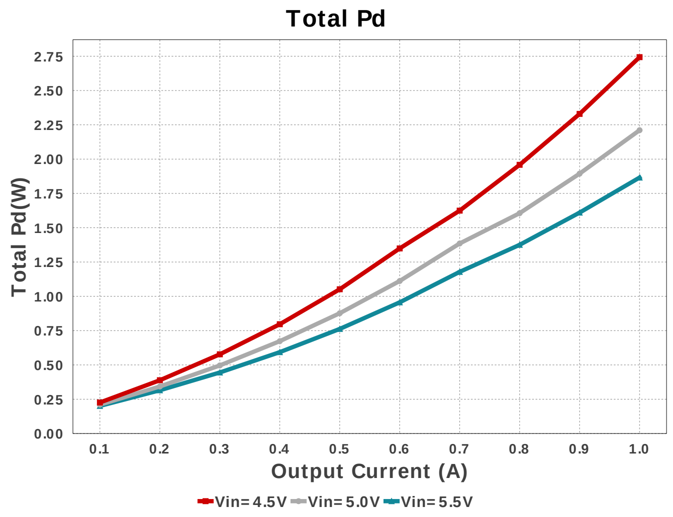

M1 Irms
M1 Irms(A)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=4.5V
Vin=5.0V
Vin=5.5V

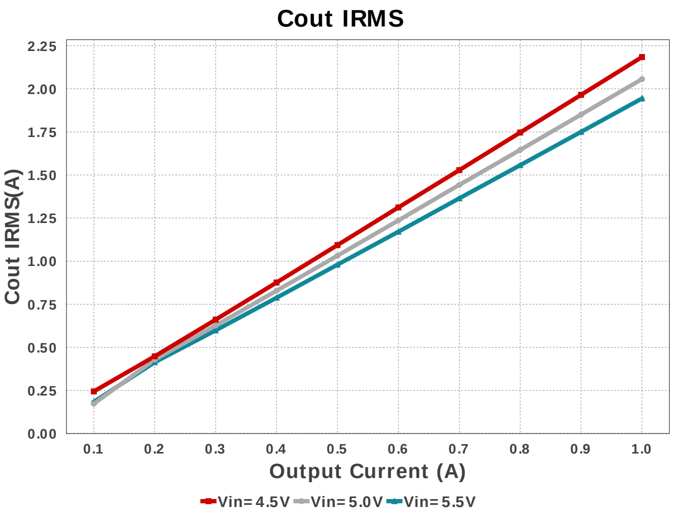

L1 Irms
L1 Irms(A)
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=4.5V
Vin=5.0V
Vin=5.5V

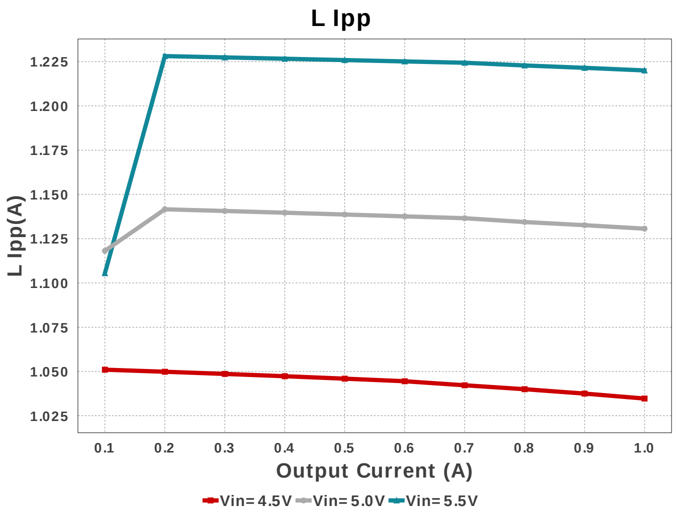

Pout
Pout(W)
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Output Current (A)
Vin=4.5V
Vin=5.0V
Vin=5.5V

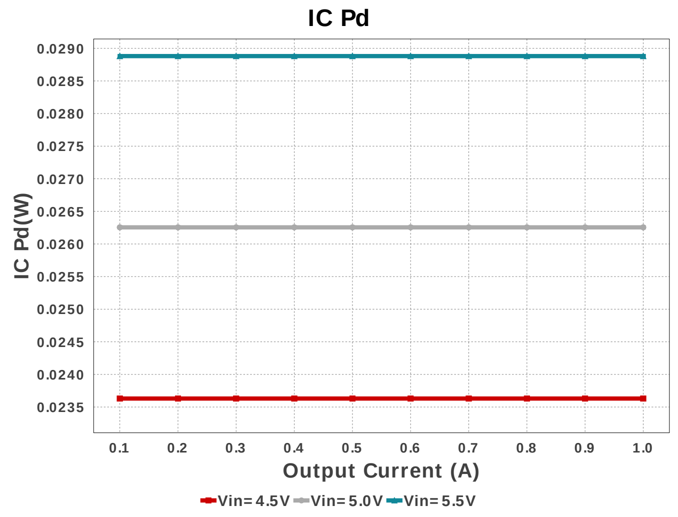

SW Ipk
SW Ipk(A)
Output Current (A)
Vin= 4.5V
Vin= 5.0V
Vin= 5.5V

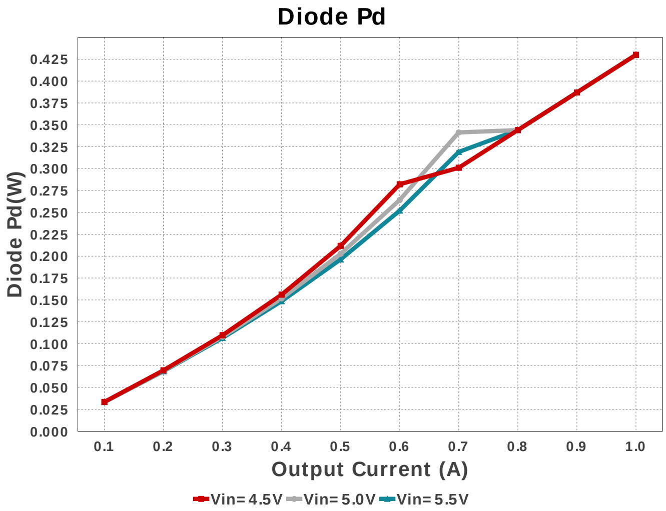

Iin Avg
Iin Avg(A)
Output Current (A)
Vin= 4.5V
Vin= 5.0V
Vin= 5.5V

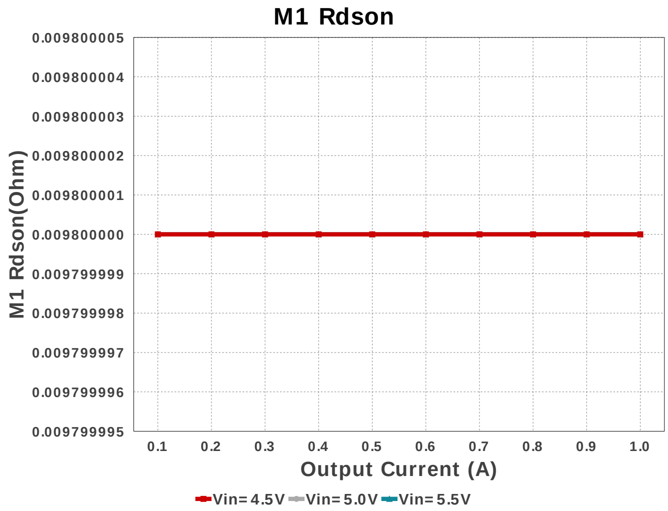

Total Pd
Total Pd(W)
Output Current (A)
Vin= 4.5V
Vin= 5.0V
Vin= 5.5V

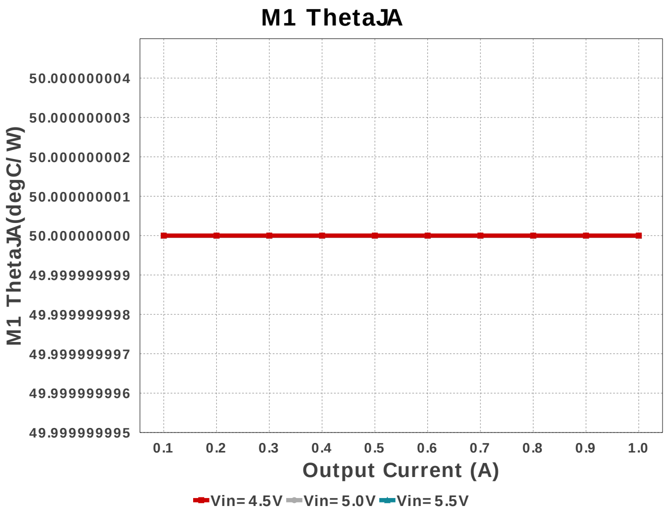

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin= 4.5V
Vin= 5.0V
Vin= 5.5V

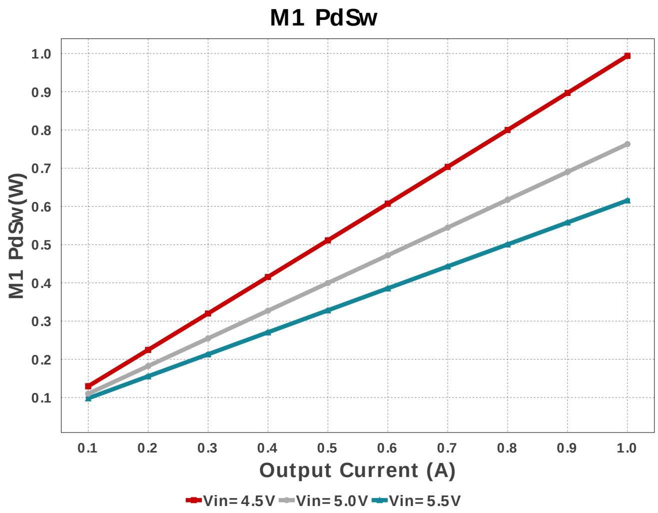

L Ipp
L Ipp(A)
Output Current (A)
Vin= 4.5V
Vin= 5.0V
Vin= 5.5V

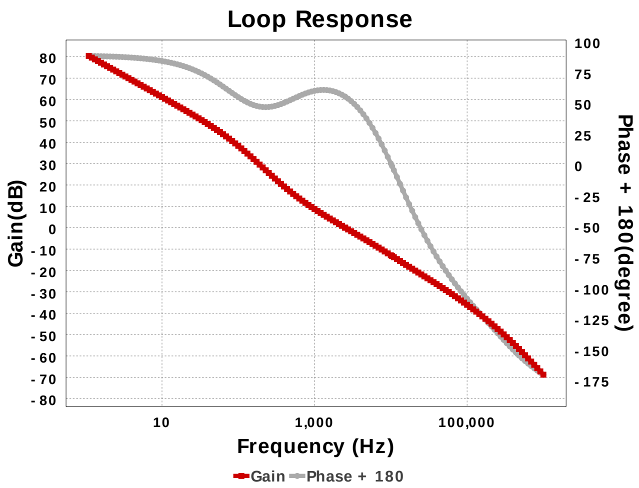

IC Pd
IC Pd(W)
Output Current (A)
Vin= 4.5V
Vin= 5.0V
Vin= 5.5V











Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	326.889 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	18.166 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	2.189 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	47.924 mW	Capacitor	Output capacitor power dissipation
5.	Coutx IRMS	42.723 mA	Capacitor	Output capacitor_x RMS ripple current
6.	Coutx Pd	608.42 nW	Capacitor	Output capacitor_x power loss
7.	D1 Tj	63.54 degC	Diode	D1 junction temperature
8.	Diode Pd	430.0 mW	Diode	Diode power dissipation
9.	IC Pd	22.565 mW	IC	IC power dissipation
10.	IC Tj	31.302 degC	IC	IC junction temperature
11.	IC Tolerance	14.0 mV	IC	IC Feedback Tolerance

#	Name	Value	Category	Description
12.	ICThetaJA	57.7 degC/W	IC	IC junction-to-ambient thermal resistance
13.	Iin Avg	6.6 A	IC	Average input current
14.	L Ipp	1.132 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	325.14 mW	Inductor	Inductor power dissipation
16.	L1 Irms	6.222 A	Inductor	Inductor ripple current
17.	M1 Irms	6.551 A	Mosfet	M1 MOSFET Irms
18.	M1 Pd	1.621 W	Mosfet	M1 MOSFET total power dissipation
19.	M1 PdCond	663.65 mW	Mosfet	M1 MOSFET conduction losses
20.	M1 PdSw	957.05 mW	Mosfet	M1 MOSFET switching losses
21.	M1 Rdson	9.8 mOhm	Mosfet	Drain-Source On-resistance
22.	M1 ThetaJA	50.0 degC/W	Mosfet	MOSFET junction-to-ambient thermal resistance
23.	M1 TjOP	111.04 degC	Mosfet	M1 MOSFET junction temperature
24.	Cin Pd	18.166 mW	Power	Input capacitor power dissipation
25.	Cout Pd	47.924 mW	Power	Output capacitor power dissipation
26.	Coutx Pd	608.42 nW	Power	Output capacitor_x power loss
27.	Diode Pd	430.0 mW	Power	Diode power dissipation
28.	IC Pd	22.565 mW	Power	IC power dissipation
29.	L Pd	325.14 mW	Power	Inductor power dissipation
30.	M1 Pd	1.621 W	Power	M1 MOSFET total power dissipation
31.	M1 PdCond	663.65 mW	Power	M1 MOSFET conduction losses
32.	M1 PdSw	957.05 mW	Power	M1 MOSFET switching losses
33.	Rfb Pd	12.534 mW	Power	Rfb Power Dissipation
34.	Total Pd	2.698 W	Power	Total Power Dissipation
35.	Rfb Pd	12.534 mW	Resistor	Rfb Power Dissipation
36.	BOM Count	24	System Information	Total Design BOM count
37.	Cross Freq	2.07 kHz	System Information	Bode plot crossover frequency
38.	Duty Cycle	84.838 %	System Information	Duty cycle
39.	Efficiency	90.914 %	System Information	Steady state efficiency
40.	FootPrint	1.517 k mm^2	System Information	Total Foot Print Area of BOM components
41.	Frequency	272.12 kHz	System Information	Switching frequency
42.	Gain Marg	-11.803 dB	System Information	Bode Plot Gain Margin
43.	Iout	1.0 A	System Information	Iout operating point
44.	Low Freq Gain	79.126 dB	System Information	Gain at 1Hz
45.	Mode	CCM	System Information	Conduction Mode
46.	Phase Marg	54.616 deg	System Information	Bode Plot Phase Margin
47.	Pout	27.0 W	System Information	Total output power
48.	SW Ipk	6.779 A	System Information	Peak switch current
49.	Total BOM	$5.08	System Information	Total BOM Cost
50.	Vin	4.5 V	System Information	Vin operating point
51.	Vout	27.0 V	System Information	Operational Output Voltage
52.	Vout Actual	27.003 V	System Information	Vout Actual calculated based on selected voltage divider resistors
53.	Vout Tolerance	7.493 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
54.	Vout p-p	81.625 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	5.5	Maximum input voltage
VinMin	4.5	Minimum input voltage
Vout	27.0	Output Voltage
base_pn	TPS40211	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature

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

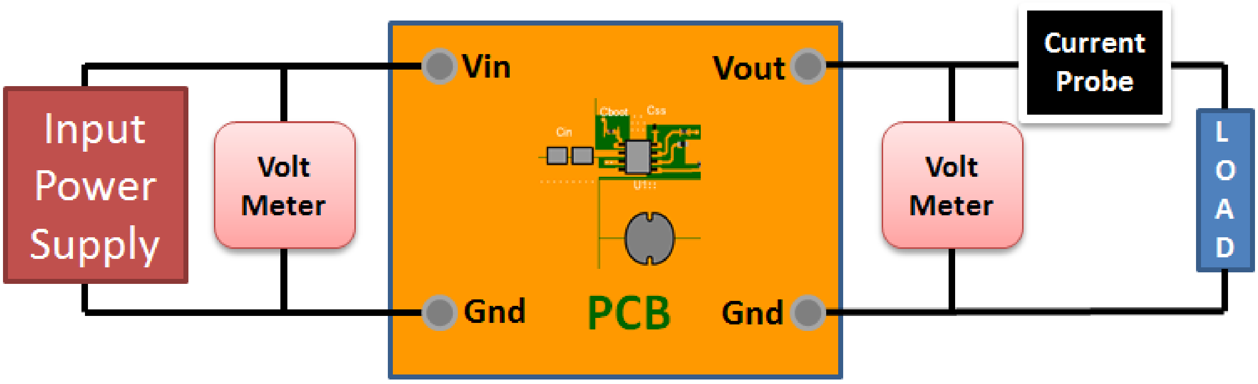
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 4.5V 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. Master key : E56AD4253327D321[v1]

2. **TPS40211** Product Folder : http://www.ti.com/product/TPS40211 : contains the data sheet and other resources.

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