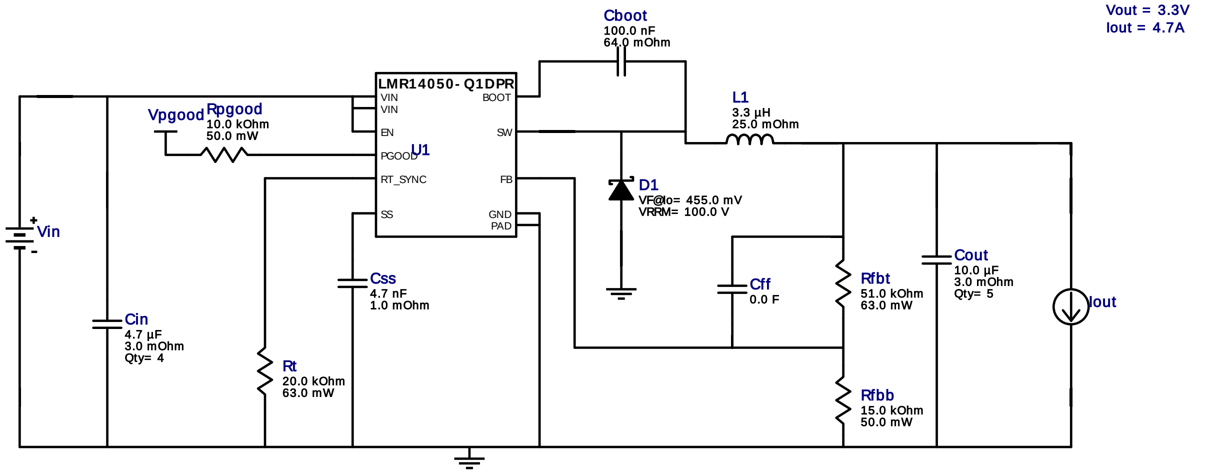
TEXAS INSTRUMENTS

VinMin = 4.75V
VinMax = 17.0V
Vout = 3.3V
Iout = 4.7A

Device = LMR14050QDPRRQ1
Topology = Buck
Created = 2020-05-20 01:14:29.646
BOM Cost = NA
BOM Count = 19
Total Pd = 3.8W

WEBENCH ® Design Report

Design : 25 LMR14050QDPRRQ1
LMR14050QDPRRQ1 4.75V-17V to 3.30V @ 4.7A



1. This regulator device is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.View WEBENCH(R) Disclaimer.

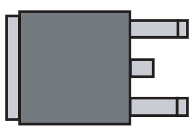
Design Alerts

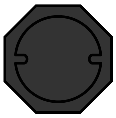
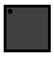
Component Selection Information

The LMR14050SDPR-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.LMR14050SDPR-Q1 is a Spread Spectrum option for reduced EMI. For additional information or assistance regarding the frequency dithering, please contact your local TI FAE.

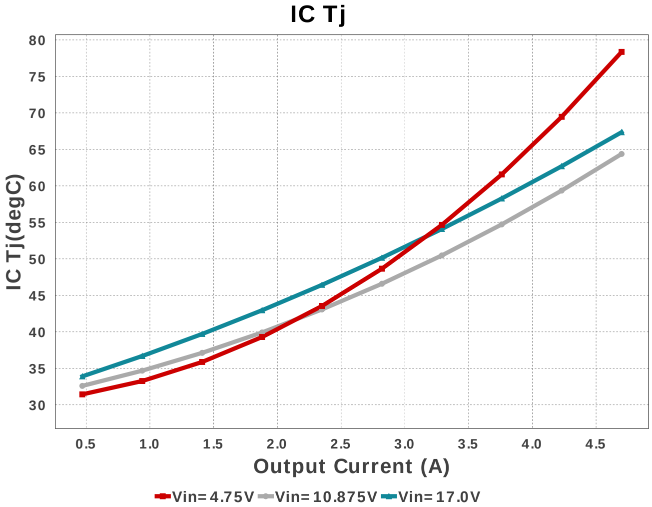
Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm^2
Cff	CUSTOM	CUSTOM Series= X7R	Cap= 0.0 F VDC= 16.0 V IRMS= 0.0 A	0	NA	0201 0 mm^2
Cin	CUSTOM	CUSTOM Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 5.0 A	4	NA	1210 0 mm^2
Cout	CUSTOM	CUSTOM Series= X5R	Cap= 10.0 uF ESR= 3.0 mOhm VDC= 6.3 V IRMS= 4.4118 A	5	NA	1206_190 0 mm^2
Css	CUSTOM	CUSTOM Series= X7R	Cap= 4.7 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	NA	0402 0 mm^2
D1	STMicroelectronics	STPS20M100SG-TR	VF@Io= 455.0 mV VRRM= 100.0 V	1	$1.33	DDPAK 210 mm^2

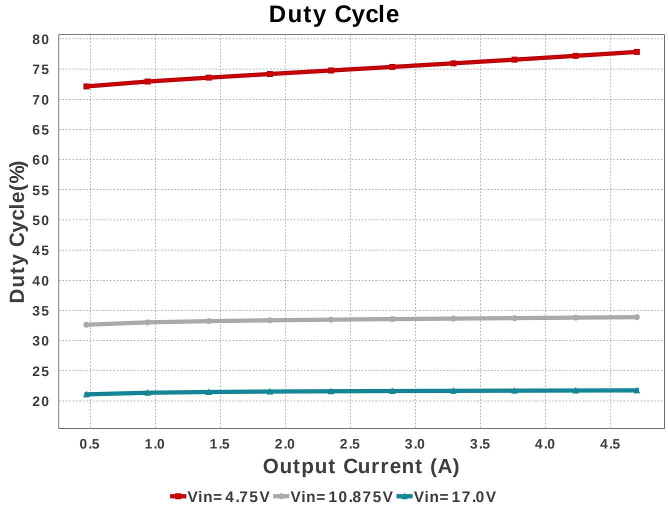


Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L1	CUSTOM	CUSTOM	L= 3.3 µH 25.0 mOhm	1	NA	 SRU1048 0 mm²
Rfbb	CUSTOM	CUSTOM Series= ?	Res= 15.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	NA	0201 0 mm²
Rfbt	CUSTOM	CUSTOM Series= CRCW..e3	Res= 51.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	NA	0402 0 mm²
Rpgood	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rt	CUSTOM	CUSTOM Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	NA	0402 0 mm²
U1	Texas Instruments	LMR14050QDPRRQ1	Switcher	1	$1.35	 DPR0010A 25 mm²

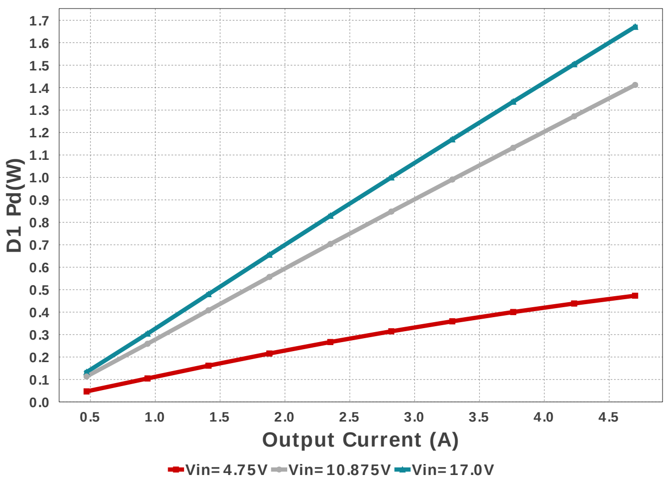
IC Tj



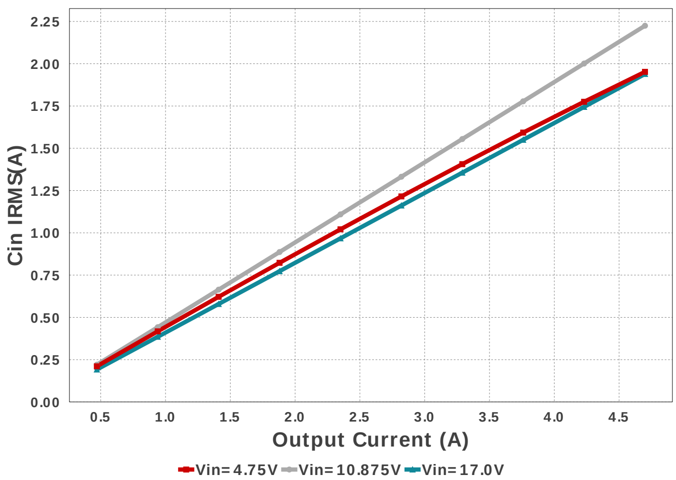
Duty Cycle

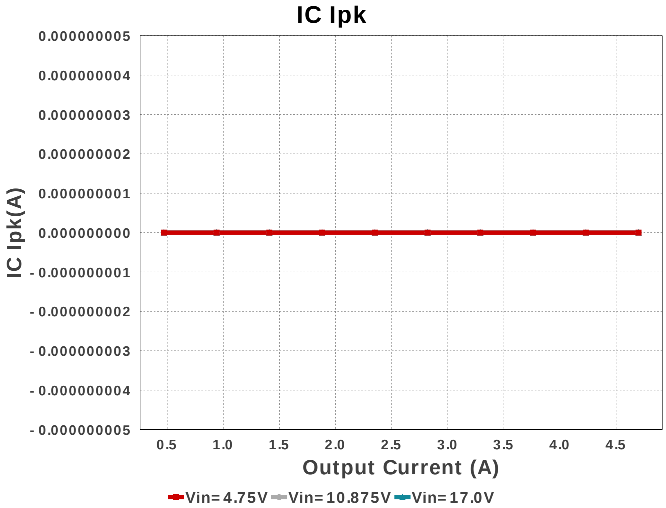


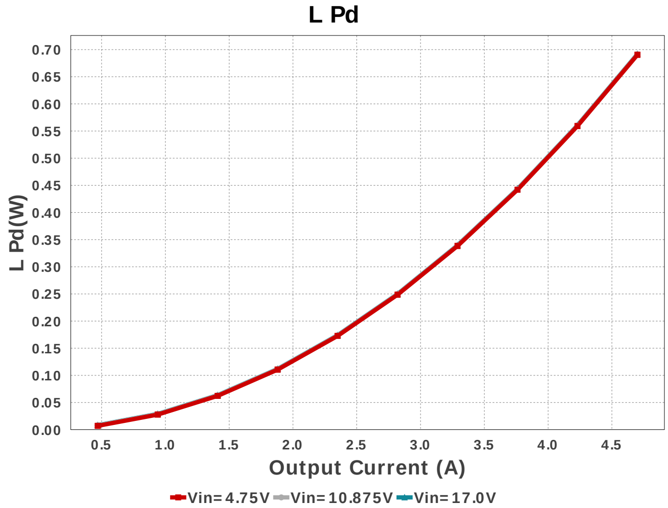
D1 Pd

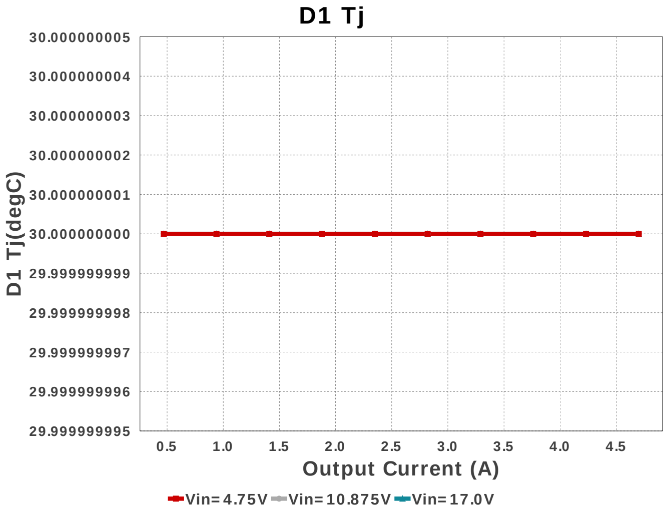


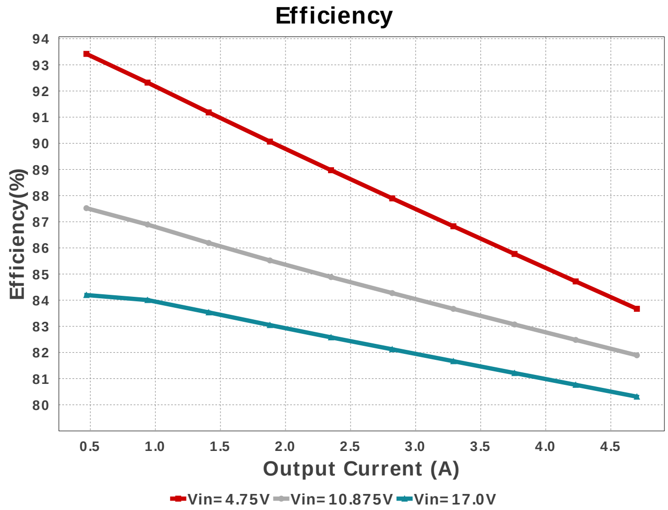
Cin IRMS

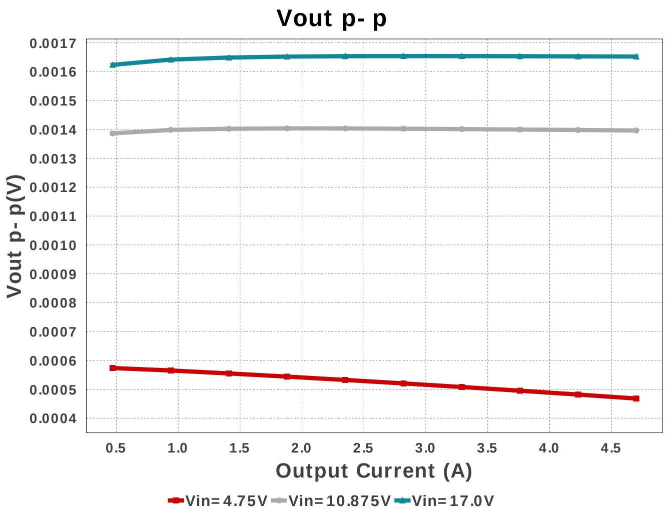


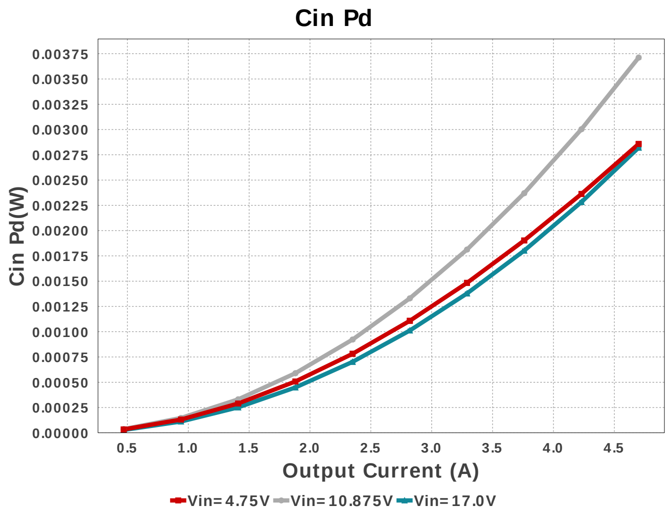

IC Ipk
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
IC Ipk(A)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

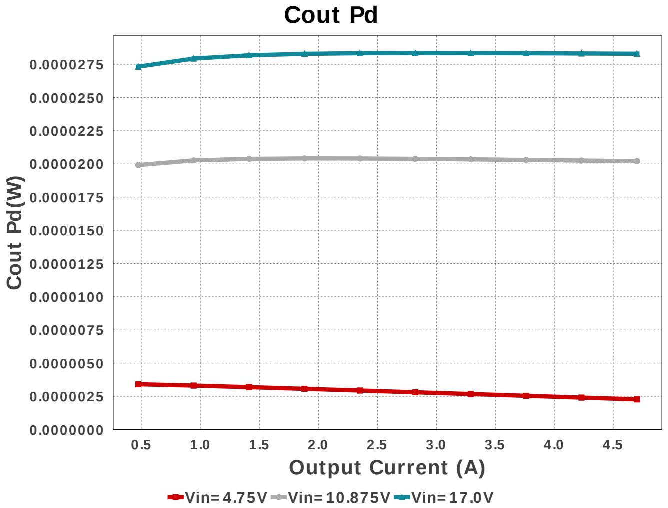

L Pd
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
L Pd(W)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

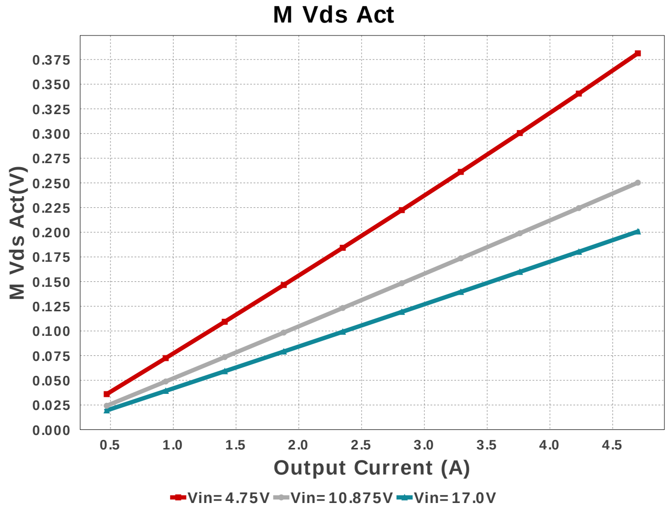

D1 Tj
30.000000005
30.000000004
30.000000003
30.000000002
30.000000001
30.000000000
29.999999999
29.999999998
29.999999997
29.999999996
29.999999995
D1 Tj(degC)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

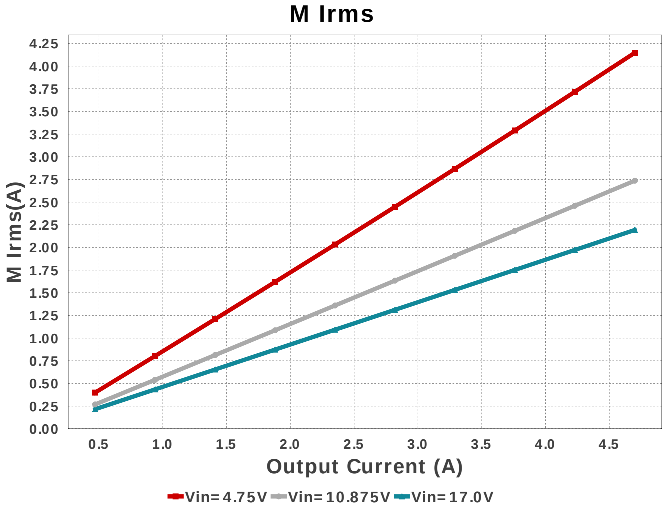

Efficiency
94
93
92
91
90
89
88
87
86
85
84
83
82
81
80
Efficiency(%)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

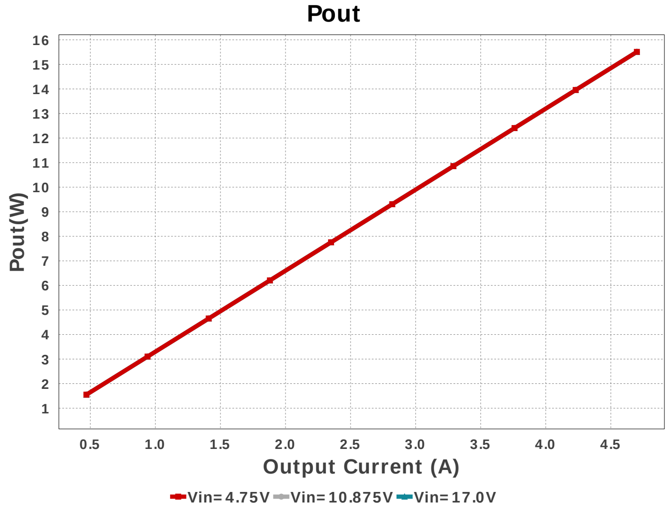

Vout p-p
0.0017
0.0016
0.0015
0.0014
0.0013
0.0012
0.0011
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
Vout p-p(V)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

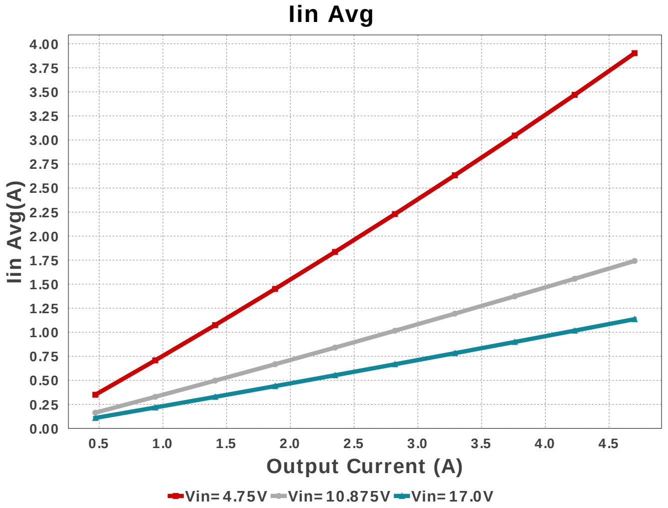

Cin Pd
0.00375
0.00350
0.00325
0.00300
0.00275
0.00250
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
Cin Pd(W)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

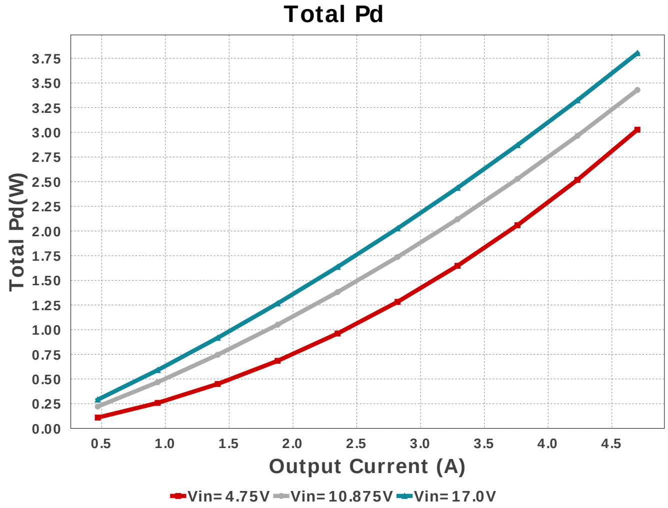

Cout Pd
Cout Pd(W)
0.0000275
0.0000250
0.0000225
0.0000200
0.0000175
0.0000150
0.0000125
0.0000100
0.0000075
0.0000050
0.0000025
0.0000000
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

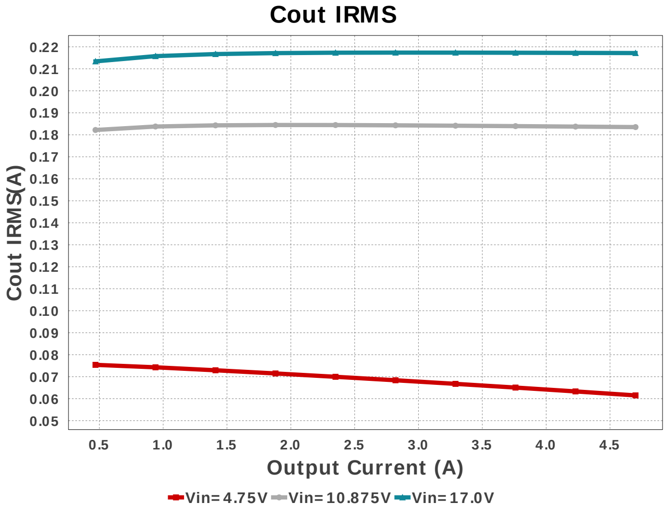

M Vds Act
M Vds Act(V)
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

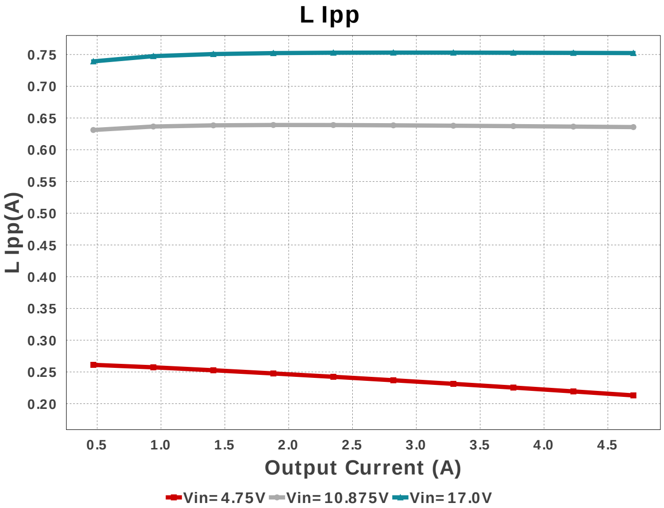

M Irms
M Irms(A)
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

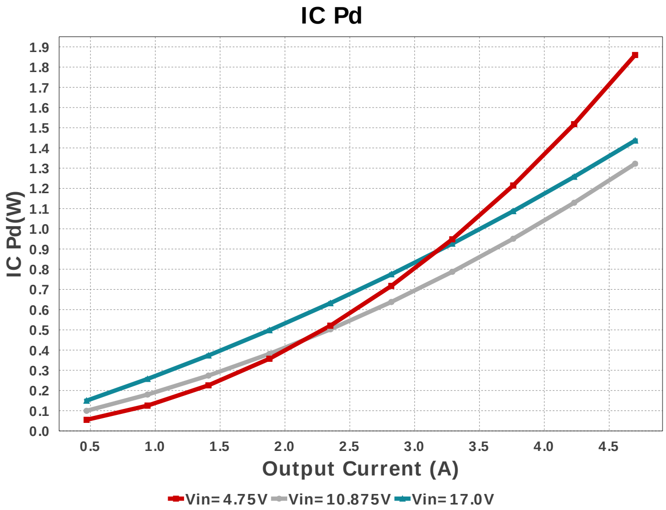

Pout
Pout(W)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V

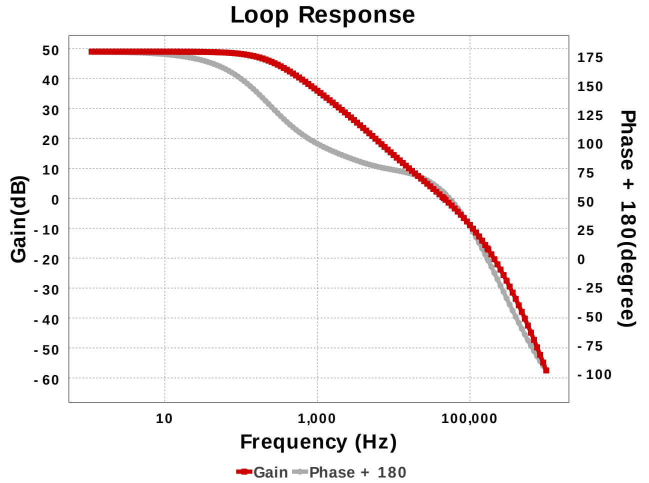

Iin Avg
Iin Avg(A)
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V


Total Pd
Total Pd(W)
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5
Output Current (A)
Vin=4.75V Vin=10.875V Vin=17.0V









Operating Values

#	Name	Value	Category	Description
1.	BOM Count	19		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	1.939 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	2.821 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	217.173 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	28.298 µW	Capacitor	Output capacitor power dissipation
7.	D1 Pd	1.671 W	Diode	Output Diode Power Dissipation
8.	D1 Tj	30.0 degC	Diode	D1 junction temperature
9.	IC Ipk	0.0 A	IC	Peak switch current in IC
10.	IC Pd	1.436 W	IC	IC power dissipation
11.	IC Tj	67.35 degC	IC	IC junction temperature
12.	IC Tolerance	18.0 mV	IC	IC Feedback Tolerance
13.	ICThetaJA	26.0 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	1.136 A	IC	Average input current
15.	L Ipp	752.309 mA	Inductor	Peak-to-peak inductor ripple current
16.	L Pd	691.79 mW	Inductor	Inductor power dissipation
17.	M Irms	2.192 A	Mosfet	MOSFET RMS ripple current
18.	M Vds Act	200.759 mV	Mosfet	Voltage drop across the MosFET
19.	Cin Pd	2.821 mW	Power	Input capacitor power dissipation
20.	Cout Pd	28.298 µW	Power	Output capacitor power dissipation
21.	D1 Pd	1.671 W	Power	Output Diode Power Dissipation
22.	IC Pd	1.436 W	Power	IC power dissipation
23.	L Pd	691.79 mW	Power	Inductor power dissipation
24.	Total Pd	3.802 W	Power	Total Power Dissipation
25.	Cross Freq	45.383 kHz	System Information	Bode plot crossover frequency
26.	Duty Cycle	21.76 %	System Information	Duty cycle
27.	Efficiency	80.311 %	System Information	Steady state efficiency

#	Name	Value	Category	Description
28.	FootPrint	514.0 mm^2	System Information	Total Foot Print Area of BOM components
29.	Frequency	1.183 MHz	System Information	Switching frequency
30.	Gain Marg	-16.724 dB	System Information	Bode Plot Gain Margin
31.	Iout	4.7 A	System Information	Iout operating point
32.	Low Freq Gain	48.929 dB	System Information	Gain at 1Hz
33.	Mode	CCM	System Information	Conduction Mode
34.	Phase Marg	57.518 deg	System Information	Bode Plot Phase Margin
35.	Pout	15.51 W	System Information	Total output power
36.	Vin	17.0 V	System Information	Vin operating point
37.	Vout	3.3 V	System Information	Operational Output Voltage
38.	Vout Actual	3.3 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	3.999 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	1.652 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	4.7	Maximum Output Current
VinMax	17.0	Maximum input voltage
VinMin	4.75	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LMR14050SDPR-Q1	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

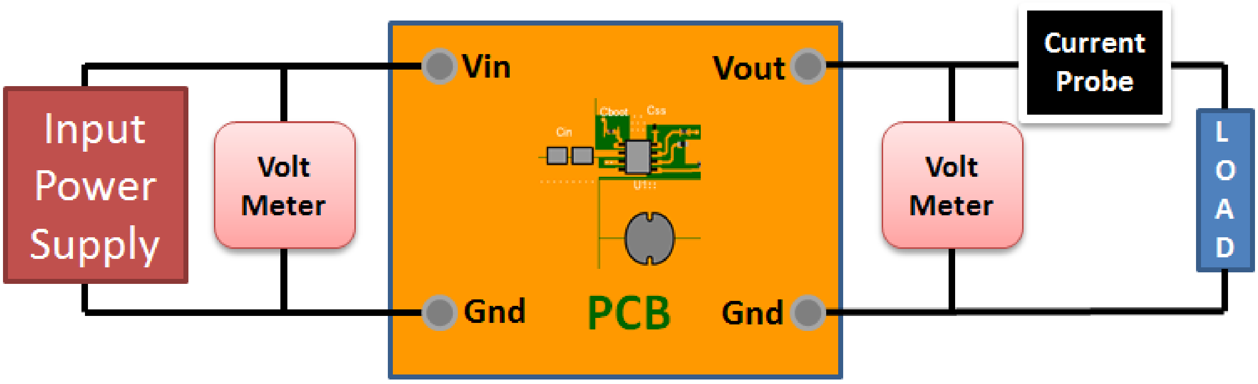
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 4.75V 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.

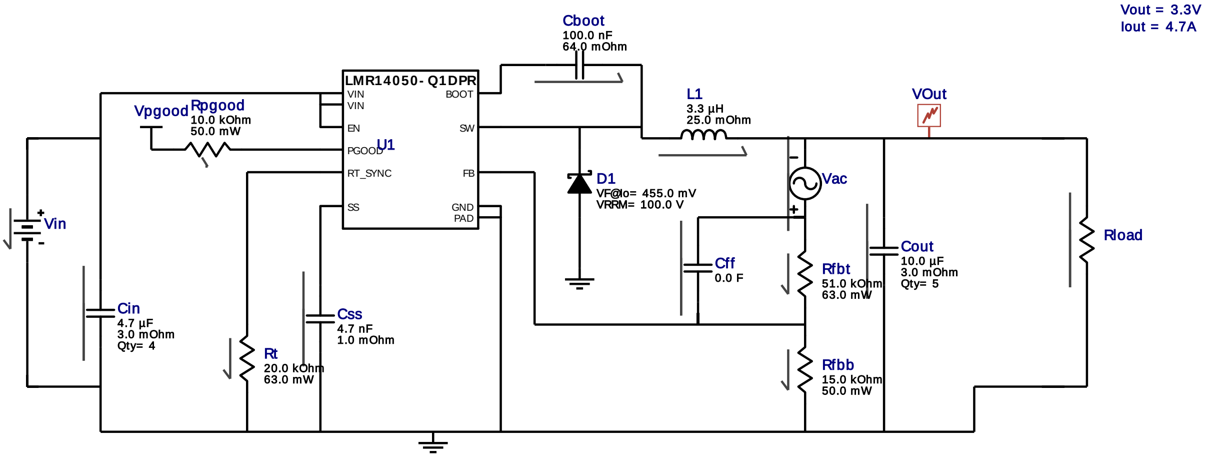


WEBENCH® Electrical Simulation Report

Design Id = 25

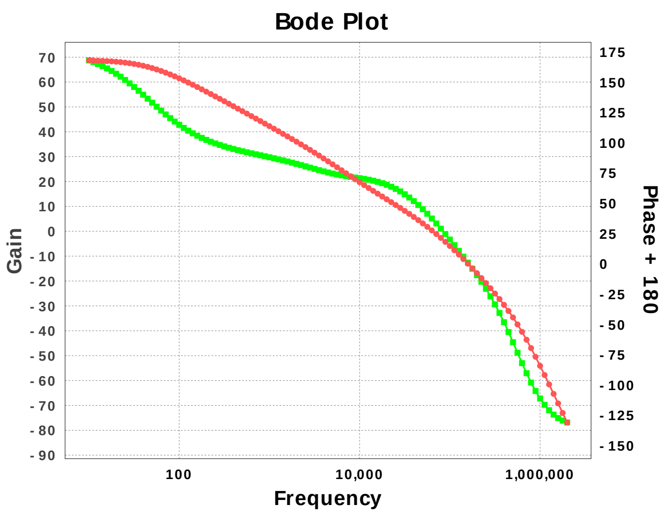
sim_id = 14

Simulation Type = Bode Plot



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cinj	C	no description	10000000 F
2.	Linj	L	no description	10000000 H
3.	Vinj	AC	no description	1
4.	Rload	R	Load Resistance	0.702127659574468 Ohm



Design Assistance

1. Master key : 1B4DF71BE2EA87F4[v1]

2. **LMR14050SDPR-Q1** Product Folder : http://www.ti.com/product/LMR14050%2DQ1 : contains the data sheet and other resources.