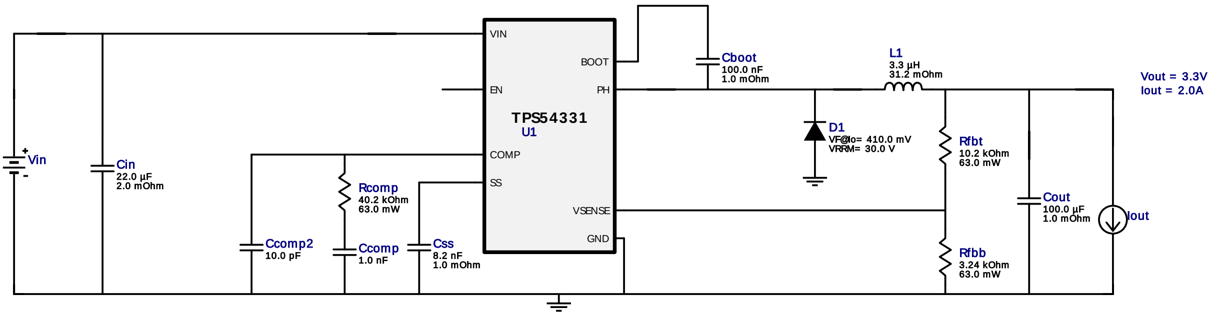
Texas Instruments

WEBENCH ® Design Report

VinMin = 3.9V
VinMax = 5.0V
Vout = 3.3V
Iout = 2.0A

Device = TPS54331DDAR
Topology = Buck
Created = 2021-05-13 05:26:17.848
BOM Cost = $2.44
BOM Count = 12
Total Pd = 0.74W

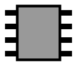
Design : 52 TPS54331DDAR
TPS54331DDAR 6V-8V to 3.50V @ 3A

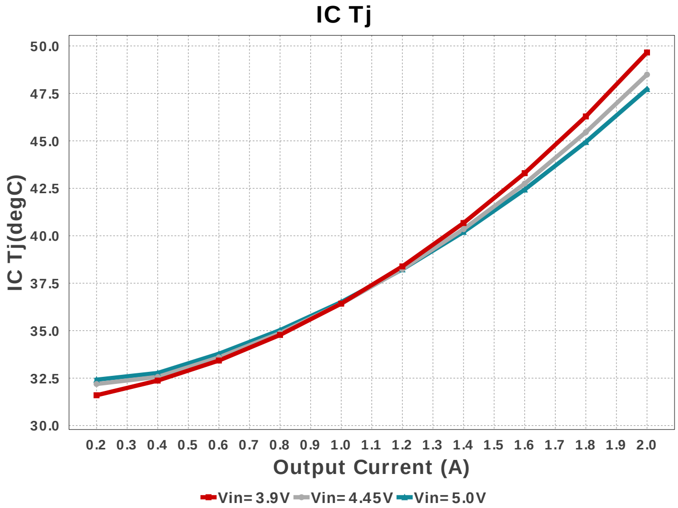


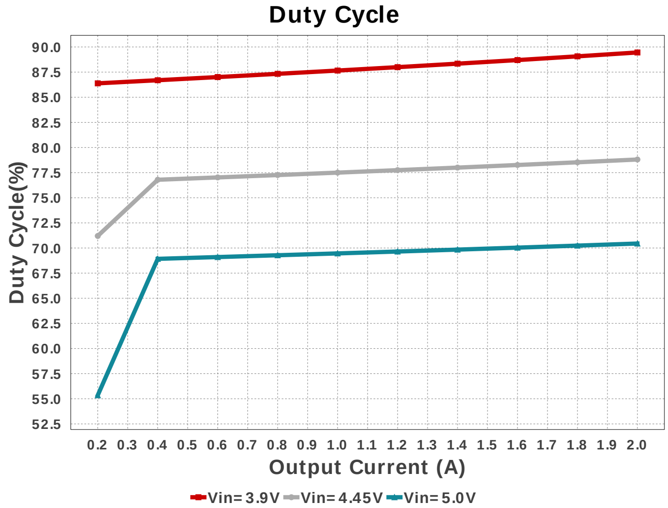
Electrical BOM

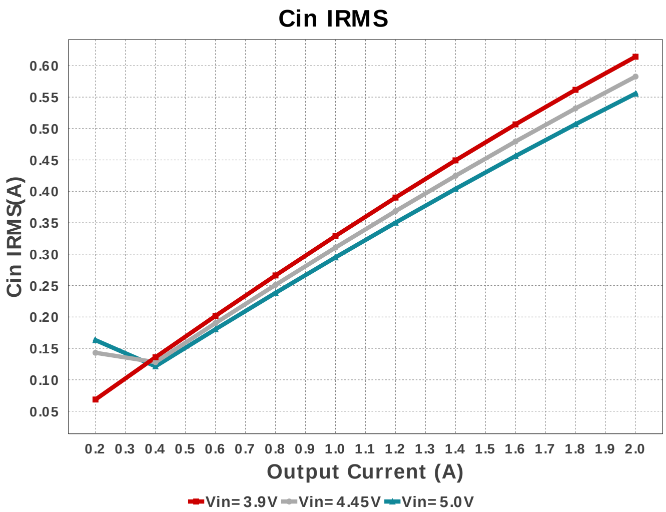
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp	MuRata	GRM1555C1H102JA01J Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp2	Samsung Electro-Mechanics	CL21C100JBANNNC Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	MuRata	GRM32ER61C226ME20L Series= X5R	Cap= 22.0 uF ESR= 2.0 mOhm VDC= 16.0 V IRMS= 3.68 A	1	$0.55	1210 15 mm^2
Cout	MuRata	GRM32ER60J107ME20L Series= X5R	Cap= 100.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	1	$0.52	1210_270 15 mm^2
Css	MuRata	GRM033R71A822KA01D Series= X7R	Cap= 8.2 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
D1	Diodes Inc.	B130L-13-F	VF@Io= 410.0 mV VRRM= 30.0 V	1	$0.10	SMA 37 mm^2
L1	Wurth Elektronik	74404054033	L= 3.3 µH 31.2 mOhm	1	$0.69	WE-LQS_5040 49 mm^2
Rcomp	Vishay-Dale	CRCW040240K2FKED Series= CRCW..e3	Res= 40.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Vishay-Dale	CRCW04023K24FKED Series= CRCW..e3	Res= 3.24 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Vishay-Dale	CRCW040210K2FKED Series= CRCW..e3	Res= 10.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2

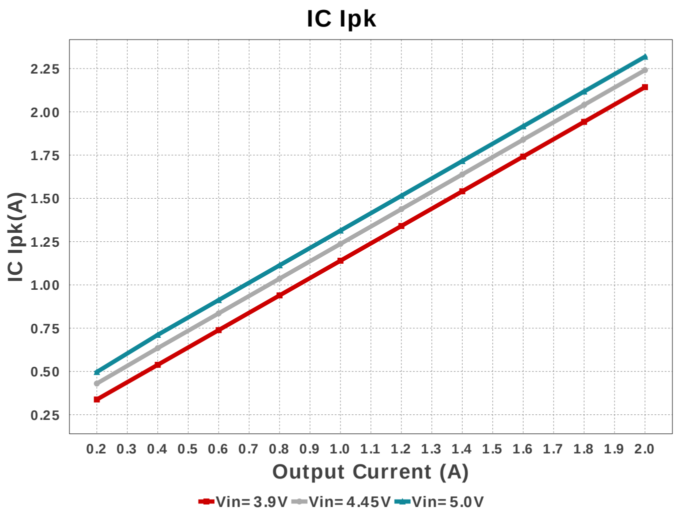
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	TPS54331DDAR	Switcher	1	$0.51	DDA0008H 55 mm^2

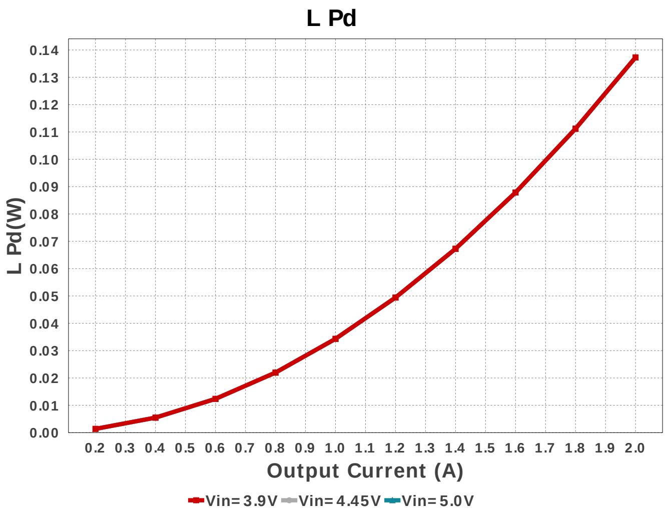


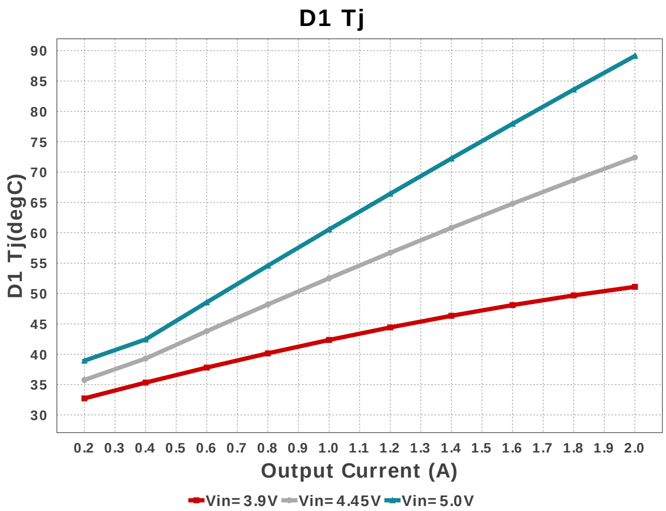


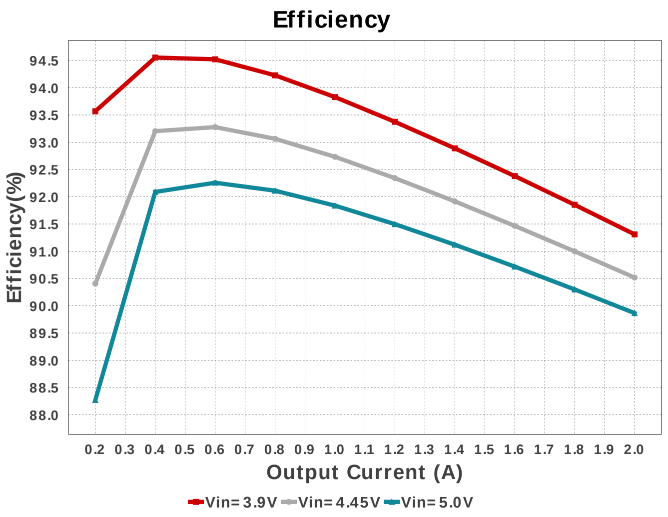


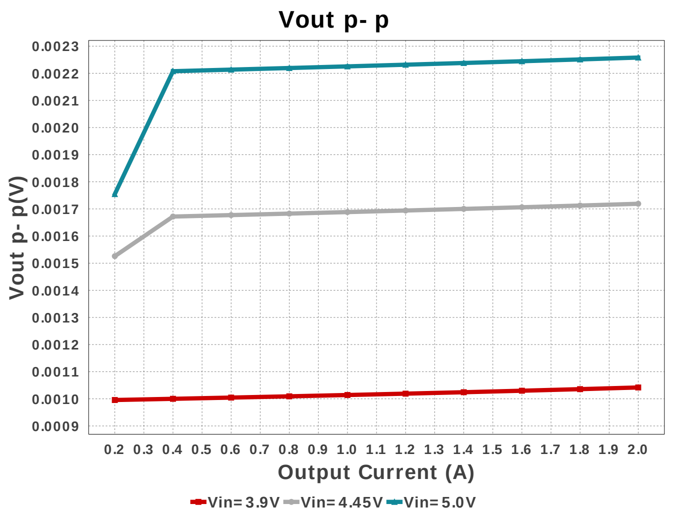


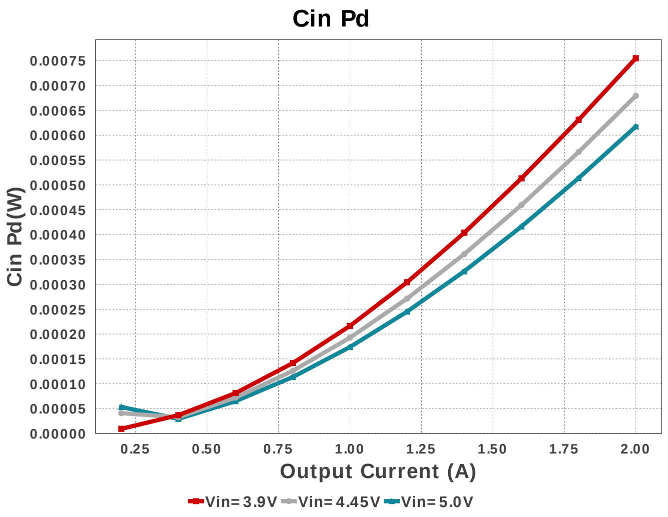


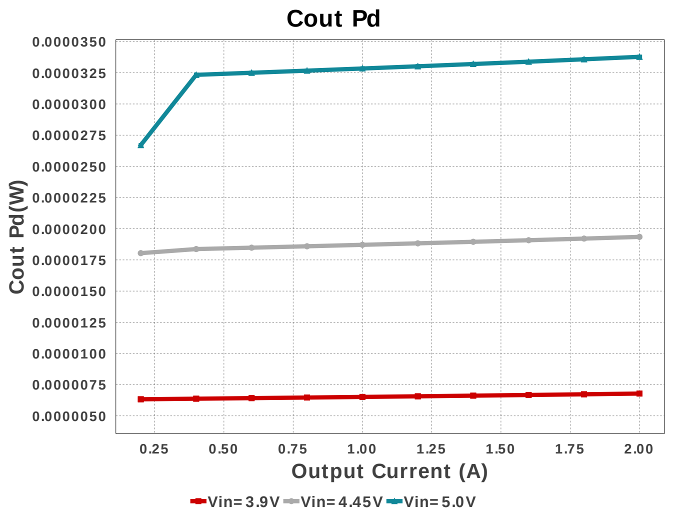


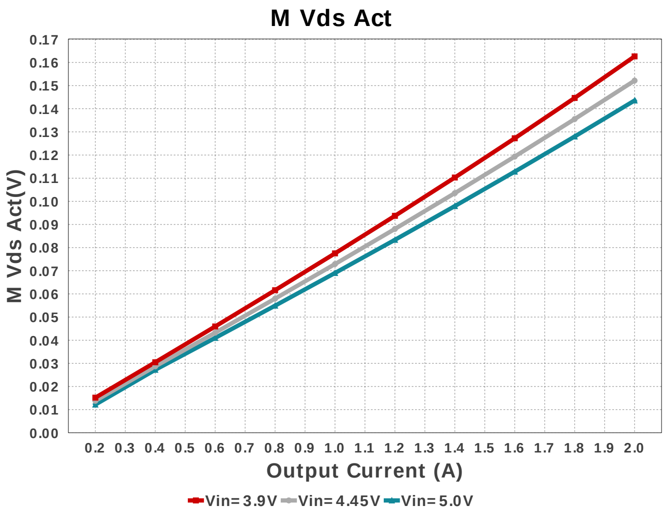


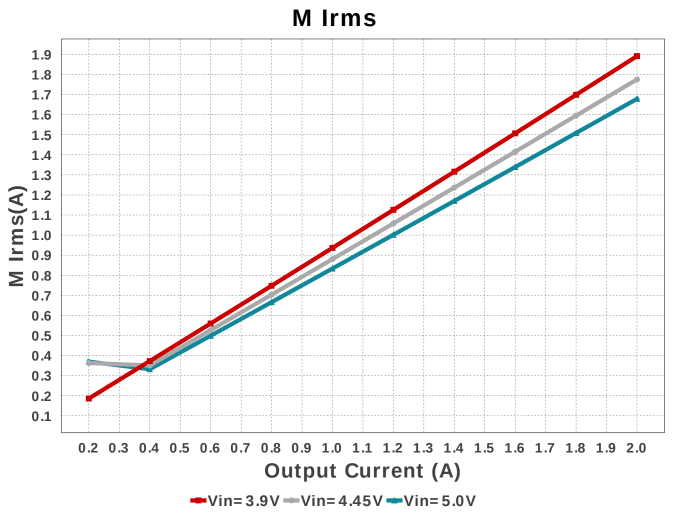

Efficiency
Efficiency(%)
Output Current (A)
Vin=3.9V
Vin=4.45V
Vin=5.0V

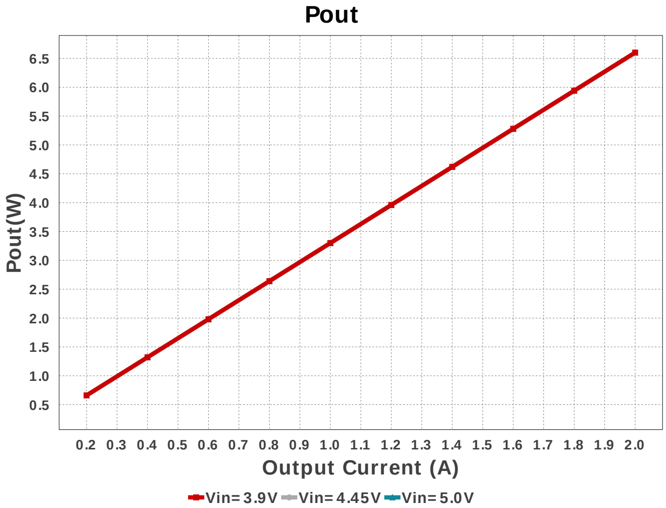

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=3.9V
Vin=4.45V
Vin=5.0V

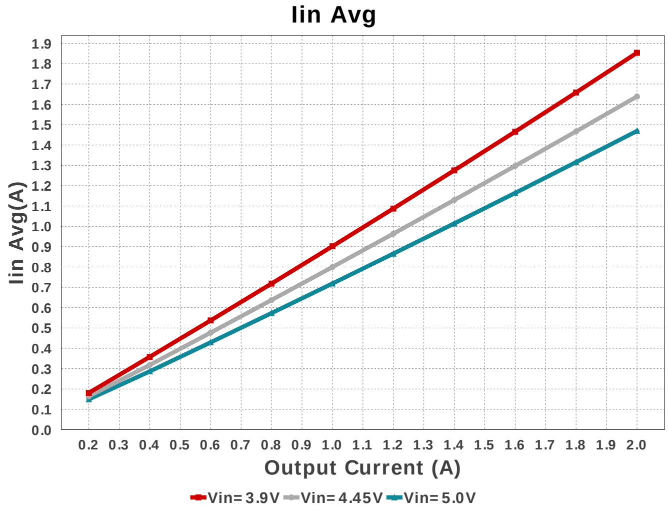

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=3.9V
Vin=4.45V
Vin=5.0V

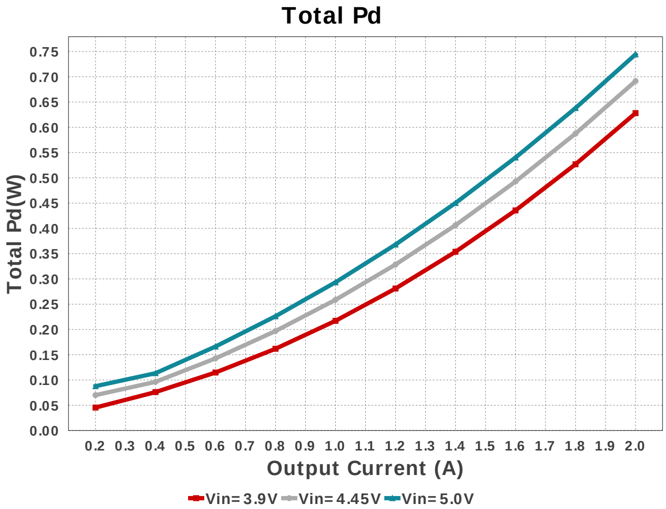

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=3.9V
Vin=4.45V
Vin=5.0V

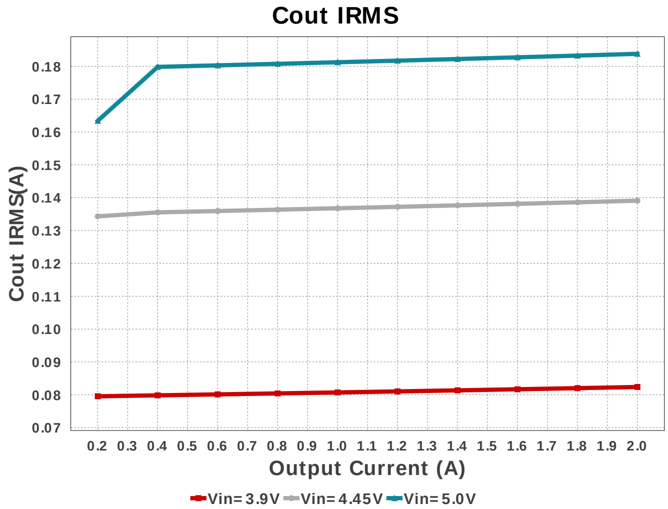

M Vds Act
M Vds Act(V)
Output Current (A)
Vin=3.9V
Vin=4.45V
Vin=5.0V

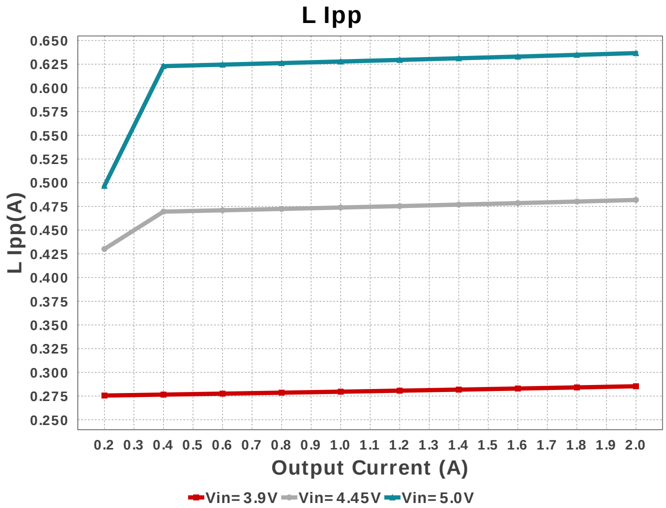

M Irms
M Irms(A)
Output Current (A)
Vin=3.9V
Vin=4.45V
Vin=5.0V

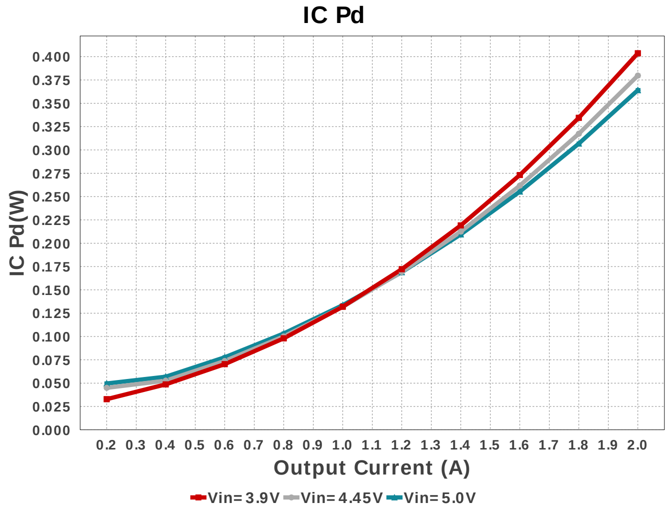

Pout
Pout(W)
Output Current (A)
Vin=3.9V Vin=4.45V Vin=5.0V

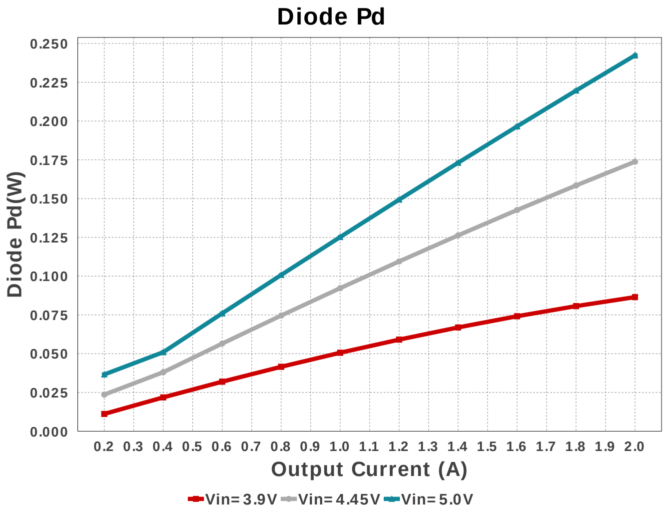

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=3.9V Vin=4.45V Vin=5.0V

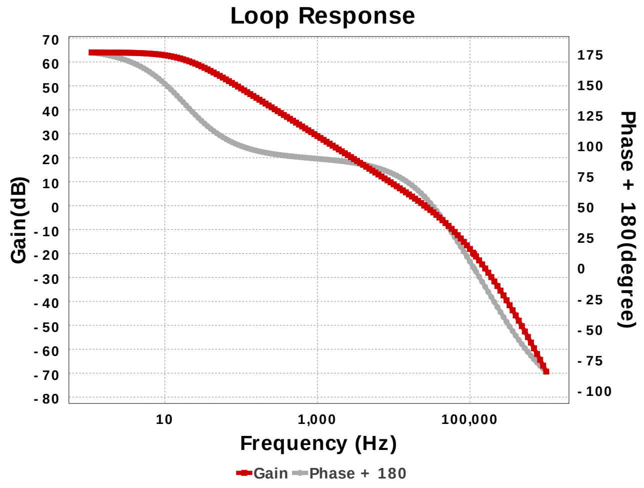

Total Pd
Total Pd(W)
Output Current (A)
Vin=3.9V Vin=4.45V Vin=5.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=3.9V Vin=4.45V Vin=5.0V


L Ipp
L Ipp(A)
Output Current (A)
Vin=3.9V Vin=4.45V Vin=5.0V


IC Pd
IC Pd(W)
Output Current (A)
Vin=3.9V Vin=4.45V Vin=5.0V





Operating Values

#	Name	Value	Category	Description
1.	BOM Count	12		Total Design BOM count
2.	Total BOM	$2.44		Total BOM Cost
3.	Cin IRMS	555.606 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	617.4 µW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	183.792 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	33.779 µW	Capacitor	Output capacitor power dissipation
7.	D1 Tj	89.131 degC	Diode	D1 junction temperature
8.	Diode Pd	242.34 mW	Diode	Diode power dissipation
9.	IC Ipk	2.318 A	IC	Peak switch current in IC
10.	IC Pd	364.09 mW	IC	IC power dissipation
11.	IC Tj	47.731 degC	IC	IC junction temperature
12.	ICThetaJA	48.7 degC/W	IC	IC junction-to-ambient thermal resistance
13.	Iin Avg	1.469 A	IC	Average input current
14.	L Ipp	636.674 mA	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	137.28 mW	Inductor	Inductor power dissipation
16.	M Irms	1.679 A	Mosfet	MOSFET RMS ripple current
17.	M Vds Act	143.561 mV	Mosfet	Voltage drop across the MosFET
18.	Cin Pd	617.4 µW	Power	Input capacitor power dissipation
19.	Cout Pd	33.779 µW	Power	Output capacitor power dissipation
20.	Diode Pd	242.34 mW	Power	Diode power dissipation
21.	IC Pd	364.09 mW	Power	IC power dissipation
22.	L Pd	137.28 mW	Power	Inductor power dissipation
23.	Total Pd	744.365 mW	Power	Total Power Dissipation
24.	Cross Freq	25.459 kHz	System Information	Bode plot crossover frequency
25.	Duty Cycle	70.446 %	System Information	Duty cycle
26.	Efficiency	89.865 %	System Information	Steady state efficiency
27.	FootPrint	195.0 mm^2	System Information	Total Foot Print Area of BOM components
28.	Frequency	570.0 kHz	System Information	Switching frequency
29.	Gain Marg	-20.255 dB	System Information	Bode Plot Gain Margin
30.	Iout	2.0 A	System Information	Iout operating point
31.	Low Freq Gain	63.976 dB	System Information	Gain at 1Hz
32.	Mode	CCM	System Information	Conduction Mode
33.	Phase Marg	58.516 deg	System Information	Bode Plot Phase Margin
34.	Pout	6.6 W	System Information	Total output power
35.	Vin	5.0 V	System Information	Vin operating point
36.	Vout	3.3 V	System Information	Operational Output Voltage
37.	Vout Actual	3.319 V	System Information	Vout Actual calculated based on selected voltage divider resistors

#	Name	Value	Category	Description
38.	Vout Tolerance	5.087 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
39.	Vout p-p	2.258 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	5.0	Maximum input voltage
VinMin	3.9	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	TPS54331	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

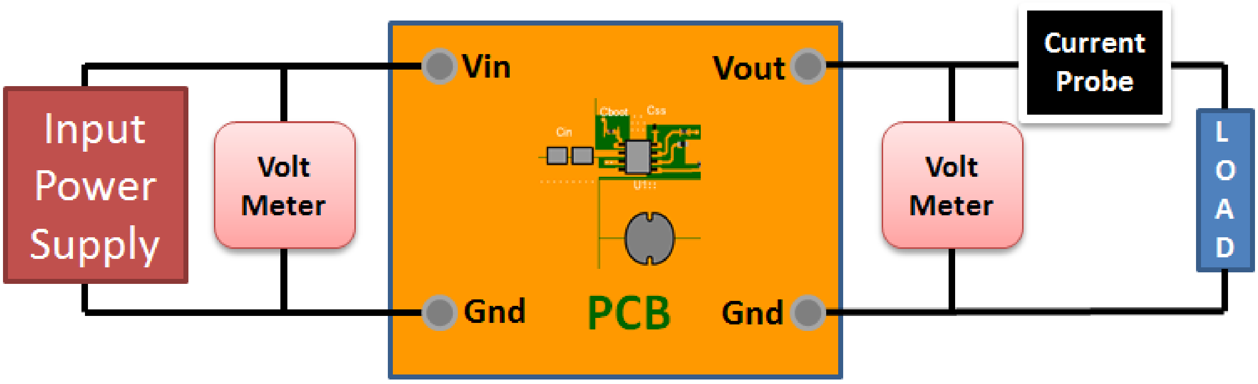
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 3.9V 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 : A0D20B49BADC7557[v1]

2. **TPS54331** Product Folder : http://www.ti.com/product/TPS54331 : contains the data sheet and other resources.

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