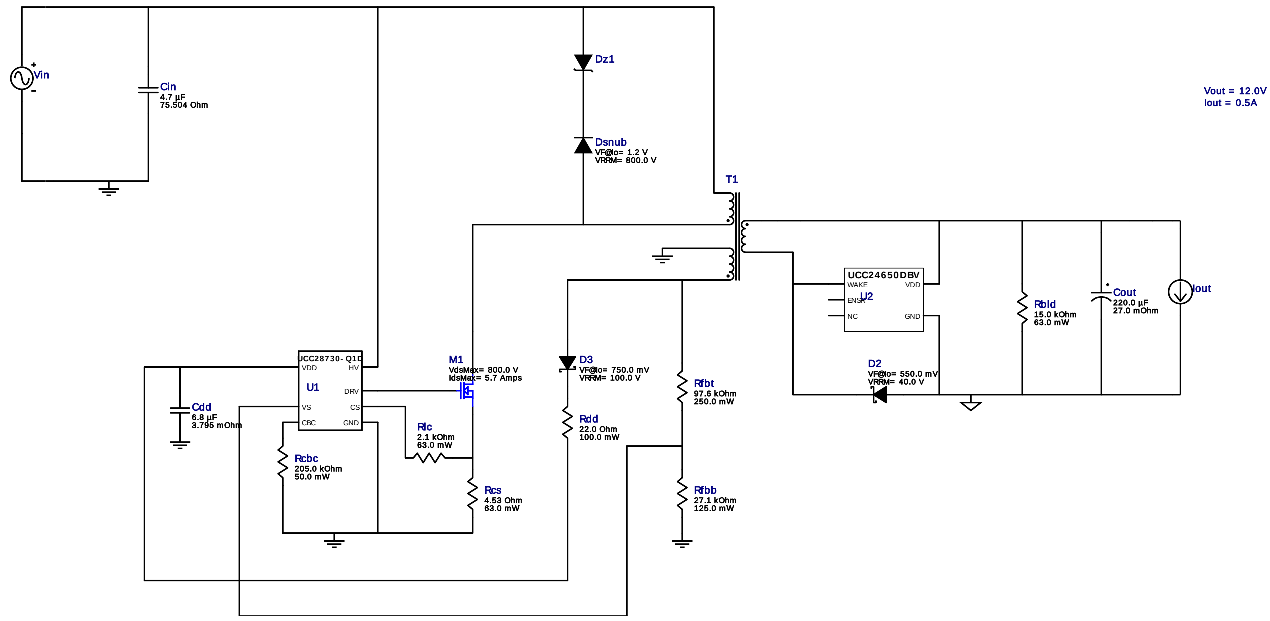
WEBENCH® Design Report

VinMin = 300.0V
VinMax = 400.0V
Vout = 12.0V
Iout = 0.5A

Device = UCC28730QDRQ1
Topology = Flyback
Created = 2020-08-09 12:15:16.225
BOM Cost = NA
BOM Count = 19
Total Pd = 0.54W

Design : 7 UCC28730QDRQ1
UCC28730QDRQ1 300V-400V to 12.00V @ .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. 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

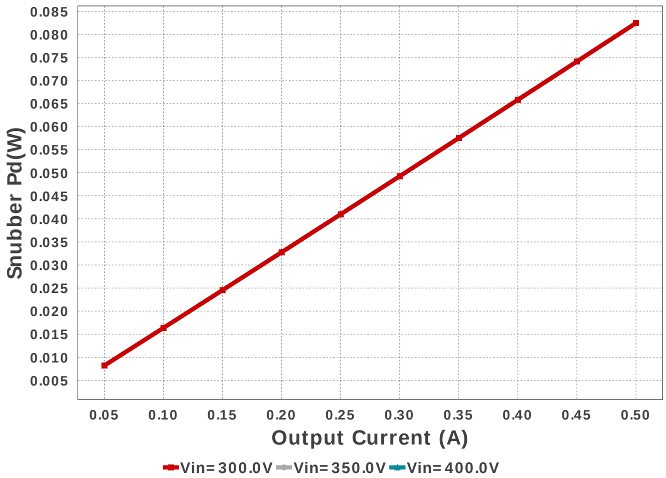
Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.The UCC28730-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application.

Electrical BOM

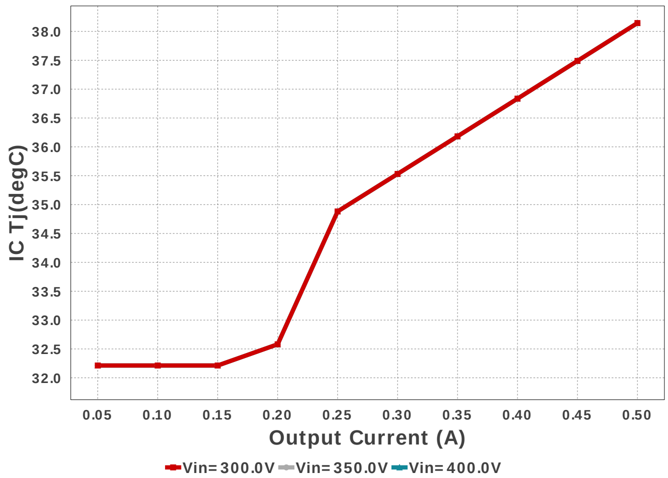
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cdd	TDK	C2012X5R1V685K125AC Series= X5R	Cap= 6.8 uF ESR= 3.795 mOhm VDC= 35.0 V IRMS= 3.3493 A	1	$0.18	0805 7 mm²
Cin	CUSTOM	CUSTOM Series= ?	Cap= 4.7 uF ESR= 75.504 Ohm VDC= 480.0 V IRMS= 32.727 mA	1	NA	CUSTOM 0 mm²
Cout	Panasonic	EEHZA1E221P Series= ZA	Cap= 220.0 uF ESR= 27.0 mOhm VDC= 25.0 V IRMS= 2.3 A	1	$1.12	SM_RADIAL_8MM 113 mm²
D2	Fairchild Semiconductor	SS14FL	VF@Io= 550.0 mV VRRM= 40.0 V	1	$0.04	SOD-123F 12 mm²

Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
D3	Diodes Inc.	B1100LB-13-F	VF@Io= 750.0 mV VRRM= 100.0 V	1	$0.09	SMB 44 mm²
Dsnub	Microsemi	UFS180JE3/TR13	VF@Io= 1.2 V VRRM= 800.0 V	1	$0.73	DO-214BA 42 mm²
Dz1	ON Semiconductor	1SMB5953BT3G	Zener	1	$0.09	SMB 44 mm²
M1	Infineon Technologies	IPD80R1K0CEBTMA1	VdsMax= 800.0 V IdsMax= 5.7 Amps	1	$0.60	DPAK 102 mm²
Rbld	Vishay-Dale	CRCW040215K0FKED Series= CRCW..e3	Res= 15.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcbc	Yageo	RC0201FR-07205KL Series= ?	Res= 205.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Rcs	Vishay-Dale	CRCW04024R53FKED Series= CRCW..e3	Res= 4.53 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rdd	Yageo	RC0603FR-0722RL Series= ?	Res= 22.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbb	Yageo	RT0805BRD0727K1L Series= ?	Res= 27.1 kOhm Power= 125.0 mW Tolerance= 0.1%	1	$0.05	0805 7 mm²
Rfbt	Vishay-Dale	CMF5097K600FHEB Series= CMF50	Res= 97.6 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.20	CMF50 46 mm²
Rlc	Vishay-Dale	CRCW04022K10FKED Series= CRCW..e3	Res= 2.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
T1	Core=TDK , CoilFormer=TDK	Core=B66311G0000X127 , CoilFormer=B66206B1110T001	Lp= 7.52 mH Turns Ratio(Nas)= 12:8 Turns Ratio(Nps)= 140:8 Npri= 140.0 Naux= 12.0 Nsec= 8.0	1	$0.18	TDK_B66305 377 mm²
U1	Texas Instruments	UCC28730QDRQ1	Switcher	1	$0.50	D0007A 55 mm²
U2	Texas Instruments	UCC24650DBVR	Switcher	0	$0.16	DBV0005A 15 mm²

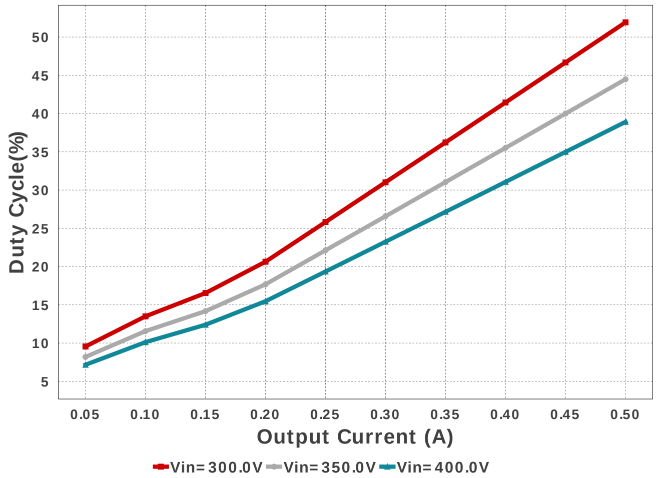
Snubber Pd



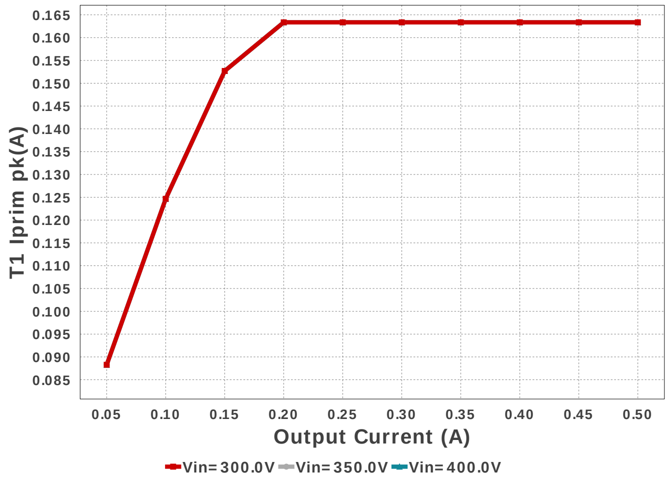
IC Tj



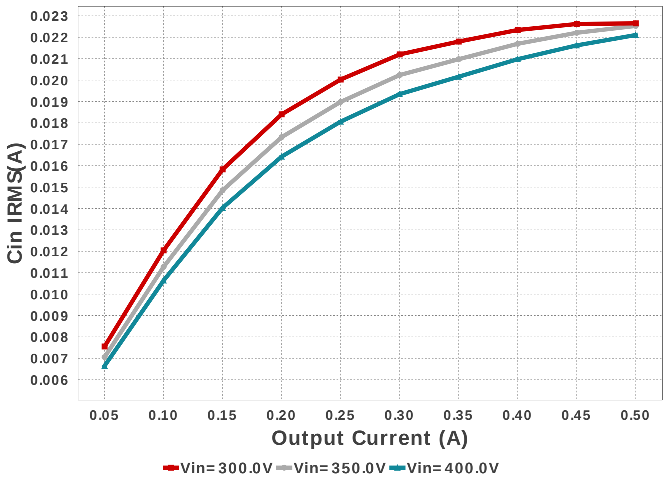
Duty Cycle



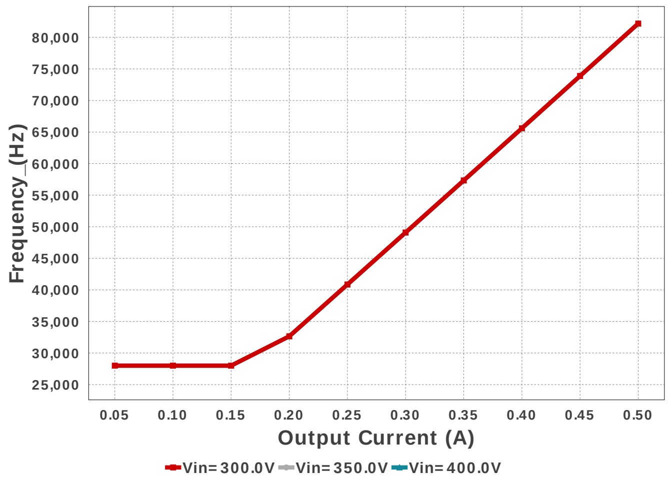
T1 Iprim pk

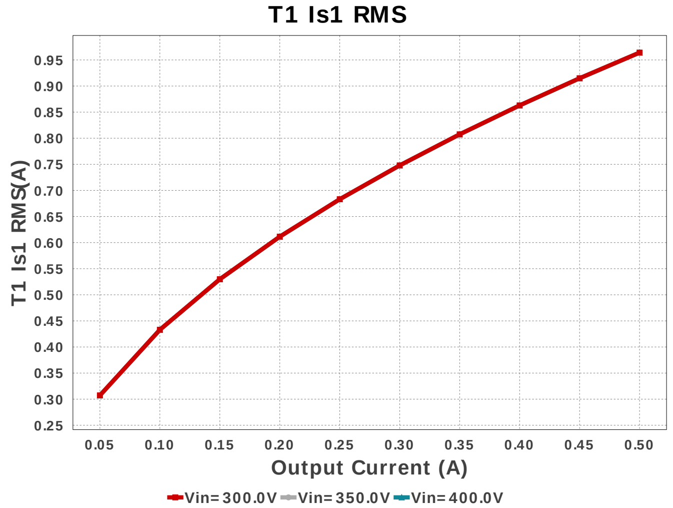


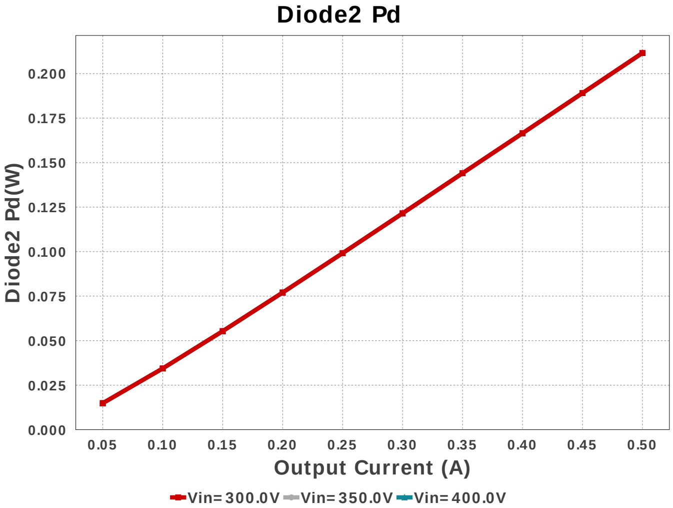
Cin IRMS

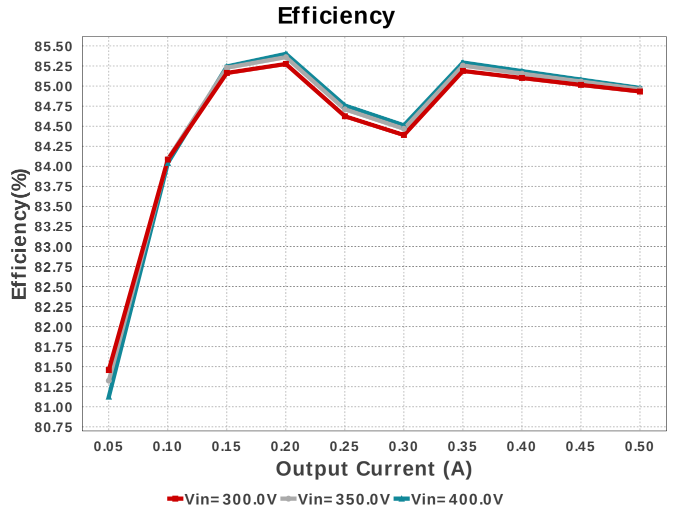


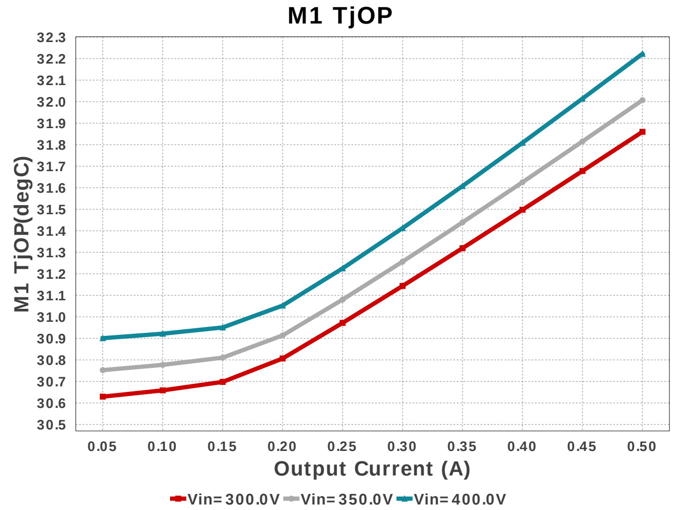
Frequency_

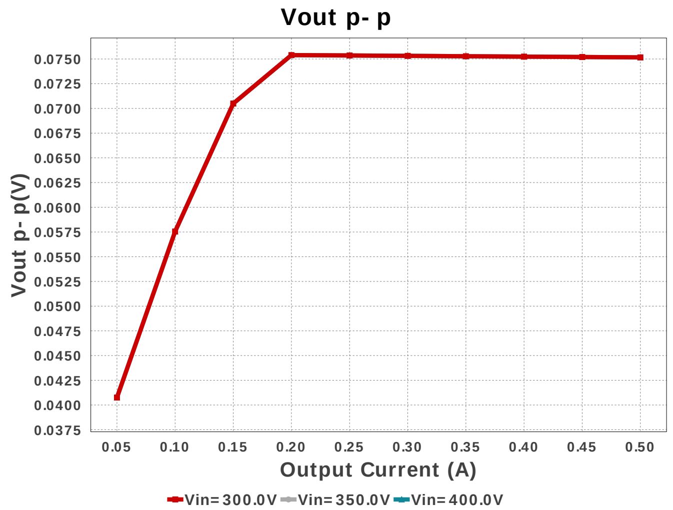


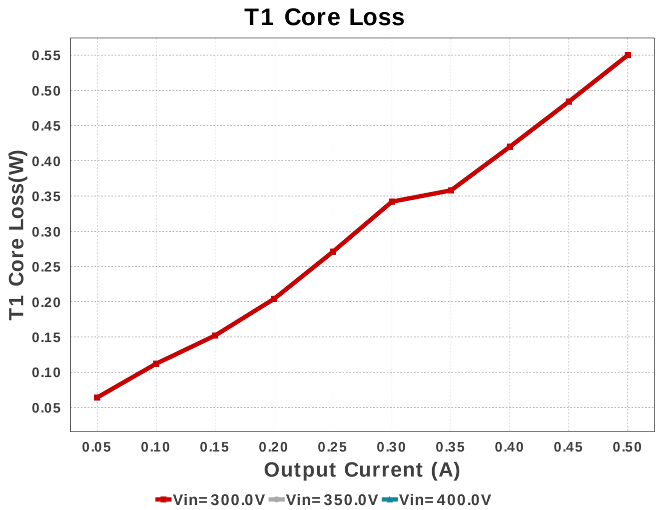

T1 Is1 RMS
T1 Is1 RMS(A)
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

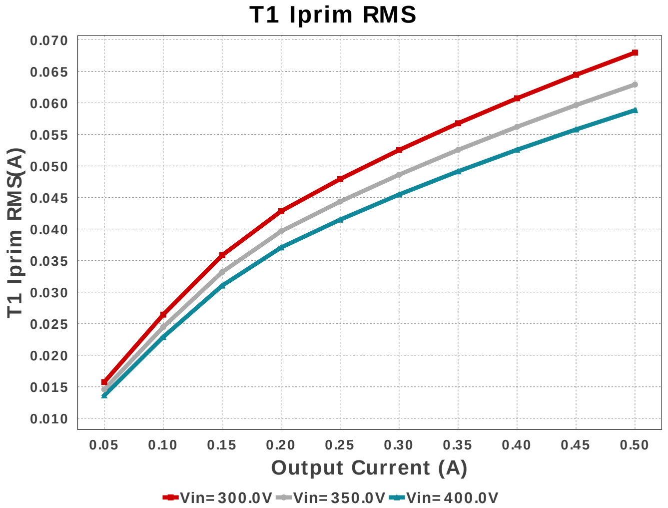

Diode2 Pd
Diode2 Pd(W)
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

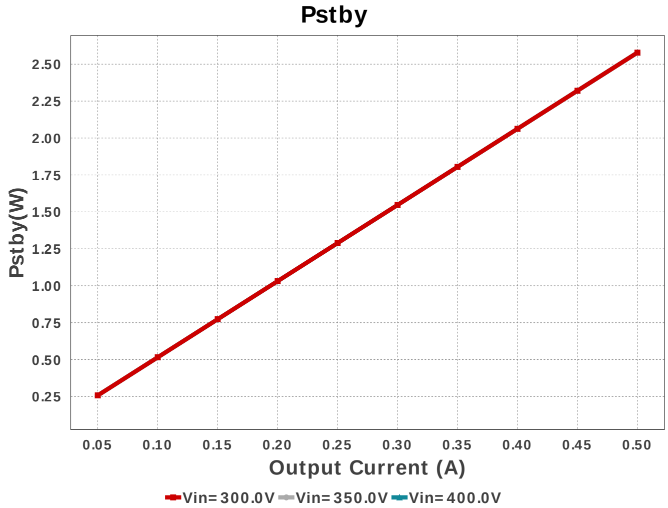

Efficiency
Efficiency(%)
85.50
85.25
85.00
84.75
84.50
84.25
84.00
83.75
83.50
83.25
83.00
82.75
82.50
82.25
82.00
81.75
81.50
81.25
81.00
80.75
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

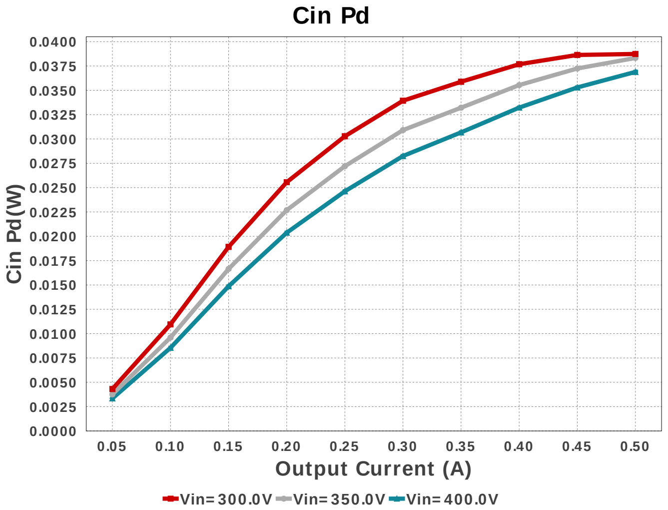

M1 TjOP
M1 TjOP(degC)
32.3
32.2
32.1
32.0
31.9
31.8
31.7
31.6
31.5
31.4
31.3
31.2
31.1
31.0
30.9
30.8
30.7
30.6
30.5
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

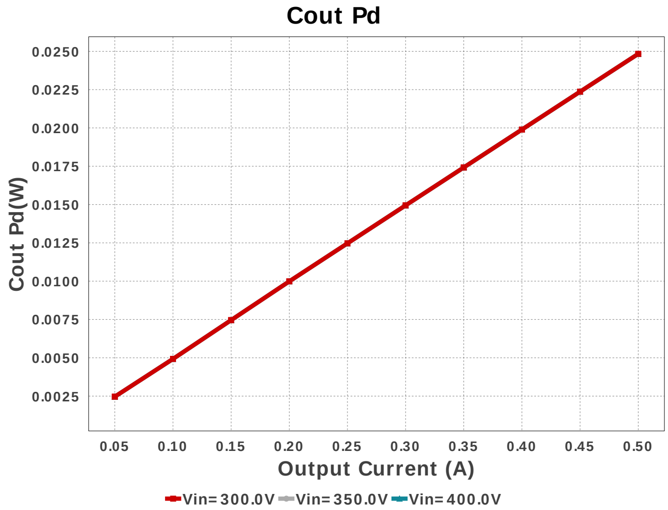

Vout p- p
Vout p- p(V)
0.0750
0.0725
0.0700
0.0675
0.0650
0.0625
0.0600
0.0575
0.0550
0.0525
0.0500
0.0475
0.0450
0.0425
0.0400
0.0375
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

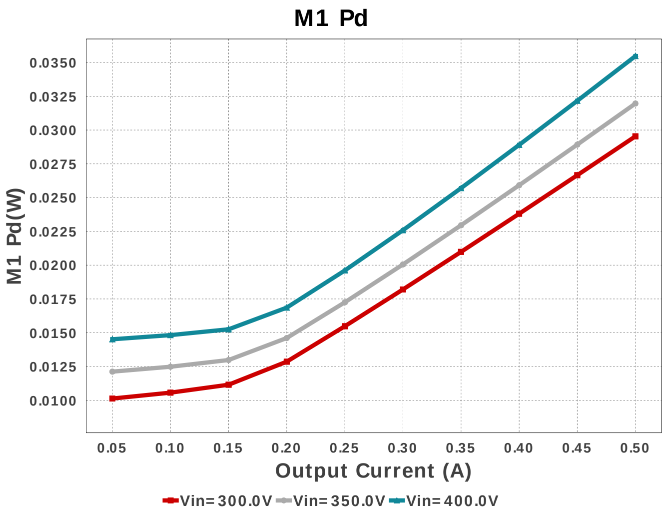

T1 Core Loss
T1 Core Loss(W)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

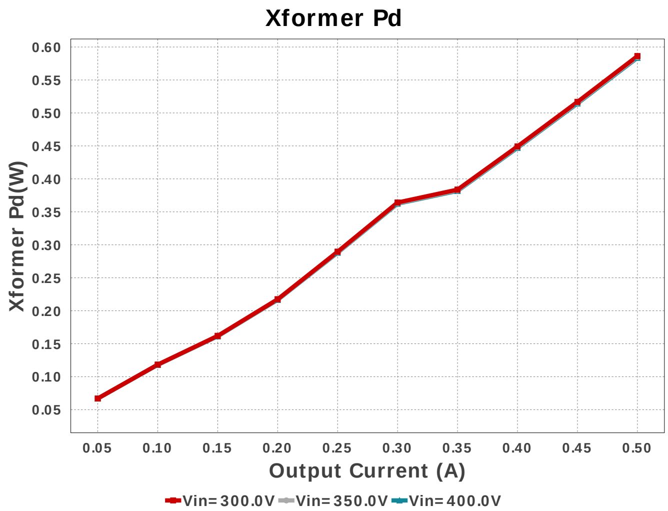

T1 Iprim RMS
T1 Iprim RMS(A)
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V


Pstby
Pstby(W)
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

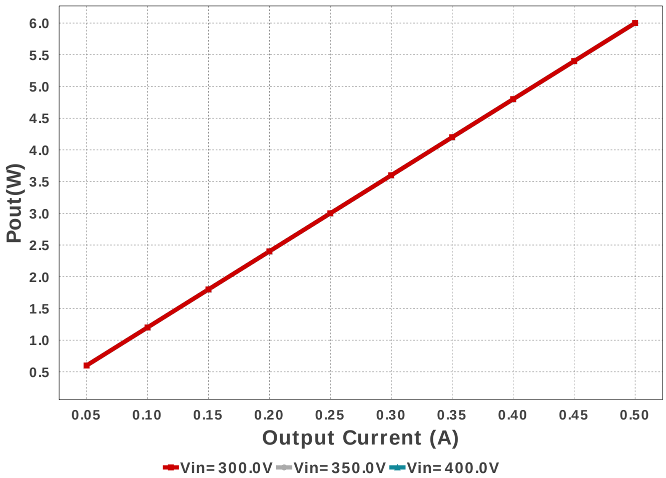

Cin Pd
Cin Pd(W)
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V


Cout Pd
Cout Pd(W)
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

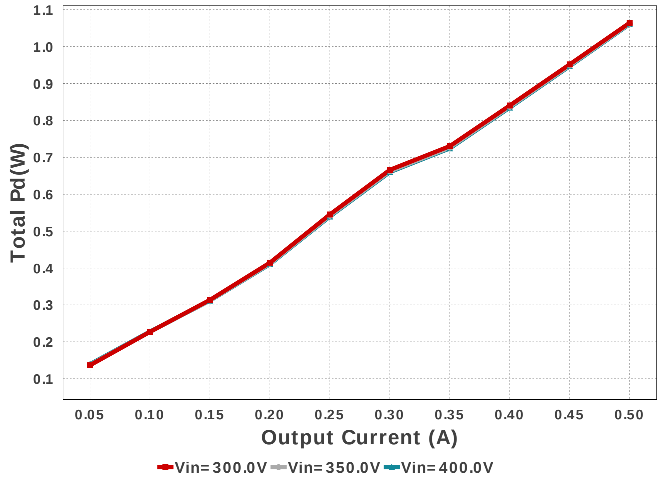

M1 Pd
M1 Pd(W)
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V


Xformer Pd
Xformer Pd(W)
Output Current (A)
Vin=300.0V Vin=350.0V Vin=400.0V

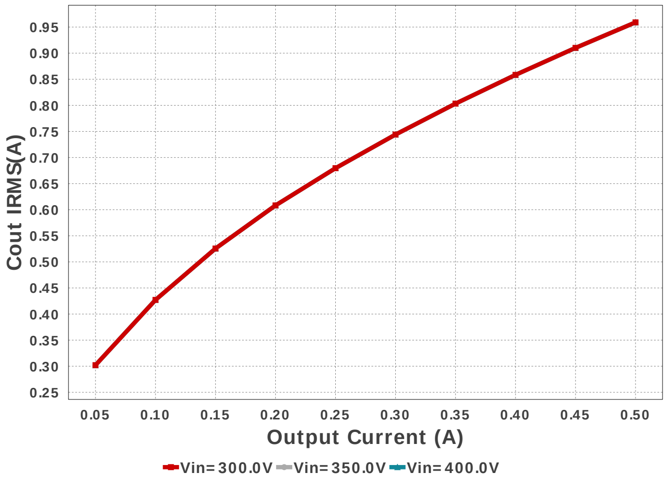
Pout



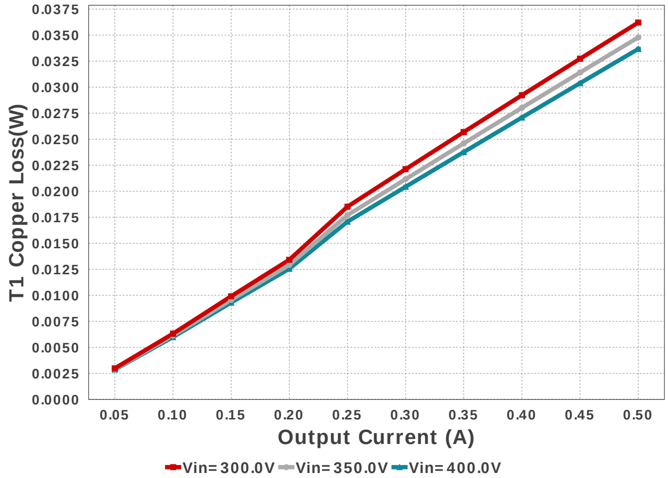
Total Pd



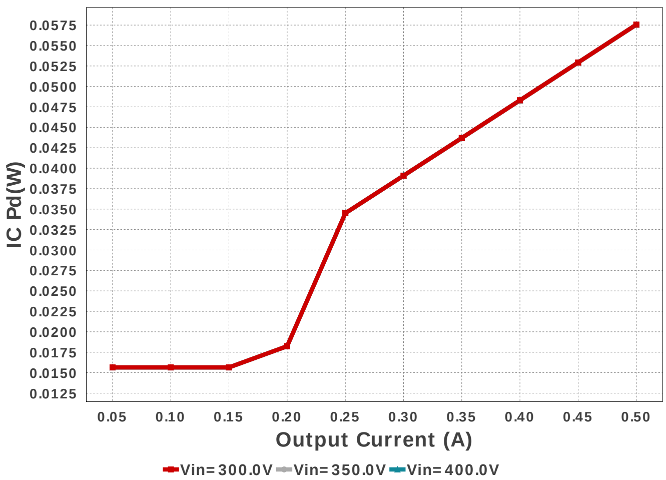
Cout IRMS



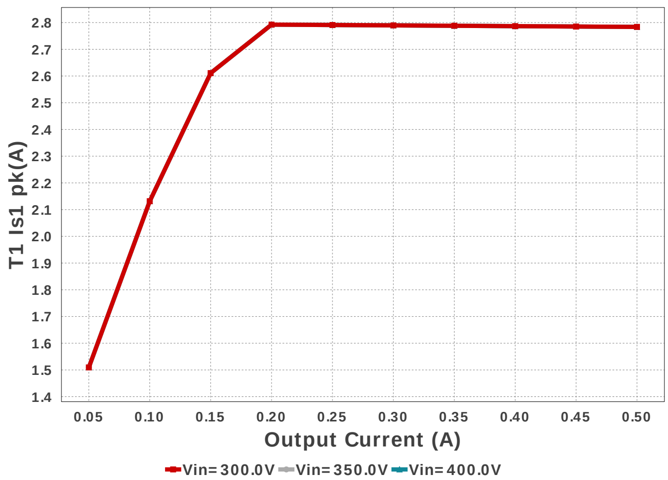
T1 Copper Loss



IC Pd



T1 Is1 pk



Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	20.995 mA	Capacitor	Input capacitor RMS ripple current
2.	Cin Pd	33.281 mW	Capacitor	Input capacitor power dissipation
3.	Cout IRMS	959.02 mA	Capacitor	Output capacitor RMS ripple current
4.	Cout Pd	24.832 mW	Capacitor	Output capacitor power dissipation
5.	Diode2 Pd	211.61 mW	Diode	Diode2 power dissipation
6.	IC Pd	57.556 mW	IC	IC power dissipation
7.	IC Tj	38.144 degC	IC	IC junction temperature
8.	ICThetaJA	141.5 degC/W	IC	IC junction-to-ambient thermal resistance
9.	M1 Pd	29.535 mW	Mosfet	M1 MOSFET total power dissipation
10.	M1 TjOP	31.86 degC	Mosfet	M1 MOSFET junction temperature
11.	Cin Pd	33.281 mW	Power	Input capacitor power dissipation

#	Name	Value	Category	Description
12.	Cout Pd	24.832 mW	Power	Output capacitor power dissipation
13.	Diode2 Pd	211.61 mW	Power	Diode2 power dissipation
14.	IC Pd	57.556 mW	Power	IC power dissipation
15.	M1 Pd	29.535 mW	Power	M1 MOSFET total power dissipation
16.	Snubber Pd	82.455 mW	Power	Snubber Power Dissipation
17.	T1 Copper Loss	35.144 mW	Power	Transformer Copper Loss Power Dissipation
18.	T1 Core Loss	35.144 mW	Power	Transformer Core Loss Power Dissipation
19.	Total Pd	542.938 mW	Power	Total Power Dissipation
20.	Xformer Pd	70.288 mW	Power	Transformer power dissipation
21.	BOM Count	19	System Information	Total Design BOM count
22.	Duty Cycle	51.929 %	System Information	Duty cycle
23.	Efficiency	91.702 %	System Information	Steady state efficiency
24.	FootPrint	903.0 mm^2	System Information	Total Foot Print Area of BOM components
25.	Frequency	82.18 kHz	System Information	Switching frequency
26.	Frequency	82.18 kHz	System Information	Switching frequency
27.	Iout	500.0 mA	System Information	Iout operating point
28.	Mode	DCM	System Information	Conduction Mode
29.	Pout	6.0 W	System Information	Total output power
30.	Total BOM	NA	System Information	Total BOM Cost
31.	Vin	300.0 V	System Information	Vin operating point
32.	Vout	12.0 V	System Information	Operational Output Voltage
33.	Vout Actual	18.636 V	System Information	Vout Actual calculated based on selected voltage divider resistors
34.	Vout Tolerance	1.858 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
35.	Vout p-p	75.162 mV	System Information	Peak-to-peak output ripple voltage
36.	T1 Copper Loss	35.144 mW	Transformer	Transformer Copper Loss Power Dissipation
37.	T1 Core Loss	35.144 mW	Transformer	Transformer Core Loss Power Dissipation
38.	T1 Iprim RMS	67.964 mA	Transformer	Transformer Primary RMS Current
39.	T1 Iprim pk	163.355 mA	Transformer	Transformer Primary Peak Current
40.	T1 Is1 RMS	964.062 mA	Transformer	Transformer Secondary1 RMS Current
41.	T1 Is1 pk	2.784 A	Transformer	Transformer Secondary1 Peak Current
42.	Xformer Pd	70.288 mW	Transformer	Transformer power dissipation
43.	Pstby	2.578 W	power	Pstby

Design Inputs

Name	Value	Description
Iout	500.0 m	Maximum Output Current
VinMax	400.0	Maximum input voltage
VinMin	300.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	UCC28730-Q1	Base Product Number
source	DC	Input Source Type
Ta	30.0	Ambient temperature
UserFsw	83.0 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

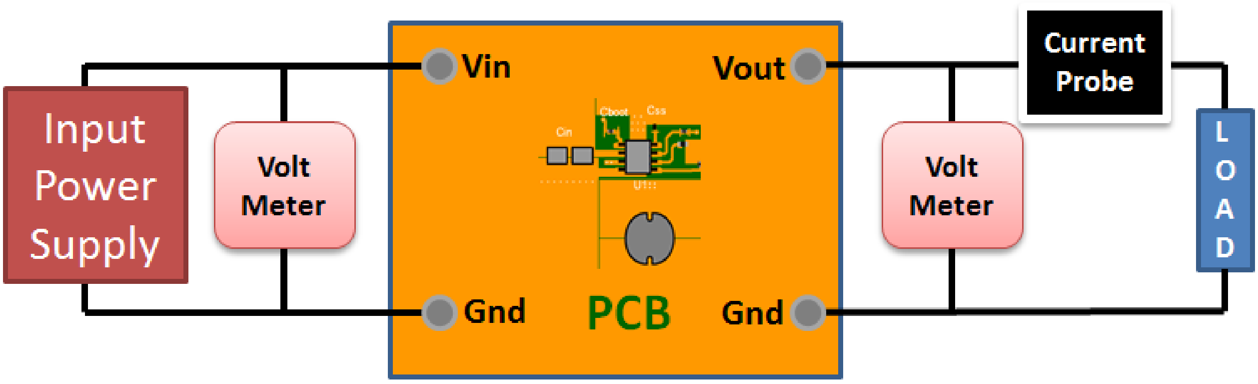
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 300.0V 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.



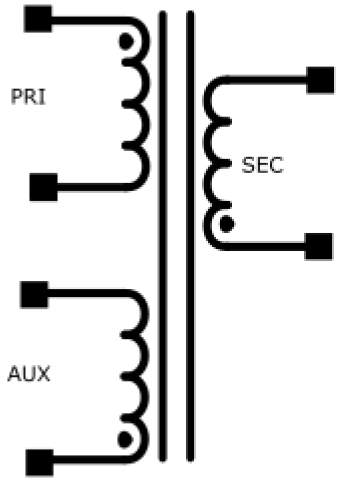
WEBENCH® Transformer Report

#	Name	Value
1.	Core Part Number	B66311G0000X127
2.	Core Manufacturer	TDK
3.	Coil Former Part Number	B66206B1110T001
4.	Coil Former Manufacturer	TDK

Transformer Electrical Diagram

Primary

Turns	140.0
AWG	30.0
Layers	4.0
Strands	1.0
Insulation Type	Heavy Insulated Magnet Wire



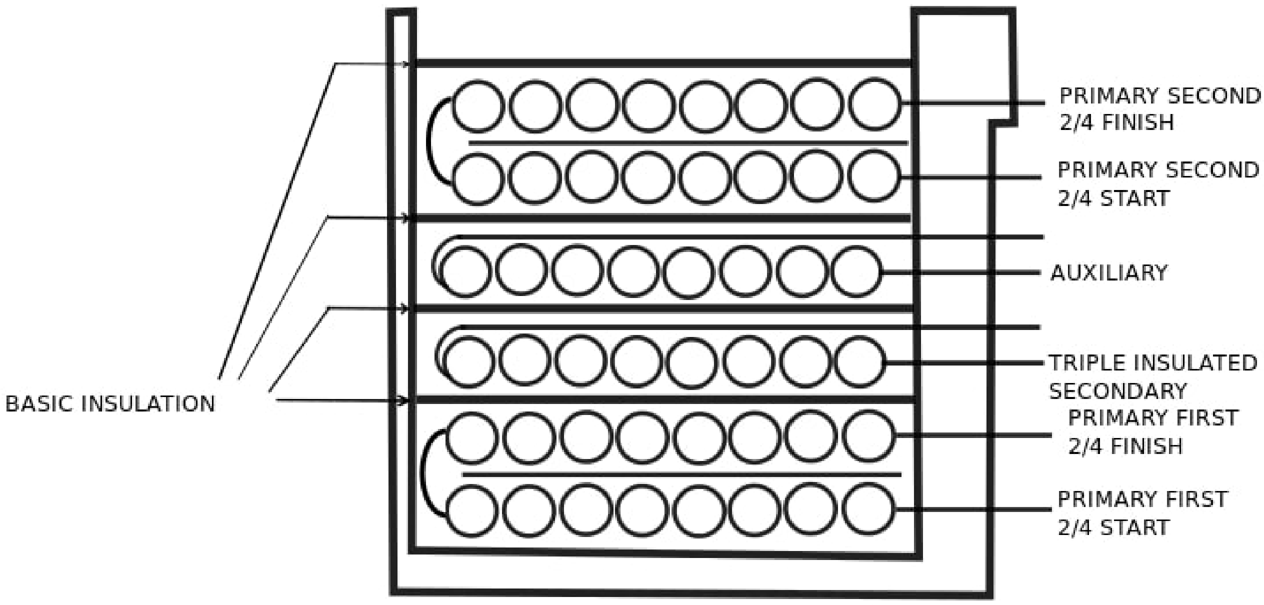
Secondary

Turns	8.0
AWG	27.0
Layers	1.0
Strands	2.0
Insulation Type	Triple Insulated

Auxiliary

Turns	12.0
AWG	28.0
Layers	1.0
Strands	2.0
Insulation Type	Heavy Insulated Magnet Wire

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 2/4.0	30.0	70	Clockwise
Triple Insulated Secondary	27.0	8.0	Counter Clockwise
Auxiliary	28.0	12.0	Counter Clockwise
Primary Second 2/4.0	30.0	70	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	0.00752H
2.	Inductance Factor(Al)	384.0nH
3.	Npri	140.0
4.	Nsec	8.0
5.	Naux	12.0
6.	Core Type	E20/10/6
7.	Core Material	N27
8.	Bmax	0.25T
9.	Switching Frequency	83.00kHz
10.	DMax	0.49
11.	Ipk(Primary)	0.15A
12.	Irms(Primary)	0.06A
13.	Ipk(Secondary)	2.61A
14.	Irms(Secondary)	0.98A

Design Assistance

1. Feature Highlights: See the data sheet for detailed features

2. The UCC28730-Q1 is qualified for Automotive applications. All passives and other components selected in this design may not be qualified for Automotive applications. The user is required to verify that all components in the design meet the qualification and safety requirements for their specific application

3. Master key : 8539E8D1B888CCB1[v1]

4. **UCC28730-Q1** Product Folder : http://www.ti.com/product/UCC28730%2DQ1 : contains the data sheet and other resources.