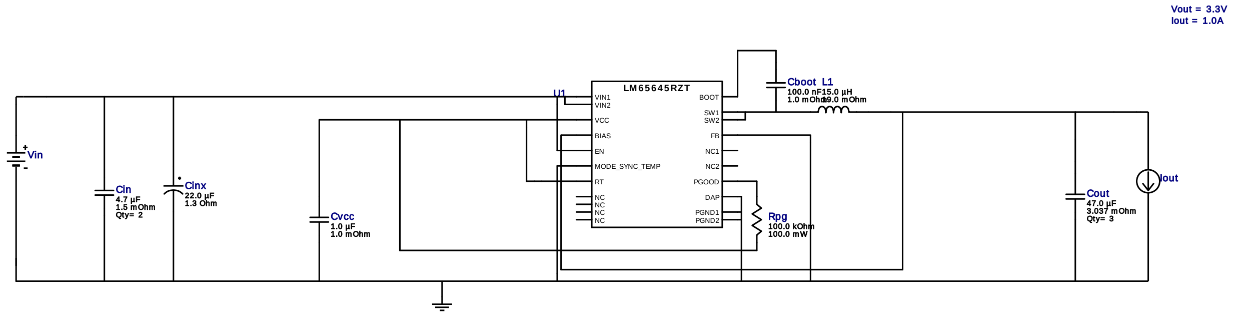
Texas Instruments

WEBENCH ® Design Report

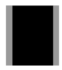
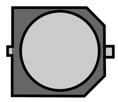
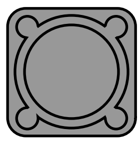
VinMin = 9.0V
VinMax = 57.0V
Vout = 3.3V
Iout = 1.0A

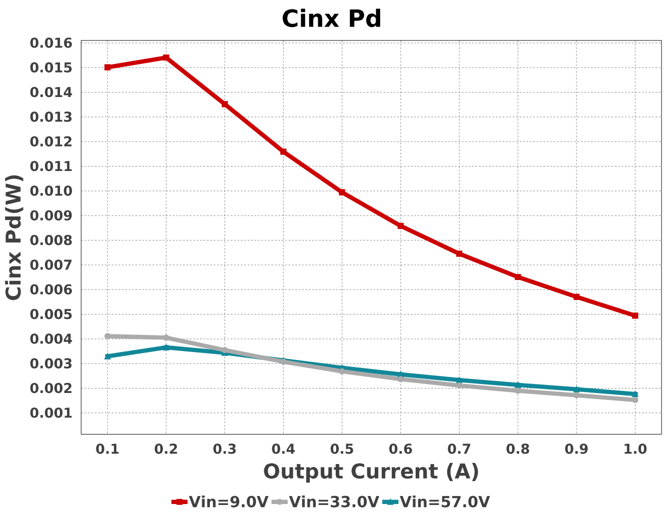
Device = LM65645RZTR
Topology = Buck
Created = 2025-09-01 00:39:56.471
BOM Cost = $5.25
BOM Count = 11
Total Pd = 0.19W

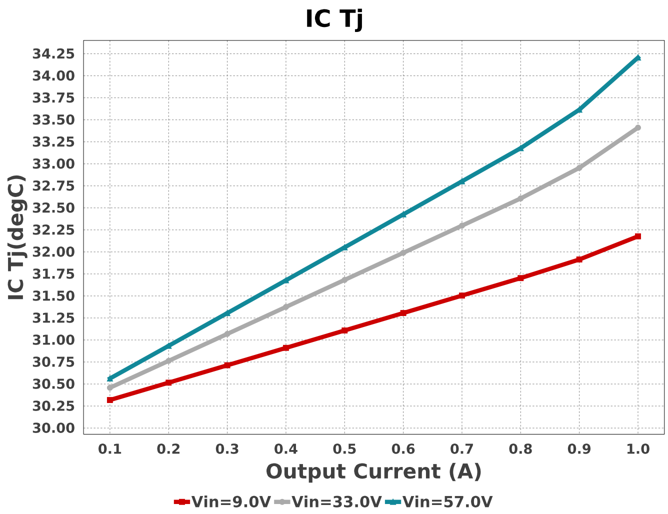
Design : 130 LM65645RZTR
LM65645RZTR 9V-57V to 3.30V @ 1A

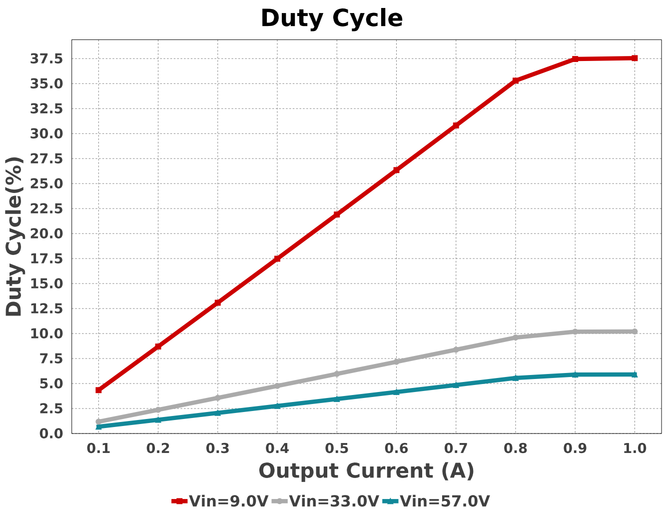


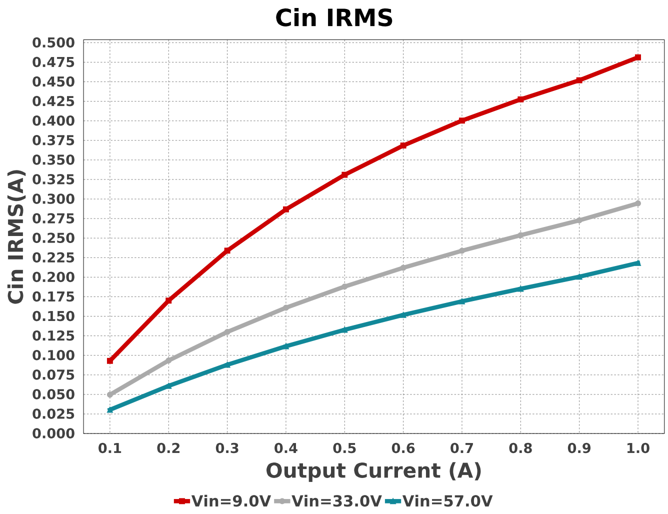
Electrical BOM

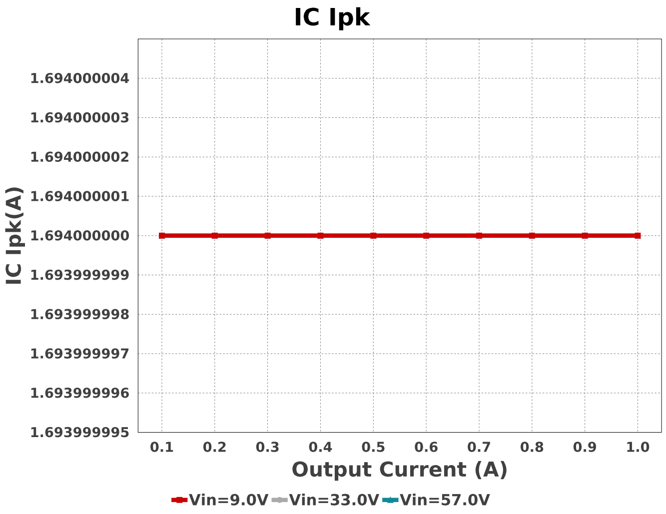
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	TDK	C5750X7R2A475M230KA Series= X7R	Cap= 4.7 uF ESR= 1.5 mOhm VDC= 100.0 V IRMS= 5.5 A	2	$0.86	 2220_280 54 mm²
Cinx	Panasonic	EEE-FK2A220P Series= FK	Cap= 22.0 uF ESR= 1.3 Ohm VDC= 100.0 V IRMS= 130.0 mA	1	$0.37	 SM_RADIAL_F 124 mm²
Cout	MuRata	GRM32ER61C476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.037 mOhm VDC= 16.0 V IRMS= 4.59346 A	3	$0.17	 1210_280 15 mm²
Cvcc	Taiyo Yuden	EMK107B7105KA-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
L1	Coilcraft	MSS1210-153MEB	L= 15.0 µH 19.0 mOhm	1	$0.81	 MSS1210 204 mm²
Rpg	Yageo	RT0603BRD07100KL Series= ?	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 0.1%	1	$0.04	0603 5 mm²
U1	Texas Instruments	LM65645RZTR	Switcher	1	$1.78	RZT0020A 17 mm²

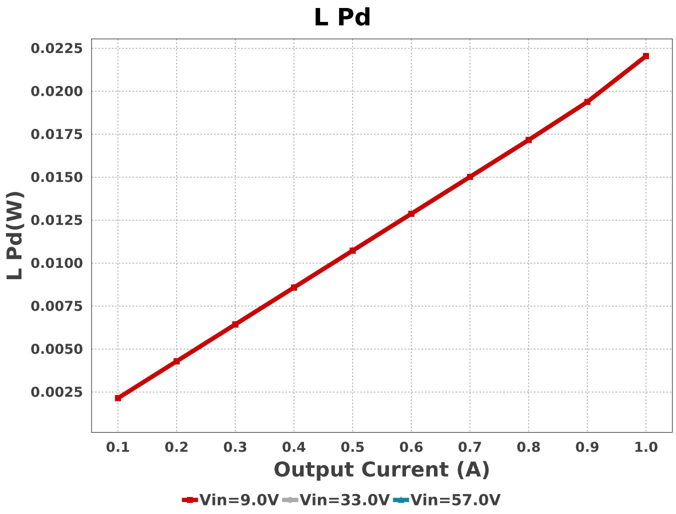

Cinx Pd
Cinx Pd(W)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

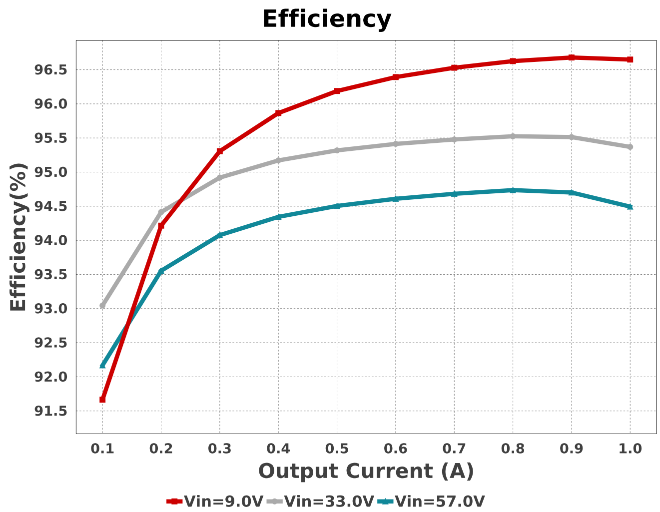

IC Tj
IC Tj(degC)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

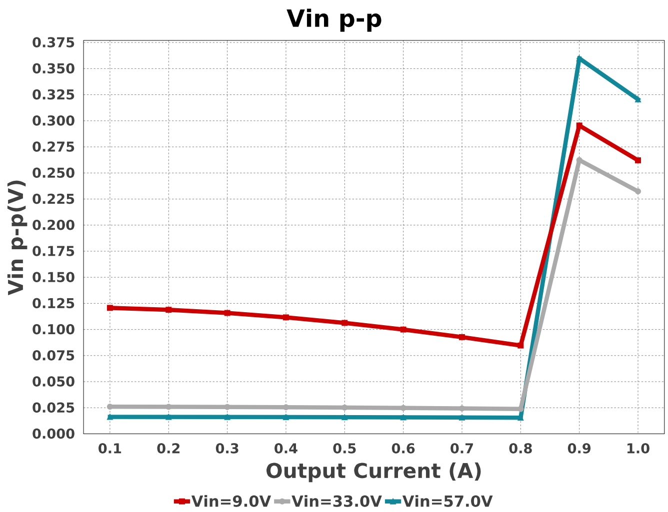

Duty Cycle
Duty Cycle(%)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

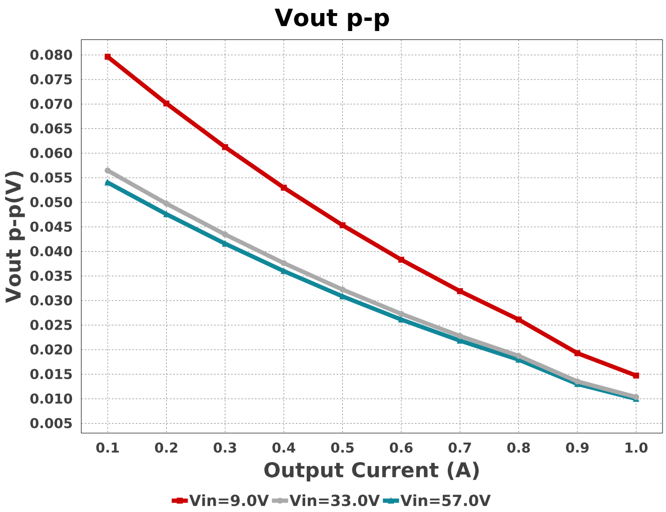

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

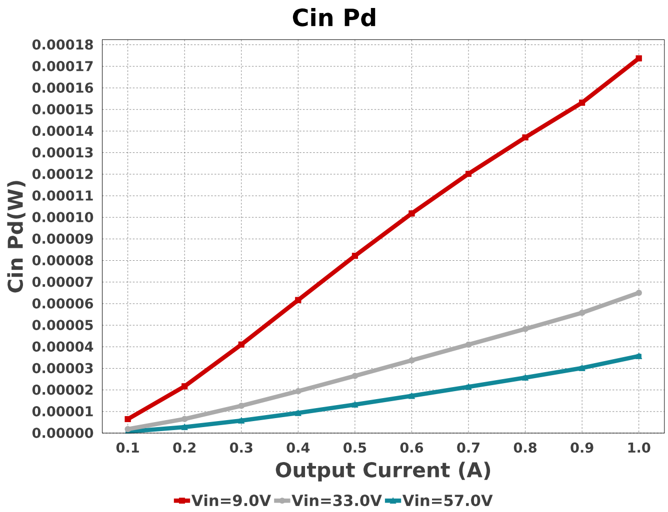

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

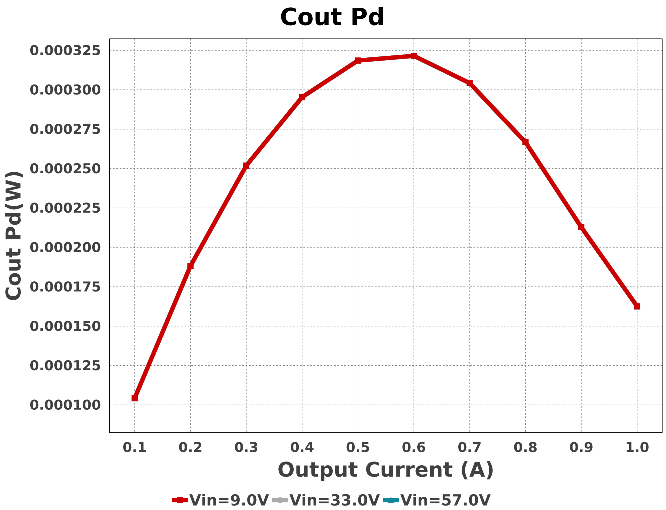

L Pd
L Pd(W)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

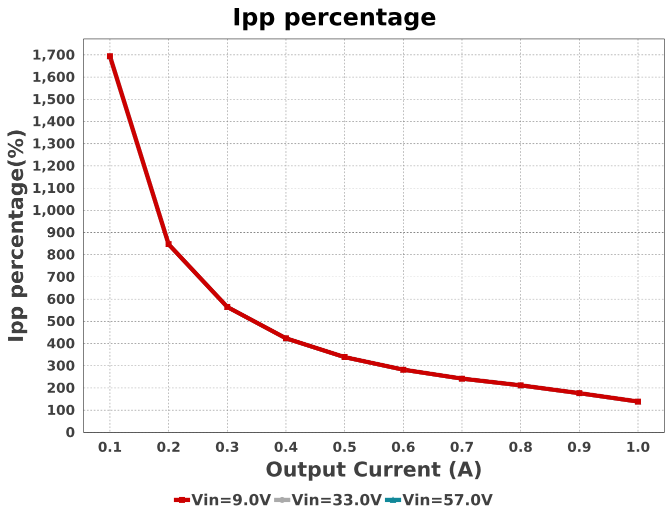

Efficiency
Efficiency(%)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V


Vin p-p
Vin p-p(V)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

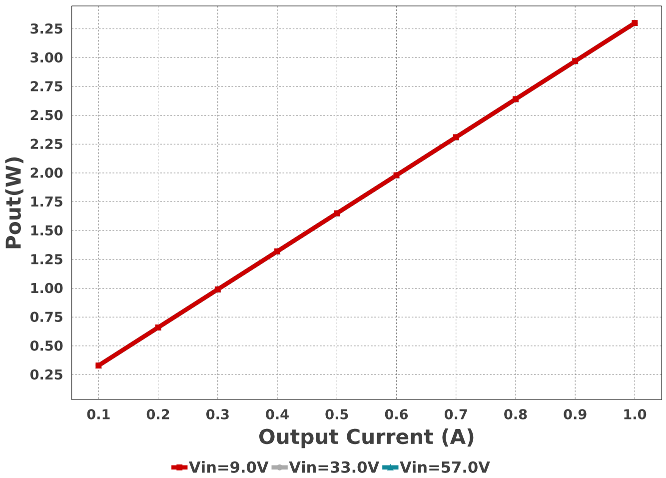

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V


Cin Pd
Cin Pd(W)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

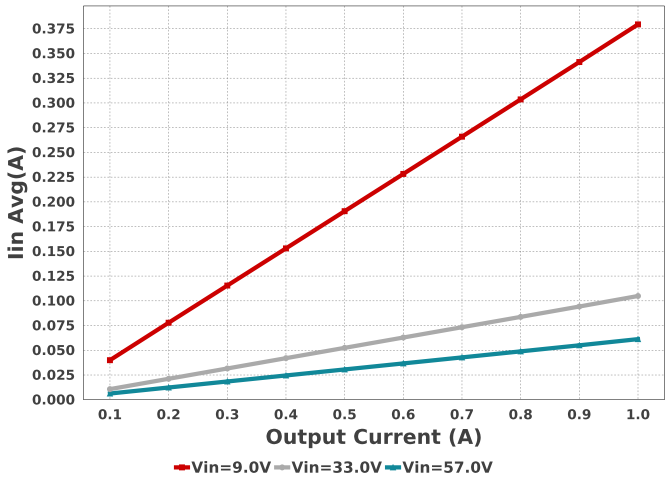

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V


Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=9.0V Vin=33.0V Vin=57.0V

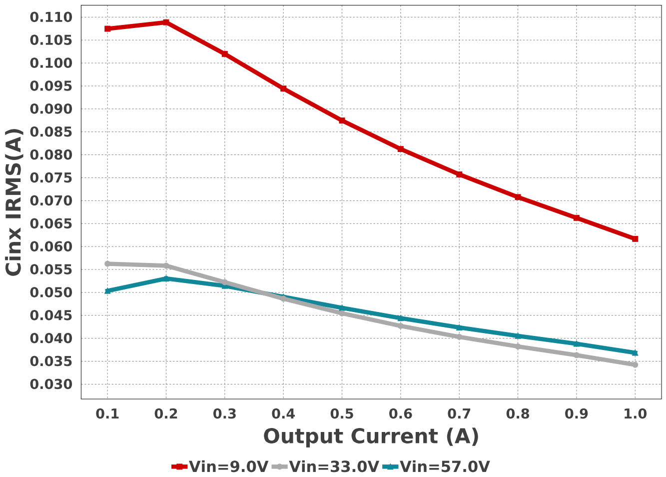
Pout



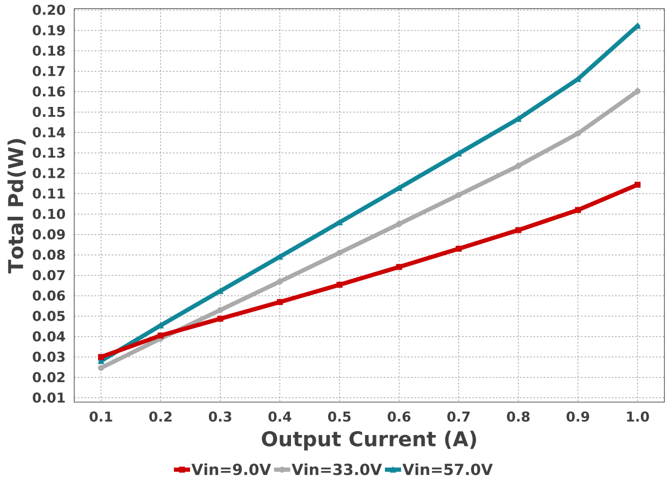
Iin Avg



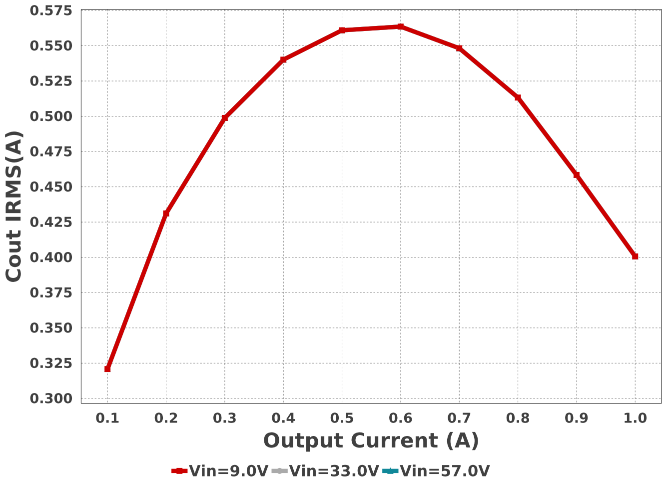
Cinx IRMS



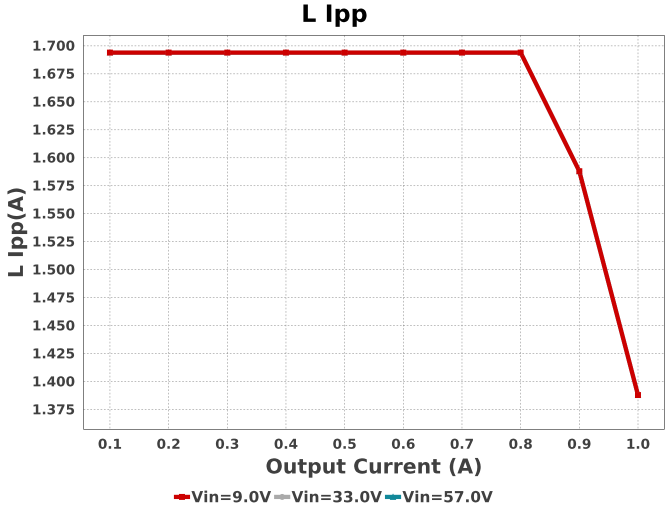
Total Pd

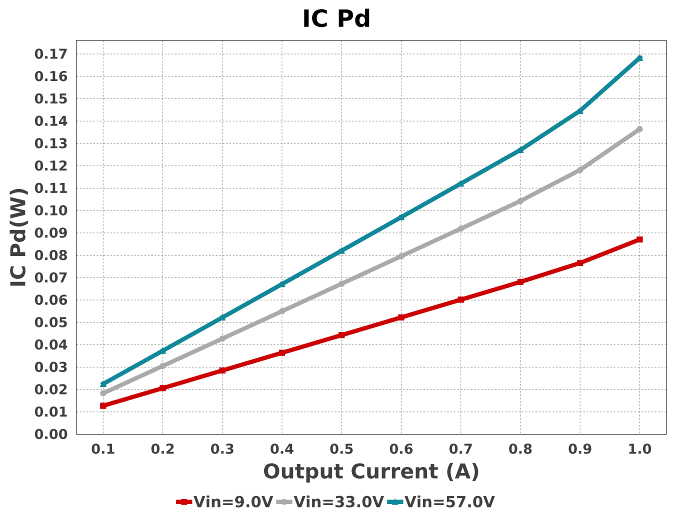


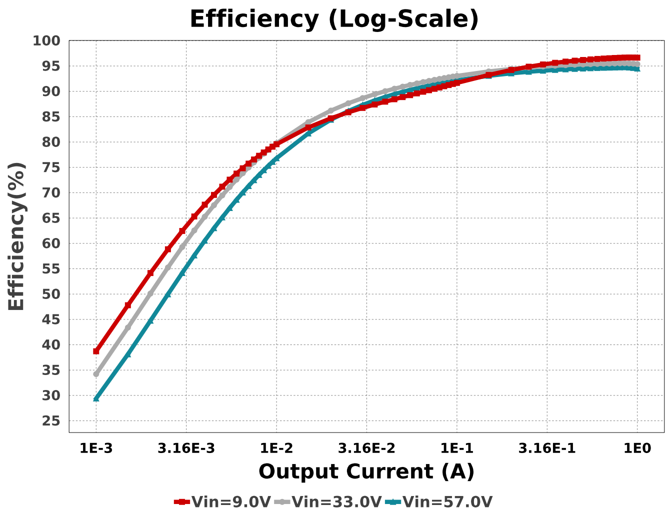
Cout IRMS



L Ipp







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	218.202 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	35.709 µW	Capacitor	Input capacitor power dissipation
3.	Cinx IRMS	36.846 mA	Capacitor	Bulk capacitor RMS ripple current
4.	Cinx Pd	1.765 mW	Capacitor	Bulk capacitor power dissipation
5.	Cout IRMS	400.681 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	162.53 µW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	1.694 A	IC	Peak switch current in IC
8.	IC Pd	168.27 mW	IC	IC power dissipation
9.	IC Tj	34.207 degC	IC	IC junction temperature
10.	IC Tolerance	8.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA Effective	25.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
12.	Iin Avg	61.268 mA	IC	Average input current
13.	Ipp percentage	138.8 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	1.388 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	22.05 mW	Inductor	Inductor power dissipation
16.	Cin Pd	35.709 µW	Power	Input capacitor power dissipation
17.	Cinx Pd	1.765 mW	Power	Bulk capacitor power dissipation
18.	Cout Pd	162.53 µW	Power	Output capacitor power dissipation
19.	IC Pd	168.27 mW	Power	IC power dissipation
20.	L Pd	22.05 mW	Power	Inductor power dissipation
21.	Total Pd	192.285 mW	Power	Total Power Dissipation
22.	BOM Count	11	System Information	Total Design BOM count
23.	Duty Cycle	5.906 %	System Information	Duty cycle
24.	Efficiency	94.494 %	System Information	Steady state efficiency
25.	FootPrint	509.0 mm^2	System Information	Total Foot Print Area of BOM components
26.	Frequency	152.023 kHz	System Information	Switching frequency
27.	Iout	1.0 A	System Information	Iout operating point
28.	Mode	PFM	System Information	Conduction Mode
29.	Pout	3.3 W	System Information	Total output power
30.	Total BOM	$5.25	System Information	Total BOM Cost
31.	Vin	57.0 V	System Information	Vin operating point
32.	Vin p-p	320.547 mV	System Information	Peak-to-peak input voltage
33.	Vout	3.3 V	System Information	Operational Output Voltage
34.	Vout Tolerance	242.42 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
35.	Vout p-p	9.986 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	57.0	Maximum input voltage
VinMin	9.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LM65645	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

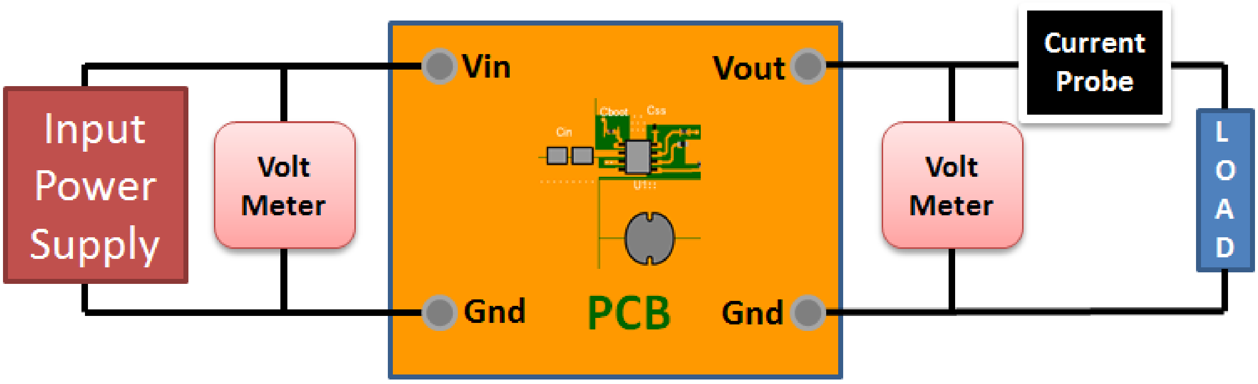
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 9.0V 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 : E4AAB3A58648DDFC[v1]

2. **LM65645** Product Folder : https://www.ti.com/product/LM65645 : contains the data sheet and other resources.

Important Notice and Disclaimer

TI provides technical and reliability data (including datasheets), design resources (including reference designs), application or other design advice, web tools, safety information, and other resources AS IS and with all faults, and disclaims all warranties. These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

Providing these resources does not expand or otherwise alter TI's applicable Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with TI products.