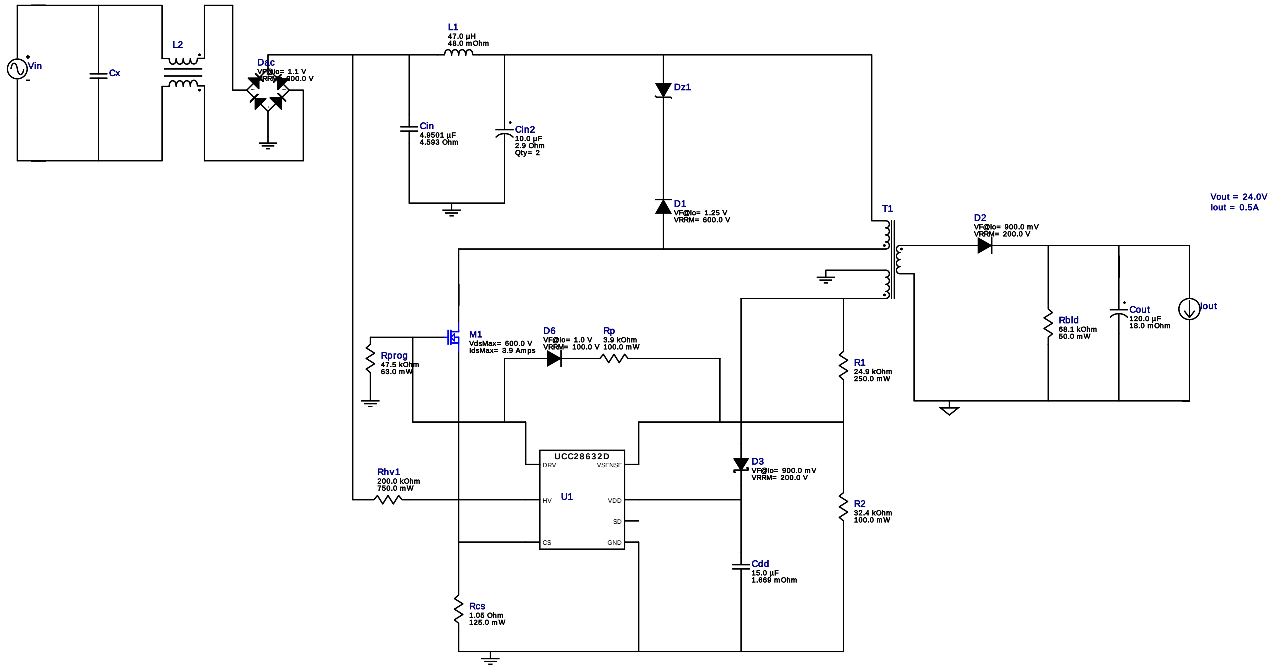
VinMin = 90.0V
VinMax = 250.0V
Vout = 24.0V
Iout = 0.5A

Device = UCC28632DR
Topology = Flyback
Created = 2021-12-22 09:32:04.011
BOM Cost = NA
BOM Count = 22
Total Pd = 1.64W

WEBENCH ® Design Report

Design : 25 UCC28632DR
UCC28632DR 90V-250V to 24.00V @ 0.5A



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. For more information please click the design assistance button.

2. Device operates in peak power region. So user needs to ensure the safe operation of 'D2' diode by using Heat sink if required.

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

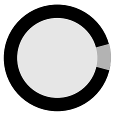
Design Alerts

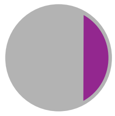
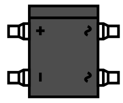
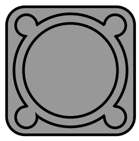
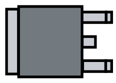
Component Selection Information

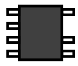
Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.

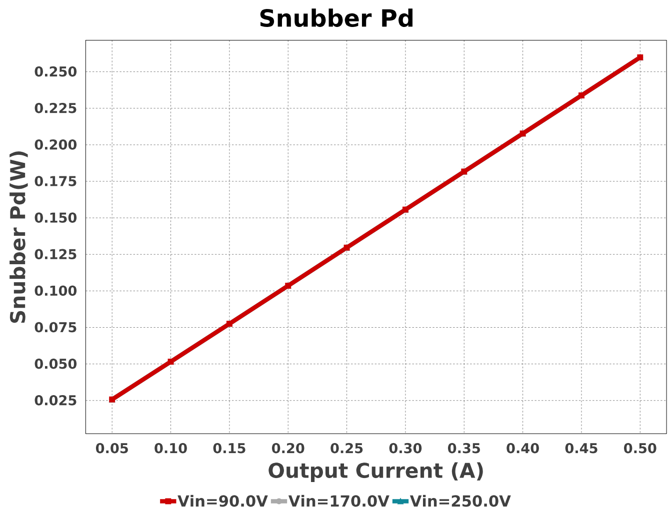
Electrical BOM

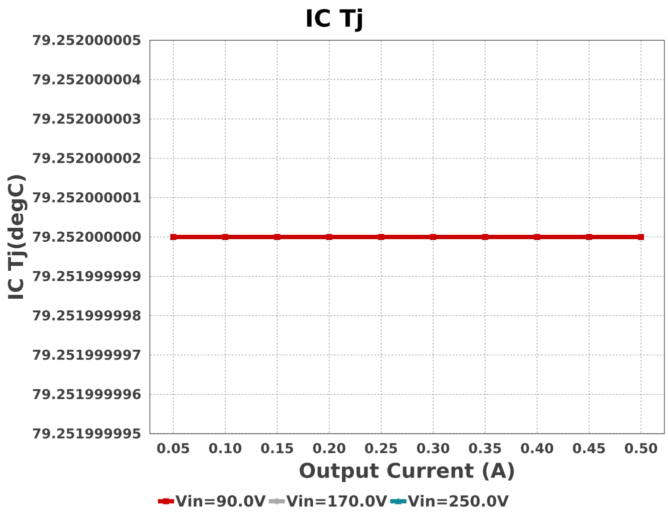
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cdd	TDK	C2012X5R1V156M125AC Series= X5R	Cap= 15.0 uF ESR= 1.669 mOhm VDC= 35.0 V IRMS= 5.0498 A	1	$0.21	0805 7 mm^2
Cin	CUSTOM	CUSTOM Series= ?	Cap= 4.9501 uF ESR= 4.5931 Ohm VDC= 374.76 V IRMS= 93.321 mA	1	NA	CUSTOM 0 mm^2
Cin2	Kemet	ESG106M400AH4AA Series= 2334	Cap= 10.0 uF ESR= 2.9 Ohm VDC= 400.0 V IRMS= 100.0 mA	2	$0.21	ESG106 144 mm^2

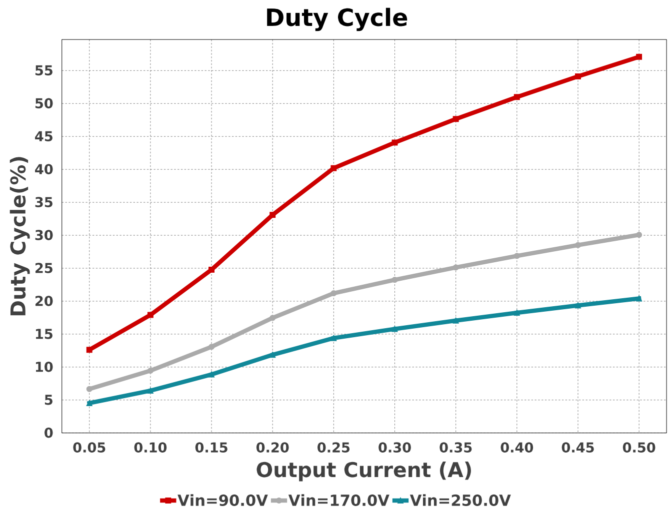


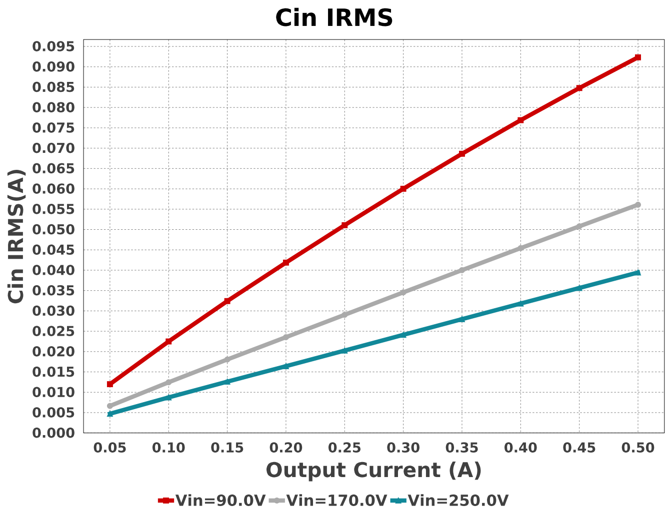
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	Panasonic	35SEPF120M Series= SEPF	Cap= 120.0 uF ESR= 18.0 mOhm VDC= 35.0 V IRMS= 4.4 A	1	$0.69	 SEPF_F13 144 mm²
D1	Diodes Inc.	MURS160-13-F	VF@Io= 1.25 V VRRM= 600.0 V	1	$0.11	 SMB 44 mm²
D2	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.04	 SMA 37 mm²
D3	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.04	 SMA 37 mm²
D6	Comchip Technology	CDBW46-G	VF@Io= 1.0 V VRRM= 100.0 V	1	$0.03	 SOD-123 13 mm²
Dac	Vishay-Semiconductor	DF08SA	VF@Io= 1.1 V VRRM= 800.0 V	1	$0.24	 DF-S 99 mm²
Dz1	Diodes Inc.	SMBJ170A-13-F	Zener	1	$0.09	 SMB 44 mm²
L1	Coilcraft	MSS1210-473MEB	L= 47.0 µH 48.0 mOhm	1	$0.81	 MSS1210 204 mm²
M1	Fairchild Semiconductor	FCD4N60TM	VdsMax= 600.0 V IdsMax= 3.9 Amps	1	$0.48	 DPAK 102 mm²
R1	Panasonic	ERJ-8ENF2492V Series= ERJ-8E	Res= 24.9 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm²
R2	Vishay-Dale	CRCW060332K4FKEA Series= CRCW..e3	Res= 32.4 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Rbld	Yageo	RC0201FR-7D68K1L Series= ?	Res= 68.1 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	 0201 2 mm²
Rcs	Vishay-Dale	CRCW08051R05FKEA Series= CRCW..e3	Res= 1.05 Ohm Power= 125.0 mW Tolerance= 1.0%	1	NA	 0805 7 mm²
Rhv1	Vishay-Semiconductor	CRCW2010200KFKEF Series= ?	Res= 200.0 kOhm Power= 750.0 mW Tolerance= 1.0%	1	$0.03	 2010 32 mm²
Rp	Yageo	RC0603FR-073K9L Series= ?	Res= 3.9 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	 0603 5 mm²
Rprog	Vishay-Dale	CRCW040247K5FKED Series= CRCW..e3	Res= 47.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
T1	Core=TDK , CoilFormer=TDK	Core=B66421G0000X197 , CoilFormer=B66422W1010D001	Lp= 1.4 mH Turns Ratio(Nas)= 8:14 Turns Ratio(Nps)= 62:14 Npri= 62.0 Naux= 8.0 Nsec= 14.0	1	$0.35	 TDK_B66305 756 mm²

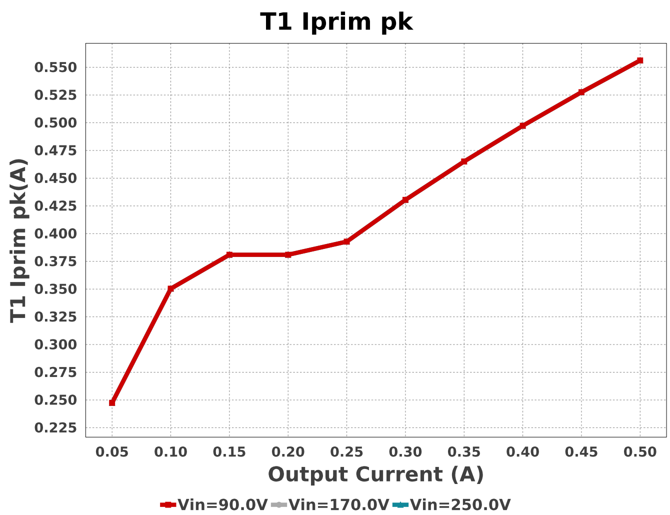
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	UCC28632DR	Switcher	1	$0.66	 R-PDSO-G7 55 mm²

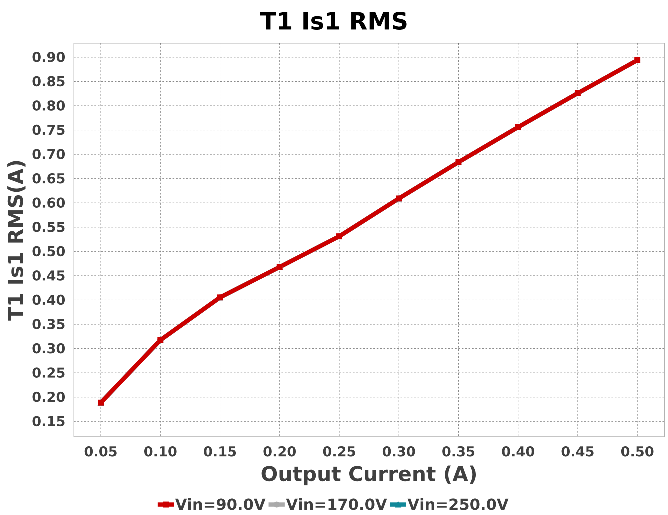


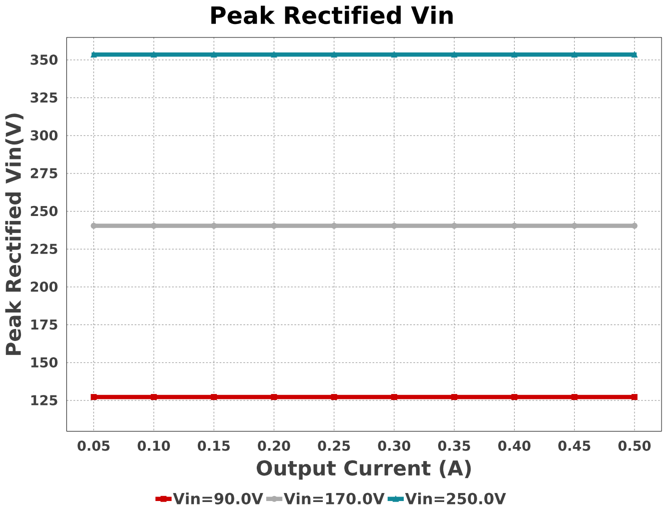


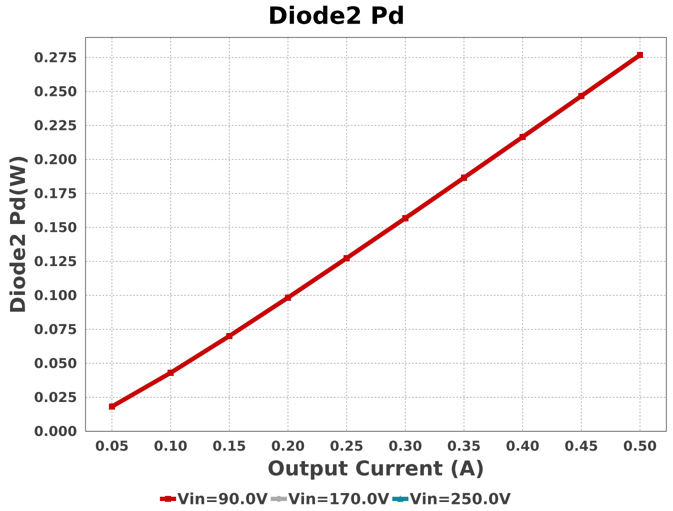


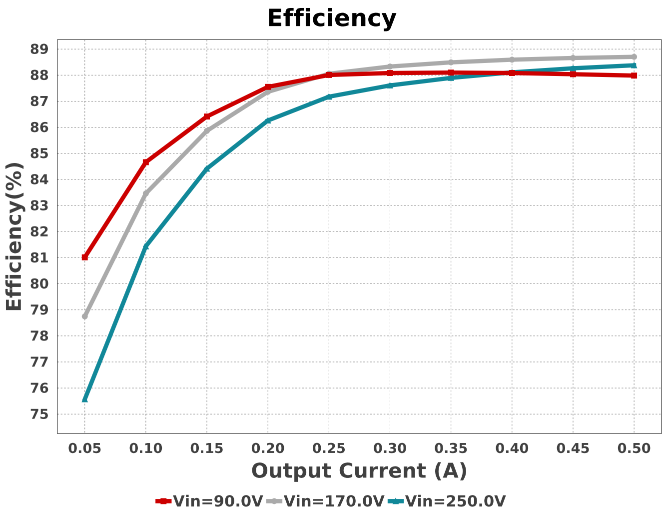


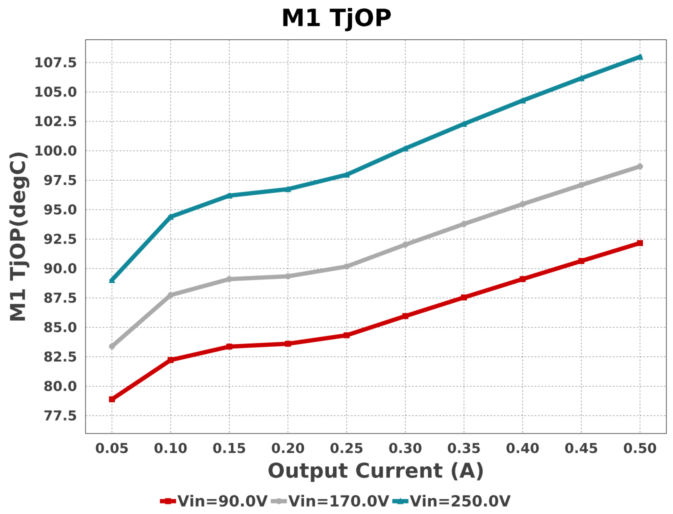


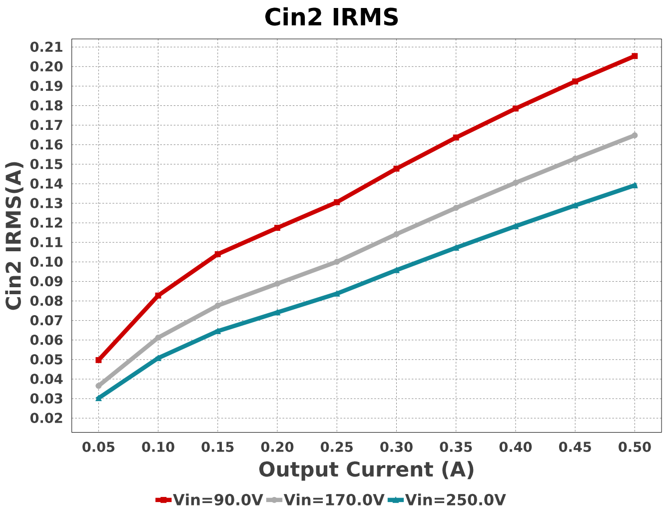


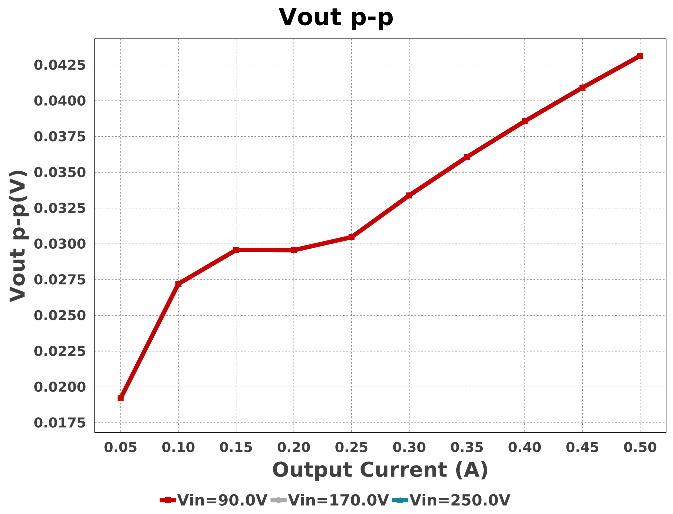

Peak Rectified Vin
Peak Rectified Vin(V)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

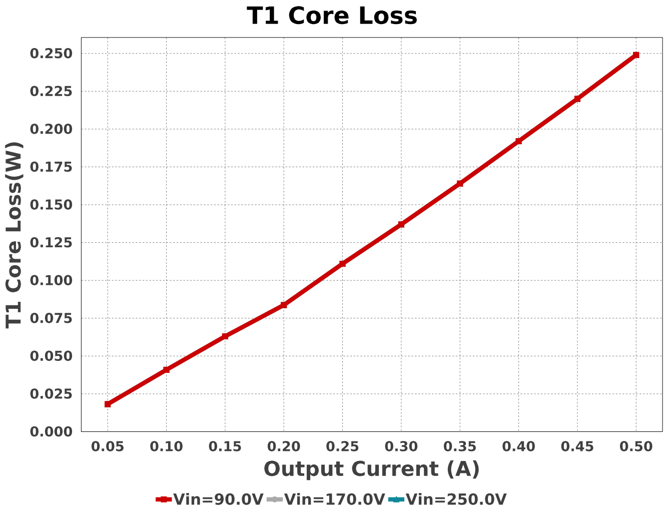

Diode2 Pd
Diode2 Pd(W)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

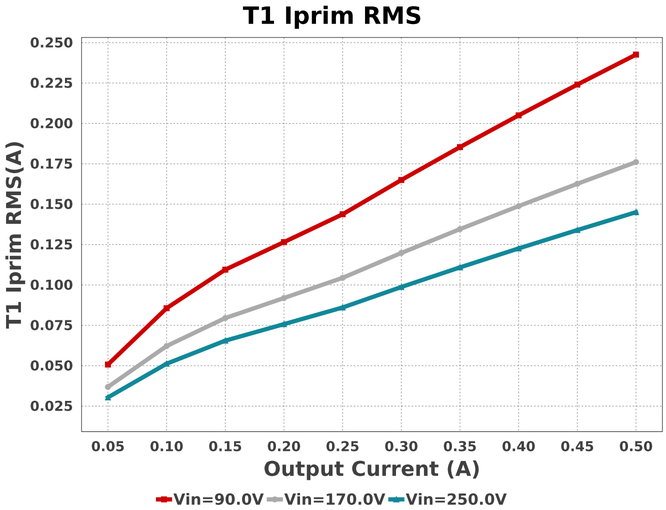

Efficiency
Efficiency(%)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

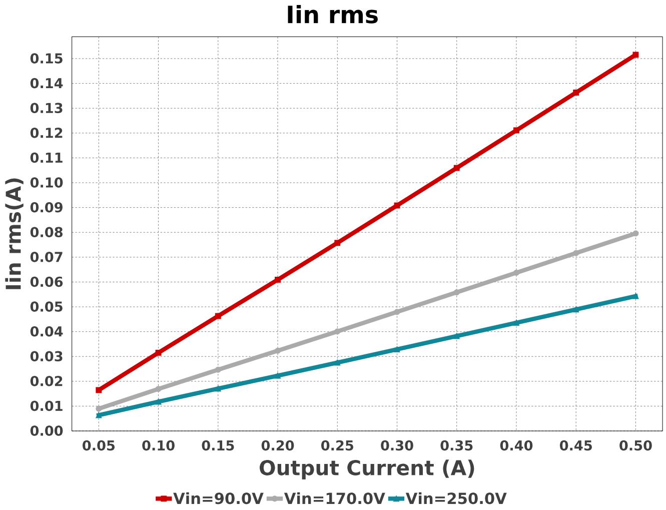

M1 TjOP
M1 TjOP(degC)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

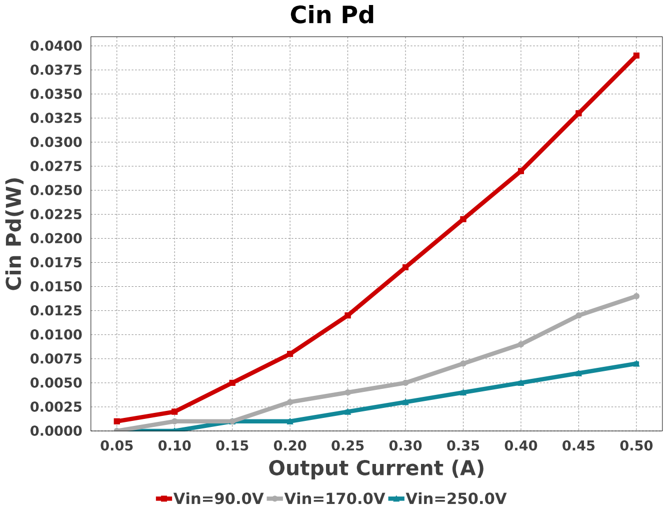

Cin2 IRMS
Cin2 IRMS(A)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

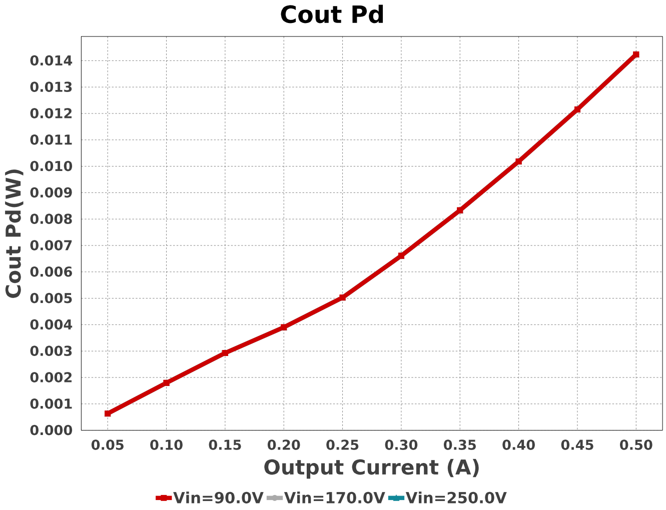

Vout p-p
Vout p-p(V)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

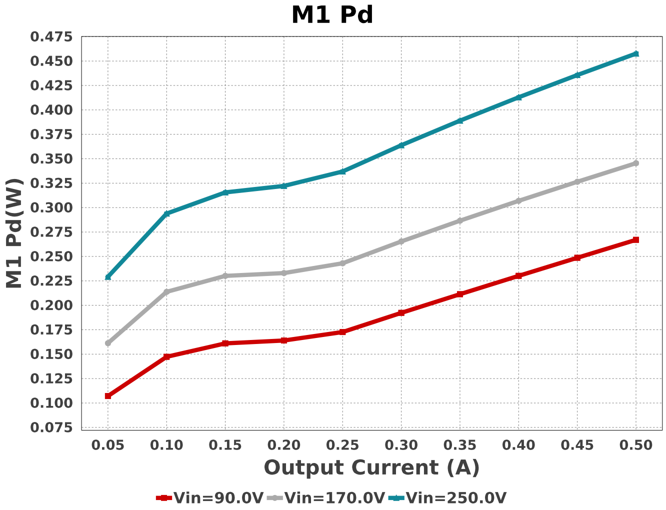

T1 Core Loss
T1 Core Loss(W)
Output Current (A)
Vin=90.0V Vin=170.0V Vin=250.0V

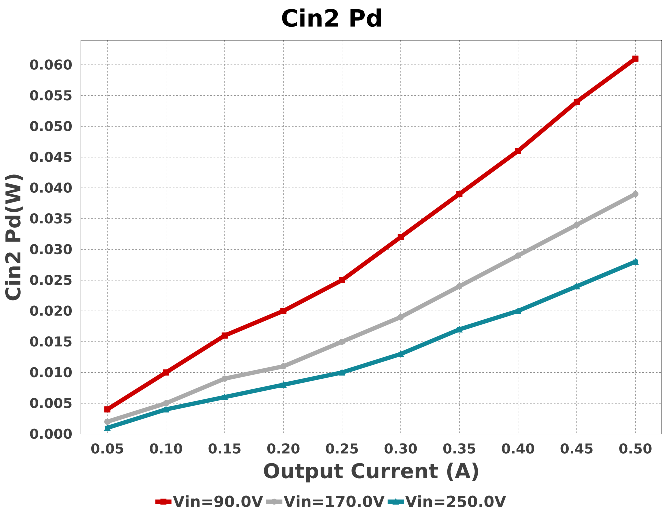

T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin=90.0V Vin=170.0V Vin=250.0V

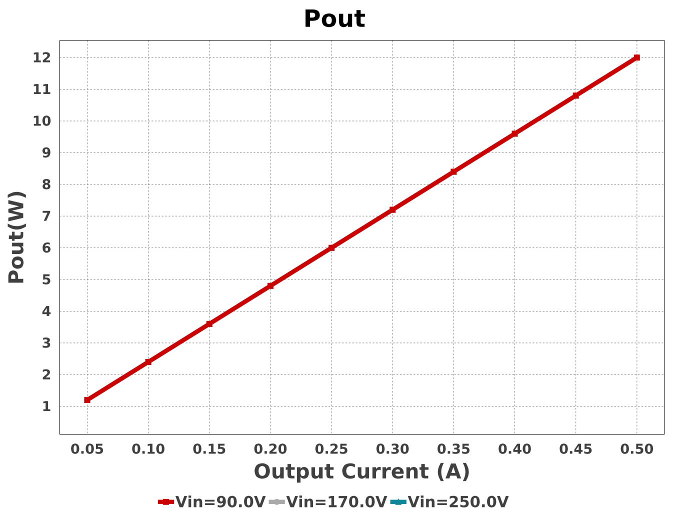

Iin rms
Iin rms(A)
Output Current (A)
Vin=90.0V Vin=170.0V Vin=250.0V

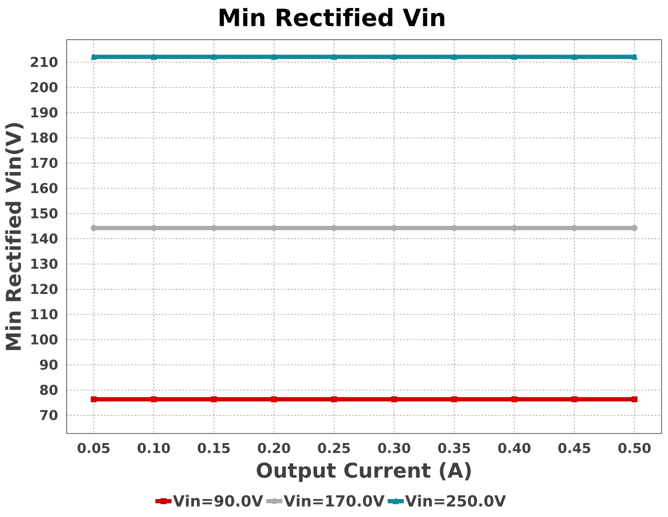

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=90.0V Vin=170.0V Vin=250.0V

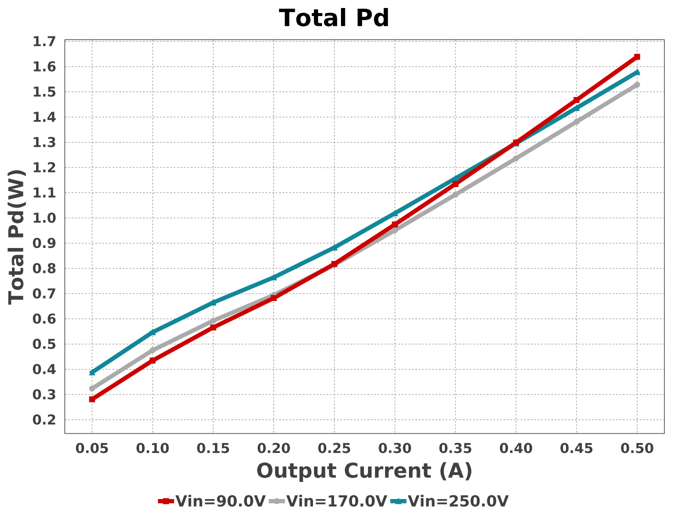

Cout Pd
Cout Pd(W)
Output Current (A)
Vin=90.0V Vin=170.0V Vin=250.0V

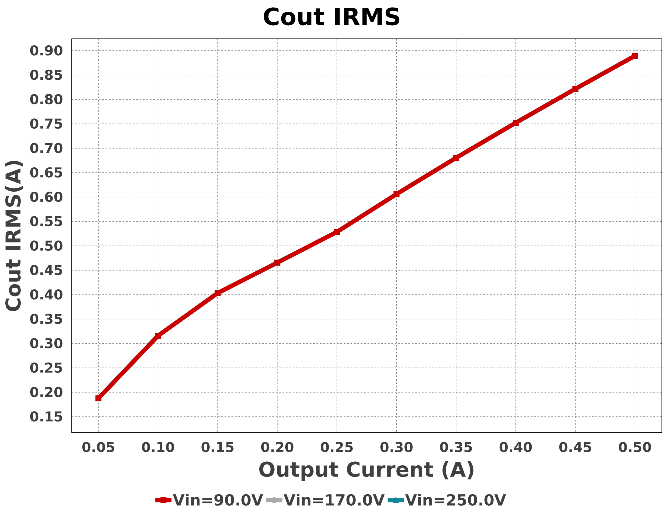

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=90.0V Vin=170.0V Vin=250.0V

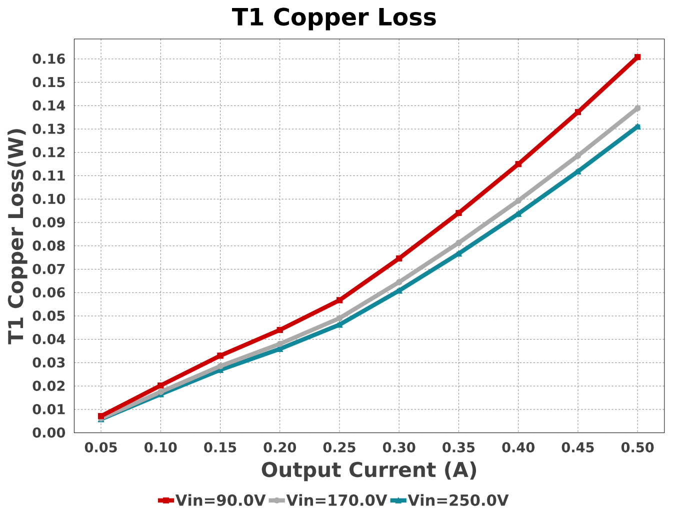

Cin2 Pd
Cin2 Pd(W)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

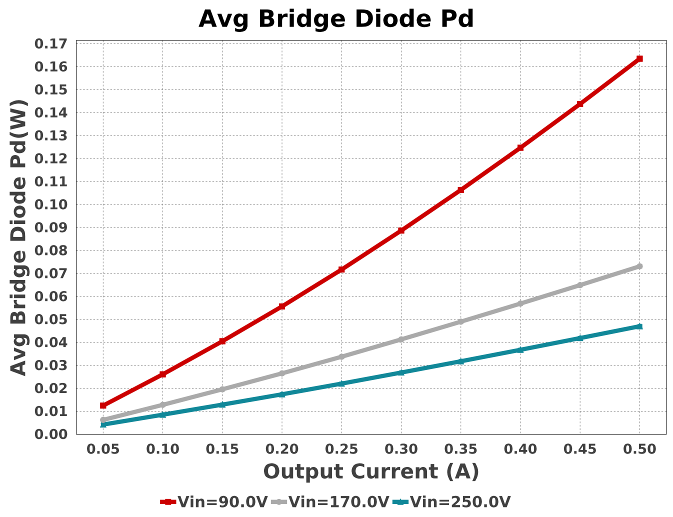

Pout
Pout(W)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

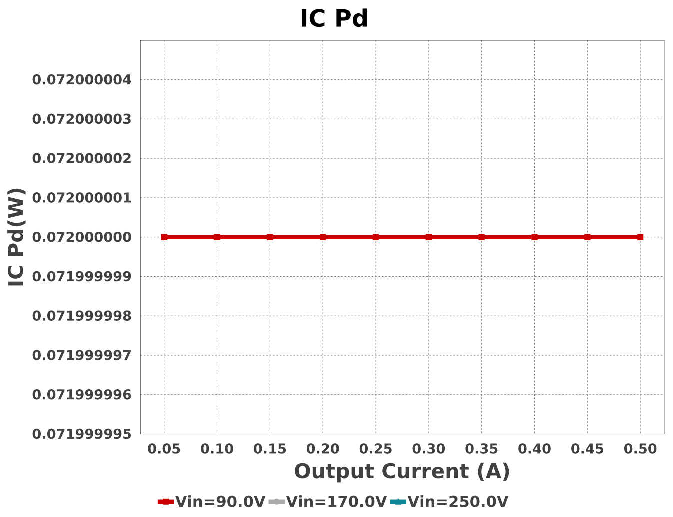

Min Rectified Vin
Min Rectified Vin(V)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

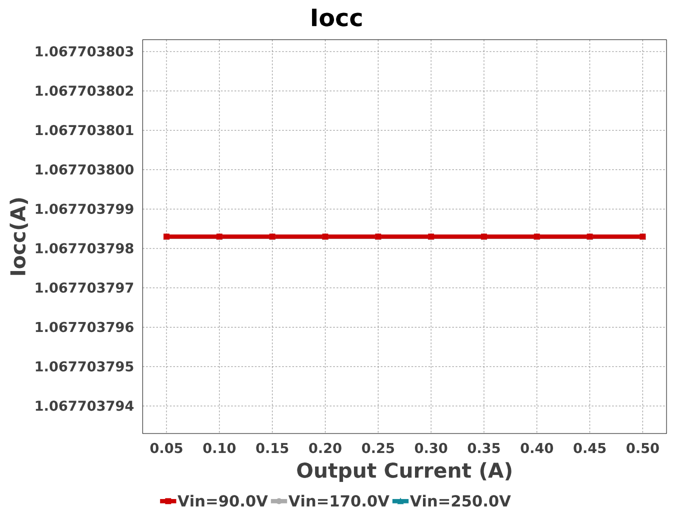

Total Pd
Total Pd(W)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

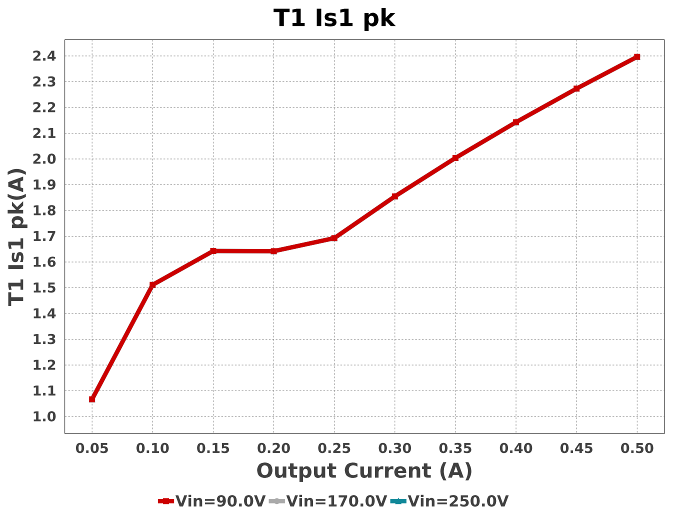

Cout IRMS
Cout IRMS(A)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

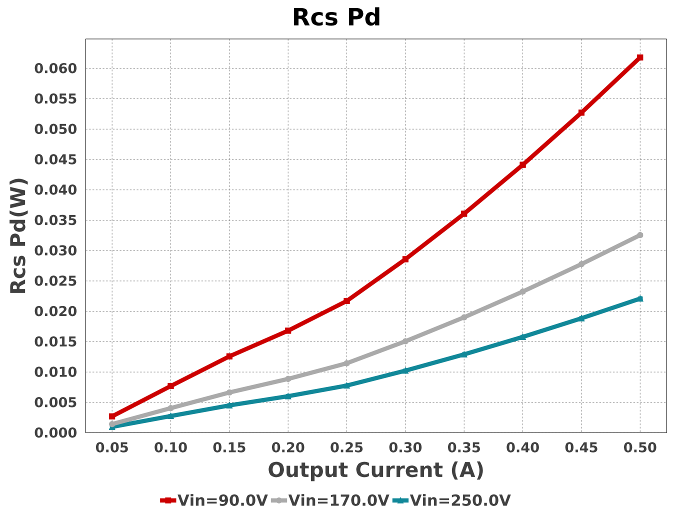

T1 Copper Loss
T1 Copper Loss(W)
Output Current (A)
Vin=90.0V
Vin=170.0V
Vin=250.0V

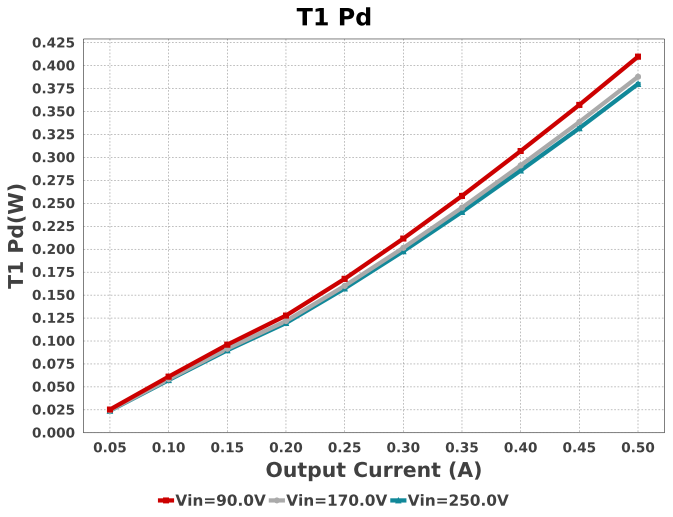












Operating Values

#	Name	Value	Category	Description
1.	BOM Count	22		Total Design BOM count
2.	Total BOM	NA		Total BOM Cost
3.	Cin IRMS	92.324 mA	Capacitor	Input capacitor RMS ripple current
4.	Cin Pd	39.0 mW	Capacitor	Input capacitor power dissipation
5.	Cin2 IRMS	205.388 mA	Capacitor	Input Capacitor Cin2 RMS Ripple Current
6.	Cin2 Pd	61.0 mW	Capacitor	Average Power Dissipation in the Input Capacitor Cin2
7.	Cout IRMS	889.313 mA	Capacitor	Output capacitor RMS ripple current
8.	Cout Pd	14.236 mW	Capacitor	Output capacitor power dissipation
9.	Avg Bridge Diode Pd	163.46 mW	Diode	Average Power Dissipation in the Bridge Diode over the AC Line Period
10.	Diode2 Pd	276.83 mW	Diode	Diode2 power dissipation
11.	IC Pd	72.0 mW	IC	IC power dissipation

#	Name	Value	Category	Description
12.	IC Tj	79.252 degC	IC	IC junction temperature
13.	ICThetaJA	128.5 degC/W	IC	IC junction-to-ambient thermal resistance
14.	M1 Pd	267.01 mW	Mosfet	M1 MOSFET total power dissipation
15.	M1 TjOP	92.162 degC	Mosfet	M1 MOSFET junction temperature
16.	Avg Bridge Diode Pd	163.46 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
17.	Cin Pd	39.0 mW	Power	Input capacitor power dissipation
18.	Cin2 Pd	61.0 mW	Power	Average Power Dissipation in the Input Capacitor Cin2
19.	Cout Pd	14.236 mW	Power	Output capacitor power dissipation
20.	Diode2 Pd	276.83 mW	Power	Diode2 power dissipation
21.	IC Pd	72.0 mW	Power	IC power dissipation
22.	M1 Pd	267.01 mW	Power	M1 MOSFET total power dissipation
23.	Rcs Pd	61.803 mW	Power	Current Limit Sense Resistor Power Dissipation
24.	Snubber Pd	259.842 mW	Power	Snubber Power Dissipation
25.	T1 Copper Loss	160.8 mW	Power	Transformer Copper Loss Power Dissipation
26.	T1 Core Loss	249.0 mW	Power	Transformer Core Loss Power Dissipation
27.	T1 Pd	409.8 mW	Power	Estimated Losses in Transformer
28.	Total Pd	1.639 W	Power	Total Power Dissipation
29.	Rcs Pd	61.803 mW	Resistor	Current Limit Sense Resistor Power Dissipation
30.	Duty Cycle	57.083 %	System Information	Duty cycle
31.	Efficiency	87.984 %	System Information	Steady state efficiency
32.	FootPrint	1.995 k mm^2	System Information	Total Foot Print Area of BOM components
33.	Frequency	60.0 kHz	System Information	Switching frequency
34.	Iin rms	151.54 mA	System Information	RMS Input Current
35.	Iocc	1.068 A	System Information	Constant Current Limit
36.	Iout	500.0 mA	System Information	Iout operating point
37.	Min Rectified Vin	76.367 V	System Information	Minimum voltage seen at rectified input
38.	Mode	DCM	System Information	Conduction Mode
39.	Peak Rectified Vin	127.278 V	System Information	Peak voltage seen at rectified input
40.	Pout	12.0 W	System Information	Total output power
41.	Vin_RMS	90.0 V	System Information	Vin operating point
42.	Vout	24.0 V	System Information	Operational Output Voltage
43.	Vout Tolerance	33.333 m%	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
44.	Vout p-p	43.139 mV	System Information	Peak-to-peak output ripple voltage
45.	T1 Copper Loss	160.8 mW	Transformer	Transformer Copper Loss Power Dissipation
46.	T1 Core Loss	249.0 mW	Transformer	Transformer Core Loss Power Dissipation
47.	T1 Iprim RMS	242.61 mA	Transformer	Transformer Primary RMS Current
48.	T1 Iprim pk	556.179 mA	Transformer	Transformer Primary Peak Current
49.	T1 Is1 RMS	893.793 mA	Transformer	Transformer Secondary1 RMS Current
50.	T1 Is1 pk	2.397 A	Transformer	Transformer Secondary1 Peak Current
51.	T1 Pd	409.8 mW	Transformer	Estimated Losses in Transformer

Design Inputs

Name	Value	Description
Iout	500.0 m	Maximum Output Current
VinMax	250.0	Maximum input voltage
VinMin	90.0	Minimum input voltage
Vout	24.0	Output Voltage
acFrequency	60.0	AC Frequency
base_pn	UCC28632	Base Product Number
source	AC	Input Source Type
Ta	70.0	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

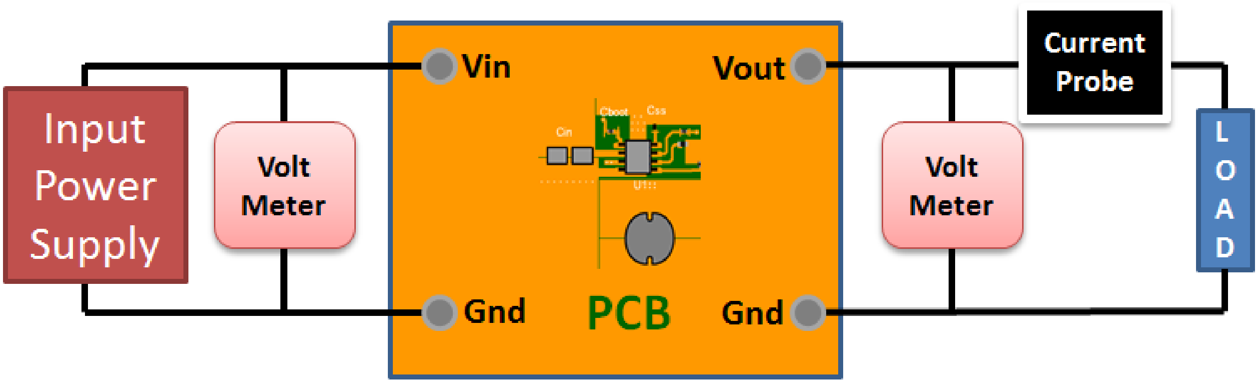
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 90.0V 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	B66421G0000X197
2.	Core Manufacturer	TDK
3.	Coil Former Part Number	B66422W1010D001
4.	Coil Former Manufacturer	TDK

Transformer Electrical Diagram

Primary

Turns	62.0
AWG	26.0
Layers	2.0
Strands	1.0
Insulation Type	Heavy Insulated Magnet Wire

Secondary

Turns	14.0
AWG	31.0
Layers	1.0
Strands	2.0
Insulation Type	Triple Insulated

Auxiliary

Turns	8.0
AWG	28.0
Layers	1.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire

Transformer Construction Diagram

Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 1/2.0	26.0	31	Clockwise
Triple Insulated Secondary	31.0	14.0	Counter Clockwise
Auxiliary	28.0	8.0	Counter Clockwise
Primary Second 1/2.0	26.0	31	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	0.0014H
2.	Inductance Factor(Al)	365.0nH
3.	Npri	62.0
4.	Nsec	14.0
5.	Naux	8.0
6.	Core Type	EFD25/13/9
7.	Core Material	N97

#	Name	Value
8.	Bmax	0.24T
9.	Switching Frequency	60.00kHz
10.	DMax	0.56
11.	Ipk(Primary)	0.61A
12.	Irms(Primary)	0.26A
13.	Ipk(Secondary)	2.7A
14.	Irms(Secondary)	1.03A

Design Assistance

1. Application Hints High Power Operation The UCC28630 allows a peak power delivery up to 200% the nominal rating with only a modest increase in peak current. The combination of up to 2x frequency increase and 1.25x peak current increase in CCM allows up to 2x peak power delivery capability for a given transformer size. 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. Active X-Cap Discharge The X-capacitor discharge function discharges the X-capacitor to the SELV 60V level in 1 sec. When adjusting the components for the design, ensure that the bulk capacitance value is not too large for the power level desired, which ensures that the bulk capacitor discharge rate is fast enough to discharge the X-capacitor to meet the 1-second discharge target. The VSENSE terminal In order to protect the VSENSE terminal from excessive negative current, an additional series limiting resistor and clamping diode can be added on the VSENSE terminal. The DRV pull up diode can be combined with the clamping diode in a single package common-cathode diode to reduce the component count of the circuit (see Figure 24 in the datasheet for illustration). Magnetic Sense Resistor Network When adjusting components for the design, check that the equivalent Thevenin resistance (Rth) of the R1/R2 falls within the required range of 10kOhm and 20kOhm. If the Rth is outside of this range, it triggers the VSENSE terminal open or short terminal check at start-up. Peak Current Mode Control and the CS Terminal Depending on the PCB layout, an additional RC filter may be required on the CS terminal, as show in Figure 30 of the datasheet. The capacitor, Ccs, should be positioned as close as possible to terminals 3 and 4 and tracked directly to the terminals. Rcs2 should also be located close to terminal 3 to minimize noise, and should not exceed 20kOhms since larger values could be detected as a possible open circuit on the CS terminal during the start-up terminal checks. The time constant for this RC filter should no be excessive so that the filter does not reduce the measured peak current. Typical time values would fall between 100ns and 200ns. Primary-Side Overload Timer An internal overload timer tracks the power stage thermal stress and protects the power stage against output overload. The overload timer trip level and time constant are both selectable from a defined list of combinations (See Table 1 in datasheet for combinations), and is set using a pull-down resistance, Rprog, on the DRV terminal. The values of the Rprog resistor that corresponds to specific trip levels and time constants can also be seen in Table 1 in the datasheet. Please see the datasheet for further design guidance and recommendations. http://www.ti.com/lit/ds/symlink/ucc28630.pdf

2. Master key : 815BD290AAC7979B[v1]

3. **UCC28632** Product Folder : http://www.ti.com/product/UCC28632 : contains the data sheet and other resources.