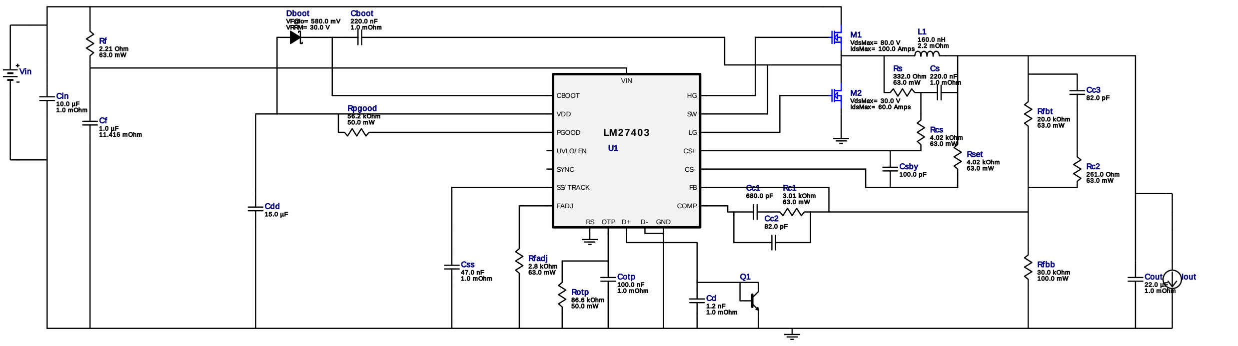
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 3.0V
VinMax = 13.0V
Vout = 1.0V
Iout = 13.4A

Device = LM27403SQ/NOPB
Topology = Buck
Created = 2020-04-23 11:54:32.073
BOM Cost = $3.72
BOM Count = 30
Total Pd = 2.58W

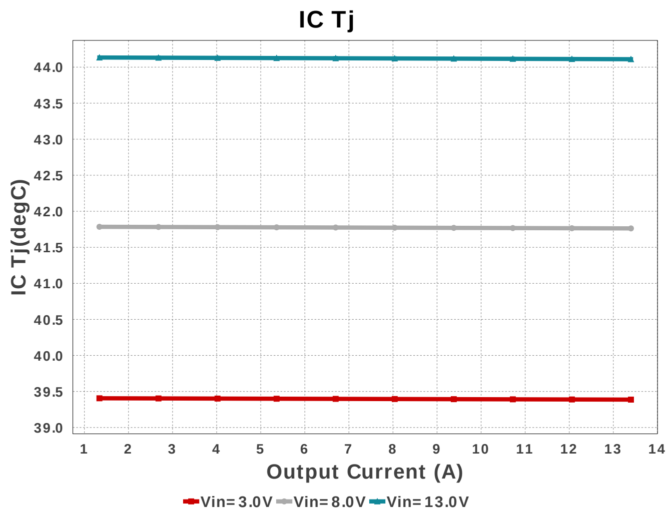
Design : 9 LM27403SQ/NOPB
LM27403SQ/NOPB 3V-13V to 1.00V @ 13.4A

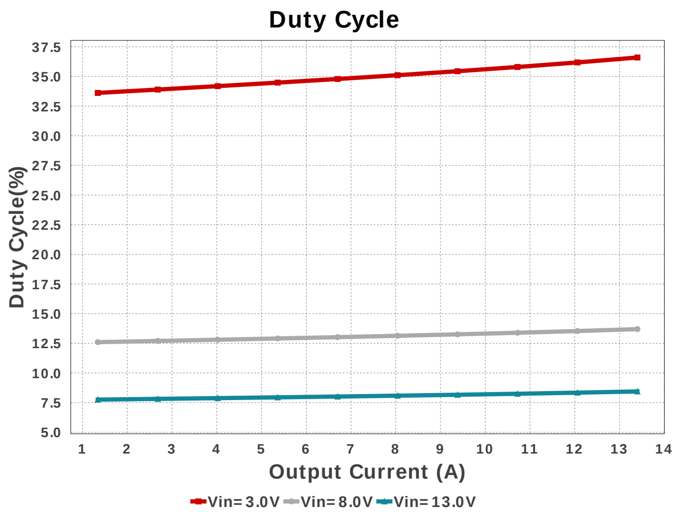


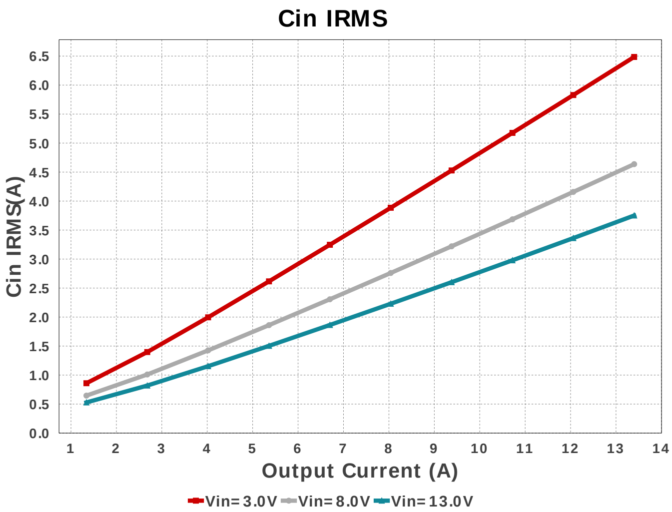
Electrical BOM

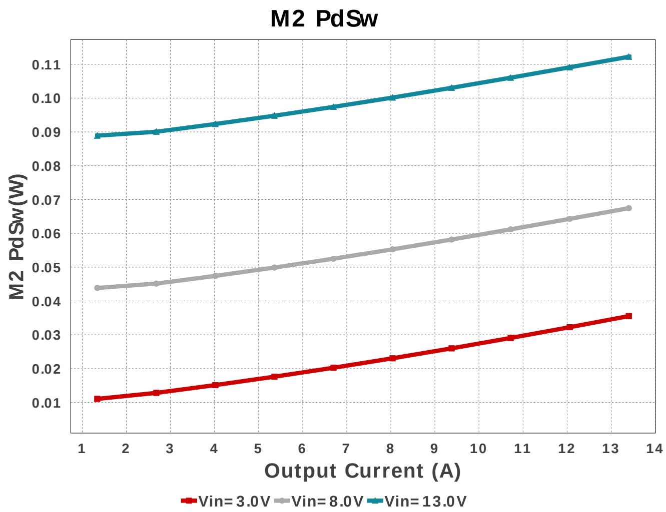
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM188R61E224KA88D Series= X5R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.03	0603 5 mm^2
Cc1	Samsung Electro-Mechanics	CL05C681JB5NNNC Series= C0G/NP0	Cap= 680.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cc2	TDK	C0402C0G1C820J020BC Series= C0G/NP0	Cap= 82.0 pF VDC= 16.0 V IRMS= 0.0 A	1	$0.03	01005 2 mm^2
Cc3	TDK	C0402C0G1C820J020BC Series= C0G/NP0	Cap= 82.0 pF VDC= 16.0 V IRMS= 0.0 A	1	$0.03	01005 2 mm^2
Cd	MuRata	GRM033R71A122KA01D Series= X7R	Cap= 1.2 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
Cdd	TDK	C3216X6S1C156M160AC Series= X6S	Cap= 15.0 uF VDC= 16.0 V IRMS= 0.0 A	1	$0.29	1206_180 11 mm^2
Cf	TDK	C1005X5R1V105K050BC Series= X5R	Cap= 1.0 uF ESR= 11.416 mOhm VDC= 35.0 V IRMS= 1.483 A	1	$0.03	0402 3 mm^2
Cin	MuRata	GRT31CR61H106KE01L Series= X5R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.21	1206_180 11 mm^2
Cotp	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cout	MuRata	GRM21BD70J226ME44L Series= X7T	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.10	0805 7 mm^2

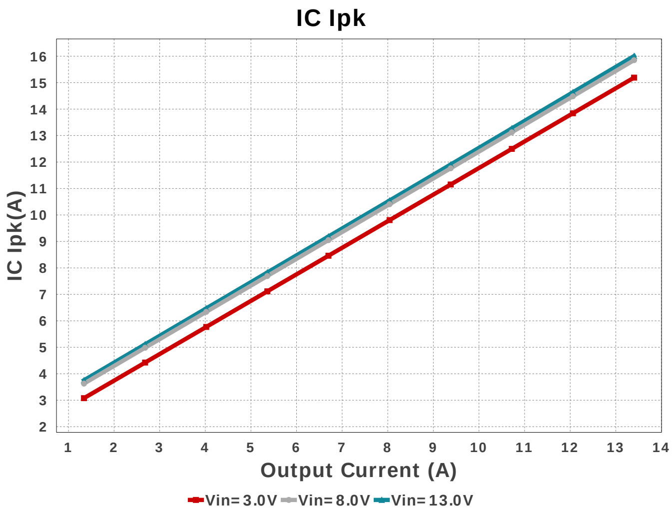
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cs	MuRata	GRM155R71C224KA12D Series= X7R	Cap= 220.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.02	0402 3 mm^2
Csby	Taiyo Yuden	EMK042CG101JC-FW Series= C0G/NP0	Cap= 100.0 pF VDC= 16.0 V IRMS= 0.0 A	1	$0.04	01005 2 mm^2
Css	MuRata	GRM155R71E473KA88D Series= X7R	Cap= 47.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Dboot	Diodes Inc.	SBR0230T5-7-F	VF@Io= 580.0 mV VRRM= 30.0 V	1	$0.10	SOD-523 5 mm^2
L1	Coilcraft	XAL5030-161MEB	L= 160.0 nH 2.2 mOhm	1	$0.63	XAL5030 54 mm^2
M1	Texas Instruments	CSD19502Q5B	VdsMax= 80.0 V IdsMax= 100.0 Amps	1	$0.85	DQK0006C 9 mm^2
M2	Texas Instruments	CSD17575Q3	VdsMax= 30.0 V IdsMax= 60.0 Amps	1	$0.31	DQG0008A 18 mm^2
Q1	Diodes Inc.	MMBT3904T	Bipolar Transistor	1	$0.06	SOT-523 7 mm^2
Rc1	Vishay-Dale	CRCW04023K01FKED Series= CRCW..e3	Res= 3.01 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rc2	Vishay-Dale	CRCW0402261RFKED Series= CRCW..e3	Res= 261.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcs	Vishay-Dale	CRCW04024K02FKED Series= CRCW..e3	Res= 4.02 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rf	Vishay-Dale	CRCW04022R21FKED Series= CRCW..e3	Res= 2.21 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfadj	Vishay-Dale	CRCW04022K80FKED Series= CRCW..e3	Res= 2.8 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Yageo	RC0603FR-0730KL Series= ?	Res= 30.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbt	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rotp	Yageo	RC0201FR-0786K6L Series= ?	Res= 86.6 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rpgood	Yageo	RC0201FR-0756K2L Series= ?	Res= 56.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rs	Vishay-Dale	CRCW0402332RFKED Series= CRCW..e3	Res= 332.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rset	Vishay-Dale	CRCW04024K02FKED Series= CRCW..e3	Res= 4.02 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	LM27403SQ/NOPB	Switcher	1	$0.84	WQFN-24 25 mm^2

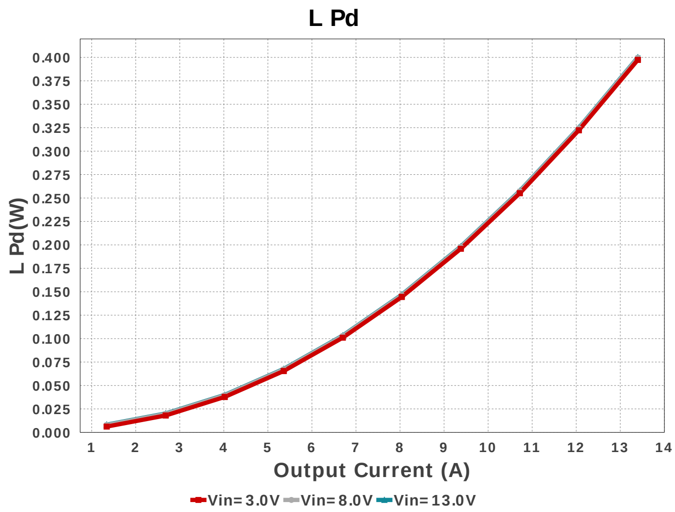

IC Tj
IC Tj(degC)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

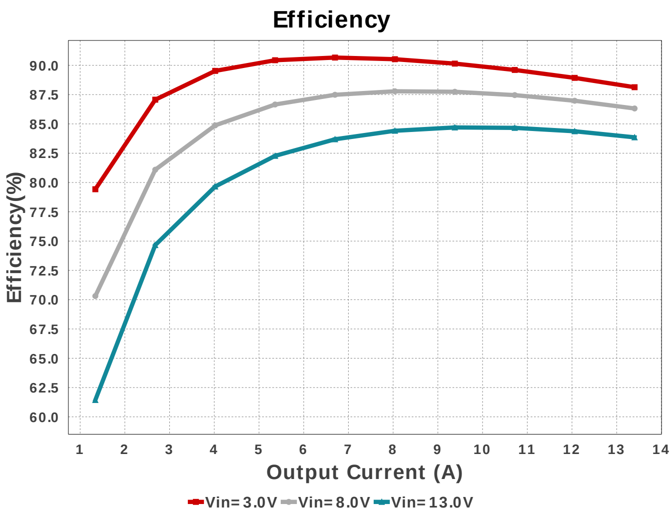

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

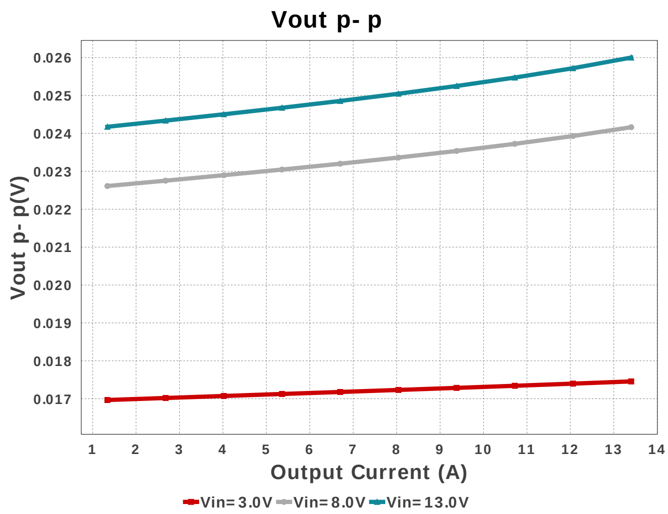

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

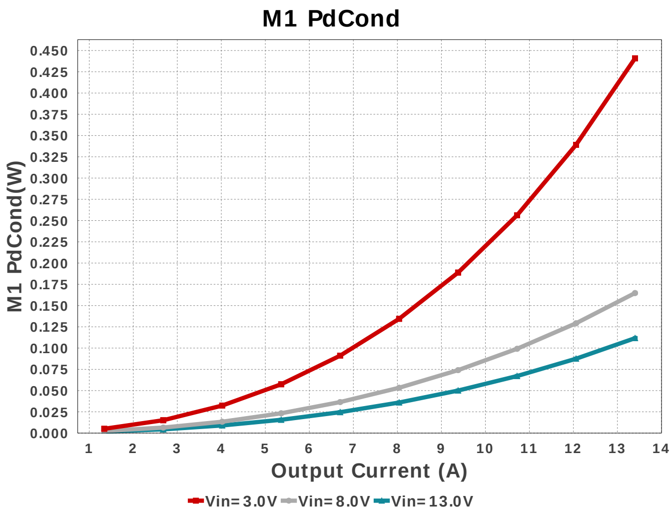

M2 PdSw
M2 PdSw(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

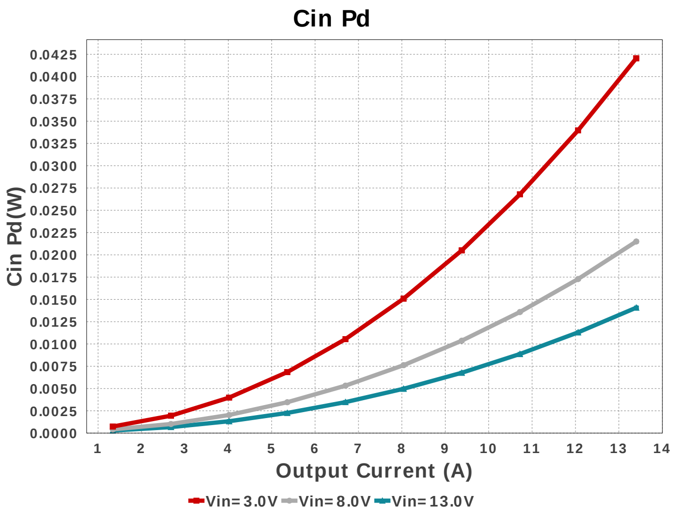

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

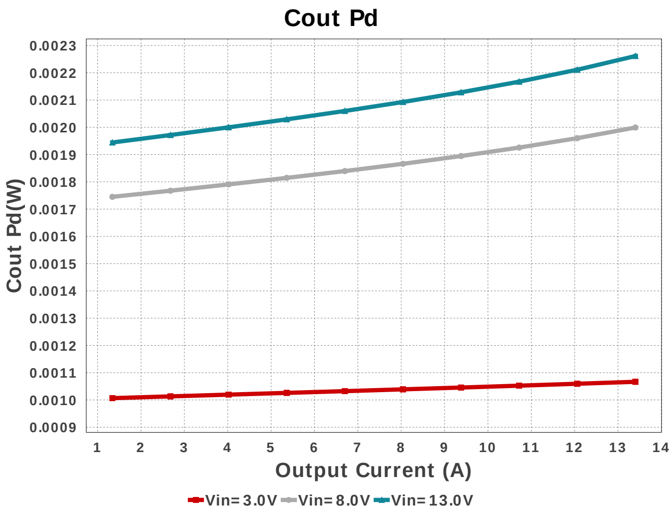

L Pd
L Pd(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

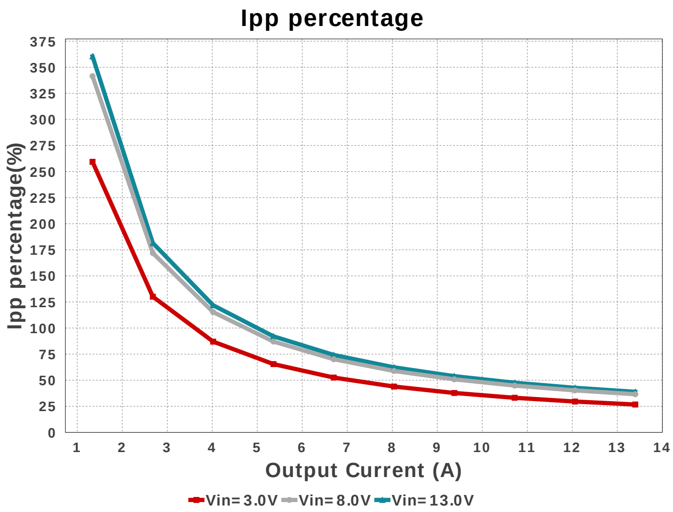

Efficiency
Efficiency(%)
90.0
87.5
85.0
82.5
80.0
77.5
75.0
72.5
70.0
67.5
65.0
62.5
60.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

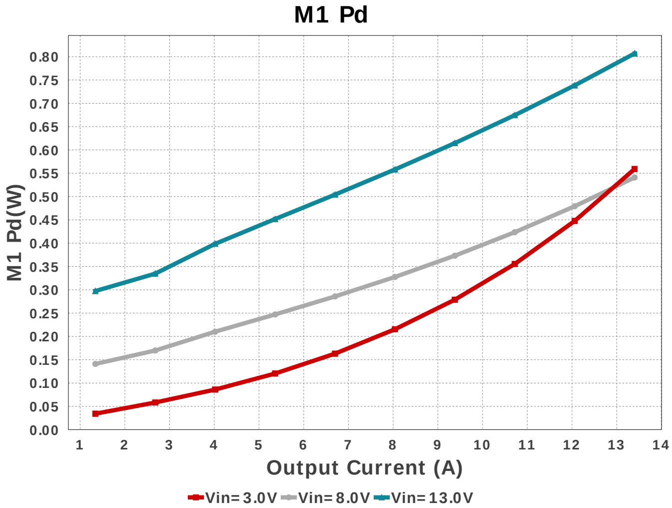

Vout p- p
Vout p- p(V)
0.026
0.025
0.024
0.023
0.022
0.021
0.020
0.019
0.018
0.017
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

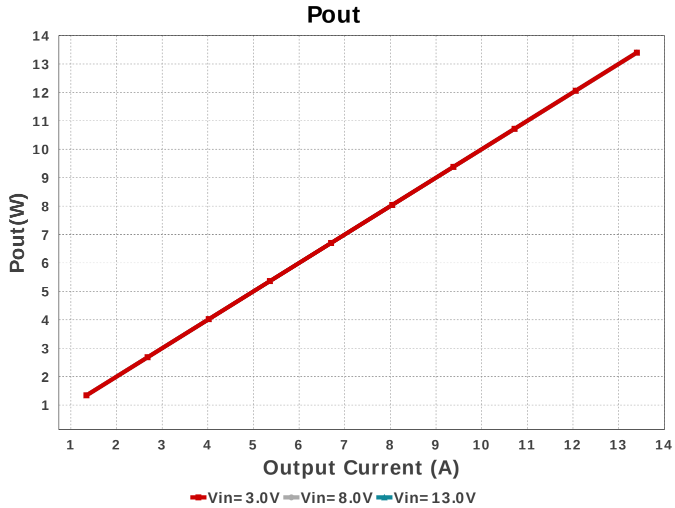

M1 PdCond
M1 PdCond(W)
0.450
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

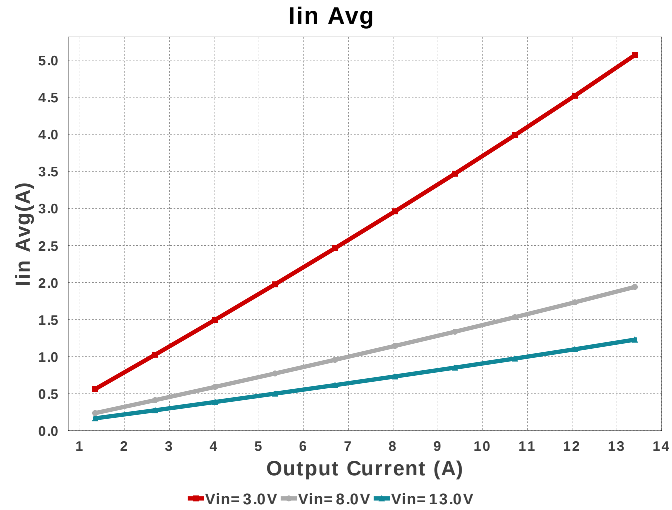

Cin Pd
Cin Pd(W)
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

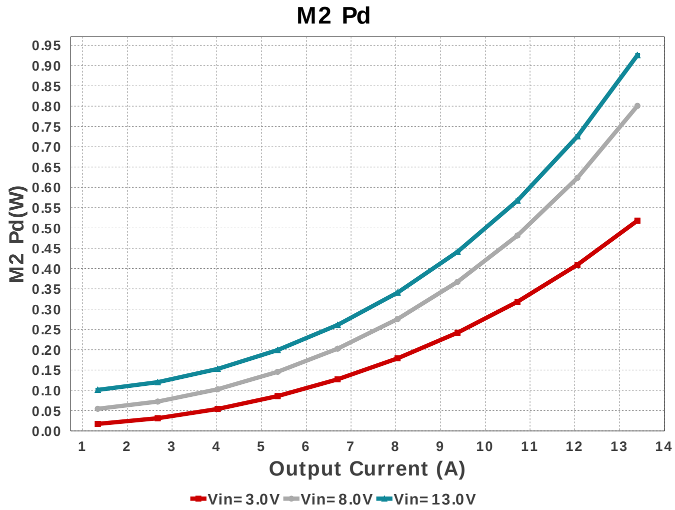

Cout Pd
Cout Pd(W)
0.0023
0.0022
0.0021
0.0020
0.0019
0.0018
0.0017
0.0016
0.0015
0.0014
0.0013
0.0012
0.0011
0.0010
0.0009
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

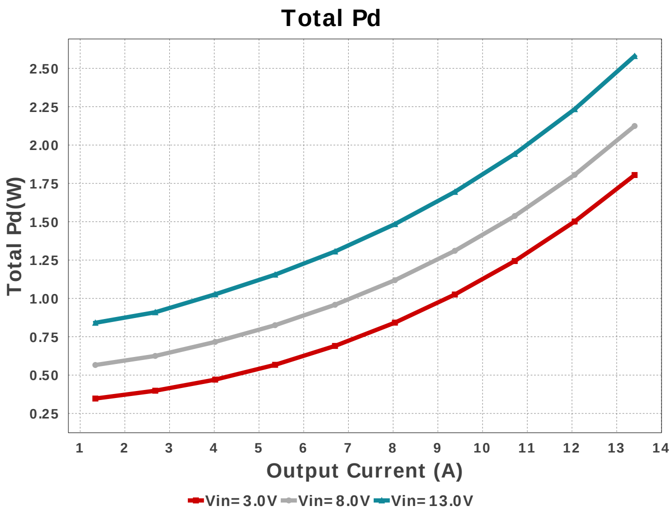

Ipp percentage
Ipp percentage(%)
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

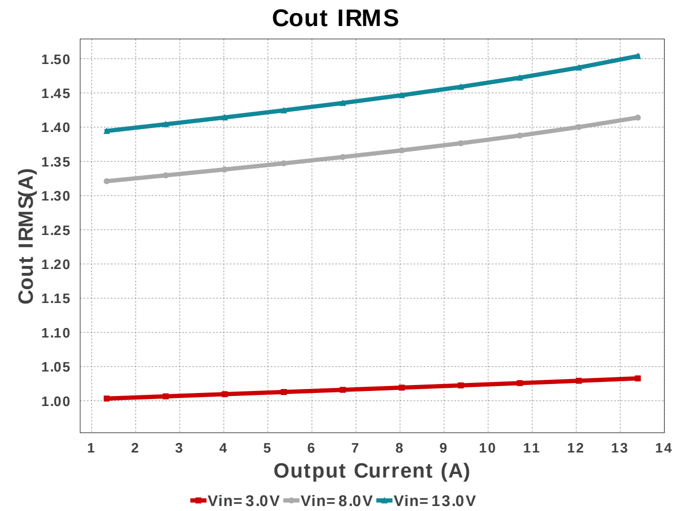

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

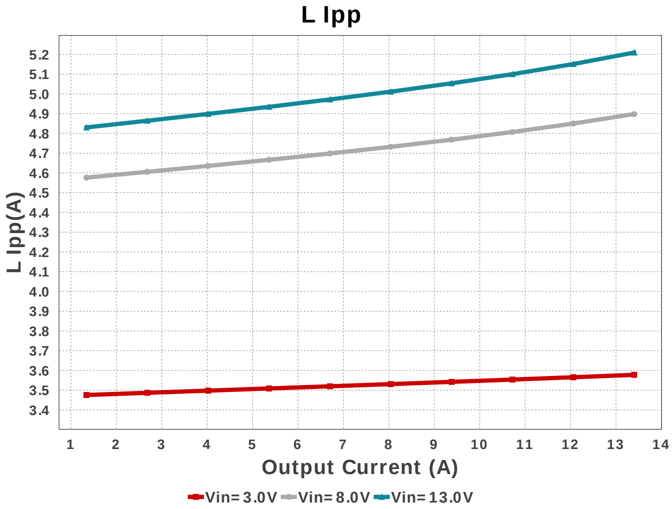

Pout
Pout(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

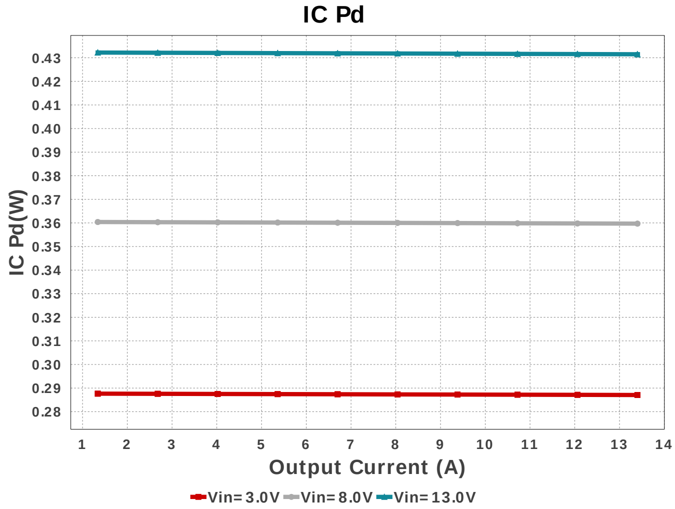

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

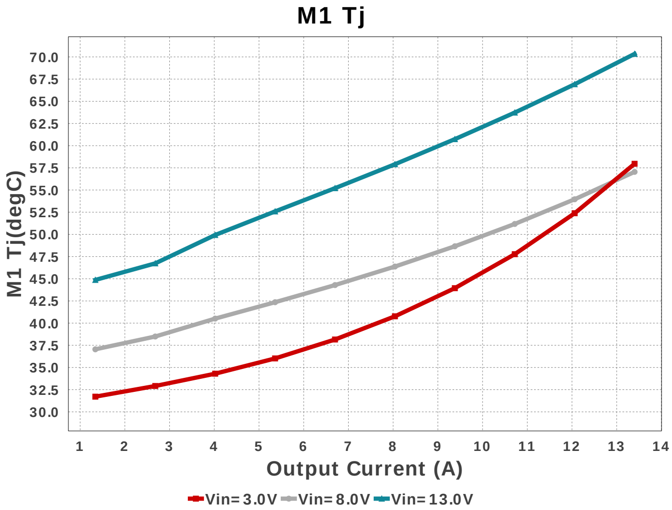

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

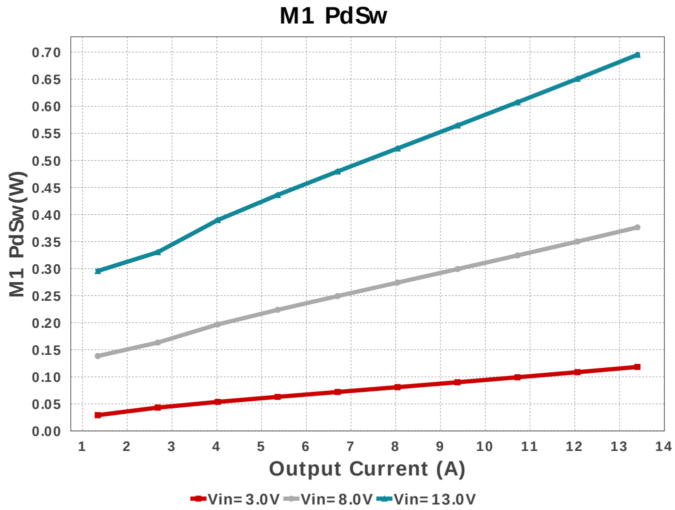

Total Pd
Total Pd(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

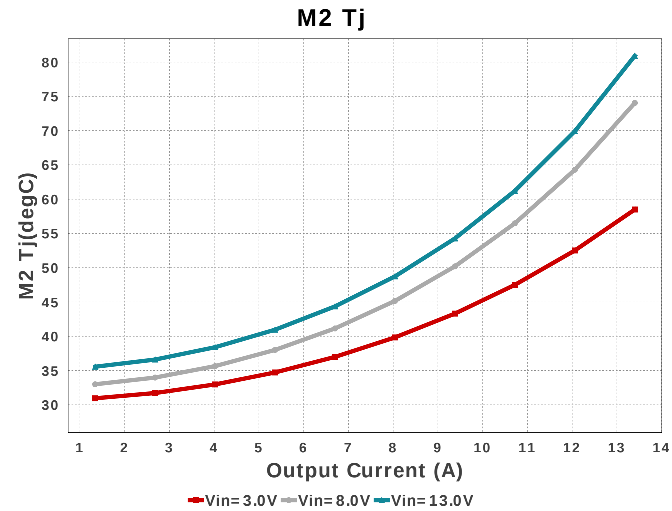

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

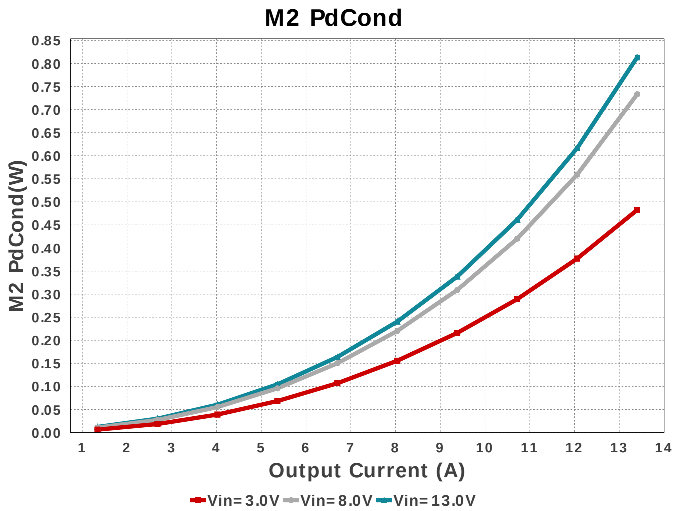

L Ipp
L Ipp(A)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V

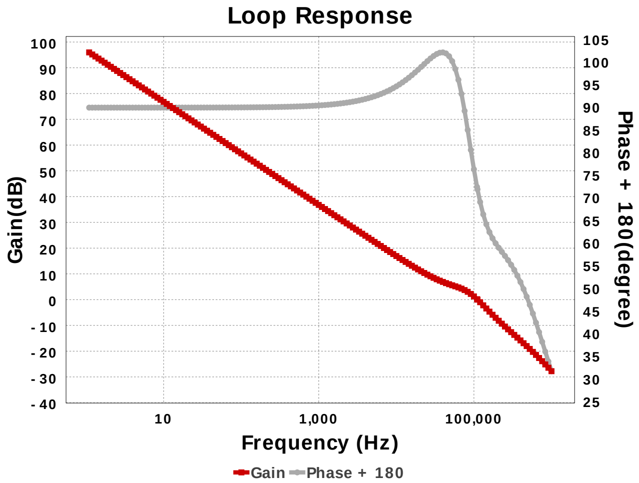

IC Pd
IC Pd(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V


M1 Tj
M1 Tj(degC)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V


M1 PdSw
M1 PdSw(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V


M2 Tj
M2 Tj(degC)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V


M2 PdCond
M2 PdCond(W)
Output Current (A)
Vin=3.0V Vin=8.0V Vin=13.0V



Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	3.751 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	14.072 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	1.504 A	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	2.261 mW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	16.005 A	IC	Peak switch current in IC
6.	IC Pd	431.49 mW	IC	IC power dissipation
7.	IC Tj	44.11 degC	IC	IC junction temperature
8.	IC Tolerance	6.0 mV	IC	IC Feedback Tolerance
9.	ICThetaJA	32.7 degC/W	IC	IC junction-to-ambient thermal resistance
10.	Iin Avg	1.229 A	IC	Average input current
11.	Ipp percentage	38.876 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
12.	L Ipp	5.209 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	400.01 mW	Inductor	Inductor power dissipation
14.	M1 Pd	806.86 mW	Mosfet	M1 MOSFET total power dissipation
15.	M1 PdCond	111.65 mW	Mosfet	M1 MOSFET conduction losses
16.	M1 PdSw	695.2 mW	Mosfet	M1 MOSFET switching losses
17.	M1 Tj	70.343 degC	Mosfet	M1 MOSFET junction temperature
18.	M2 Pd	925.5 mW	Mosfet	M2 MOSFET total power dissipation
19.	M2 PdCond	813.28 mW	Mosfet	M2 MOSFET conduction losses
20.	M2 PdSw	112.22 mW	Mosfet	M2 MOSFET switching losses
21.	M2 Tj	80.902 degC	Mosfet	M2 MOSFET junction temperature
22.	Cin Pd	14.072 mW	Power	Input capacitor power dissipation
23.	Cout Pd	2.261 mW	Power	Output capacitor power dissipation
24.	IC Pd	431.49 mW	Power	IC power dissipation
25.	L Pd	400.01 mW	Power	Inductor power dissipation
26.	M1 Pd	806.86 mW	Power	M1 MOSFET total power dissipation
27.	M1 PdCond	111.65 mW	Power	M1 MOSFET conduction losses
28.	M1 PdSw	695.2 mW	Power	M1 MOSFET switching losses
29.	M2 Pd	925.5 mW	Power	M2 MOSFET total power dissipation
30.	M2 PdCond	813.28 mW	Power	M2 MOSFET conduction losses
31.	M2 PdSw	112.22 mW	Power	M2 MOSFET switching losses
32.	Total Pd	2.58 W	Power	Total Power Dissipation
33.	BOM Count	30	System Information	Total Design BOM count
34.	Cross Freq	100.055 kHz	System Information	Bode plot crossover frequency
35.	Duty Cycle	8.443 %	System Information	Duty cycle
36.	Efficiency	83.854 %	System Information	Steady state efficiency
37.	FootPrint	207.0 mm^2	System Information	Total Foot Print Area of BOM components
38.	Frequency	1.203 MHz	System Information	Switching frequency
39.	Gain Marg	-41.635 dB	System Information	Bode Plot Gain Margin
40.	Iout	13.4 A	System Information	Iout operating point
41.	Low Freq Gain	94.4 dB	System Information	Gain at 1Hz

#	Name	Value	Category	Description
42.	Mode	CCM	System Information	Conduction Mode
43.	Phase Marg	80.867 deg	System Information	Bode Plot Phase Margin
44.	Pout	13.4 W	System Information	Total output power
45.	Total BOM	$3.72	System Information	Total BOM Cost
46.	Vin	13.0 V	System Information	Vin operating point
47.	Vout	1.0 V	System Information	Operational Output Voltage
48.	Vout Actual	1000.0 mV	System Information	Vout Actual calculated based on selected voltage divider resistors
49.	Vout Tolerance	1.816 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
50.	Vout p-p	26.001 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	13.4	Maximum Output Current
VinMax	13.0	Maximum input voltage
VinMin	3.0	Minimum input voltage
Vout	1.0	Output Voltage
base_pn	LM27403	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

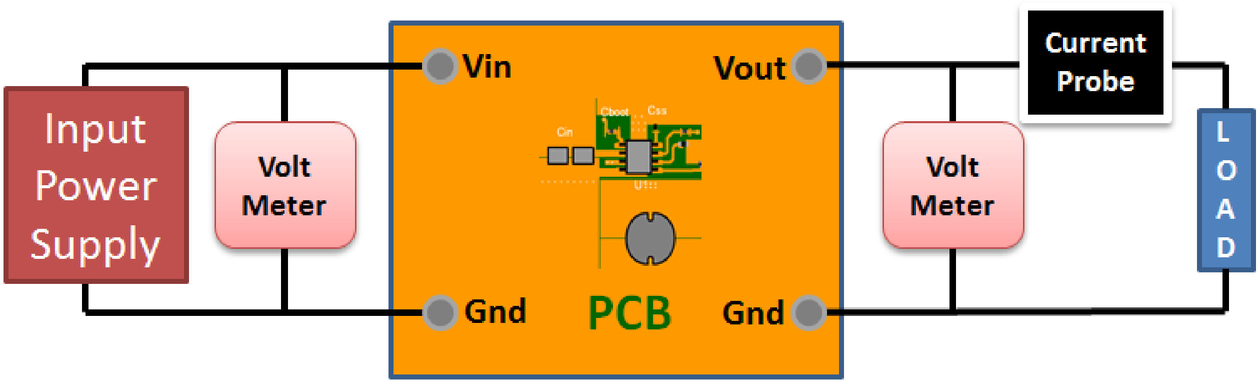
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 3.0V 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. Tip: LM27403 High Current PCB Layout Design Guidance For higher current designs, please take care in designing the PCB layout. Consider good thermal management practices and proper routing of traces. Please see the following for more guidelines. Best Layout Practices for Switching Power Supplies http://sva.ti.com/assets/en/appnotes/national_power_designer114.pdf SIMPLE SWITCHER Layout Guidelines http://www.ti.com/lit/an/snva054c/snva054c.pdf Thermal Design by Insight, not Hindsight http://www.ti.com/lit/an/snva419c/snva419c.pdf

2. General Description: The LM27403 is a synchronous voltage mode buck controller with inductor DCR current sense capability. Sensing the inductor current eliminates the need to add resistive powertrain elements which increases overall efficiency and allows for accurate continuous current limit sensing. A 0.6V +/-1% voltage reference permits high accuracy and low voltage capability at the output. An operating voltage range of 3V to 20V makes the LM27403 suitable for a large variety of input rails. The LM27403 voltage mode control loop incorporates input voltage feed-forward to maintain stability throughout the entire input voltage range. The switching frequency is adjustable from 200 kHz to 1.2 MHz allowing a flexible design space. A power good indicator provides power rail sequencing capability and output fault detection. Programmable external softstart capability limits inrush current and provides monotonic output control at startup. Other features include external tracking of other power supplies, integrated LDO bias supply, and synchronization capability.

3. Master key : C96DB803457EDC60[v1]

4. **LM27403** Product Folder : http://www.ti.com/product/LM27403 : contains the data sheet and other resources.