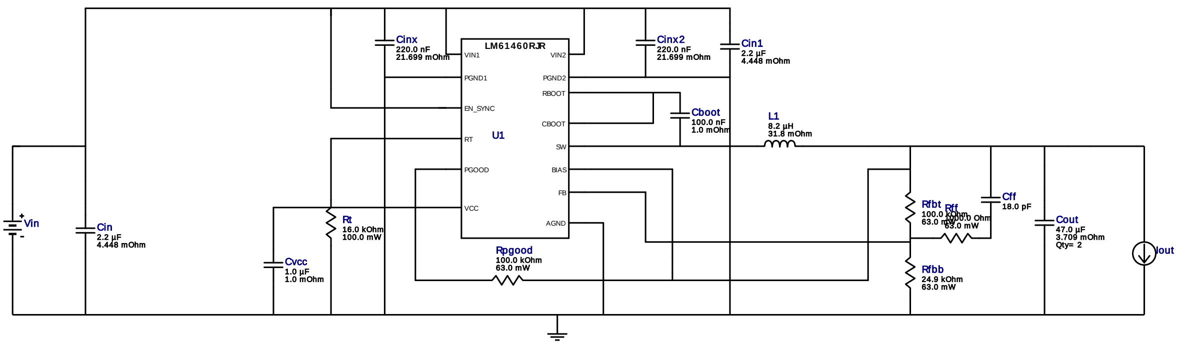
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 12.0V
VinMax = 32.0V
Vout = 5.0V
Iout = 2.0A

Device = LM61460AANRJRR
Topology = Buck
Created = 2021-01-29 07:10:26.482
BOM Cost = $3.23
BOM Count = 16
Total Pd = 0.93W

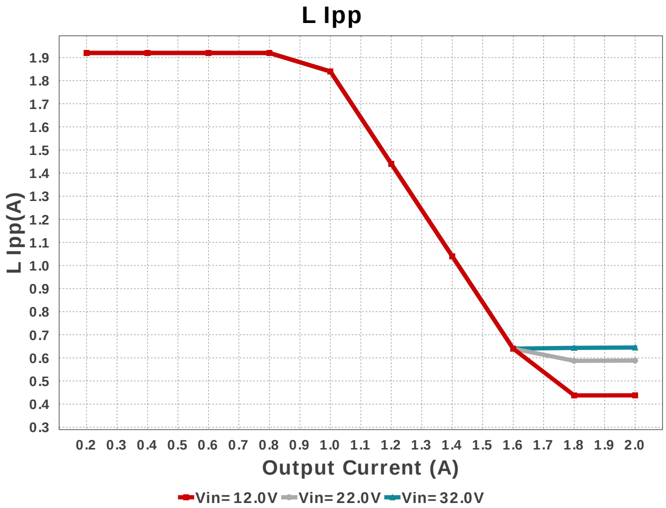
Design : 6786 LM61460AANRJRR
LM61460AANRJRR 12V-32V to 5.00V @ 2A

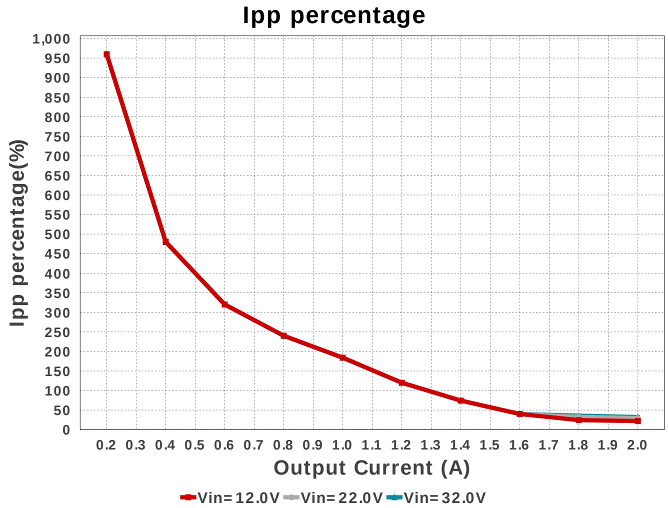


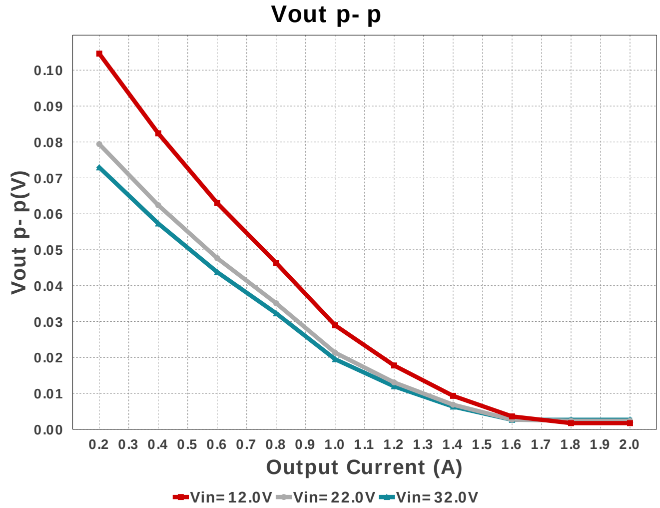
Electrical BOM

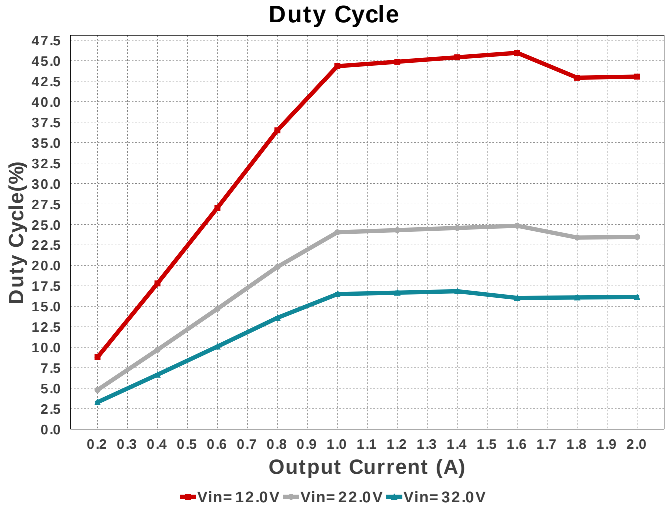
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cboot	MuRata	GRM155R71A104KA01D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cff	Samsung Electro-Mechanics	CL21C180JBANNNC Series= C0G/NP0	Cap= 18.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm²
Cin	MuRata	GRM31CR61H225KA88L Series= X5R	Cap= 2.2 uF ESR= 4.448 mOhm VDC= 50.0 V IRMS= 2.2252 A	1	$0.10	1206_190 11 mm²
Cin1	MuRata	GRM31CR61H225KA88L Series= X5R	Cap= 2.2 uF ESR= 4.448 mOhm VDC= 50.0 V IRMS= 2.2252 A	1	$0.10	1206_190 11 mm²
Cinx	TDK	CGA3E3X7R1H224K080AB Series= X7R	Cap= 220.0 nF ESR= 21.699 mOhm VDC= 50.0 V IRMS= 1.125 A	1	$0.03	0603 5 mm²
Cinx2	TDK	CGA3E3X7R1H224K080AB Series= X7R	Cap= 220.0 nF ESR= 21.699 mOhm VDC= 50.0 V IRMS= 1.125 A	1	$0.03	0603 5 mm²
Cout	MuRata	GRM31CR61A476KE15L Series= X5R	Cap= 47.0 uF ESR= 3.709 mOhm VDC= 10.0 V IRMS= 4.2862 A	2	$0.26	1206_190 11 mm²
Cvcc	Kemet	C0603C105Z8VACTU Series= Y5V	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
L1	Coilcraft	XAL5050-822MEB	L= 8.2 µH 31.8 mOhm	1	$0.92	XAL5050 54 mm²
Rfbb	Vishay-Dale	CRCW040224K9FKED Series= CRCW..e3	Res= 24.9 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²

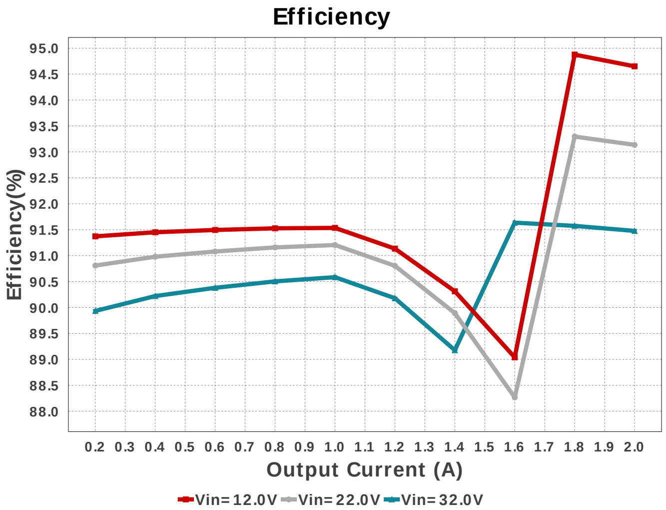
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rfbt	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rff	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rpgood	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rt	Yageo	RC0603FR-0716KL Series= ?	Res= 16.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM61460AANRJRR	Switcher	1	$1.45	RJR0014A 22 mm^2

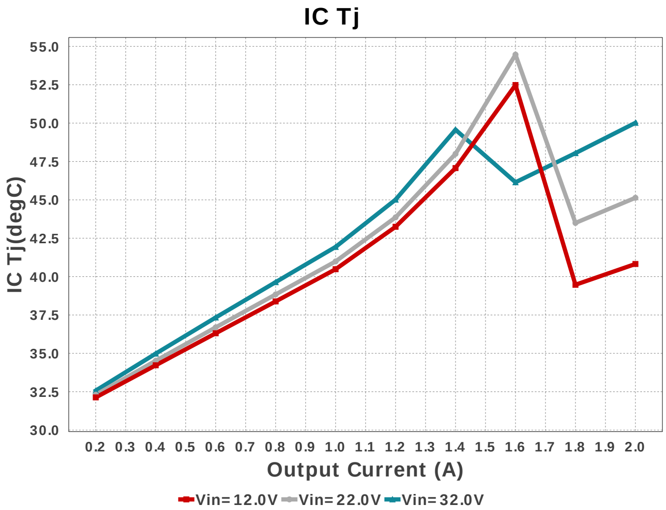


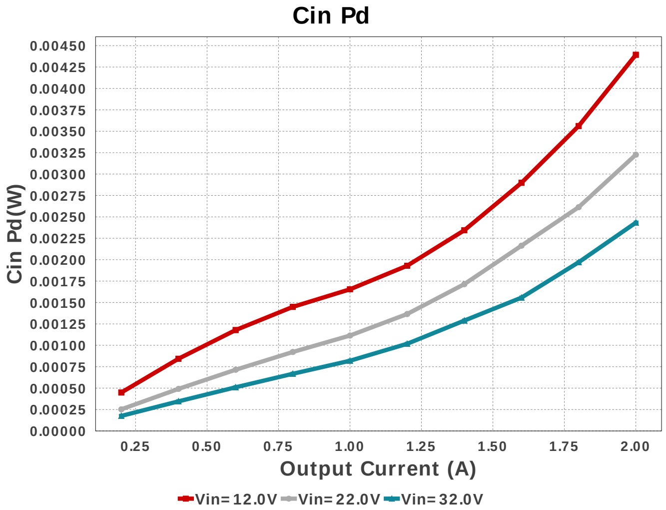


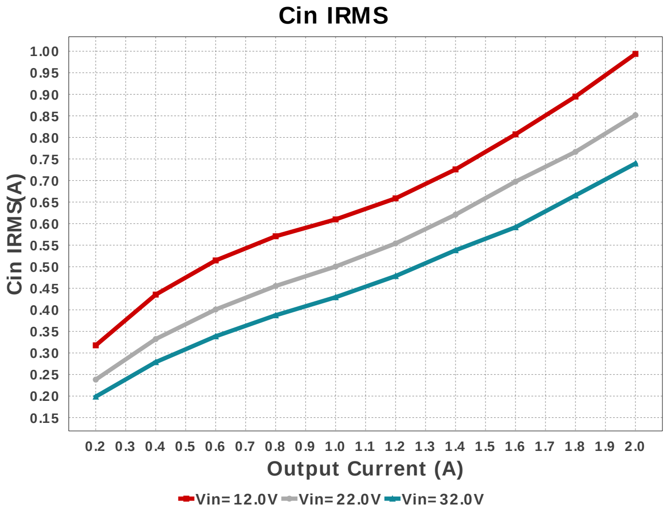


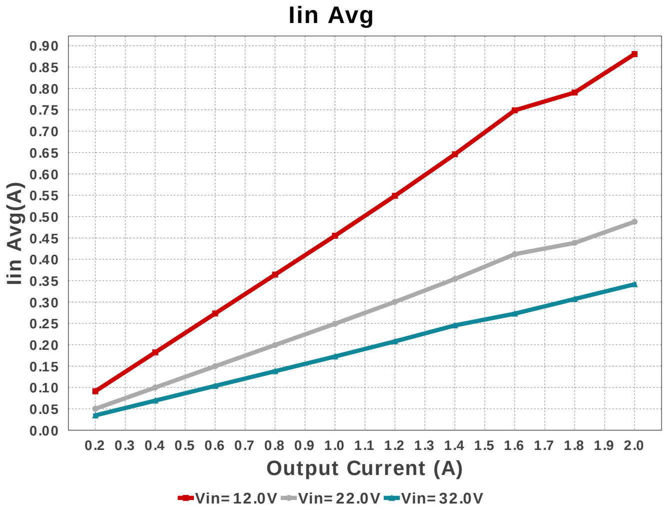


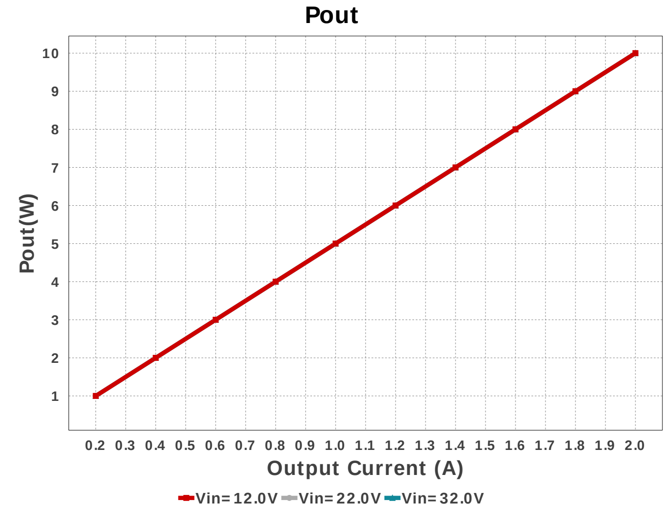

Efficiency
Efficiency(%)
95.0
94.5
94.0
93.5
93.0
92.5
92.0
91.5
91.0
90.5
90.0
89.5
89.0
88.5
88.0
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

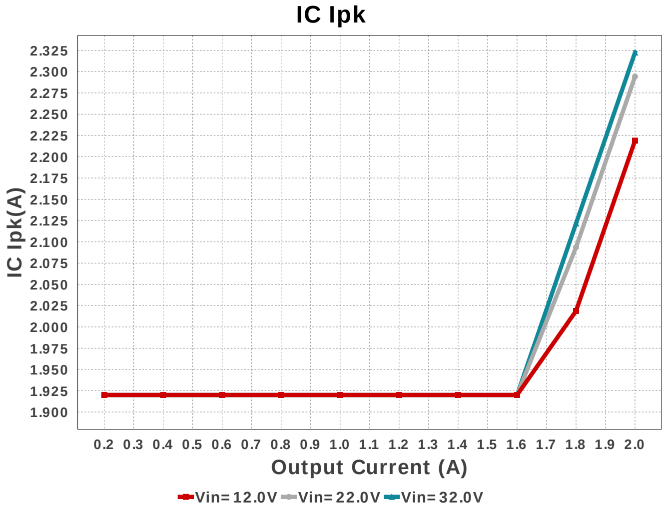

IC Tj
IC Tj(degC)
55.0
52.5
50.0
47.5
45.0
42.5
40.0
37.5
35.0
32.5
30.0
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

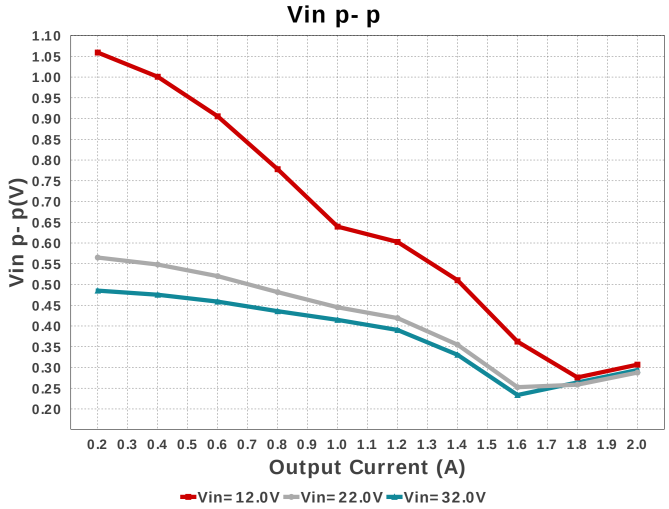

Cin Pd
Cin Pd(W)
0.00450
0.00425
0.00400
0.00375
0.00350
0.00325
0.00300
0.00275
0.00250
0.00225
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
0.25 0.50 0.75 1.00 1.25 1.50 1.75 2.00
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

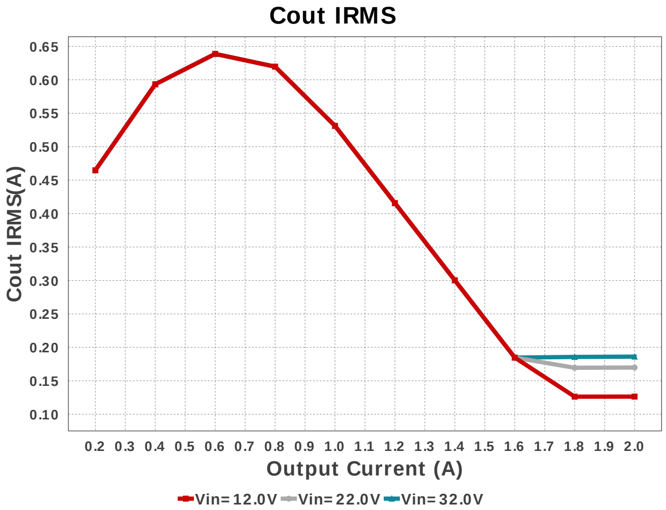

Cin IRMS
Cin IRMS(A)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

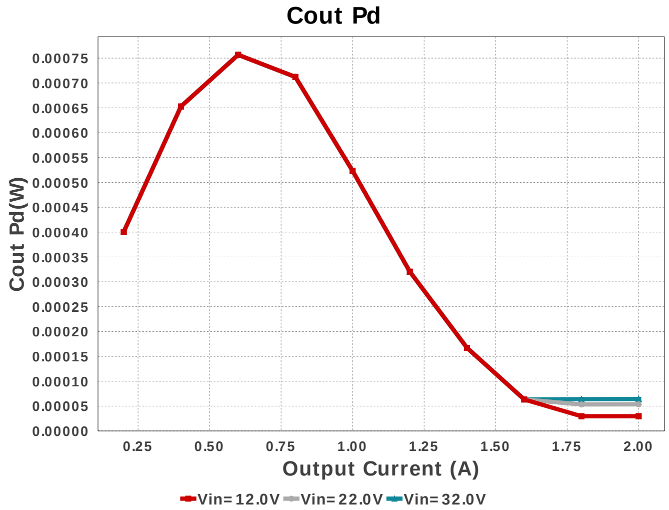

Iin Avg
Iin Avg(A)
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

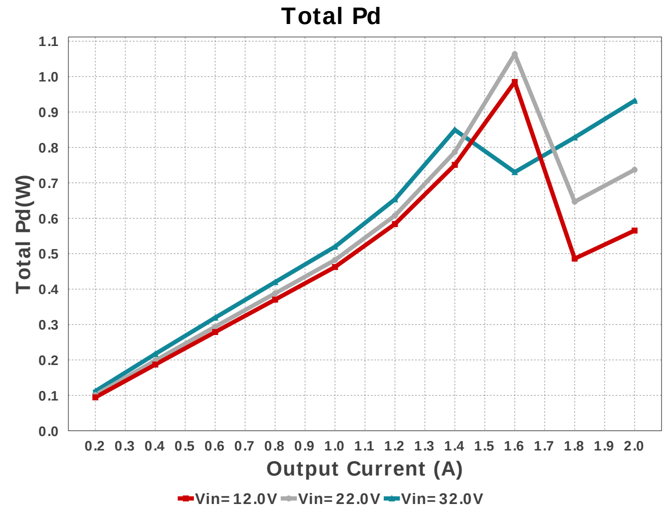

Pout
Pout(W)
10
9
8
7
6
5
4
3
2
1
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

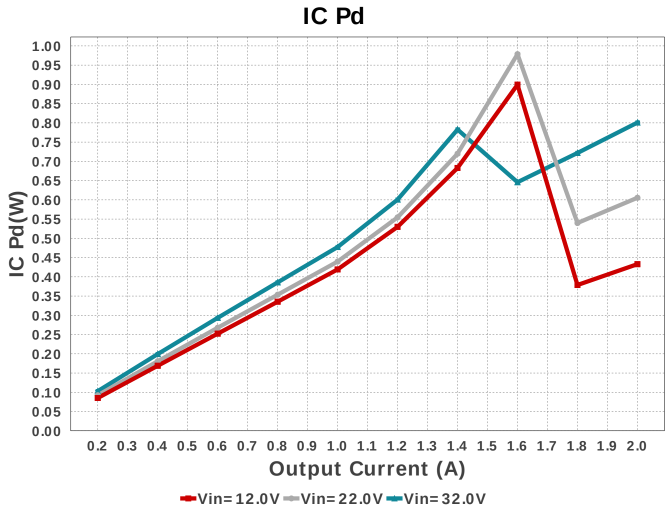

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

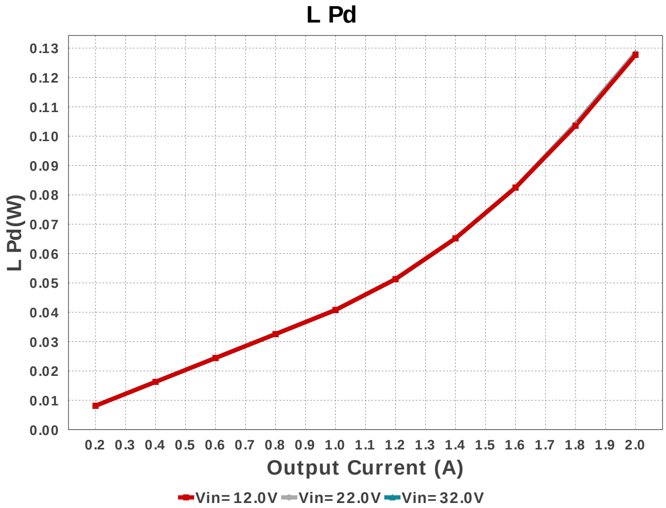

Vin p-p
Vin p-p(V)
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

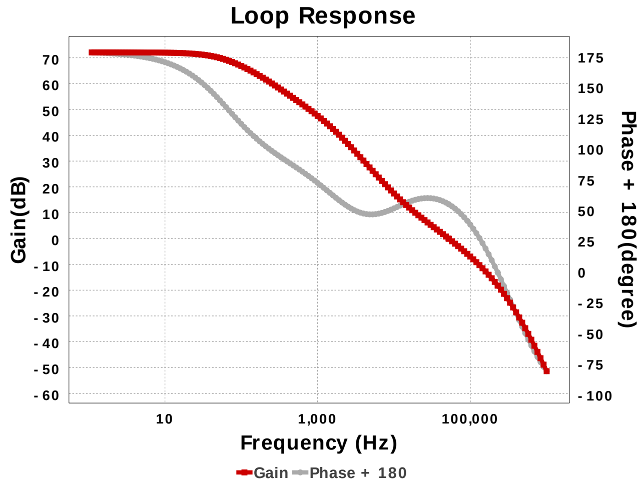

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V

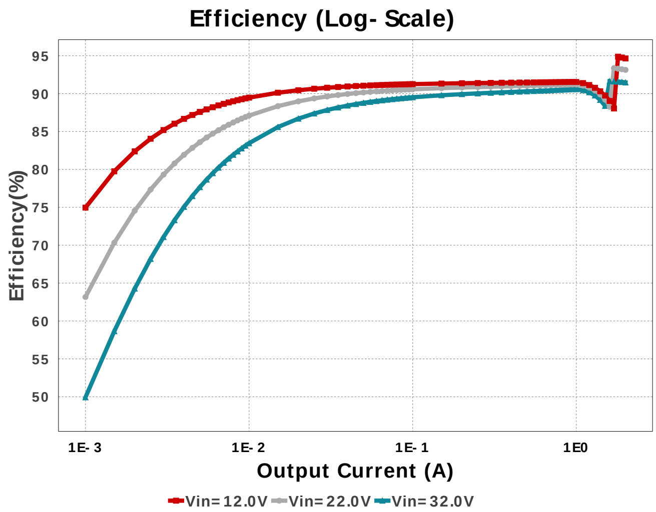

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V


Total Pd
Total Pd(W)
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V


IC Pd
IC Pd(W)
Output Current (A)
Vin=12.0V Vin=22.0V Vin=32.0V







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	739.495 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	2.432 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	186.157 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	64.267 µW	Capacitor	Output capacitor power dissipation
5.	IC Ipk	2.322 A	IC	Peak switch current in IC
6.	IC Pd	800.74 mW	IC	IC power dissipation
7.	IC Tj	50.019 degC	IC	IC junction temperature
8.	IC Tolerance	12.5 mV	IC	IC Feedback Tolerance
9.	ICThetaJA	25.0 degC/W	IC	IC junction-to-ambient thermal resistance
10.	Iin Avg	341.62 mA	IC	Average input current
11.	Ipp percentage	32.243 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
12.	L Ipp	644.87 mA	Inductor	Peak-to-peak inductor ripple current
13.	L Pd	128.3 mW	Inductor	Inductor power dissipation
14.	Cin Pd	2.432 mW	Power	Input capacitor power dissipation
15.	Cout Pd	64.267 µW	Power	Output capacitor power dissipation
16.	IC Pd	800.74 mW	Power	IC power dissipation
17.	L Pd	128.3 mW	Power	Inductor power dissipation
18.	Total Pd	931.721 mW	Power	Total Power Dissipation
19.	BOM Count	16	System Information	Total Design BOM count
20.	Cross Freq	51.753 kHz	System Information	Bode plot crossover frequency
21.	Duty Cycle	16.135 %	System Information	Duty cycle
22.	Efficiency	91.477 %	System Information	Steady state efficiency
23.	FootPrint	161.0 mm^2	System Information	Total Foot Print Area of BOM components
24.	Frequency	818.527 kHz	System Information	Switching frequency

#	Name	Value	Category	Description
25.	Gain Marg	-18.206 dB	System Information	Bode Plot Gain Margin
26.	Iout	2.0 A	System Information	Iout operating point
27.	Low Freq Gain	72.1 dB	System Information	Gain at 1Hz
28.	Mode	CCM	System Information	Conduction Mode
29.	Phase Marg	55.587 deg	System Information	Bode Plot Phase Margin
30.	Pout	10.0 W	System Information	Total output power
31.	Total BOM	$3.23	System Information	Total BOM Cost
32.	Vin	32.0 V	System Information	Vin operating point
33.	Vin p-p	293.81 mV	System Information	Peak-to-peak input voltage
34.	Vout	5.0 V	System Information	Operational Output Voltage
35.	Vout Actual	5.016 V	System Information	Vout Actual calculated based on selected voltage divider resistors
36.	Vout Tolerance	2.888 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
37.	Vout p-p	2.671 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	32.0	Maximum input voltage
VinMin	12.0	Minimum input voltage
Vout	5.0	Output Voltage
base_pn	LM61460	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	800.0 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

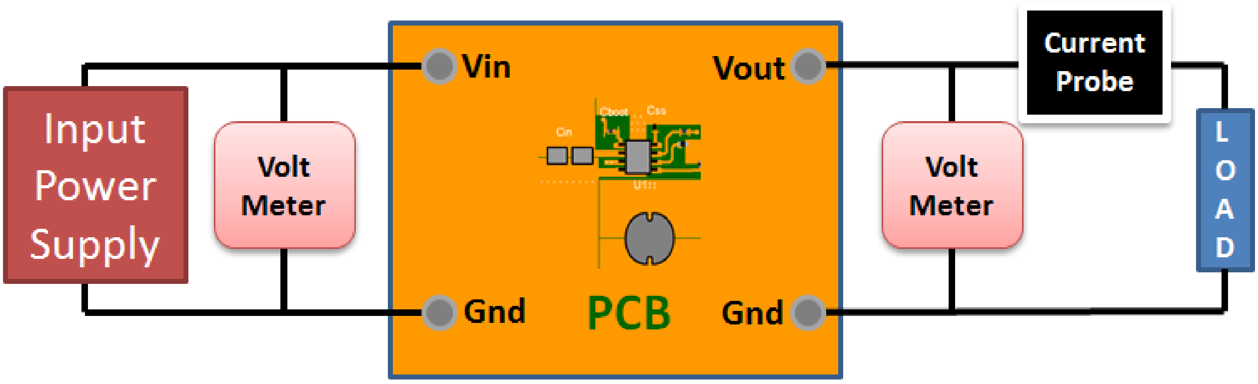
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 12.0V 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 : AE3011FD2EE8F4EB[v1]

2. **LM61460** Product Folder : http://www.ti.com/product/LM61460%2DQ1 : contains the data sheet and other resources.

