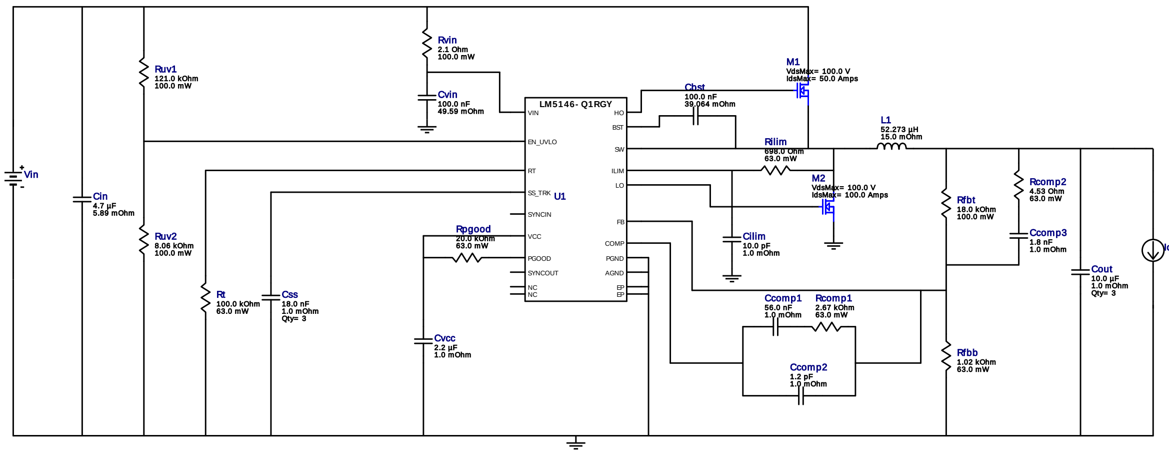
VinMin = 24.0V
VinMax = 75.0V
Vout = 15.0V
Iout = 5.0A

Device = LM5146QRGYRQ1
Topology = Buck
Created = 2020-08-31 21:48:02.443
BOM Cost = NA
BOM Count = 29
Total Pd = 2.37W

WEBENCH ® Design Report

Design : 53 LM5146QRGYRQ1
LM5146QRGYRQ1 24V-75V to 15.00V @ 5A



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.

Design Alerts

Component Selection Information

The LM5146-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.

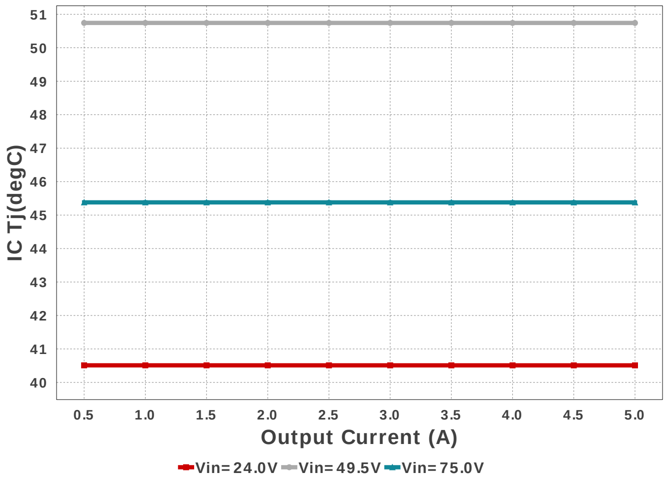
Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst	TDK	C1005X5R1H104K050BB Series= X5R	Cap= 100.0 nF ESR= 39.064 mOhm VDC= 50.0 V IRMS= 814.67 mA	1	$0.02	0402 3 mm^2
Ccomp1	MuRata	GRM155R71C563KA88D Series= X7R	Cap= 56.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp2	MuRata	GRM1555C1H1R2CA01D Series= C0G/NP0	Cap= 1.2 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp3	MuRata	GRM155R71H182KA01D Series= X7R	Cap= 1.8 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cilim	MuRata	GRM1885C2A100JA01D Series= C0G/NP0	Cap= 10.0 pF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.02	0603 5 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

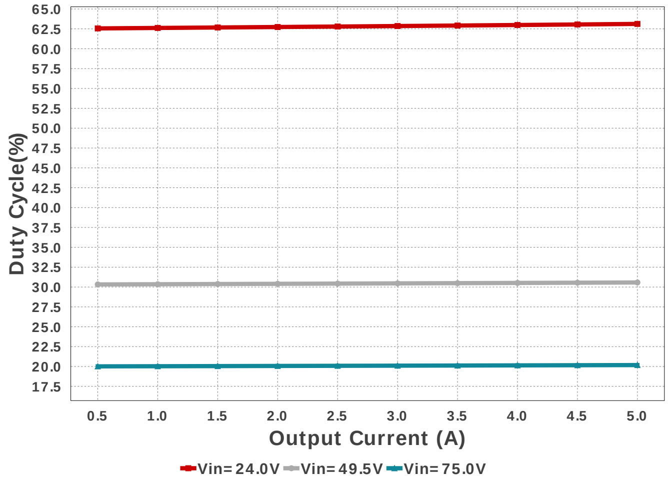
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	3	$0.28	1210 15 mm²
Css	MuRata	GRM155R71C183KA01D Series= X7R	Cap= 18.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	3	$0.01	0402 3 mm²
Cvcc	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.07	0402_065 3 mm²
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 mm²
L1	CUSTOM	CUSTOM	L= 52.273 µH 15.0 mOhm	1	NA	CUSTOM 0 mm²
M1	Texas Instruments	CSD19534Q5A	VdsMax= 100.0 V IdsMax= 50.0 Amps	1	$0.32	TRANS_NexFET_Q5A 55 mm²
M2	Texas Instruments	CSD19531Q5A	VdsMax= 100.0 V IdsMax= 100.0 Amps	1	$0.58	TRANS_NexFET_Q5A 55 mm²
Rcomp1	Vishay-Dale	CRCW04022K67FKED Series= CRCW..e3	Res= 2.67 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcomp2	Vishay-Dale	CRCW04024R53FKED Series= CRCW..e3	Res= 4.53 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Vishay-Dale	CRCW04021K02FKED Series= CRCW..e3	Res= 1.02 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Yageo	RC0603FR-0718KL Series= ?	Res= 18.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rilim	Vishay-Dale	CRCW0402698RFKED Series= CRCW..e3	Res= 698.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rpgood	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rt	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Ruv1	Vishay-Dale	CRCW0603121KFKEA Series= CRCW..e3	Res= 121.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Ruv2	Vishay-Dale	CRCW06038K06FKEA Series= CRCW..e3	Res= 8.06 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rvcc	Vishay-Dale	CRCW040220K0FKED Series= CRCW..e3	Res= 20.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rvin	Vishay-Dale	CRCW06032R10FKEA Series= CRCW..e3	Res= 2.1 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	LM5146QRGYRQ1	Switcher	1	$1.36	RGY0020B 25 mm^2

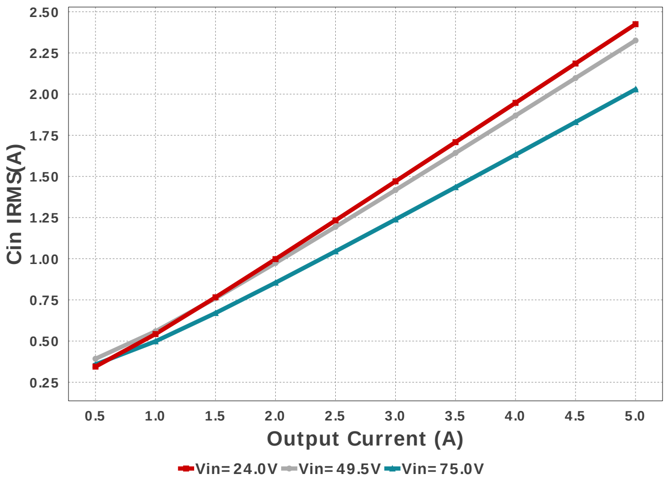
IC Tj



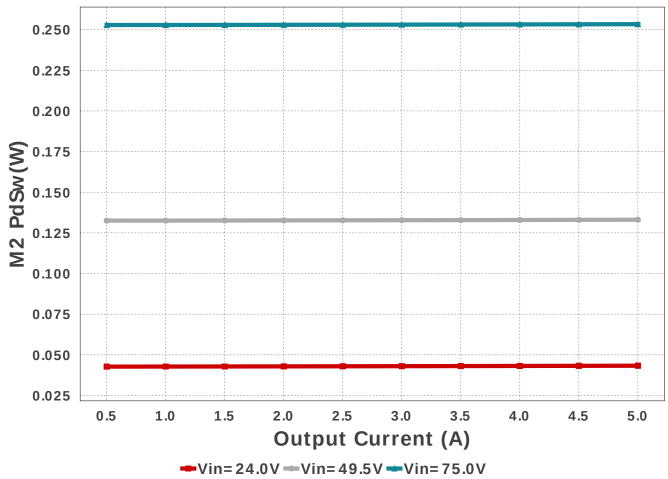
Duty Cycle



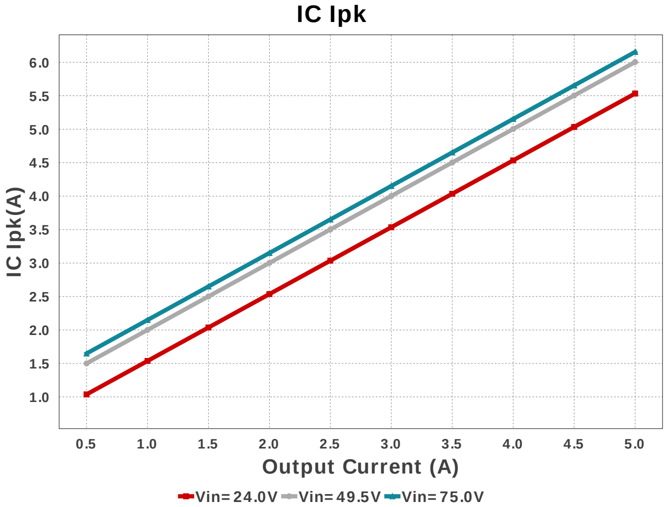
Cin IRMS



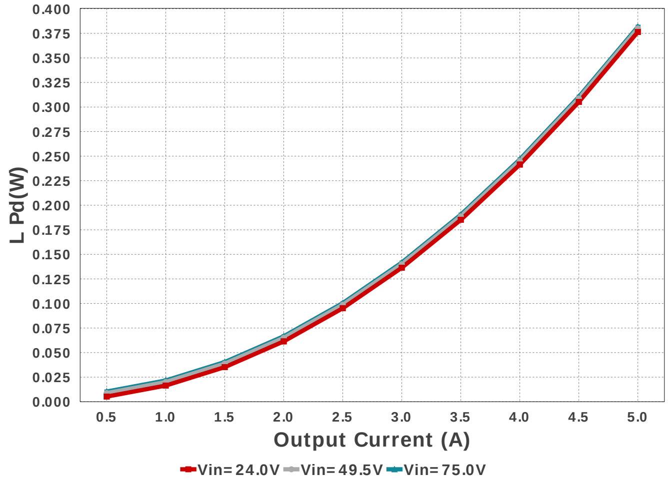
M2 PdSw



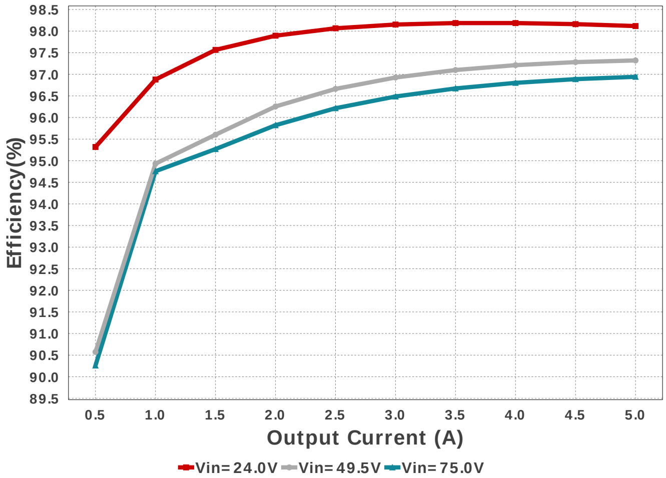
IC Ipk



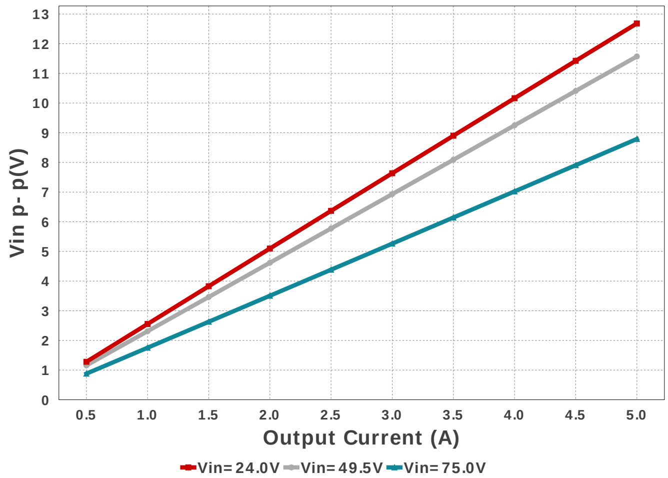
L Pd



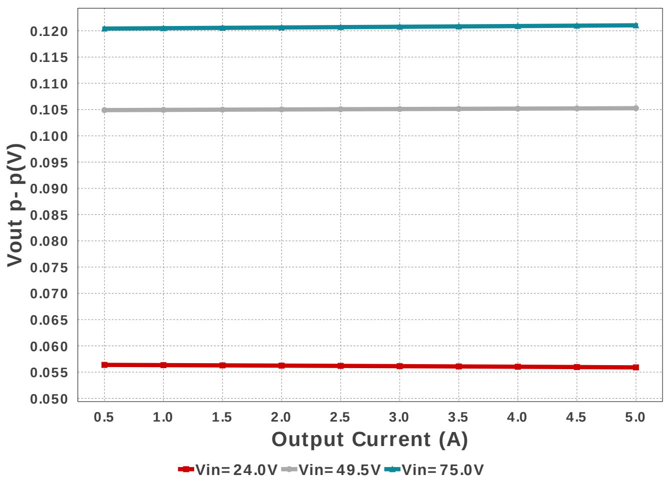
Efficiency



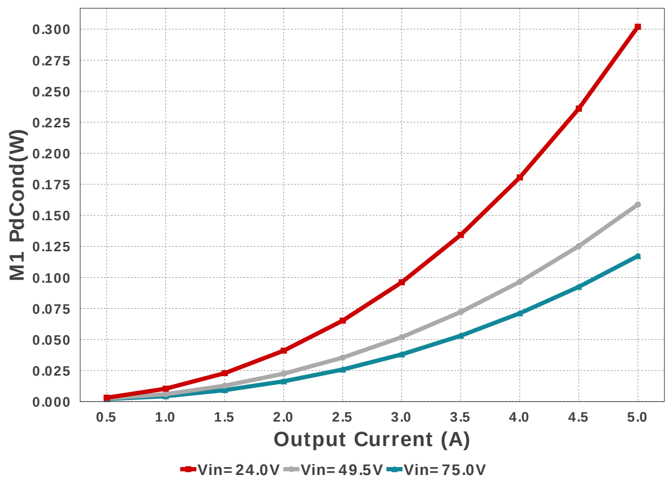
Vin p-p



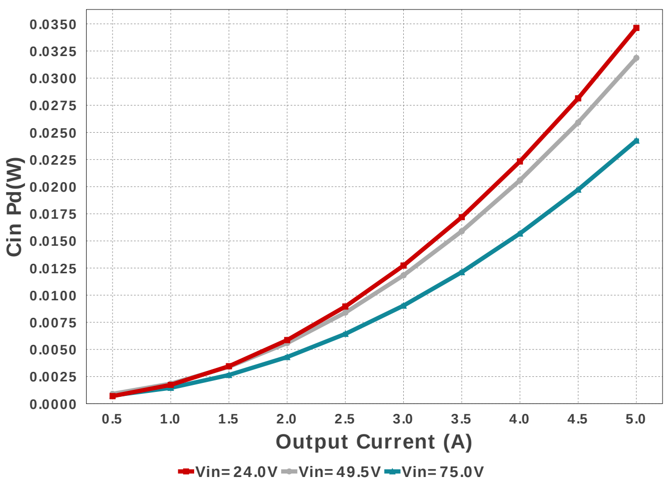
Vout p-p



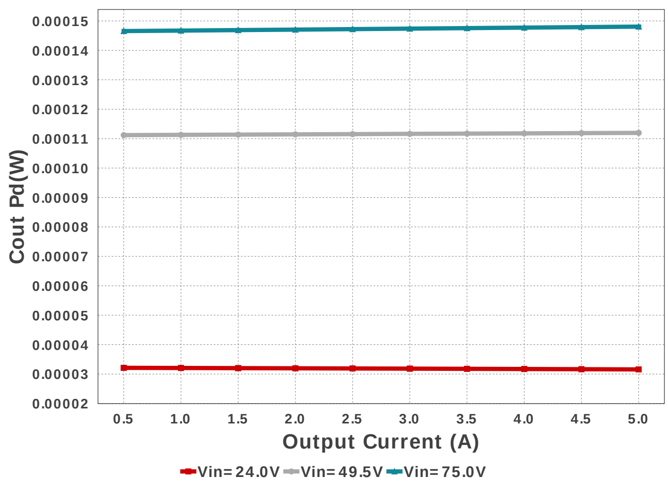
M1 PdCond

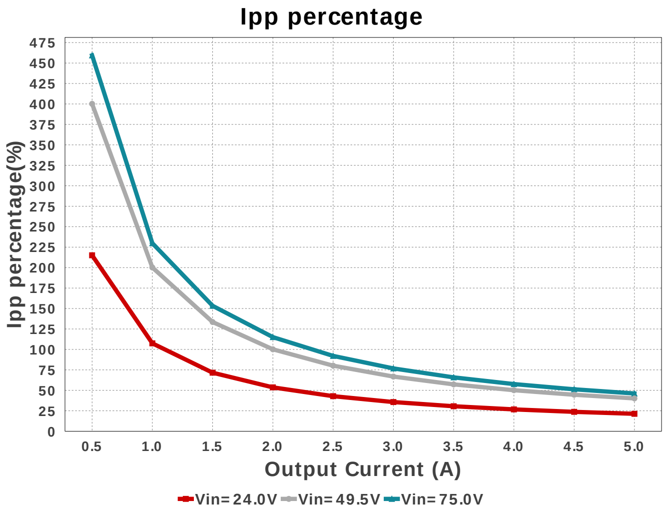


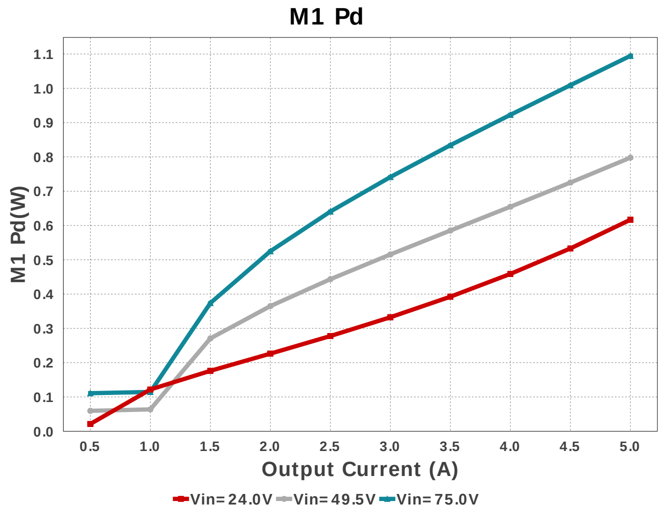
Cin Pd

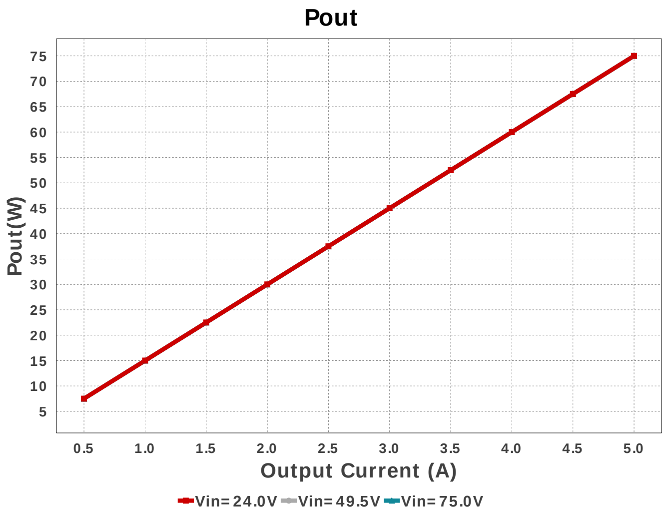


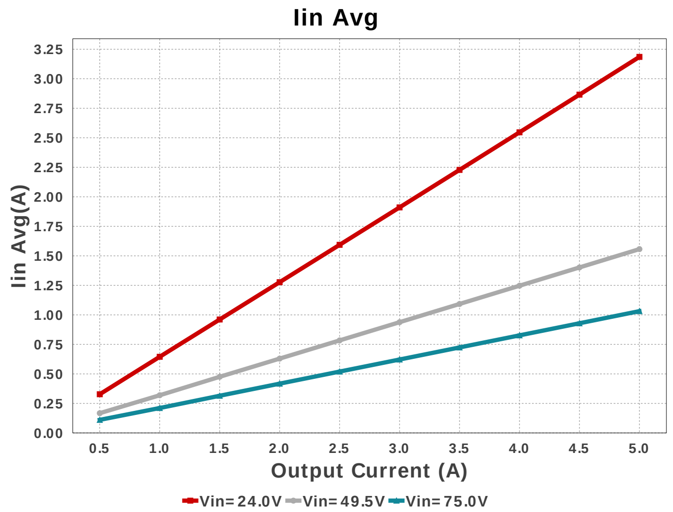
Cout Pd

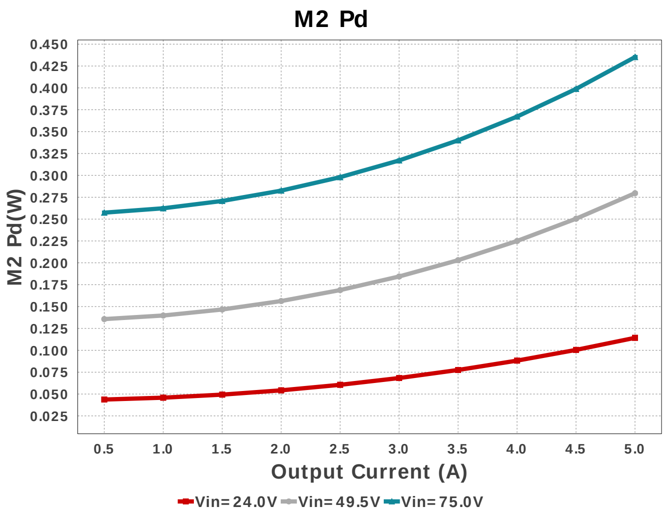


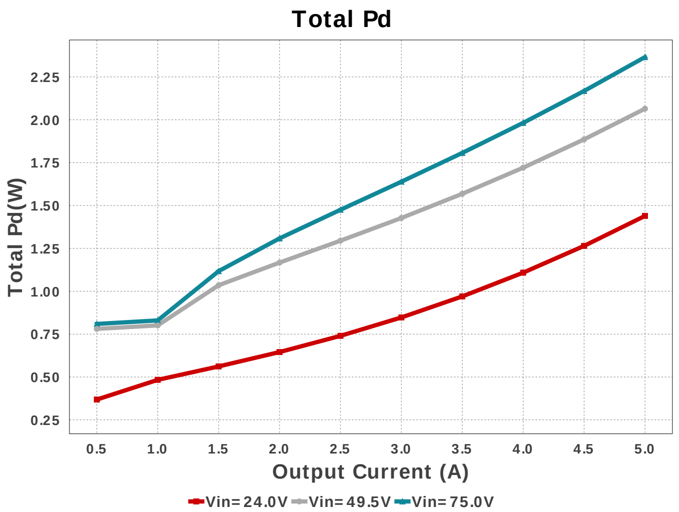

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=24.0V Vin=49.5V Vin=75.0V


M1 Pd
M1 Pd(W)
Output Current (A)
Vin=24.0V Vin=49.5V Vin=75.0V

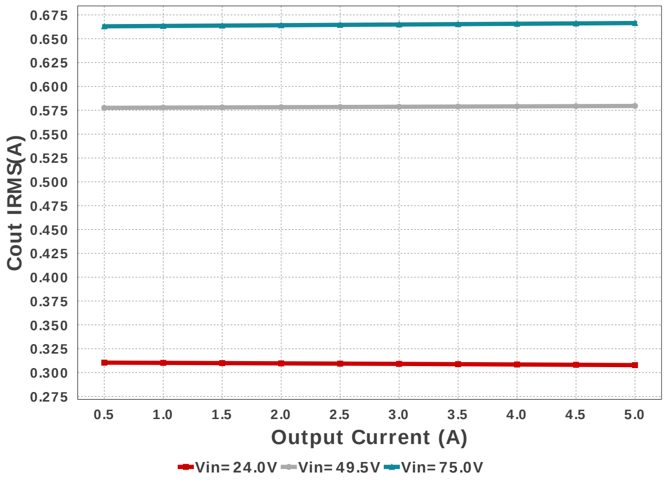

Pout
Pout(W)
Output Current (A)
Vin=24.0V Vin=49.5V Vin=75.0V


Iin Avg
Iin Avg(A)
Output Current (A)
Vin=24.0V Vin=49.5V Vin=75.0V

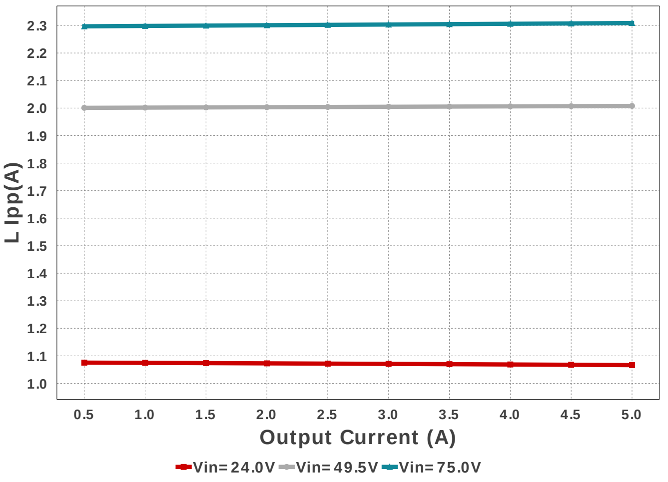

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=24.0V Vin=49.5V Vin=75.0V


Total Pd
Total Pd(W)
Output Current (A)
Vin=24.0V Vin=49.5V Vin=75.0V

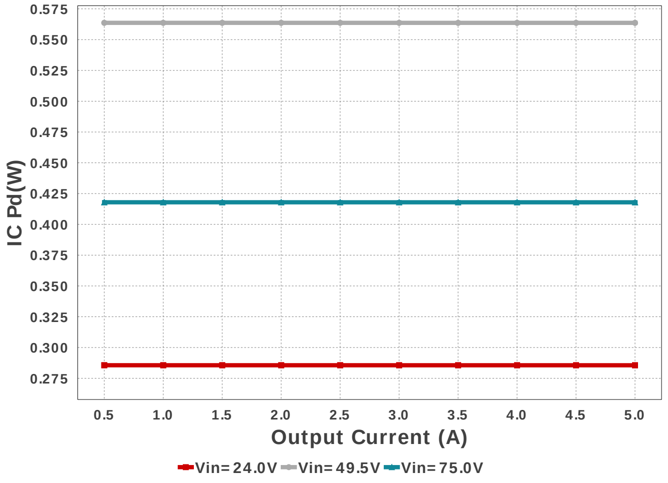
Cout IRMS



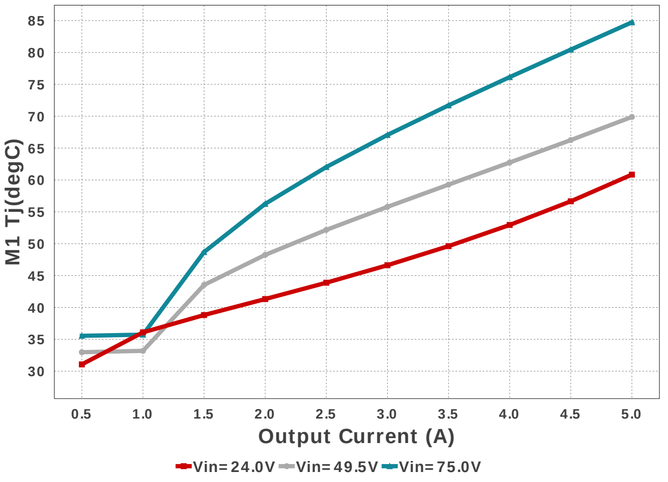
L Ipp



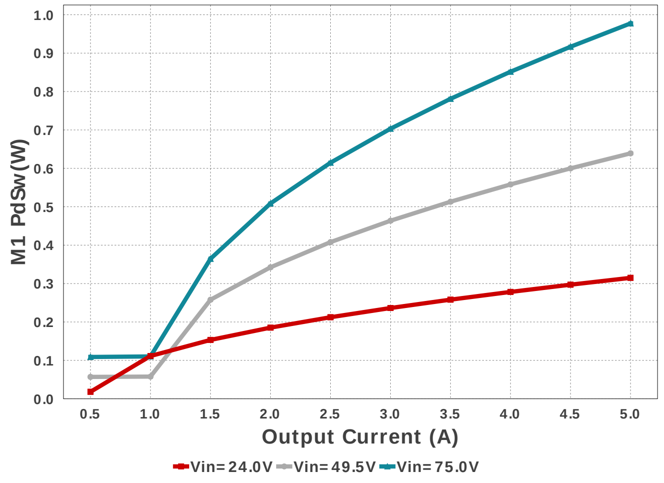
IC Pd



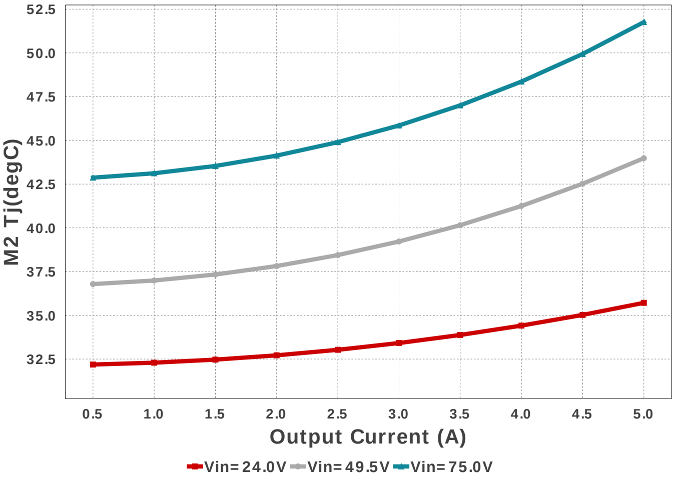
M1 Tj

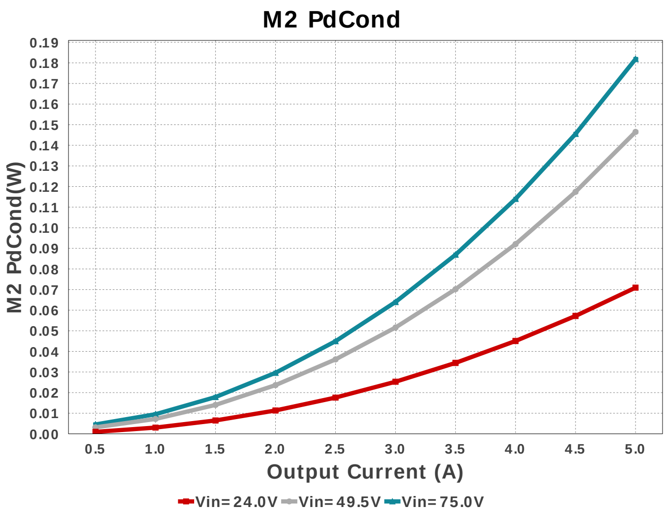


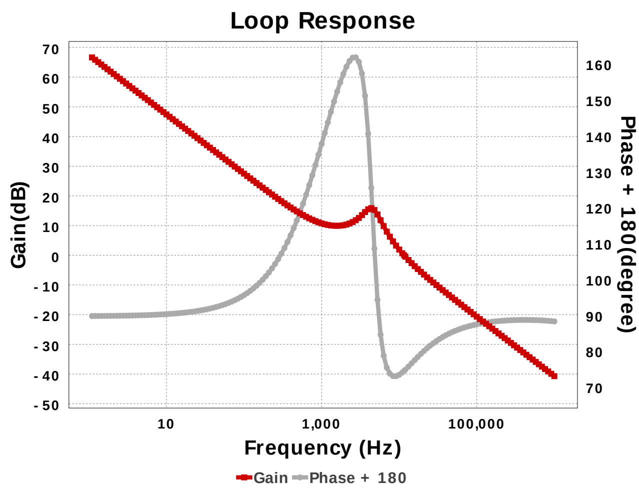
M1 PdSw



M2 Tj







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	2.029 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	24.245 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	666.5 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	148.07 µW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	6.154 A	IC	Peak switch current in IC
6.	IC Pd	417.92 mW	IC	IC power dissipation
7.	IC Tj	44.544 degC	IC	IC junction temperature
8.	IC Tolerance	8.0 mV	IC	IC Feedback Tolerance
9.	ICThetaJA	34.8 degC/W	IC	IC junction-to-ambient thermal resistance
10.	Iin Avg	1.032 A	IC	Average input current
11.	Ipp percentage	46.176 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
12.	L Ipp	2.309 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	381.66 mW	Inductor	Inductor power dissipation
14.	M1 Pd	1.095 W	Mosfet	M1 MOSFET total power dissipation
15.	M1 PdCond	117.23 mW	Mosfet	M1 MOSFET conduction losses
16.	M1 PdSw	977.43 mW	Mosfet	M1 MOSFET switching losses
17.	M1 Tj	84.733 degC	Mosfet	M1 MOSFET junction temperature
18.	M2 Pd	435.2 mW	Mosfet	M2 MOSFET total power dissipation
19.	M2 PdCond	181.86 mW	Mosfet	M2 MOSFET conduction losses
20.	M2 PdSw	253.34 mW	Mosfet	M2 MOSFET switching losses
21.	M2 Tj	51.76 degC	Mosfet	M2 MOSFET junction temperature
22.	Cin Pd	24.245 mW	Power	Input capacitor power dissipation
23.	Cout Pd	148.07 µW	Power	Output capacitor power dissipation
24.	IC Pd	417.92 mW	Power	IC power dissipation
25.	L Pd	381.66 mW	Power	Inductor power dissipation
26.	M1 Pd	1.095 W	Power	M1 MOSFET total power dissipation
27.	M1 PdCond	117.23 mW	Power	M1 MOSFET conduction losses
28.	M1 PdSw	977.43 mW	Power	M1 MOSFET switching losses
29.	M2 Pd	435.2 mW	Power	M2 MOSFET total power dissipation
30.	M2 PdCond	181.86 mW	Power	M2 MOSFET conduction losses
31.	M2 PdSw	253.34 mW	Power	M2 MOSFET switching losses
32.	Total Pd	2.366 W	Power	Total Power Dissipation
33.	BOM Count	29	System Information	Total Design BOM count
34.	Cross Freq	11.574 kHz	System Information	Bode plot crossover frequency
35.	Duty Cycle	20.178 %	System Information	Duty cycle
36.	Efficiency	96.942 %	System Information	Steady state efficiency
37.	FootPrint	667.0 mm^2	System Information	Total Foot Print Area of BOM components
38.	Frequency	100.0 kHz	System Information	Switching frequency
39.	Gain Marg	-86.346 dB	System Information	Bode Plot Gain Margin
40.	Iout	5.0 A	System Information	Iout operating point
41.	Low Freq Gain	66.646 dB	System Information	Gain at 1Hz

#	Name	Value	Category	Description
42.	Mode	CCM	System Information	Conduction Mode
43.	Phase Marg	74.777 deg	System Information	Bode Plot Phase Margin
44.	Pout	75.0 W	System Information	Total output power
45.	Total BOM	NA	System Information	Total BOM Cost
46.	Vin	75.0 V	System Information	Vin operating point
47.	Vin p-p	8.803 V	System Information	Peak-to-peak input voltage
48.	Vout	15.0 V	System Information	Operational Output Voltage
49.	Vout Actual	14.918 V	System Information	Vout Actual calculated based on selected voltage divider resistors
50.	Vout Tolerance	2.931 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
51.	Vout p-p	121.048 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	5.0	Maximum Output Current
SoftStart	4.0 ms	Soft Start Time (ms)
VinMax	75.0	Maximum input voltage
VinMin	24.0	Minimum input voltage
Vout	15.0	Output Voltage
base_pn	LM5146-Q1	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	100.0 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

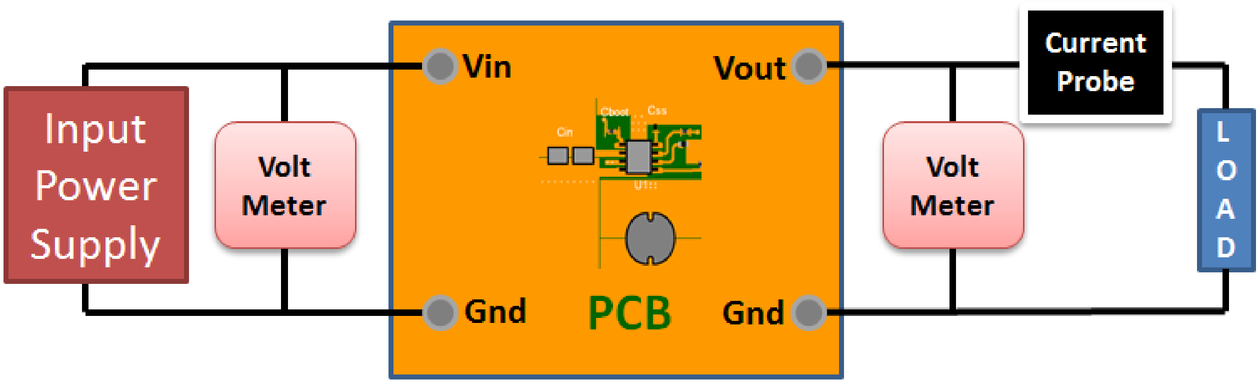
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 24.0V 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. The LM5146-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

2. Master key : BE5D32129D021133[v1]

3. **LM5146-Q1** Product Folder : http://www.ti.com/product/lm5146%2DQ1 : contains the data sheet and other resources.