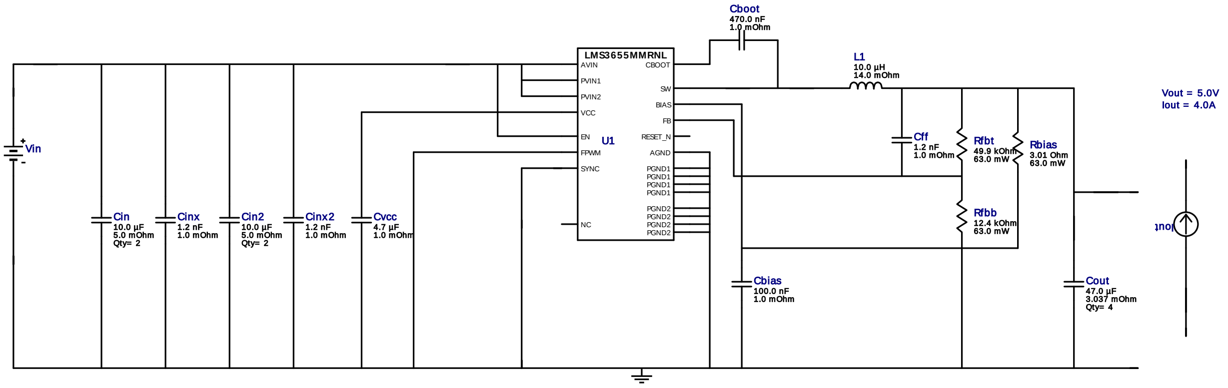
VinMin = 16.5V
VinMax = 19.0V
Vout = 5.0V
Iout = 4.0A

Device = LMS3655MRNLR
Topology = Buck
Created = 2019-12-25 17:46:19.294
BOM Cost = $6.82
BOM Count = 19
Total Pd = 1.44W

WEBENCH ® Design Report

Design : 38 LMS3655MRNLR
LMS3655MRNLR 16.5V-19V to 5.00V @ 4A



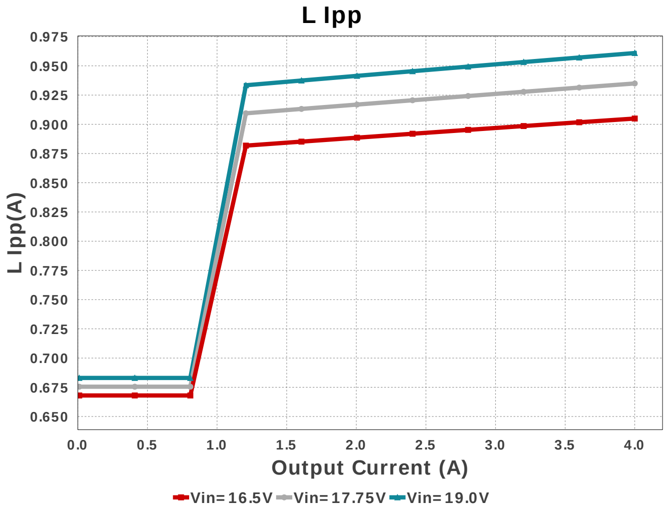
1. The input capacitor included in the BOM only contains a small filter capacitor that should be placed near the IC. Depending on where the power supply is laid out in the system additional bulk capacitance may need to be added to filter the line ripple.

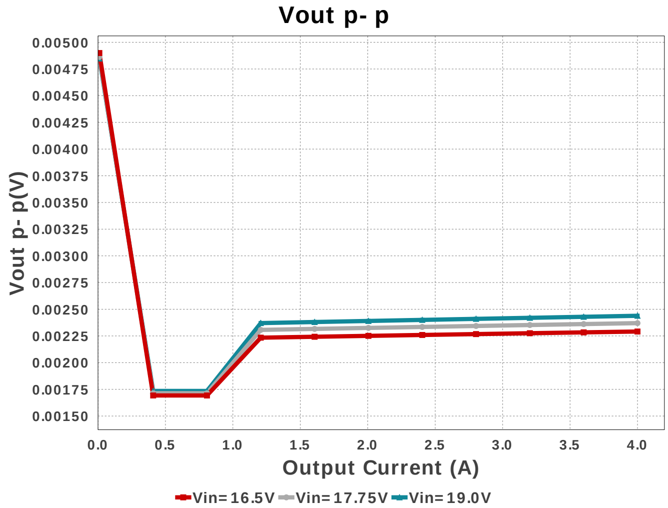
2. If there is no VinTyp specified, WEBENCH will use the VinMax value. To change the VinTyp value, click on the "Change Design Inputs" button under the Optimization Tuning knob. In some applications, while the design requires the input voltage to be a wide range, for a majority of the time, it is operating at a much lower voltage than the maximum input voltage. Sizing the inductor based on the maximum input voltage may yield an inductance much larger than typically needed, causing a larger footprint for the overall design. At the same time, components such as the input capacitor must be rated based on the maximum input voltage. WEBENCH now supports the use of this additional input voltage specification.

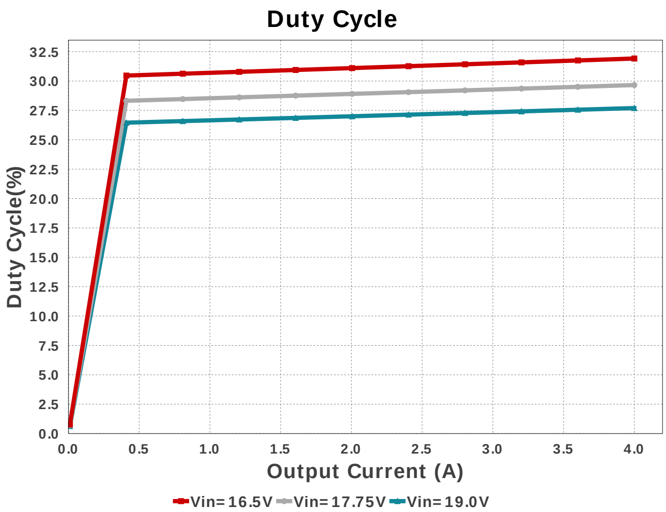
Electrical BOM

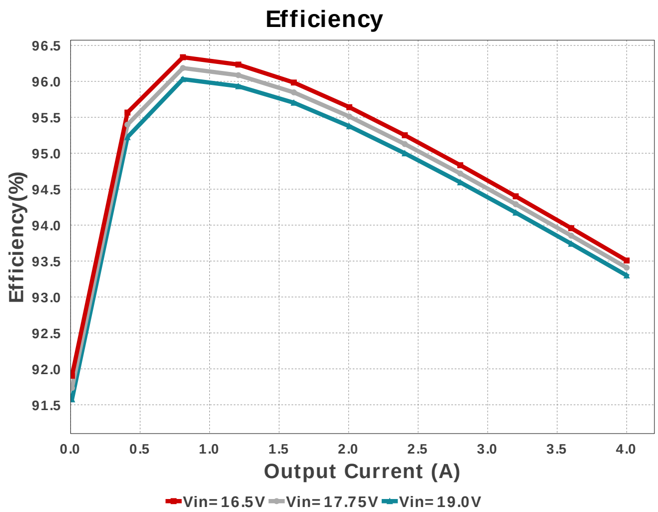
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbias	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cboot	MuRata	GRM155R60J474KE19D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 6.3 V IRMS= 0.0 A	1	$0.02	0402 3 mm^2
Cff	MuRata	GRM216R71E122KA01D Series= X7R	Cap= 1.2 nF ESR= 1.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Cin	Samsung Electro-Mechanics	CL32B106KBJNNWE Series= X7R	Cap= 10.0 uF ESR= 5.0 mOhm VDC= 50.0 V IRMS= 0.0 A	2	$0.17	1210_270 15 mm^2
Cin2	Samsung Electro-Mechanics	CL32B106KBJNNWE Series= X7R	Cap= 10.0 uF ESR= 5.0 mOhm VDC= 50.0 V IRMS= 0.0 A	2	$0.17	1210_270 15 mm^2
Cinx	MuRata	GRM155R71H122KA01D Series= X7R	Cap= 1.2 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
Cinx2	MuRata	GRM155R71H122KA01D Series= X7R	Cap= 1.2 nF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2

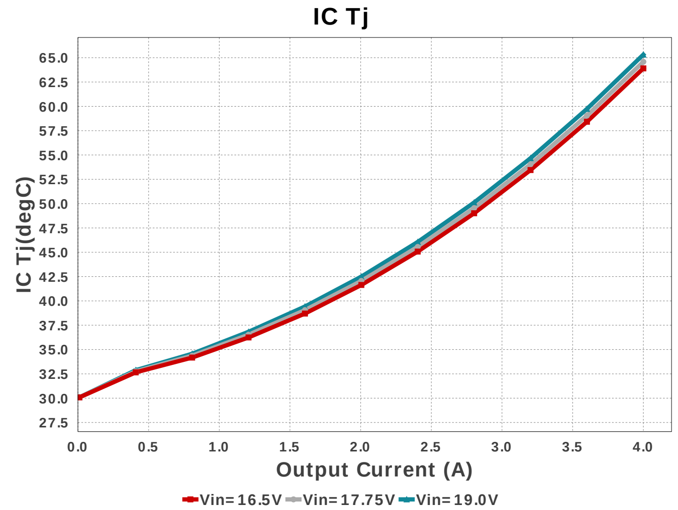
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	MuRata	GRM32ER61C476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.037 mOhm VDC= 16.0 V IRMS= 4.59346 A	4	$0.38	1210_280 15 mm²
Cvcc	Taiyo Yuden	LMK212BJ475KD-T Series= X5R	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.03	0805 7 mm²
L1	Coiltronics	HC9-100-R	L= 10.0 µH 14.0 mOhm	1	$1.70	HC9 243 mm²
Rbias	Vishay-Dale	CRCW04023R01FKED Series= CRCW..e3	Res= 3.01 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Vishay-Dale	CRCW040212K4FKED Series= CRCW..e3	Res= 12.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbt	Vishay-Dale	CRCW040249K9FKED Series= CRCW..e3	Res= 49.9 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
U1	Texas Instruments	LMS3655MRNLR	Switcher	1	$2.80	RNL0022A 42 mm²

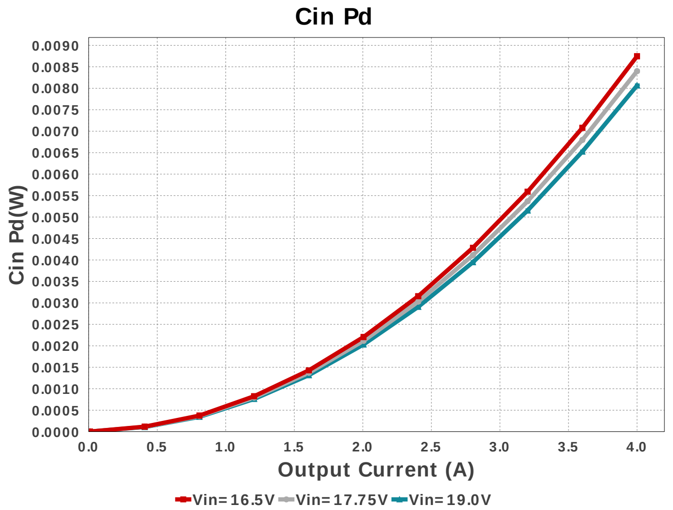


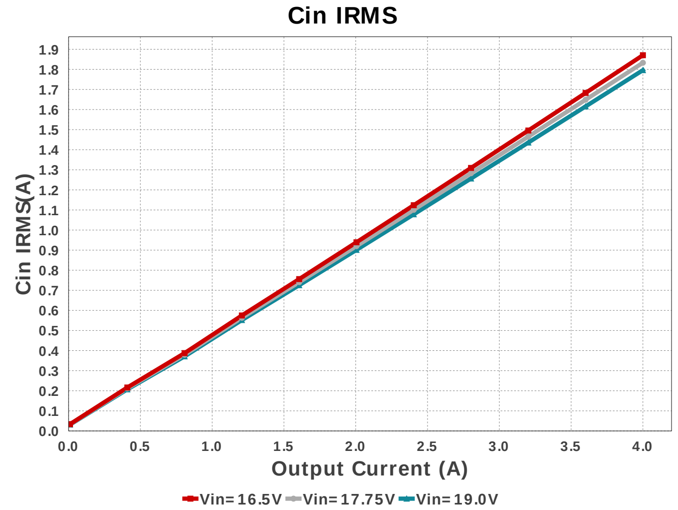


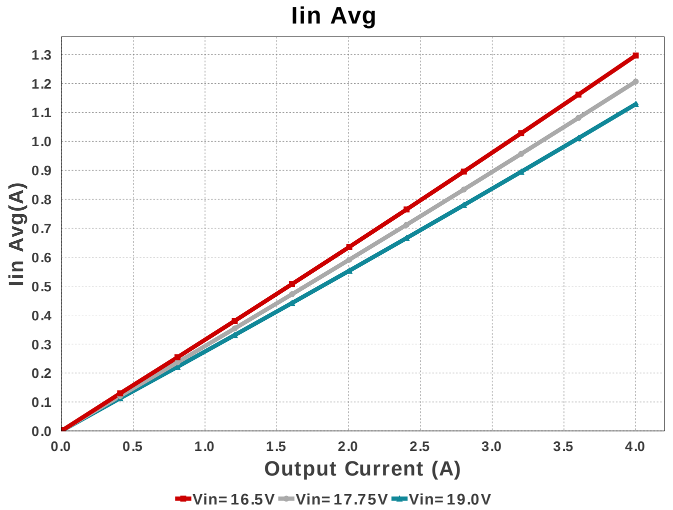


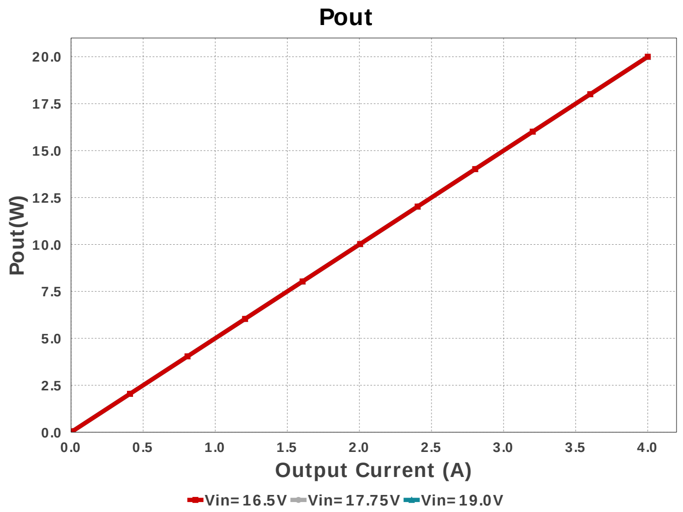


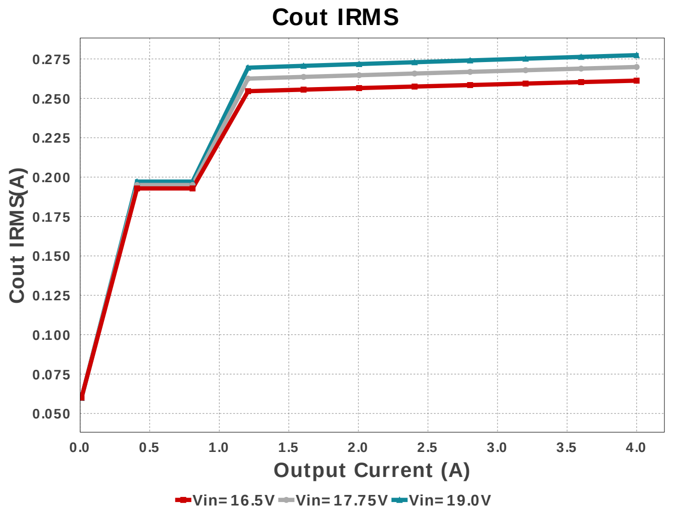

IC Tj
IC Tj(degC)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V

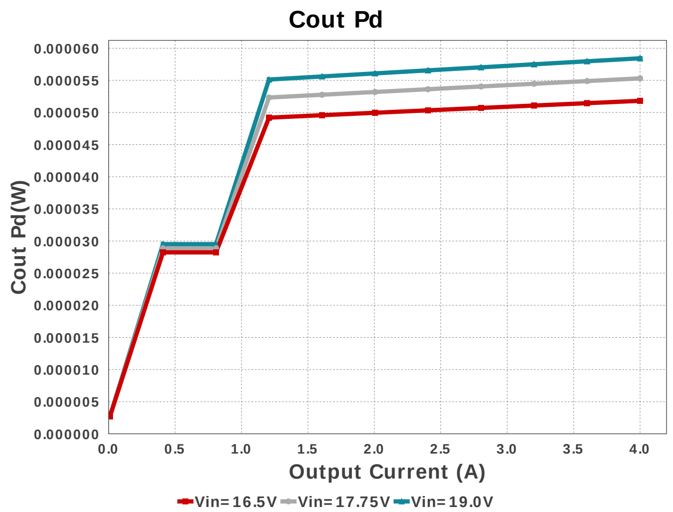

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V


Cin IRMS
Cin IRMS(A)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V

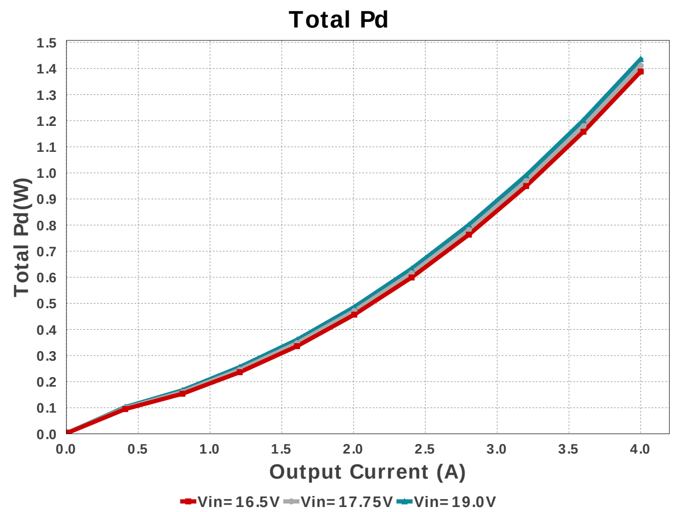

Iin Avg
Iin Avg(A)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V


Pout
Pout(W)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V

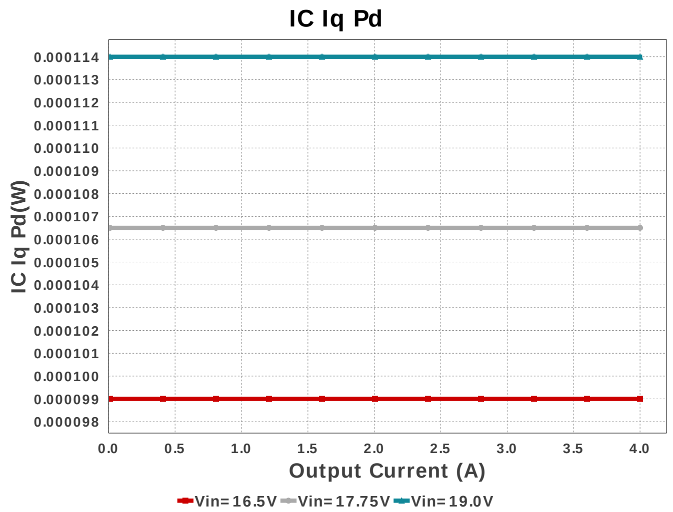

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V



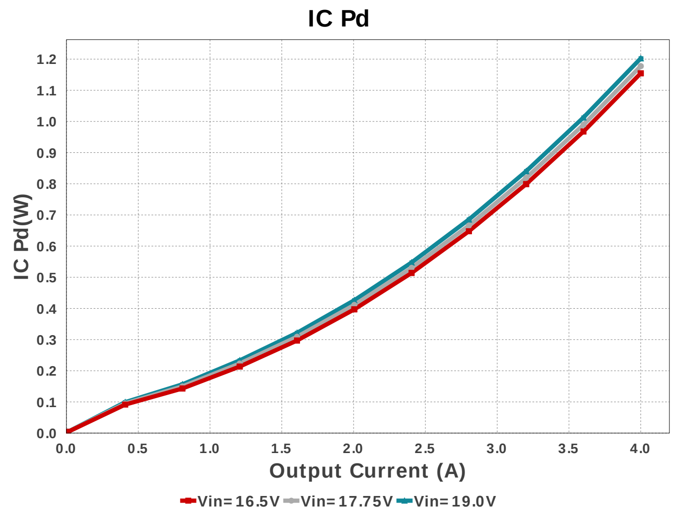
Cout Pd
Cout Pd(W)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V



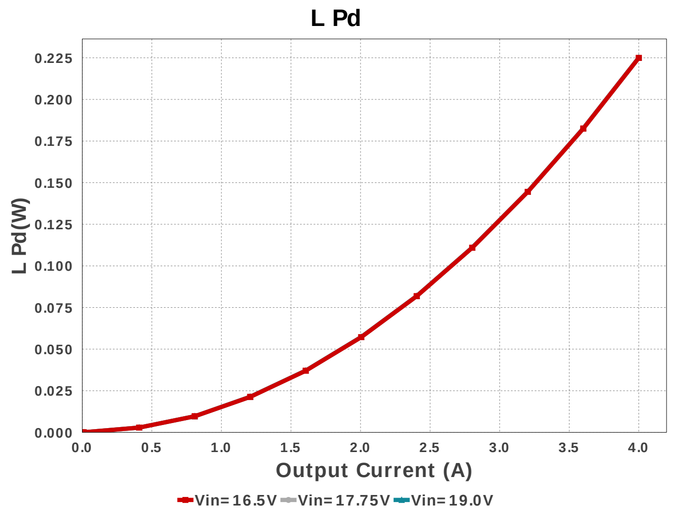
Total Pd
Total Pd(W)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V



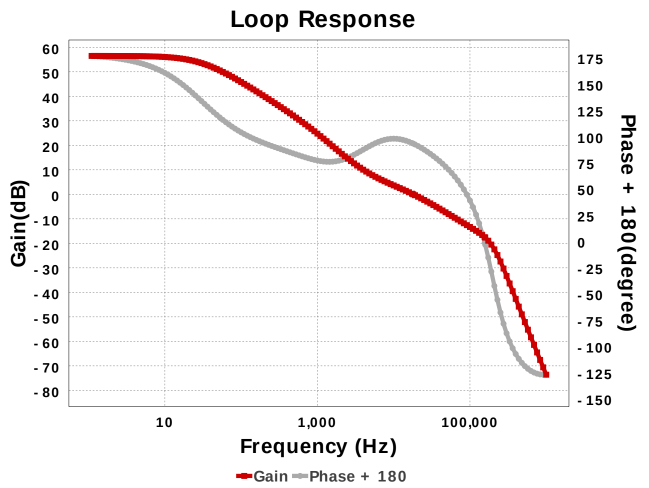
IC Iq Pd
IC Iq Pd(W)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V



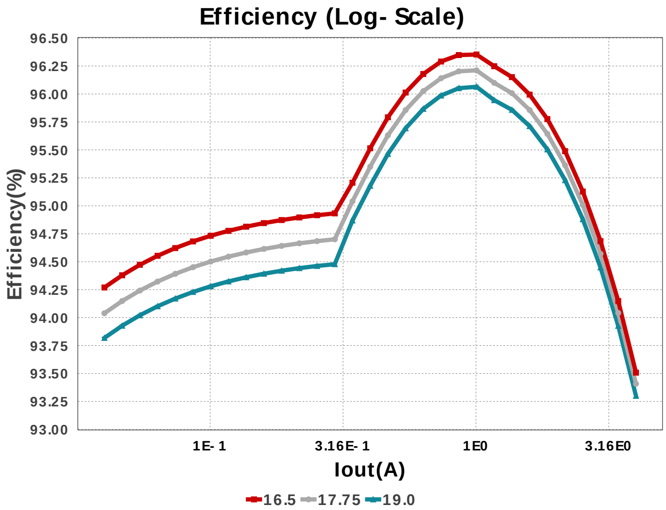
IC Pd
IC Pd(W)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V



L Pd
L Pd(W)
Output Current (A)
Vin=16.5V Vin=17.75V Vin=19.0V



Loop Response
Gain(dB)
Phase + 180(degree)
Frequency (Hz)
Gain Phase + 180



Operating Values

#	Name	Value	Category	Description
1.	BOM Count	19		Total Design BOM count
2.	Total BOM	$6.82		Total BOM Cost
3.	Cin IRMS	1.796 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	8.064 mW	Capacitor	Input capacitor power dissipation
5.	Cout IRMS	277.41 mA	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	58.429 µW	Capacitor	Output capacitor power dissipation
7.	IC Iq Pd	114.0 µW	IC	IC Iq Pd
8.	IC Pd	1.202 W	IC	IC power dissipation
9.	IC Tj	65.318 degC	IC	IC junction temperature
10.	ICThetaJA	29.4 degC/W	IC	IC junction-to-ambient thermal resistance
11.	Iin Avg	1.128 A	IC	Average input current
12.	L Ipp	960.976 mA	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	225.08 mW	Inductor	Inductor power dissipation
14.	Cin Pd	8.064 mW	Power	Input capacitor power dissipation
15.	Cout Pd	58.429 µW	Power	Output capacitor power dissipation
16.	IC Pd	1.202 W	Power	IC power dissipation
17.	L Pd	225.08 mW	Power	Inductor power dissipation
18.	Total Pd	1.436 W	Power	Total Power Dissipation
19.	Cross Freq	18.037 kHz	System Information	Bode plot crossover frequency
20.	Duty Cycle	27.7 %	System Information	Duty cycle
21.	Efficiency	93.3 %	System Information	Steady state efficiency
22.	FootPrint	437.0 mm^2	System Information	Total Foot Print Area of BOM components
23.	Frequency	400.0 kHz	System Information	Switching frequency
24.	Gain Marg	-17.472 dB	System Information	Bode Plot Gain Margin
25.	Iout	4.0 A	System Information	Iout operating point
26.	Low Freq Gain	56.473 dB	System Information	Gain at 1Hz
27.	Mode	CCM	System Information	Conduction Mode
28.	Phase Marg	94.414 deg	System Information	Bode Plot Phase Margin
29.	Pout	20.0 W	System Information	Total output power
30.	Vin	19.0 V	System Information	Vin operating point
31.	Vout	5.0 V	System Information	Operational Output Voltage
32.	Vout Actual	5.024 V	System Information	Vout Actual calculated based on selected voltage divider resistors
33.	Vout Tolerance	2.634 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
34.	Vout p-p	2.439 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	4.0	Maximum Output Current
VinMax	19.0	Maximum input voltage
VinMin	16.5	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LMS3655MM	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

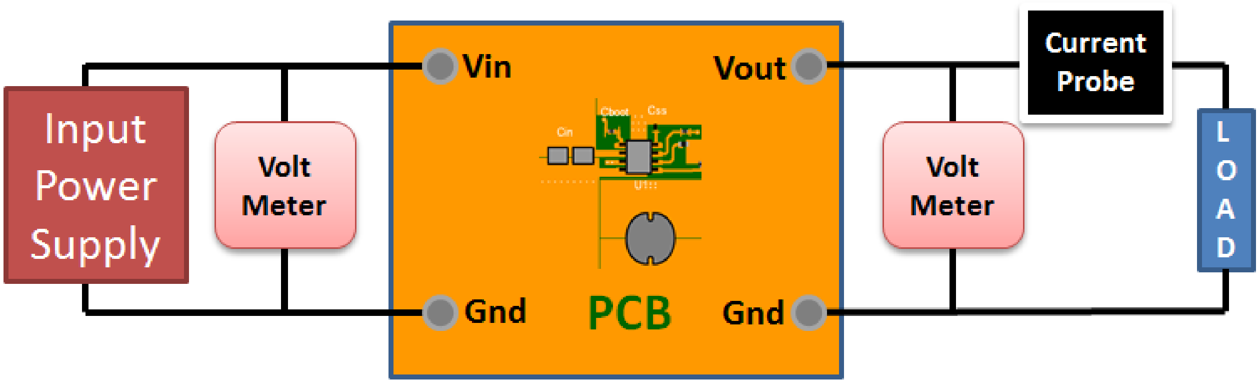
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 16.5V 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. Master key : AB125DE3D7ECC385[v1]

2. **LMS3655MM** Product Folder : http://www.ti.com/product/LMS3655 : contains the data sheet and other resources.

Important Notice and Disclaimer