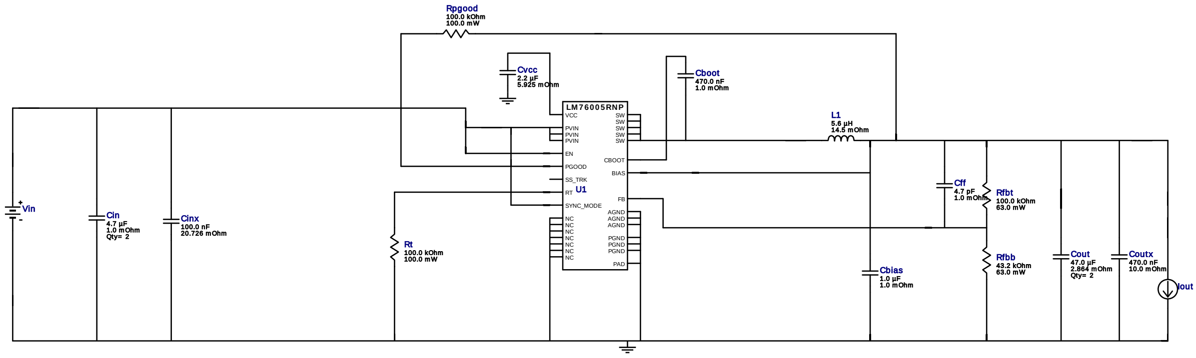
VinMin = 36.0V
VinMax = 36.0V
Vout = 3.3V
Iout = 5.0A

Device = LM76005RNPR
Topology = Buck
Created = 2021-12-21 03:28:37.025
BOM Cost = $5.57
BOM Count = 16
Total Pd = 2.03W

WEBENCH ® Design Report

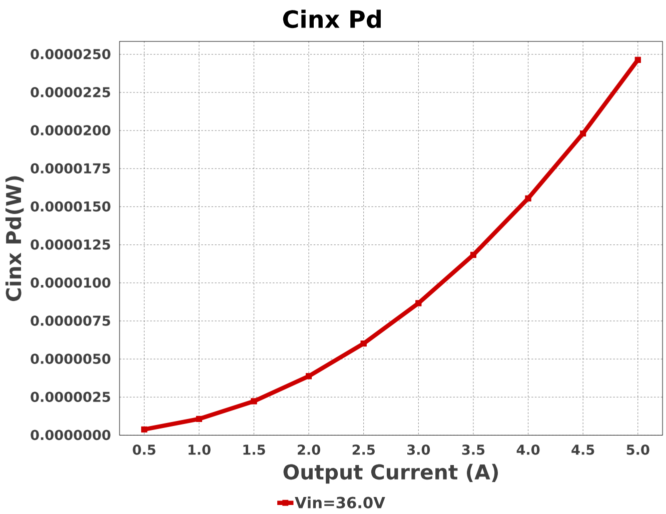
Design : 10 LM76005RNPR
LM76005RNPR 5V-60V to 3.30V @ 5A

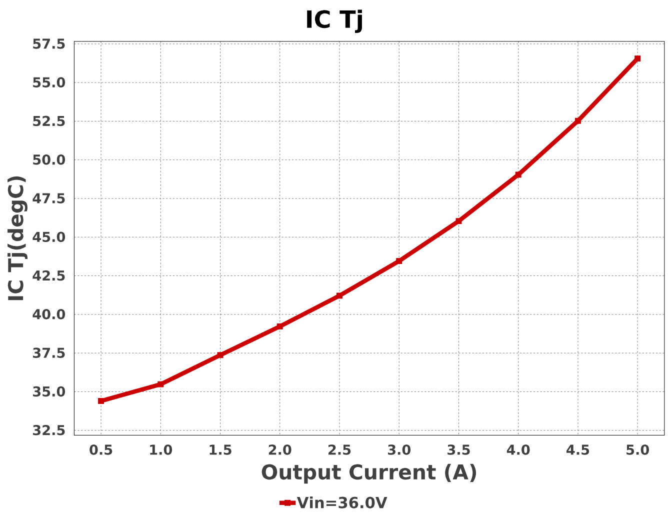


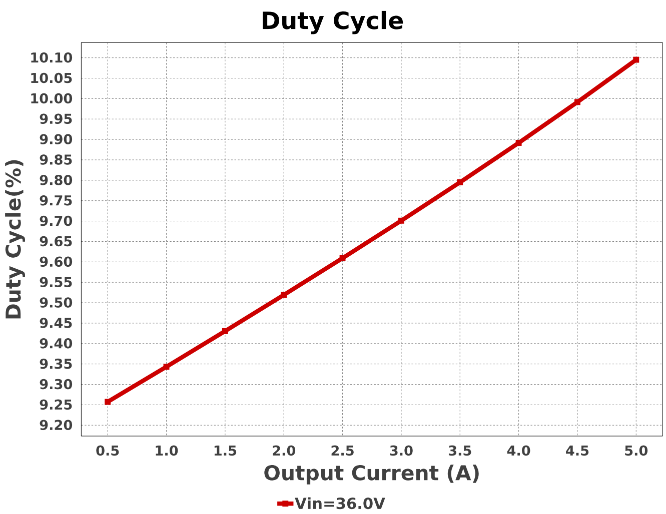
Electrical BOM

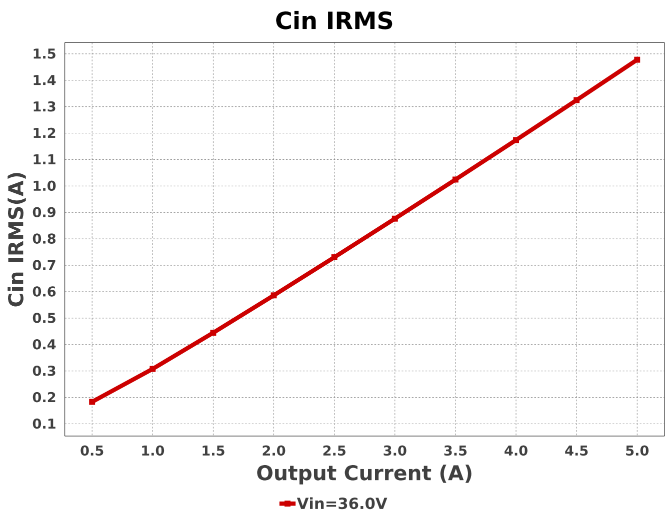
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cbias	Kemet	C0603C105K8PACTU Series= X5R	Cap= 1.0 uF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0603 5 mm²
Cboot	MuRata	GRM155R61A474KE15D Series= X5R	Cap= 470.0 nF ESR= 1.0 mOhm VDC= 10.0 V IRMS= 0.0 A	1	$0.02	0402 3 mm²
Cff	MuRata	GRM1555C1H4R7CA01D Series= C0G/NP0	Cap= 4.7 pF ESR= 1.0 mOhm VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm²
Cin	MuRata	GCM32DC72A475KE02L Series= X7S	Cap= 4.7 uF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 6.0 A	2	$0.60	1210_220 15 mm²
Cinx	TDK	C2012X7R2A104K125AA Series= X7R	Cap= 100.0 nF ESR= 20.726 mOhm VDC= 100.0 V IRMS= 1.456 A	1	$0.03	0805 7 mm²
Cout	MuRata	GRM32ER71A476KE15L Series= X7R	Cap= 47.0 uF ESR= 2.864 mOhm VDC= 10.0 V IRMS= 4.8625 A	2	$0.68	1210_280 15 mm²
Coutx	MuRata	GRM188R70J474KA01D Series= X7R	Cap= 470.0 nF ESR= 10.0 mOhm VDC= 6.3 V IRMS= 2.91 A	1	$0.03	0603 5 mm²
Cvcc	TDK	C1005X6S1C225K050BC Series= X6S	Cap= 2.2 uF ESR= 5.925 mOhm VDC= 16.0 V IRMS= 2.0559 A	1	$0.06	0402_065 3 mm²
L1	Coilcraft	XAL6060-562MEB	L= 5.6 µH 14.5 mOhm	1	$0.82	XAL6060 72 mm²
Rfbb	Vishay-Dale	CRCW040243K2FKED Series= CRCW..e3	Res= 43.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²

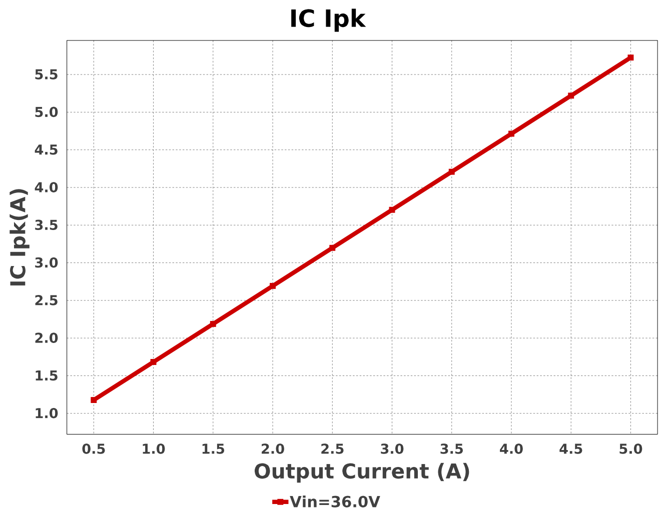
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rfbt	Vishay-Dale	CRCW0402100KFKED Series= CRCW..e3	Res= 100.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
Rpgood	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
Rt	Vishay-Dale	CRCW0603100KFKEA Series= CRCW..e3	Res= 100.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
U1	Texas Instruments	LM76005RNPR	Switcher	1	$2.00	RNP0030B 48 mm^2

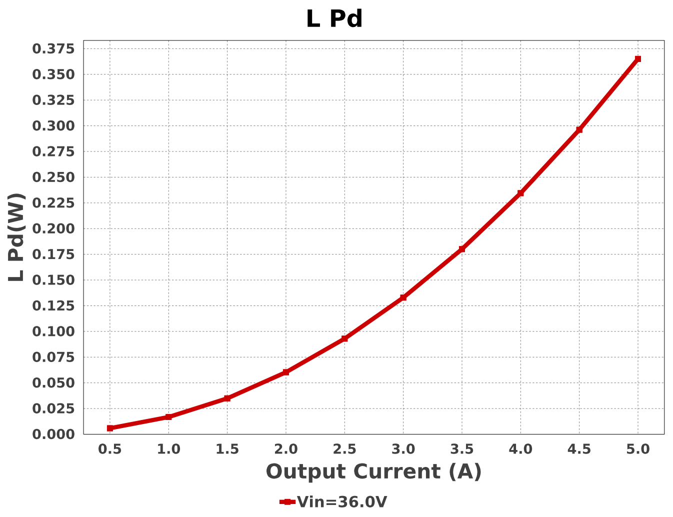


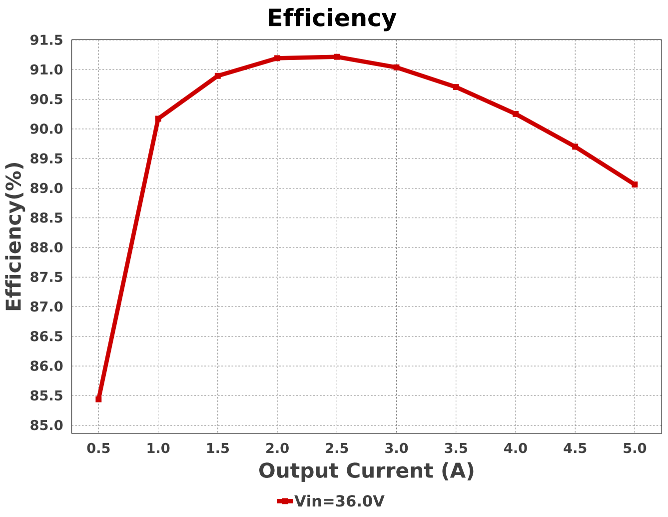


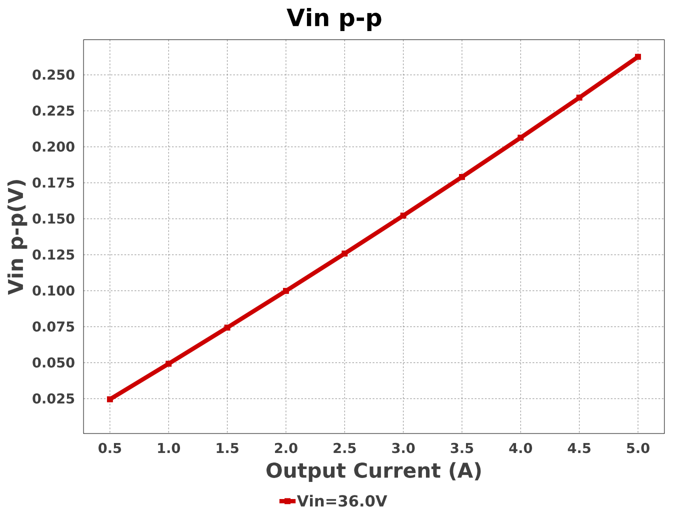


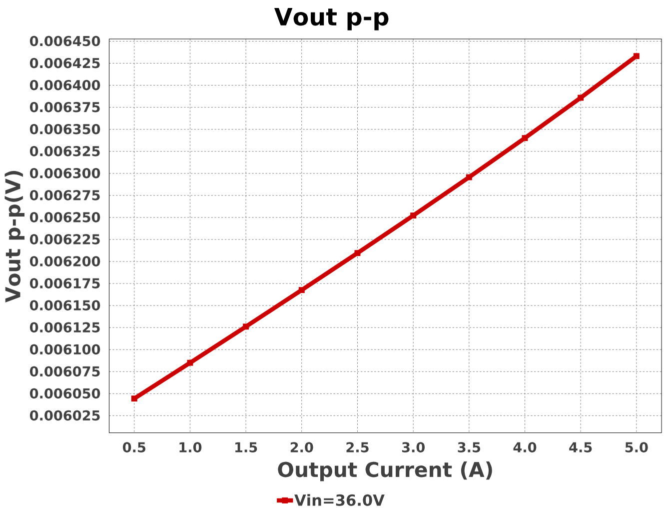


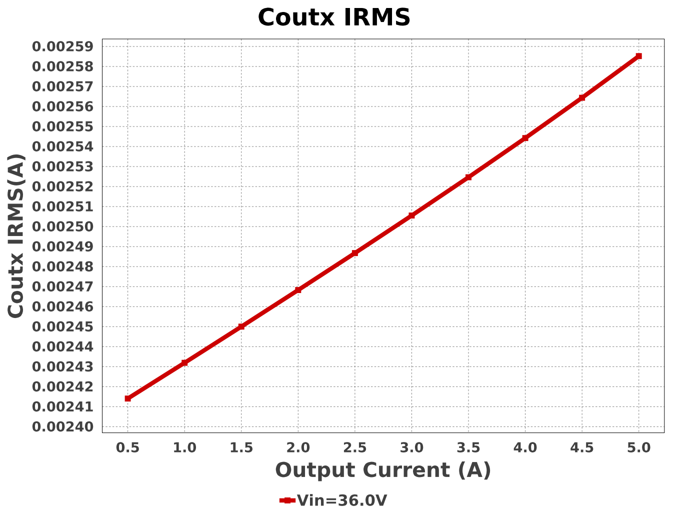

IC Ipk
IC Ipk(A)
Output Current (A)
Vin=36.0V


L Pd
L Pd(W)
Output Current (A)
Vin=36.0V

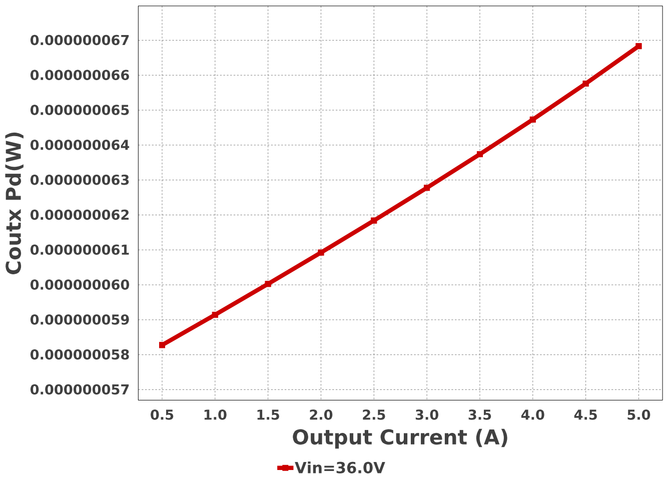

Efficiency
Efficiency(%)
Output Current (A)
Vin=36.0V


Vin p-p
Vin p-p(V)
Output Current (A)
Vin=36.0V

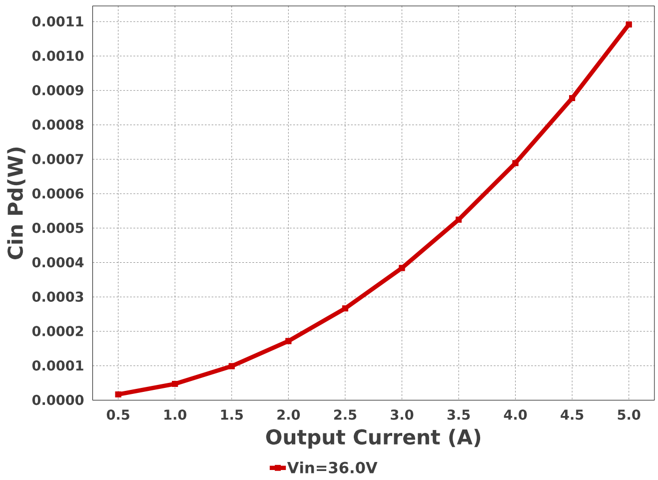

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=36.0V


Coutx IRMS
Coutx IRMS(A)
Output Current (A)
Vin=36.0V

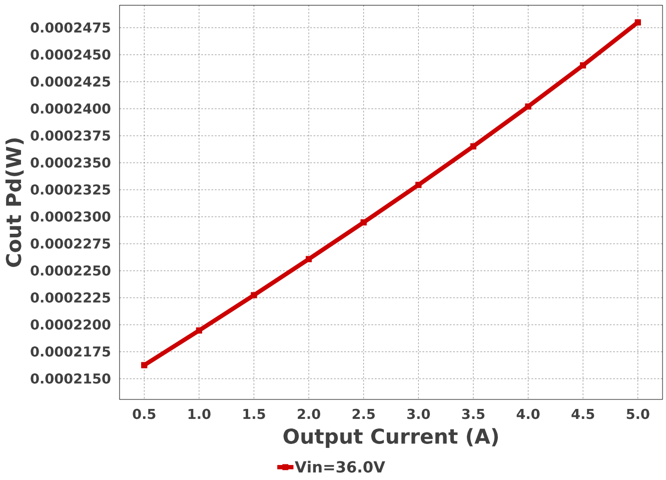
Coutx Pd



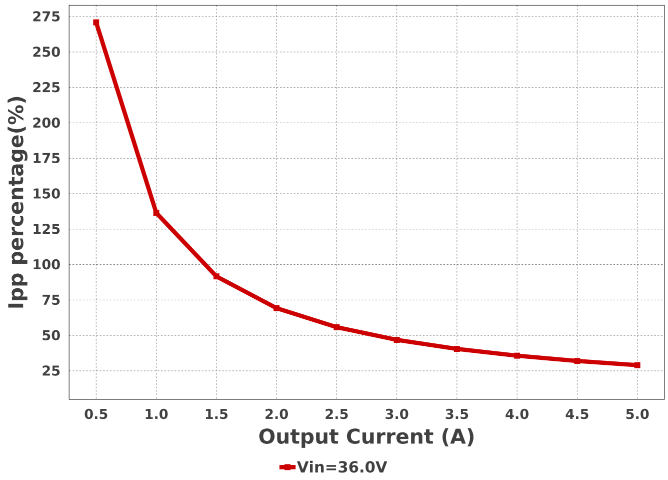
Cin Pd



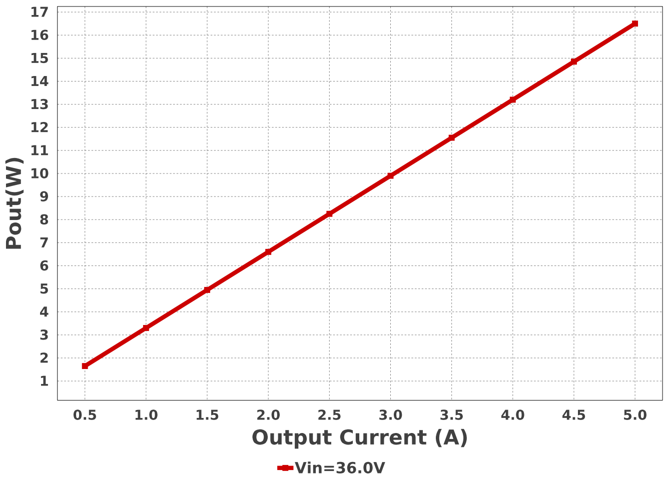
Cout Pd



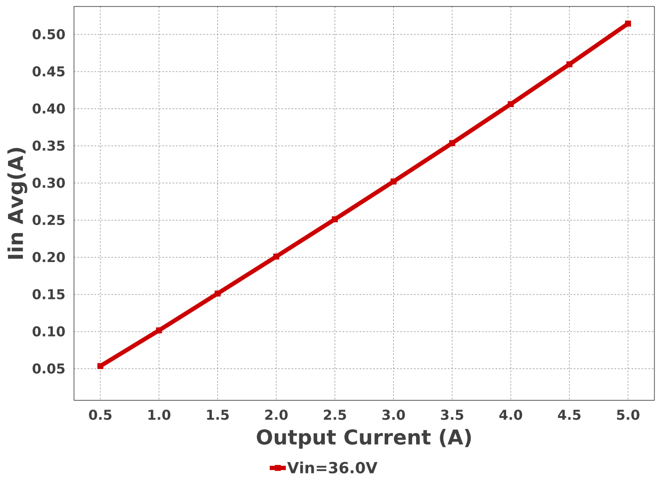
Ipp percentage

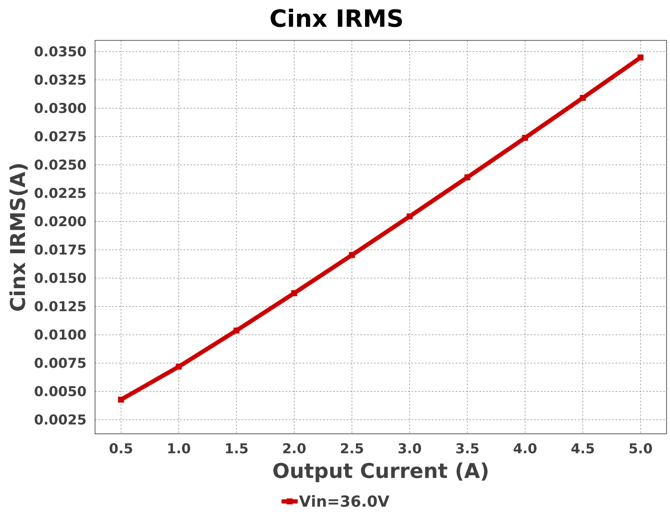


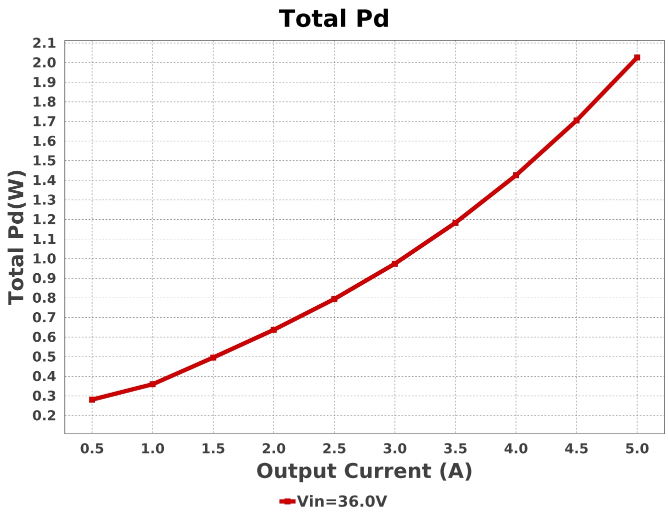
Pout

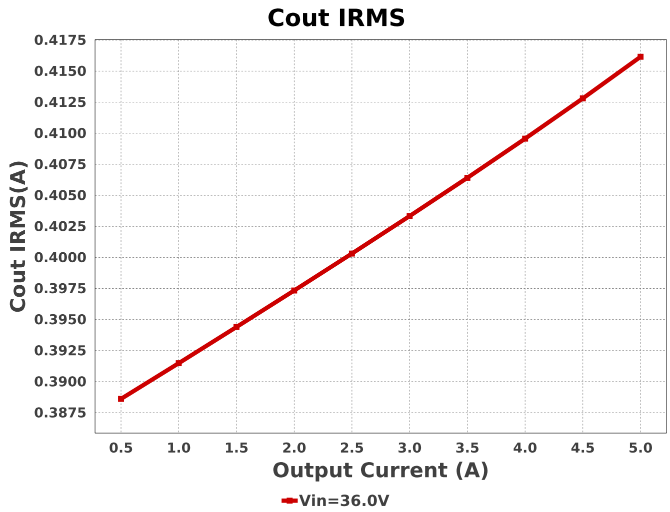


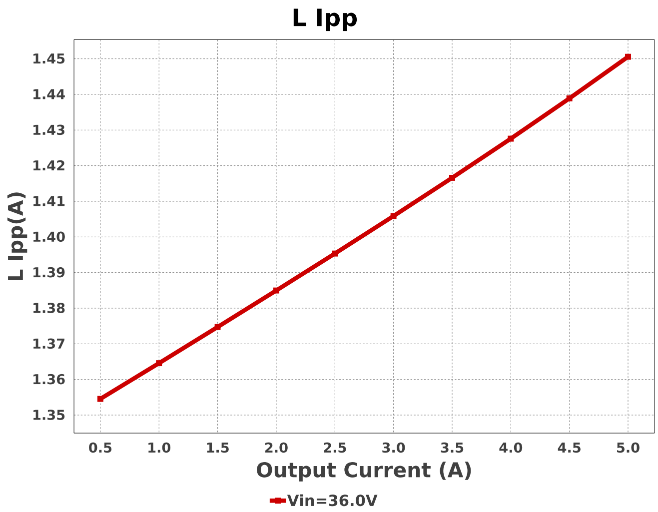
Iin Avg

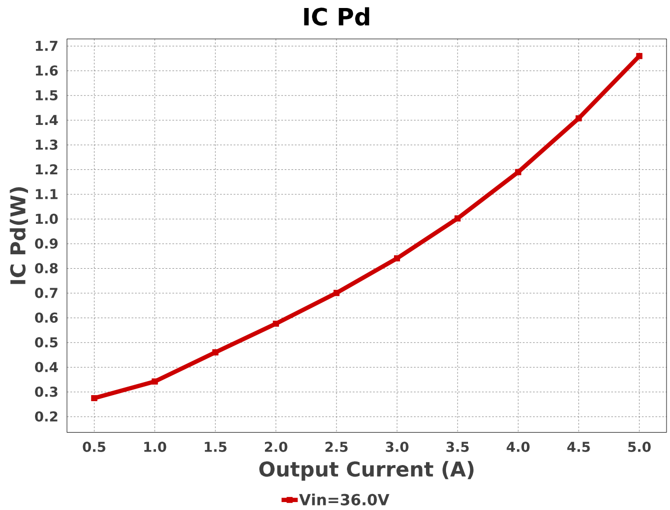


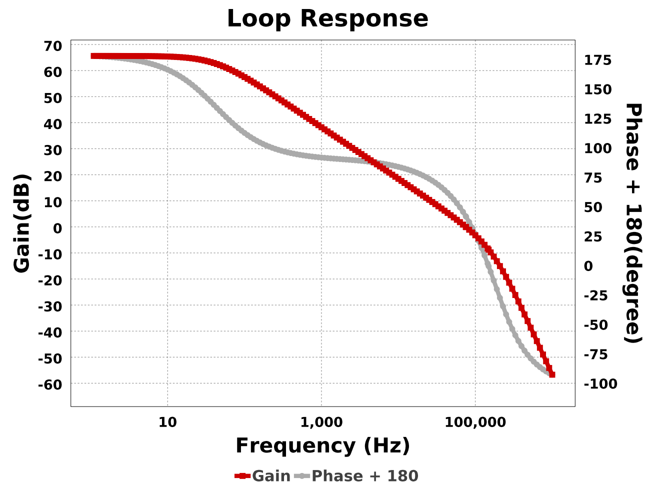

Cinx IRMS
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
Cinx IRMS(A)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=36.0V

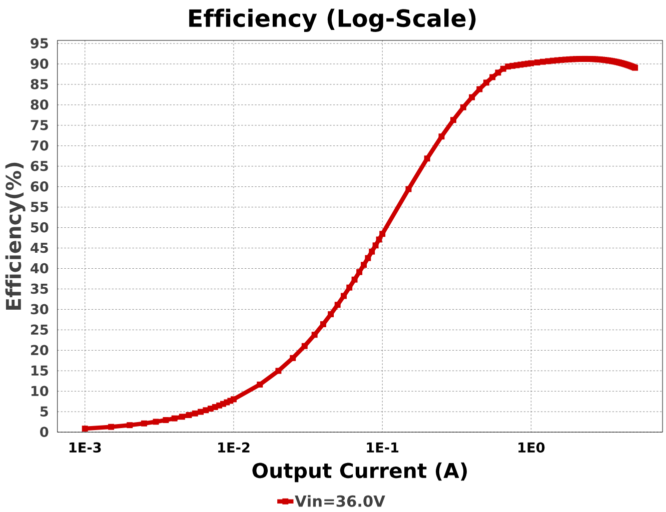

Total Pd
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
Total Pd(W)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=36.0V


Cout IRMS
0.4175
0.4150
0.4125
0.4100
0.4075
0.4050
0.4025
0.4000
0.3975
0.3950
0.3925
0.3900
0.3875
Cout IRMS(A)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=36.0V


L Ipp
1.45
1.44
1.43
1.42
1.41
1.40
1.39
1.38
1.37
1.36
1.35
L Ipp(A)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=36.0V


IC Pd
1.7
1.6
1.5
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
IC Pd(W)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
Output Current (A)
Vin=36.0V


Loop Response
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
Gain(dB)
175
150
125
100
75
50
25
0
-25
-50
-75
-100
Phase + 180(degree)
10 1,000 100,000
Frequency (Hz)
Gain Phase + 180



Operating Values

#	Name	Value	Category	Description
1.	BOM Count	16		Total Design BOM count
2.	Total BOM	$5.575		Total BOM Cost
3.	Cin IRMS	1.478 A	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	1.092 mW	Capacitor	Input capacitor power dissipation
5.	Cinx IRMS	34.477 mA	Capacitor	Bulk capacitor RMS ripple current
6.	Cinx Pd	24.637 µW	Capacitor	Bulk capacitor power dissipation
7.	Cout IRMS	416.156 mA	Capacitor	Output capacitor RMS ripple current
8.	Cout Pd	248.0 µW	Capacitor	Output capacitor power dissipation
9.	Coutx IRMS	2.585 mA	Capacitor	Output capacitor_x RMS ripple current
10.	Coutx Pd	66.832 nW	Capacitor	Output capacitor_x power loss
11.	IC Ipk	5.725 A	IC	Peak switch current in IC
12.	IC Pd	1.66 W	IC	IC power dissipation
13.	IC Tj	56.555 degC	IC	IC junction temperature
14.	IC Tolerance	20.0 mV	IC	IC Feedback Tolerance
15.	ICThetaJA Effective	16.0 degC/W	IC	Effective IC Junction-to-Ambient Thermal Resistance
16.	Iin Avg	514.62 mA	IC	Average input current
17.	Ipp percentage	29.011 %	Inductor	Inductor ripple current percentage (with respect to average inductor current)
18.	L Ipp	1.451 A	Inductor	Peak-to-peak inductor ripple current
19.	L Pd	365.04 mW	Inductor	Inductor power dissipation
20.	Cin Pd	1.092 mW	Power	Input capacitor power dissipation
21.	Cinx Pd	24.637 µW	Power	Bulk capacitor power dissipation
22.	Cout Pd	248.0 µW	Power	Output capacitor power dissipation
23.	Coutx Pd	66.832 nW	Power	Output capacitor_x power loss
24.	IC Pd	1.66 W	Power	IC power dissipation
25.	L Pd	365.04 mW	Power	Inductor power dissipation
26.	Total Pd	2.026 W	Power	Total Power Dissipation
27.	Cross Freq	75.198 kHz	System Information	Bode plot crossover frequency
28.	Duty Cycle	10.095 %	System Information	Duty cycle
29.	Efficiency	89.063 %	System Information	Steady state efficiency
30.	FootPrint	219.0 mm^2	System Information	Total Foot Print Area of BOM components
31.	Frequency	398.33 kHz	System Information	Switching frequency
32.	Gain Marg	-8.747 dB	System Information	Bode Plot Gain Margin
33.	Iout	5.0 A	System Information	Iout operating point
34.	Low Freq Gain	65.62 dB	System Information	Gain at 1Hz
35.	Mode	FCCM	System Information	Conduction Mode
36.	Phase Marg	42.389 deg	System Information	Bode Plot Phase Margin
37.	Pout	16.5 W	System Information	Total output power
38.	Vin	36.0 V	System Information	Vin operating point

#	Name	Value	Category	Description
39.	Vin p-p	262.544 mV	System Information	Peak-to-peak input voltage
40.	Vout	3.3 V	System Information	Operational Output Voltage
41.	Vout Actual	3.315 V	System Information	Vout Actual calculated based on selected voltage divider resistors
42.	Vout Tolerance	3.439 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
43.	Vout p-p	6.433 mV	System Information	Peak-to-peak output ripple voltage

Design Inputs

Name	Value	Description
Iout	5.0	Maximum Output Current
SoftStart	6.3 ms	Soft Start Time (ms)
VinMax	36.0	Maximum input voltage
VinMin	36.0	Minimum input voltage
Vout	3.3	Output Voltage
base_pn	LM76005	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	407.773 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

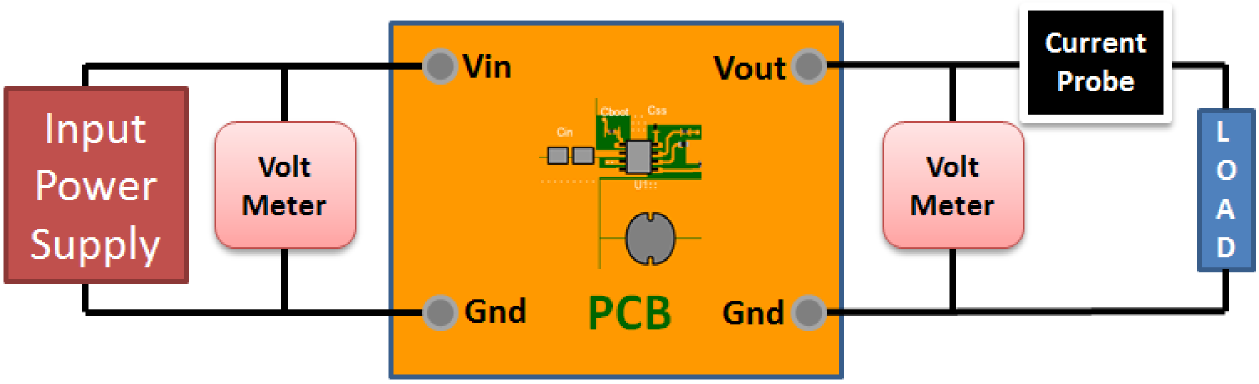
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 36.0V 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 : 08E633507C34C478[v1]

2. **LM76005** Product Folder : http://www.ti.com/product/LM76005 : contains the data sheet and other resources.