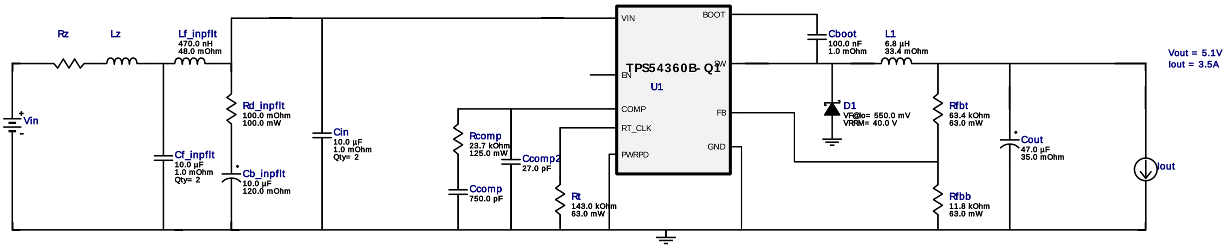
VinMin = 6.5V
VinMax = 30.0V
Vout = 5.1V
Iout = 3.5A

Device = TPS54360BQDDARQ1
Topology = Buck
Created = 2020-01-24 14:27:16.870
BOM Cost = $5.83
BOM Count = 18
Total Pd = 2.61W

WEBENCH ® Design Report

Design : 20 TPS54360BQDDARQ1
TPS54360BQDDARQ1 6.5V-30V to 5.10V @ 3.5A



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.

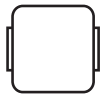
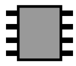
Design Alerts

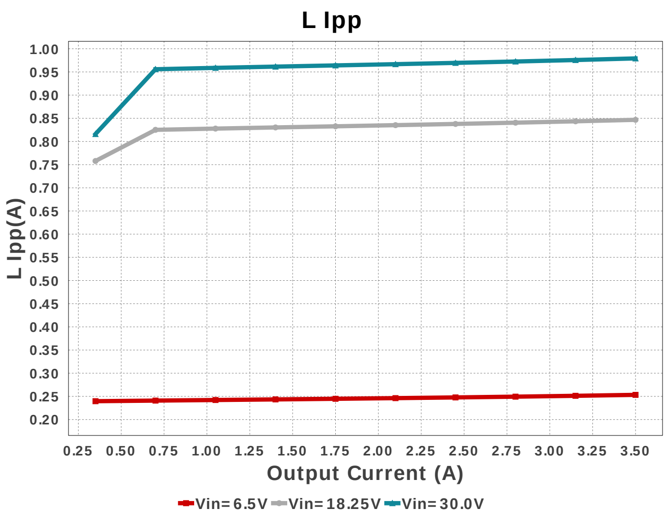
Component Selection Information

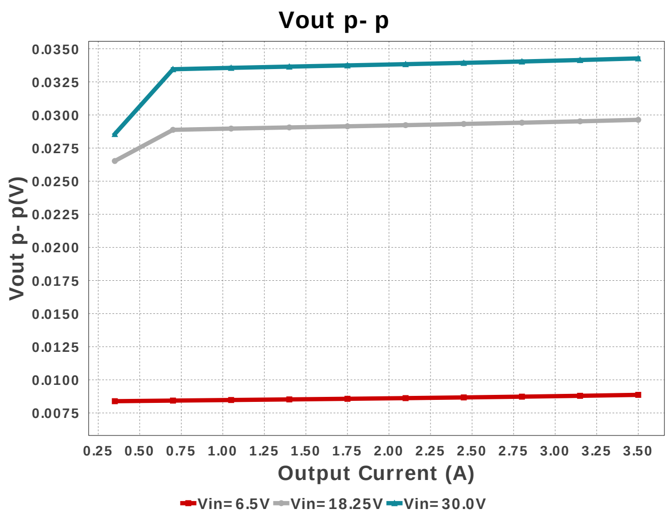
The TPS54360B-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

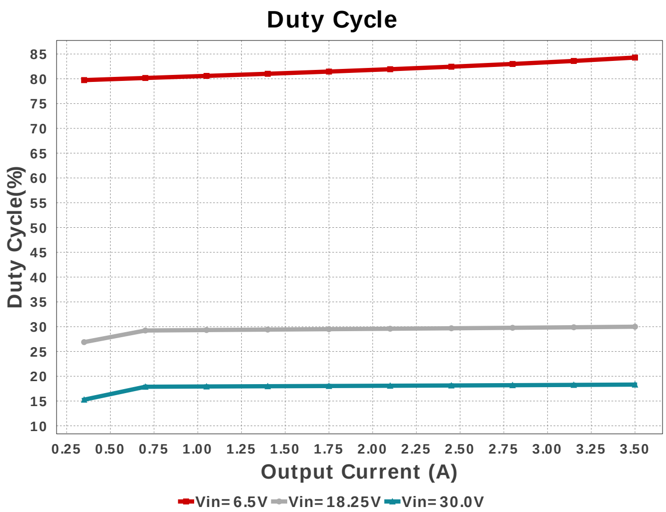
Electrical BOM

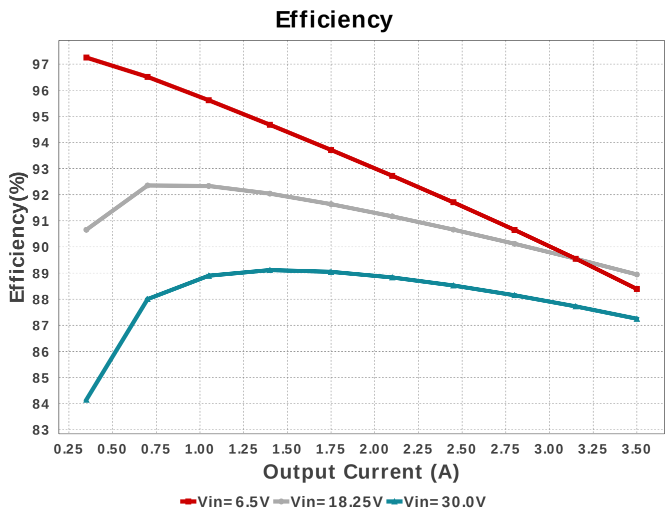
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cb_inpflt	Panasonic	EEHZA1H100R Series= ZA	Cap= 10.0 uF ESR= 120.0 mOhm VDC= 50.0 V IRMS= 750.0 mA	1	$0.46	SM_RADIAL_5MM 58 mm^2
Cboot	Kemet	C0603C104Z4VACTU Series= Y5V	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm^2
Ccomp	Kemet	C0805C751J5GACTU Series= C0G/NP0	Cap= 750.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.09	0805 7 mm^2
Ccomp2	Samsung Electro-Mechanics	CL21C270JBANNNC Series= C0G/NP0	Cap= 27.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cf_inpflt	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	2	$0.28	1210 15 mm^2
Cin	TDK	C3225X7R1H106M250AC Series= X7R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 5.0 A	2	$0.28	1210 15 mm^2
Cout	Panasonic	10TPE47MAZB Series= TPE	Cap= 47.0 uF ESR= 35.0 mOhm VDC= 10.0 V IRMS= 1.4 A	1	$0.38	3528-21 17 mm^2
D1	Diodes Inc.	B540C-13-F	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.17	SMC 83 mm^2

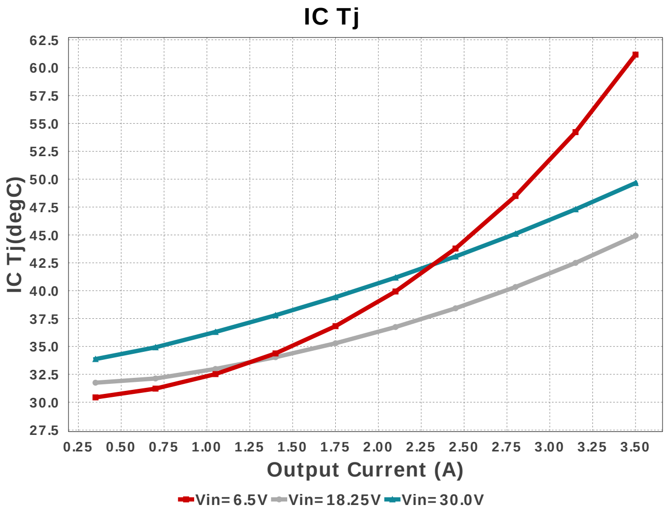
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L1	Vishay-Dale	IHLP3232DZER6R8M11	L= 6.8 µH 33.4 mOhm	1	$0.66	 IHLP-3232DZ 112 mm²
Lf_inpflt	Wurth Elektronik	744383230047	L= 470.0 nH 48.0 mOhm	1	$0.74	WE-MAPI_2510 10 mm²
Rcomp	Vishay-Dale	CRCW080523K7FKEA Series= CRCW..e3	Res= 23.7 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rd_inpflt	Panasonic	ERJ-3RSFR10V Series= ERJ-3R	Res= 100.0 mOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.03	0603 5 mm²
Rfbb	Vishay-Dale	CRCW040211K8FKED Series= CRCW..e3	Res= 11.8 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Vishay-Dale	CRCW040263K4FKED Series= CRCW..e3	Res= 63.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rt	Vishay-Dale	CRCW0402143KFKED Series= CRCW..e3	Res= 143.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	TPS54360BQDDARQ1	Switcher	1	$2.12	 DDA0008E 55 mm²

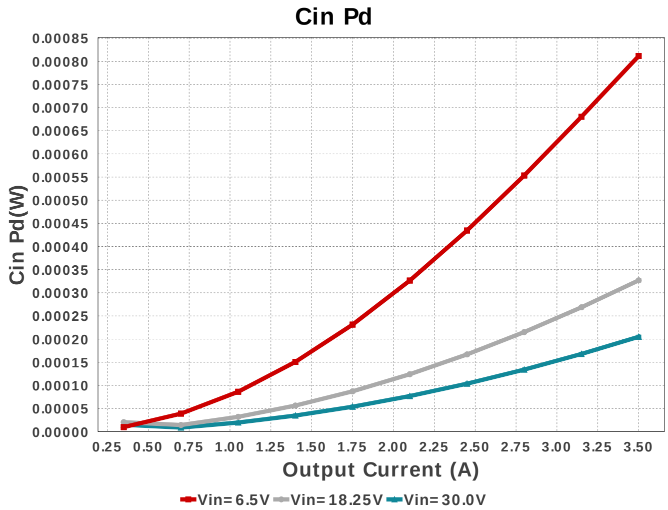


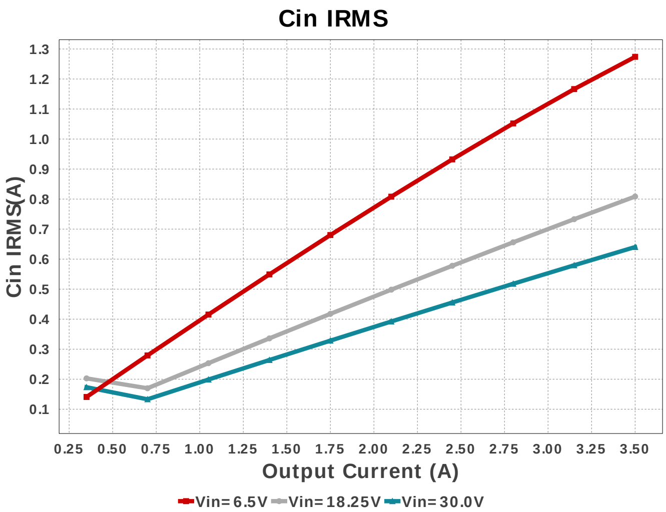


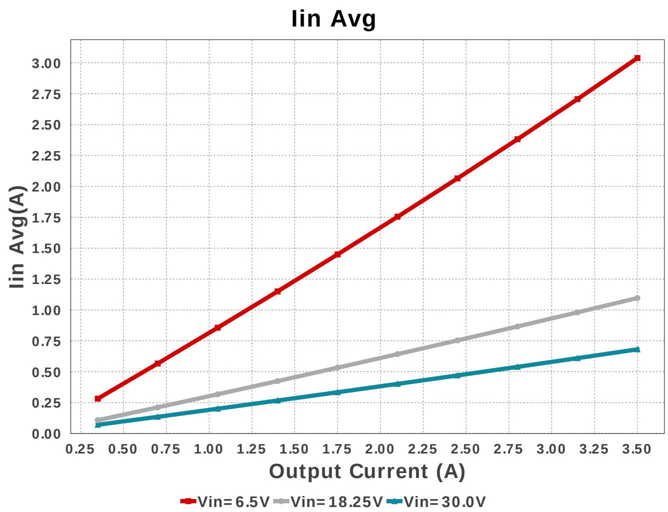


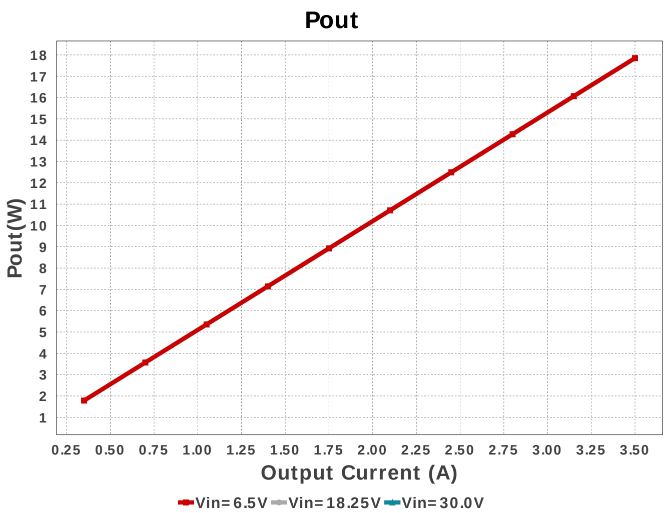


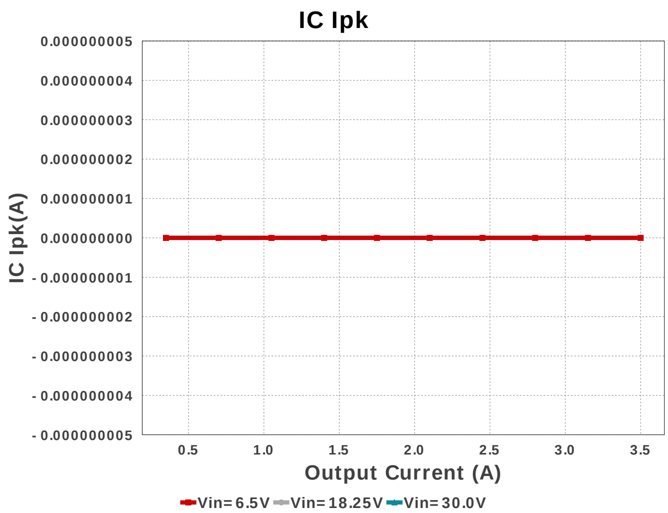

IC Tj
IC Tj(degC)
62.5
60.0
57.5
55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
32.5
30.0
27.5
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

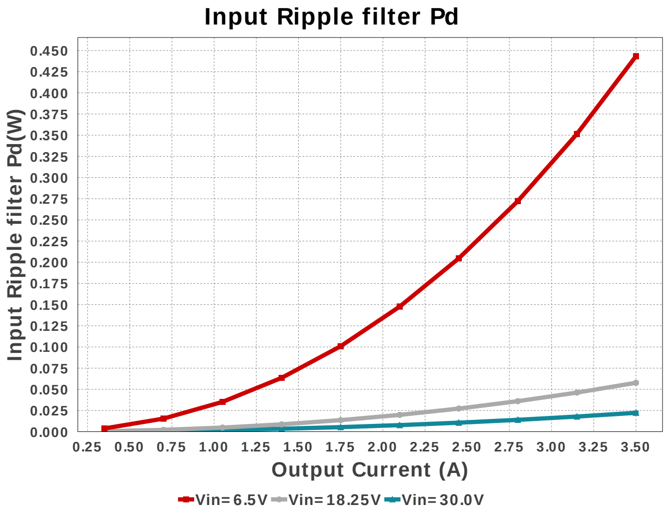

Cin Pd
Cin Pd(W)
0.00085
0.00080
0.00075
0.00070
0.00065
0.00060
0.00055
0.00050
0.00045
0.00040
0.00035
0.00030
0.00025
0.00020
0.00015
0.00010
0.00005
0.00000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

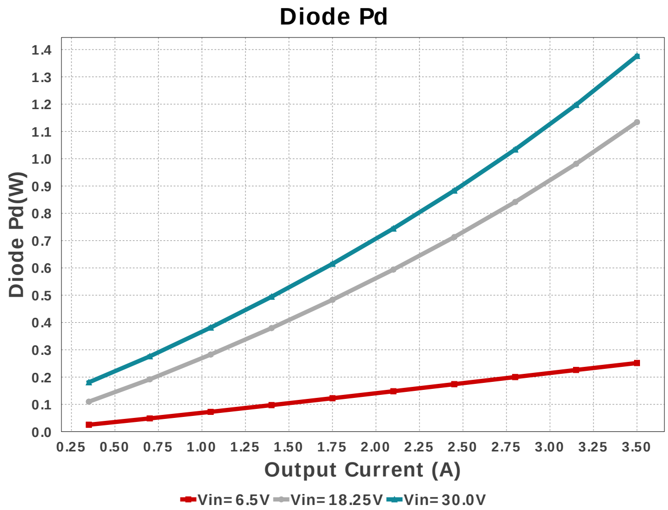

Cin IRMS
Cin IRMS(A)
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

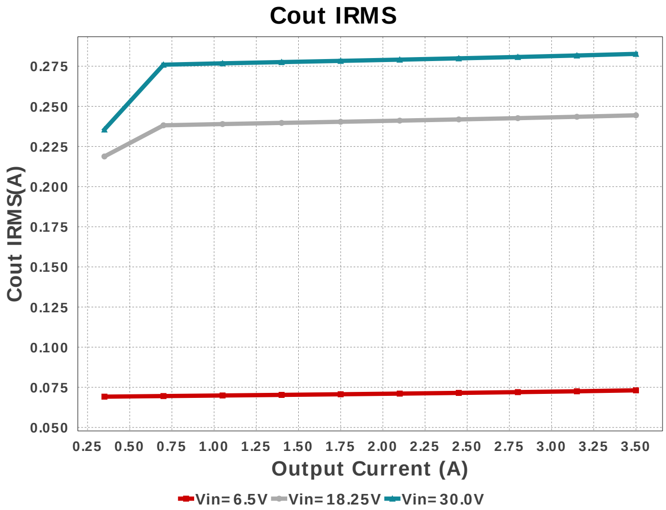

Iin Avg
Iin Avg(A)
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

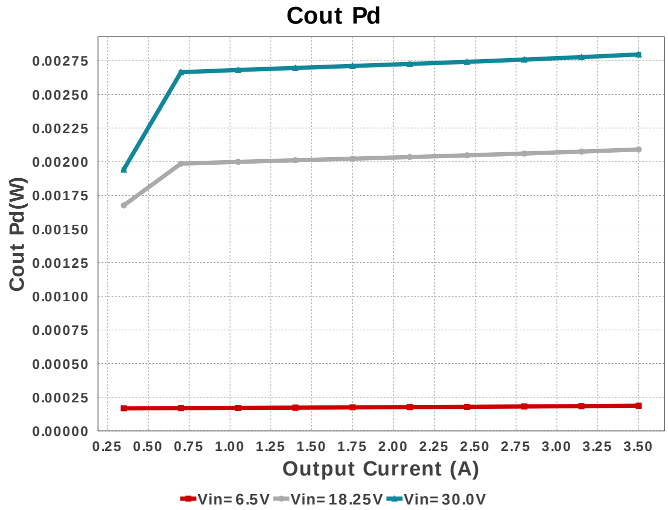

Pout
Pout(W)
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

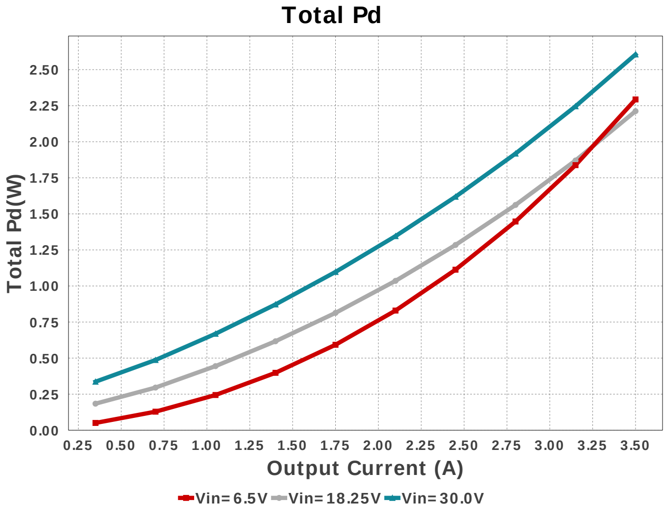

IC Ipk
IC Ipk(A)
0.000000005
0.000000004
0.000000003
0.000000002
0.000000001
0.000000000
-0.000000001
-0.000000002
-0.000000003
-0.000000004
-0.000000005
0.5 1.0 1.5 2.0 2.5 3.0 3.5
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

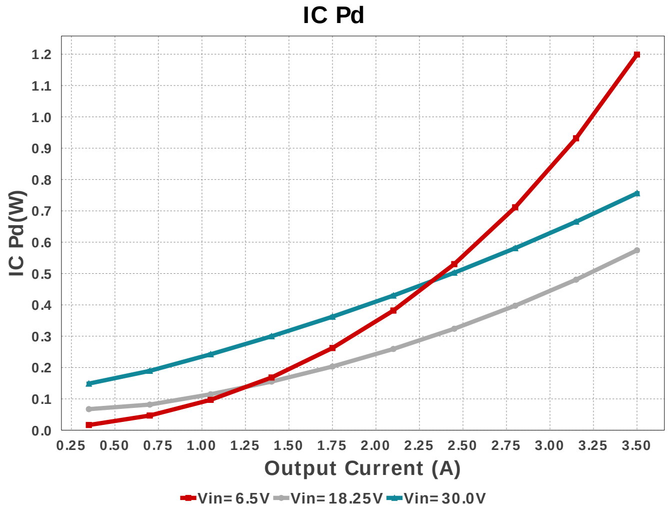

Input Ripple filter Pd
Input Ripple filter Pd(W)
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V


Diode Pd
Diode Pd(W)
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

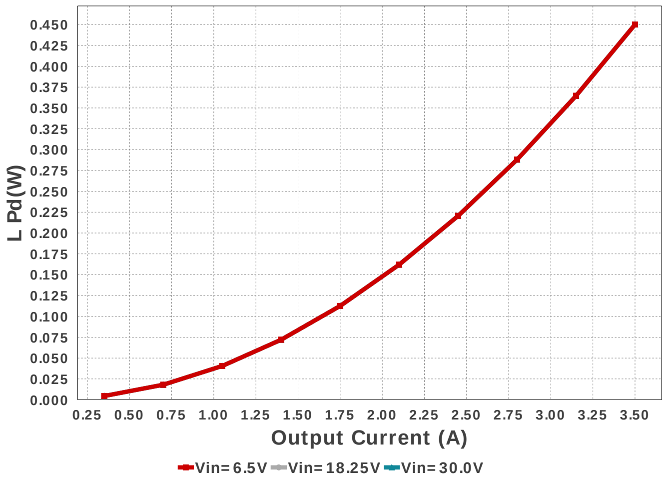

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V


Cout Pd
Cout Pd(W)
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

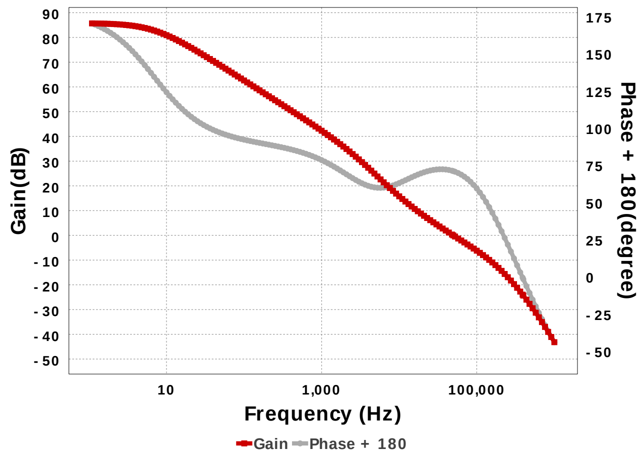

Total Pd
Total Pd(W)
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V


IC Pd
IC Pd(W)
Output Current (A)
Vin=6.5V Vin=18.25V Vin=30.0V

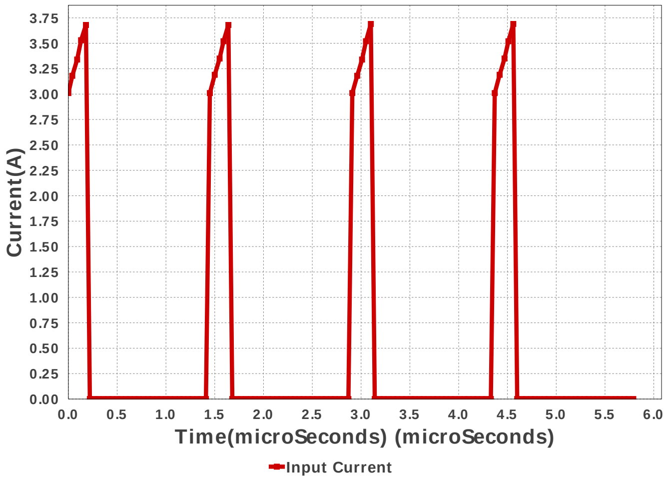
L Pd



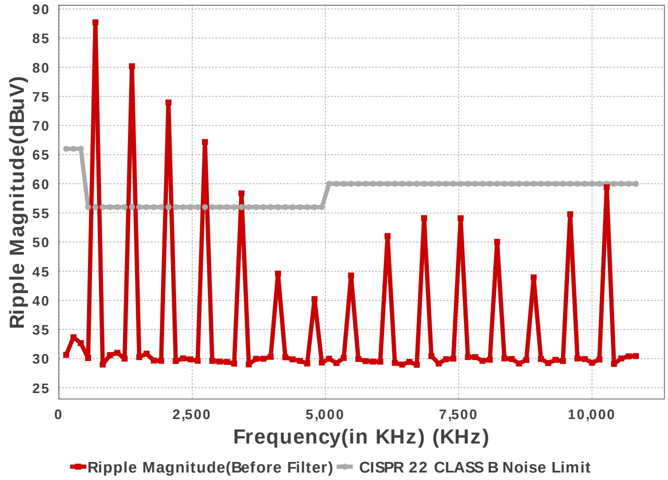
Loop Response



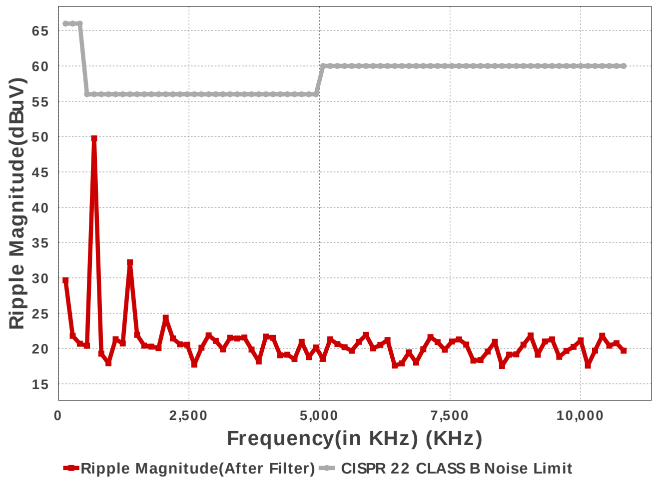
Input Current



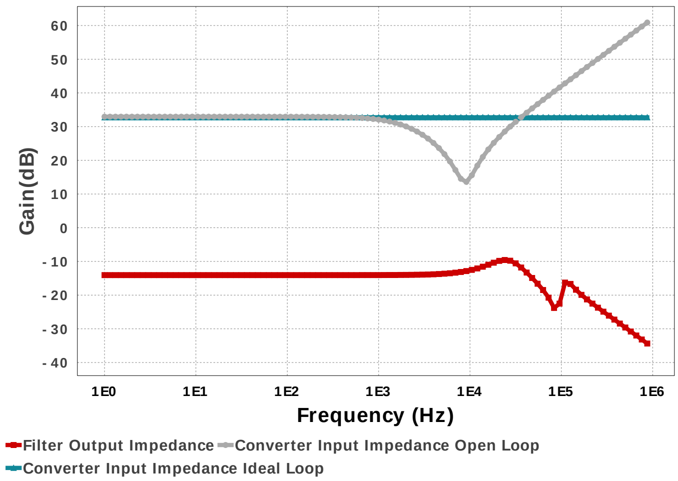
Ripple Freq Spectrum(Before Filter)

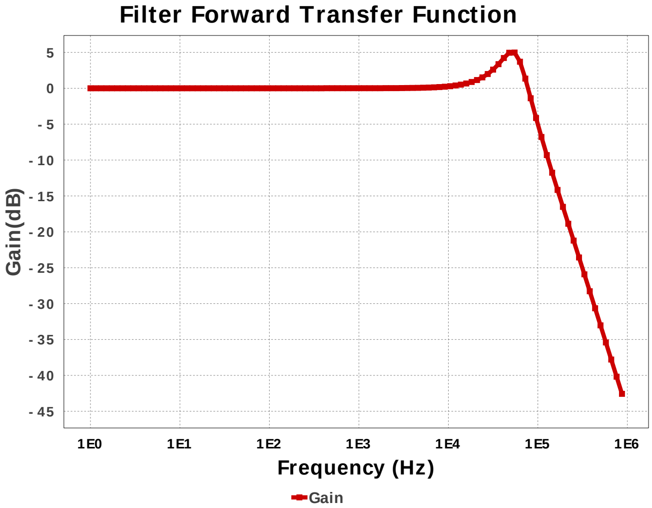


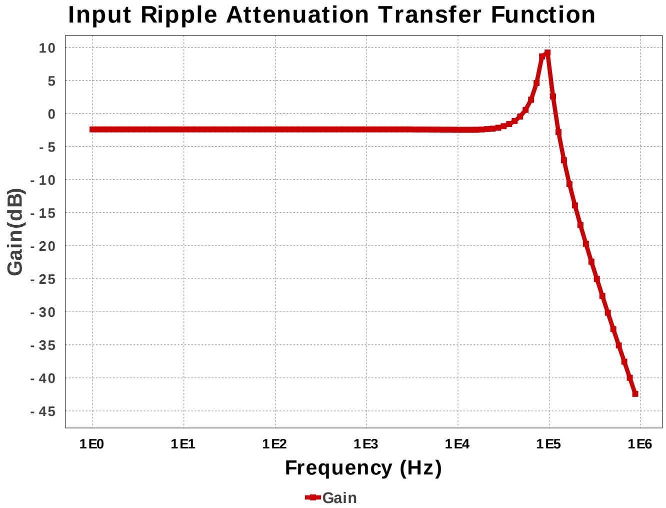
Ripple Freq Spectrum(After Filter)



Filter vs Converter Impedance Comparison







Operating Values

#	Name	Value	Category	Description
1.	BOM Count	18		Total Design BOM count
2.	Total BOM	$5.827		Total BOM Cost
3.	Cin IRMS	640.242 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	204.95 µW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	282.666 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	2.796 mW	Capacitor	Output capacitor power dissipation
7.	Diode Pd	1.377 W	Diode	Diode power dissipation
8.	Input Ripple Noise After input filter	49.74 dBuV	EMI Noise	Input Ripple Noise after filter at switching frequency
9.	Input Ripple Noise before input filter	87.7 dBuV	EMI Noise	Input Ripple Noise before filter at switching frequency
10.	Input Ripple filter Pd	22.273 mW	EMI Noise	Input Ripple Filter Power Dissipation
11.	Noise limits defined by CISPR Standards	56.0 dBuV	EMI Noise	Noise limits for CLASS B of CISPR 22 standard
12.	IC Ipk	0.0 A	IC	Peak switch current in IC
13.	IC Pd	756.08 mW	IC	IC power dissipation
14.	IC Tj	49.658 degC	IC	IC junction temperature
15.	ICThetaJA Effective	26.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
16.	Iin Avg	681.19 mA	IC	Average input current
17.	L Ipp	979.185 mA	Inductor	Peak-to-peak inductor ripple current
18.	L Pd	450.07 mW	Inductor	Inductor power dissipation
19.	Cin Pd	204.95 µW	Power	Input capacitor power dissipation
20.	Cout Pd	2.796 mW	Power	Output capacitor power dissipation
21.	Diode Pd	1.377 W	Power	Diode power dissipation
22.	IC Pd	756.08 mW	Power	IC power dissipation
23.	Input Ripple filter Pd	22.273 mW	Power	Input Ripple Filter Power Dissipation
24.	L Pd	450.07 mW	Power	Inductor power dissipation
25.	Total Pd	2.605 W	Power	Total Power Dissipation
26.	Cross Freq	49.736 kHz	System Information	Bode plot crossover frequency
27.	Duty Cycle	18.318 %	System Information	Duty cycle
28.	Efficiency	87.251 %	System Information	Steady state efficiency
29.	FootPrint	434.0 mm^2	System Information	Total Foot Print Area of BOM components
30.	Frequency	685.024 kHz	System Information	Switching frequency
31.	Gain Marg	-23.973 dB	System Information	Bode Plot Gain Margin
32.	Iout	3.5 A	System Information	Iout operating point
33.	Low Freq Gain	85.68 dB	System Information	Gain at 1Hz
34.	Mode	CCM	System Information	Conduction Mode
35.	Phase Marg	71.667 deg	System Information	Bode Plot Phase Margin
36.	Pout	17.85 W	System Information	Total output power
37.	Vin	30.0 V	System Information	Vin operating point

#	Name	Value	Category	Description
38.	Vout	5.1 V	System Information	Operational Output Voltage
39.	Vout Actual	5.098 V	System Information	Vout Actual calculated based on selected voltage divider resistors
40.	Vout Tolerance	2.72 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
41.	Vout p-p	34.271 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	3.5	Maximum Output Current
VinMax	30.0	Maximum input voltage
VinMin	6.5	Minimum input voltage
Vout	5.1	Output Voltage
base_pn	TPS54360B-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

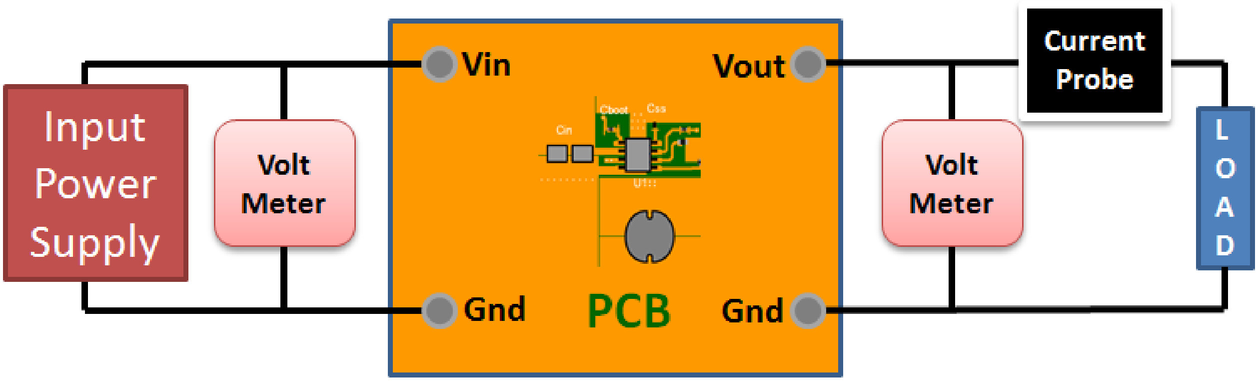
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 6.5V 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 TPS54360B-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 : 305710B8CC4DC84B[v1]

3. **TPS54360B-Q1** Product Folder : http://www.ti.com/product/TPS54360B%2DQ1 : contains the data sheet and other resources.

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