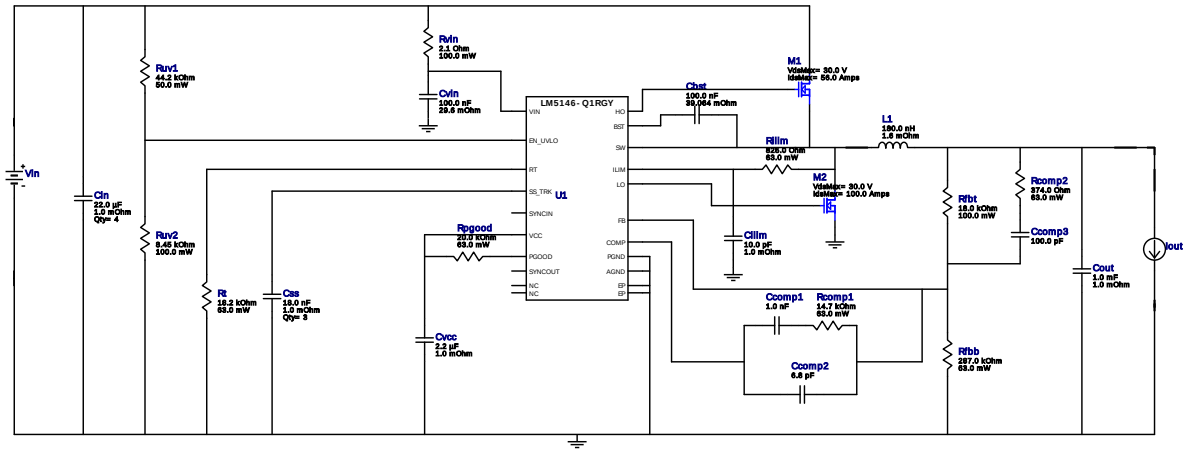
VinMin = 9.0V
VinMax = 15.0V
Vout = 0.85V
Iout = 18.0A

Device = LM5146QRGYRQ1
Topology = Buck
Created = 2020-04-14 17:59:49.702
BOM Cost = NA
BOM Count = 30
Total Pd = 2.15W

WEBENCH ® Design Report

Design : 131 LM5146QRGYRQ1
LM5146QRGYRQ1 36V-75V to 12.00V @ 8A



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

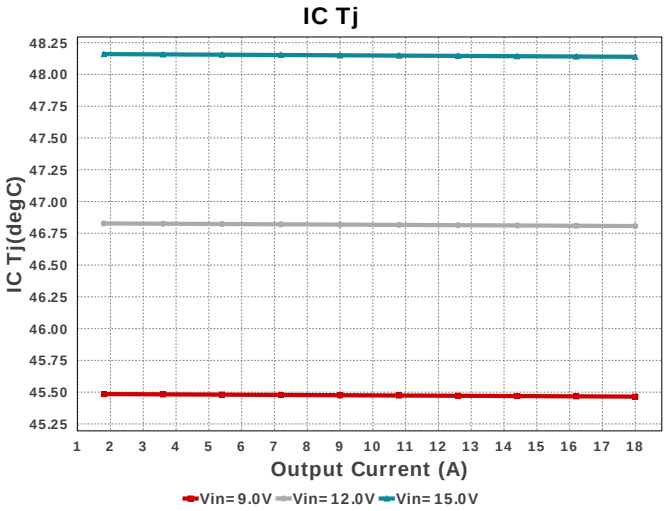
Component Selection Information

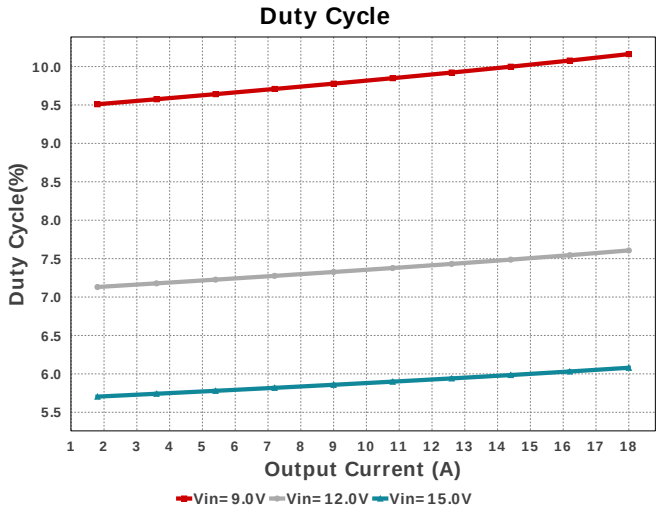
The LM5146-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

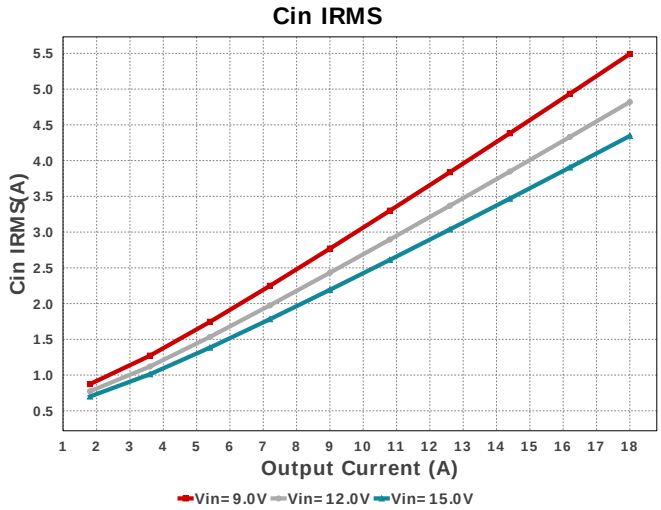
Electrical BOM

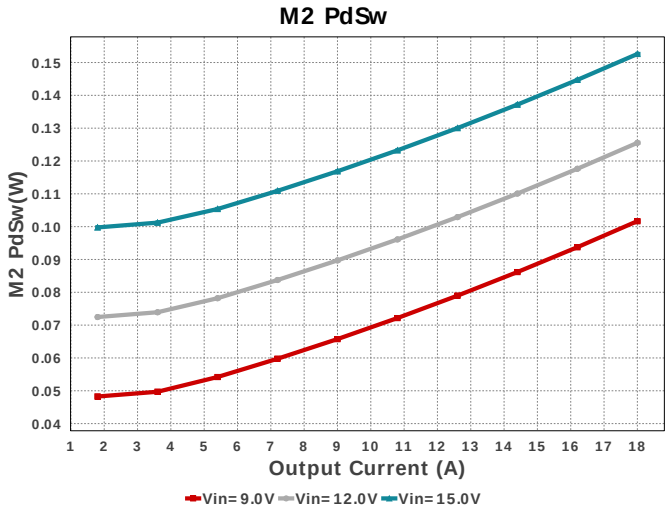
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbst	TDK	C1005X5R1H104K050BB Series= X5R	Cap= 100.0 nF ESR= 39.064 mOhm VDC= 50.0 V IRMS= 814.67 mA	1	$0.02	0402 3 mm²
Ccomp1	MuRata	GRM1555C1H102JA01J Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Ccomp2	AVX	06031U6R8BAT2A Series= C0G/NP0	Cap= 6.8 pF VDC= 100.0 V IRMS= 0.0 A	1	$0.07	0603 5 mm²
Ccomp3	Samsung Electro-Mechanics	CL21C101JBANNNC Series= C0G/NP0	Cap= 100.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
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 mm²
Cin	CUSTOM	CUSTOM Series= X7R	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	4	NA	1210 0 mm²
Cout	CUSTOM	CUSTOM Series= X5R	Cap= 1.0 mF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 7.24 A	1	NA	0603 0 mm²

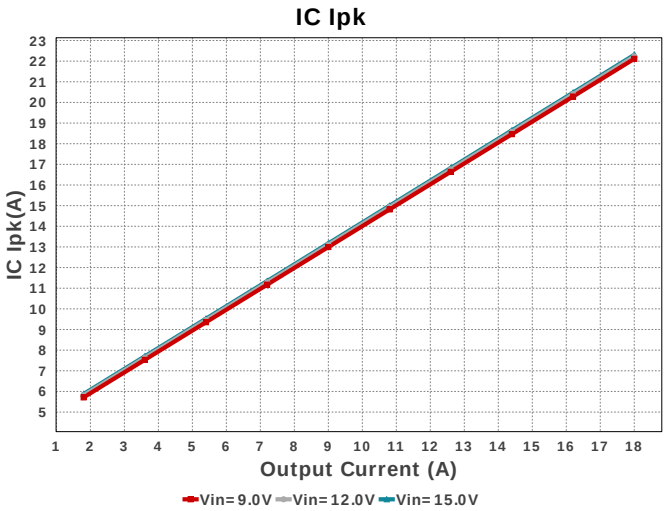
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Css	MuRata	GRM155R71C183KA01D Series= X7R	Cap= 18.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	3	$0.01	0402 3 mm²
Cvcc	TDK	C1005X5R1V225K050BC Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 35.0 V IRMS= 0.0 A	1	$0.07	0402_065 3 mm²
Cvin	TDK	CGA3E2X7R1H104K080AA Series= X7R	Cap= 100.0 nF ESR= 29.6 mOhm VDC= 50.0 V IRMS= 971.99 mA	1	$0.01	0603 5 mm²
L1	Coilcraft	XAL6030-181MEB	L= 180.0 nH 1.6 mOhm	1	$0.65	XAL6030 72 mm²
M1	Texas Instruments	CSD17304Q3	VdsMax= 30.0 V IdsMax= 56.0 Amps	1	$0.25	DQG0008A 18 mm²
M2	Texas Instruments	CSD17573Q5B	VdsMax= 30.0 V IdsMax= 100.0 Amps	1	$0.52	DNK0008A 56 mm²
Rcomp1	Vishay-Dale	CRCW040214K7FKED Series= CRCW..e3	Res= 14.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcomp2	Vishay-Dale	CRCW0402374RFKED Series= CRCW..e3	Res= 374.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Vishay-Dale	CRCW0402287KFKED Series= CRCW..e3	Res= 287.0 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	CRCW0402825RFKED Series= CRCW..e3	Res= 825.0 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	CRCW040218K2FKED Series= CRCW..e3	Res= 18.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Ruv1	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Ruv2	Yageo	RC0603FR-078K45L Series= ?	Res= 8.45 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
U1	Texas Instruments	LM5146QRGYRQ1	Switcher	1	$2.49	RGY0020B 25 mm²

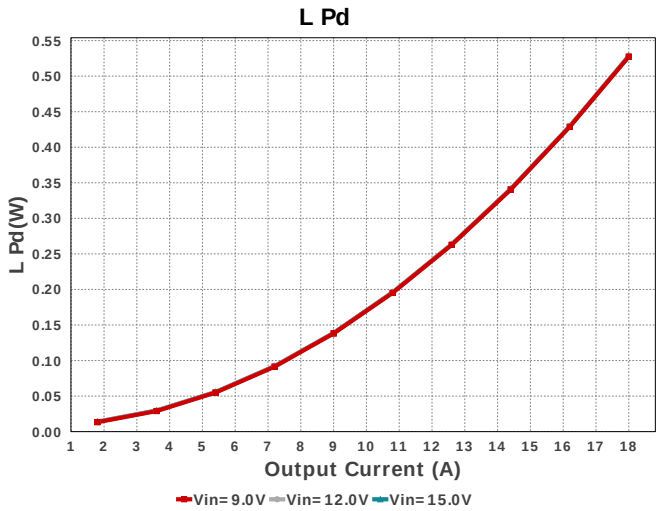

IC Tj
IC Tj(degC)
48.25
48.00
47.75
47.50
47.25
47.00
46.75
46.50
46.25
46.00
45.75
45.50
45.25
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

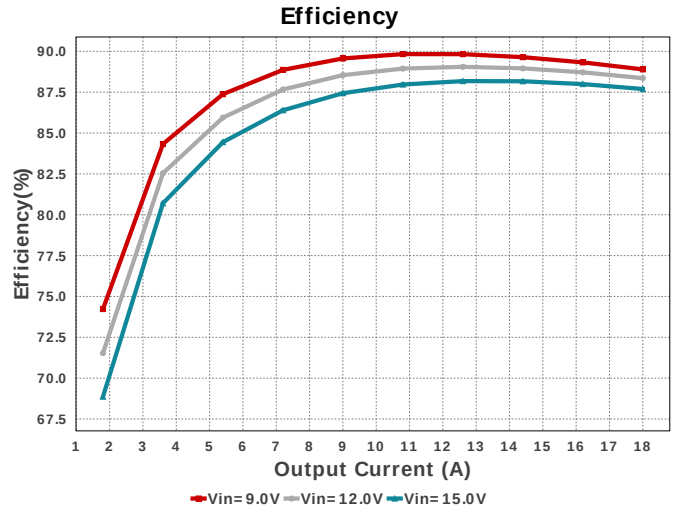

Duty Cycle
Duty Cycle(%)
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

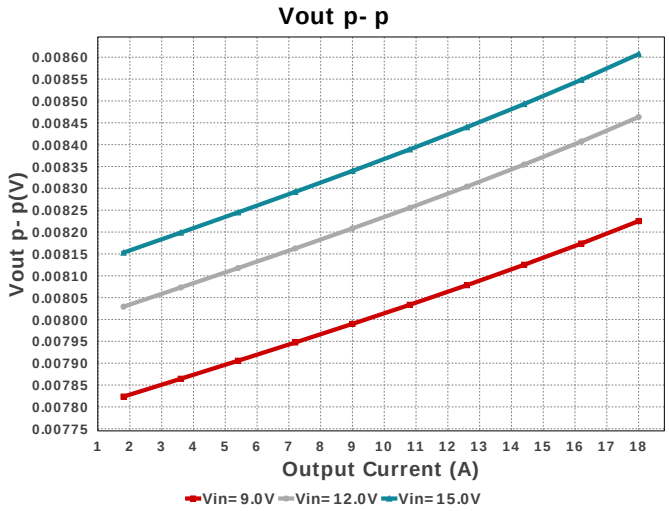

Cin IRMS
Cin IRMS(A)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

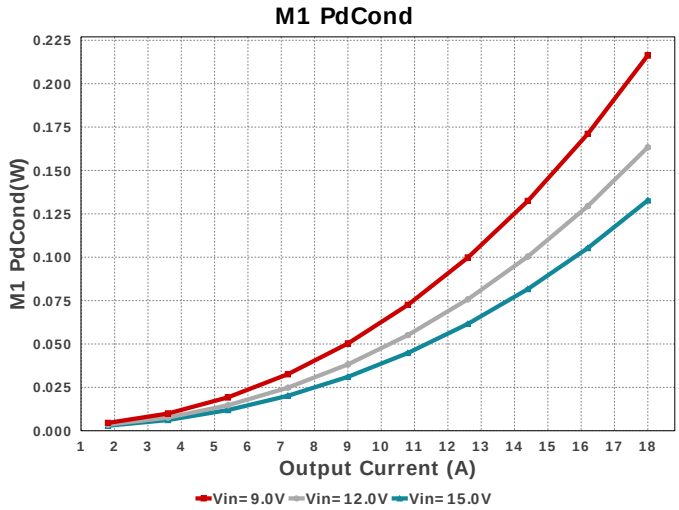

M2 PdSw
M2 PdSw(W)
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

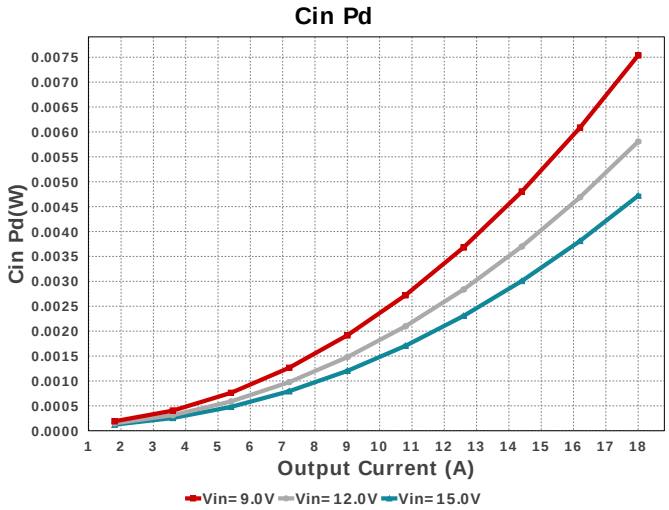

IC Ipk
IC Ipk(A)
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

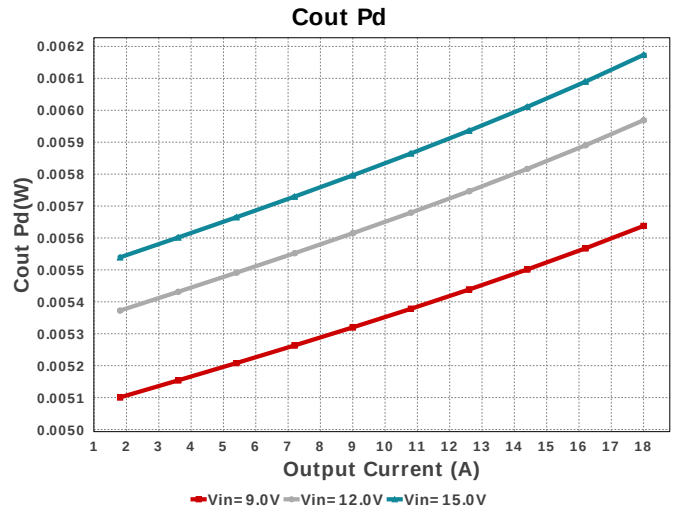

L Pd
L Pd(W)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

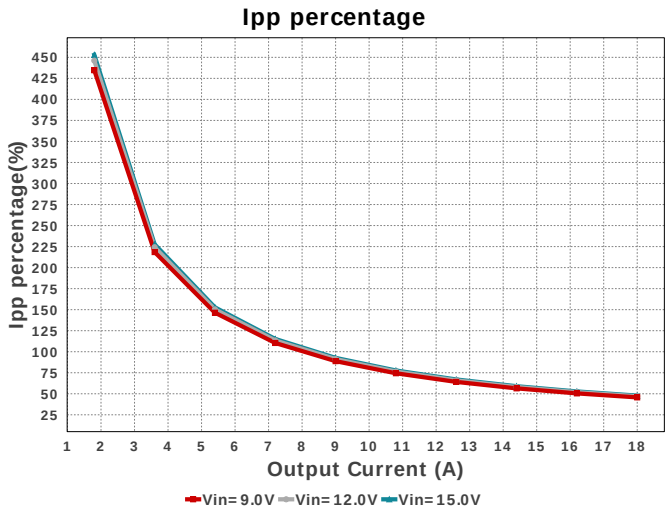

Efficiency
Efficiency(%)
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

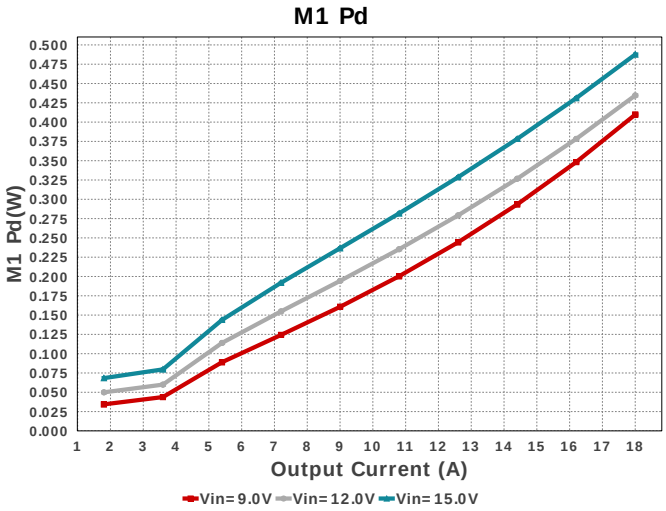

Vout p- p
Vout p- p(V)
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

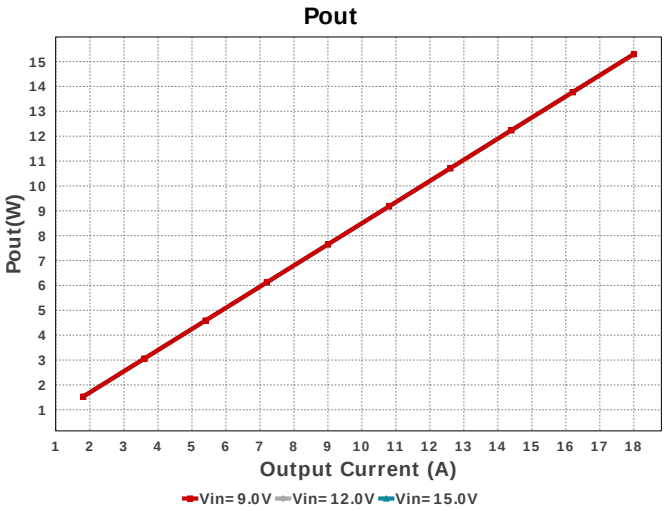

M1 PdCond
M1 PdCond(W)
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

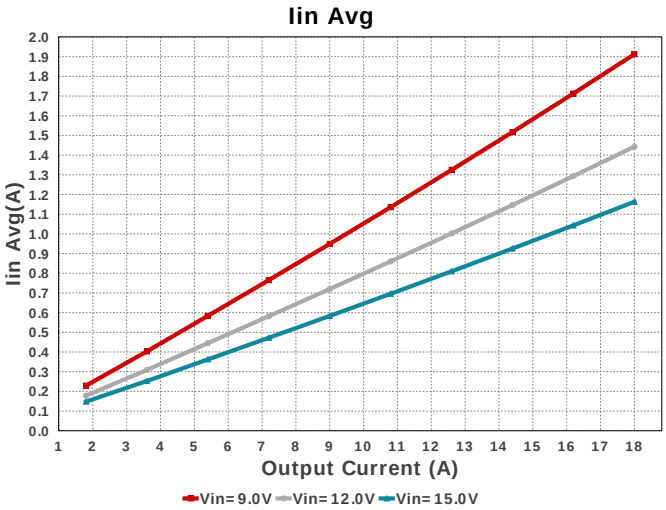

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

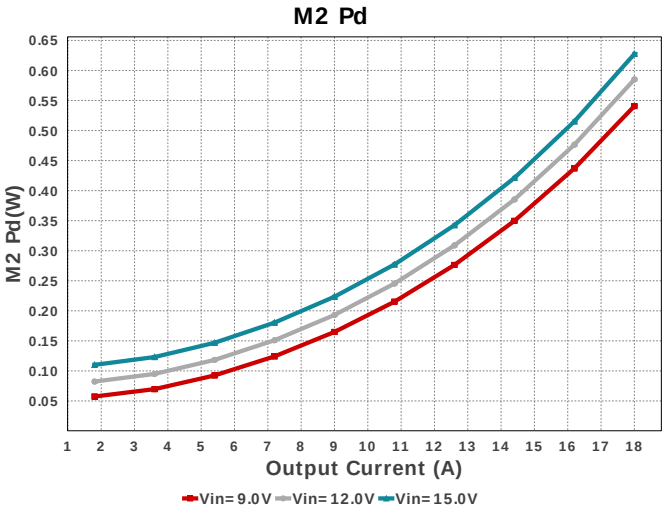

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

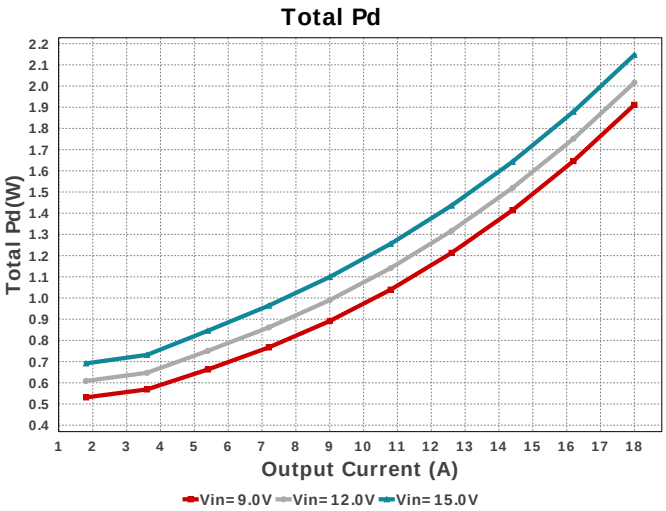

Ipp percentage
Ipp percentage(%)
Output Current (A)
Vin=9.0V Vin=12.0V Vin=15.0V

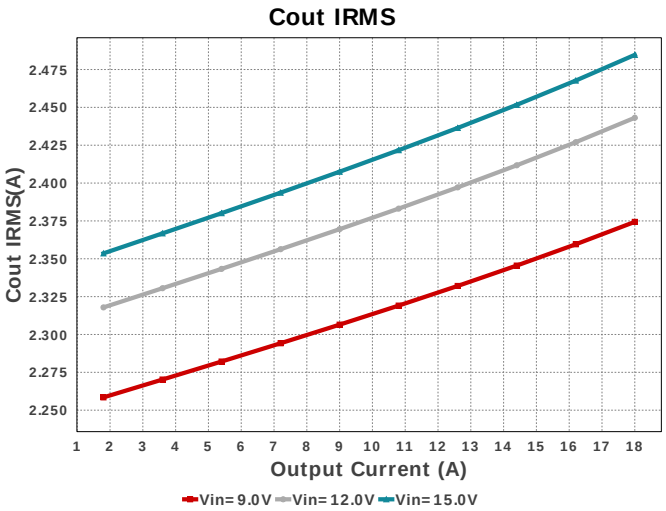


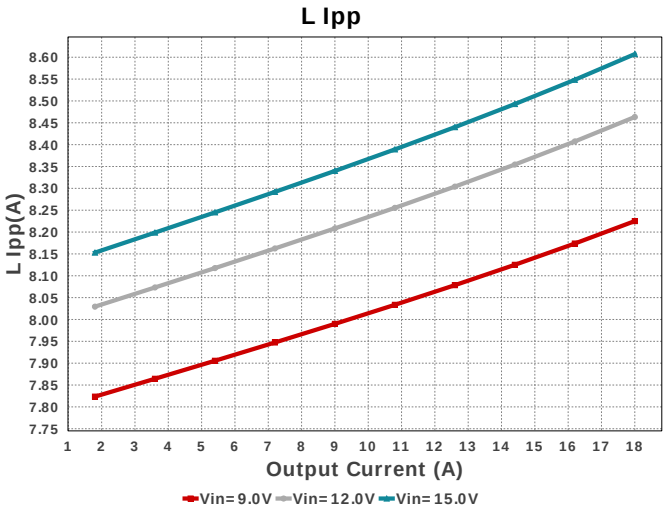


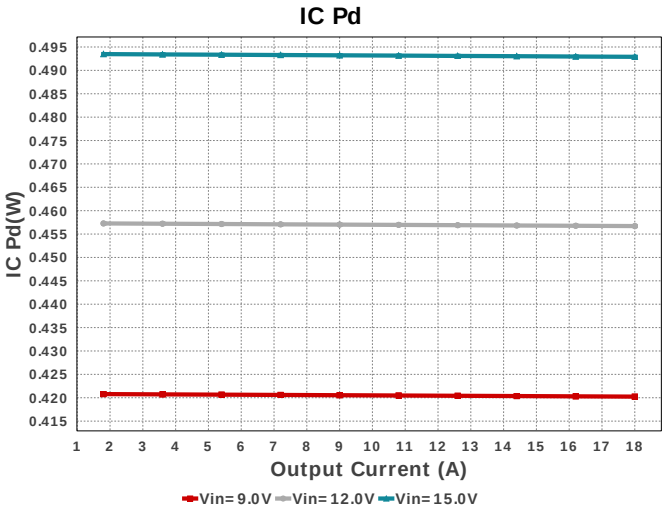


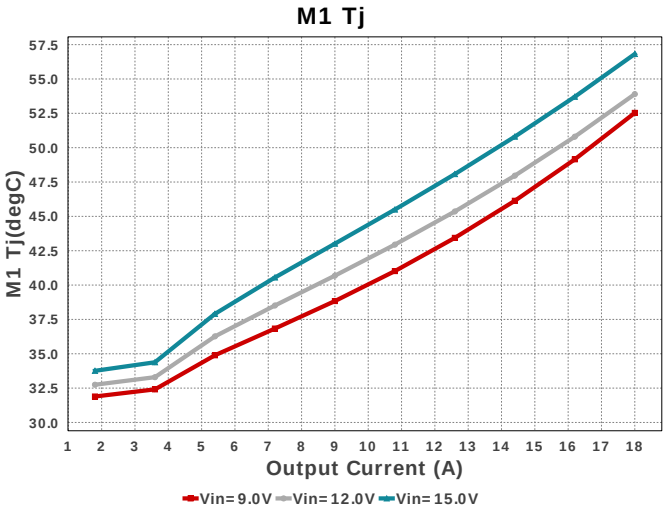


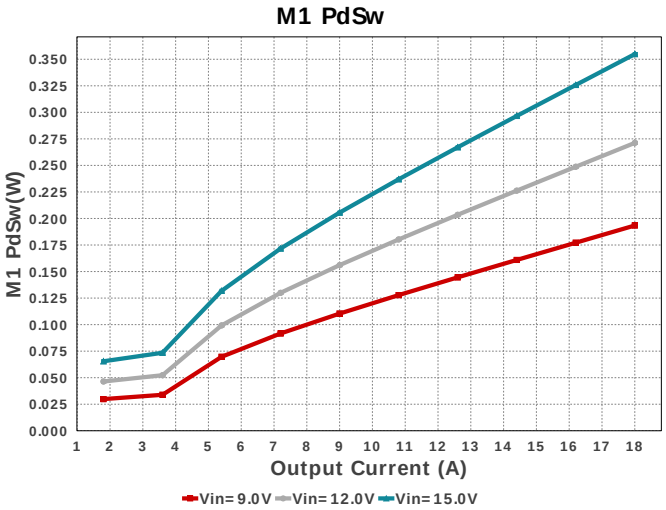


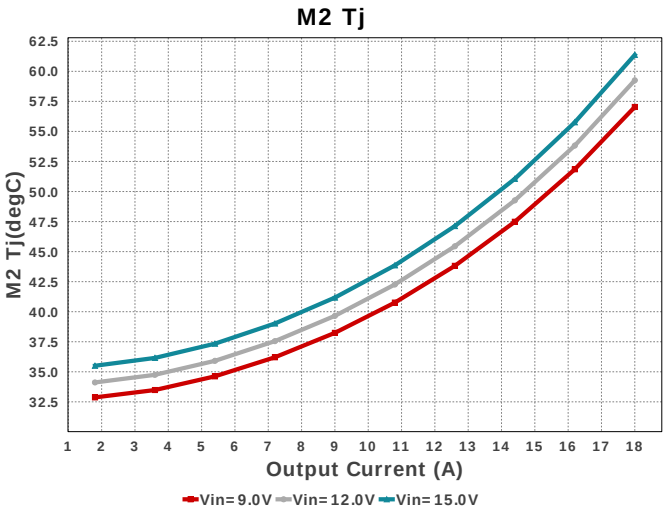


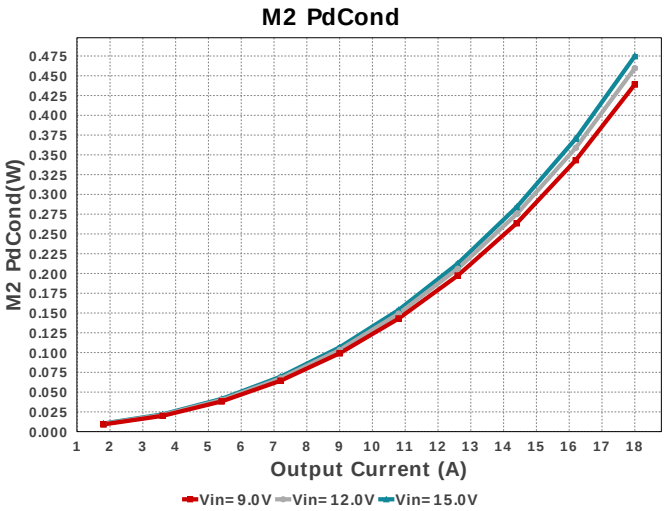


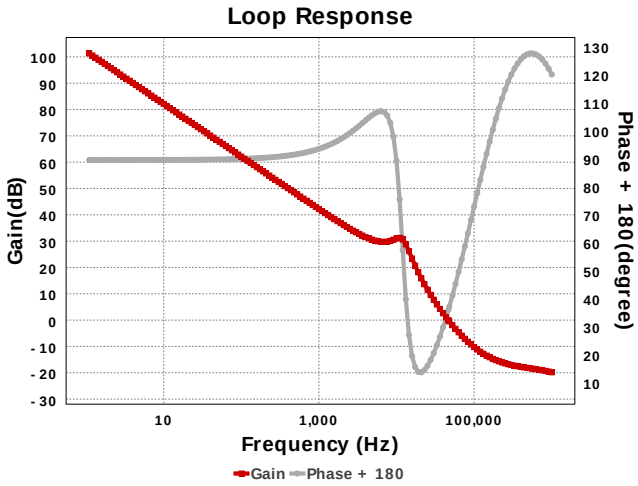












Operating Values

#	Name	Value	Category	Description
1.	BOM Count	30		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	4.345 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	4.719 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	2.485 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	6.174 mW	Capacitor	Output capacitor power dissipation
7.	IC Ipk	22.304 A	IC	Peak switch current in IC
8.	IC Pd	492.9 mW	IC	IC power dissipation
9.	IC Tj	48.139 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	1.163 A	IC	Average input current
13.	Ipp percentage	47.818 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
14.	L Ipp	8.607 A	Inductor	Peak-to-peak inductor ripple current
15.	L Pd	528.28 mW	Inductor	Inductor power dissipation
16.	M1 Pd	487.62 mW	Mosfet	M1 MOSFET total power dissipation
17.	M1 PdCond	132.77 mW	Mosfet	M1 MOSFET conduction losses
18.	M1 PdSw	354.86 mW	Mosfet	M1 MOSFET switching losses
19.	M1 Tj	56.819 degC	Mosfet	M1 MOSFET junction temperature
20.	M2 Pd	627.4 mW	Mosfet	M2 MOSFET total power dissipation
21.	M2 PdCond	474.81 mW	Mosfet	M2 MOSFET conduction losses
22.	M2 PdSw	152.6 mW	Mosfet	M2 MOSFET switching losses
23.	M2 Tj	61.37 degC	Mosfet	M2 MOSFET junction temperature
24.	Cin Pd	4.719 mW	Power	Input capacitor power dissipation
25.	Cout Pd	6.174 mW	Power	Output capacitor power dissipation
26.	IC Pd	492.9 mW	Power	IC power dissipation
27.	L Pd	528.28 mW	Power	Inductor power dissipation
28.	M1 Pd	487.62 mW	Power	M1 MOSFET total power dissipation
29.	M1 PdCond	132.77 mW	Power	M1 MOSFET conduction losses
30.	M1 PdSw	354.86 mW	Power	M1 MOSFET switching losses
31.	M2 Pd	627.4 mW	Power	M2 MOSFET total power dissipation
32.	M2 PdCond	474.81 mW	Power	M2 MOSFET conduction losses
33.	M2 PdSw	152.6 mW	Power	M2 MOSFET switching losses
34.	Total Pd	2.147 W	Power	Total Power Dissipation
35.	Cross Freq	46.54 kHz	System Information	Bode plot crossover frequency
36.	Duty Cycle	6.079 %	System Information	Duty cycle
37.	Efficiency	87.694 %	System Information	Steady state efficiency
38.	FootPrint	310.0 mm^2	System Information	Total Foot Print Area of BOM components
39.	Frequency	549.451 kHz	System Information	Switching frequency
40.	Gain Marg	-34.996 dB	System Information	Bode Plot Gain Margin
41.	Iout	18.0 A	System Information	Iout operating point
42.	Low Freq Gain	101.304 dB	System Information	Gain at 1Hz

#	Name	Value	Category	Description
43.	Mode	CCM	System Information	Conduction Mode
44.	Phase Marg	36.478 deg	System Information	Bode Plot Phase Margin
45.	Pout	15.3 W	System Information	Total output power
46.	Vin	15.0 V	System Information	Vin operating point
47.	Vout	850.0 mV	System Information	Operational Output Voltage
48.	Vout Actual	850.174 mV	System Information	Vout Actual calculated based on selected voltage divider resistors
49.	Vout Tolerance	1.12 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
50.	Vout p-p	8.607 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	18.0	Maximum Output Current
SoftStart	4.0 ms	Soft Start Time (ms)
VinMax	15.0	Maximum input voltage
VinMin	9.0	Minimum input voltage
Vout	850.0 m	Output Voltage
base_pn	LM5146-Q1	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	549.0 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

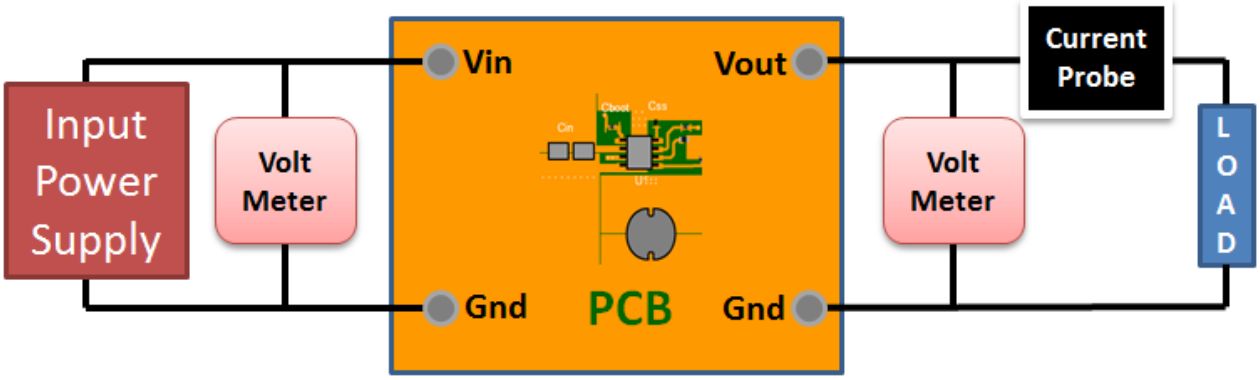
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 9.0V 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.

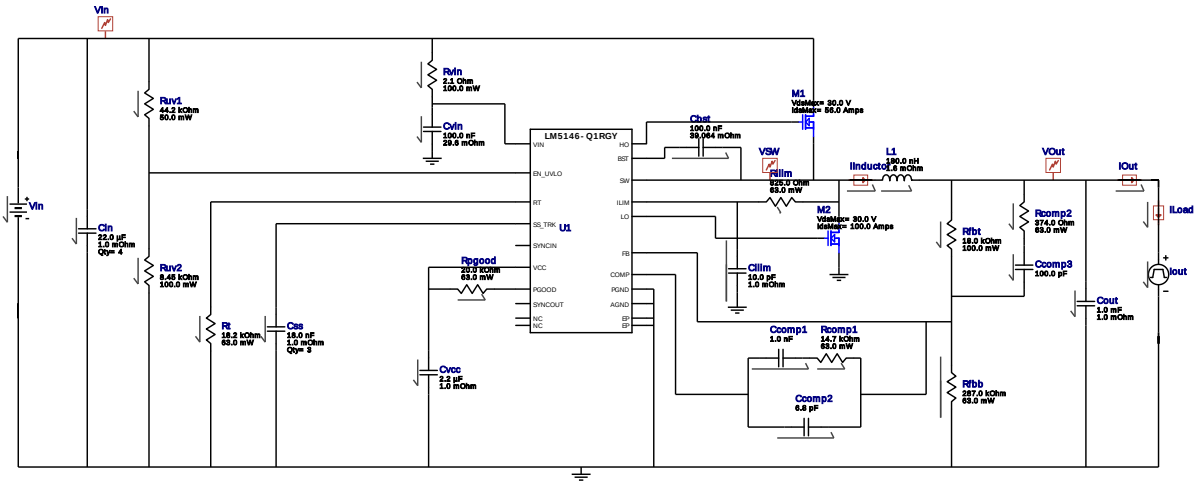


WEBENCH® Electrical Simulation Report

Design Id = 131

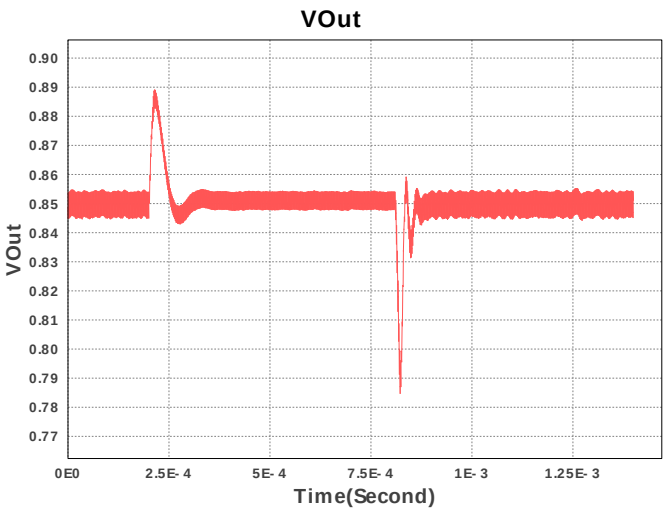
sim_id = 7

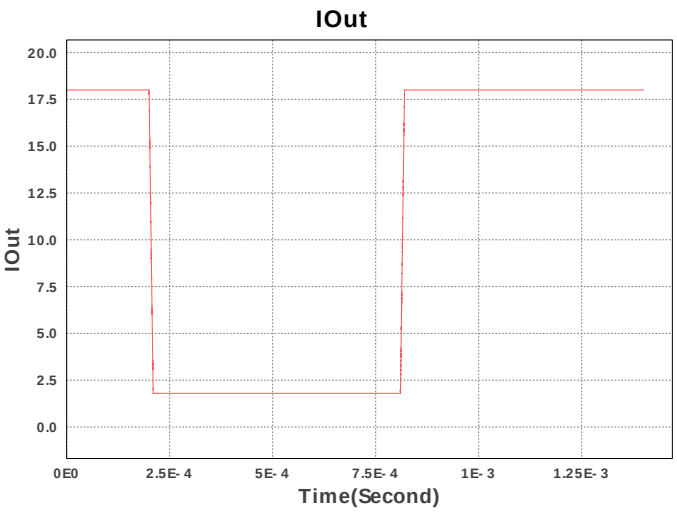
Simulation Type = Load Transient



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
4.	Css	IC	Initial condition	1 V
5.	Iout	signal_type	Signal Type	PULSE
		I1	Initial Load Current	18.0 A
		I2	Minimum Load Current	1.8 A
		Td	Initial Time Delay	2.0E-4 s
		Tf	Fall Time	10u s
		Tr	Rise Time	10u s
		Pw	Pulse Width	6.0E-4 s





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 : 24020EFC3FBD770E[v1]

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