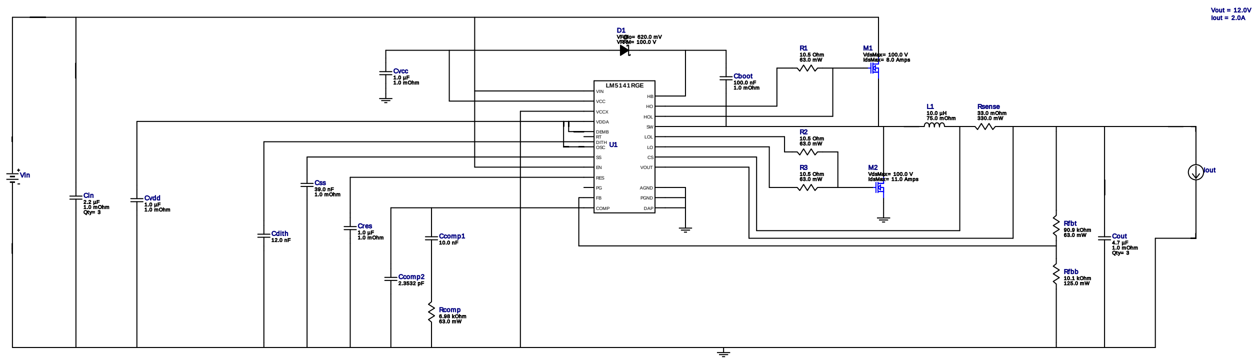
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 16.0V
VinMax = 60.0V
Vout = 12.0V
Iout = 2.0A

Device = LM5141RGER
Topology = Buck
Created = 2019-03-27 22:55:35.544
BOM Cost = NA
BOM Count = 26
Total Pd = 1.65W

Design : 417 LM5141RGER
LM5141RGER 16V-60V to 12.00V @ 2A



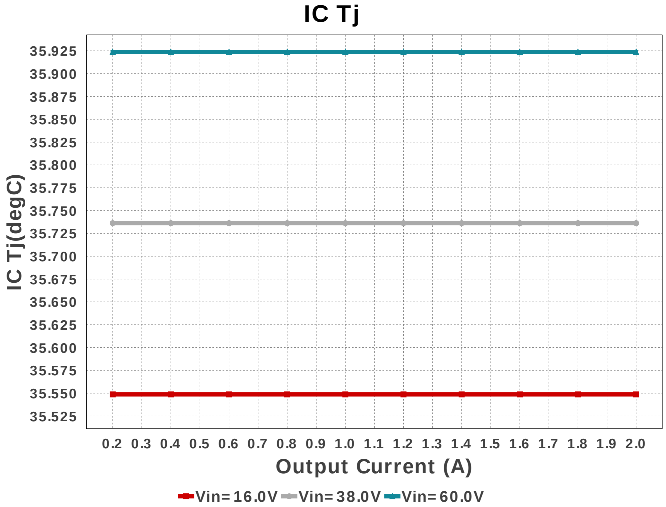
1. This regulator device is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific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

Electrical BOM

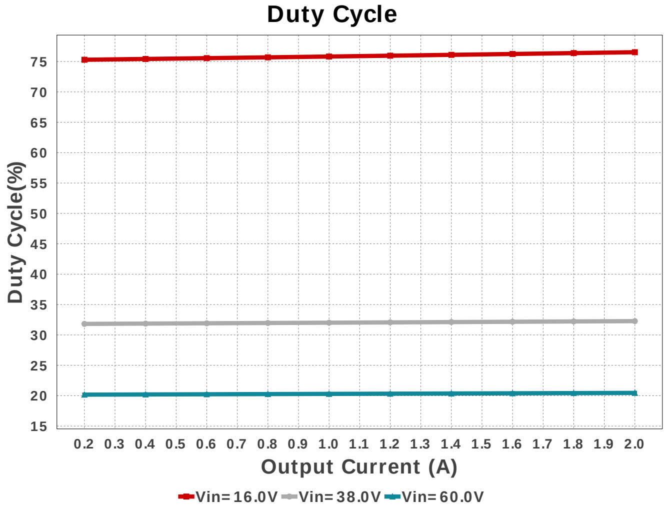
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R70J104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp1	TDK	C2012C0G1H103K060AA Series= C0G/NP0	Cap= 10.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.06	0805 7 mm²
Ccomp2	CUSTOM	CUSTOM Series= ?	Cap= 2.3532 pF VDC= 10.0 V IRMS= 0.0 A	1	NA	CUSTOM 0 mm²
Cdith	Kemet	C0603C123J3GACTU Series= C0G/NP0	Cap= 12.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.12	0603 5 mm²
Cin	CUSTOM	CUSTOM Series= X7R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 5.5932 A	3	NA	1210_250 0 mm²
Cout	CUSTOM	CUSTOM Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 3.3493 A	3	NA	0805 0 mm²
Cres	Taiyo Yuden	LMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm²
Css	MuRata	GRM155R71A393KA01D Series= X7R	Cap= 39.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cvcc	Taiyo Yuden	LMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm²
Cvdd	Taiyo Yuden	LMK212B7105KG-T Series= X7R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm²

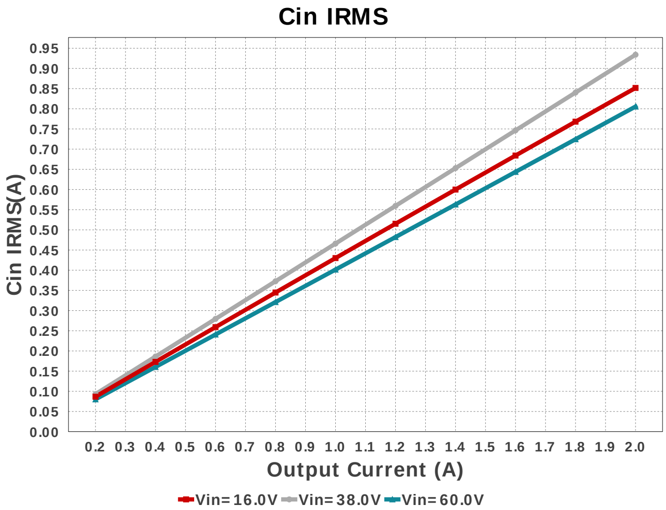
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D1	Vishay-Semiconductor	SS2PH10-M3	VF@Io= 620.0 mV VRRM= 100.0 V	1	$0.14	DO-220AA 14 mm²
L1	Wurth Elektronik	74437346100	L= 10.0 µH 75.0 mOhm	1	$1.30	WE-LHMI_7030 74 mm²
M1	ON Semiconductor	NVMFS6B25NLT3G	VdsMax= 100.0 V IdsMax= 8.0 Amps	1	$0.26	SO-8FL 58 mm²
M2	ON Semiconductor	NVMFS6B14NLT1G	VdsMax= 100.0 V IdsMax= 11.0 Amps	1	$2.31	SO-8FL 58 mm²
R1	Vishay-Dale	CRCW040210R5FKED Series= CRCW..e3	Res= 10.5 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R2	Vishay-Dale	CRCW040210R5FKED Series= CRCW..e3	Res= 10.5 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R3	Vishay-Dale	CRCW040210R5FKED Series= CRCW..e3	Res= 10.5 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcomp	Vishay-Dale	CRCW04026K98FKED Series= CRCW..e3	Res= 6.98 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Yageo	RT0805BRD0710K1L Series= ?	Res= 10.1 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.05	0805 7 mm²
Rfbt	Vishay-Dale	CRCW040290K9FKED Series= CRCW..e3	Res= 90.9 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsense	Panasonic	ERJ-L14KF33MU Series= ERJ-L14	Res= 33.0 mOhm Power= 330.0 mW Tolerance= 1.0%	1	$0.11	1210 15 mm²
U1	Texas Instruments	LM5141RGER	Switcher	1	$1.90	RGE0024J 25 mm²

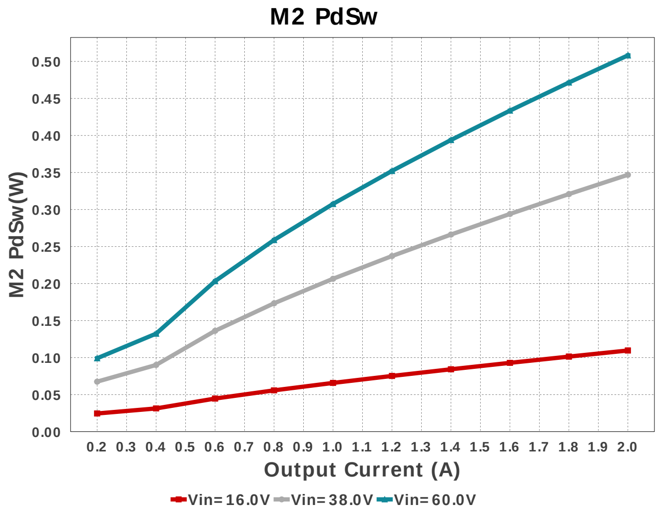
IC Tj

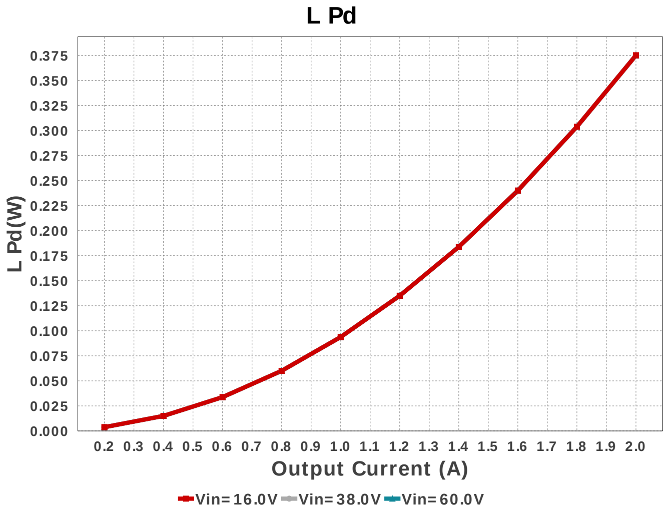


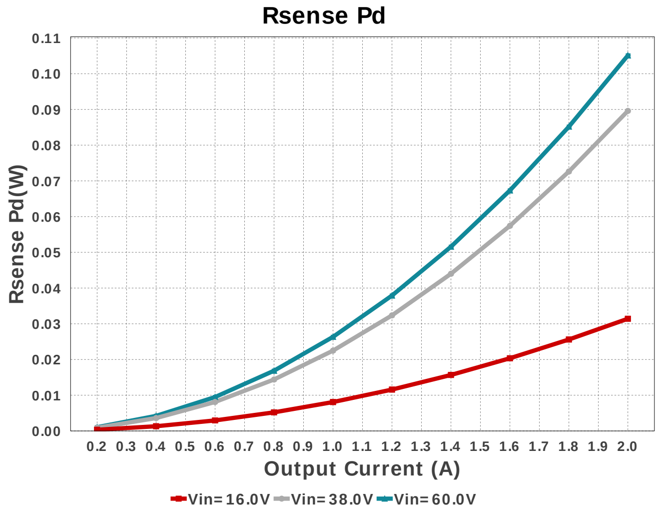
Duty Cycle

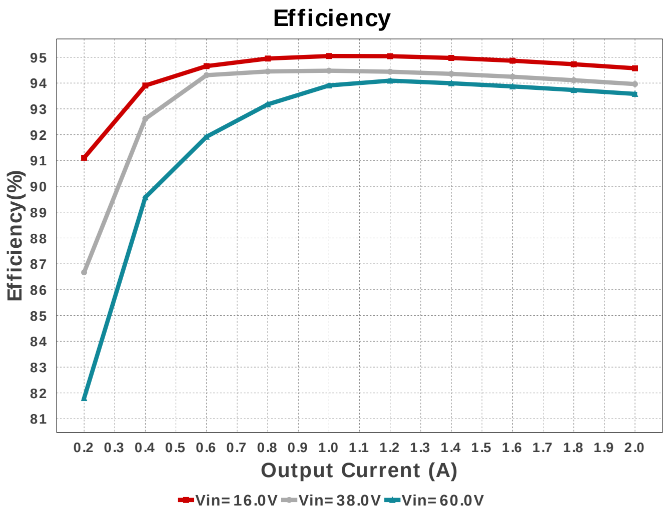


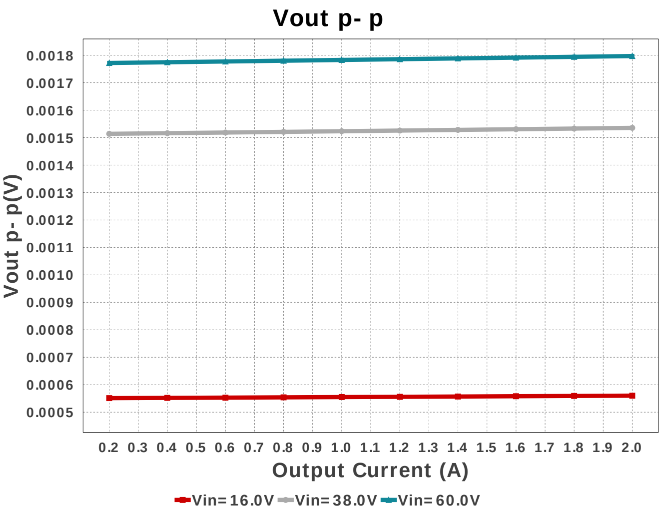

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V


M2 PdSw
M2 PdSw(W)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V

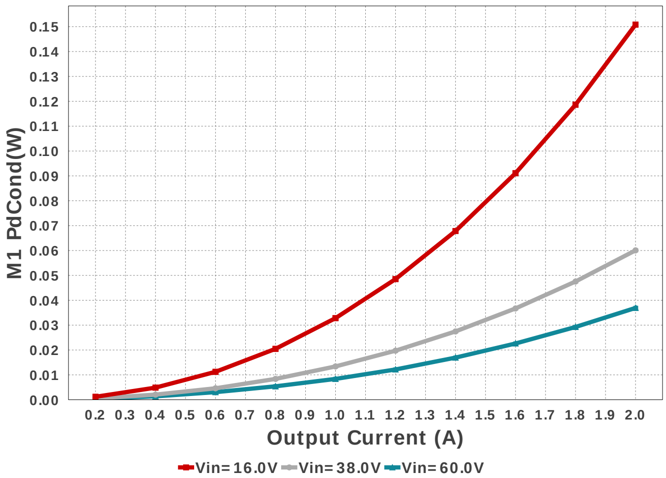

L Pd
L Pd(W)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V


Rsense Pd
Rsense Pd(W)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V

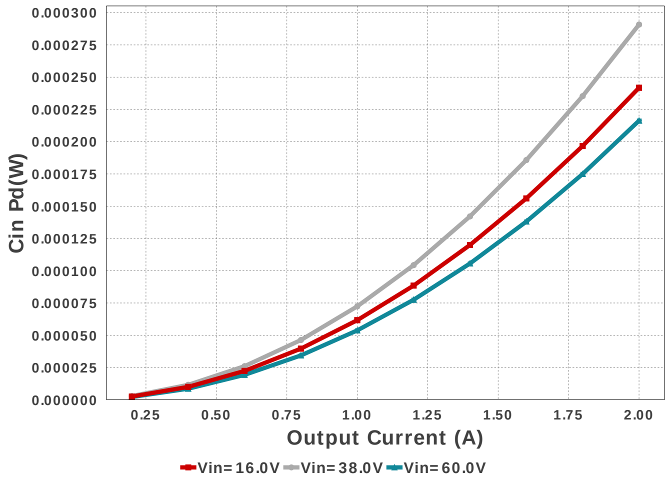

Efficiency
Efficiency(%)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V


Vout p-p
Vout p-p(V)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V

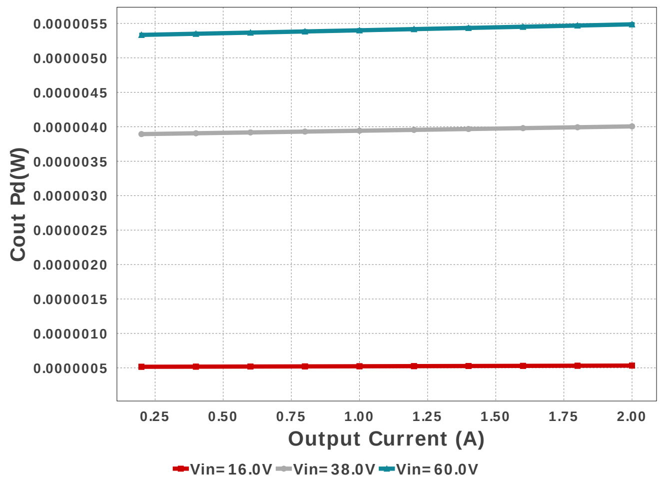
M1 PdCond



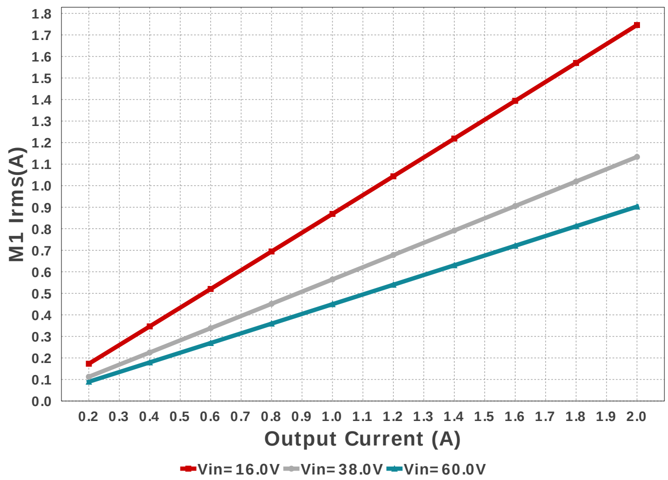
Cin Pd



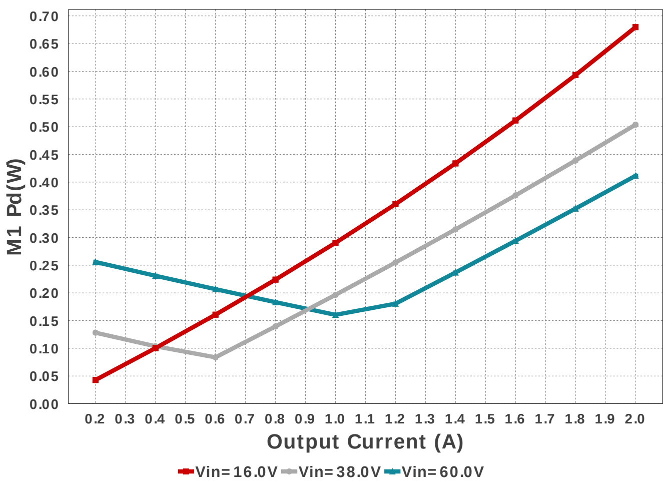
Cout Pd



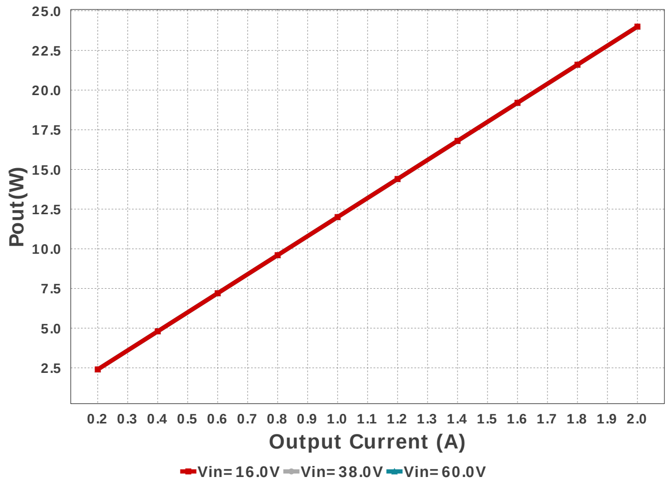
M1 Irms

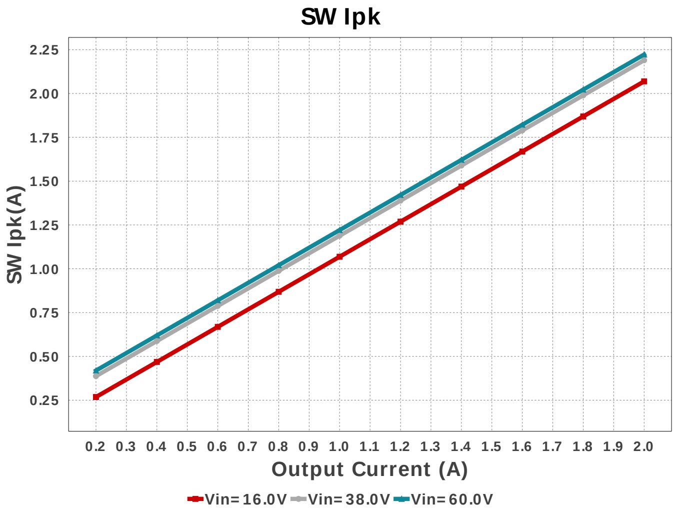


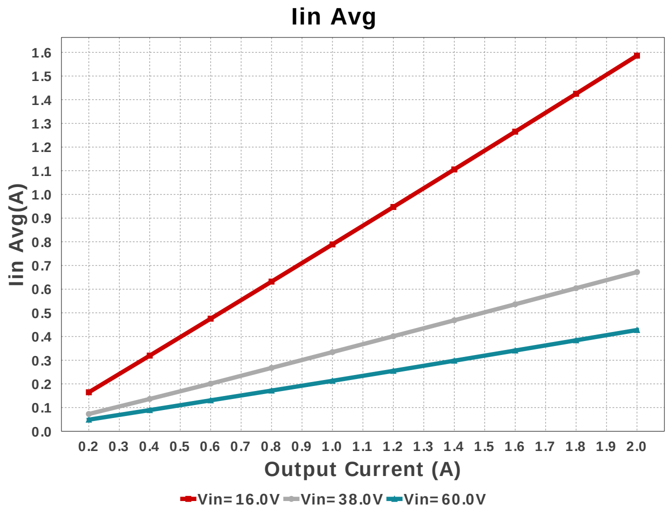
M1 Pd

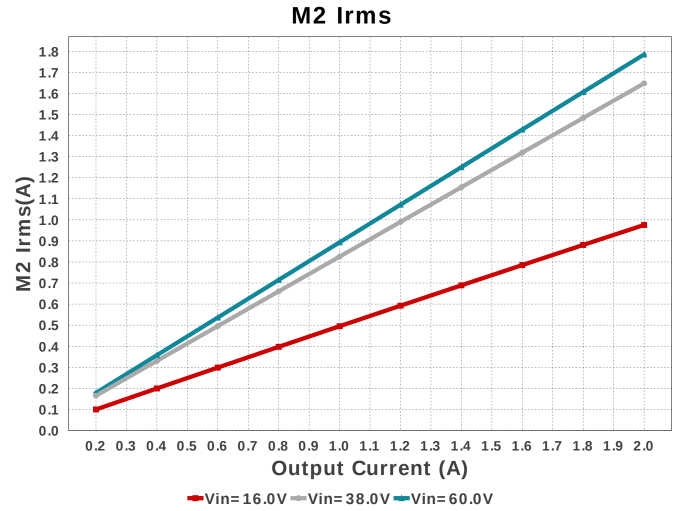


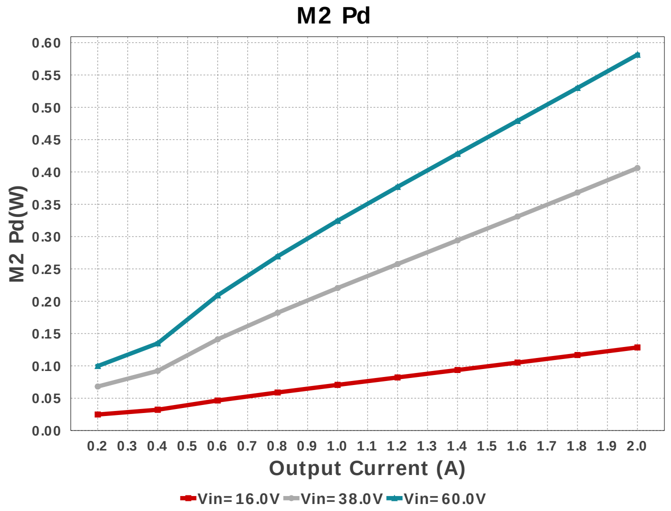
Pout

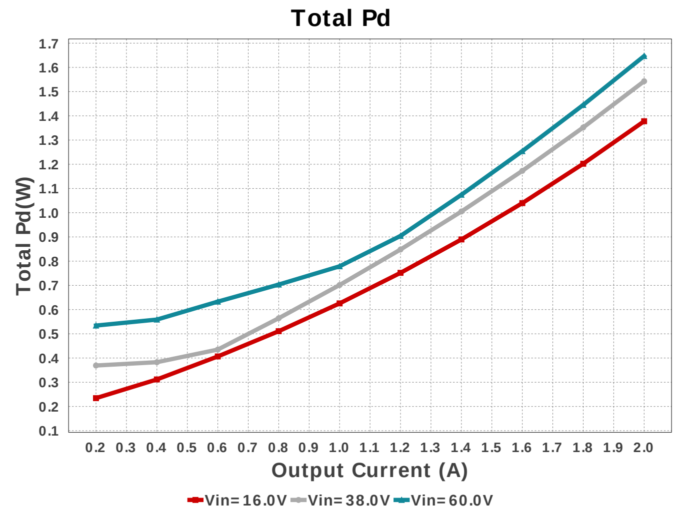


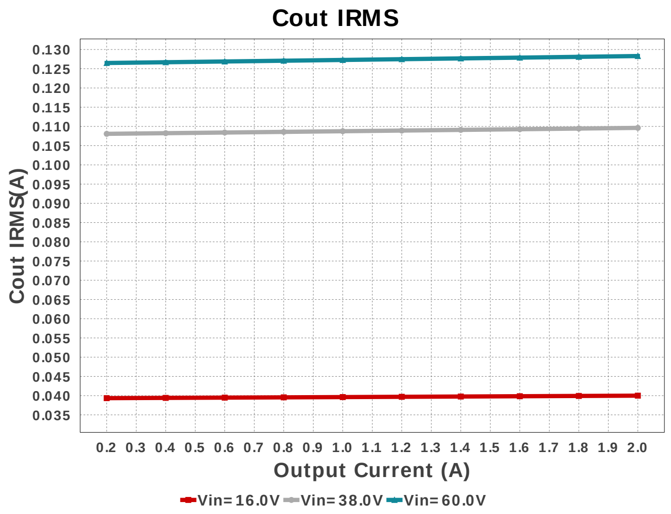

SW Ipk
SW Ipk(A)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V


Iin Avg
Iin Avg(A)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V

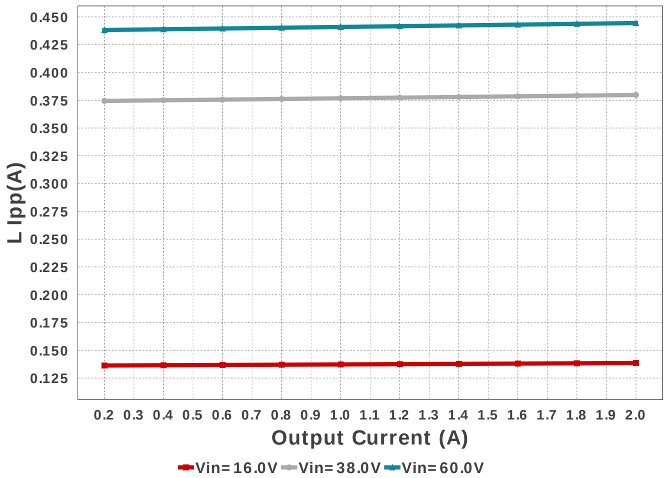

M2 Irms
M2 Irms(A)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V


M2 Pd
M2 Pd(W)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V

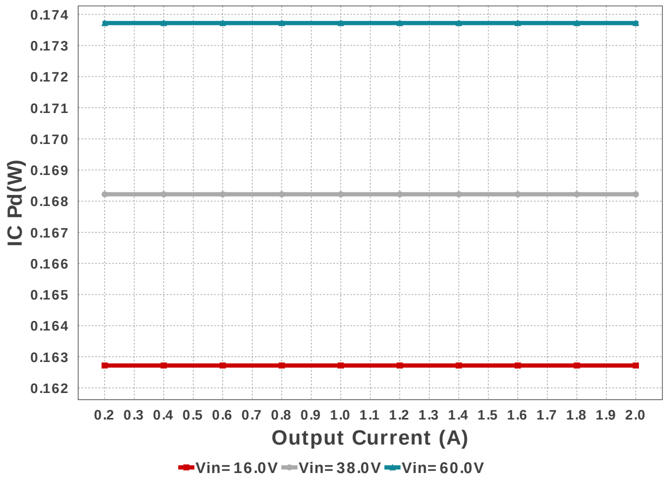

Total Pd
Total Pd(W)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V


Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=16.0V
Vin=38.0V
Vin=60.0V

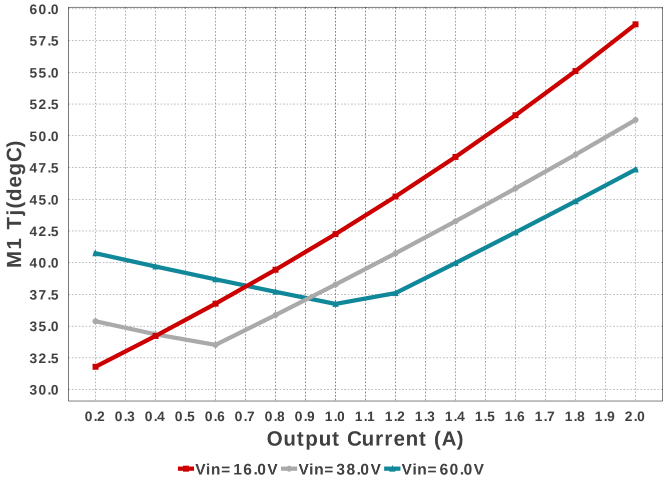
L Ipp



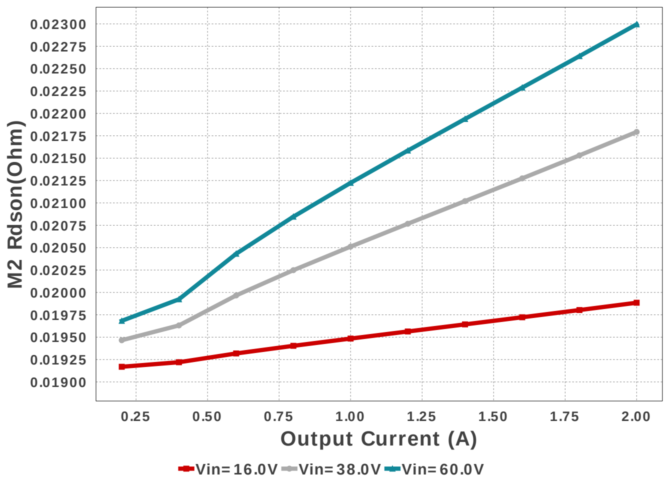
IC Pd



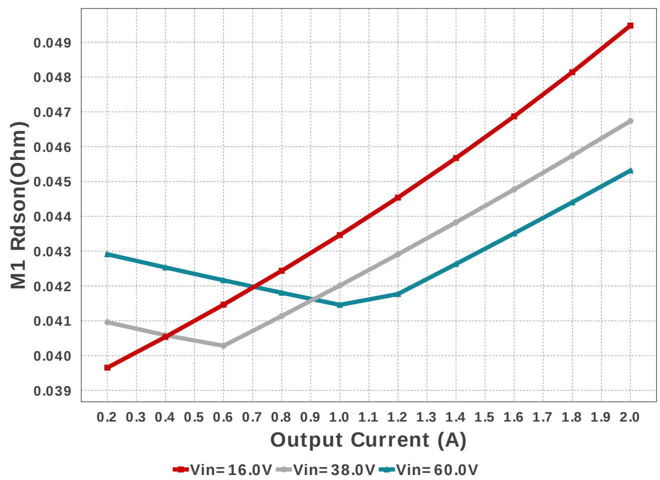
M1 Tj



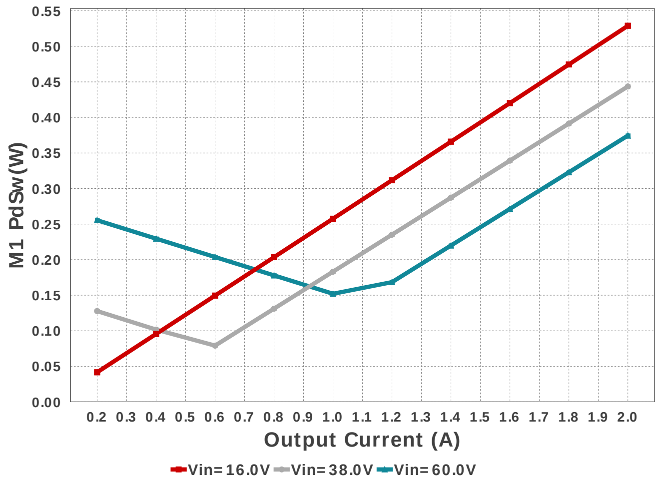
M2 Rdson

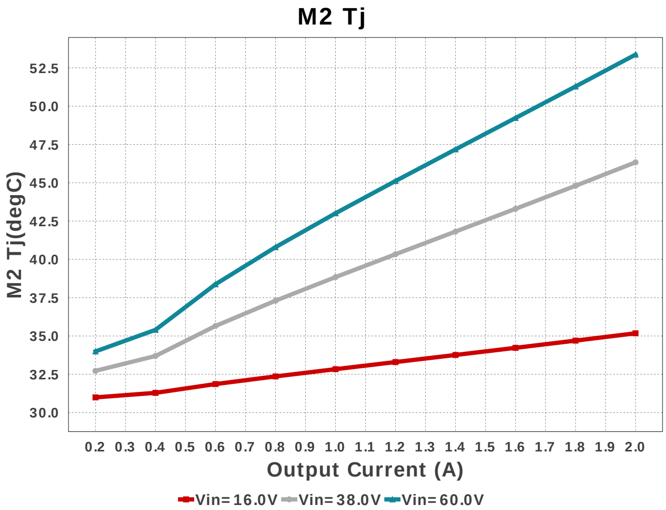


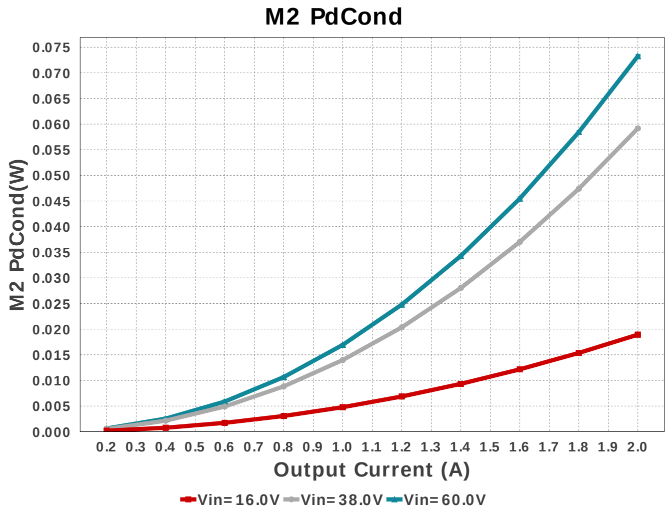
M1 Rdson

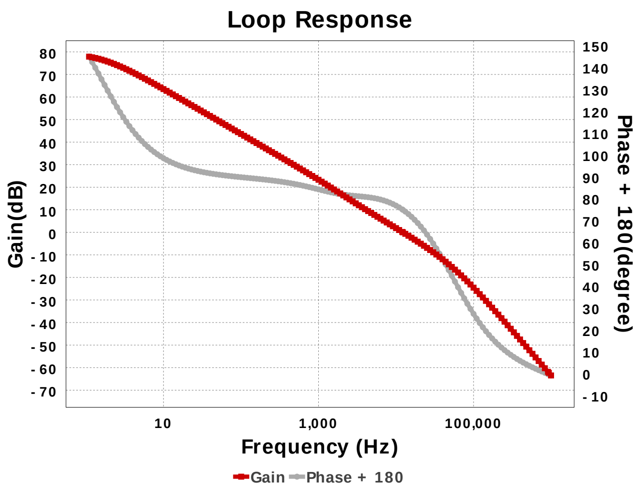


M1 PdSw









Operating Values

#	Name	Value	Category	Description
1.	BOM Count	26		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	805.504 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	216.28 µW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	128.301 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	5.487 µW	Capacitor	Output capacitor power dissipation
7.	IC Pd	173.72 mW	IC	IC power dissipation
8.	IC Tj	35.924 degC	IC	IC junction temperature
9.	IC Tolerance	12.0 mV	IC	IC Feedback Tolerance
10.	Iin Avg	427.45 mA	IC	Average input current
11.	L Ipp	444.447 mA	Inductor	Peak-to-peak inductor ripple current
12.	L Pd	375.0 mW	Inductor	Inductor power dissipation
13.	M1 Irms	902.674 mA	Mosfet	MOSFET RMS ripple current
14.	M1 Pd	411.39 mW	Mosfet	M1 MOSFET total power dissipation
15.	M1 PdCond	36.921 mW	Mosfet	M1 MOSFET conduction losses
16.	M1 PdSw	374.47 mW	Mosfet	M1 MOSFET switching losses
17.	M1 Rdson	45.312 mOhm	Mosfet	Drain-Source On-resistance
18.	M1 Tj	47.341 degC	Mosfet	M1 MOSFET junction temperature
19.	M2 Irms	1.785 A	Mosfet	MOSFET RMS ripple current
20.	M2 Pd	581.38 mW	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	73.244 mW	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	508.14 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Rdson	22.995 mOhm	Mosfet	Drain-Source On-resistance
24.	M2 Tj	53.364 degC	Mosfet	M2 MOSFET junction temperature
25.	Cin Pd	216.28 µW	Power	Input capacitor power dissipation
26.	Cout Pd	5.487 µW	Power	Output capacitor power dissipation
27.	IC Pd	173.72 mW	Power	IC power dissipation
28.	L Pd	375.0 mW	Power	Inductor power dissipation
29.	M1 Pd	411.39 mW	Power	M1 MOSFET total power dissipation
30.	M1 PdCond	36.921 mW	Power	M1 MOSFET conduction losses
31.	M1 PdSw	374.47 mW	Power	M1 MOSFET switching losses
32.	M2 Pd	581.38 mW	Power	M2 MOSFET total power dissipation

#	Name	Value	Category	Description
33.	M2 PdCond	73.244 mW	Power	M2 MOSFET conduction losses
34.	M2 PdSw	508.14 mW	Power	M2 MOSFET switching losses
35.	Rsense Pd	105.11 mW	Power	LED Current Rsns Power Dissipation
36.	Total Pd	1.647 W	Power	Total Power Dissipation
37.	Rsense Pd	105.11 mW	Resistor	LED Current Rsns Power Dissipation
38.	Cross Freq	12.268 kHz	System Information	Bode plot crossover frequency
39.	Duty Cycle	20.458 %	System Information	Duty cycle
40.	Efficiency	93.579 %	System Information	Steady state efficiency
41.	FootPrint	373.0 mm^2	System Information	Total Foot Print Area of BOM components
42.	Frequency	2.2 MHz	System Information	Switching frequency
43.	Gain Marg	-62.319 dB	System Information	Bode Plot Gain Margin
44.	Iout	2.0 A	System Information	Iout operating point
45.	Low Freq Gain	77.889 dB	System Information	Gain at 1Hz
46.	Mode	CCM	System Information	Conduction Mode
47.	Phase Marg	75.332 deg	System Information	Bode Plot Phase Margin
48.	Pout	24.0 W	System Information	Total output power
49.	SW Ipk	2.222 A	System Information	Peak switch current
50.	Vin	60.0 V	System Information	Vin operating point
51.	Vout Actual	12.0 V	System Information	Vout Actual calculated based on selected voltage divider resistors
52.	Vout Tolerance	2.001 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
53.	Vout p-p	1.797 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
SoftStart	2.0 ms	Soft Start Time (ms)
VinMax	60.0	Maximum input voltage
VinMin	16.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	LM5141	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	2.169 M	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

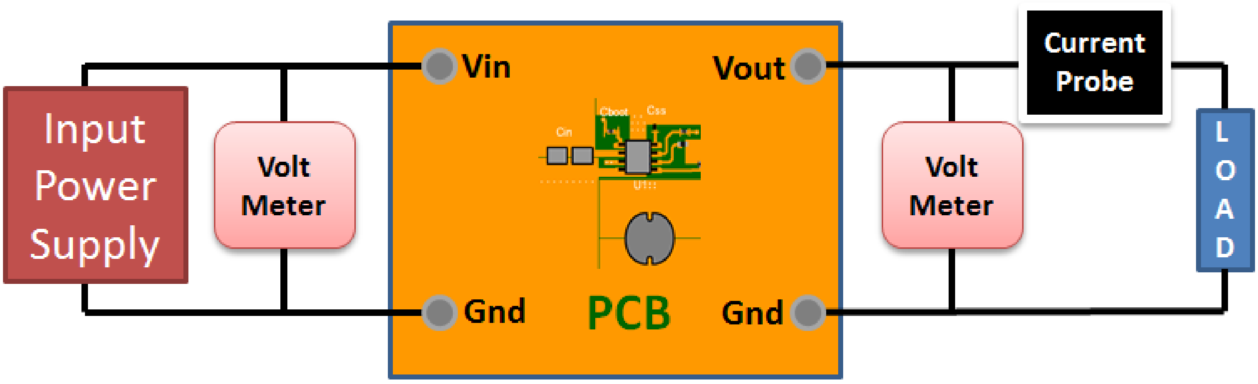
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 16.0V 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 : 05AF44C182267F21[v1]

2. **LM5141** Product Folder : http://www.ti.com/product/LM5141 : contains the data sheet and other resources.

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