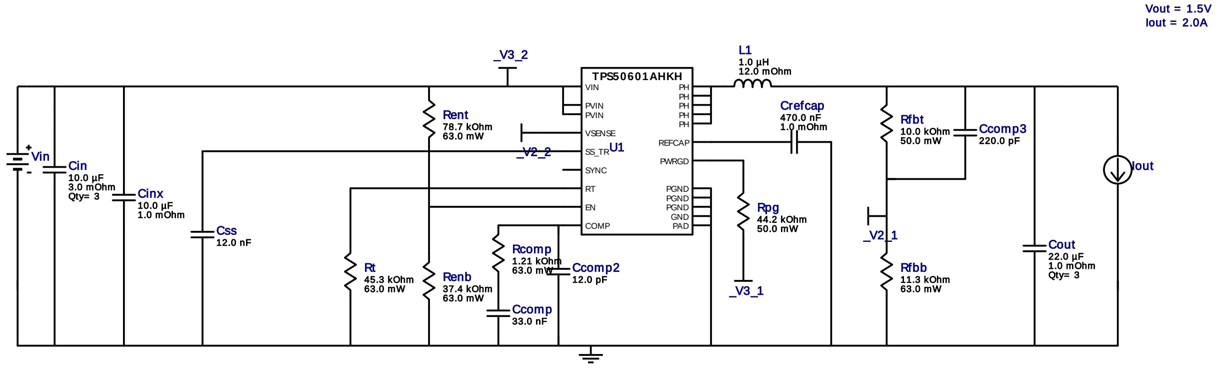
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 3.2V
VinMax = 3.4V
Vout = 1.5V
Iout = 2.0A

Device = TPS50601AHKWEM
Topology = Buck
Created = 2020-12-17 00:48:14.092
BOM Cost = $3.38
BOM Count = 21
Total Pd = 0.67W

Design : 6639 TPS50601AHKWEM
TPS50601AHKWEM 3V-6V to 1.80V @ 5A



1. This regulator device is qualified for harsh environment applications. All passives and other components selected in this design may not be qualified for harsh environment applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.To select smaller inductor adjust inductor peak to peak current. Go to "Use Advanced Options" and enter the current ripple percentage in the box provided . View WEBENCH(R) Disclaimer.

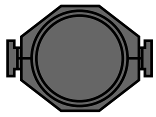
Design Alerts

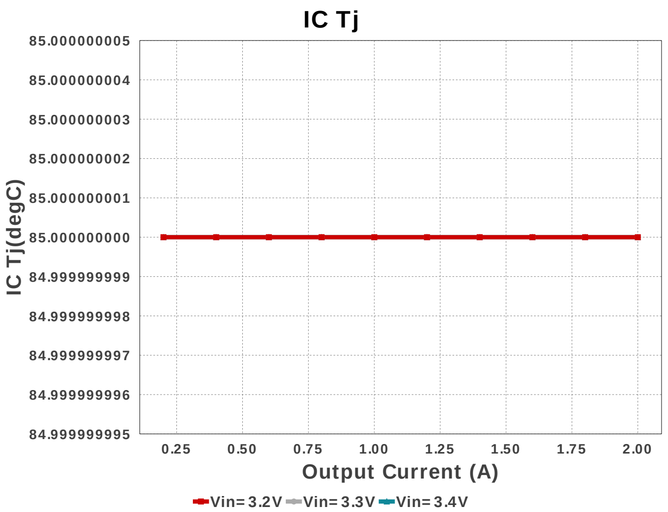
Component Selection Information

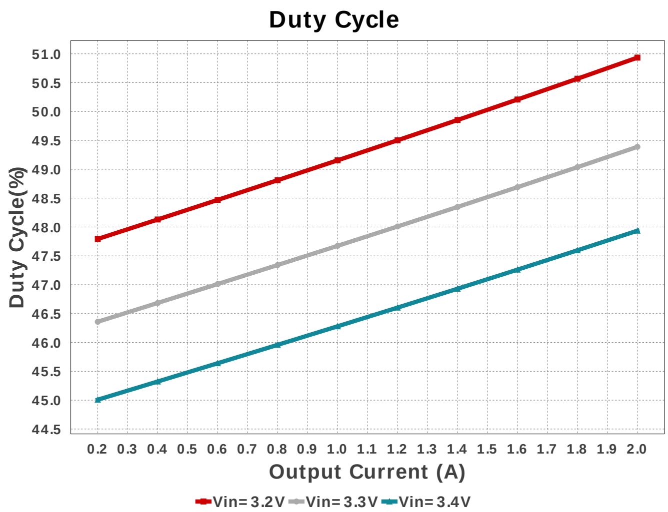
The TPS50601A-SP is qualified for harsh environment applications. All passives and other components selected in this design may not be qualified for harsh environment applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application. This part is targeted for Space application, hence No air is considered for temperature calculation. User must evaluate thermals for their system based on the application.

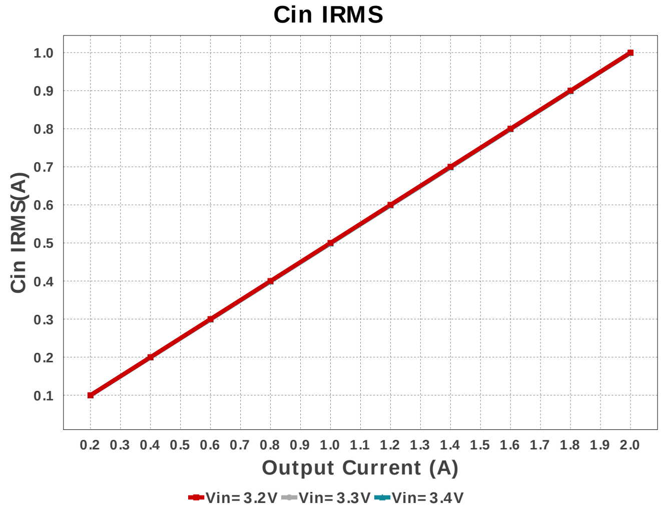
Electrical BOM

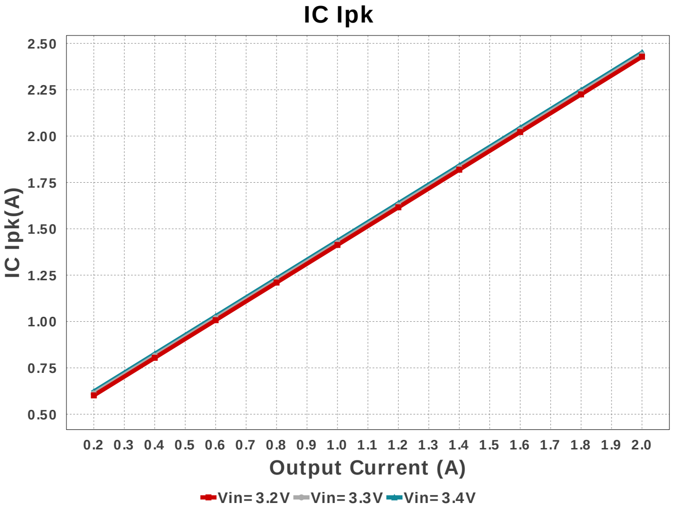
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Ccomp	TDK	CGA4J2C0G1H333J125AA Series= C0G/NP0	Cap= 33.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.09	0805 7 mm^2
Ccomp2	Yageo	CC0805JRNPO9BN120 Series= C0G/NP0	Cap= 12.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Ccomp3	Samsung Electro-Mechanics	CL21C221JBANNNC Series= C0G/NP0	Cap= 220.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	Kemet	C0805C106K8PACTU Series= X5R	Cap= 10.0 uF ESR= 3.0 mOhm VDC= 10.0 V IRMS= 11.43 A	3	$0.03	0805 7 mm^2
Cinx	Taiyo Yuden	LMK212BJ106KG-T Series= X5R	Cap= 10.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0805 7 mm^2
Cout	MuRata	GRM188R60J226MEA0D Series= X5R	Cap= 22.0 uF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 6.0 A	3	$0.05	0603 5 mm^2
Crefcap	MuRata	GRM188R61E474KA12D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.04	0603 5 mm^2
Css	Kemet	C0603C123J3GACTU Series= C0G/NP0	Cap= 12.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.11	0603 5 mm^2

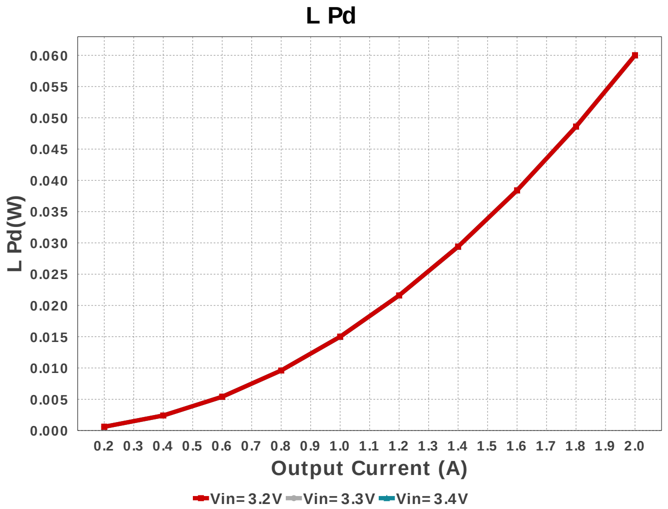
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
L1	NIC Components	NPI31P1R0MTRF	L= 1.0 µH 12.0 mOhm	1	$0.29	 IND_NPI31P 185 mm^2
Rcomp	Vishay-Dale	CRCW04021K21FKED Series= CRCW..e3	Res= 1.21 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Renb	Vishay-Dale	CRCW040237K4FKED Series= CRCW..e3	Res= 37.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rent	Vishay-Dale	CRCW040278K7FKED Series= CRCW..e3	Res= 78.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbb	Vishay-Dale	CRCW040211K3FKED Series= CRCW..e3	Res= 11.3 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rfbt	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rpg	Vishay-Dale	CRCW020144K2FNED Series= ?	Res= 44.2 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm^2
Rt	Vishay-Dale	CRCW040245K3FKED Series= CRCW..e3	Res= 45.3 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
U1	Texas Instruments	TPS50601AHKWEM	Switcher	1	$2.50	HKW0020A 246 mm^2

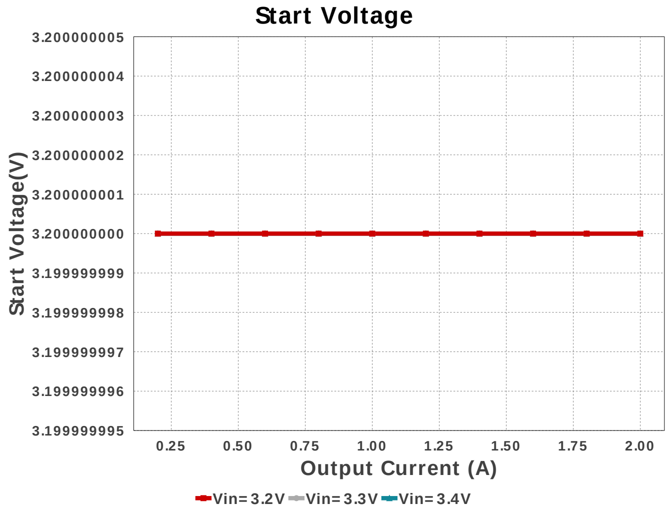


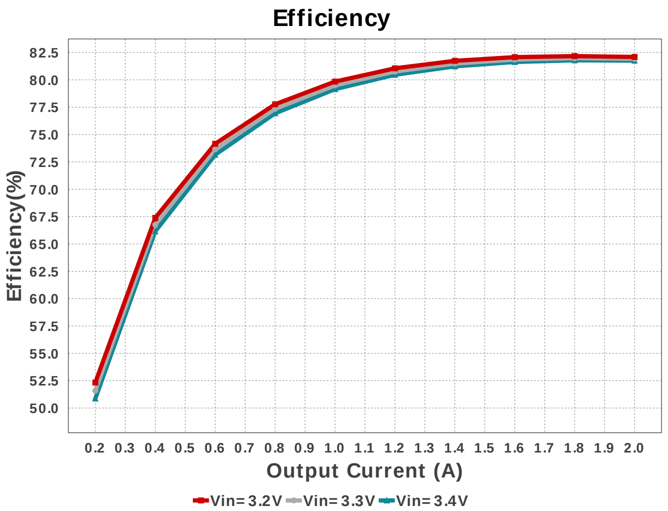


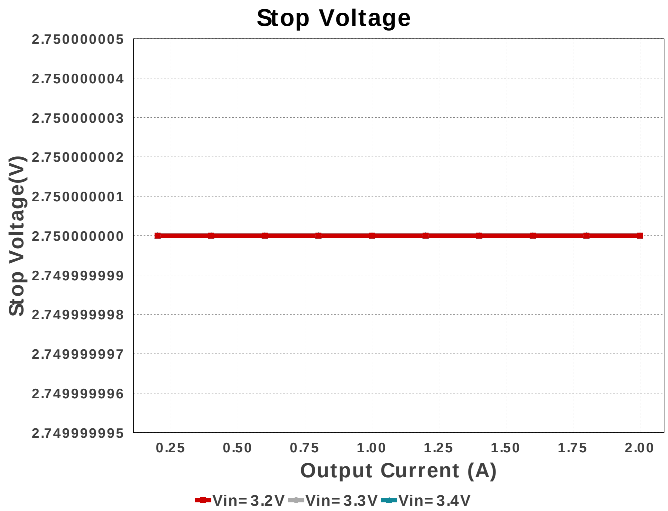

Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=3.2V Vin=3.3V Vin=3.4V

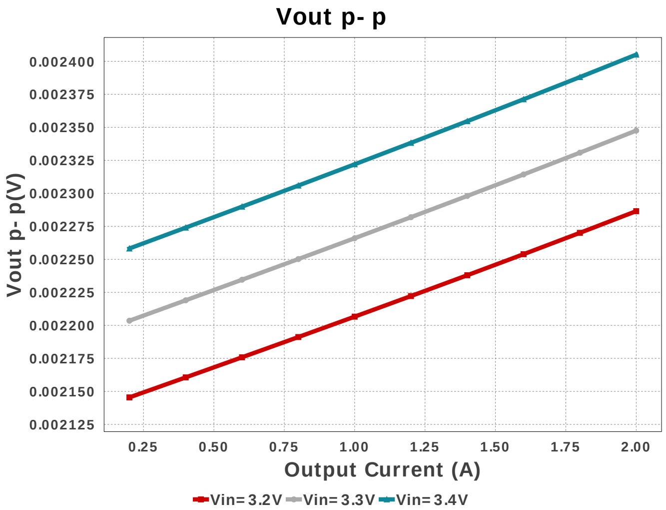

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=3.2V Vin=3.3V Vin=3.4V

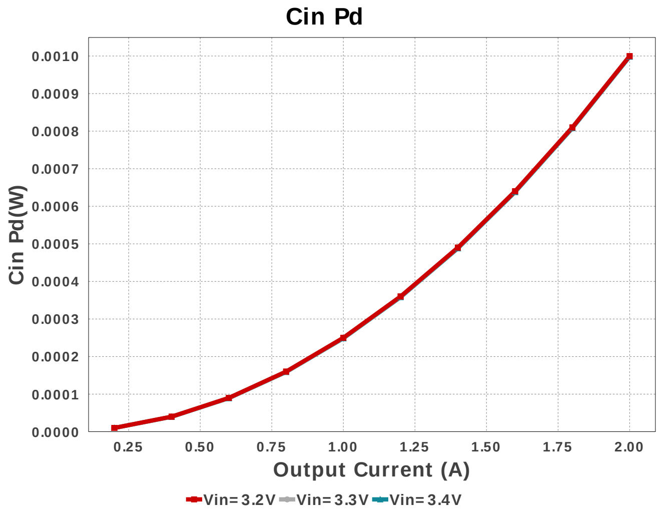

L Pd
L Pd(W)
Output Current (A)
Vin=3.2V Vin=3.3V Vin=3.4V

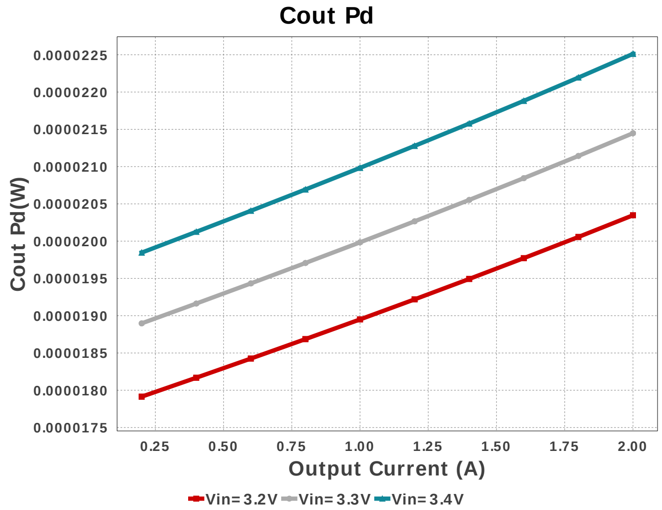

Start Voltage
Start Voltage(V)
Output Current (A)
Vin=3.2V Vin=3.3V Vin=3.4V

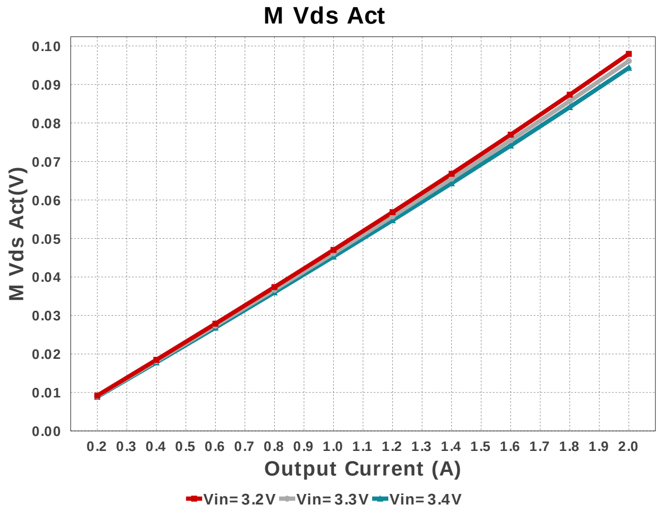

Efficiency
Efficiency(%)
Output Current (A)
Vin=3.2V Vin=3.3V Vin=3.4V

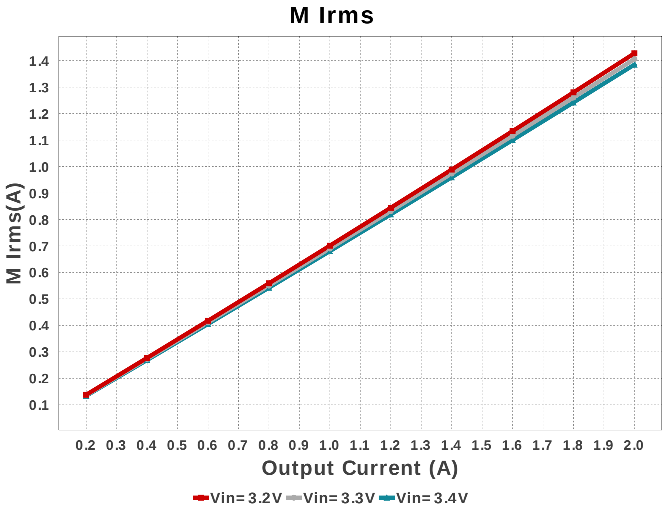

Stop Voltage
Stop Voltage(V)
Output Current (A)
Vin=3.2V Vin=3.3V Vin=3.4V

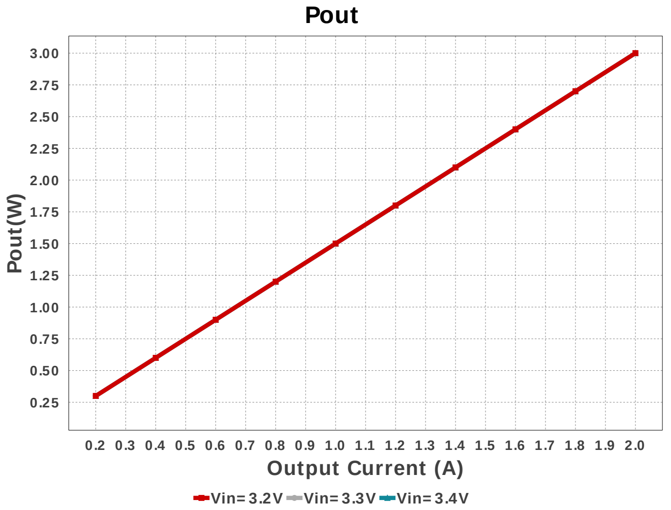

Vout p- p
Vout p- p(V)
0.002400
0.002375
0.002350
0.002325
0.002300
0.002275
0.002250
0.002225
0.002200
0.002175
0.002150
0.002125
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin= 3.2V Vin= 3.3V Vin= 3.4V


Cin Pd
Cin Pd(W)
0.0010
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin= 3.2V Vin= 3.3V Vin= 3.4V

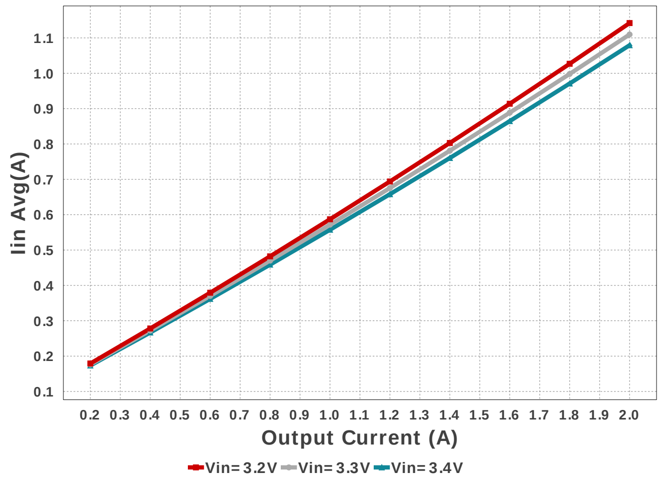

Cout Pd
Cout Pd(W)
0.0000225
0.0000220
0.0000215
0.0000210
0.0000205
0.0000200
0.0000195
0.0000190
0.0000185
0.0000180
0.0000175
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin= 3.2V Vin= 3.3V Vin= 3.4V


M Vds Act
M Vds Act(V)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 3.2V Vin= 3.3V Vin= 3.4V

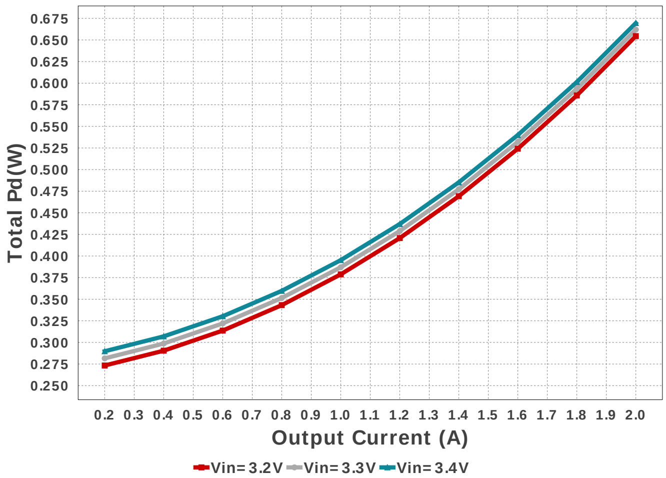

M Irms
M Irms(A)
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 3.2V Vin= 3.3V Vin= 3.4V


Pout
Pout(W)
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 3.2V Vin= 3.3V Vin= 3.4V

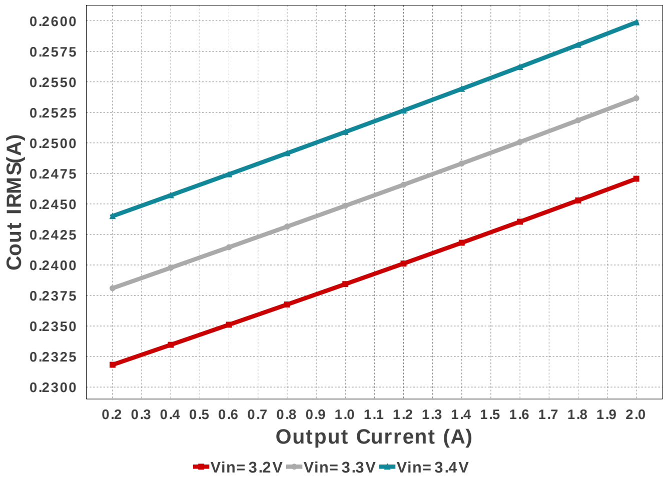
Iin Avg



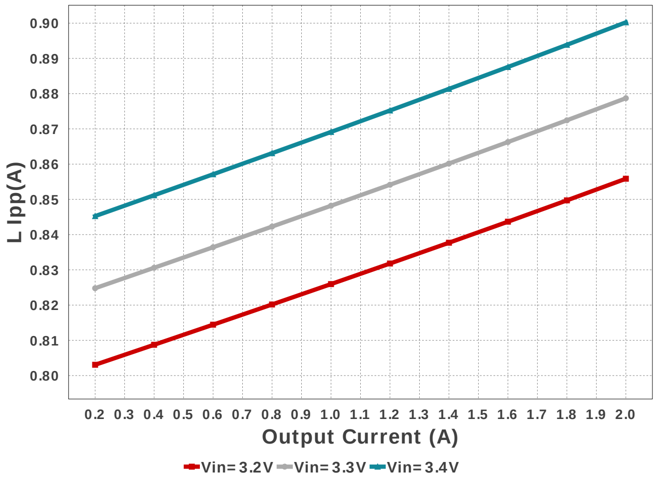
Total Pd



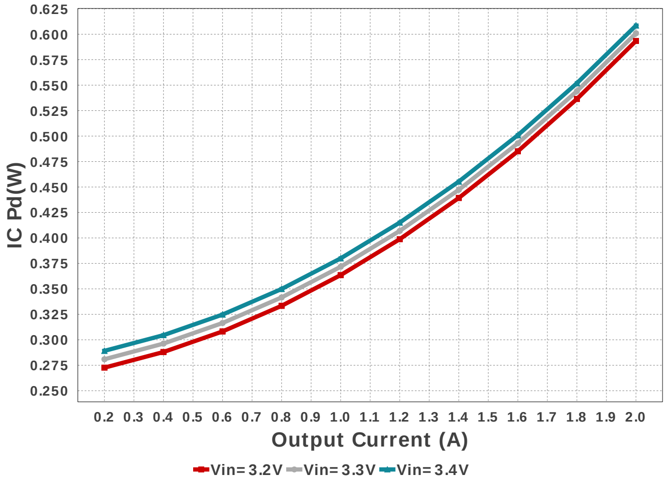
Cout IRMS



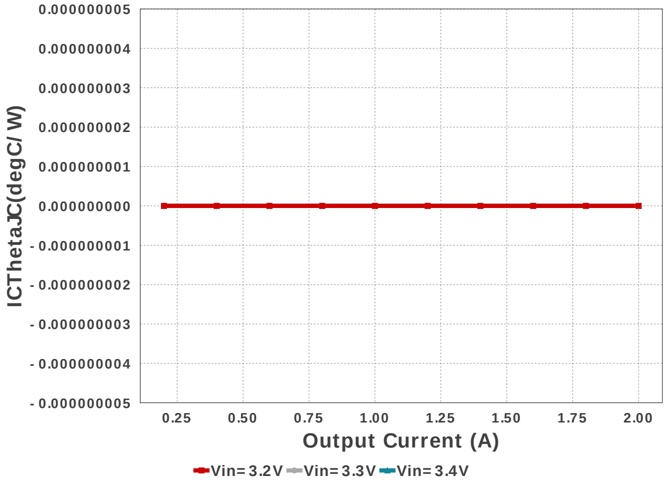
L Ipp

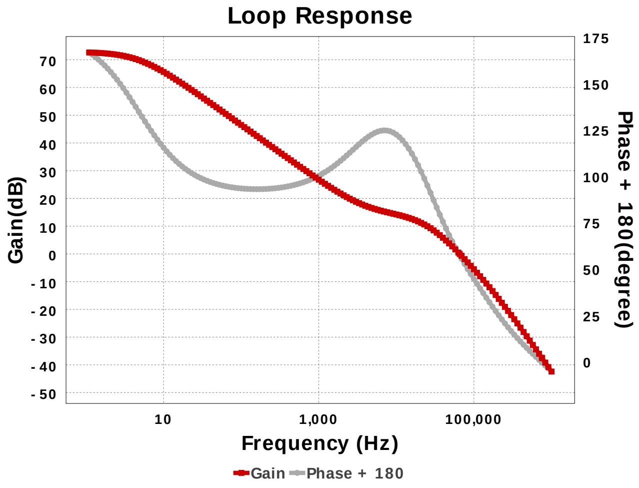


IC Pd



ICThetaJC





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	999.147 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	998.3 µW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	259.875 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	22.512 µW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	2.45 A	IC	Peak switch current in IC
6.	IC Pd	608.5 mW	IC	IC power dissipation
7.	IC Tj	85.0 degC	IC	IC junction temperature
8.	IC Tolerance	8.0 mV	IC	IC Feedback Tolerance
9.	ICThetaJA	39.9 degC/W	IC	IC junction-to-ambient thermal resistance
10.	ICThetaJC	0.0 degC/W	IC	IC Junction to case temperature
11.	Iin Avg	1.079 A	IC	Average input current
12.	L Ipp	900.23 mA	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	60.0 mW	Inductor	Inductor power dissipation
14.	M1 Irms	1.385 A	Mosfet	Q Iavg
15.	M Vds Act	94.32 mV	Mosfet	Voltage drop across the MosFET
16.	Cin Pd	998.3 µW	Power	Input capacitor power dissipation
17.	Cout Pd	22.512 µW	Power	Output capacitor power dissipation
18.	IC Pd	608.5 mW	Power	IC power dissipation
19.	L Pd	60.0 mW	Power	Inductor power dissipation
20.	Total Pd	669.559 mW	Power	Total Power Dissipation
21.	BOM Count	21	System Information	Total Design BOM count
22.	Cross Freq	65.602 kHz	System Information	Bode plot crossover frequency
23.	Duty Cycle	47.936 %	System Information	Duty cycle
24.	Efficiency	81.754 %	System Information	Steady state efficiency
25.	FootPrint	521.0 mm^2	System Information	Total Foot Print Area of BOM components
26.	Frequency	1.012 MHz	System Information	Switching frequency
27.	Gain Marg	-37.425 dB	System Information	Bode Plot Gain Margin
28.	Iout	2.0 A	System Information	Iout operating point
29.	Low Freq Gain	72.655 dB	System Information	Gain at 1Hz
30.	Mode	CCM	System Information	Conduction Mode
31.	Phase Marg	57.668 deg	System Information	Bode Plot Phase Margin
32.	Pout	3.0 W	System Information	Total output power
33.	Start Voltage	3.2 V	System Information	Start Voltage with External UVLO Resistors
34.	Stop Voltage	2.75 V	System Information	Stop Voltage with External UVLO Resistors
35.	Total BOM	$3.38	System Information	Total BOM Cost
36.	Vin	3.4 V	System Information	Vin operating point

#	Name	Value	Category	Description
37.	Vout	1.5 V	System Information	Operational Output Voltage
38.	Vout Actual	1.499 V	System Information	Vout Actual calculated based on selected voltage divider resistors
39.	Vout Tolerance	1.964 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
40.	Vout p-p	2.405 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
SoftStart	3.5 ms	Soft Start Time (ms)
VinMax	3.4	Maximum input voltage
VinMin	3.2	Minimum input voltage
Vout	1.5	Output Voltage
base_pn	TPS50601A-SP	Base Product Number
source	DC	Input Source Type
Ta	85.0	Ambient temperature
UserFsw	1000.0 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

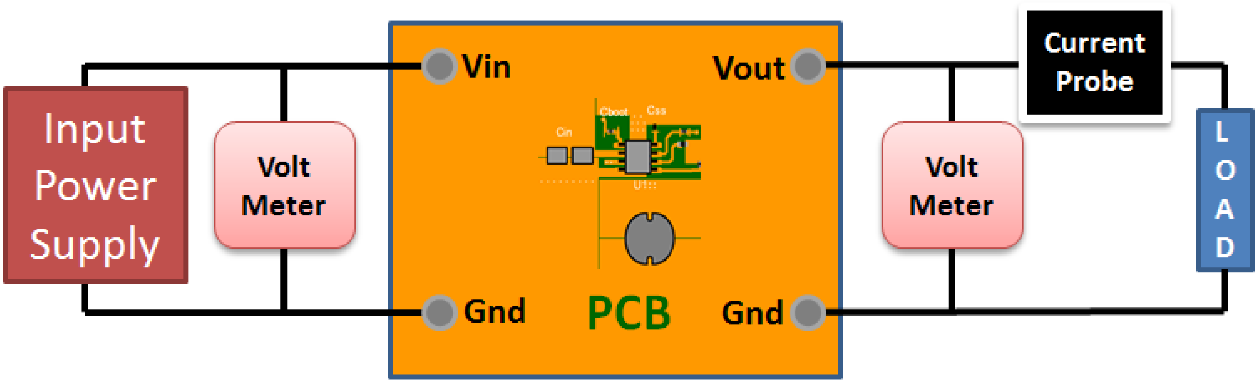
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 3.2V 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 TPS50601A-SPis qualified for harsh environment applications. All passives and other components selected in this design may not be qualified for harsh environment 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 : AE3011FD2EE8F4EB[v1]

3. **TPS50601A-SP** Product Folder : http://www.ti.com/product/TPS50601A%2DSP : 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.