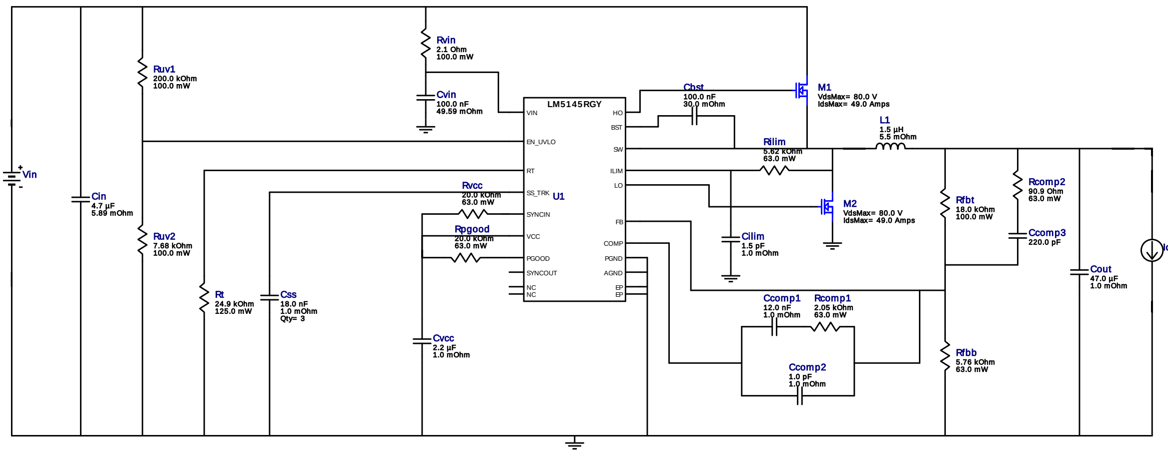
TEXAS INSTRUMENTS

WEBENCH® Design Report

VinMin = 40.0V
VinMax = 60.0V
Vout = 3.3V
Iout = 12.0A

Device = LM5145RGYR
Topology = Buck
Created = 2020-05-20 23:37:10.002
BOM Cost = $5.11
BOM Count = 27
Total Pd = 5.47W

Design : 9 LM5145RGYR
LM5145RGYR 40V-60V to 3.30V @ 12A infineon FET



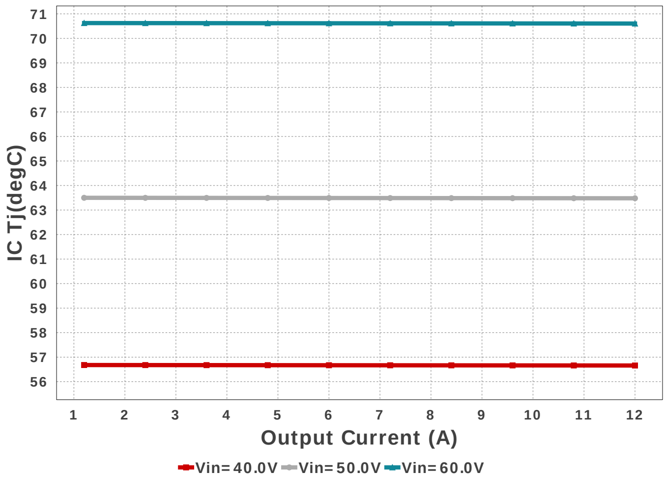
1. This regulator device is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific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

Electrical BOM

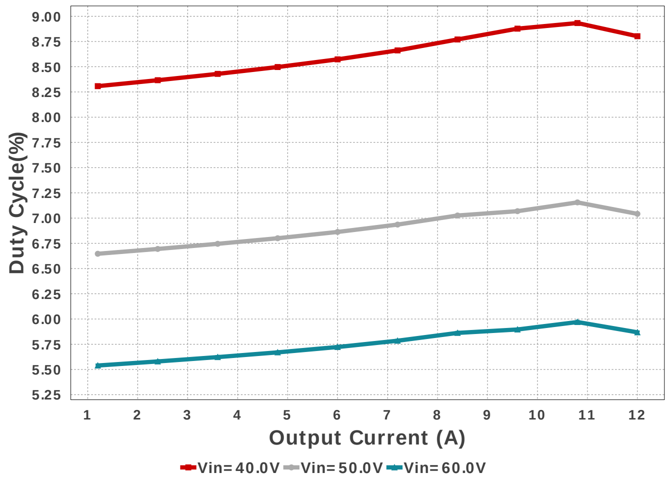
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst	MuRata	GRM188R61E104KA01D Series= X5R	Cap= 100.0 nF ESR= 30.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Ccomp1	MuRata	GRM155R71C123KA01D Series= X7R	Cap= 12.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp2	MuRata	GRM1555C1H1R0CA01D Series= C0G/NP0	Cap= 1.0 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp3	Samsung Electro-Mechanics	CL05C221JA5NNNC Series= C0G/NP0	Cap= 220.0 pF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cilim	MuRata	GQM2195C2A1R5CB01D Series= C0G/NP0	Cap= 1.5 pF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.15	0805 7 mm^2
Cin	TDK	C3225X7S2A475M200AB Series= X7S	Cap= 4.7 uF ESR= 5.89 mOhm VDC= 100.0 V IRMS= 6.7739 A	1	$0.50	1210 15 mm^2
Cout	MuRata	GCM32ER70J476KE19L Series= X7R	Cap= 47.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 2.9 A	1	$0.40	1210_270 15 mm^2
Css	MuRata	GRM155R71C183KA01D Series= X7R	Cap= 18.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	3	$0.01	0402 3 mm^2

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cvcc	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.07	0402_065 3 mm^2
Cvin	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
L1	Bourns	SRP1235-1R5M	L= 1.5 µH 5.5 mOhm	1	$0.72	SRP1235 253 mm^2
M1	Infineon Technologies	BSC117N08NS5ATMA1	VdsMax= 80.0 V IdsMax= 49.0 Amps	1	$0.52	PG-TDSON-8 55 mm^2
M2	Infineon Technologies	BSC117N08NS5ATMA1	VdsMax= 80.0 V IdsMax= 49.0 Amps	1	$0.52	PG-TDSON-8 55 mm^2
Rcomp1	Vishay-Dale	CRCW04022K05FKED Series= CRCW..e3	Res= 2.05 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcomp2	Vishay-Dale	CRCW040290R9FKED Series= CRCW..e3	Res= 90.9 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Vishay-Dale	CRCW04025K76FKED Series= CRCW..e3	Res= 5.76 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Yageo	RC0603FR-0718KL Series= ?	Res= 18.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rilim	Vishay-Dale	CRCW04025K62FKED Series= CRCW..e3	Res= 5.62 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rpgood	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rt	Vishay-Dale	CRCW080524K9FKEA Series= CRCW..e3	Res= 24.9 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Ruv1	Vishay-Dale	CRCW0603200KFKEA Series= CRCW..e3	Res= 200.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Ruv2	Yageo	RC0603FR-077K68L Series= ?	Res= 7.68 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rvcc	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rvin	Vishay-Dale	CRCW06032R10FKEA Series= CRCW..e3	Res= 2.1 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM5145RGYR	Switcher	1	$2.02	RGY0020B 25 mm^2

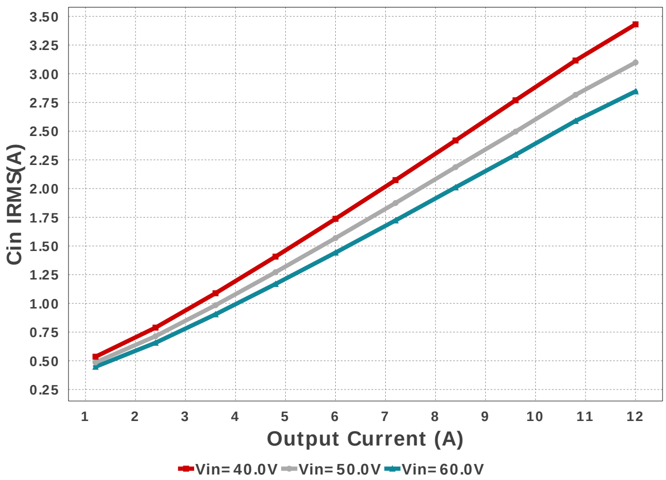
IC Tj



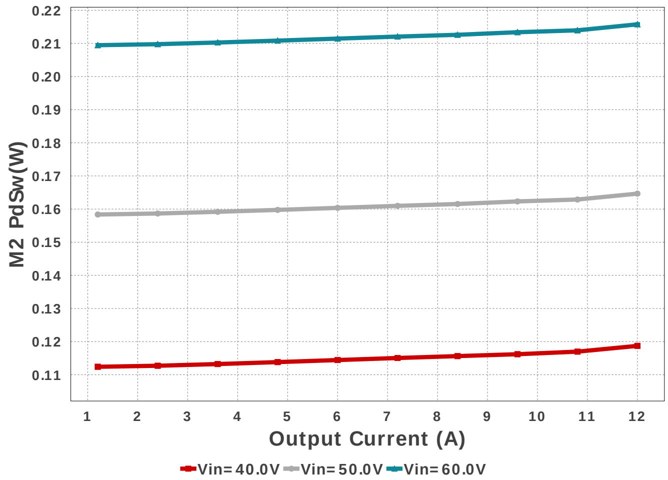
Duty Cycle



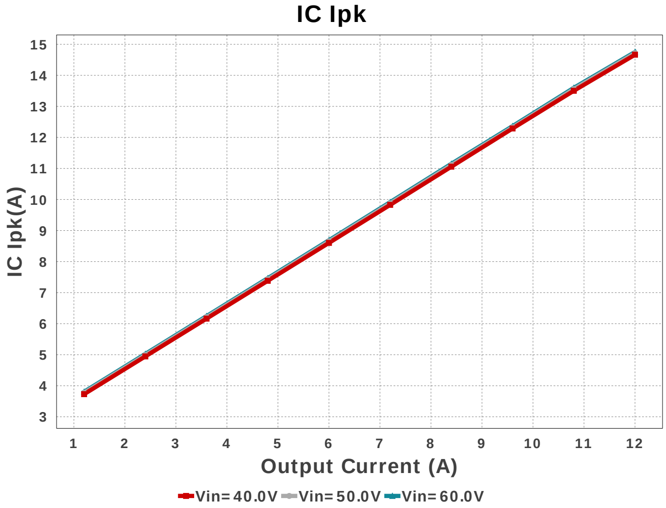
Cin IRMS



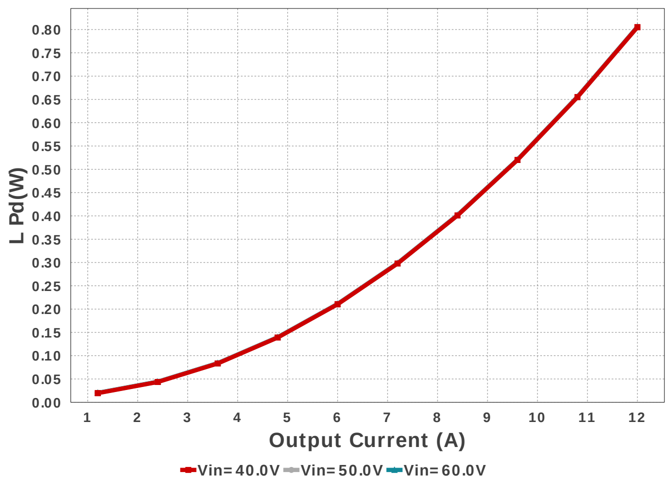
M2 PdSw



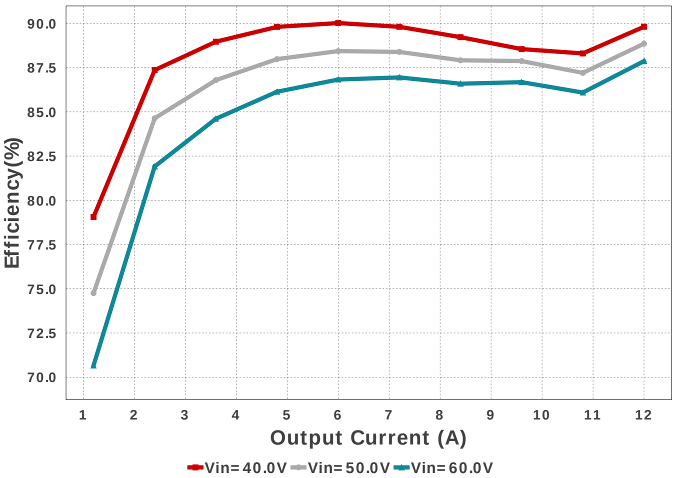
IC Ipk



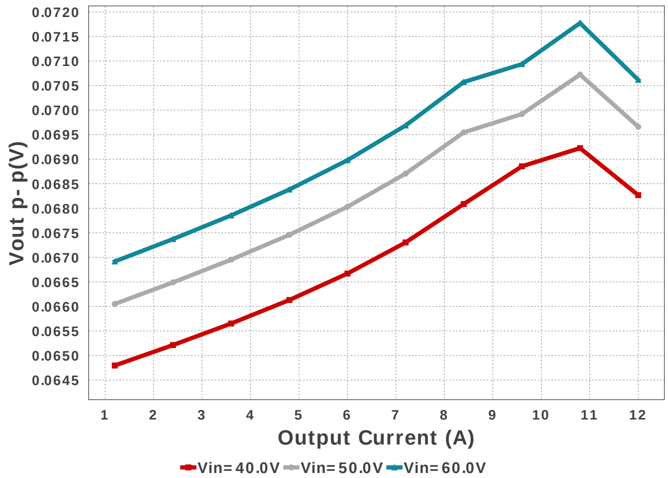
L Pd



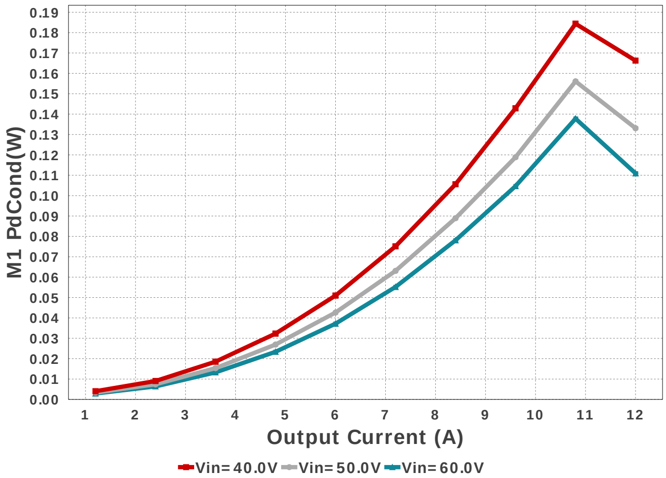
Efficiency



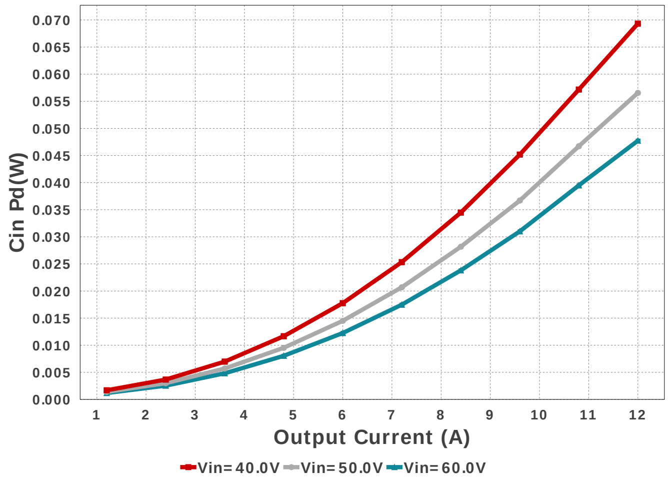
Vout p-p



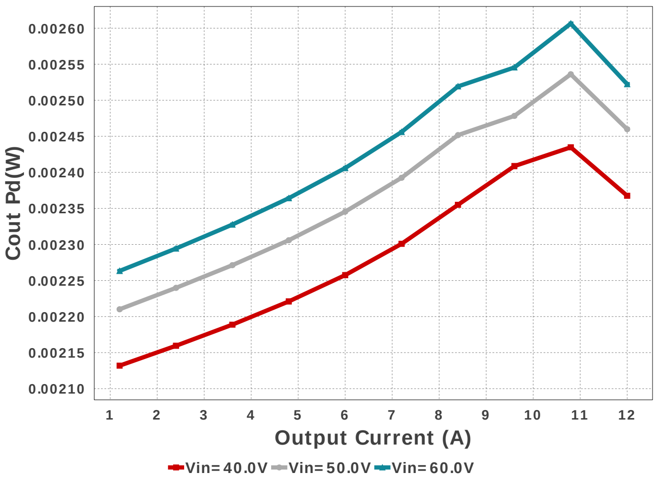
M1 PdCond



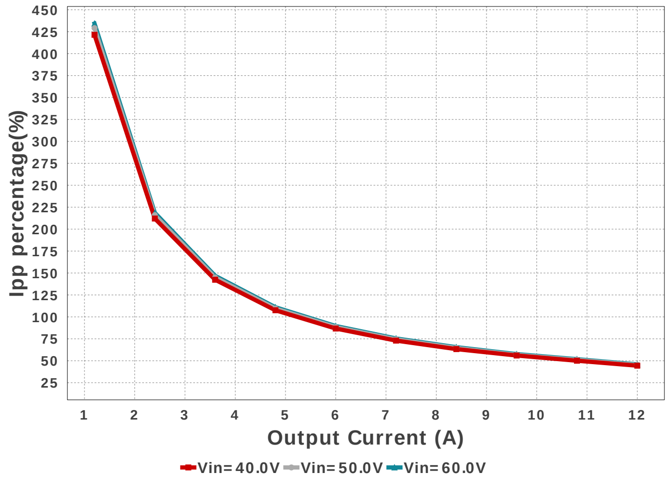
Cin Pd

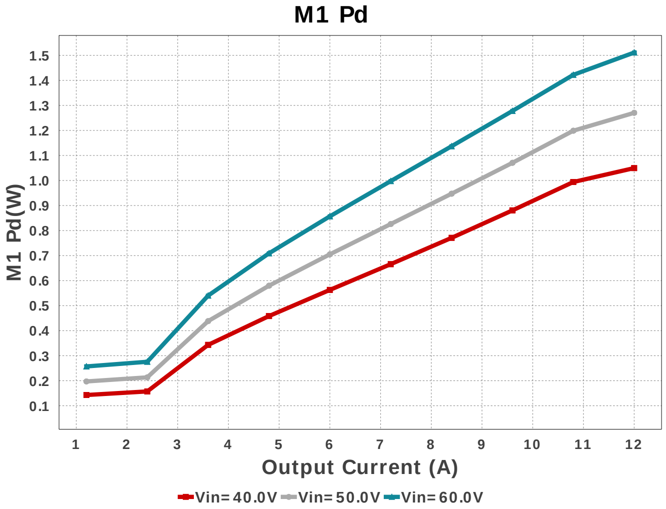


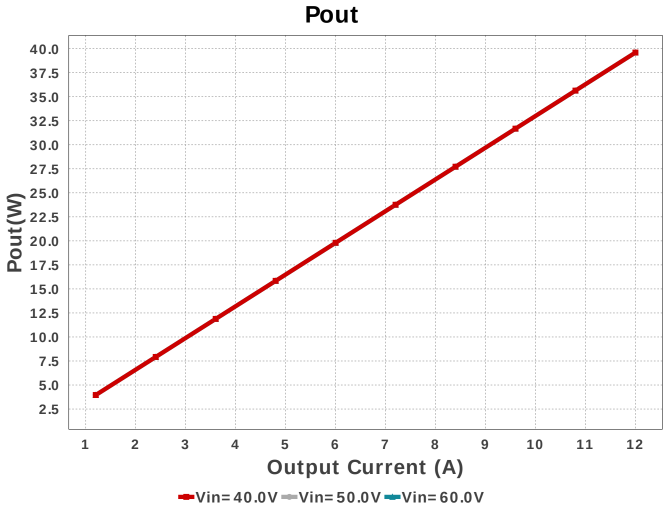
Cout Pd

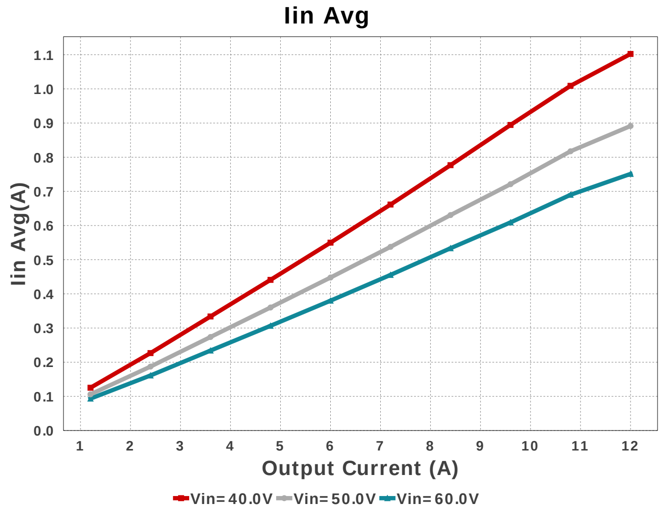


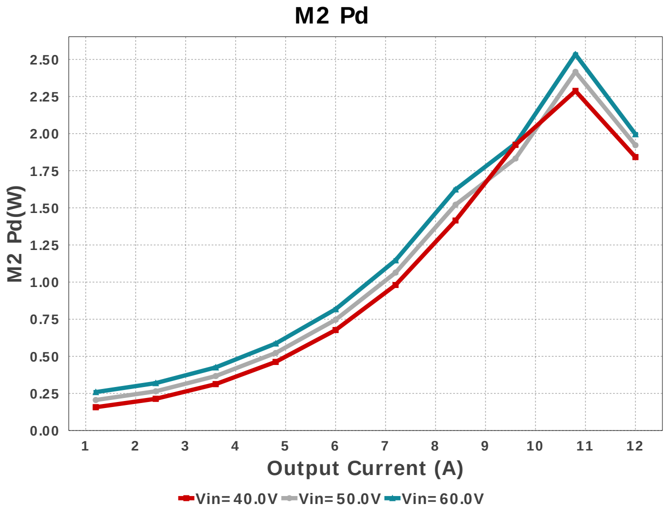
Ipp percentage

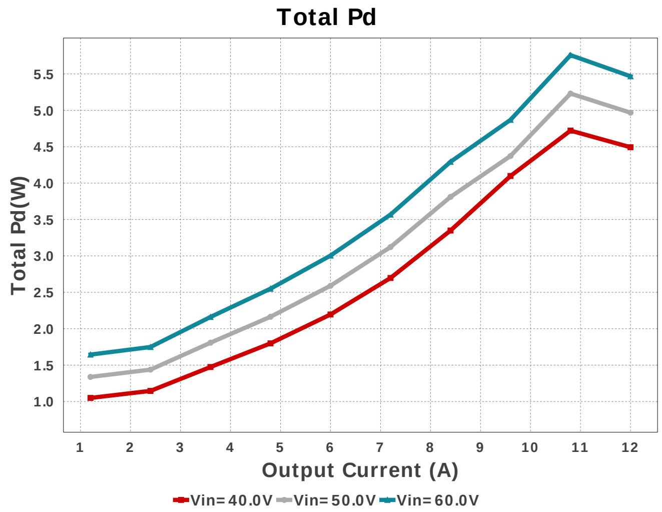


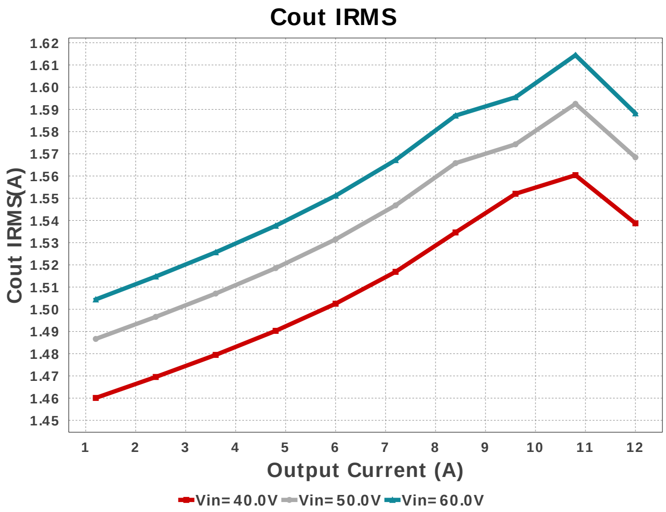

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=40.0V Vin=50.0V Vin=60.0V


Pout
Pout(W)
Output Current (A)
Vin=40.0V Vin=50.0V Vin=60.0V

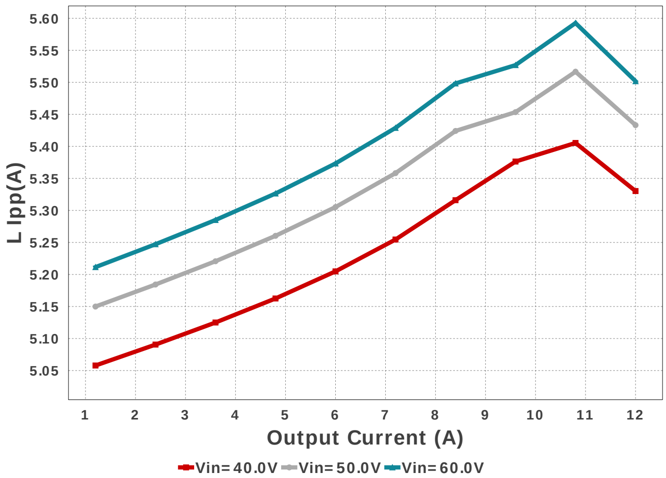

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=40.0V Vin=50.0V Vin=60.0V


M2 Pd
M2 Pd(W)
Output Current (A)
Vin=40.0V Vin=50.0V Vin=60.0V

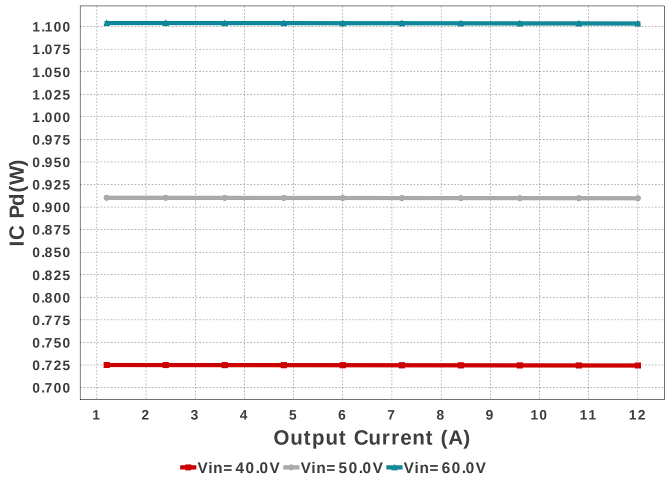

Total Pd
Total Pd(W)
Output Current (A)
Vin=40.0V Vin=50.0V Vin=60.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=40.0V Vin=50.0V Vin=60.0V

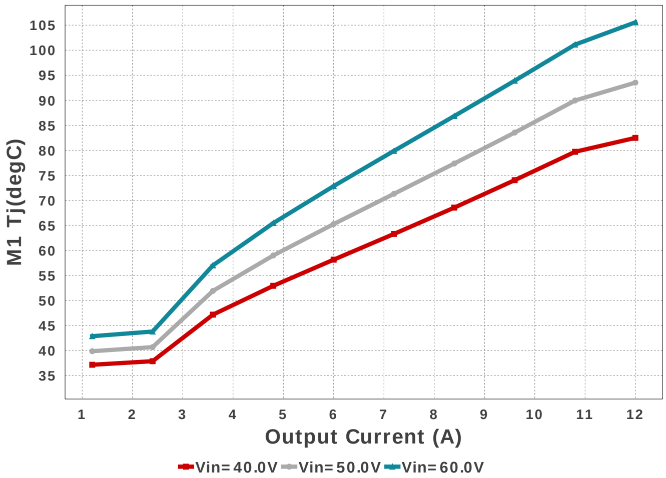
L Ipp



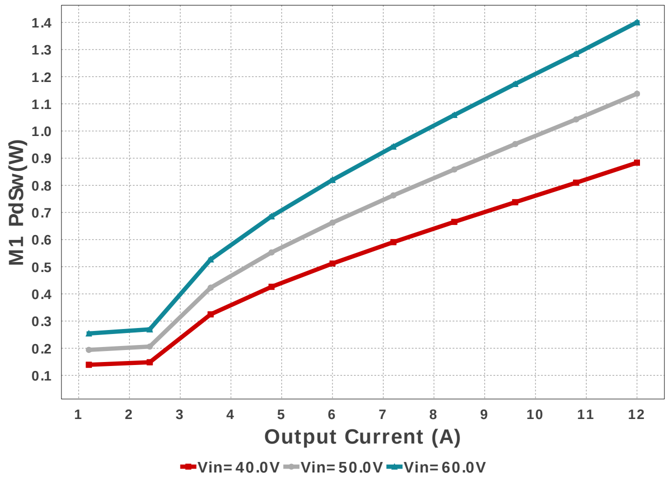
IC Pd



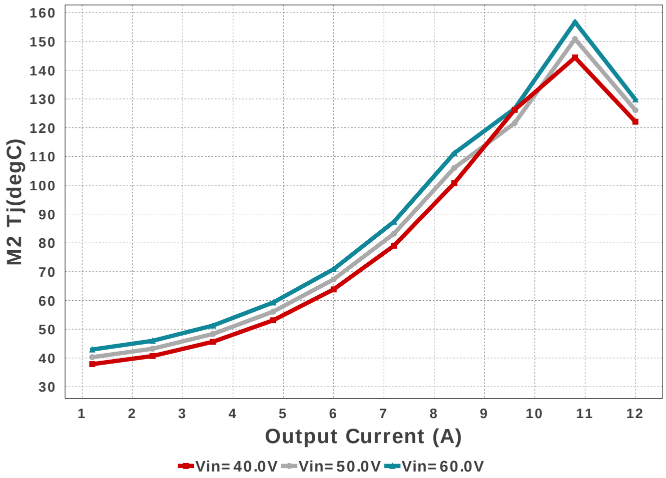
M1 Tj



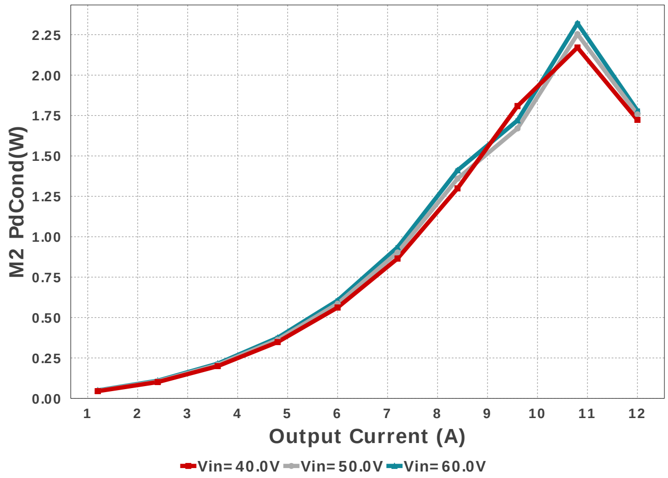
M1 PdSw

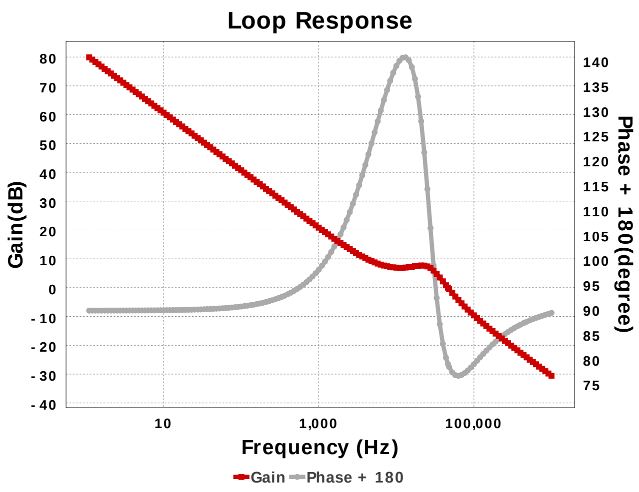


M2 Tj



M2 PdCond





Operating Values

#	Name	Value	Category	Description
1.	BOM Count	27		Total Design BOM count
2.	Total BOM	$5.11		Total BOM Cost
3.	Cin IRMS	2.846 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	47.723 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	1.588 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	2.522 mW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	14.751 A	IC	Peak switch current in IC
8.	IC Pd	1.103 W	IC	IC power dissipation
9.	IC Tj	70.606 degC	IC	IC junction temperature
10.	IC Tolerance	8.0 mV	IC	IC Feedback Tolerance
11.	ICThetaJA	36.8 degC/W	IC	IC junction-to-ambient thermal resistance
12.	Iin Avg	751.13 mA	IC	Average input current
13.	Ipp percentage	45.848 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	5.502 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	805.87 mW	Inductor	Inductor power dissipation
16.	M1 Pd	1.511 W	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	110.95 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	1.4 W	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	105.562 degC	Mosfet	M1 MOSFET junction temperature
20.	M2 Pd	1.996 W	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	1.781 W	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	215.76 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Tj	129.817 degC	Mosfet	M2 MOSFET junction temperature
24.	Cin Pd	47.723 mW	Power	Input capacitor power dissipation
25.	Cout Pd	2.522 mW	Power	Output capacitor power dissipation
26.	IC Pd	1.103 W	Power	IC power dissipation
27.	L Pd	805.87 mW	Power	Inductor power dissipation
28.	M1 Pd	1.511 W	Power	M1 MOSFET total power dissipation
29.	M1 PdCond	110.95 mW	Power	M1 MOSFET conduction losses
30.	M1 PdSw	1.4 W	Power	M1 MOSFET switching losses
31.	M2 Pd	1.996 W	Power	M2 MOSFET total power dissipation
32.	M2 PdCond	1.781 W	Power	M2 MOSFET conduction losses
33.	M2 PdSw	215.76 mW	Power	M2 MOSFET switching losses
34.	Total Pd	5.468 W	Power	Total Power Dissipation
35.	Cross Freq	46.209 kHz	System Information	Bode plot crossover frequency
36.	Duty Cycle	5.868 %	System Information	Duty cycle
37.	Efficiency	87.868 %	System Information	Steady state efficiency
38.	FootPrint	498.0 mm^2	System Information	Total Foot Print Area of BOM components
39.	Frequency	401.606 kHz	System Information	Switching frequency
40.	Gain Marg	-62.148 dB	System Information	Bode Plot Gain Margin
41.	Iout	12.0 A	System Information	Iout operating point
42.	Low Freq Gain	79.896 dB	System Information	Gain at 1Hz

#	Name	Value	Category	Description
43.	Mode	CCM	System Information	Conduction Mode
44.	Phase Marg	79.295 deg	System Information	Bode Plot Phase Margin
45.	Pout	39.6 W	System Information	Total output power
46.	Vin	60.0 V	System Information	Vin operating point
47.	Vout	3.3 V	System Information	Operational Output Voltage
48.	Vout Actual	3.3 V	System Information	Vout Actual calculated based on selected voltage divider resistors
49.	Vout Tolerance	2.546 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
50.	Vout p-p	70.617 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	12.0	Maximum Output Current
VinMax	60.0	Maximum input voltage
VinMin	40.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LM5145	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

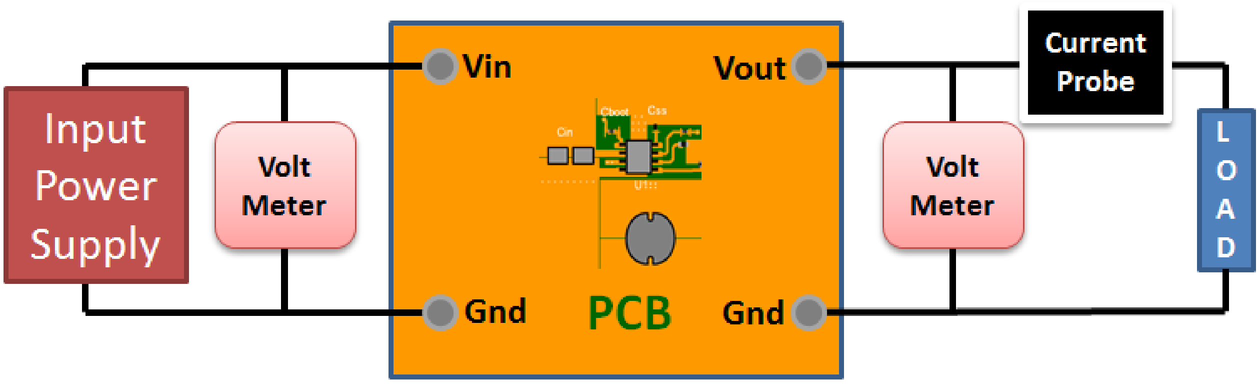
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 40.0V 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.

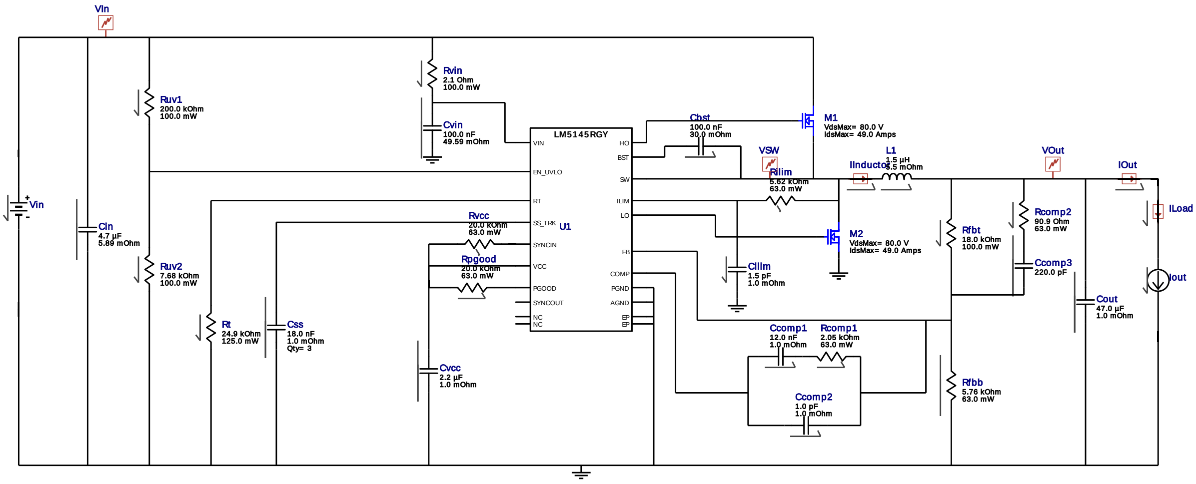


WEBENCH® Electrical Simulation Report

Design Id = 9

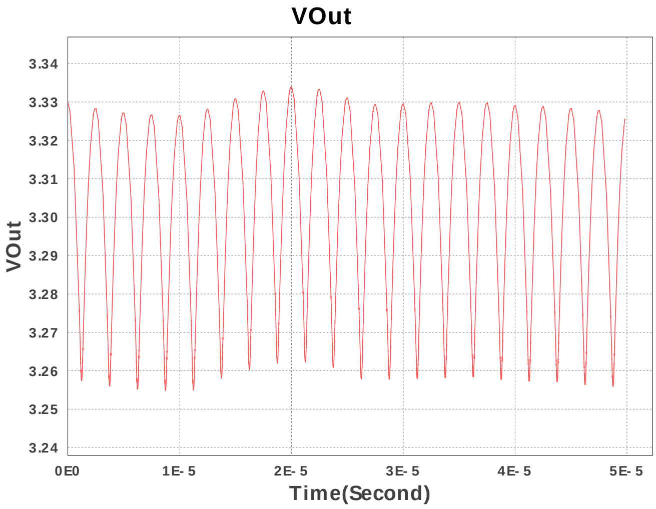
sim_id = 6

Simulation Type = Steady State



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cout	IC	Initial condition	3.3 V
2.	Cvcc	IC	Initial Voltage	3.3 V
3.	L1	IC	Initial condition	12.0 A
4.	Css	IC	Initial Condition	0.9 V
5.	Iout	I	Load Current	12.0 A



Design Assistance

1. Master key : 8A0AF5216BD2F6FD[v1]

2. **LM5145** Product Folder : http://www.ti.com/product/lm5145 : contains the data sheet and other resources.

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