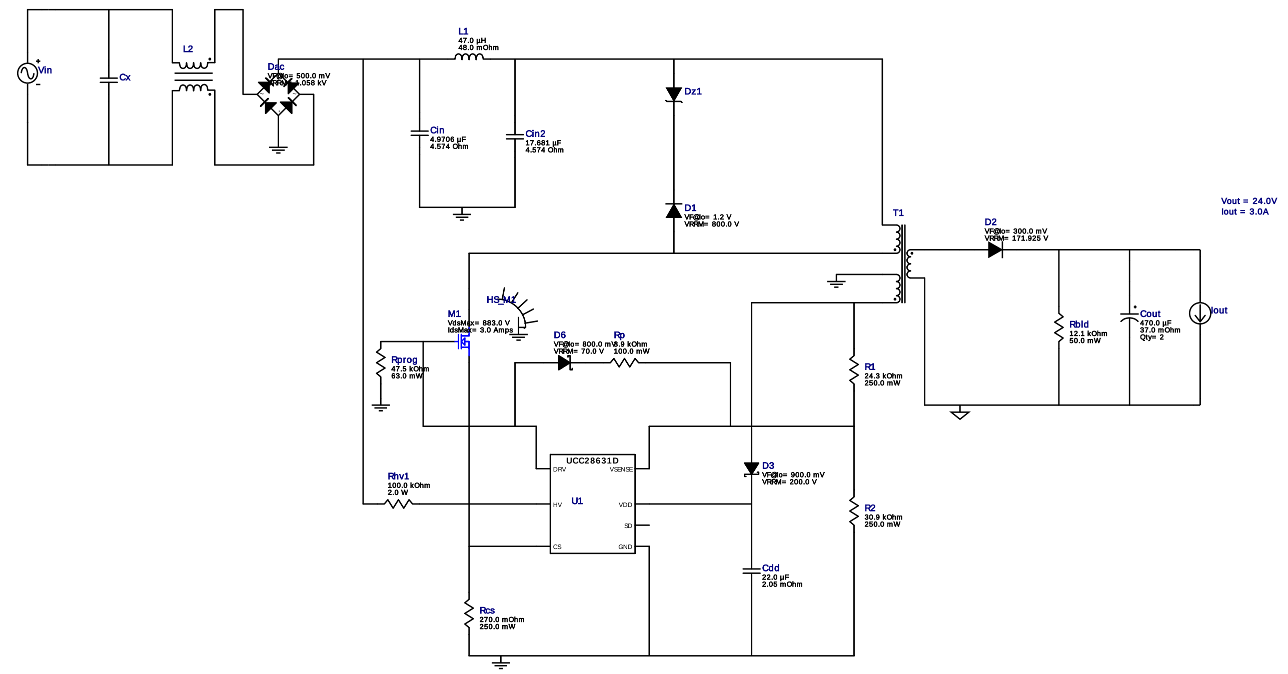
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 220.0V
VinMax = 440.0V
Vout = 24.0V
Iout = 3.0A

Device = UCC28631DR
Topology = Flyback
Created = 2020-04-03 04:04:55.016
BOM Cost = NA
BOM Count = 22
Total Pd =

Design : 24 UCC28631DR
UCC28631DR 220V-440V to 24.00V @ 3A



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

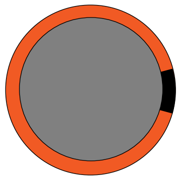
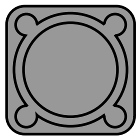
Design Alerts

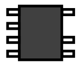
Component Selection Information

Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin. With the current design condition, suitable FET could not be found in the current database. Hence, this design is created using an ideal FET. Please note that the resulting FET parameters are ideal, so the efficiency/loss values have been disabled. Also, the schematic/PCB export and Thermal simulations will not work with the ideal FET.

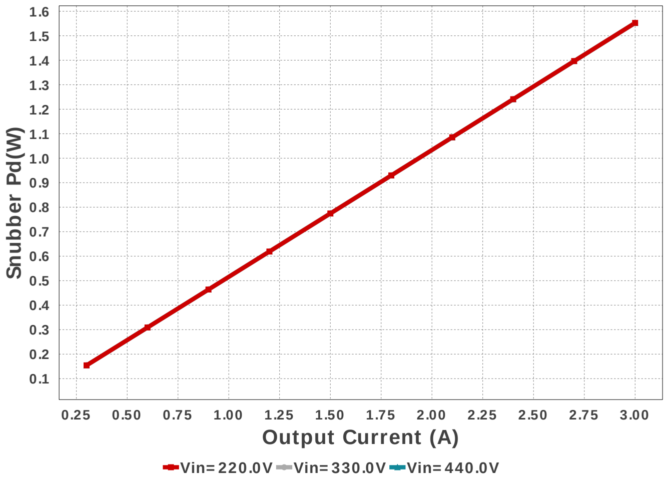
Electrical BOM

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cdd	TDK	C2012X5R1V226M125AC Series= X5R	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 35.0 V IRMS= 4.5559 A	1	$0.33	0805 7 mm²
Cin	CUSTOM	CUSTOM Series= ?	Cap= 4.9706 uF ESR= 4.5742 Ohm VDC= 659.58 V IRMS= 229.06 mA	1	NA	CUSTOM 0 mm²
Cin2	CUSTOM	CUSTOM Series= ?	Cap= 17.681 uF ESR= 4.5742 Ohm VDC= 659.58 V IRMS= 229.06 mA	1	NA	CUSTOM 0 mm²

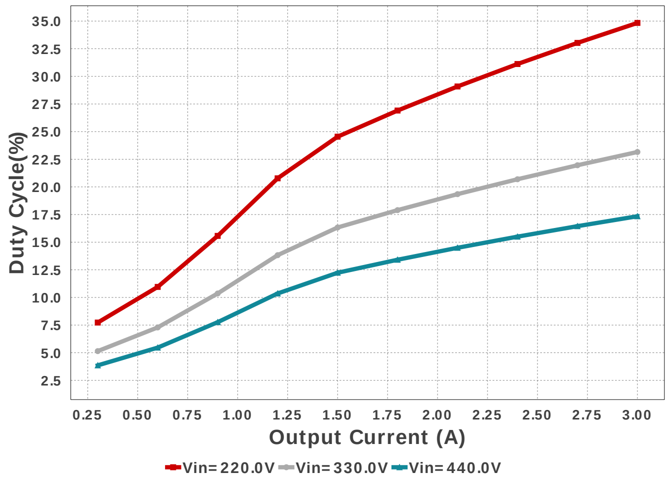
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cout	TDK	B41896D6477M000 Series= 2355	Cap= 470.0 uF ESR= 37.0 mOhm VDC= 50.0 V IRMS= 2.28 A	2	$0.65	 B41896_1600x2000 324 mm²
D1	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.73	 DO-214BA 42 mm²
D2	CUSTOM	CUSTOM	VF@Io= 300.0 mV VRRM= 171.925 V	1	NA	CUSTOM 0 mm²
D3	SMC Diode Solutions	SK220ATR	VF@Io= 900.0 mV VRRM= 200.0 V	1	$0.04	 SMA 37 mm²
D6	Diodes Inc.	1N5711WS-7-F	VF@Io= 800.0 mV VRRM= 70.0 V	1	$0.09	SOD-323 9 mm²
Dac	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 1.058 kV	1	NA	CUSTOM 0 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	NA	IdealFET	VdsMax= 883.0 V IdsMax= 3.0 Amps	1	NA	NA 0 mm²
R1	Vishay-Dale	CMF5024K300FHEB Series= CMF50	Res= 24.3 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.20	 CMF50 46 mm²
R2	Vishay-Dale	CMF5030K900FHEB Series= CMF50	Res= 30.9 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.20	 CMF50 46 mm²
Rbld	Yageo	RC0201FR-0712K1L Series= ?	Res= 12.1 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rcs	Panasonic	ERJ-8RQFR27V Series= ERJ-8R	Res= 270.0 mOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.04	 1206 11 mm²
Rhv1	Vishay-Bccomponents	PR02000201003JR500 Series= ?	Res= 100.0 kOhm Power= 2.0 W Tolerance= 5.0%	1	$0.05	 PR02 117 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=Wurth Elektronik , CoilFormer=Wurth Elektronik	Core=150-2504 , CoilFormer=070-5565	Lp= 524.0 µH Turns Ratio(Nas)= 8:14 Turns Ratio(Nps)= 64:14 Npri= 64.0 Naux= 8.0 Nsec= 14.0	1	NA	ER28/17 828 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
U1	Texas Instruments	UCC28631DR	Switcher	1	$0.60	 R-PDSO-G7 55 mm²

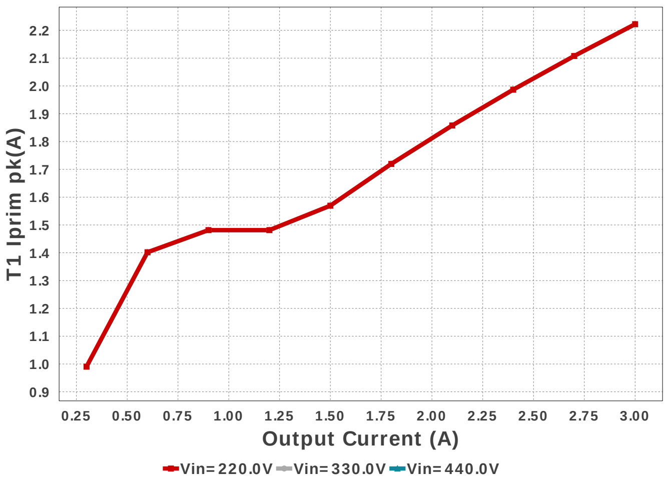
Snubber Pd



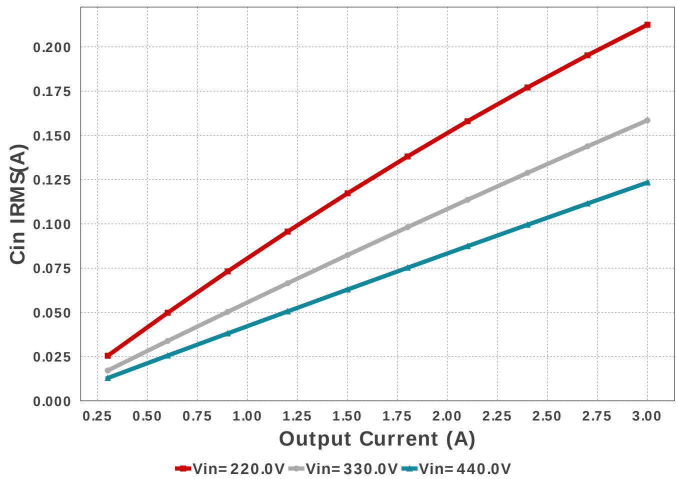
Duty Cycle



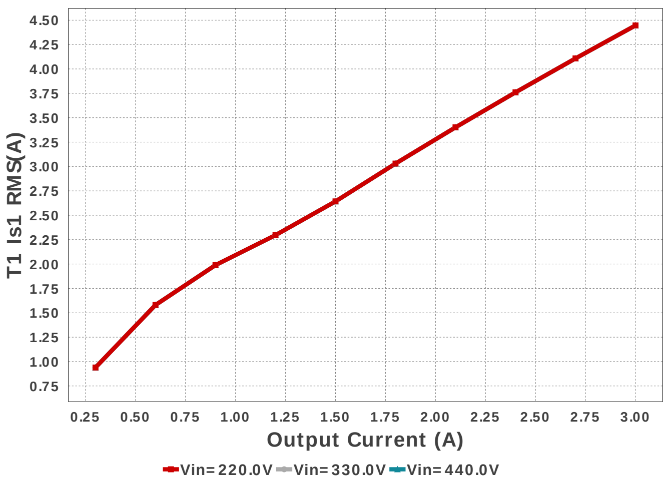
T1 Iprim pk



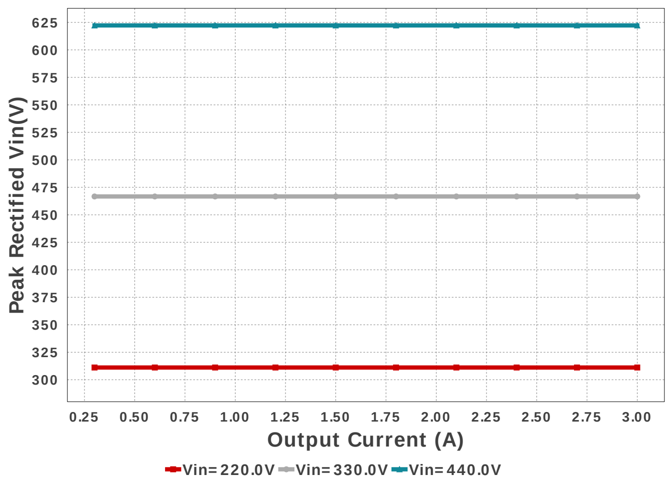
Cin IRMS

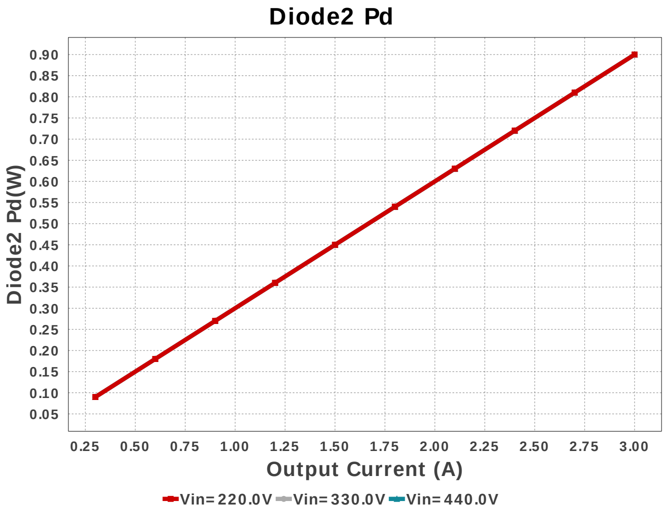


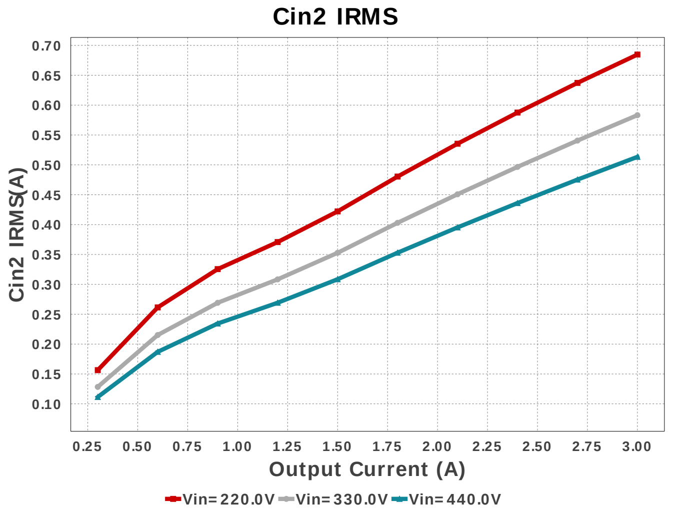
T1 Is1 RMS

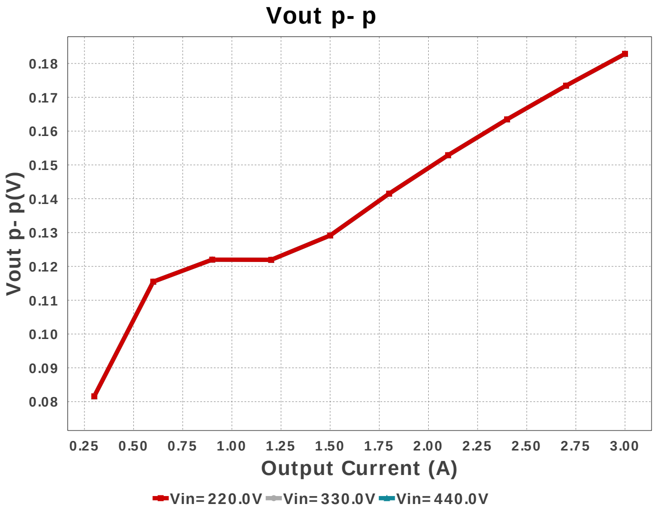


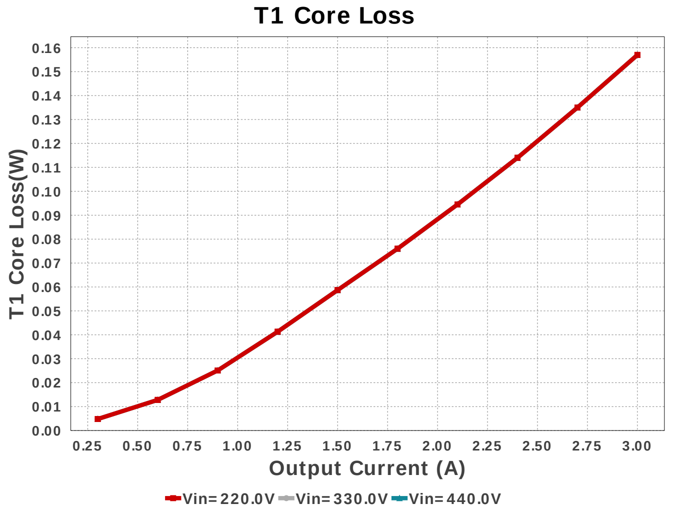
Peak Rectified Vin

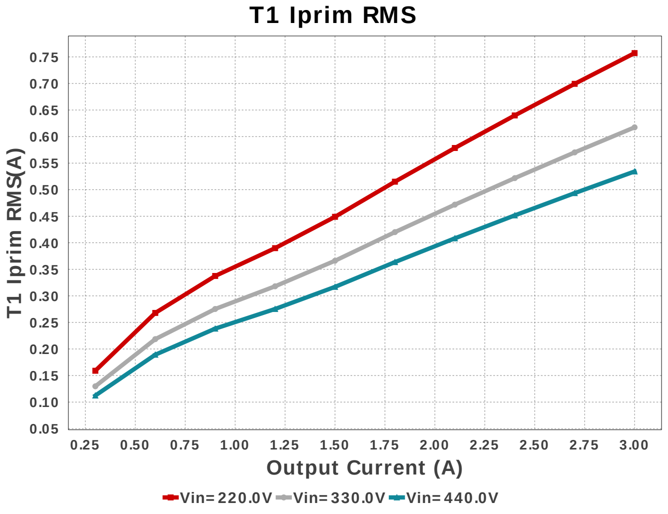


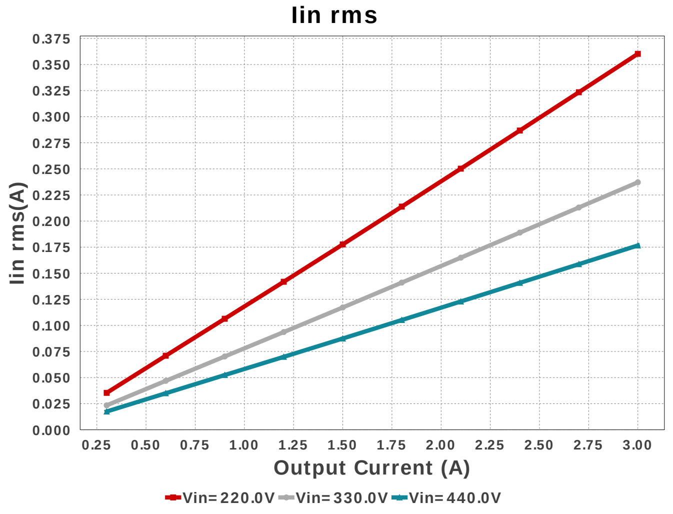

Diode2 Pd
Diode2 Pd(W)
Output Current (A)
Vin= 220.0V Vin= 330.0V Vin= 440.0V


Cin2 IRMS
Cin2 IRMS(A)
Output Current (A)
Vin= 220.0V Vin= 330.0V Vin= 440.0V

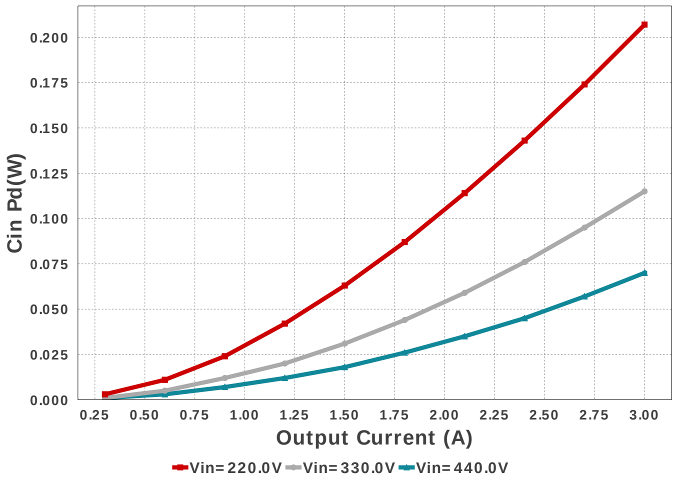

Vout p- p
Vout p- p(V)
Output Current (A)
Vin= 220.0V Vin= 330.0V Vin= 440.0V


T1 Core Loss
T1 Core Loss(W)
Output Current (A)
Vin= 220.0V Vin= 330.0V Vin= 440.0V

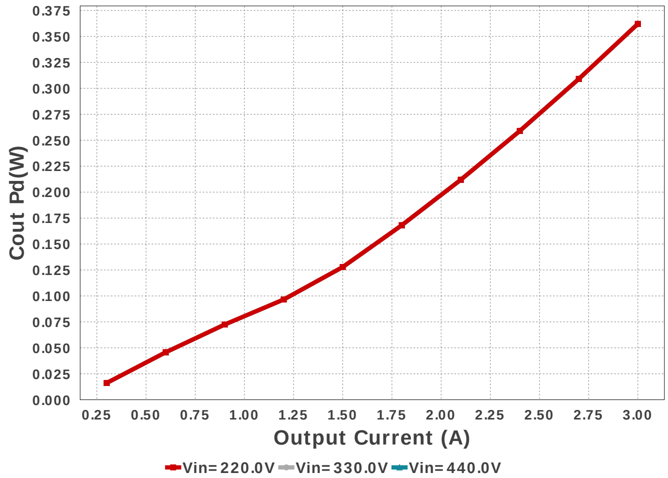

T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin= 220.0V Vin= 330.0V Vin= 440.0V


Iin rms
Iin rms(A)
Output Current (A)
Vin= 220.0V Vin= 330.0V Vin= 440.0V

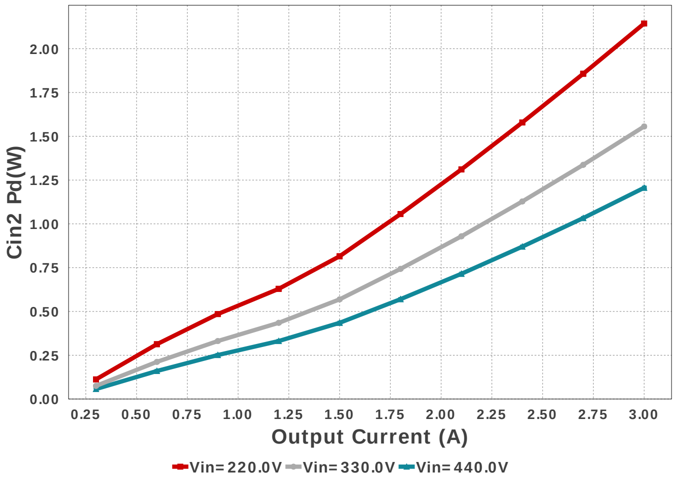
Cin Pd



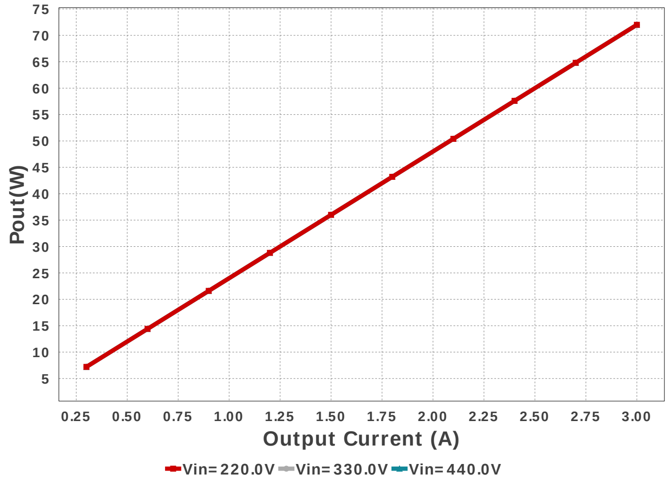
Cout Pd



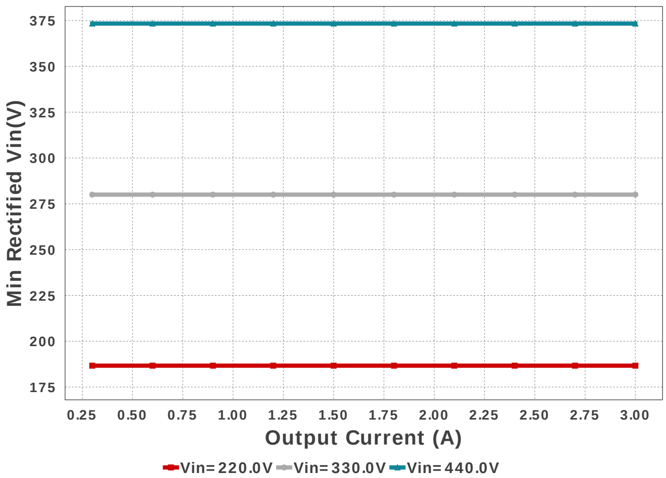
Cin2 Pd



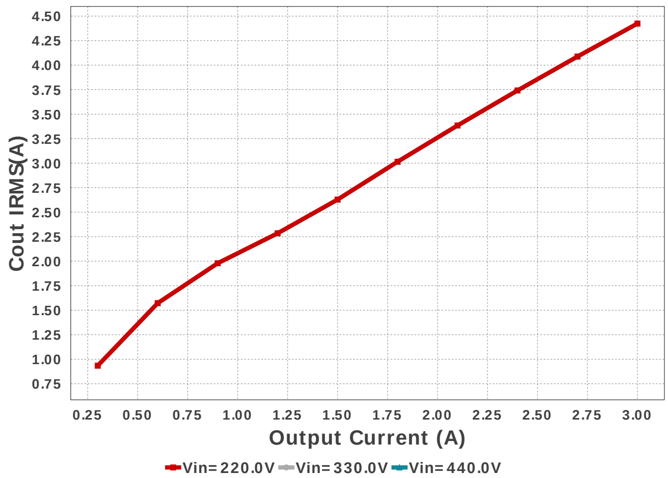
Pout



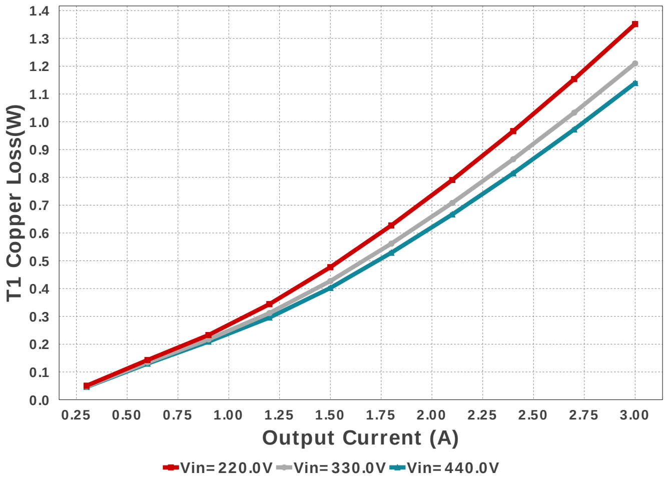
Min Rectified Vin



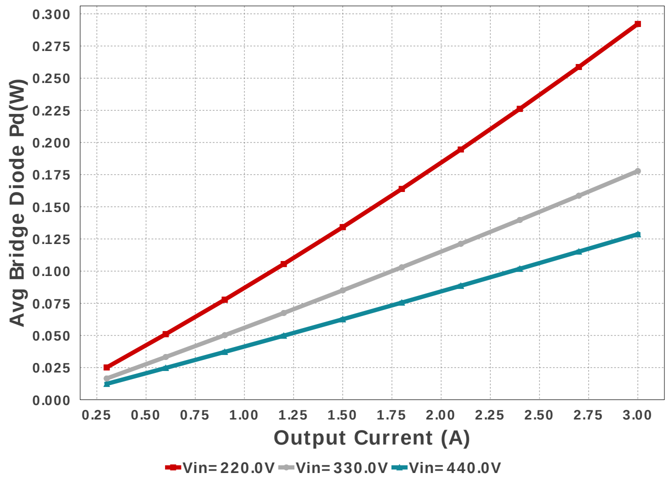
Cout IRMS



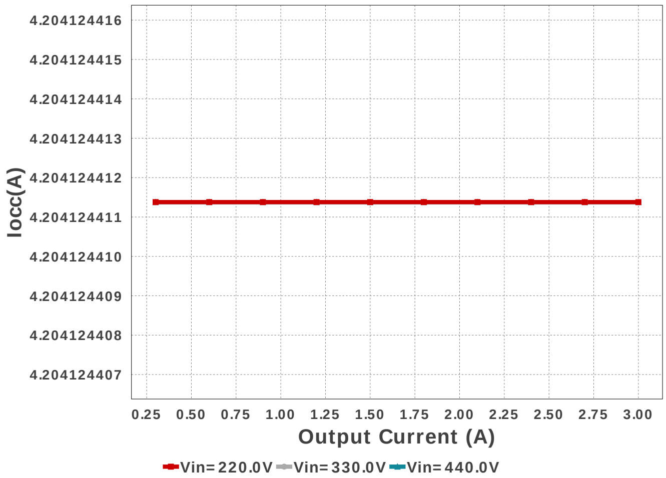
T1 Copper Loss



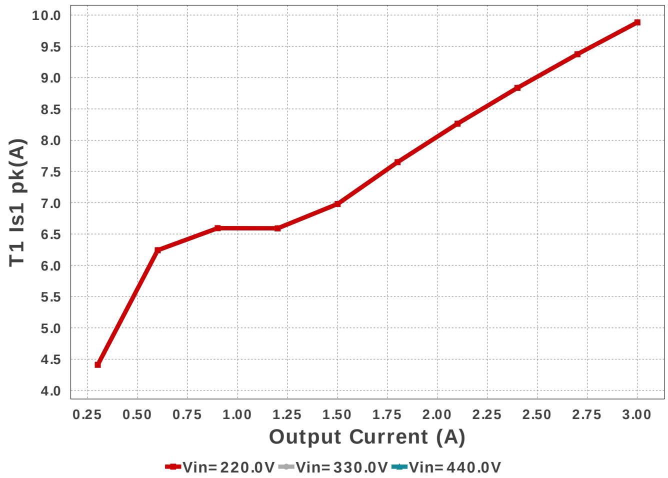
Avg Bridge Diode Pd



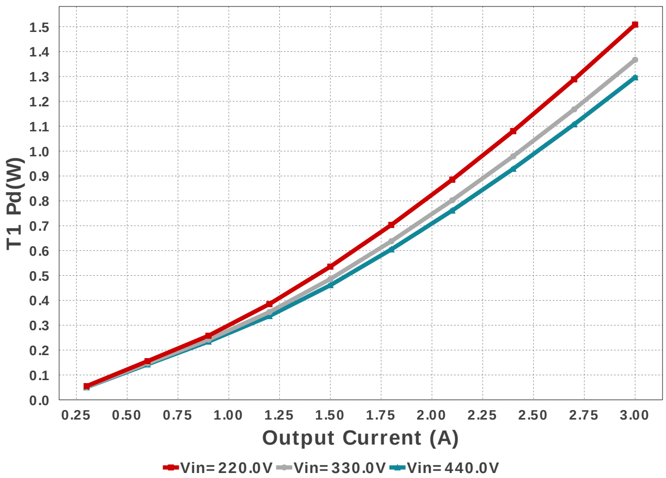
Iocc



T1 Is1 pk



T1 Pd



Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	212.49 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	207.0 mW	Capacitor	Input capacitor power dissipation
3.	Cin2 IRMS	684.433 mA	Capacitor	Input Capacitor Cin2 RMS Ripple Current
4.	Cin2 Pd	2.143 W	Capacitor	Average Power Dissipation in the Input Capacitor Cin2
5.	Cout IRMS	4.423 A	Capacitor	Output capacitor RMS ripple current
6.	Cout Pd	361.89 mW	Capacitor	Output capacitor power dissipation
7.	Avg Bridge Diode Pd	294.17 mW	Diode	Average Power Dissipation in the Bridge Diode over the AC Line Period
8.	Diode2 Pd	900.0 mW	Diode	Diode2 power dissipation
9.	ICThetaJA	128.5 degC/W	IC	IC junction-to-ambient thermal resistance
10.	Avg Bridge Diode Pd	294.17 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
11.	Cin Pd	207.0 mW	Power	Input capacitor power dissipation

#	Name	Value	Category	Description
12.	Cin2 Pd	2.143 W	Power	Average Power Dissipation in the Input Capacitor Cin2
13.	Cout Pd	361.89 mW	Power	Output capacitor power dissipation
14.	Diode2 Pd	900.0 mW	Power	Diode2 power dissipation
15.	Snubber Pd	1.552 W	Power	Snubber Power Dissipation
16.	T1 Copper Loss	1.61 W	Power	Transformer Copper Loss Power Dissipation
17.	T1 Core Loss	188.0 mW	Power	Transformer Core Loss Power Dissipation
18.	T1 Pd	1.798 W	Power	Estimated Losses in Transformer
19.	BOM Count	22	System Information	Total Design BOM count
20.	Duty Cycle	34.849 %	System Information	Duty cycle
21.	FootPrint	2.376 k mm^2	System Information	Total Foot Print Area of BOM components
22.	Frequency	60.0 kHz	System Information	Switching frequency
23.	Iin rms	361.604 mA	System Information	RMS Input Current
24.	Iocc	4.25 A	System Information	Constant Current Limit
25.	Iout	3.0 A	System Information	Iout operating point
26.	Min Rectified Vin	186.674 V	System Information	Minimum voltage seen at rectified input
27.	Mode	DCM	System Information	Conduction Mode
28.	Peak Rectified Vin	311.124 V	System Information	Peak voltage seen at rectified input
29.	Pout	72.0 W	System Information	Total output power
30.	Total BOM	NA	System Information	Total BOM Cost
31.	Vin_RMS	220.0 V	System Information	Vin operating point
32.	Vout	24.0 V	System Information	Operational Output Voltage
33.	Vout p-p	182.773 mV	System Information	Peak-to-peak output ripple voltage
34.	T1 Copper Loss	1.61 W	Transformer	Transformer Copper Loss Power Dissipation
35.	T1 Core Loss	188.0 mW	Transformer	Transformer Core Loss Power Dissipation
36.	T1 Iprim RMS	757.023 mA	Transformer	Transformer Primary RMS Current
37.	T1 Iprim pk	2.221 A	Transformer	Transformer Primary Peak Current
38.	T1 Is1 RMS	4.445 A	Transformer	Transformer Secondary1 RMS Current
39.	T1 Is1 pk	9.88 A	Transformer	Transformer Secondary1 Peak Current
40.	T1 Pd	1.798 W	Transformer	Estimated Losses in Transformer

Design Inputs

Name	Value	Description
Iout	3.0	Maximum Output Current
VinMax	440.0	Maximum input voltage
VinMin	220.0	Minimum input voltage
Vout	24.0	Output Voltage
acFrequency	60.0	AC Frequency
base_pn	UCC28631	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

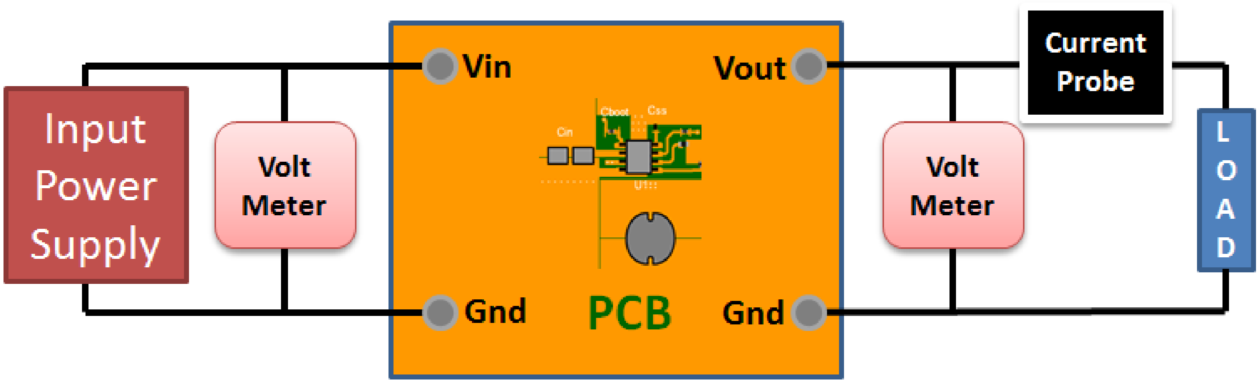
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 220.0V 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.



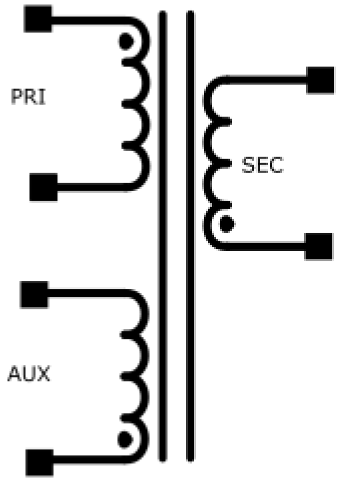
WEBENCH® Transformer Report

#	Name	Value
1.	Core Part Number	150-2504
2.	Core Manufacturer	Wurth Elektronik
3.	Coil Former Part Number	070-5565
4.	Coil Former Manufacturer	Wurth Elektronik

Transformer Electrical Diagram

Primary

Turns	64.0
AWG	26.0
Layers	3.0
Strands	2.0
Insulation Type	Heavy Insulated Magnet Wire



Secondary

Turns	14.0
AWG	26.0
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

TRANSFORMER WINDING DIAGRAM – COMING SOON

Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/3.0	26.0	43	Clockwise
Triple Insulated Secondary	26.0	14.0	Counter Clockwise
Auxiliary	28.0	8.0	Counter Clockwise
Primary Second 1/3.0	26.0	21	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	5.24E-4H
2.	Inductance Factor(Al)	129.0nH
3.	Npri	64.0
4.	Nsec	14.0
5.	Naux	8.0
6.	Core Type	ER28/17
7.	Core Material	TP4A
8.	Bmax	0.24T
9.	Switching Frequency	60.00kHz
10.	DMax	0.34
11.	Ipk(Primary)	2.37A
12.	Irms(Primary)	0.8A

#	Name	Value
13.	Ipk(Secondary)	10.8A
14.	Irms(Secondary)	5.07A

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 : D651214523F3F6B1[v1]

3. **UCC28631** Product Folder : http://www.ti.com/product/UCC28631 : contains the data sheet and other resources.