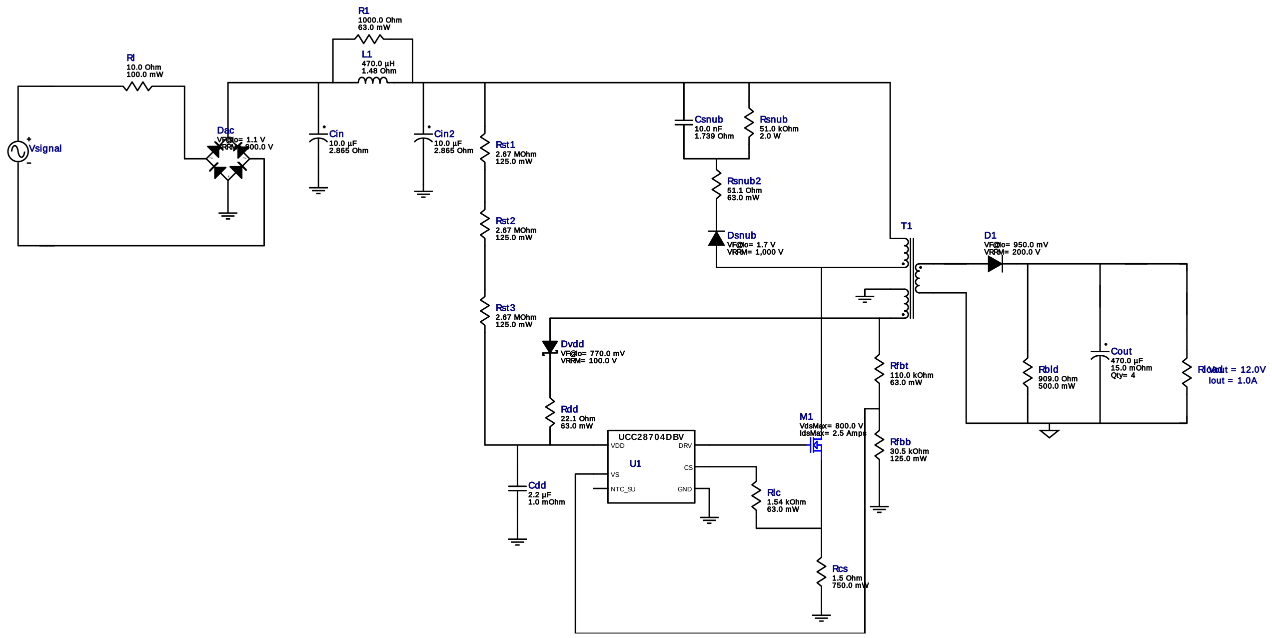
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 170.0V
VinMax = 275.0V
Vout = 12.0V
Iout = 1.0A

Device = UCC28704DBVR-1
Topology = Flyback
Created = 2020-12-22 21:03:07.208
BOM Cost = $4.12
BOM Count = 29
Total Pd = 2.58W

Design : 10 UCC28704DBVR-1
UCC28704DBVR-1 170V-275V to 12.00V @ 1A



1. Rbld is a starting point, but may need to be experimented with in order to get minimum current needed to hold Vout at no load. Rlc and the feedback resistors may also need adjustment based on the actual transformer used. It is recommended to start this device at light load condition. There is an internal series resistance of 28 kOhms to the CBC pin which sets a maximum cable compensation of a 5V output to 400 mV when CBC is shorted to ground. For more information please click the design assistance button.

2. Click on the transformer symbol and select 'Design Transformer' to design using specific transformer cores and bobbin

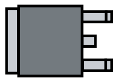
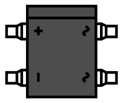
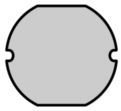
Design Alerts

Component Selection Information

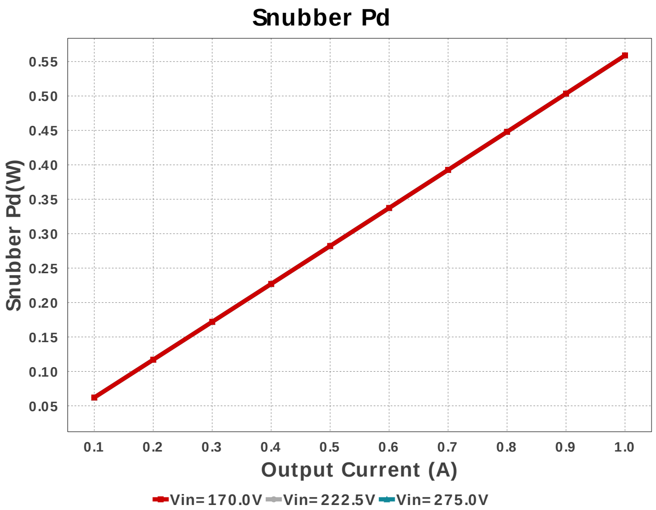
Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.

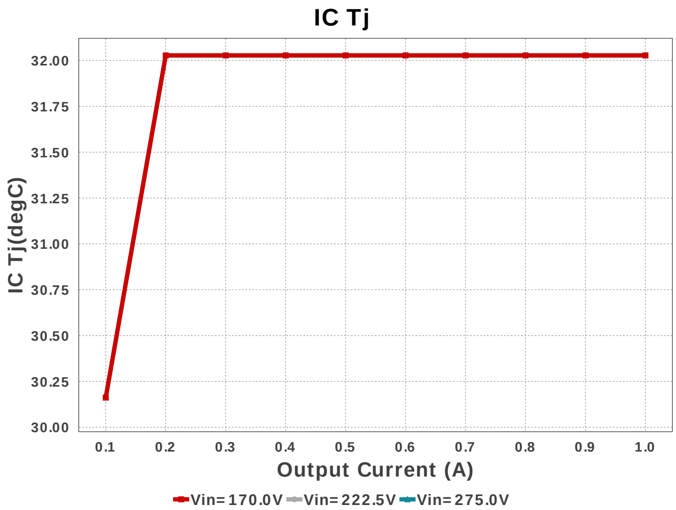
Electrical BOM

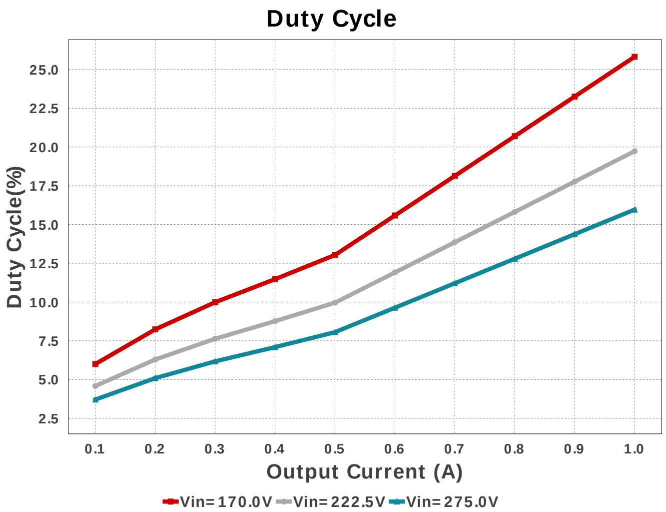
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cdd	Taiyo Yuden	TMK212BJ225KG-T Series= X5R	Cap= 2.2 uF ESR= 1.0 mOhm VDC= 20.0 V IRMS= 0.0 A	1	$0.04	0805 7 mm^2
Cin	Panasonic	EEUED2G100 Series= ED	Cap= 10.0 uF ESR= 2.8648 Ohm VDC= 400.0 V IRMS= 300.0 mA	1	$0.21	CAPPR5-10X20 144 mm^2
Cin2	Panasonic	EEUED2G100 Series= ED	Cap= 10.0 uF ESR= 2.8648 Ohm VDC= 400.0 V IRMS= 300.0 mA	1	$0.21	CAPPR5-10X20 144 mm^2
Cout	Kemet	A750MS477M1EAAE015 Series= 3273	Cap= 470.0 uF ESR= 15.0 mOhm VDC= 25.0 V IRMS= 4.9 A	4	$0.32	A750_MS 144 mm^2

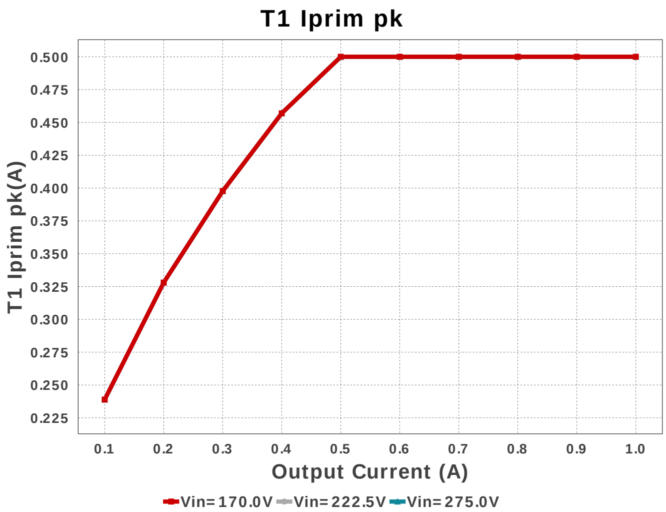
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Csnub	Kemet	C0805C103K1RACTU Series= X7R	Cap= 10.0 nF ESR= 1.739 Ohm VDC= 500.0 V IRMS= 411.0 mA	1	$0.01	0805 7 mm²
D1	SMC Diode Solutions	SBRD10200TR	VF@Io= 950.0 mV VRRM= 200.0 V	1	$0.12	 DPAK 102 mm²
Dac	Vishay-Semiconductor	DF08SA	VF@Io= 1.1 V VRRM= 800.0 V	1	$0.24	 DF-S 99 mm²
Dsnub	SMC Diode Solutions	UF4007TA	VF@Io= 1.7 V VRRM= 1,000.0 V	1	$0.22	 DO-41 43 mm²
Dvdd	Diodes Inc.	DFLS1100-7	VF@Io= 770.0 mV VRRM= 100.0 V	1	$0.14	PowerDI123 13 mm²
L1	NIC Components	NPI105C471MTRF	L= 470.0 µH 1.48 Ohm	1	$0.18	 IND_NPI105C 141 mm²
M1	STMicroelectronics	STD3NK80Z-1	VdsMax= 800.0 V IdsMax= 2.5 Amps	1	$0.70	 IPAK 37 mm²
R1	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rbld	Panasonic	ERJ14NF9090U Series= ERJ-14	Res= 909.0 Ohm Power= 500.0 mW Tolerance= 1.0%	1	$0.02	1210 15 mm²
Rcs	Stackpole Electronics Inc	RMCF2010FT1R50 Series= ?	Res= 1.5 Ohm Power= 750.0 mW Tolerance= 1.0%	1	$0.03	2010 32 mm²
Rdd	Vishay-Dale	CRCW040222R1FKED Series= CRCW..e3	Res= 22.1 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rfbb	Yageo	RT0805BRD0730K5L Series= ?	Res= 30.5 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.06	0805 7 mm²
Rfbt	Vishay-Dale	CRCW0402110KFKED Series= CRCW..e3	Res= 110.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rl	Vishay-Dale	CRCW060310R0FKEA Series= CRCW..e3	Res= 10.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rlc	Vishay-Dale	CRCW04021K54FKED Series= CRCW..e3	Res= 1.54 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsnub	Vishay-Bccomponents	PR02000205102JR500 Series= ?	Res= 51.0 kOhm Power= 2.0 W Tolerance= 5.0%	1	$0.05	 PR02 117 mm²
Rsnub2	Vishay-Dale	CRCW040251R1FKED Series= CRCW..e3	Res= 51.1 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rst1	Vishay-Dale	CRCW08052M67FKEA Series= CRCW..e3	Res= 2.67 MOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
Rst2	Vishay-Dale	CRCW08052M67FKEA Series= CRCW..e3	Res= 2.67 MOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rst3	Vishay-Dale	CRCW08052M67FKEA Series= CRCW..e3	Res= 2.67 MOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm^2
T1	Core=TDK , CoilFormer=TDK	Core=B66317G0000X187 , CoilFormer=B66208X1110T001	Lp= 2.174 mH Turns Ratio(Nas)= 13:9 Turns Ratio(Nps)= 104:9 Npri= 104.0 Naux= 13.0 Nsec= 9.0	1	$0.22	TDK_B66305 569 mm^2
U1	Texas Instruments	UCC28704DBVR-1	Switcher	1	$0.30	SOT-23-6 15 mm^2

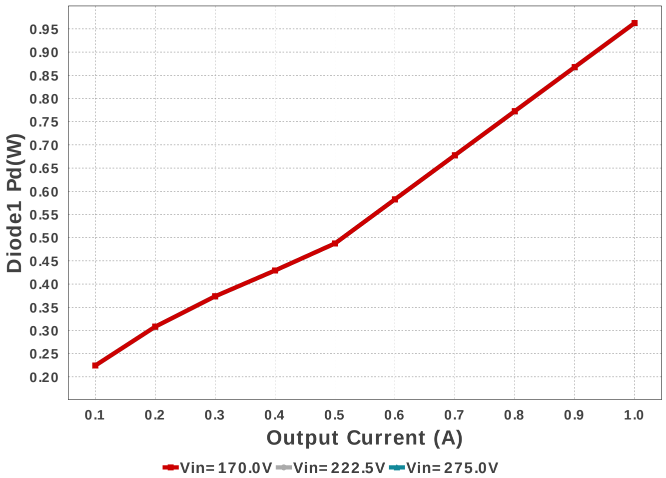




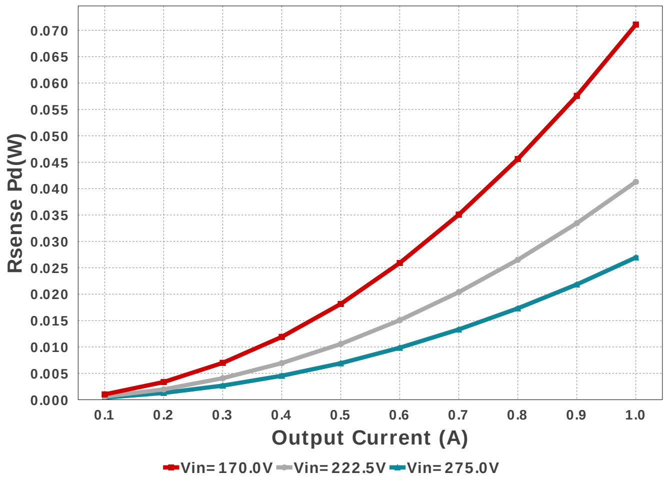




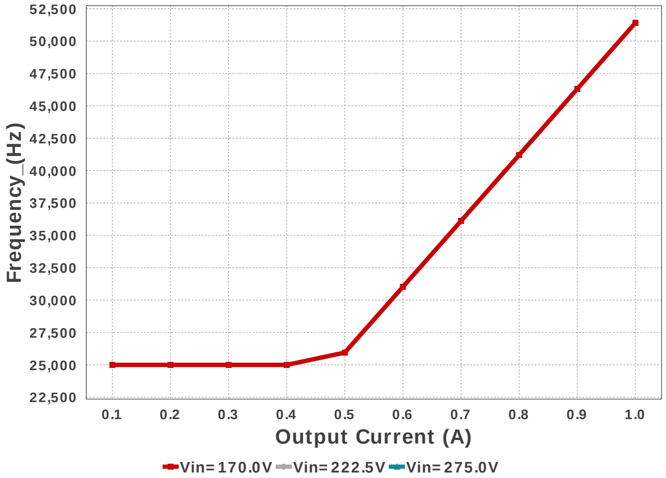
Diode1 Pd



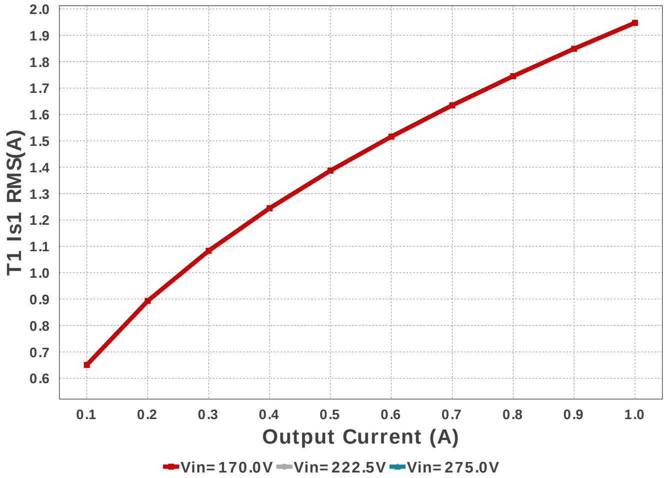
Rsense Pd



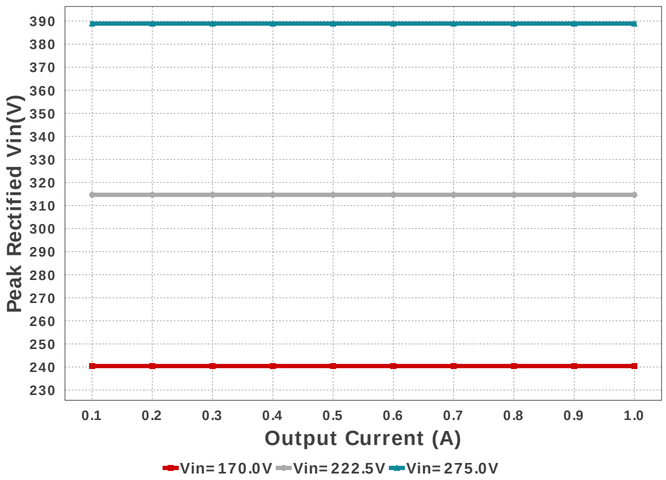
Frequency_



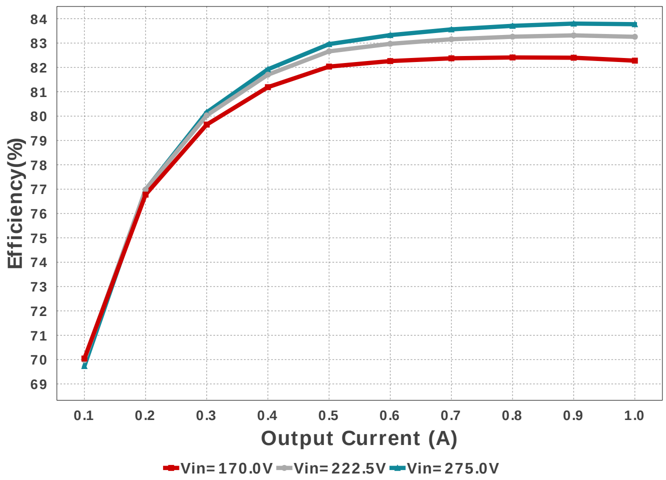
T1 Is1 RMS



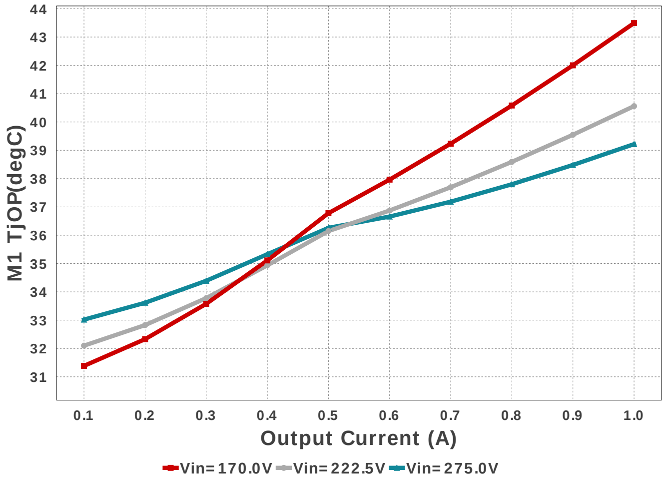
Peak Rectified Vin



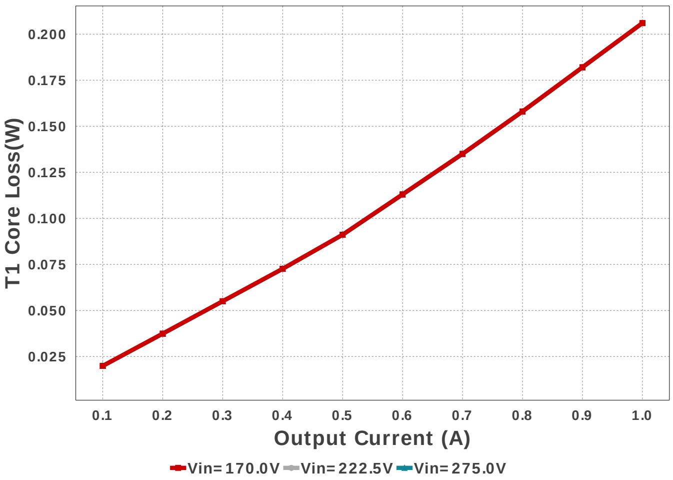
Efficiency



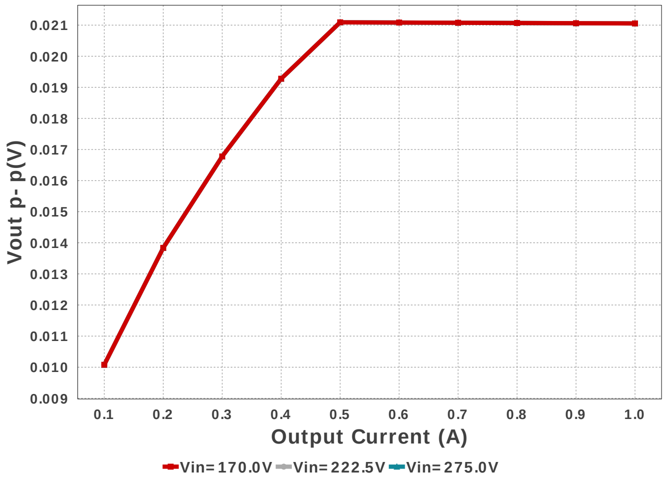
M1 TjOP



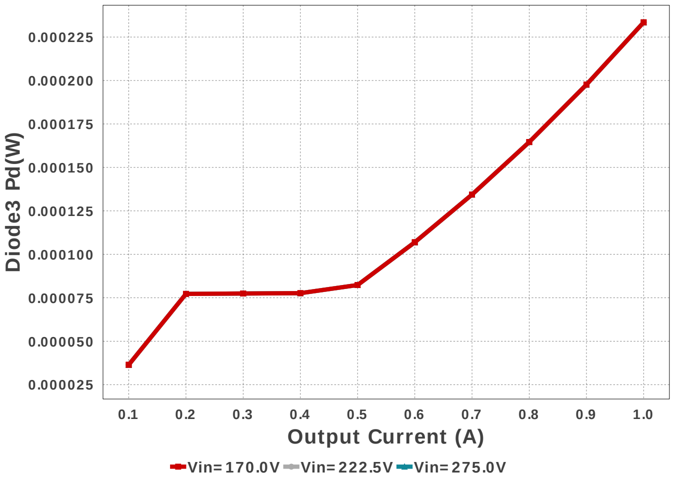
T1 Core Loss



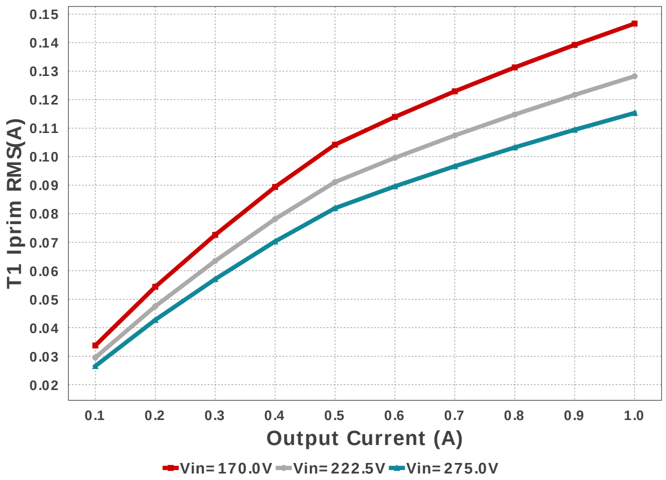
Vout p- p



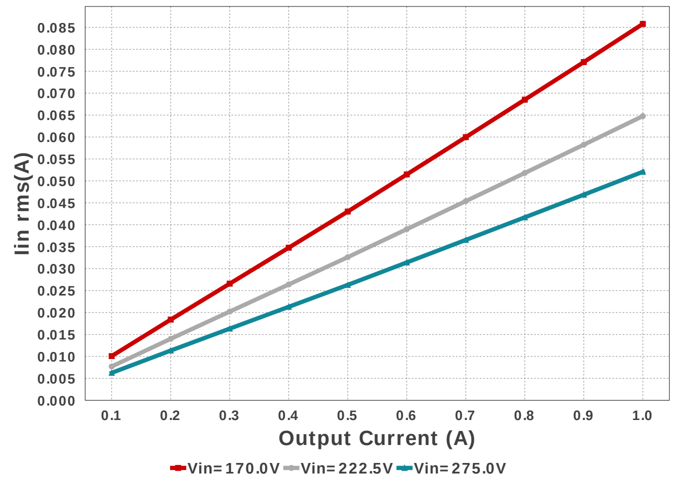
Diode3 Pd

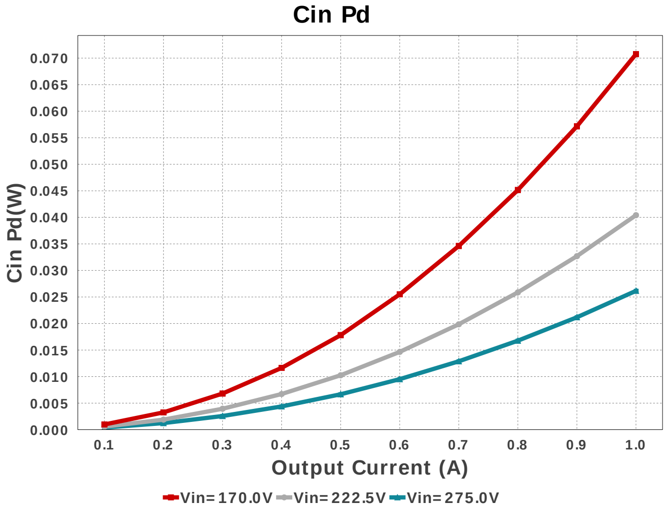


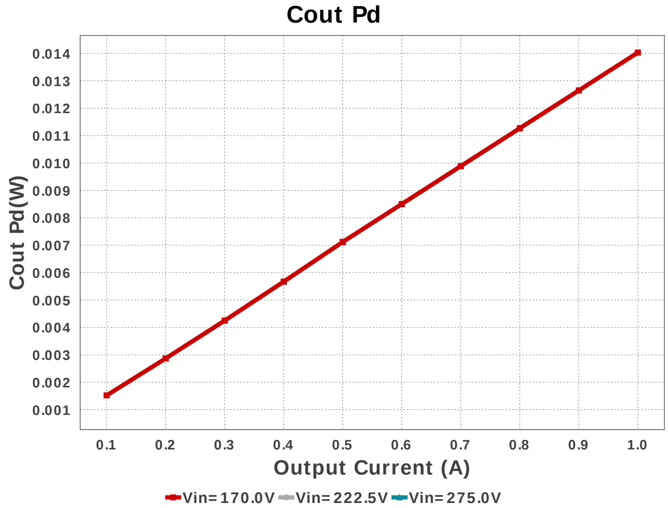
T1 Iprim RMS

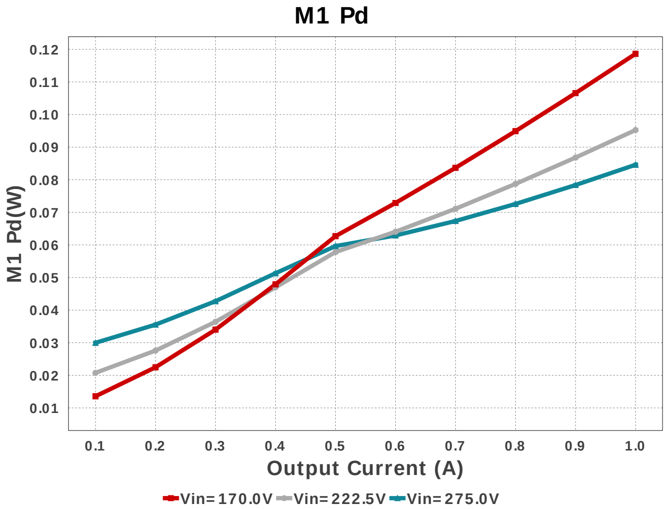


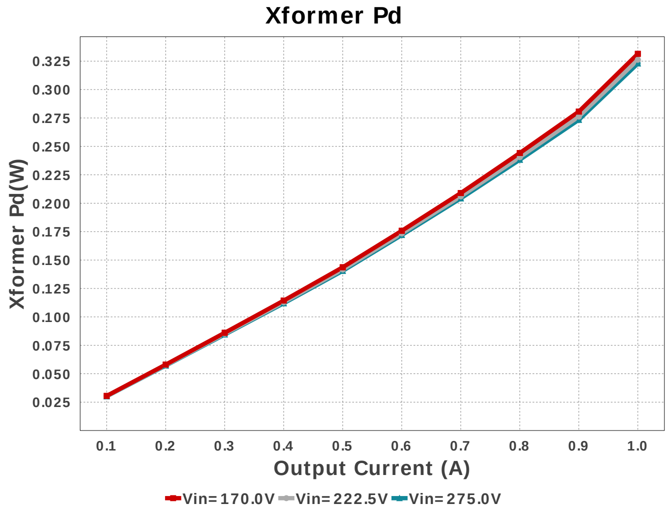
Iin rms

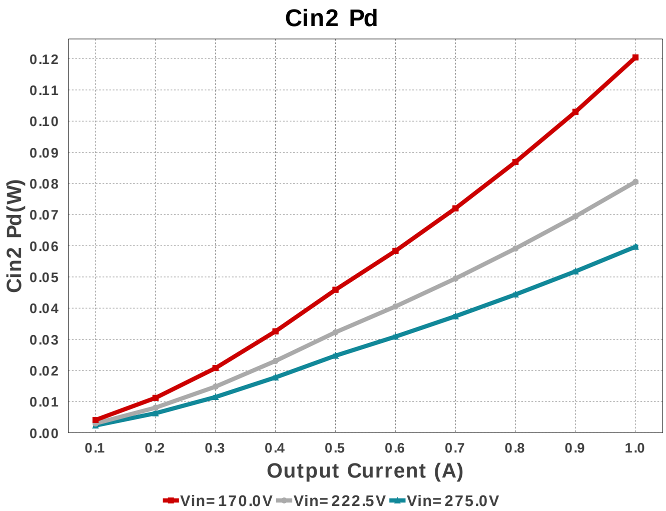


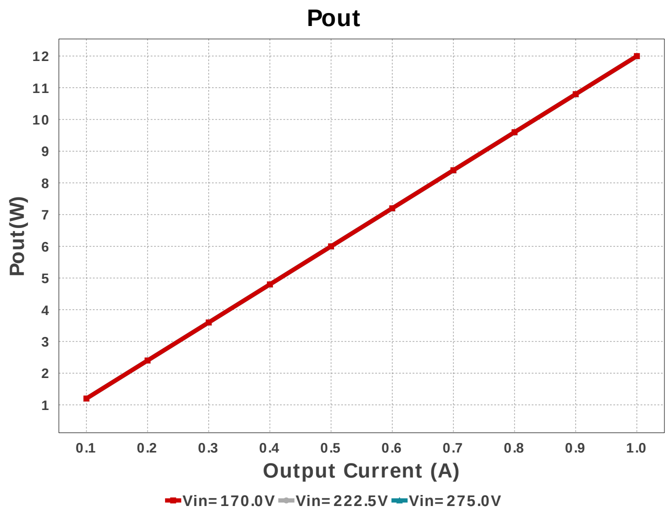

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=170.0V
Vin=222.5V
Vin=275.0V


Cout Pd
Cout Pd(W)
Output Current (A)
Vin=170.0V
Vin=222.5V
Vin=275.0V

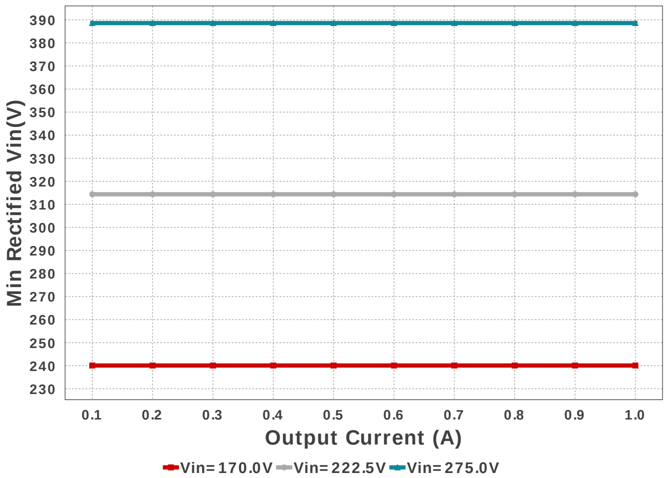

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=170.0V
Vin=222.5V
Vin=275.0V


Xformer Pd
Xformer Pd(W)
Output Current (A)
Vin=170.0V
Vin=222.5V
Vin=275.0V

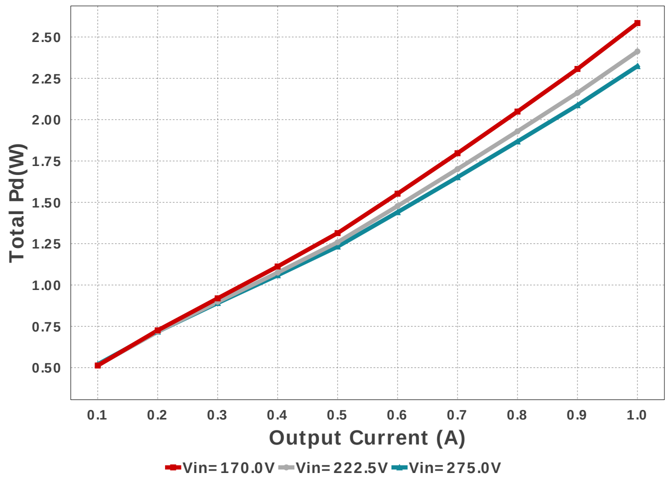

Cin2 Pd
Cin2 Pd(W)
Output Current (A)
Vin=170.0V
Vin=222.5V
Vin=275.0V


Pout
Pout(W)
Output Current (A)
Vin=170.0V
Vin=222.5V
Vin=275.0V

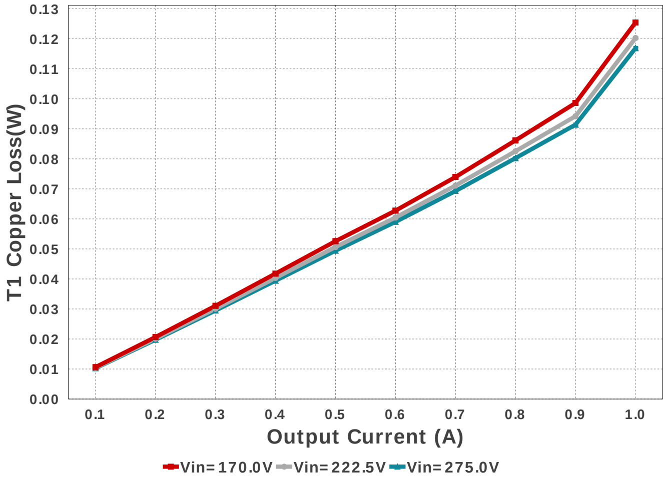
Min Rectified Vin



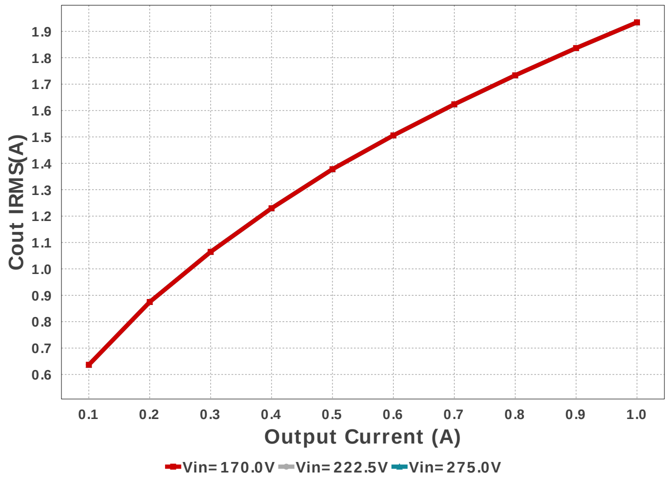
Total Pd



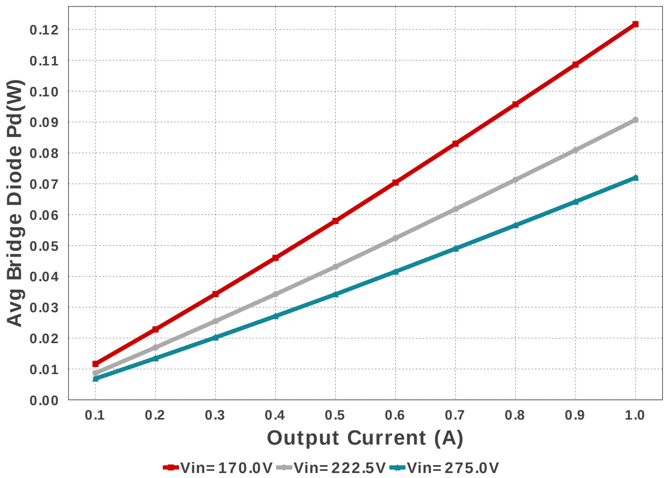
T1 Copper Loss



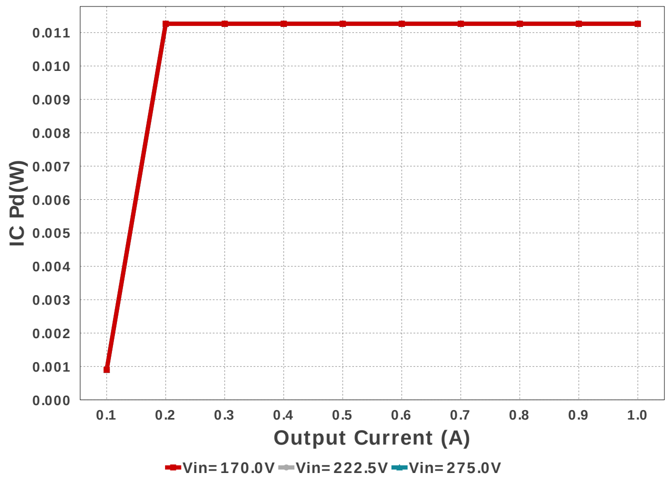
Cout IRMS

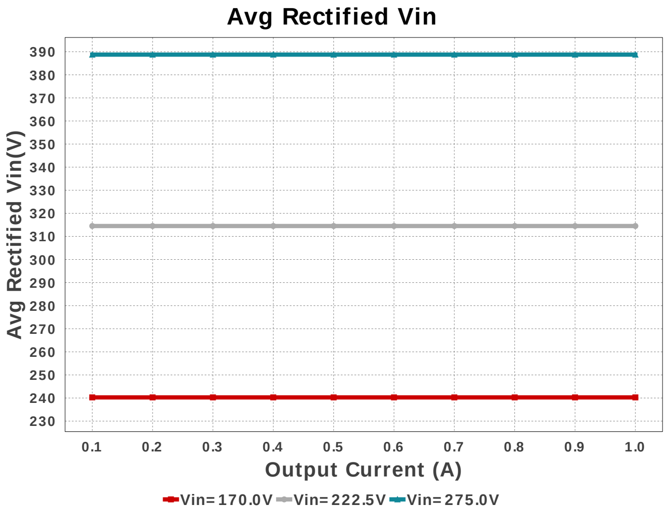


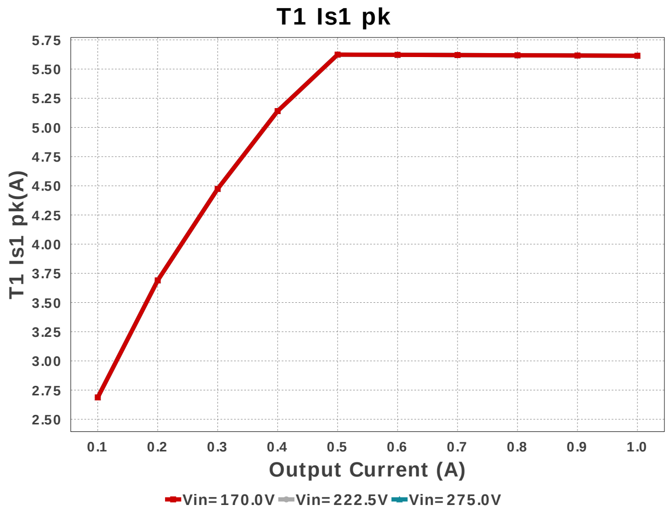
Avg Bridge Diode Pd

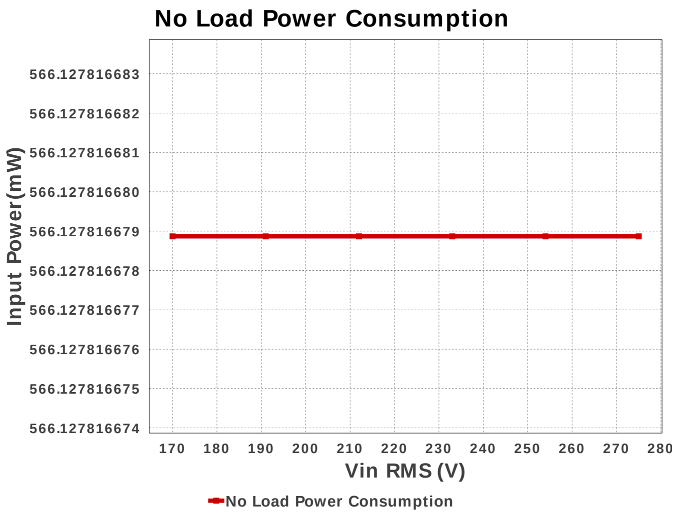


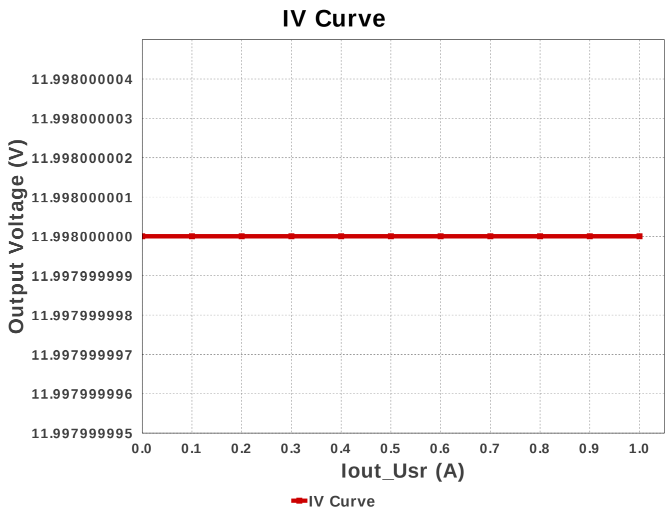
IC Pd











Operating Values

#	Name	Value	Category	Description
1.	BOM Count	29		Total Design BOM count
2.	Total BOM	$4.118		Total BOM Cost
3.	Cin Pd	70.747 mW	Capacitors	Input capacitor power dissipation
4.	Cin2 Pd	120.45 mW	Capacitors	Average Power Dissipation in the Input Capacitor Cin2
5.	Cout IRMS	1.934 A	Capacitors	Output capacitor RMS ripple current
6.	Cout Pd	14.029 mW	Capacitors	Output capacitor power dissipation
7.	Avg Bridge Diode Pd	121.7 mW	Diode	Average Power Dissipation in the Bridge Diode over the AC Line Period
8.	Diode1 Pd	962.54 mW	Diodes	Diode1 power dissipation
9.	Diode3 Pd	233.47 µW	Diodes	Diode3 power dissipation
10.	IC Pd	11.265 mW	IC	IC power dissipation
11.	IC Tj	32.028 degC	IC	IC junction temperature
12.	ICThetaJA	180.0 degC/W	IC	IC junction-to-ambient thermal resistance
13.	M1 Pd	118.62 mW	Mosfet	M1 MOSFET total power dissipation
14.	M1 TjOP	43.493 degC	Mosfet	M1 MOSFET junction temperature
15.	Avg Bridge Diode Pd	121.7 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
16.	Cin Pd	70.747 mW	Power	Input capacitor power dissipation
17.	Cin2 Pd	120.45 mW	Power	Average Power Dissipation in the Input Capacitor Cin2
18.	Cout Pd	14.029 mW	Power	Output capacitor power dissipation
19.	Diode1 Pd	962.54 mW	Power	Diode1 power dissipation
20.	Diode3 Pd	233.47 µW	Power	Diode3 power dissipation
21.	IC Pd	11.265 mW	Power	IC power dissipation
22.	M1 Pd	118.62 mW	Power	M1 MOSFET total power dissipation
23.	Rsense Pd	71.075 mW	Power	LED Current Rsns Power Dissipation
24.	Snubber Pd	558.925 mW	Power	Snubber Power Dissipation
25.	T1 Copper Loss	125.43 mW	Power	Transformer Copper Loss Power Dissipation
26.	T1 Core Loss	206.0 mW	Power	Transformer Core Loss Power Dissipation
27.	Total Pd	2.584 W	Power	Total Power Dissipation
28.	Xformer Pd	331.43 mW	Power	Transformer power dissipation
29.	Rsense Pd	71.075 mW	Rcs	LED Current Rsns Power Dissipation
30.	Avg Rectified Vin	240.264 V	System Information	Average Rectified Voltage for the AC Line Period

#	Name	Value	Category	Description
31.	Duty Cycle	25.818 %	System Information	Duty cycle
32.	Efficiency	82.278 %	System Information	Steady state efficiency
33.	FootPrint	2.106 k mm^2	System Information	Total Foot Print Area of BOM components
34.	Frequency	51.411 kHz	System Information	Switching frequency
35.	Frequency	51.411 kHz	System Information	Switching frequency
36.	Iin rms	85.778 mA	System Information	RMS Input Current
37.	Iout	1.0 A	System Information	Iout operating point
38.	Min Rectified Vin	240.114 V	System Information	Minimum voltage seen at rectified input
39.	Mode	DCM	System Information	Conduction Mode
40.	Peak Rectified Vin	240.414 V	System Information	Peak voltage seen at rectified input
41.	Pout	11.998 W	System Information	Total output power
42.	Vin_RMS	170.0 V	System Information	Vin operating point
43.	Vout	11.998 V	System Information	Operational Output Voltage
44.	Vout Actual	18.703 V	System Information	Vout Actual calculated based on selected voltage divider resistors
45.	Vout Tolerance	1.061 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
46.	Vout p-p	21.054 mV	System Information	Peak-to-peak output ripple voltage
47.	T1 Copper Loss	125.43 mW	Transformer	Transformer Copper Loss Power Dissipation
48.	T1 Core Loss	206.0 mW	Transformer	Transformer Core Loss Power Dissipation
49.	T1 Iprim RMS	146.681 mA	Transformer	Transformer Primary RMS Current
50.	T1 Iprim pk	500.0 mA	Transformer	Transformer Primary Peak Current
51.	T1 Is1 RMS	1.947 A	Transformer	Transformer Secondary1 RMS Current
52.	T1 Is1 pk	5.614 A	Transformer	Transformer Secondary1 Peak Current
53.	Xformer Pd	331.43 mW	Transformer	Transformer power dissipation

Design Inputs

Name	Value	Description
Iout	1.0	Maximum Output Current
VinMax	275.0	Maximum input voltage
VinMin	170.0	Minimum input voltage
Vout	12.0	Output Voltage
acFrequency	50.0	AC Frequency
base_pn	UCC28704	Base Product Number
source	AC	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

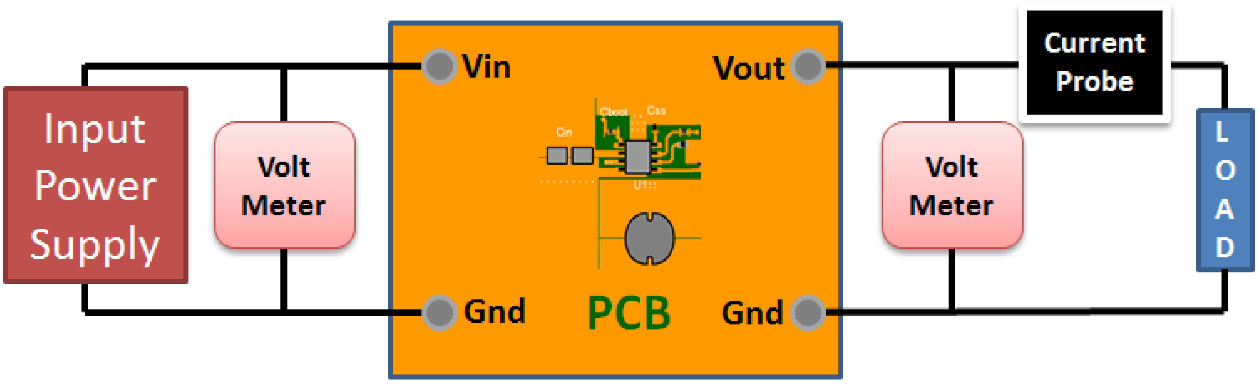
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 170.0V 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.



WEBENCH® Transformer Report

#	Name	Value
1.	Core Part Number	B66317G0000X187
2.	Core Manufacturer	TDK
3.	Coil Former Part Number	B66208X1110T001
4.	Coil Former Manufacturer	TDK

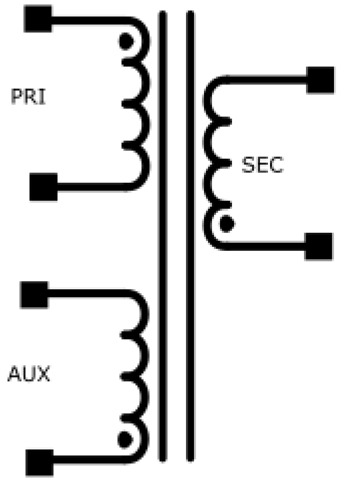
Transformer Electrical Diagram

Primary

Turns	104.0
AWG	25.0
Layers	4.0
Strands	1.0
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

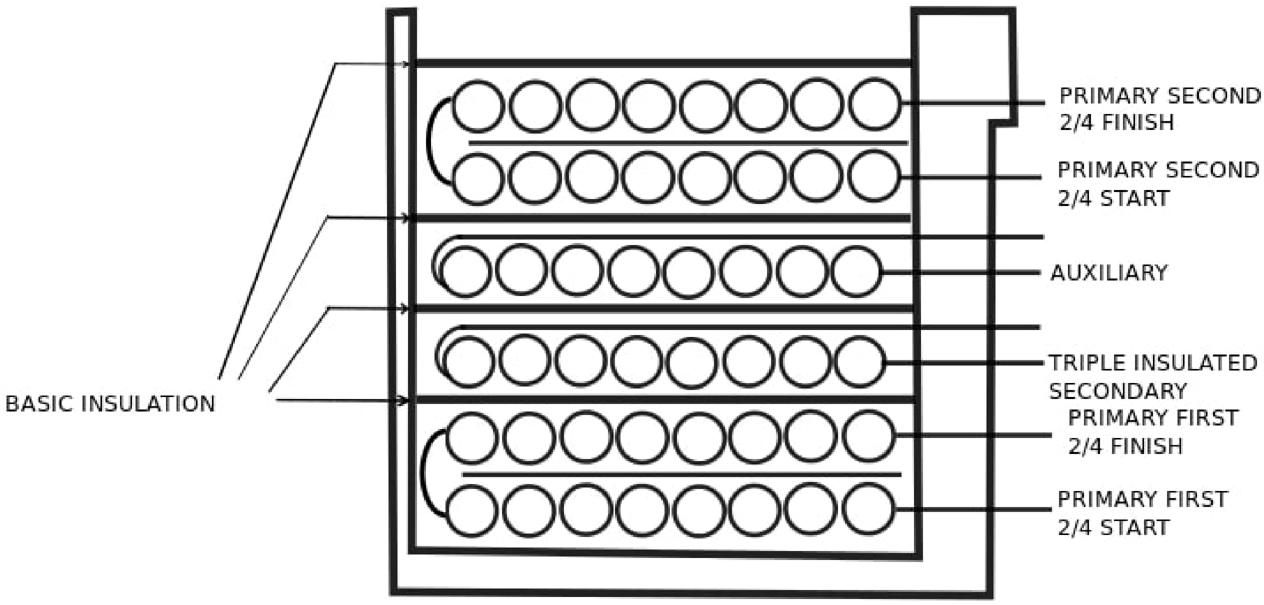
Turns	13.0
AWG	28.0
Layers	1.0
Strands	3.0
Insulation Type	Heavy Insulated Magnet Wire



Secondary

Turns	9.0
AWG	25.0
Layers	1.0
Strands	2.0
Insulation Type	Triple Insulated

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4.0	25.0	52	Clockwise
Triple Insulated Secondary	25.0	9.0	Counter Clockwise
Auxiliary	28.0	13.0	Counter Clockwise
Primary Second 2/4.0	25.0	52	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	0.00217H
2.	Inductance Factor(Al)	202.0nH
3.	Npri	104.0
4.	Nsec	9.0
5.	Naux	13.0
6.	Core Type	E25/13/7
7.	Core Material	N87
8.	Bmax	0.20T
9.	Switching Frequency	65.00kHz
10.	DMax	0.46
11.	Ipk(Primary)	0.5A
12.	Irms(Primary)	0.2A
13.	Ipk(Secondary)	5.78A
14.	Irms(Secondary)	2.3A

Design Assistance

1. Application Hints: T1: The transformer parameters assume that an RM6 core is used, and the DCR values are assumed values used only for efficiency estimates. Rdd is set to 22 Ohms by default. it can be varied between 1 Ohm to 47 Ohms depending on transformer selected and Vdd expected Rbld: Rbld is used to to set a minimum load for the circuit, so that in standby the output voltage does not float up. The value chosen by WEBENCH should be a good starting point but may need to be adjusted to achieve minimum power dissipation at standby as well. Rlc: Rlc provides the function of feed-forward line compensation to eliminate change in IPP due to change in di/dt and the propagation delay of the internal comparator and MOSFET turn-off time. For best results the chosen value may need to be adjusted based on board, FET and transformer parasitics. Rfbt & Rfbb: The feedback resistors will set the output voltage of the circuit. The values chosen may need to be fined tuned based on the final Transformer turns ratios and the voltage across the output diode at close to zero current. Cdd: Cdd supplies the device operating current until the output of the converter reaches the target minimum operating voltage. The value calculated by WEBENCH for Cdd is a good starting point since it assumes that the output current of the Flyback is available to charge the output capacitance until the minimum output voltage is acheived, but may need to be adjusted. Part Description: The UCC28704 Flyback power supply controller provides Constant-Voltage (CV) and Constant-Current (CC) output regulation. Primary-Side Regulation (PSR) eliminates the use of an Opto-Coupler. Please see the datasheet for further design guidance. http://www.ti.com/lit/ds/symlink/ucc28704.pdf

2. Master key : 1FF720AF0255931C[v1]

3. **UCC28704** Product Folder : http://www.ti.com/product/UCC28704 : contains the data sheet and other resources.