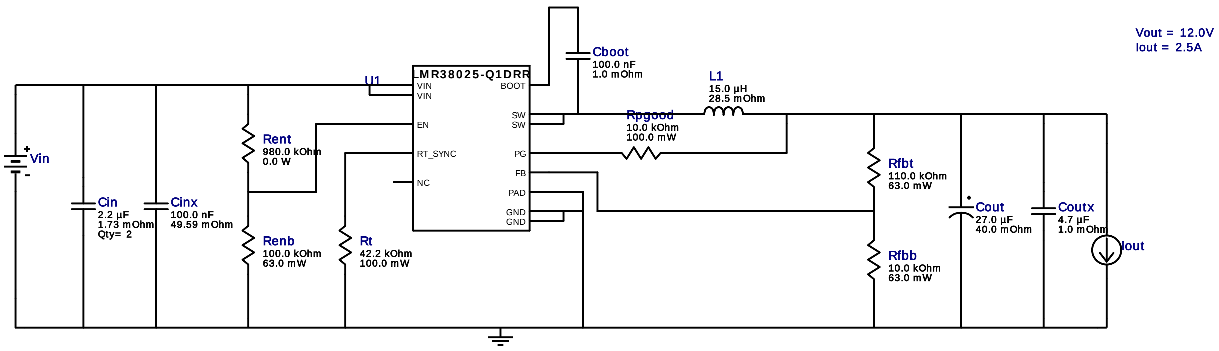
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 13.5V
VinMax = 48.0V
Vout = 12.0V
Iout = 2.5A

Device = LMR38025SQDRRRQ1
Topology = Buck
Created = 2025-06-01 18:33:04.256
BOM Cost = NA
BOM Count = 15
Total Pd = 2.97W

Design : 4 LMR38025SQDRRRQ1
LMR38025SQDRRRQ1 13.5V-48V to 12.00V @ 2.5A



Design Alerts

Component Selection Information

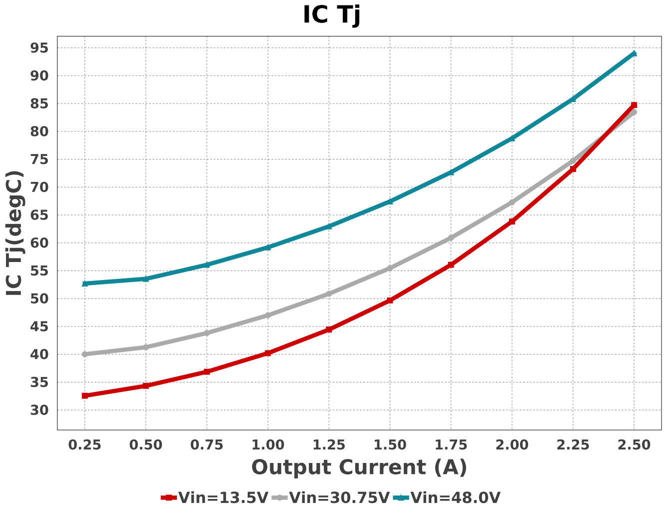
The LMR38025-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application. This device can work in steady state at Vin = 4.2V. However, needs a minimum of 4.5V during start up. See datasheet for details.

Electrical BOM

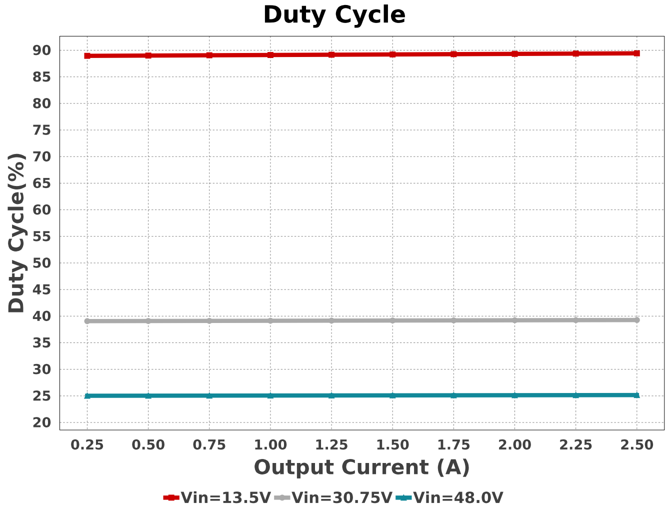
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cin	TDK	C3225X7R2A225K230AB Series= X7R	Cap= 2.2 uF ESR= 1.73 mOhm VDC= 100.0 V IRMS= 5.5932 A	2	$0.21	1210_250 15 mm^2
Cinx	TDK	C1608X7S2A104K080AB Series= X7S	Cap= 100.0 nF ESR= 49.59 mOhm VDC= 100.0 V IRMS= 751.62 mA	1	$0.03	0603 5 mm^2
Cout	Panasonic	25SVPF27MX Series= SVPF	Cap= 27.0 uF ESR= 40.0 mOhm VDC= 25.0 V IRMS= 2.45 A	1	$0.47	CAPSMT_62_E61 53 mm^2
Cout	Panasonic	25SVPF27MX Series= SVPF	Cap= 27.0 uF ESR= 40.0 mOhm VDC= 25.0 V IRMS= 2.45 A	1	$0.47	CAPSMT_62_E61 53 mm^2
Coutx	MuRata	GRM32ER71H475KA88L Series= X7R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 6.0 A	1	$0.16	1210 15 mm^2
L1	Bourns	SRR1280-150M	L= 15.0 µH 28.5 mOhm	1	$0.60	SRR1280 210 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Renb	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rent	CUSTOM	CUSTOM Series= ?	Res= 980.0 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm^2
Rfbb	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW0402110KFKED Series= CRCW..e3	Res= 110.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rpgood	Vishay-Dale	CRCW060310K0FKEA Series= CRCW..e3	Res= 10.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rt	Vishay-Dale	CRCW060342K2FKEA Series= CRCW..e3	Res= 42.2 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LMR38025SQDRRRQ1	Switcher	1	$1.35	DRR0012E 16 mm^2

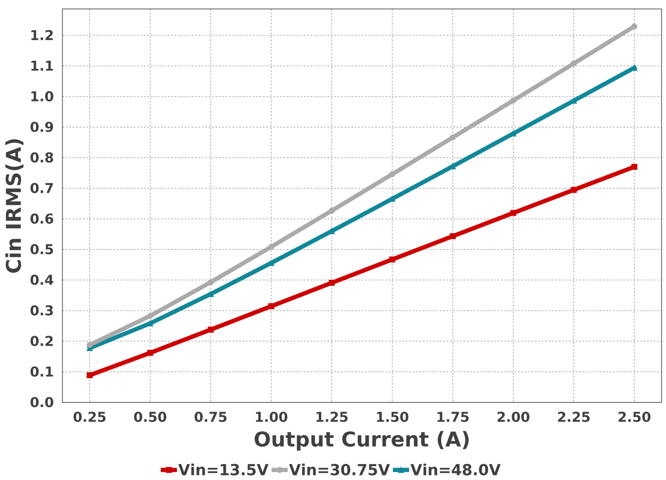
IC Tj



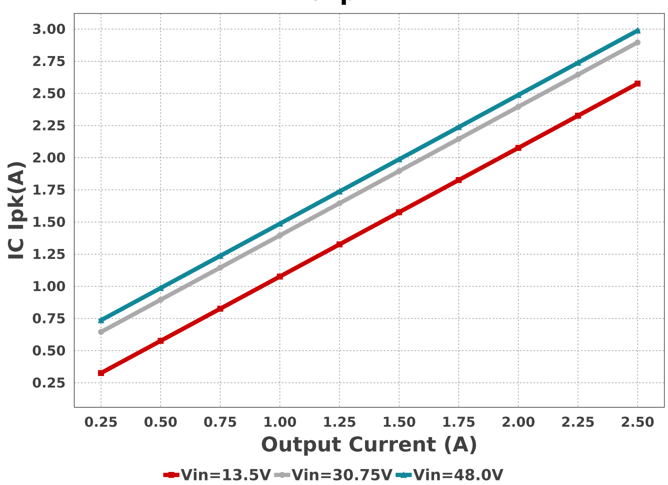
Duty Cycle

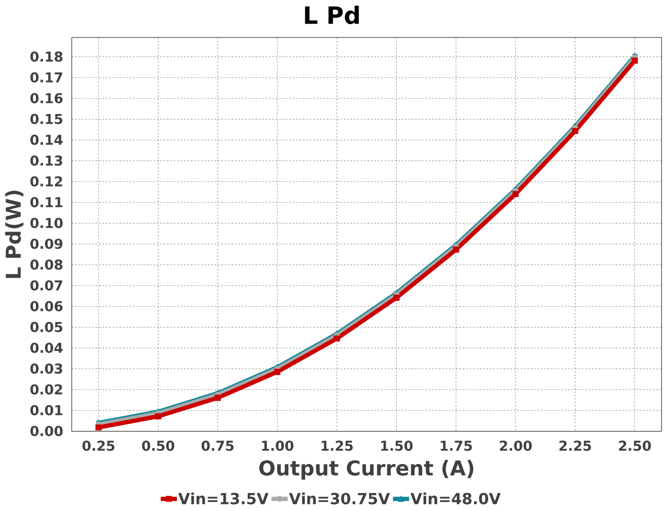


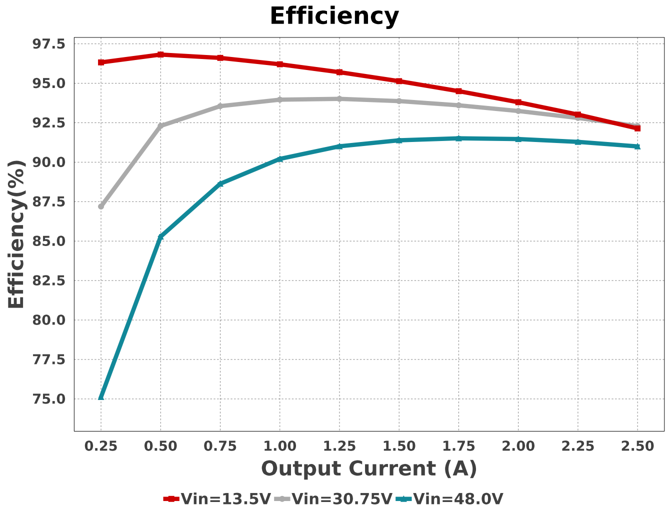
Cin IRMS

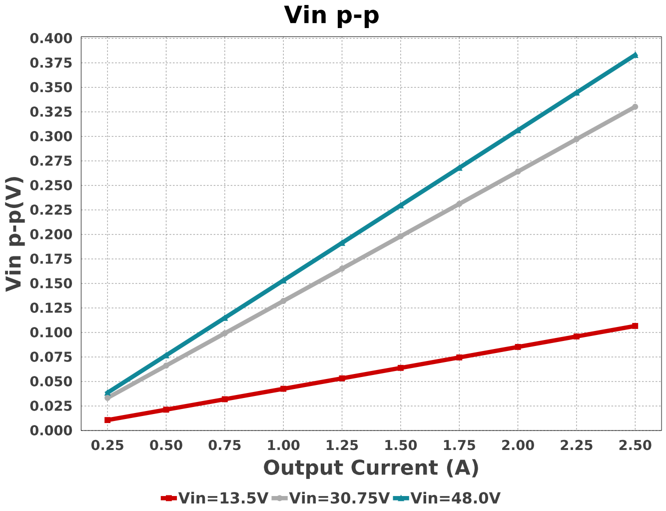


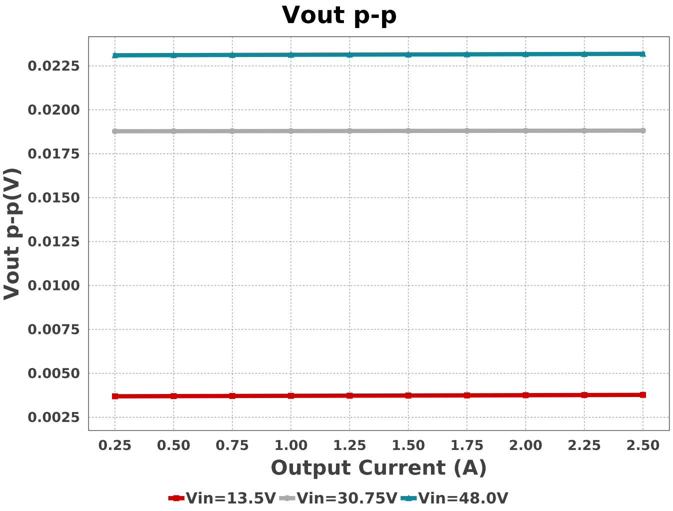
IC Ipk

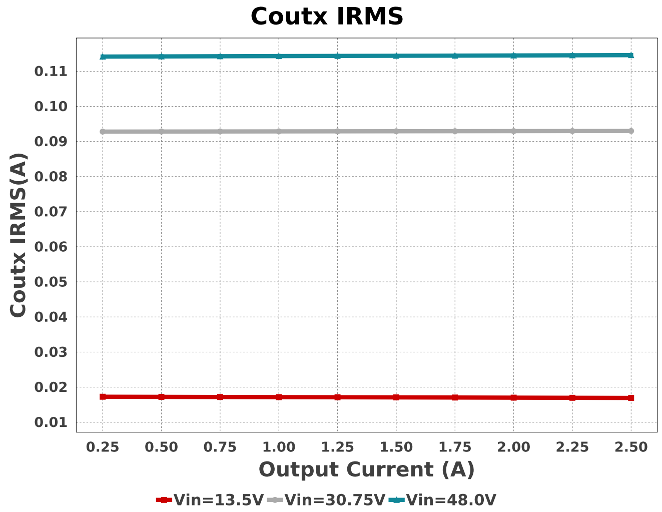


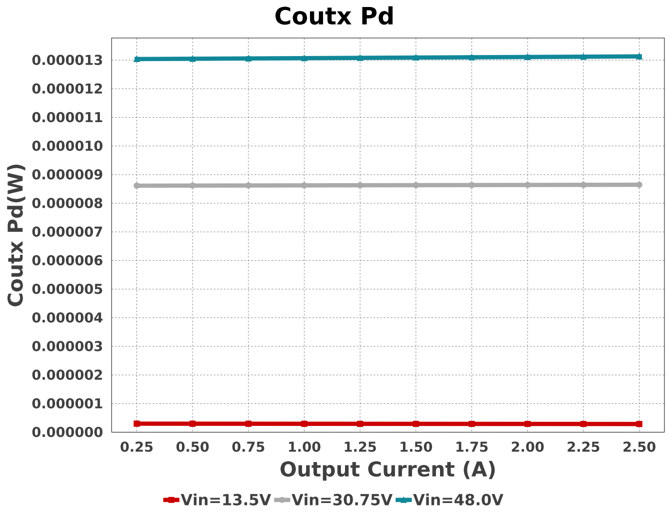

L Pd
L Pd(W)
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

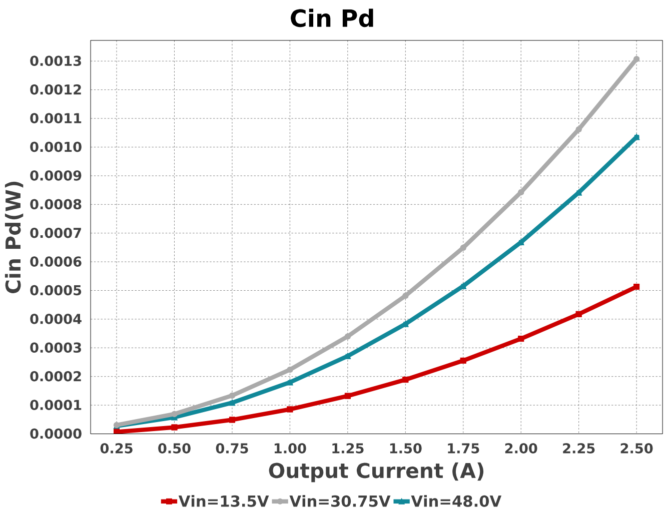

Efficiency
Efficiency(%)
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

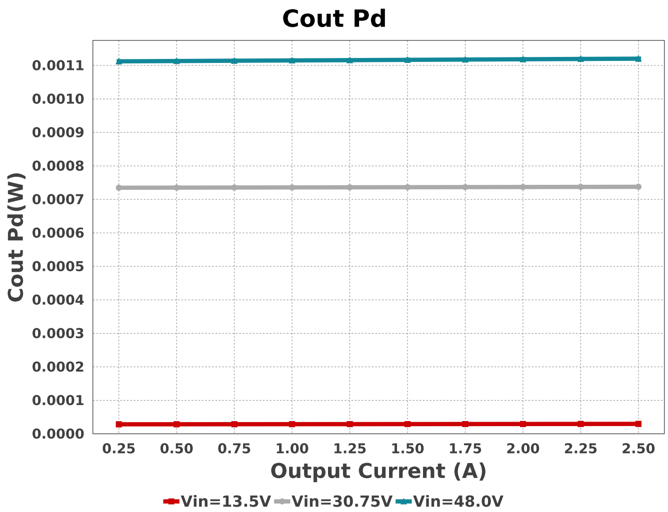

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

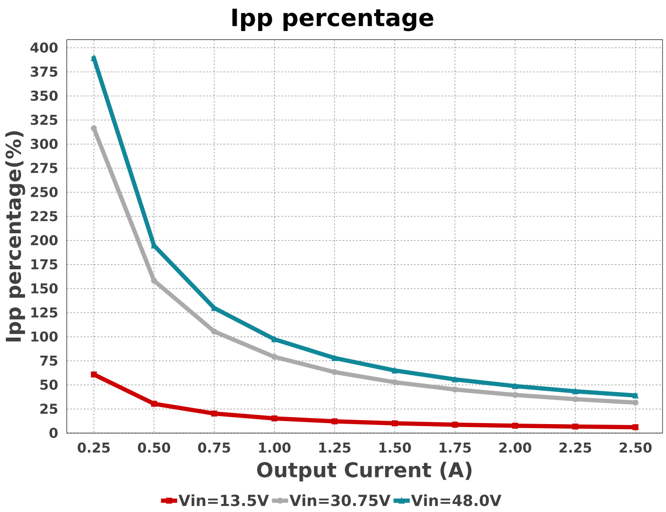

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

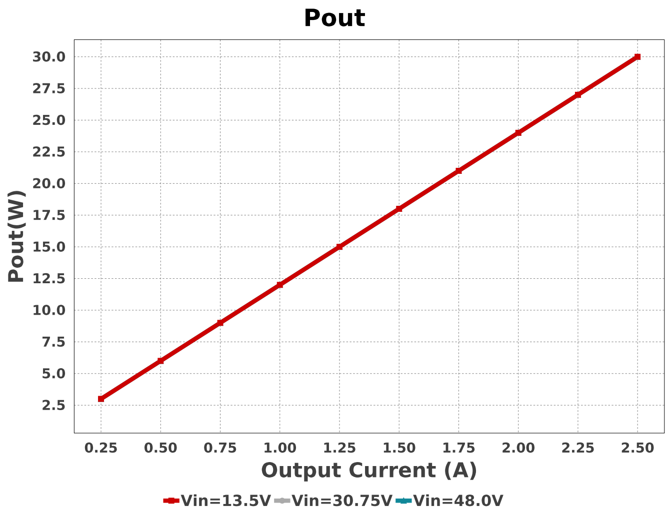

Coutx IRMS
Coutx IRMS(A)
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

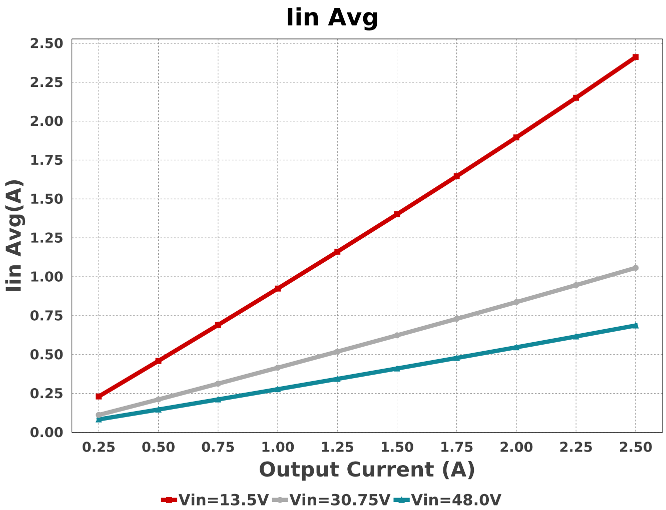

Coutx Pd
Coutx Pd(W)
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

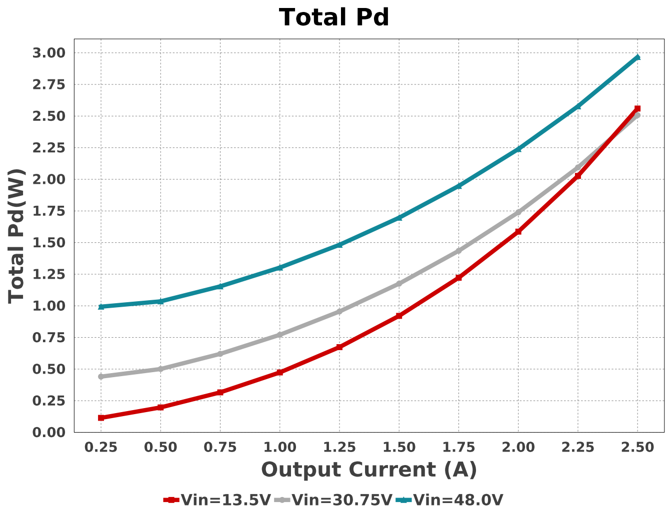

Cin Pd
Cin Pd(W)
0.0000 0.0001 0.0002 0.0003 0.0004 0.0005 0.0006 0.0007 0.0008 0.0009 0.0010 0.0011 0.0012 0.0013
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

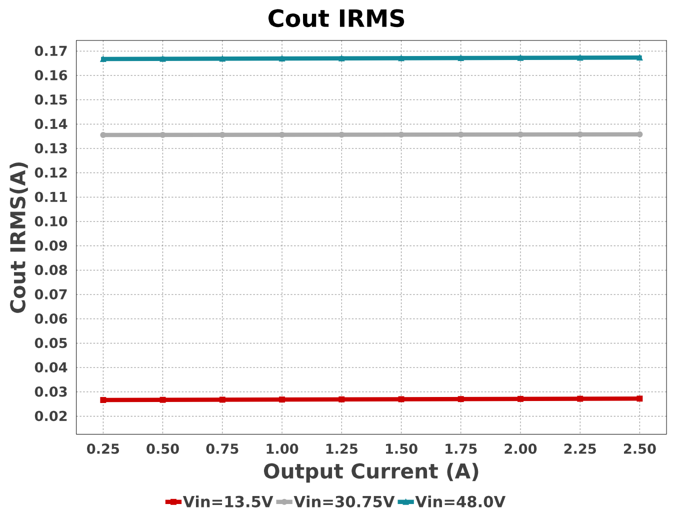

Cout Pd
Cout Pd(W)
0.0000 0.0001 0.0002 0.0003 0.0004 0.0005 0.0006 0.0007 0.0008 0.0009 0.0010 0.0011
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

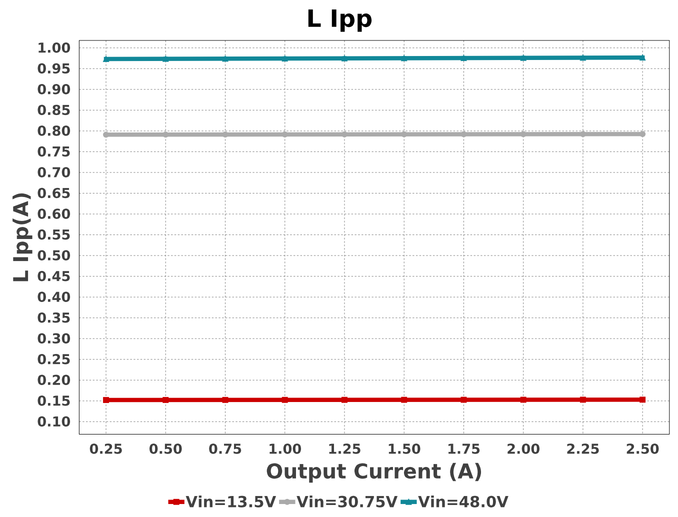

Ipp percentage
Ipp percentage(%)
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

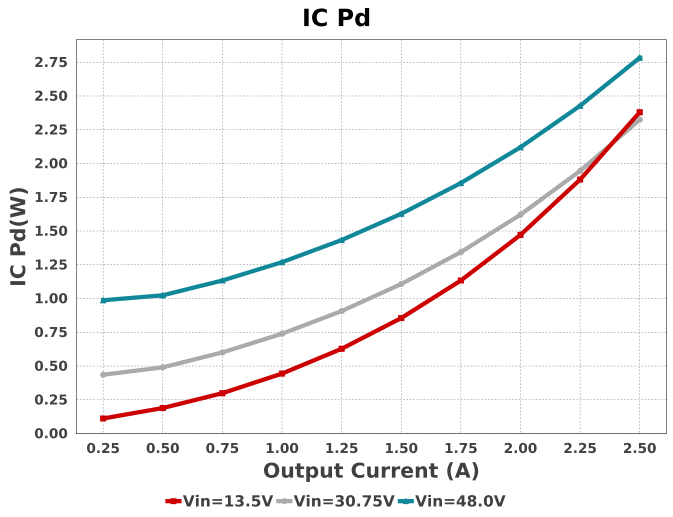

Pout
Pout(W)
2.5 5.0 7.5 10.0 12.5 15.0 17.5 20.0 22.5 25.0 27.5 30.0
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V

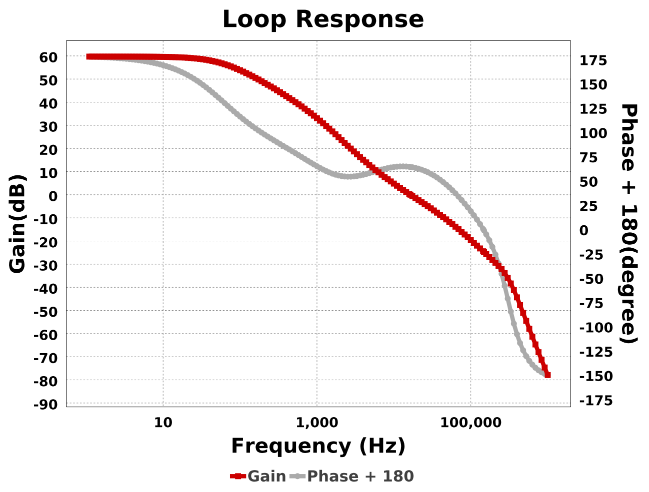

Iin Avg
Iin Avg(A)
0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V


Total Pd
Total Pd(W)
0.00 0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50
Output Current (A)
Vin=13.5V Vin=30.75V Vin=48.0V









Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.094 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.035 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	167.349 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	1.12 mW	Capacitor	Output capacitor power dissipation
5.	Coutx IRMS	114.59 mA	Capacitor	Output capacitor_x RMS ripple current
6.	Coutx Pd	13.131 µW	Capacitor	Output capacitor_x power loss
7.	IC Ipk	2.988 A	IC	Peak switch current in IC
8.	IC Pd	2.783 W	IC	IC power dissipation
9.	IC Tj	94.016 degC	IC	IC junction temperature
10.	IC Tolerance	5.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA Effective	23.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
12.	Iin Avg	686.81 mA	IC	Average input current
13.	Ipp percentage	39.067 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	976.66 mA	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	180.39 mW	Inductor	Inductor power dissipation
16.	Cin Pd	1.035 mW	Power	Input capacitor power dissipation
17.	Cout Pd	1.12 mW	Power	Output capacitor power dissipation
18.	Coutx Pd	13.131 µW	Power	Output capacitor_x power loss
19.	IC Pd	2.783 W	Power	IC power dissipation
20.	L Pd	180.39 mW	Power	Inductor power dissipation
21.	Total Pd	2.967 W	Power	Total Power Dissipation
22.	BOM Count	15	System Information	Total Design BOM count
23.	Cross Freq	16.423 kHz	System Information	Bode plot crossover frequency
24.	Duty Cycle	25.159 %	System Information	Duty cycle
25.	Efficiency	91.0 %	System Information	Steady state efficiency
26.	FootPrint	408.0 mm^2	System Information	Total Foot Print Area of BOM components

#	Name	Value	Category	Description
27.	Frequency	617.008 kHz	System Information	Switching frequency
28.	Gain Marg	-24.793 dB	System Information	Bode Plot Gain Margin
29.	Inductor ripple current requirement used for Inductor selection	40.0 %	System Information	Custom Inductor ripple current (% of average inductor current) requirement used for Inductor selection
30.	Iout	2.5 A	System Information	Iout operating point
31.	Iout transient step used for Cout calculations	1.25 A	System Information	Custom Transient current step requirement that was used for Cout selection (A).
32.	Low Freq Gain	59.692 dB	System Information	Gain at 1Hz
33.	Mode	FCCM	System Information	Conduction Mode
34.	Overshoot Value	31.205 mV	System Information	Theoretical Vout Overshoot Value
35.	Phase Marg	65.352 deg	System Information	Bode Plot Phase Margin
36.	Pout	30.0 W	System Information	Total output power
37.	Total BOM	NA	System Information	Total BOM Cost
38.	Undershoot Value	58.953 mV	System Information	Theoretical Vout Undershoot Value
39.	Vin	48.0 V	System Information	Vin operating point
40.	Vin p-p	383.064 mV	System Information	Peak-to-peak input voltage
41.	Vout	12.0 V	System Information	Operational Output Voltage
42.	Vout Actual	12.0 V	System Information	Vout Actual calculated based on selected voltage divider resistors
43.	Vout Ripple requirement used for Cout calculations	500.0 m%	System Information	Custom maximum output ripple requirement that was used for Cout selection(% of Vout).
44.	Vout Tolerance	2.361 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
45.	Vout p-p	23.189 mV	System Information	Peak-to-peak output ripple voltage
46.	Vout transient requirement used for Cout calculations	3.0 %	System Information	Custom Transient voltage change requirement that was used for Cout selection (% of Vout).

Design Inputs

Name	Value	Description
Iout	2.5	Maximum Output Current
VinMax	48.0	Maximum input voltage
VinMin	13.5	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	LMR38025-Q1	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	600.0 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

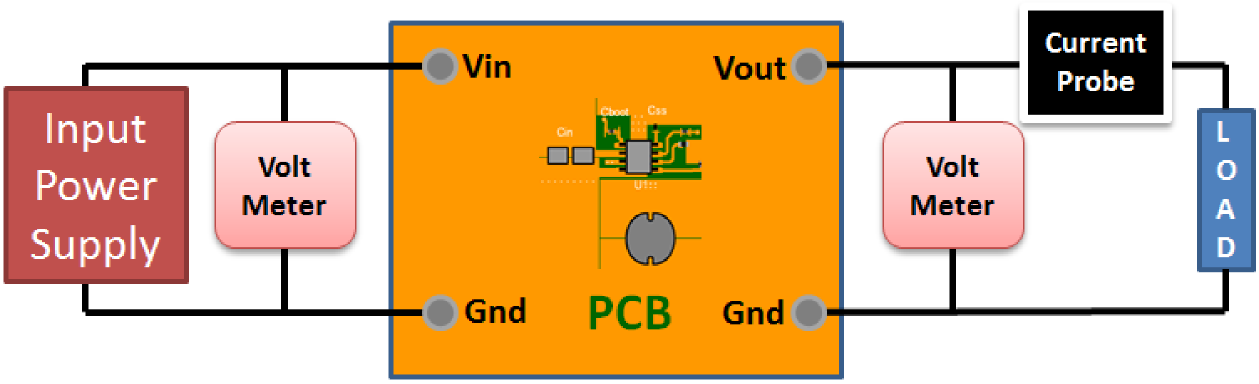
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 13.5V 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 : 3A09369785B968091A003B956300BD89[v1]

2. **LMR38025-Q1** Product Folder : http://www.ti.com/product/LMR38025%2DQ1 : contains the data sheet and other resources.

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