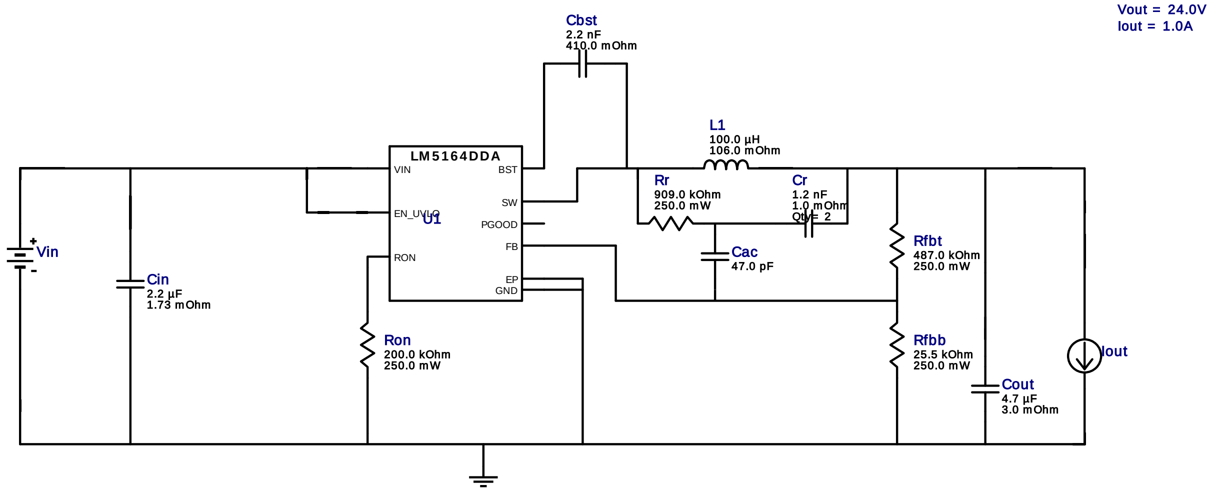
TEXAS INSTRUMENTS

WEBENCH ® Design Report

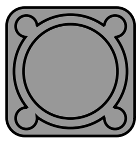
VinMin = 48.0V
VinMax = 51.6V
Vout = 24.0V
Iout = 1.0A

Device = LM5164DDAR
Topology = Buck
Created = 2024-10-14 22:03:09.404
BOM Cost = $2.71
BOM Count = 12
Total Pd = 1.05W

Design : 9 LM5164DDAR
LM5164DDAR ** FINAL** 48V-51.6V to 24.00V @ 1A

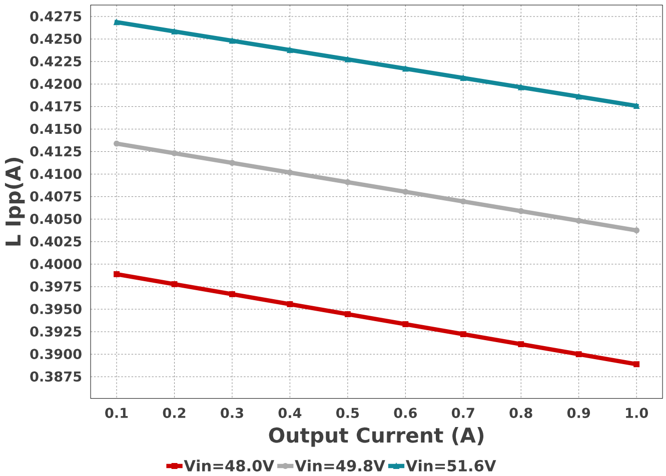


Electrical BOM

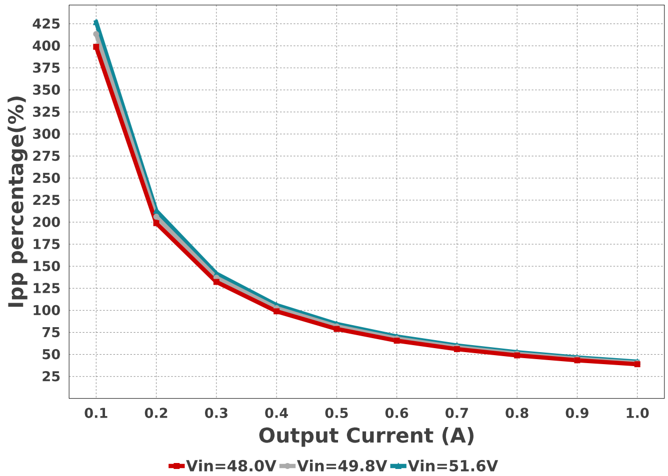
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cac	Samsung Electro-Mechanics	CL31C470JBCNNNC Series= C0G/NP0	Cap= 47.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.02	1206 11 mm^2
Cbst	Kemet	C1206C222K5RACTU Series= X7R	Cap= 2.2 nF ESR= 410.0 mOhm VDC= 50.0 V IRMS= 199.0 mA	1	$0.02	1206 11 mm^2
Cin	TDK	C3225X7R2A225K230AB Series= X7R	Cap= 2.2 uF ESR= 1.73 mOhm VDC= 100.0 V IRMS= 5.5932 A	1	$0.21	1210_250 15 mm^2
Cout	MuRata	GRM31CR71H475KA12L Series= X7R	Cap= 4.7 uF ESR= 3.0 mOhm VDC= 50.0 V IRMS= 4.98 A	1	$0.10	1206 11 mm^2
Cr	Yageo	CC1206KRX7R9BB122 Series= X7R	Cap= 1.2 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	2	$0.05	1206 11 mm^2
L1	Coilcraft	MSS1210-104KEB	L= 100.0 µH 106.0 mOhm	1	$0.81	 MSS1210 204 mm^2
Rfbb	Yageo	RC1206FR-0725K5L Series= ?	Res= 25.5 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
Rfbt	Vishay-Dale	CRCW1206487KFKEA Series= CRCW..e3	Res= 487.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
Ron	Vishay-Dale	CRCW1206200KFKEA Series= CRCW..e3	Res= 200.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rr	Yageo	RC1206FR-07909KL Series= ?	Res= 909.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm^2
U1	Texas Instruments	LM5164DDAR	Switcher	1	$1.41	DDA0008E-MFG 55 mm^2

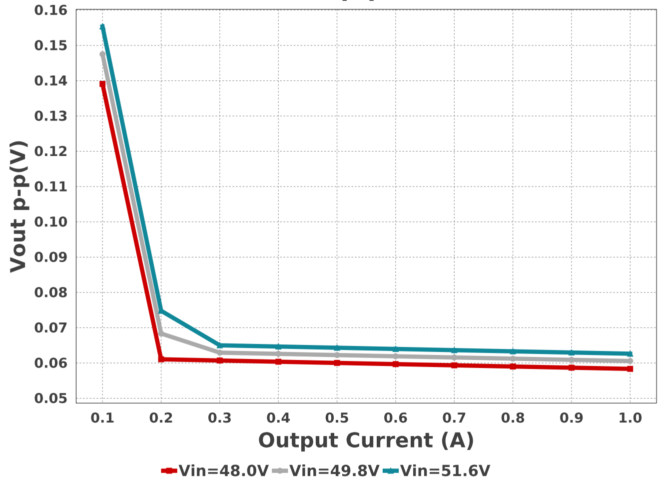
L Ipp



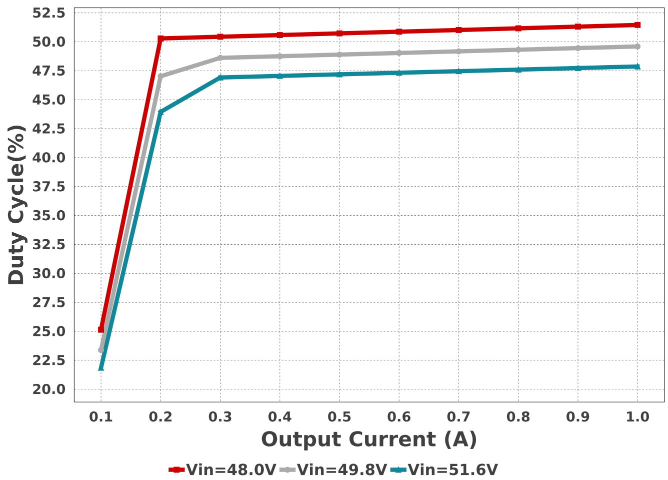
Ipp percentage



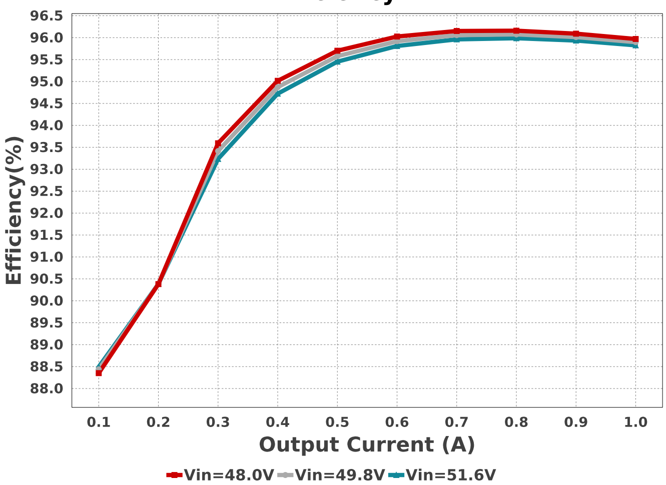
Vout p-p



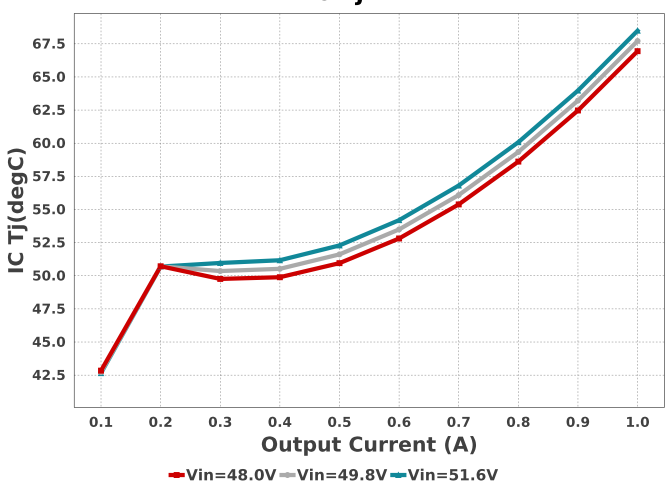
Duty Cycle

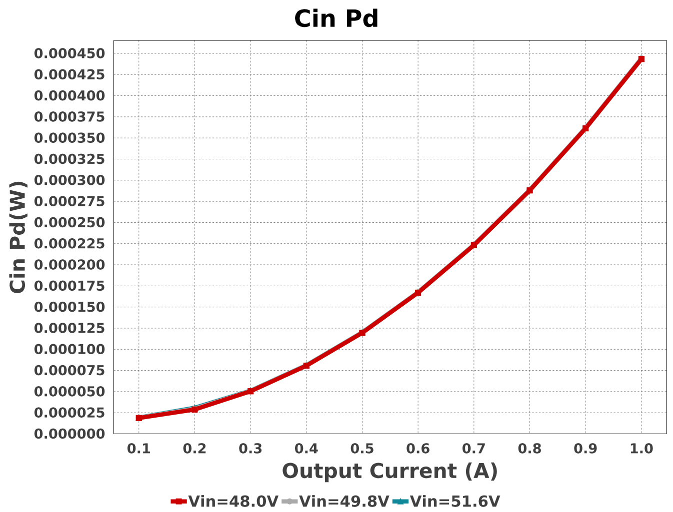


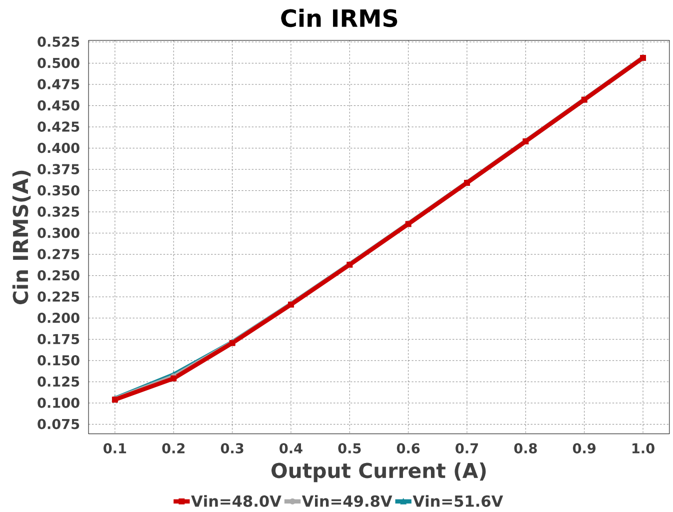
Efficiency

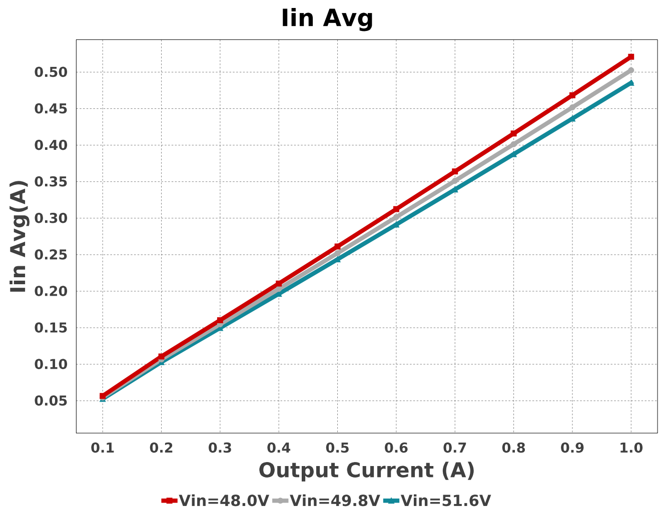


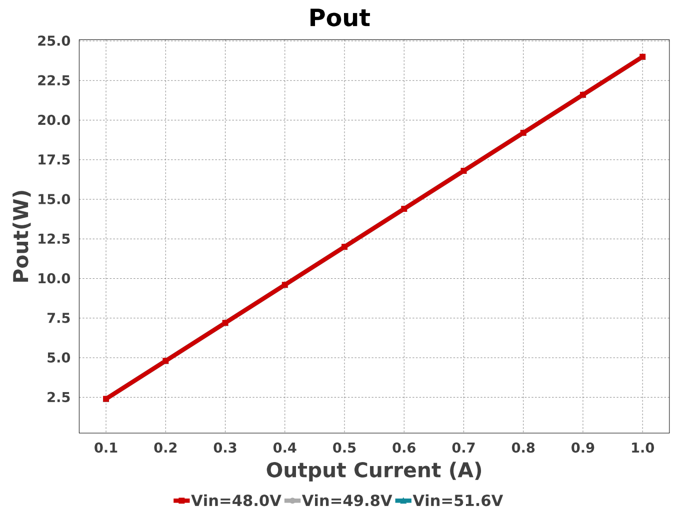
IC Tj

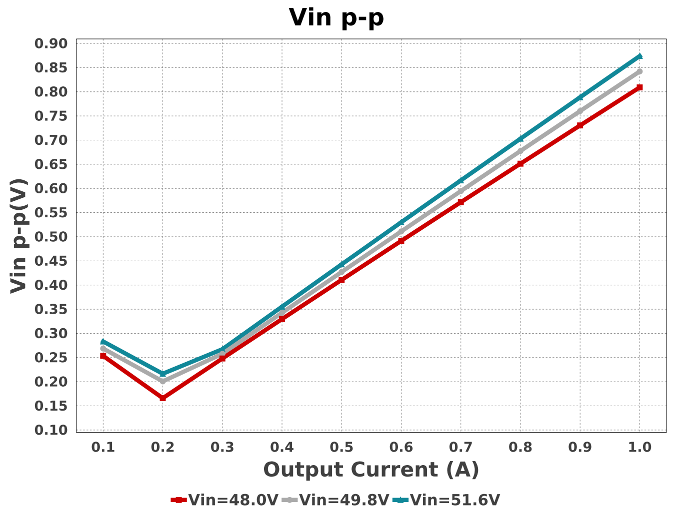


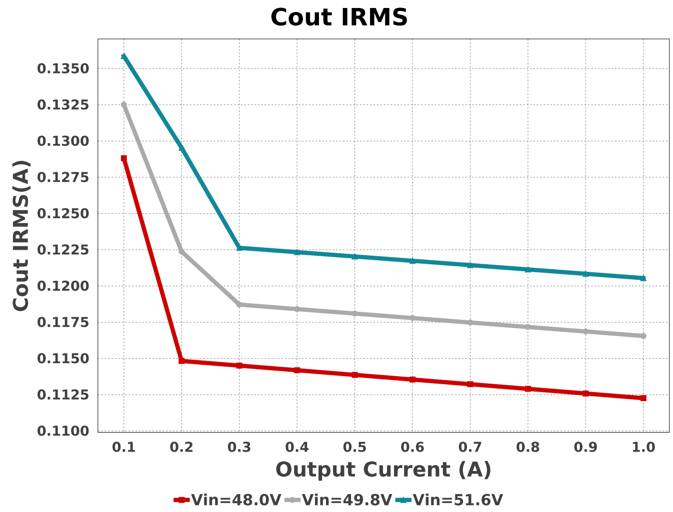

Cin Pd
Cin Pd(W)
0.000450
0.000425
0.000400
0.000375
0.000350
0.000325
0.000300
0.000275
0.000250
0.000225
0.000200
0.000175
0.000150
0.000125
0.000100
0.000075
0.000050
0.000025
0.000000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=48.0V Vin=49.8V Vin=51.6V

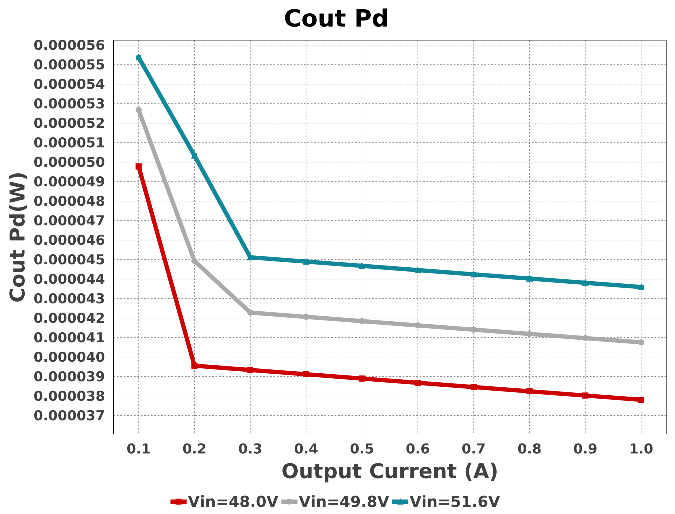

Cin IRMS
Cin IRMS(A)
0.525
0.500
0.475
0.450
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=48.0V Vin=49.8V Vin=51.6V

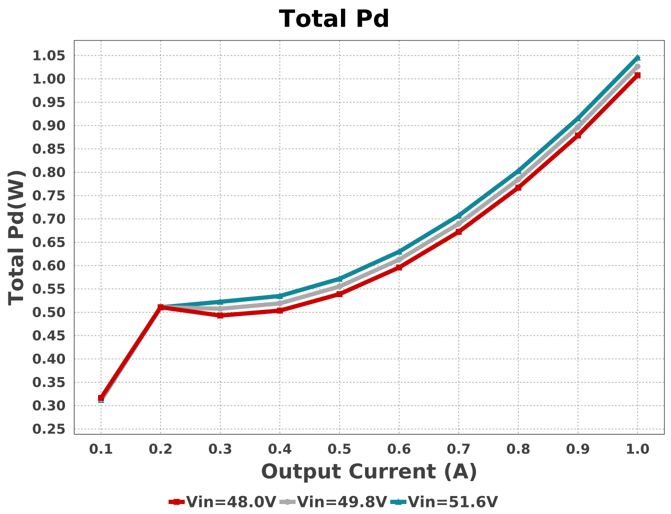

Iin Avg
Iin Avg(A)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=48.0V Vin=49.8V Vin=51.6V

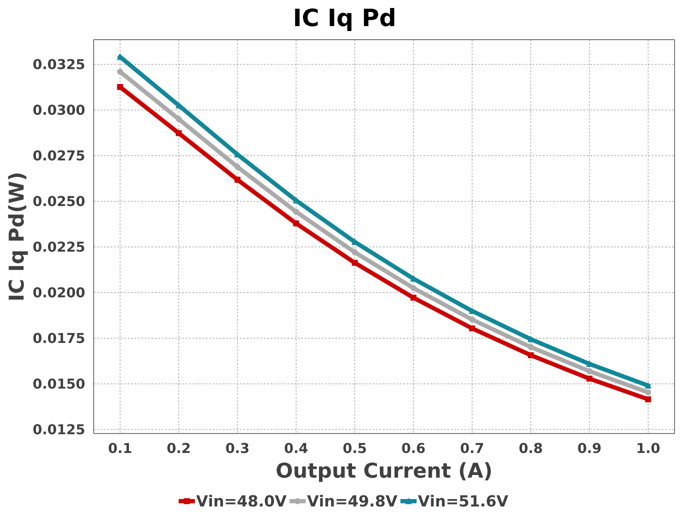

Pout
Pout(W)
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=48.0V Vin=49.8V Vin=51.6V

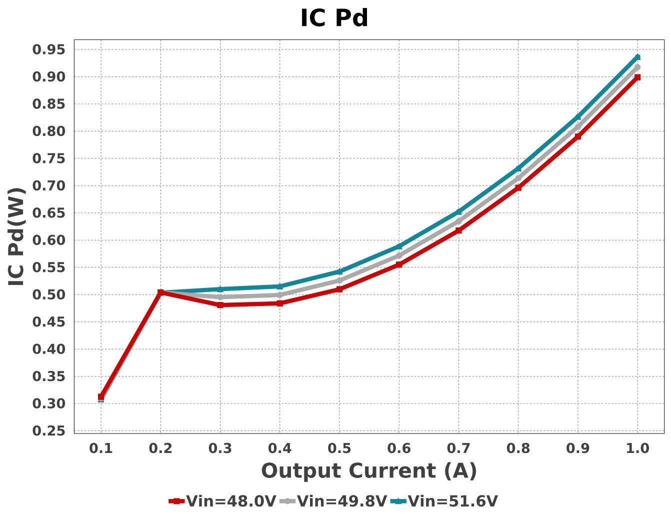

Vin p-p
Vin p-p(V)
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=48.0V Vin=49.8V Vin=51.6V

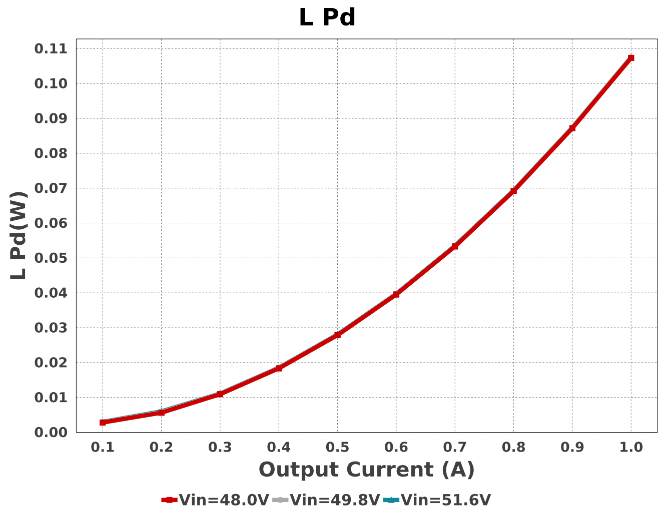

Cout IRMS
Cout IRMS(A)
0.1350
0.1325
0.1300
0.1275
0.1250
0.1225
0.1200
0.1175
0.1150
0.1125
0.1100
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=48.0V Vin=49.8V Vin=51.6V

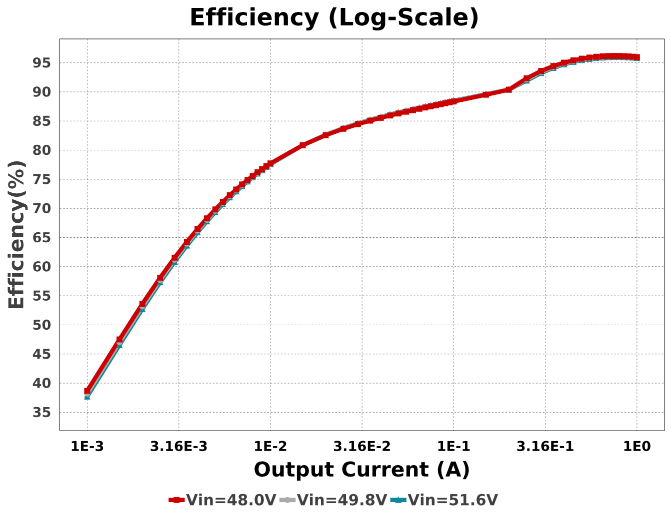












Operating Values

#	Name	Value	Category	Description
1.	BOM Count	12		Total Design BOM count
2.	Total BOM	$2.713		Total BOM Cost
3.	Cin IRMS	506.46 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	443.75 µW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	120.543 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	43.592 µW	Capacitor	Output capacitor power dissipation
7.	IC Iq Pd	14.904 mW	IC	IC Iq Pd
8.	IC Pd	936.5 mW	IC	IC power dissipation
9.	IC Tj	68.49 degC	IC	IC junction temperature
10.	ICThetaJA	41.1 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	485.38 mA	IC	Average input current

#	Name	Value	Category	Description
12.	Ipp percentage	41.757 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
13.	L Ipp	417.573 mA	Inductor	Peak-to-peak inductor ripple current
14.	L Pd	107.54 mW	Inductor	Inductor power dissipation
15.	Cin Pd	443.75 µW	Power	Input capacitor power dissipation
16.	Cout Pd	43.592 µW	Power	Output capacitor power dissipation
17.	IC Pd	936.5 mW	Power	IC power dissipation
18.	L Pd	107.54 mW	Power	Inductor power dissipation
19.	Total Pd	1.046 W	Power	Total Power Dissipation
20.	Duty Cycle	47.87 %	System Information	Duty cycle
21.	Efficiency	95.825 %	System Information	Steady state efficiency
22.	FootPrint	373.0 mm^2	System Information	Total Foot Print Area of BOM components
23.	Frequency	308.762 kHz	System Information	Switching frequency
24.	Iout	1.0 A	System Information	Iout operating point
25.	Mode	CCM	System Information	Conduction Mode
26.	Pout	24.0 W	System Information	Total output power
27.	Vin	51.6 V	System Information	Vin operating point
28.	Vin p-p	873.966 mV	System Information	Peak-to-peak input voltage
29.	Vout	24.0 V	System Information	Operational Output Voltage
30.	Vout Actual	24.118 V	System Information	Vout Actual calculated based on selected voltage divider resistors
31.	Vout Tolerance	3.533 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
32.	Vout p-p	62.637 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	51.6	Maximum input voltage
VinMin	48.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM5164	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

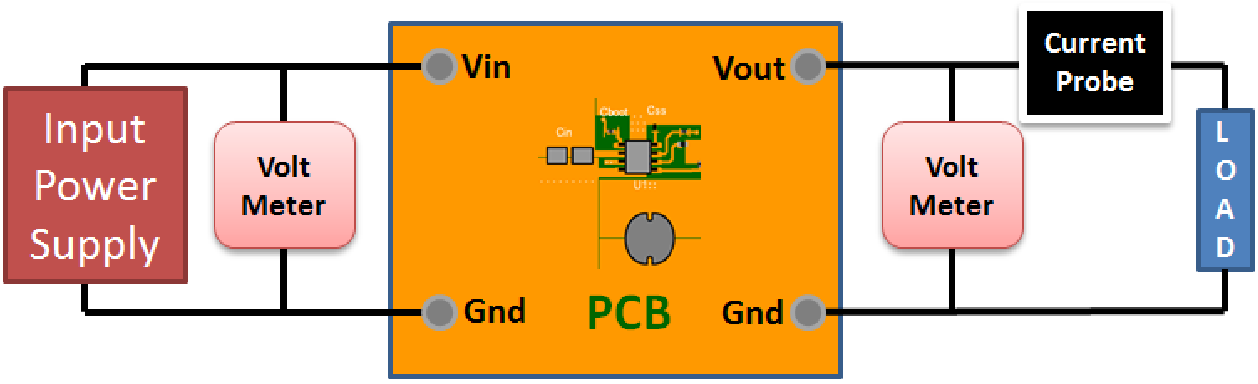
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 48.0V 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. Master key : 8D46410E296FCE97B33F99C6313555A5[v1]

2. **LM5164** Product Folder : http://www.ti.com/product/lm5164 : contains the data sheet and other resources.

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