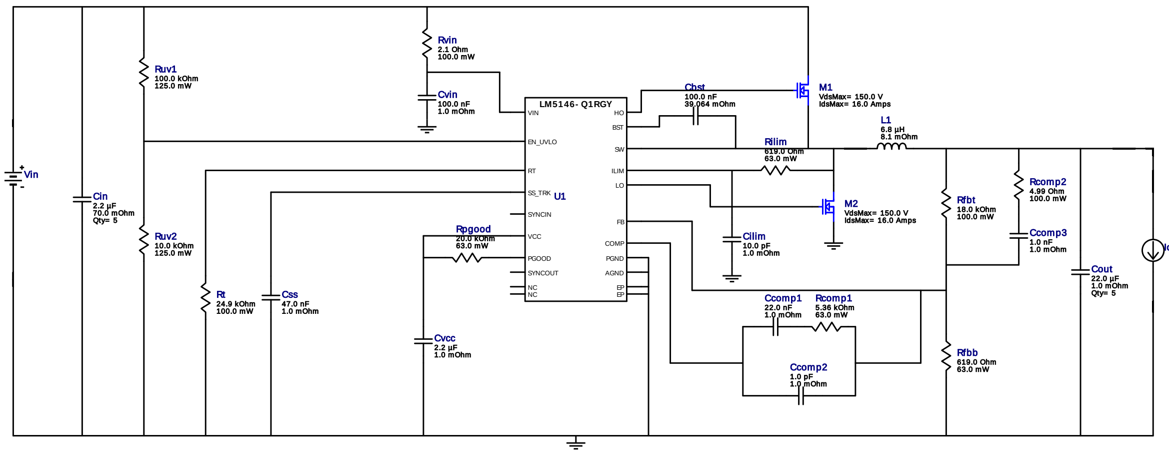
VinMin = 40.0V	Device = LM5146QRGYRQ1
VinMax = 100.0V	Topology = Buck
Vout = 24.0V	Created = 2021-04-28 04:24:35.650
Iout = 3.0A	BOM Cost = NA
	BOM Count = 33
	Total Pd = 1.94W

WEBENCH ® Design Report

Design : 103 LM5146QRGYRQ1
LM5146QRGYRQ1 40V-100V to 24.00V @ 3A



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

Please note that since parallel FETs have been chosen in this design, schematic and PCB export features will not work. 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

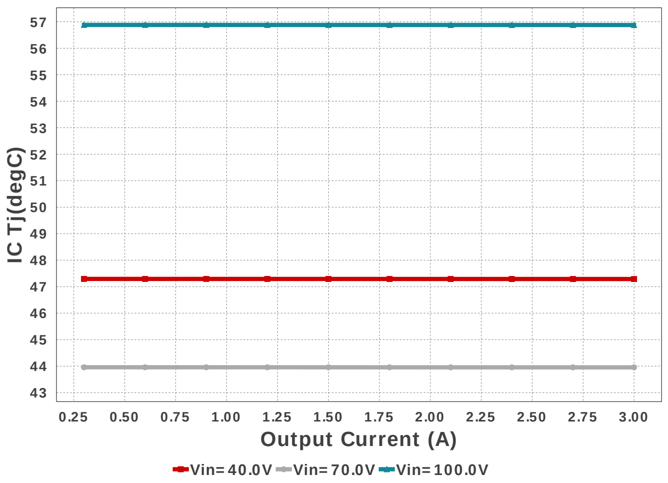
Electrical BOM

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	GRM155R71C223KA01D Series= X7R	Cap= 22.0 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	MuRata	GRM155R71C102KA01D Series= X7R	Cap= 1.0 nF ESR= 1.0 mOhm VDC= 16.0 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	CUSTOM	CUSTOM Series= X7R	Cap= 2.2 uF ESR= 70.0 mOhm VDC= 100.0 V IRMS= 4.4 A	5	NA	1210 0 mm^2

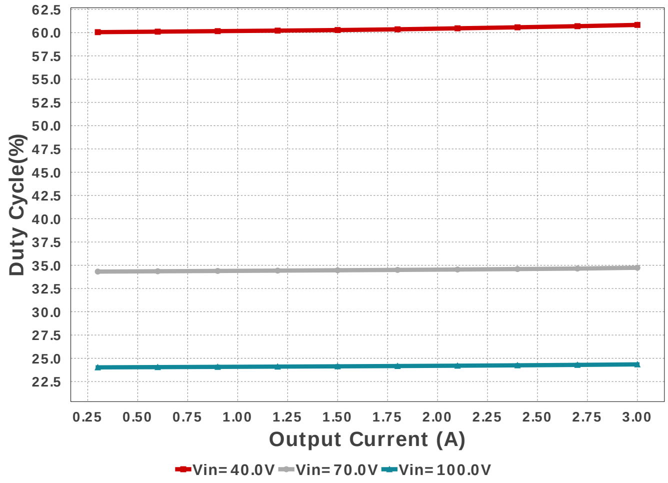
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	CUSTOM	CUSTOM Series= X7R	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	5	NA	1210 0 mm^2
Css	MuRata	GRM155R61C473KA01D Series= X5R	Cap= 47.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cvcc	TDK	C1005X5R1V225K050BC 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	CUSTOM	CUSTOM Series= ?	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 133.333 V IRMS= 1.0 mA	1	NA	CUSTOM 0 mm^2
L1	Coilcraft	XAL1010-682MEB	L= 6.8 µH 8.1 mOhm	1	$1.71	XAL1010 160 mm^2
M1	Fairchild Semiconductor	FDMC86240	VdsMax= 150.0 V IdsMax= 16.0 Amps	1	$0.93	TRANS_Fairchild_MLP08S 18 mm^2
M2	Fairchild Semiconductor	FDMC86240	VdsMax= 150.0 V IdsMax= 16.0 Amps	1	$0.93	TRANS_Fairchild_MLP08S 18 mm^2
Rcomp1	Vishay-Dale	CRCW04025K36FKED Series= CRCW..e3	Res= 5.36 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcomp2	Vishay-Dale	CRCW06034R99FKEA Series= CRCW..e3	Res= 4.99 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rfbb	Vishay-Dale	CRCW0402619RFKED Series= CRCW..e3	Res= 619.0 Ohm 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	CRCW0402619RFKED Series= CRCW..e3	Res= 619.0 Ohm 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	CRCW060324K9FKEA Series= CRCW..e3	Res= 24.9 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Ruv1	Vishay-Dale	CRCW0805100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Ruv2	Panasonic	ERJ-6ENF1002V Series= ERJ-6E	Res= 10.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 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

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

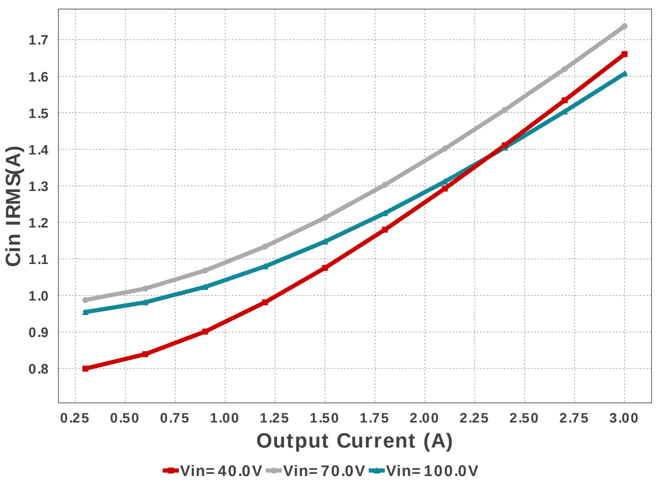
IC Tj



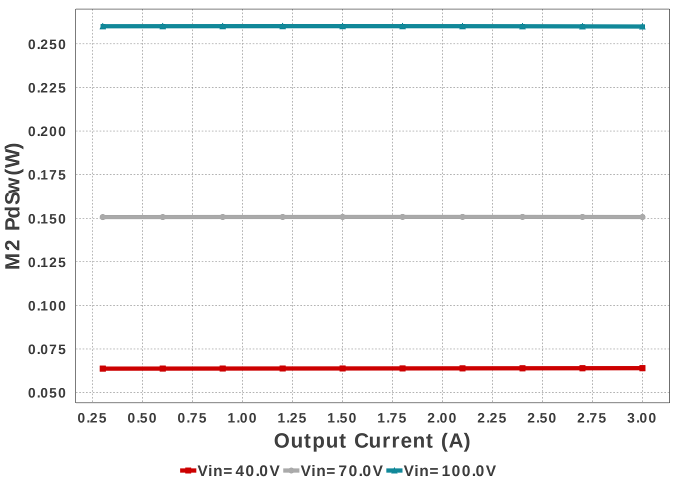
Duty Cycle



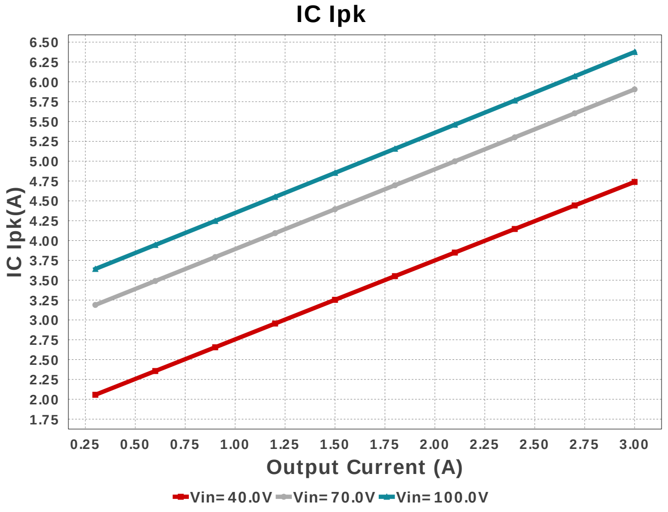
Cin IRMS



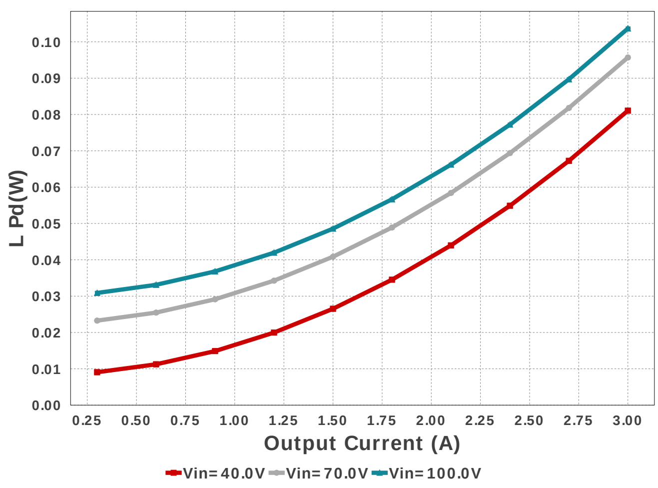
M2 PdSw

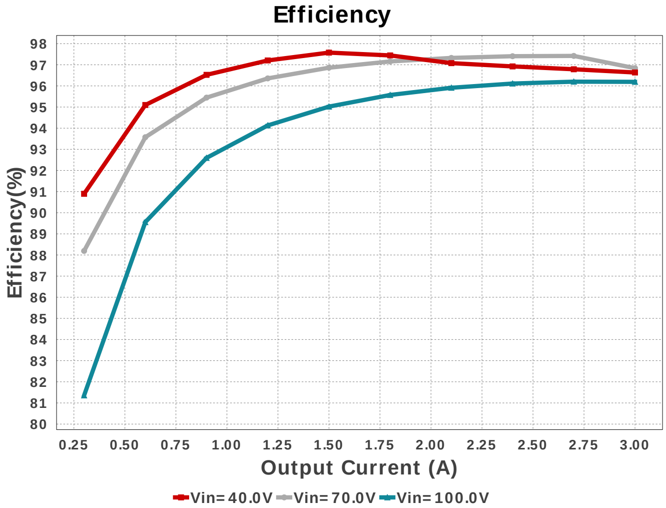


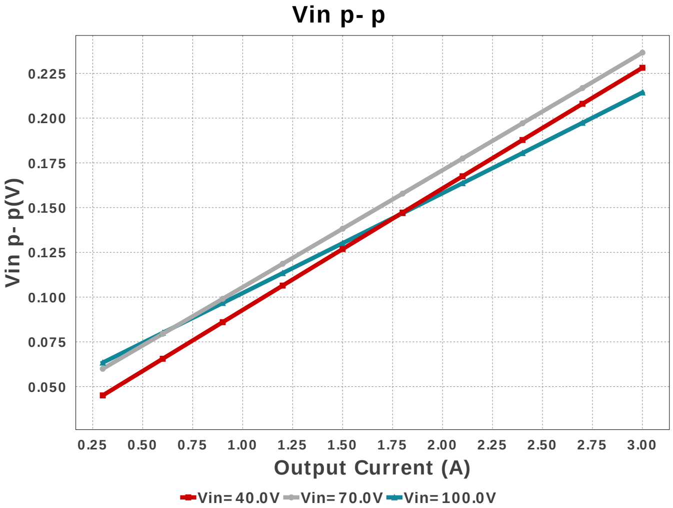
IC Ipk

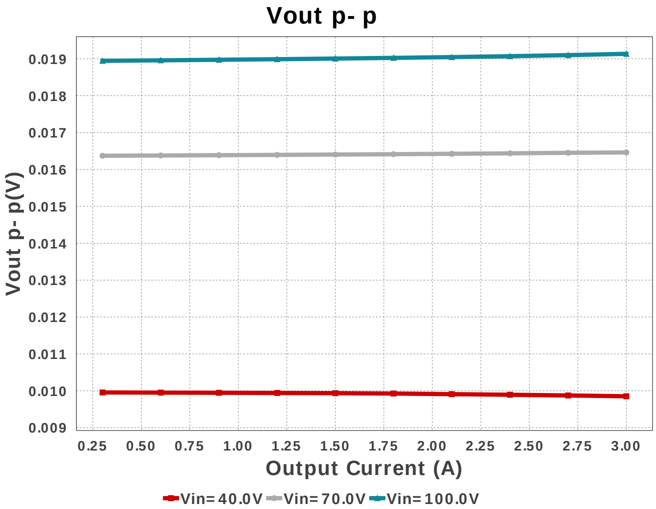


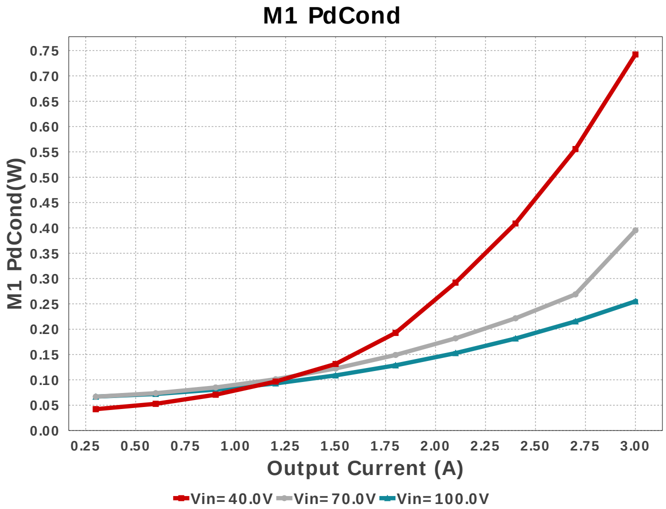
L Pd

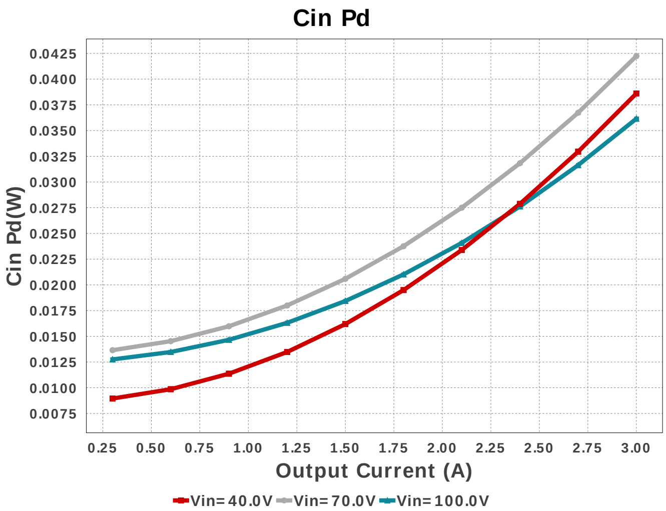


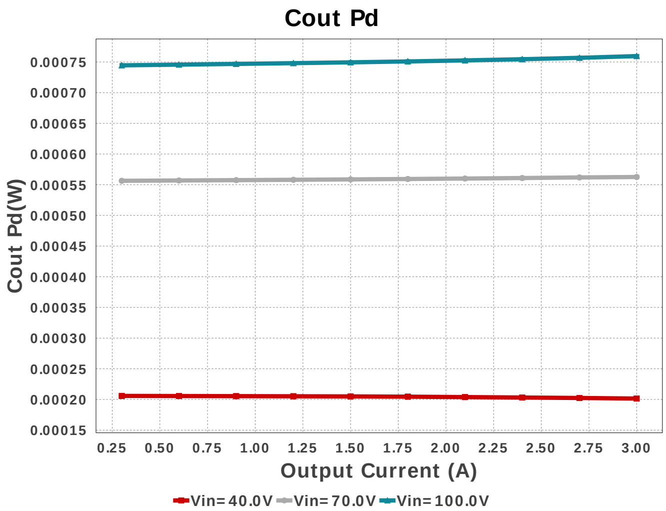

Efficiency
Efficiency(%)
Output Current (A)
Vin= 40.0V Vin= 70.0V Vin= 100.0V


Vin p- p
Vin p- p(V)
Output Current (A)
Vin= 40.0V Vin= 70.0V Vin= 100.0V

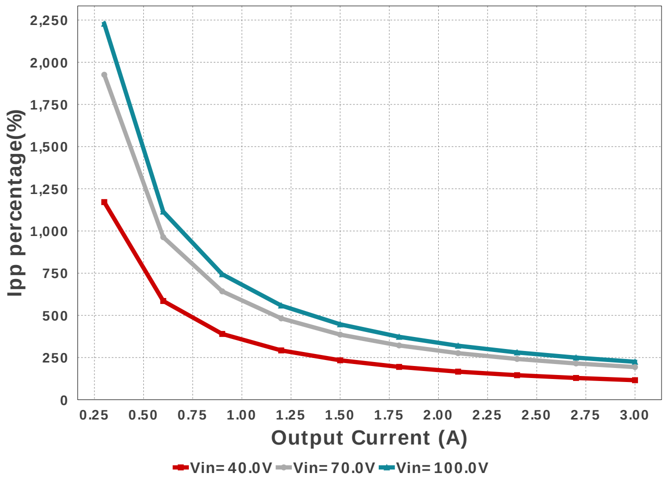

Vout p- p
Vout p- p(V)
Output Current (A)
Vin= 40.0V Vin= 70.0V Vin= 100.0V


M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin= 40.0V Vin= 70.0V Vin= 100.0V

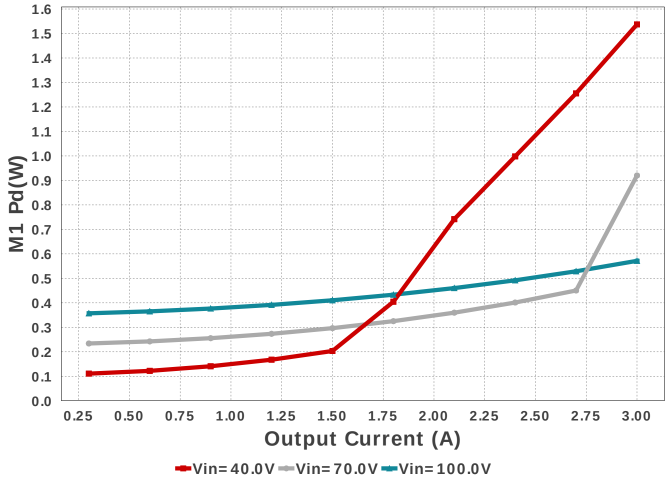

Cin Pd
Cin Pd(W)
Output Current (A)
Vin= 40.0V Vin= 70.0V Vin= 100.0V


Cout Pd
Cout Pd(W)
Output Current (A)
Vin= 40.0V Vin= 70.0V Vin= 100.0V

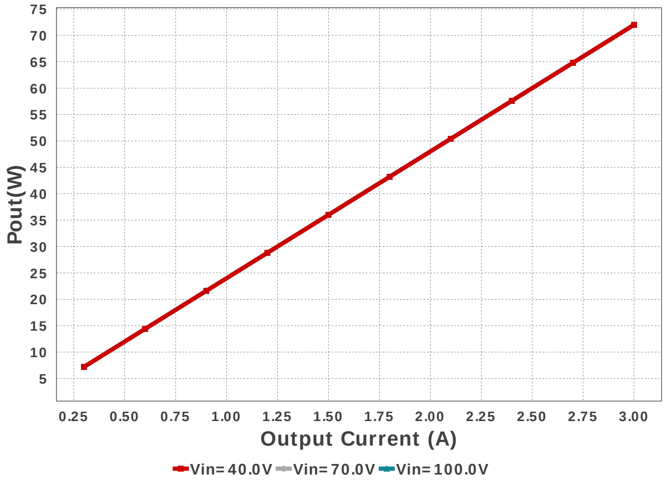
Ipp percentage



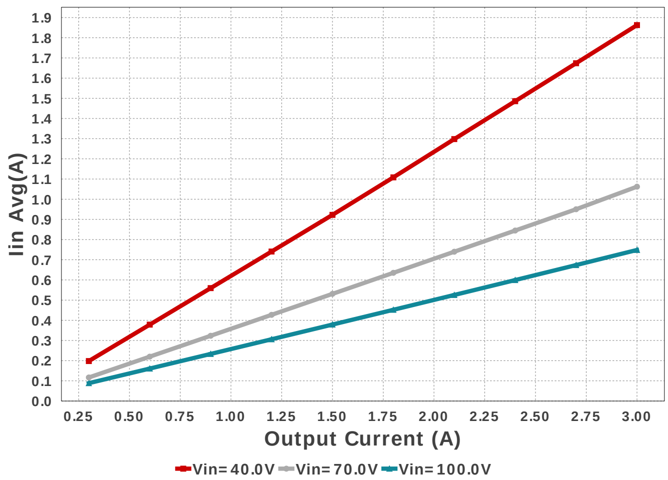
M1 Pd



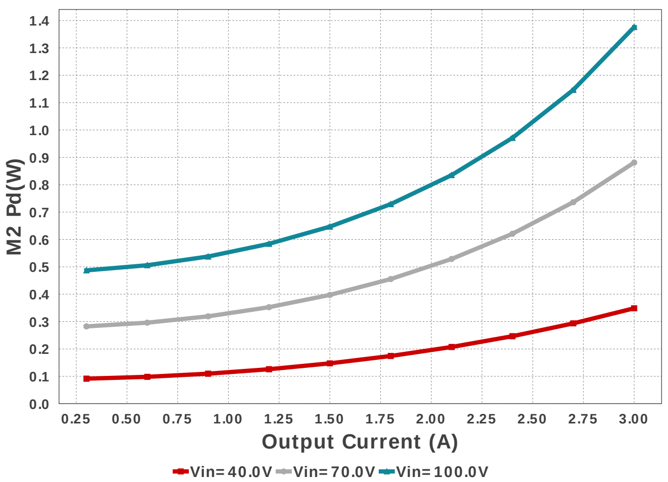
Pout



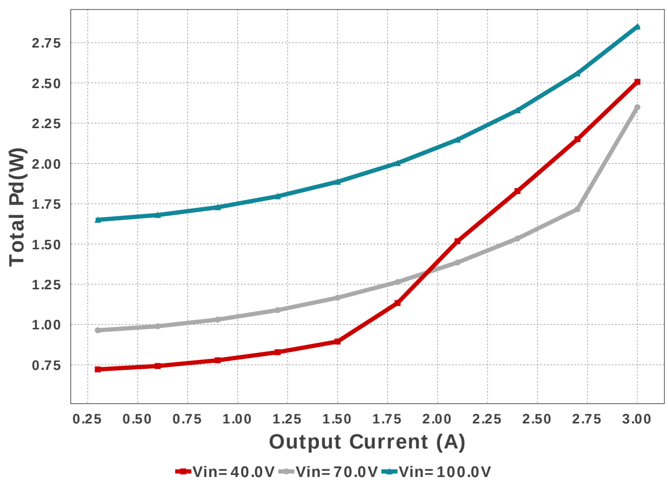
Iin Avg



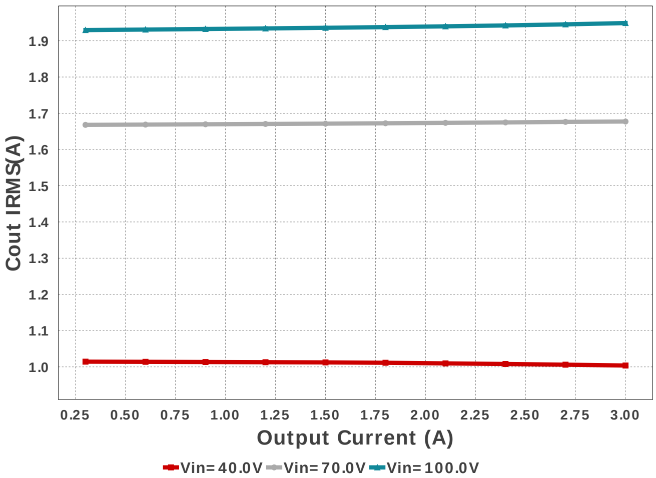
M2 Pd



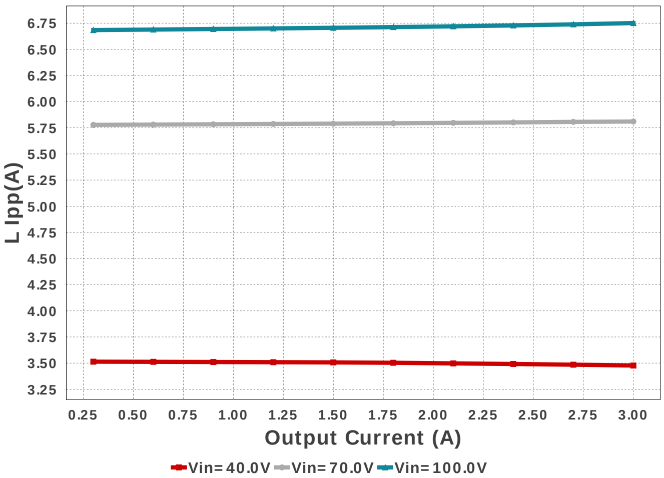
Total Pd



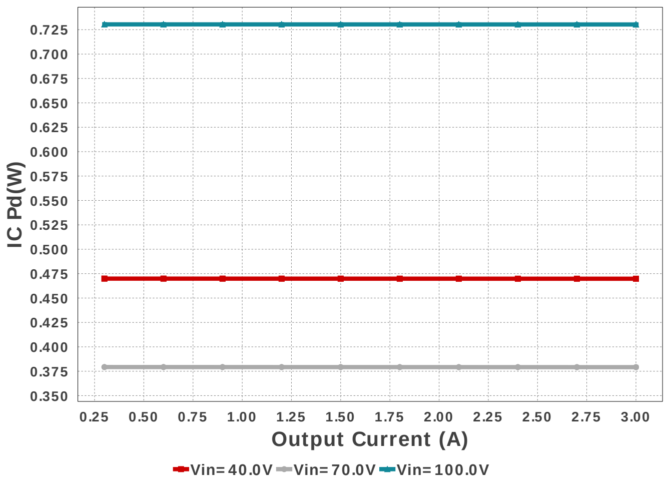
Cout IRMS



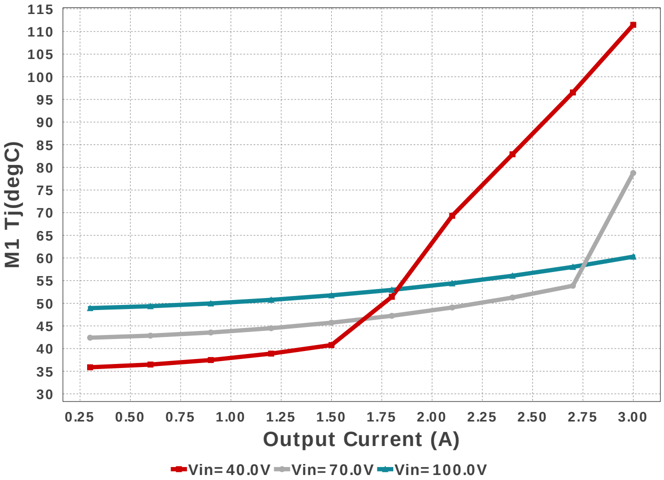
L Ipp



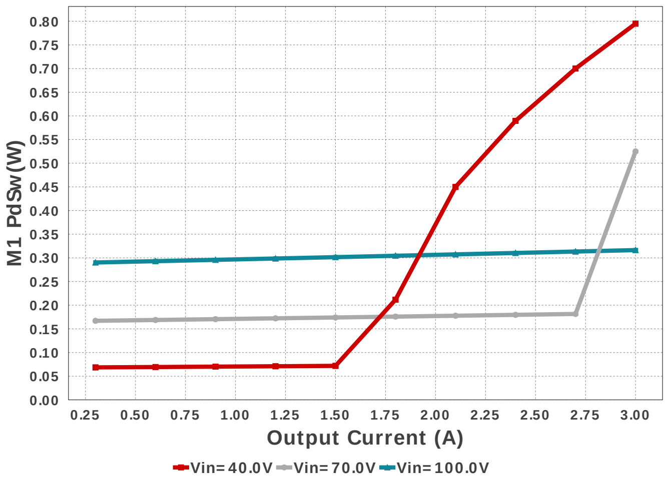
IC Pd



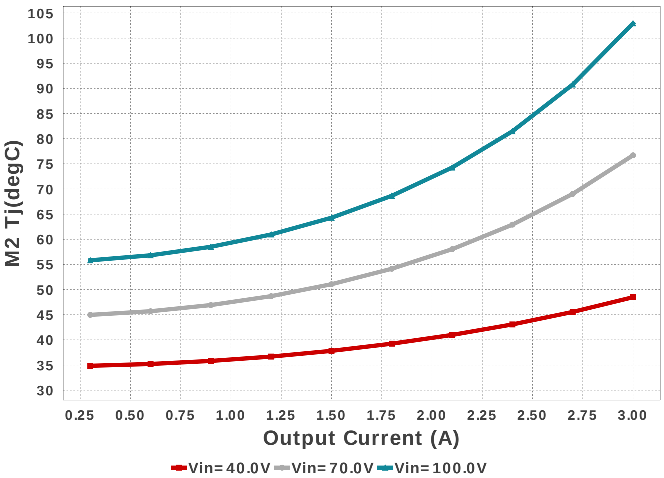
M1 Tj

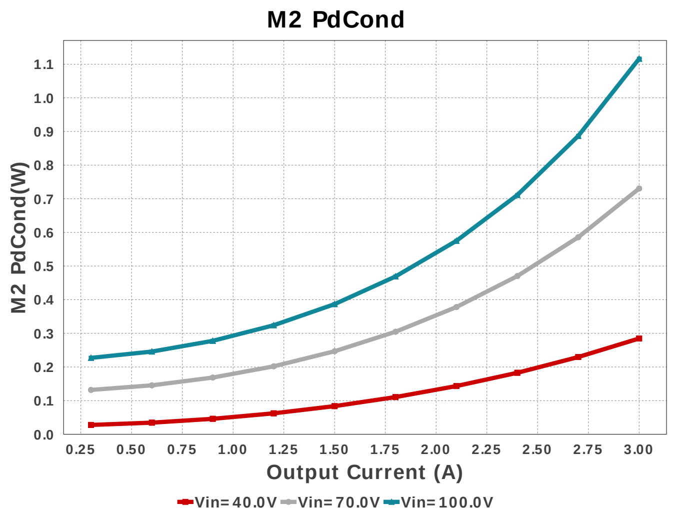


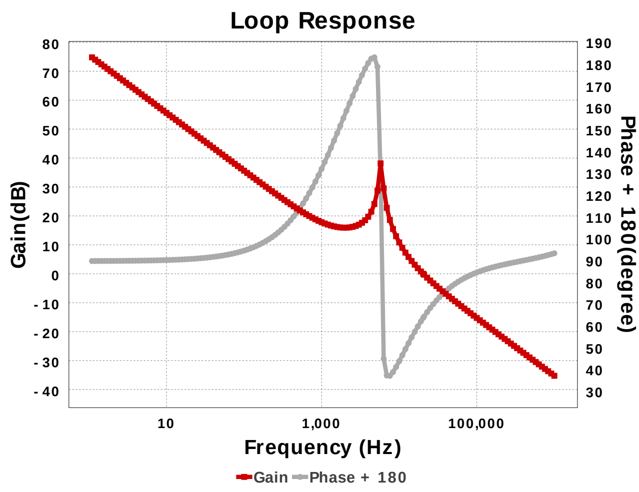
M1 PdSw



M2 Tj







Operating Values

#	Name	Value	Category	Description
1.	BOM Count	33		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	1.55 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	33.655 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	1.319 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	347.89 µW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	4.784 A	IC	Peak switch current in IC
8.	IC Pd	579.91 mW	IC	IC power dissipation
9.	IC Tj	51.341 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	1.239 A	IC	Average input current
13.	Ipp percentage	182.749 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	4.569 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	64.714 mW	Inductor	Inductor power dissipation
16.	M1 Pd	833.66 mW	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	359.02 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	474.64 mW	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	74.184 degC	Mosfet	M1 MOSFET junction temperature
20.	M2 Pd	397.43 mW	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	307.4 mW	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	90.024 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Tj	51.064 degC	Mosfet	M2 MOSFET junction temperature
24.	Cin Pd	33.655 mW	Power	Input capacitor power dissipation
25.	Cout Pd	347.89 µW	Power	Output capacitor power dissipation
26.	IC Pd	579.91 mW	Power	IC power dissipation
27.	L Pd	64.714 mW	Power	Inductor power dissipation
28.	M1 Pd	833.66 mW	Power	M1 MOSFET total power dissipation
29.	M1 PdCond	359.02 mW	Power	M1 MOSFET conduction losses
30.	M1 PdSw	474.64 mW	Power	M1 MOSFET switching losses
31.	M2 Pd	397.43 mW	Power	M2 MOSFET total power dissipation
32.	M2 PdCond	307.4 mW	Power	M2 MOSFET conduction losses
33.	M2 PdSw	90.024 mW	Power	M2 MOSFET switching losses
34.	Total Pd	1.941 W	Power	Total Power Dissipation
35.	Cross Freq	20.383 kHz	System Information	Bode plot crossover frequency
36.	Duty Cycle	48.458 %	System Information	Duty cycle
37.	Efficiency	96.867 %	System Information	Steady state efficiency
38.	FootPrint	443.0 mm^2	System Information	Total Foot Print Area of BOM components
39.	Frequency	401.606 kHz	System Information	Switching frequency
40.	Gain Marg	-54.743 dB	System Information	Bode Plot Gain Margin
41.	Iout	2.5 A	System Information	Iout operating point
42.	Low Freq Gain	74.797 dB	System Information	Gain at 1Hz

#	Name	Value	Category	Description
43.	Mode	CCM	System Information	Conduction Mode
44.	Phase Marg	63.908 deg	System Information	Bode Plot Phase Margin
45.	Pout	60.0 W	System Information	Total output power
46.	Vin	50.0 V	System Information	Vin operating point
47.	Vin p-p	208.324 mV	System Information	Peak-to-peak input voltage
48.	Vout	24.0 V	System Information	Operational Output Voltage
49.	Vout Actual	24.063 V	System Information	Vout Actual calculated based on selected voltage divider resistors
50.	Vout Tolerance	2.973 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
51.	Vout p-p	12.944 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	3.0	Maximum Output Current
VinMax	100.0	Maximum input voltage
VinMin	40.0	Minimum input voltage
Vout	24.0	Output Voltage
base_pn	LM5146-Q1	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

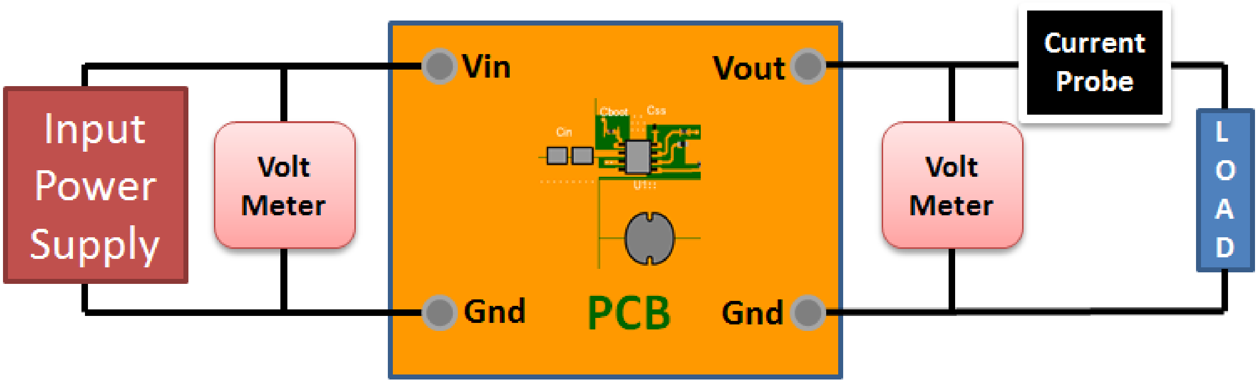
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins.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

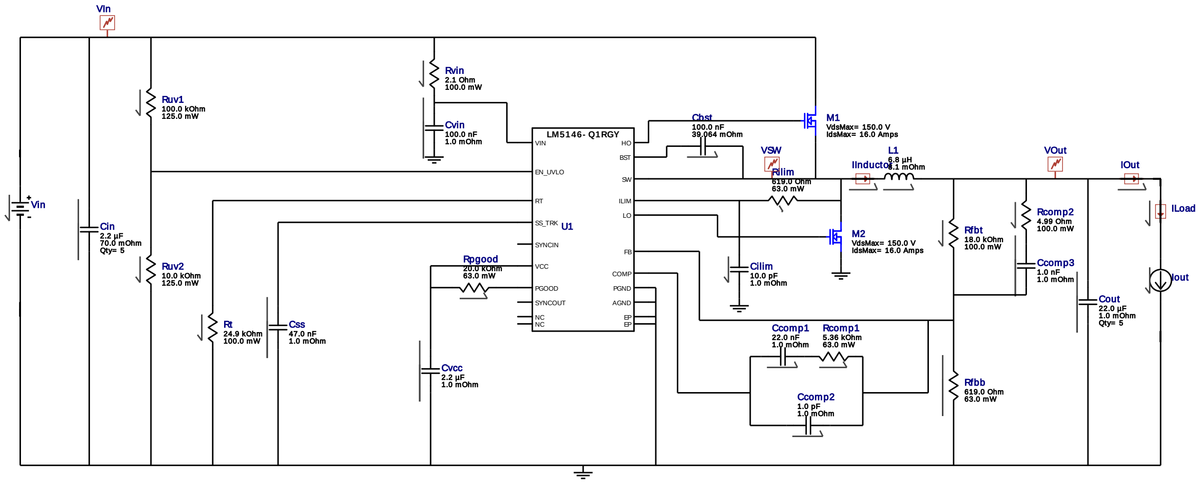


WEBENCH® Electrical Simulation Report

Design Id = 103

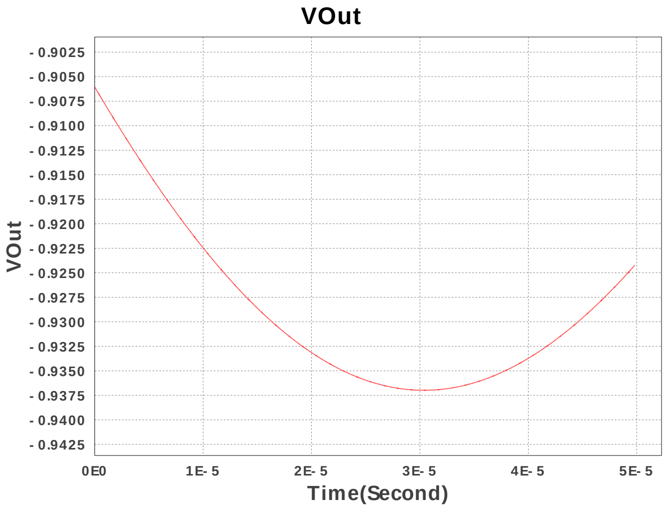
sim_id = 1

Simulation Type = Steady State



Simulation Parameters

#	Name	Parameter Name	Description	Values
1.	Cout	IC	Initial condition	0 V
2.	Cvcc	IC	Initial Voltage	3.3 V
3.	L1	IC	Initial condition	0 A
4.	Css	IC	Initial Condition	0.9 V
5.	Iout	I	Load Current	3.0 A



Design Assistance

1. Please note that since parallel FETs have been chosen in this design, schematic and PCB export features will not work. 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 : 93728AD00F2D205F[v1]

3. **LM5146-Q1** Product Folder : http://www.ti.com/product/lm5146%2DQ1 : 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.