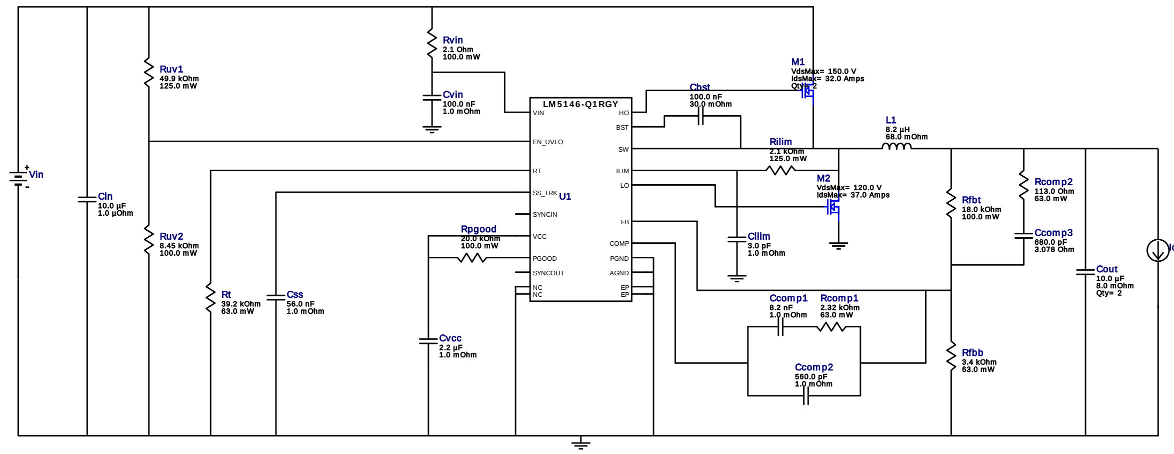
VinMin = 10.0V
VinMax = 85.0V
Vout = 5.0V
Iout = 5.0A

Device = LM5146QRGYRQ1
Topology = Buck
Created = 2023-01-27 13:37:47.264
BOM Cost = NA
BOM Count = 27
Total Pd = 6.44W

WEBENCH ® Design Report

Design : 63 LM5146QRGYRQ1
LM5146QRGYRQ1 10V-85V to 5.00V @ 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

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

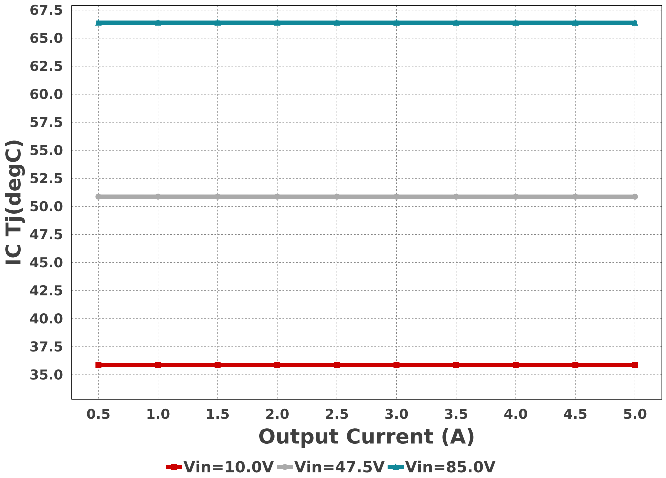
Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst	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	GRM155R71C822KA01D Series= X7R	Cap= 8.2 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp2	MuRata	GRM155R71H561KA01D Series= X7R	Cap= 560.0 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Ccomp3	TDK	CGA2B2X7R1H681K050BA Series= X7R	Cap= 680.0 pF ESR= 3.0778 Ohm VDC= 50.0 V IRMS= 257.63 mA	1	$0.01	0402 3 mm^2
Cilim	MuRata	GQM2195C2A3R0CB01D Series= C0G/NP0	Cap= 3.0 pF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.17	0805 7 mm^2
Cin	CUSTOM	CUSTOM Series= ?	Cap= 10.0 uF ESR= 1.0 uOhm VDC= 113.333 V IRMS= 3.75 A	1	NA	CUSTOM 0 mm^2

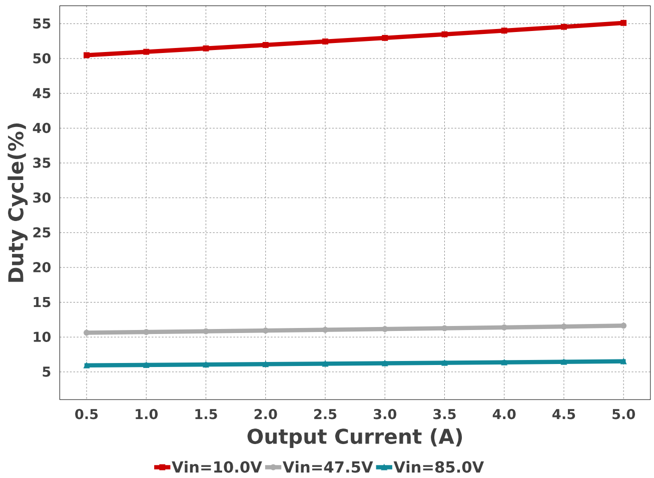
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	Kemet	C1210C106K8PACTU Series= X5R	Cap= 10.0 uF ESR= 8.0 mOhm VDC= 10.0 V IRMS= 6.9 A	2	$0.22	1210 15 mm^2
Css	MuRata	GRM155R71C563KA88D Series= X7R	Cap= 56.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cvcc	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.06	0402_065 3 mm^2
Cvin	CUSTOM	CUSTOM Series= ?	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 113.333 V IRMS= 1.0 mA	1	NA	CUSTOM 0 mm^2
L1	Vishay-Dale	IHLP2525CZER8R2M01	L= 8.2 µH 68.0 mOhm	1	$0.61	IHLP-2525CZ 75 mm^2
M1	Fairchild Semiconductor	FDMC86240	VdsMax= 150.0 V IdsMax= 32.0 Amps	2	$1.20	TRANS_Fairchild_MLP08S 18 mm^2
M2	Infineon Technologies	BSC240N12NS3 G	VdsMax= 120.0 V IdsMax= 37.0 Amps	1	NA	PG-TDSON-8 55 mm^2
Rcomp1	Vishay-Dale	CRCW04022K32FKED Series= CRCW..e3	Res= 2.32 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rcomp2	Vishay-Dale	CRCW0402113RFKED Series= CRCW..e3	Res= 113.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Vishay-Dale	CRCW04023K40FKED Series= CRCW..e3	Res= 3.4 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	Panasonic	ERJ-6ENF2101V Series= ERJ-6E	Res= 2.1 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Rpgood	Yageo	RC0603FR-0720KL Series= ?	Res= 20.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rt	Vishay-Dale	CRCW040239K2FKED Series= CRCW..e3	Res= 39.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Ruv1	Vishay-Dale	CRCW080549K9FKEA Series= CRCW..e3	Res= 49.9 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
Ruv2	Yageo	RC0603FR-078K45L Series= ?	Res= 8.45 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rvcc	Yageo	RC0603FR-0720KL Series= ?	Res= 20.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 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	$1.42	RGY0020B 25 mm^2

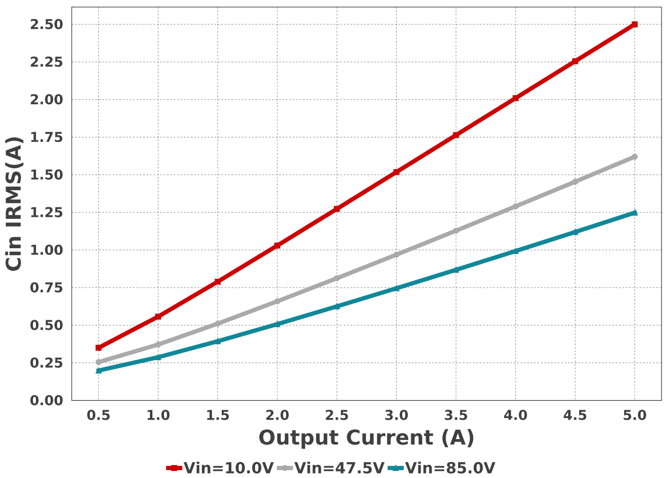
IC Tj



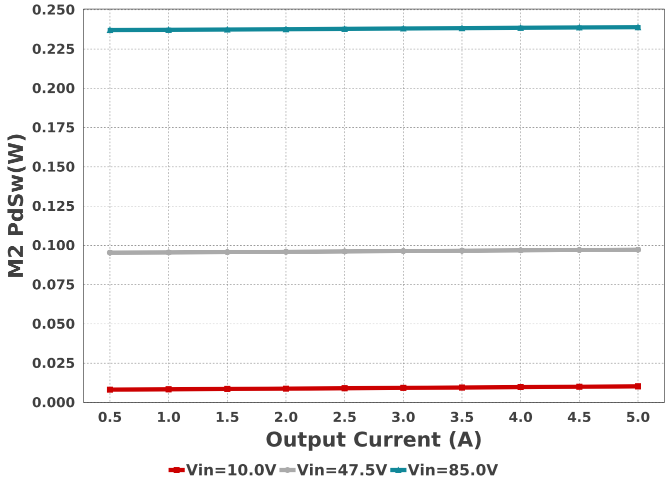
Duty Cycle



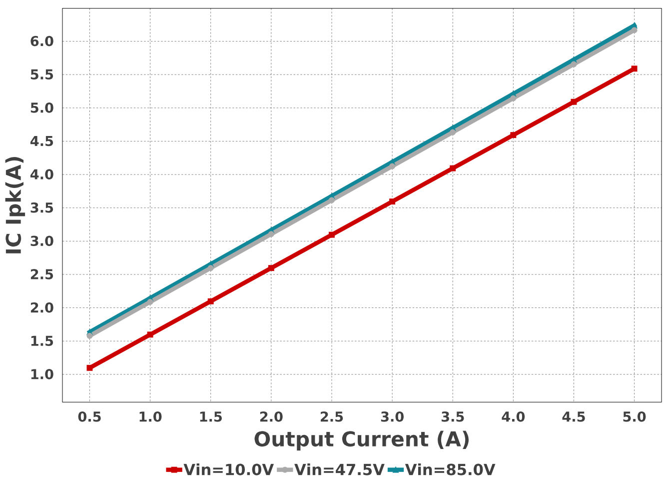
Cin IRMS



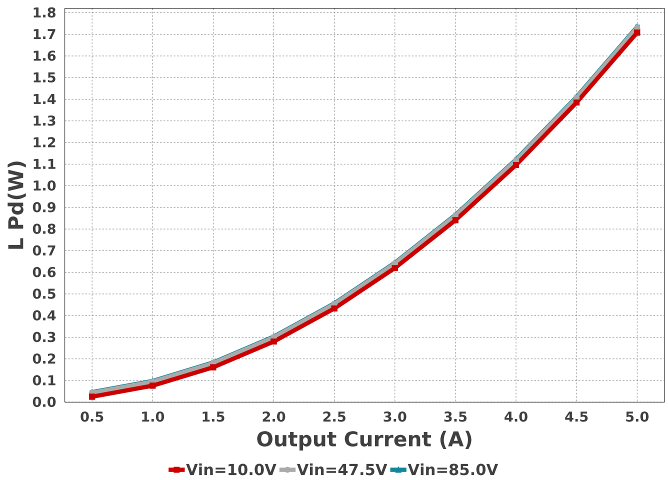
M2 PdSw

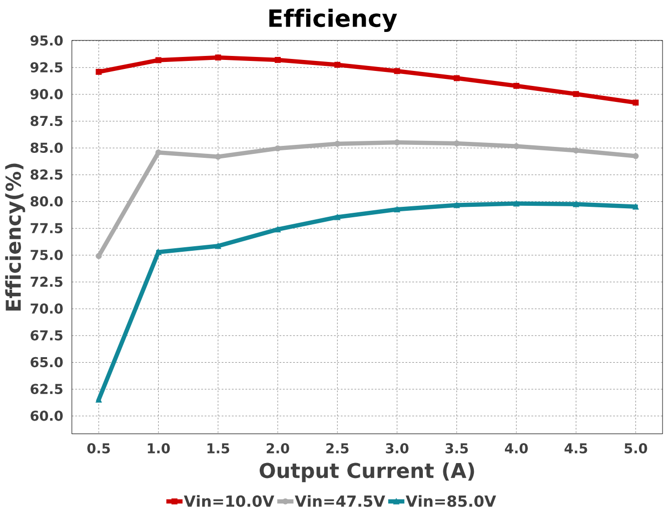


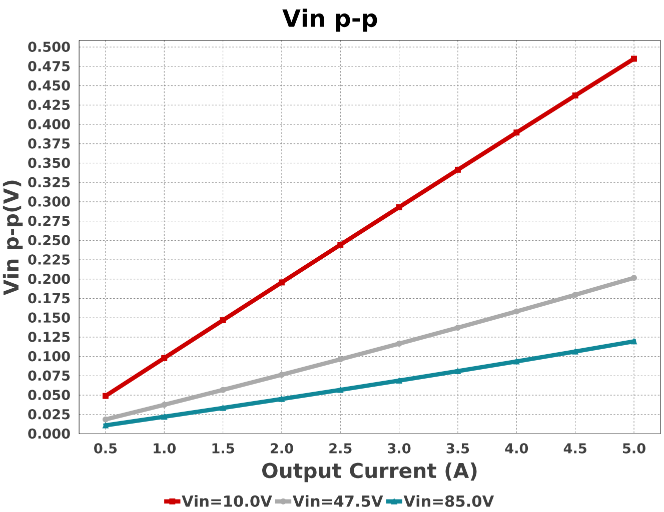
IC Ipk

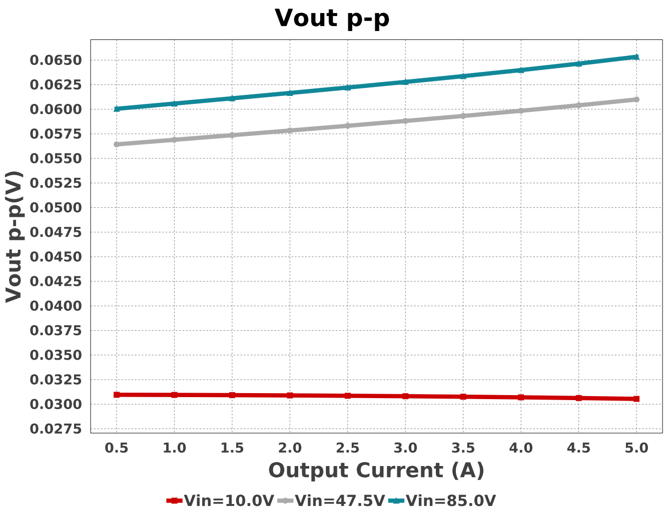


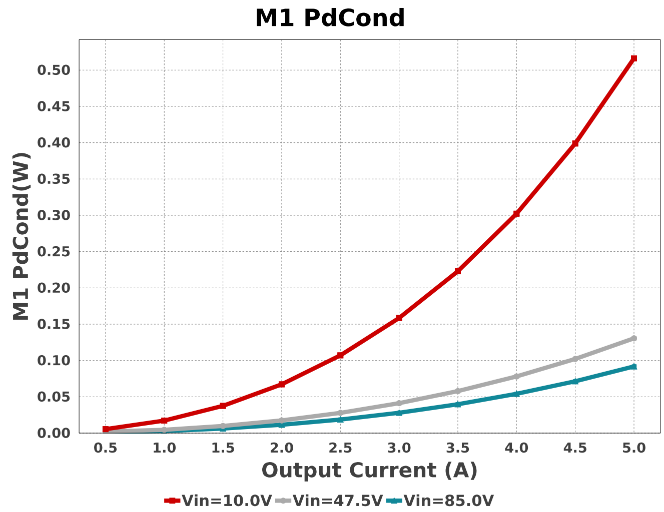
L Pd

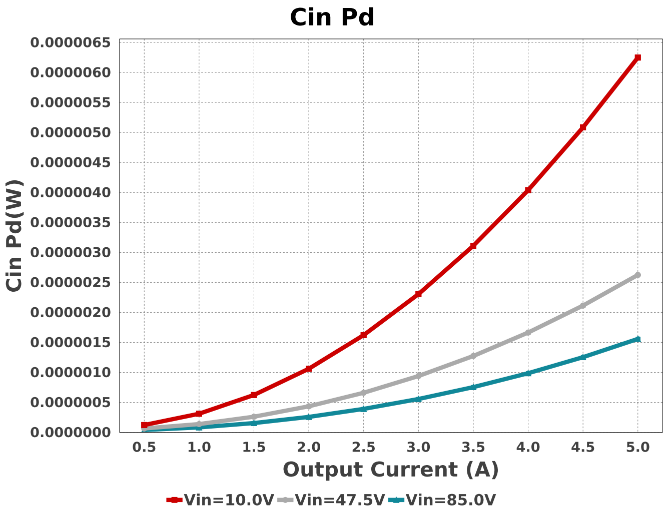


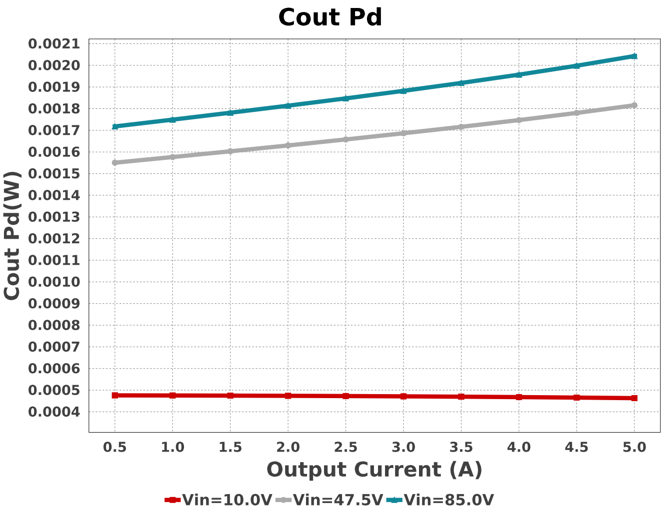

Efficiency
Efficiency(%)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

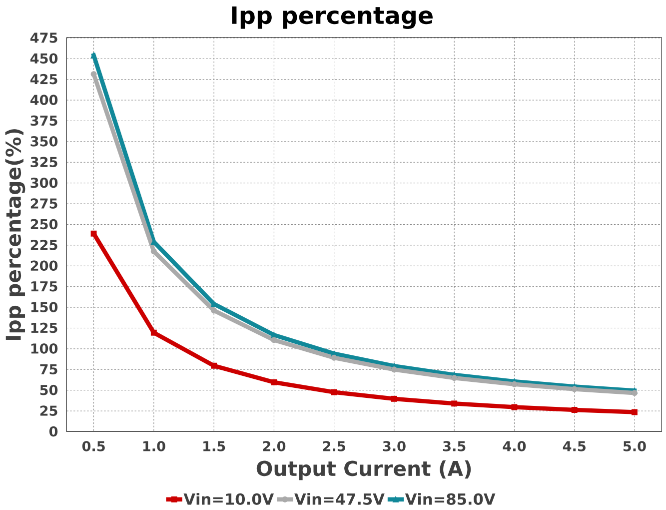

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

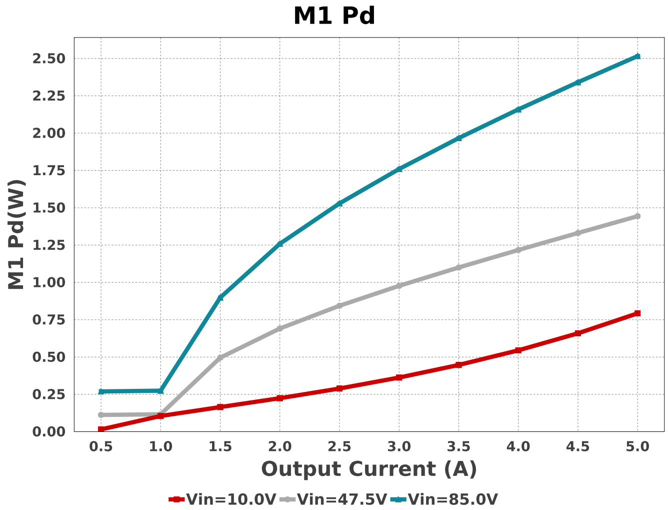

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

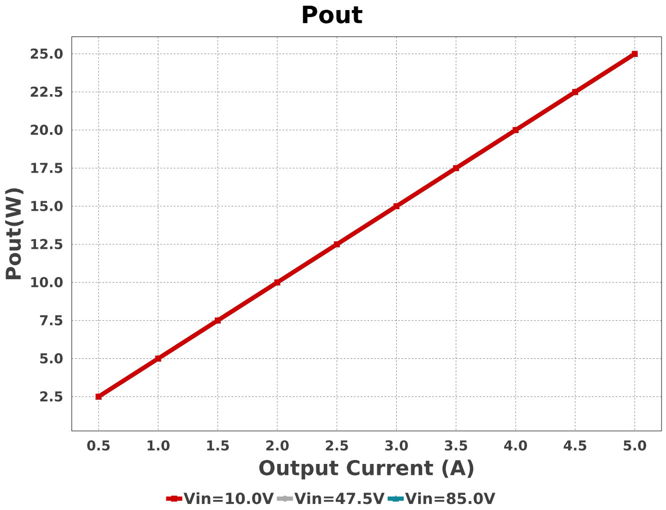

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

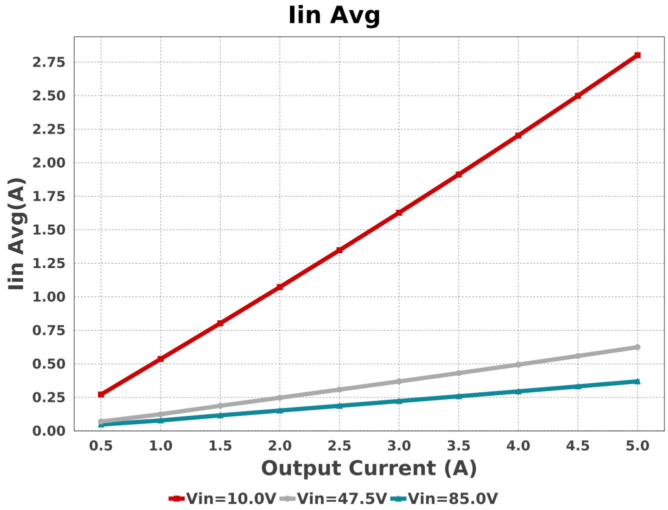

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

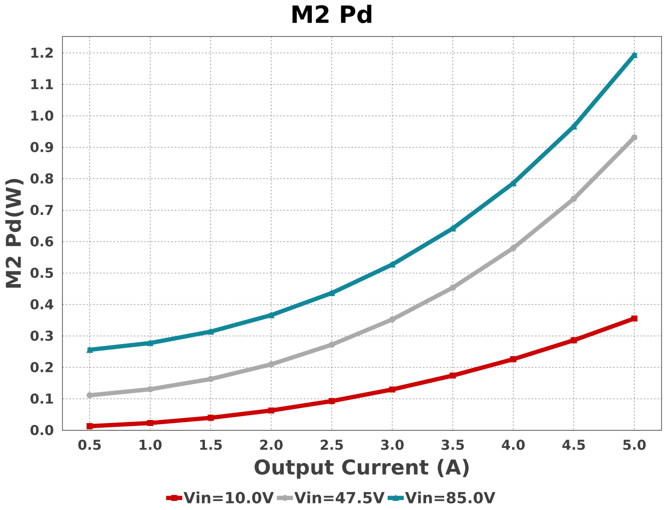

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

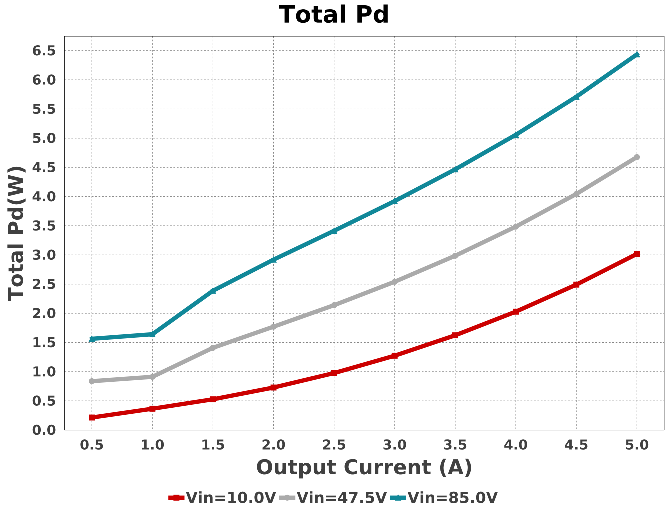

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

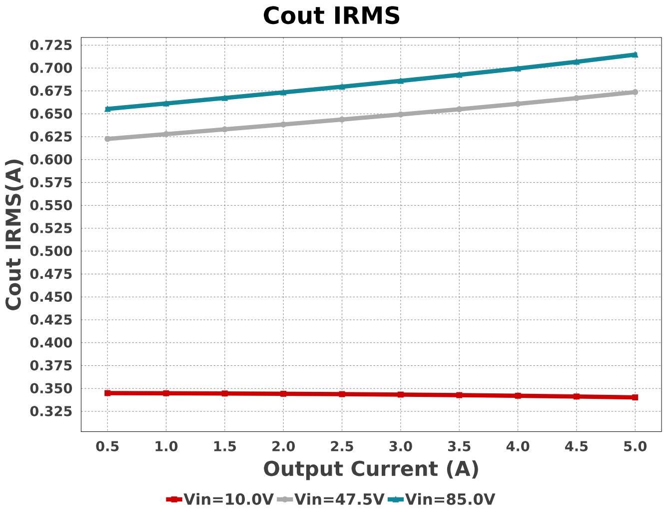

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

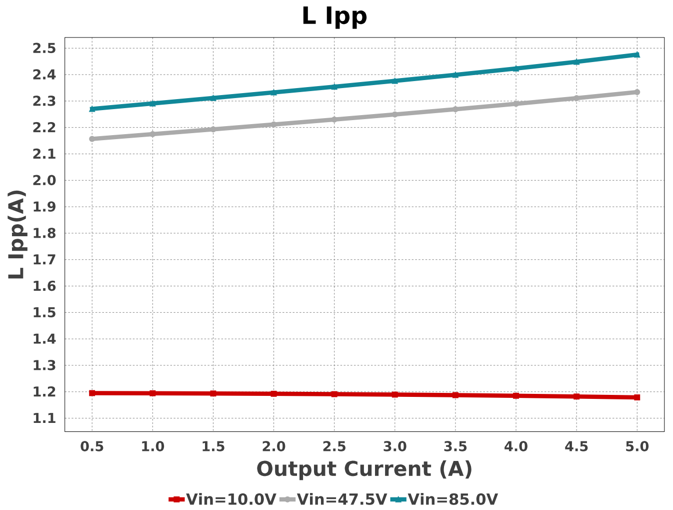

Pout
Pout(W)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

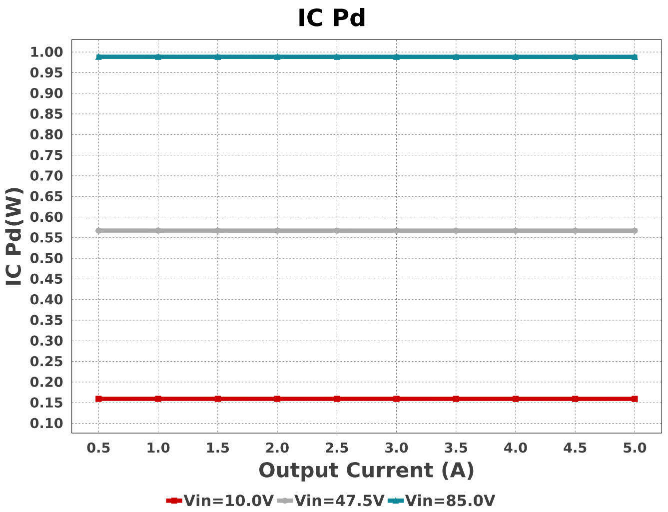

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

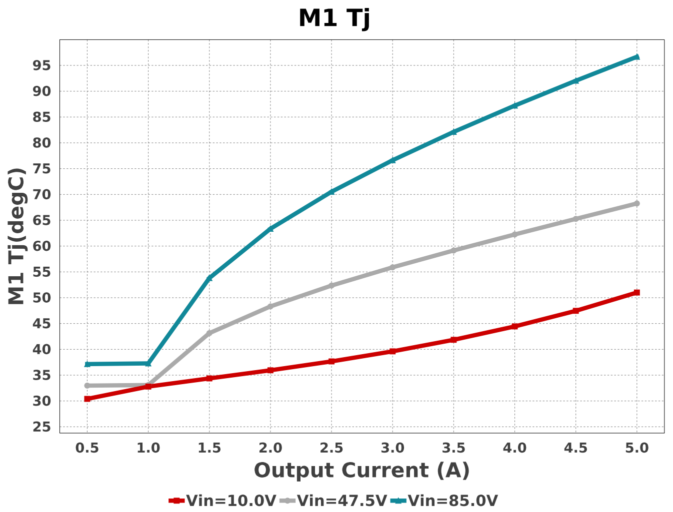

M2 Pd
M2 Pd(W)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

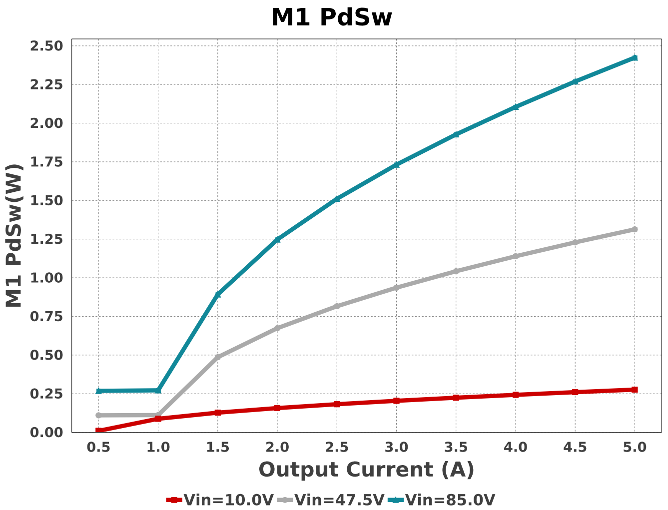

Total Pd
Total Pd(W)
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

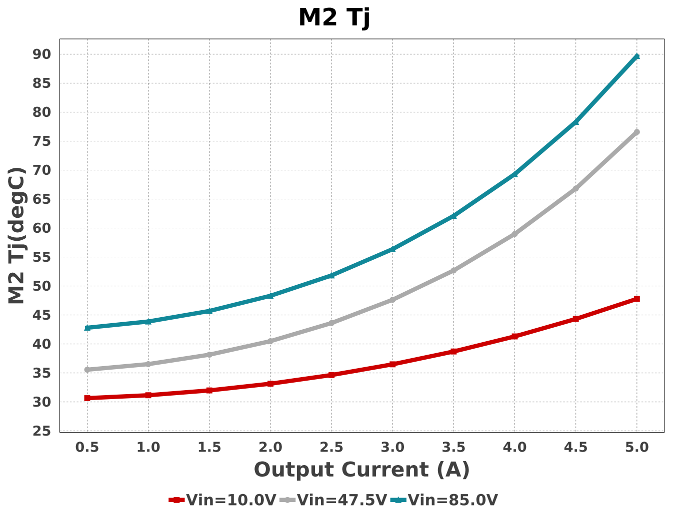

Cout IRMS
Cout IRMS(A)
0.725
0.700
0.675
0.650
0.625
0.600
0.575
0.550
0.525
0.500
0.475
0.450
0.425
0.400
0.375
0.350
0.325
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

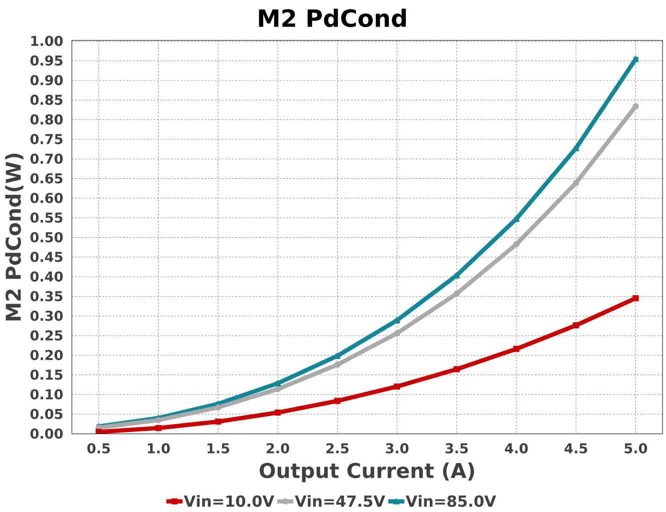

L Ipp
L Ipp(A)
2.5
2.4
2.3
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V

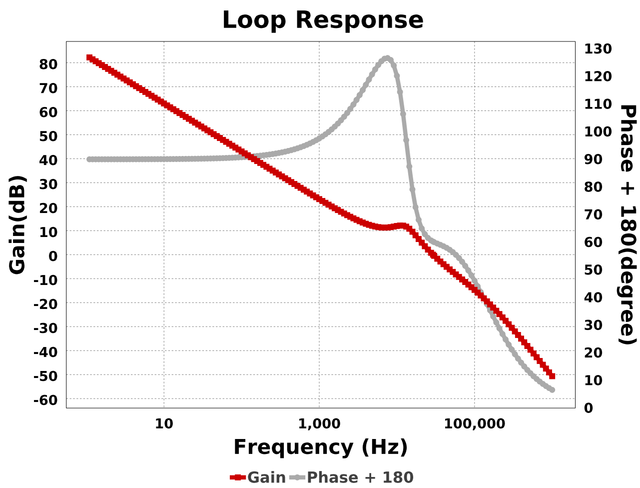

IC Pd
IC Pd(W)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V


M1 Tj
M1 Tj(degC)
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V


M1 PdSw
M1 PdSw(W)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V


M2 Tj
M2 Tj(degC)
90
85
80
75
70
65
60
55
50
45
40
35
30
25
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=10.0V Vin=47.5V Vin=85.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	1.248 A	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	1.558 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	714.665 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	2.043 mW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	6.238 A	IC	Peak switch current in IC
6.	IC Pd	988.34 mW	IC	IC power dissipation
7.	IC Tj	64.394 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	369.83 mA	IC	Average input current
11.	Ipp percentage	49.513 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
12.	L Ipp	2.476 A	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	1.735 W	Inductor	Inductor power dissipation
14.	M1 Pd	2.516 W	Mosfet	M1 MOSFET total power dissipation
15.	M1 PdCond	91.824 mW	Mosfet	M1 MOSFET conduction losses
16.	M1 PdSw	2.424 W	Mosfet	M1 MOSFET switching losses
17.	M1 Tj	96.668 degC	Mosfet	M1 MOSFET junction temperature
18.	M2 Pd	1.193 W	Mosfet	M2 MOSFET total power dissipation
19.	M2 PdCond	954.41 mW	Mosfet	M2 MOSFET conduction losses
20.	M2 PdSw	238.95 mW	Mosfet	M2 MOSFET switching losses
21.	M2 Tj	89.668 degC	Mosfet	M2 MOSFET junction temperature
22.	Cin Pd	1.558 µW	Power	Input capacitor power dissipation
23.	Cout Pd	2.043 mW	Power	Output capacitor power dissipation
24.	IC Pd	988.34 mW	Power	IC power dissipation
25.	L Pd	1.735 W	Power	Inductor power dissipation
26.	M1 Pd	2.516 W	Power	M1 MOSFET total power dissipation
27.	M1 PdCond	91.824 mW	Power	M1 MOSFET conduction losses
28.	M1 PdSw	2.424 W	Power	M1 MOSFET switching losses
29.	M2 Pd	1.193 W	Power	M2 MOSFET total power dissipation
30.	M2 PdCond	954.41 mW	Power	M2 MOSFET conduction losses
31.	M2 PdSw	238.95 mW	Power	M2 MOSFET switching losses
32.	Total Pd	6.435 W	Power	Total Power Dissipation
33.	BOM Count	27	System Information	Total Design BOM count
34.	Duty Cycle	6.524 %	System Information	Duty cycle
35.	Efficiency	79.528 %	System Information	Steady state efficiency
36.	FootPrint	336.0 mm^2	System Information	Total Foot Print Area of BOM components
37.	Frequency	255.102 kHz	System Information	Switching frequency
38.	Iout	5.0 A	System Information	Iout operating point
39.	Mode	FCCM	System Information	Conduction Mode
40.	Pout	25.0 W	System Information	Total output power
41.	Total BOM	NA	System Information	Total BOM Cost

#	Name	Value	Category	Description
42.	Vin	85.0 V	System Information	Vin operating point
43.	Vin p-p	119.528 mV	System Information	Peak-to-peak input voltage
44.	Vout	5.0 V	System Information	Operational Output Voltage
45.	Vout Actual	5.035 V	System Information	Vout Actual calculated based on selected voltage divider resistors
46.	Vout Tolerance	2.716 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
47.	Vout p-p	65.339 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	5.0	Maximum Output Current
VinMax	85.0	Maximum input voltage
VinMin	10.0	Minimum input voltage
Vout	5.0	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

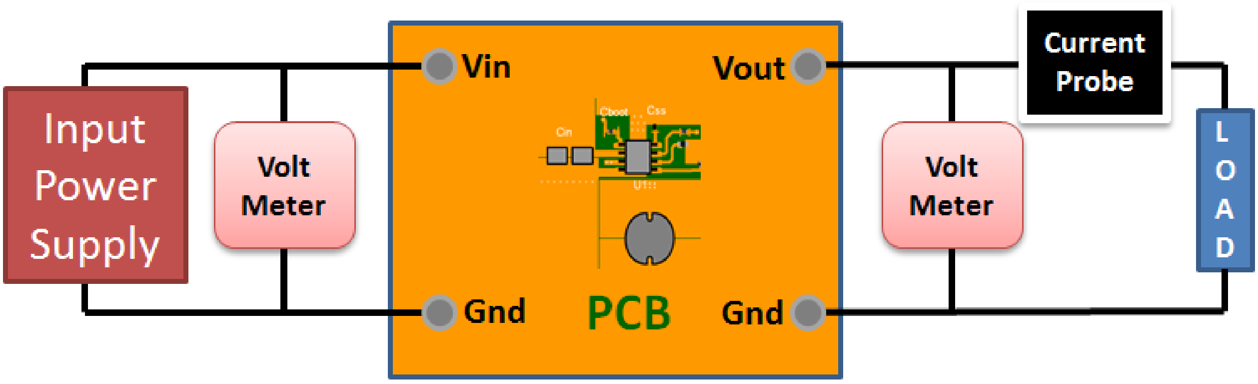
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 10.0V 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. 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 : 4252A3B24B4CB103[v1]

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

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