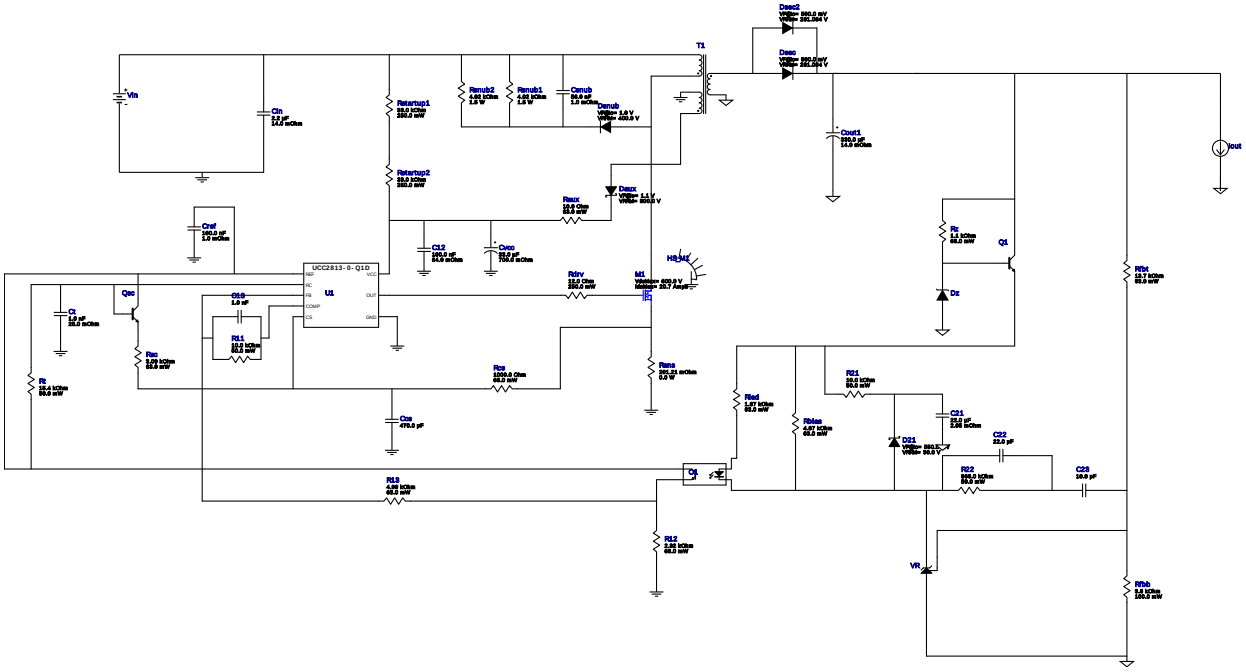
WEBENCH® Design Report

VinMin = 24.0V
VinMax = 265.0V
Vout = 12.0V
Iout = 2.0A

Device = UCC2813QDR-0Q1
Topology = Flyback
Created = 2021-03-05 10:56:32.094
BOM Cost = NA
BOM Count = 46
Total Pd = 2.71W

Design : 106 UCC2813QDR-0Q1
UCC2813QDR-0Q1 24V-265V to 12.00V @ 2A



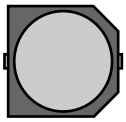
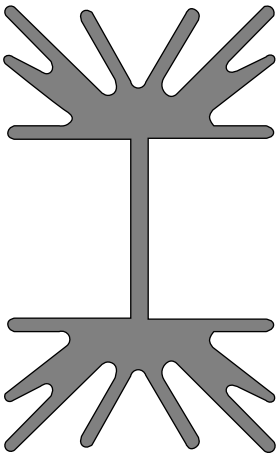
Design Alerts

Component Selection Information

The UCC2813-0-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. Click on the transformer symbol in the schematic and select "Explore Transformer Core/Bobbin Selection" to design using specific transformer cores and bobbin.

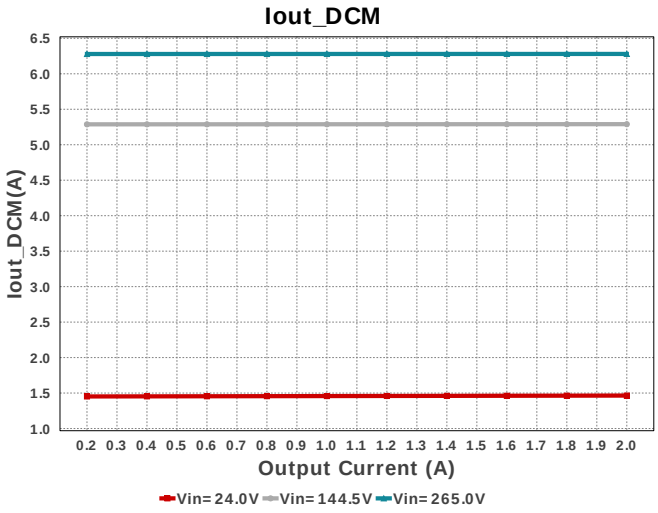
Electrical BOM

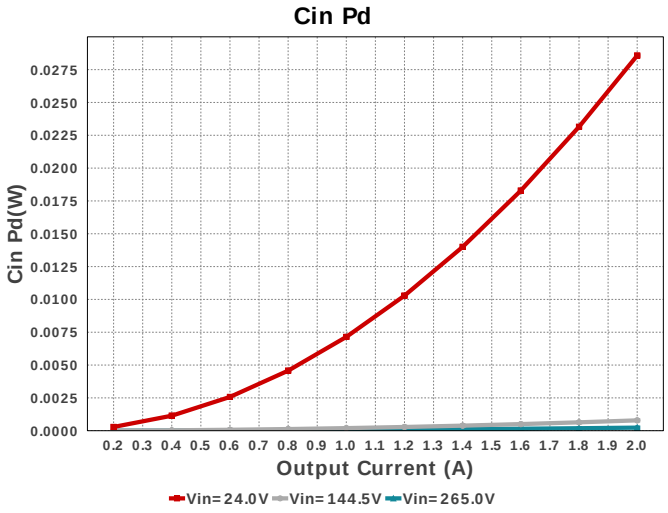
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
C12	Kemet	C0805C104M5RACTU Series= X7R	Cap= 100.0 nF ESR= 64.0 mOhm VDC= 50.0 V IRMS= 1.64 A	1	$0.01	0805 7 mm^2
C13	MuRata	GRM1555C1H102JA01J Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2
C21	TDK	C2012X5R1V226M125AC Series= X5R	Cap= 22.0 uF ESR= 2.05 mOhm VDC= 35.0 V IRMS= 4.5559 A	1	$0.33	0805 7 mm^2
C22	Samsung Electro-Mechanics	CL21C220JBANNNC Series= C0G/NP0	Cap= 22.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
C23	Samsung Electro-Mechanics	CL21C100JBANNNC Series= C0G/NP0	Cap= 10.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0805 7 mm^2
Ccs	AVX	04025A471JAT2A Series= C0G/NP0	Cap= 470.0 pF VDC= 50.0 V IRMS= 0.0 A	1	$0.01	0402 3 mm^2

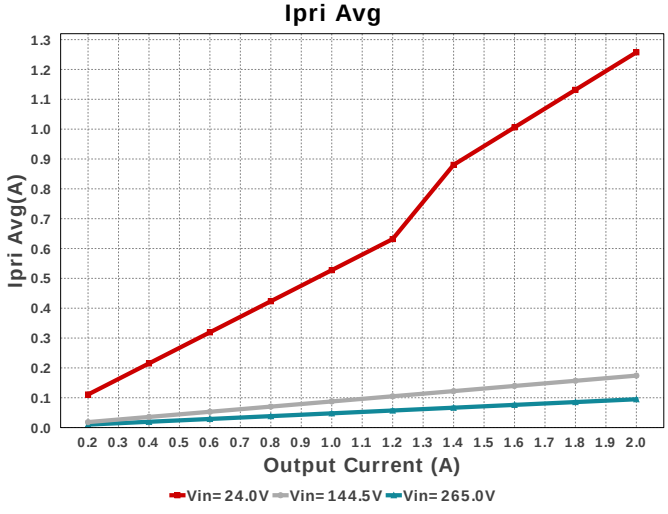
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Cin	TDK	B32674D4225K Series= B32674	Cap= 2.2 uF ESR= 14.0 mOhm VDC= 450.0 V IRMS= 6.0 A	1	$0.94	 CAPRR2750W80L3150T1250H2150 486 mm^2
Cout1	Panasonic	25SVPF330M Series= SVPF	Cap= 330.0 uF ESR= 14.0 mOhm VDC= 25.0 V IRMS= 5.0 A	1	$0.73	 CAPSMT_62_F12 151 mm^2
Cref	MuRata	GRM155R71C104KA88D Series= X7R	Cap= 100.0 nF ESR= 1.0 mOhm VDC= 16.0 V IRMS= 0.0 A	1	$0.01	 0402 3 mm^2
Csnub	MuRata	GRM31MR72A563KA01L Series= X7R	Cap= 56.0 nF ESR= 1.0 mOhm VDC= 100.0 V IRMS= 0.0 A	1	$0.05	 1206 11 mm^2
Ct	Kemet	C0805C102J1GACTU Series= C0G/NP0	Cap= 1.0 nF ESR= 25.0 mOhm VDC= 100.0 V IRMS= 1.71 A	1	$0.09	 0805 7 mm^2
Cvcc	Panasonic	EEE-FK1E330UR Series= FK	Cap= 33.0 uF ESR= 700.0 mOhm VDC= 25.0 V IRMS= 160.0 mA	1	$0.09	 SM_RADIAL_C 62 mm^2
D21	Panasonic	DB2S31600L	VF@Io= 550.0 mV VRRM= 30.0 V	1	$0.03	 SOD-523 5 mm^2
Daux	SMC Diode Solutions	ST1300ATR	VF@Io= 1.1 V VRRM= 300.0 V	1	$0.07	 SMA 37 mm^2
Dsec	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 281.084 V	1	NA	CUSTOM 0 mm^2
Dsec2	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 281.084 V	1	NA	CUSTOM 0 mm^2
Dsnub	SMC Diode Solutions	UF4004TA	VF@Io= 1.0 V VRRM= 400.0 V	1	$0.22	 DO-41 43 mm^2
Dz	ON Semiconductor	MMBZ5239BLT1G	Zener	1	$0.02	 SOT-23 14 mm^2
HS_M1	Aavid	529802B02500G	Heatsink	1	$0.91	 529802 1203 mm^2
M1	Infineon Technologies	SPA20N60C3XKSA1	VdsMax= 600.0 V IdsMax= 20.7 Amps	1	$2.49	 TO-220FP 79 mm^2

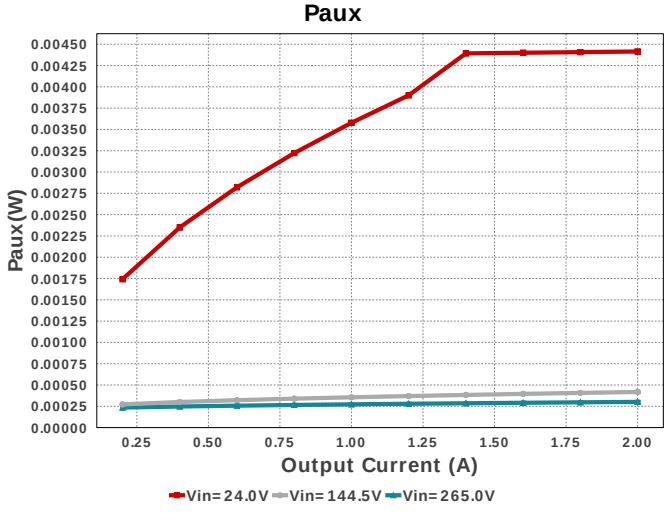
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
O1	Fairchild Semiconductor	FOD817A	Optocoupler	1	$0.11	 DIP-4 71 mm²
Q1	Diodes Inc.	MMBT4401-7-F	Bipolar Transistor	1	$0.02	 SOT-23 14 mm²
Qsc	STMicroelectronics	2N2222A	Bipolar Transistor	1	$1.11	 TO-18 57 mm²
R11	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
R12	Vishay-Dale	CRCW04022K32FKED Series= CRCW..e3	Res= 2.32 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R13	Vishay-Dale	CRCW04024K99FKED Series= CRCW..e3	Res= 4.99 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
R21	Yageo	RC0201FR-0710KL Series= ?	Res= 10.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
R22	Yageo	RC0201FR-7D866KL Series= ?	Res= 866.0 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	0201 2 mm²
Raux	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rbias	Vishay-Dale	CRCW04024K87FKED Series= CRCW..e3	Res= 4.87 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rcs	Vishay-Dale	CRCW04021K00FKED Series= CRCW..e3	Res= 1000.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rdrv	Yageo	RC1206FR-0712RL Series= ?	Res= 12.0 Ohm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm²
Rfbb	Yageo	RC0603FR-073K6L Series= ?	Res= 3.6 kOhm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm²
Rfbt	Vishay-Dale	CRCW040213K7FKED Series= CRCW..e3	Res= 13.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rled	Vishay-Dale	CRCW04021K87FKED Series= CRCW..e3	Res= 1.87 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsc	Vishay-Dale	CRCW04023K09FKED Series= CRCW..e3	Res= 3.09 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
Rsns	CUSTOM	CUSTOM Series= ?	Res= 201.21 mOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
Rsnub1	Vishay Draloric	CRCW25124K02FKEGHP Series= ?	Res= 4.02 kOhm Power= 1.5 W Tolerance= 1.0%	1	$0.20	 2512 43 mm²
Rsnub2	Vishay Draloric	CRCW25124K02FKEGHP Series= ?	Res= 4.02 kOhm Power= 1.5 W Tolerance= 1.0%	1	$0.20	 2512 43 mm²
Rstartup1	Yageo	RC1206FR-0733KL Series= ?	Res= 33.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm²

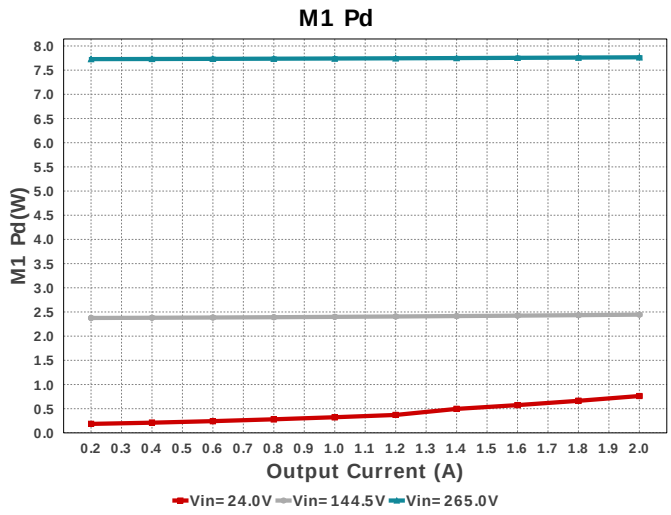
Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
Rstartup2	Yageo	RC1206FR-0733KL Series= ?	Res= 33.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	 1206 11 mm²
Rt	Yageo	RC0201FR-0715K4L Series= ?	Res= 15.4 kOhm Power= 50.0 mW Tolerance= 1.0%	1	$0.01	 0201 2 mm²
Rz	Vishay-Dale	CRCW04021K10FKED Series= CRCW..e3	Res= 1.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
T1	Core=TDK , CoilFormer=TDK	Core=B66317G0000X187 , CoilFormer=B66208X1110T001	Lp= 50.0 µH Turns Ratio(Nas)= 6:7 Turns Ratio(Nps)= 17:7 Npri= 17.0 Naux= 6.0 Nsec= 7.0	1	$0.22	 TDK_B66305 569 mm²
U1	Texas Instruments	UCC2813QDR-0Q1	Switcher	1	$1.03	 D0008A 57 mm²
VR	Texas Instruments	TL431IDBVR	Voltage References	1	$0.06	 R-PDSO-G3 16 mm²

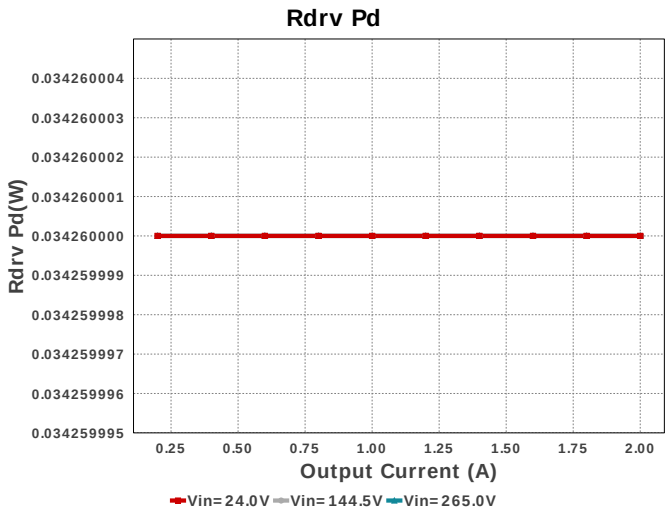


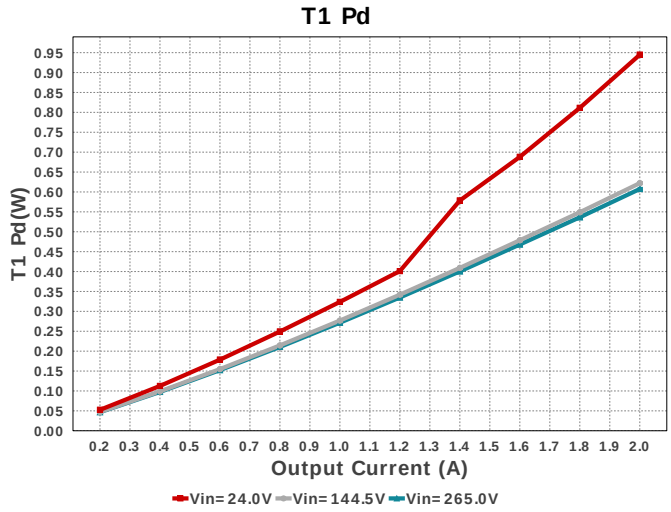


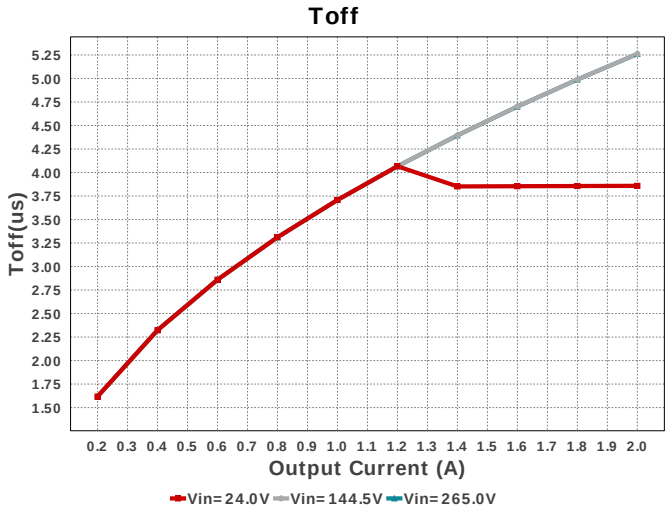


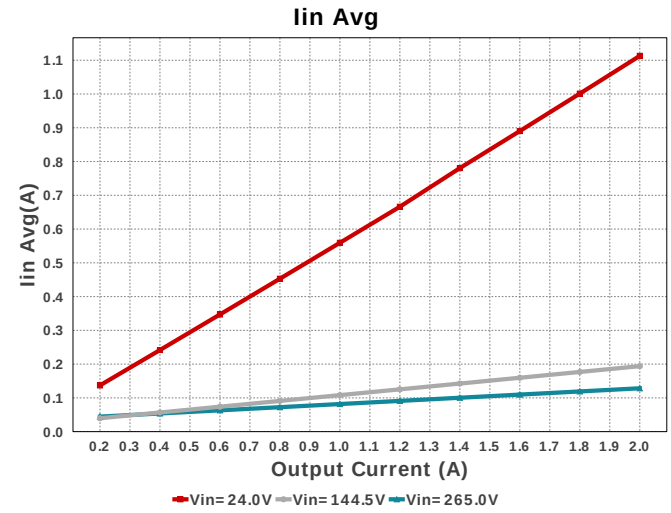


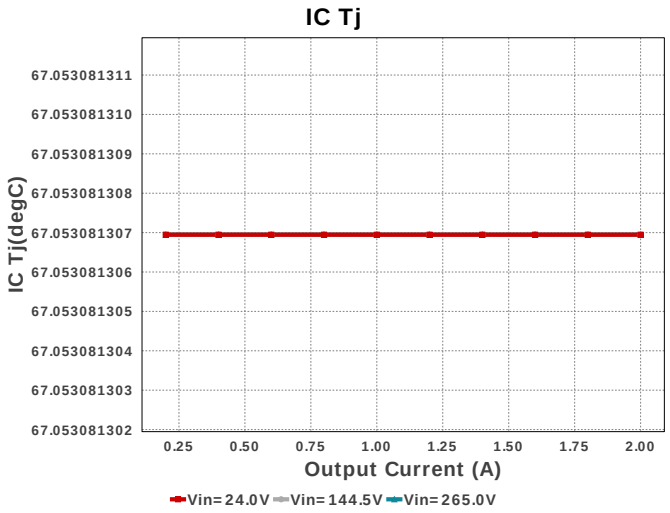


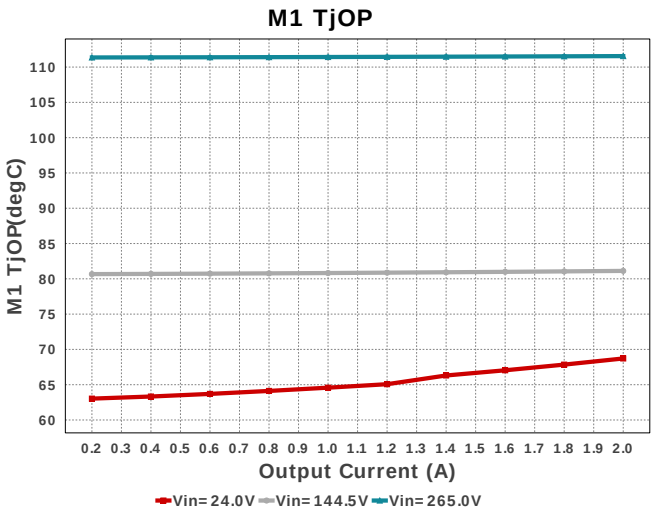


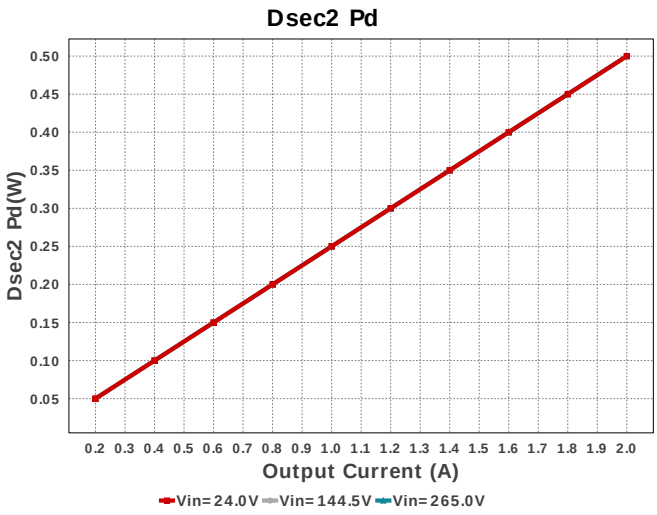


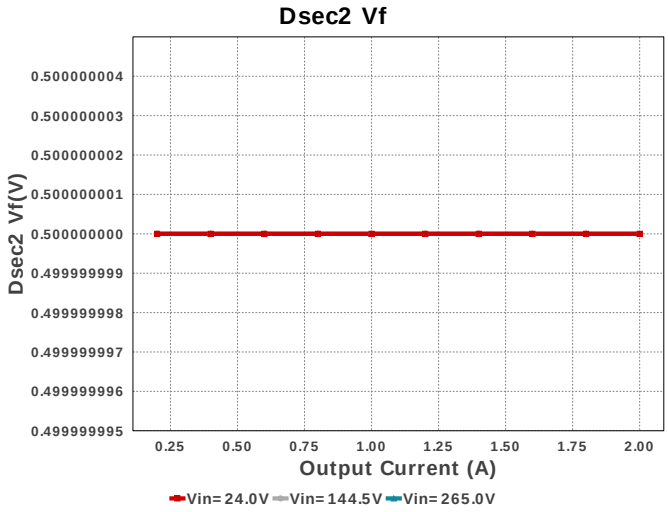


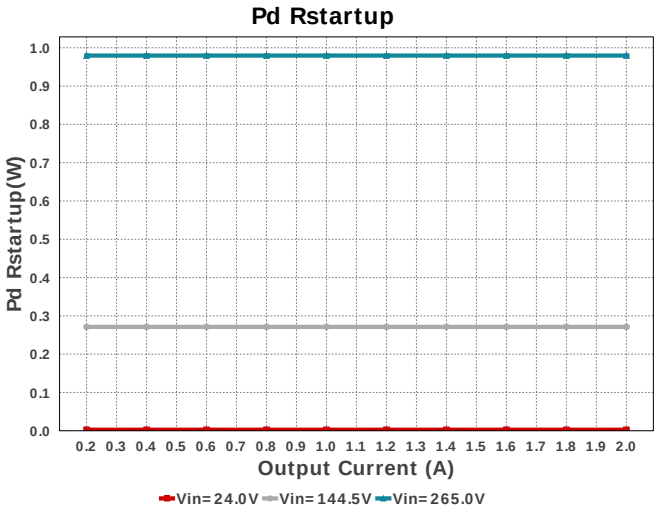


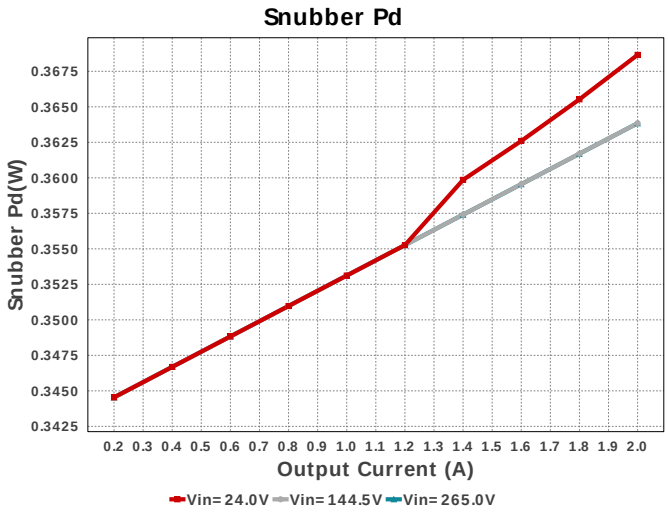


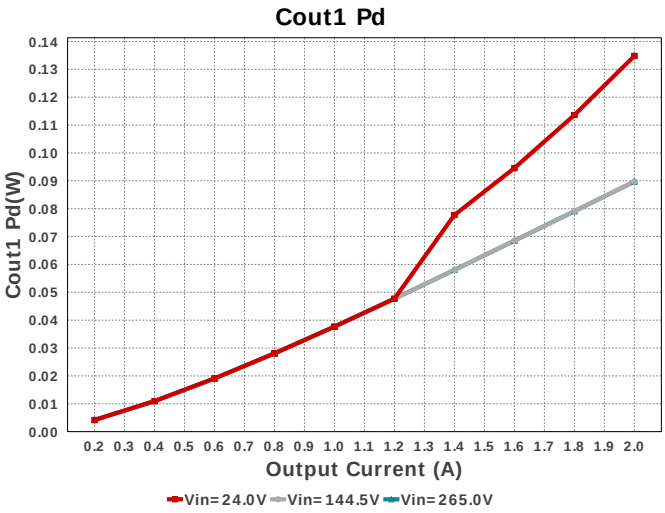


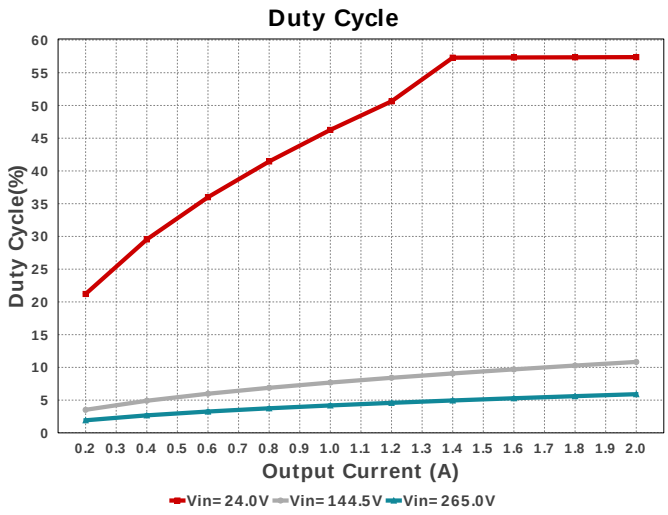


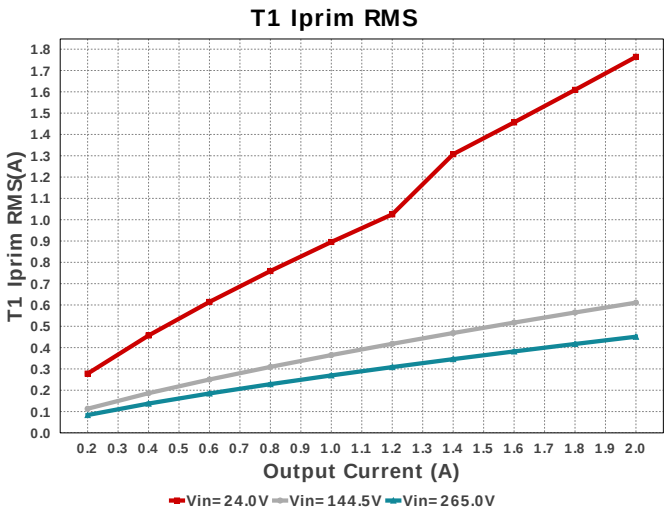


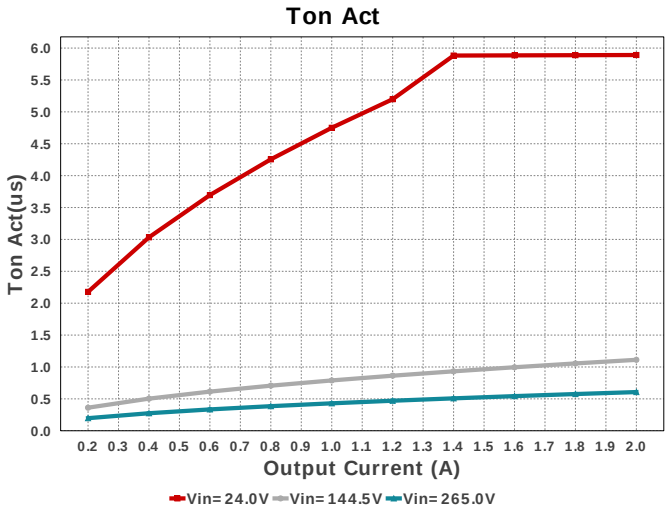


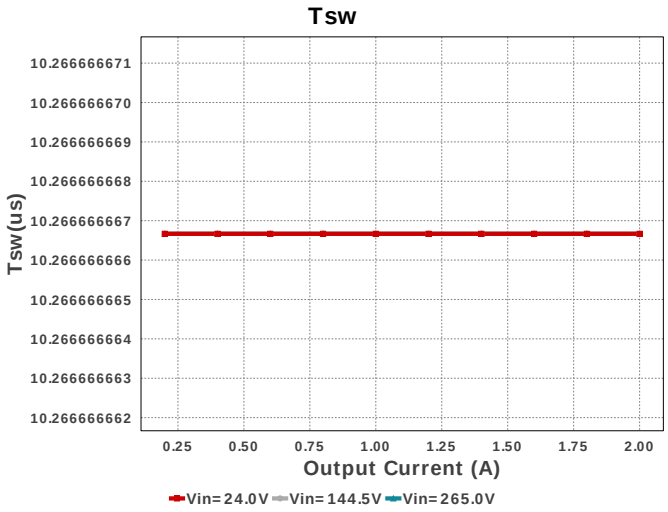


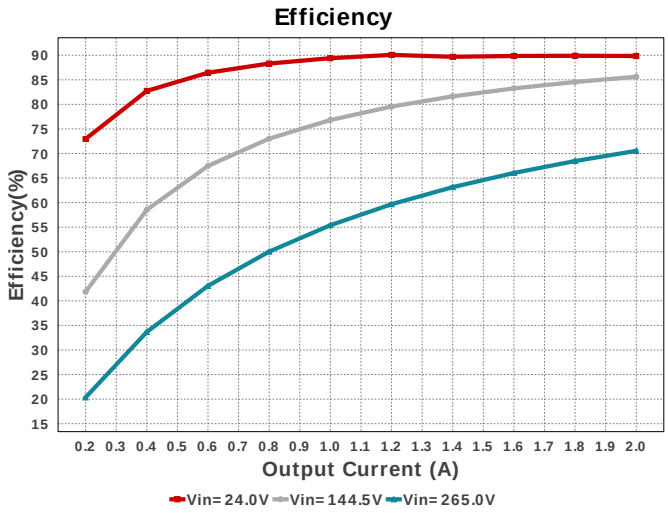


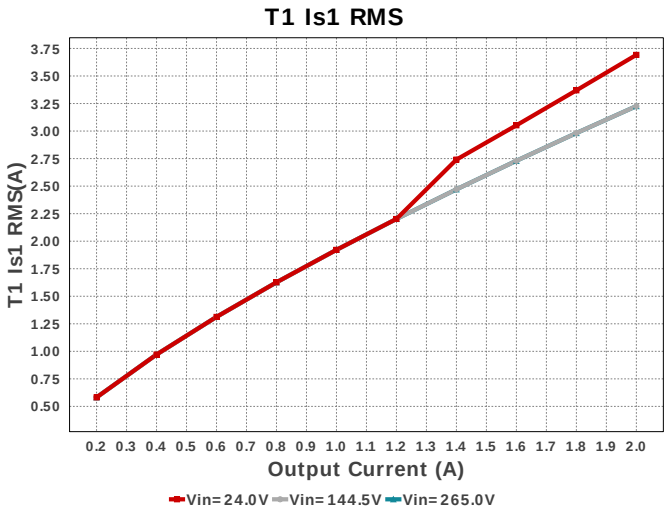


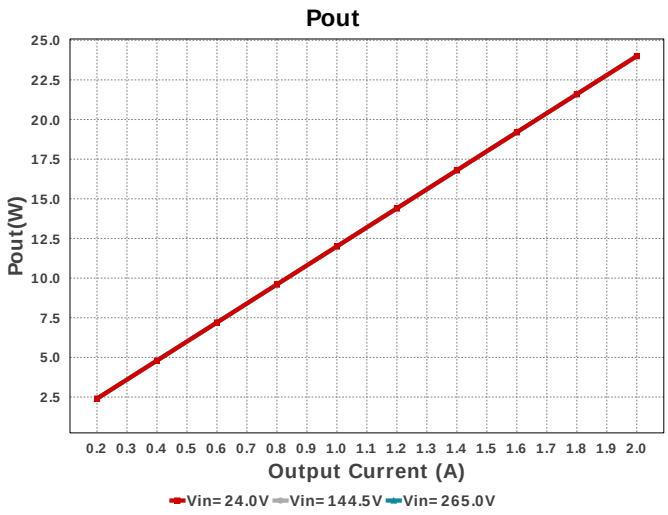


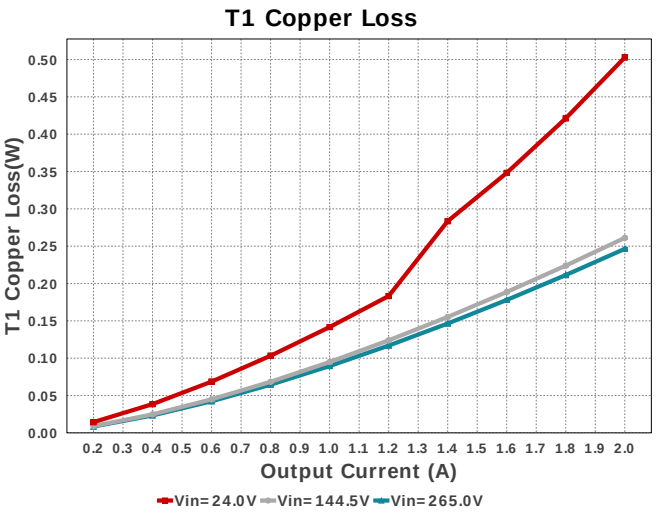


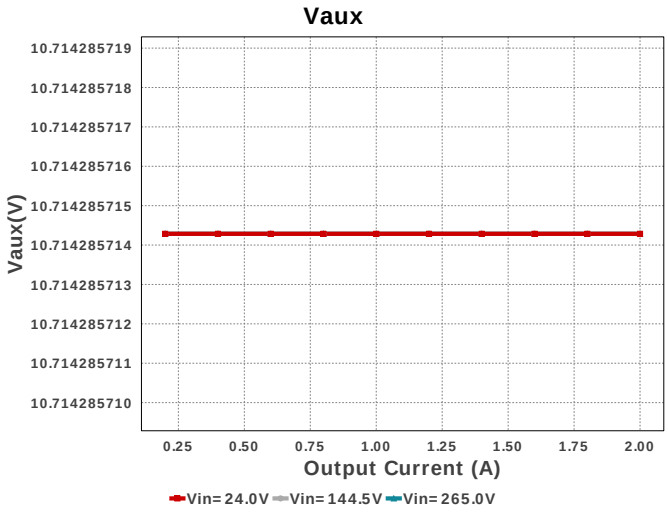


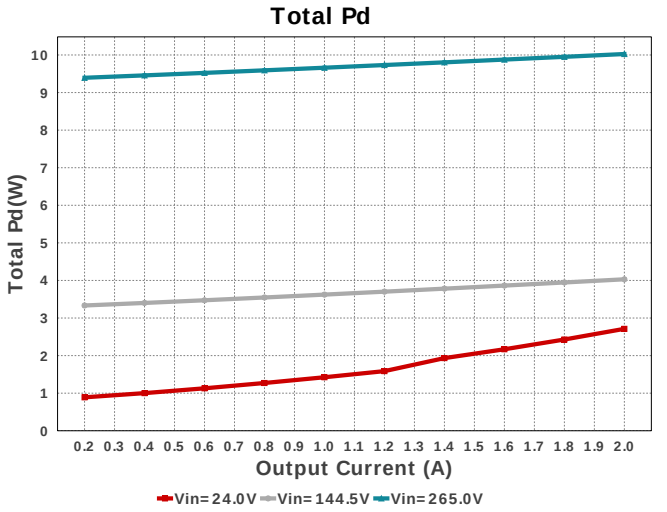


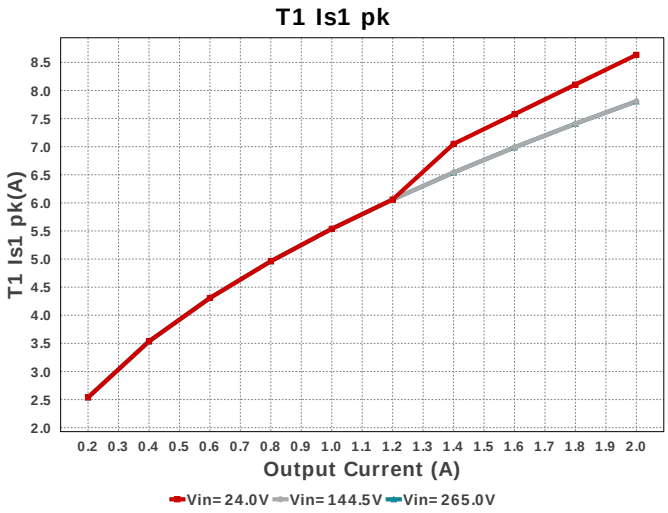


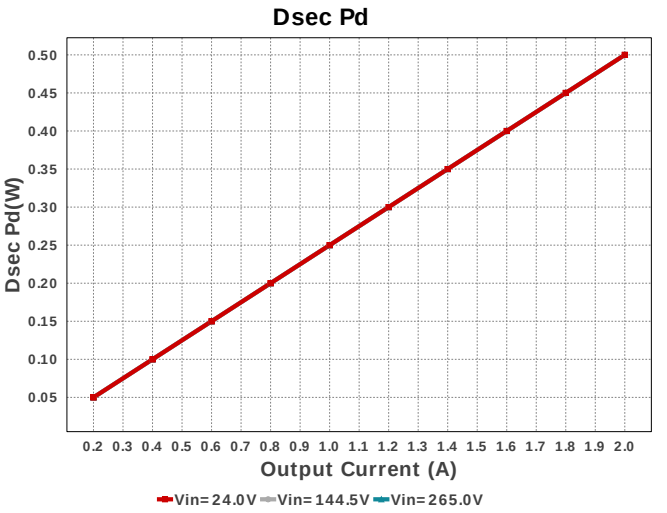


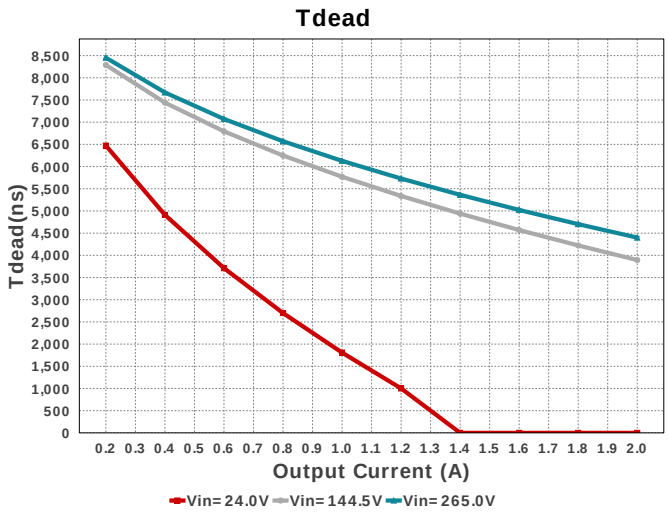


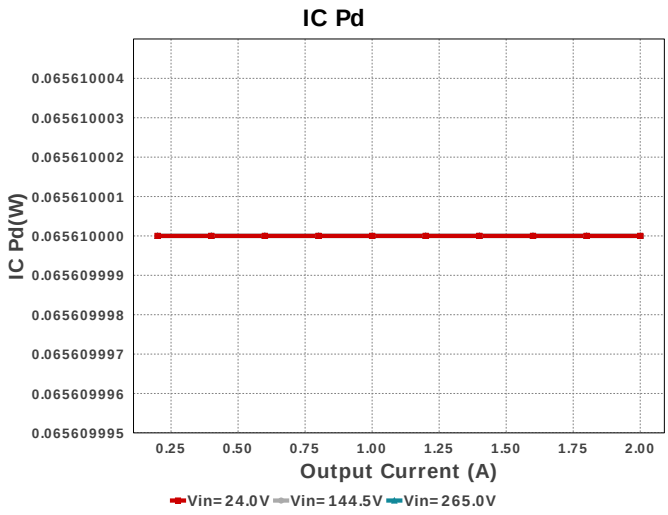


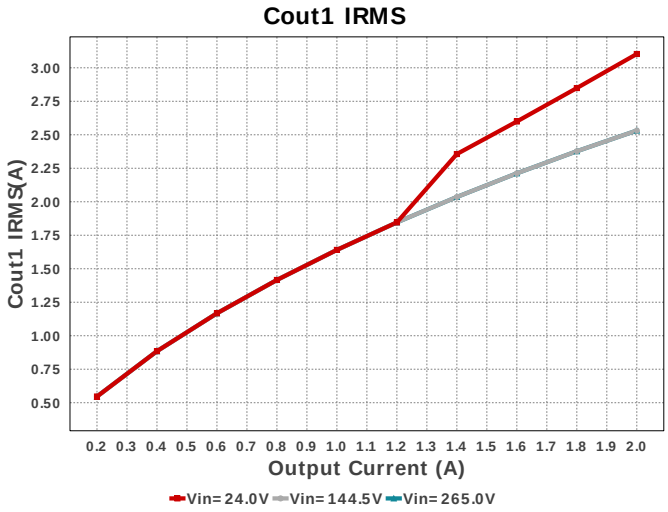


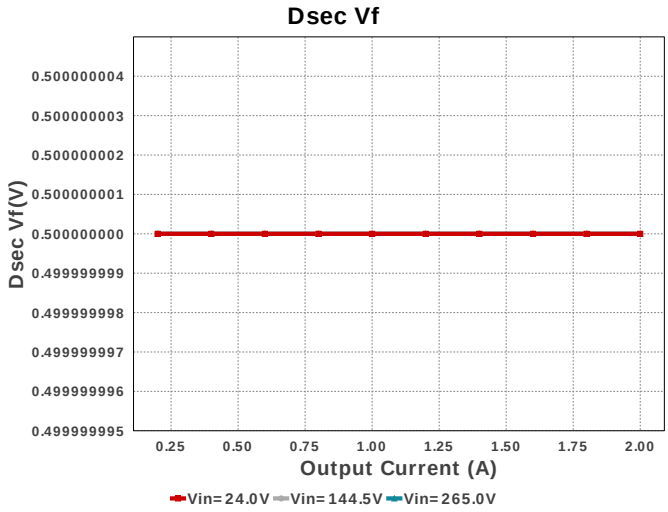


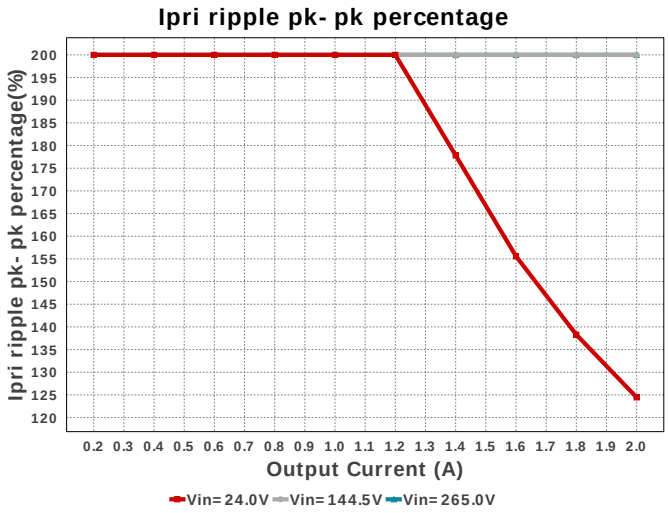


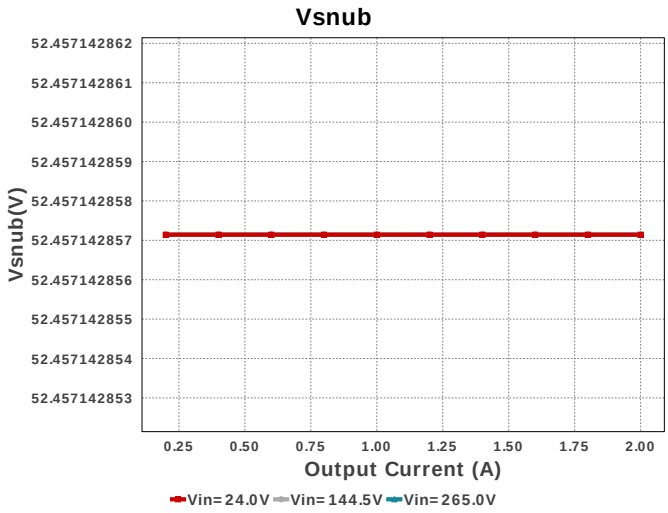


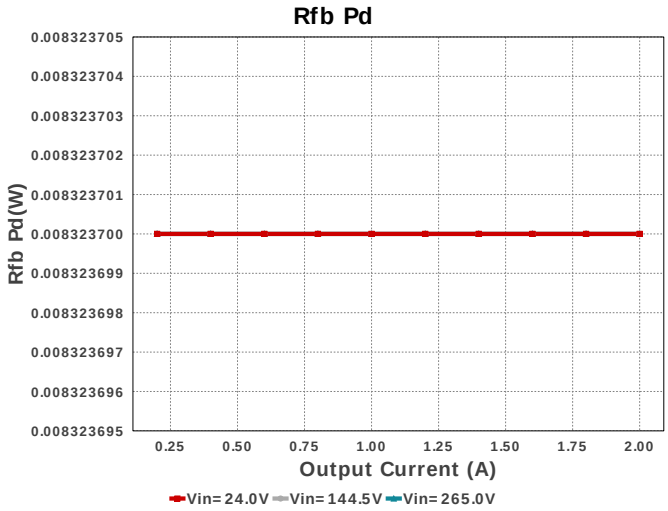


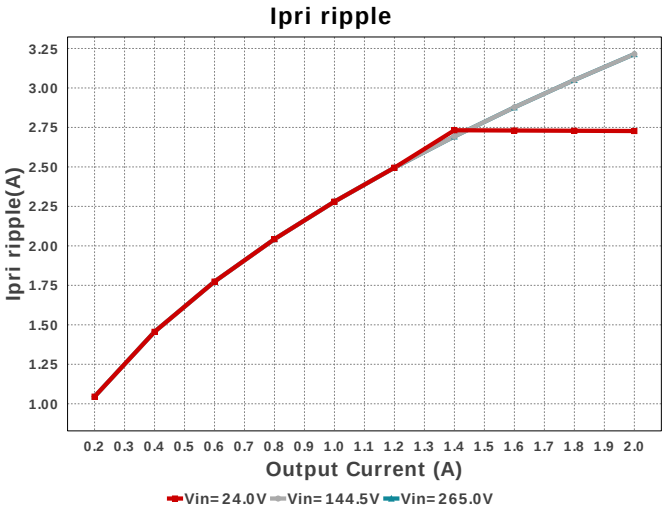


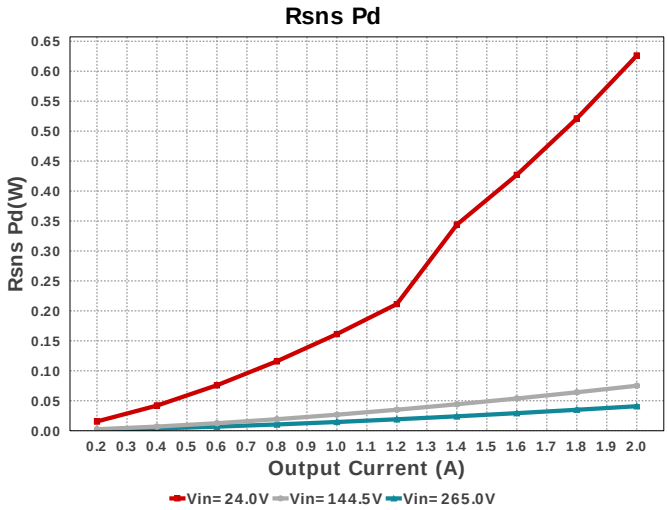


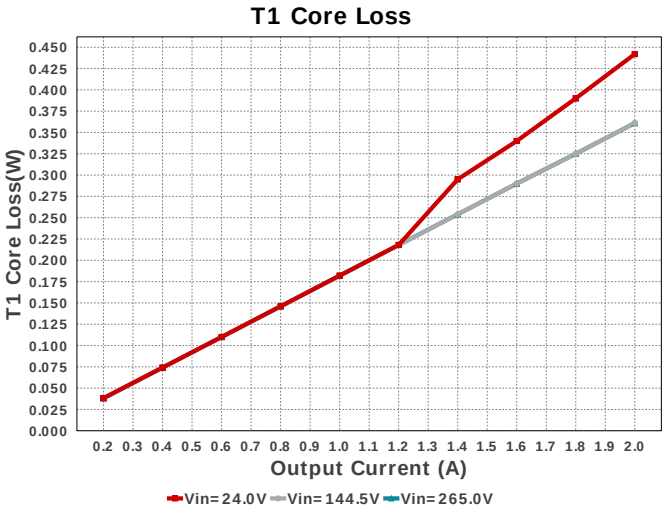


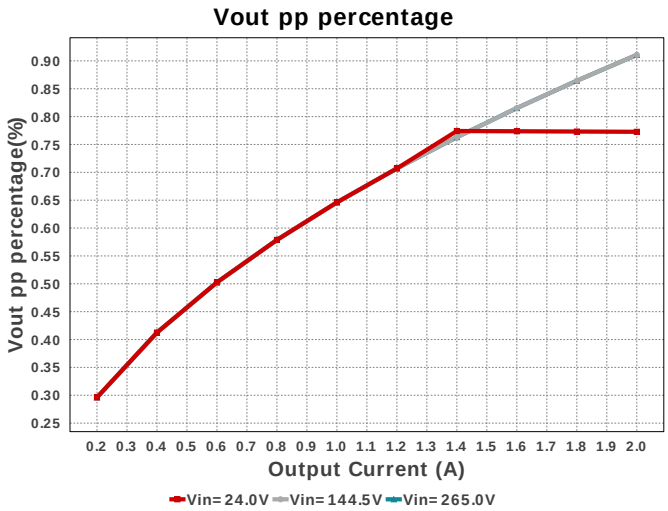


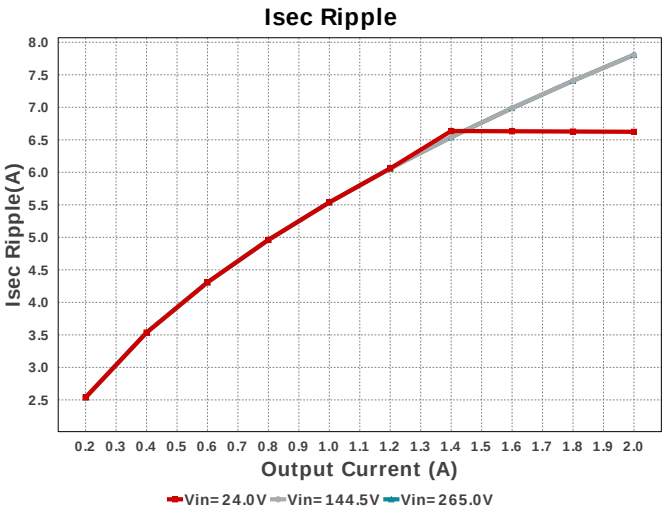


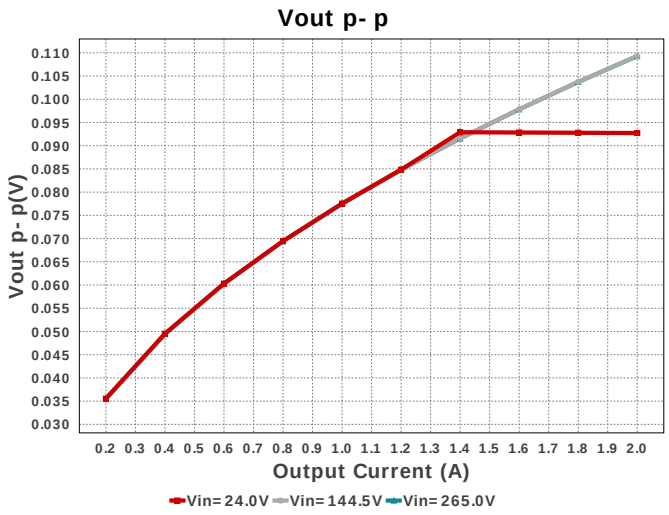


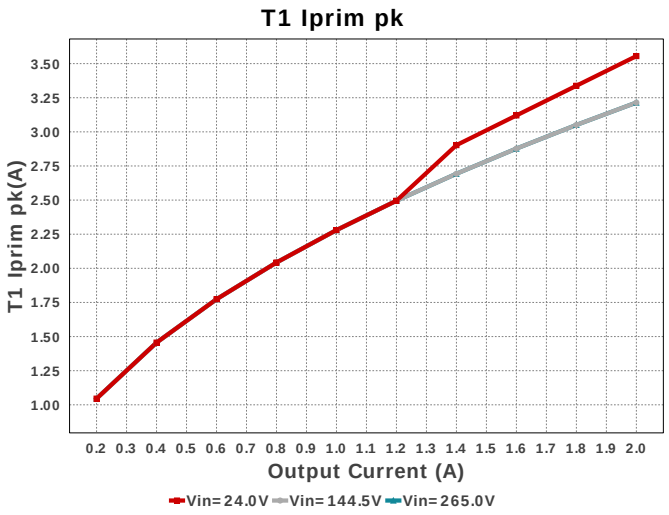












Operating Values

#	Name	Value	Category	Description
1.	Cin Pd	28.571 mW	Capacitor	Input capacitor power dissipation
2.	Cout1 IRMS	3.103 A	Capacitor	Output capacitor1 RMS ripple current
3.	Cout1 Pd	134.81 mW	Capacitor	Output capacitor1 power dissipation
4.	Daux trr	35.0 ns	Diode	Auxiliary Diode Reverse Recovery Time
5.	Dsec Pd	500.0 mW	Diode	Secondary Diode Power Dissipation
6.	Dsec Vf	500.0 mV	Diode	Effective Forward Voltage Drop at the Operating Current
7.	Dsec trr	0.0 ns	Diode	Output Diode Reverse Recovery Time
8.	Dsec2 Pd	500.0 mW	Diode	Secondary Diode Power Dissipation
9.	Dsec2 Vf	500.0 mV	Diode	Effective Forward Voltage Drop at the Operating Current
10.	Dsnub trr	50.0 ns	Diode	Snubber Diode Reverse Recovery Time
11.	IC Pd	65.61 mW	IC	IC power dissipation
12.	IC Tj	67.053 degC	IC	IC junction temperature
13.	ICThetaJA	107.5 degC/W	IC	IC junction-to-ambient thermal resistance
14.	Iin Avg	1.113 A	IC	Average input current
15.	M1 Pd	762.15 mW	Mosfet	M1 MOSFET total power dissipation
16.	M1 TjOP	68.715 degC	Mosfet	M1 MOSFET junction temperature
17.	Cin Pd	28.571 mW	Power	Input capacitor power dissipation
18.	Cout1 Pd	134.81 mW	Power	Output capacitor1 power dissipation
19.	Dsec Pd	500.0 mW	Power	Secondary Diode Power Dissipation
20.	Dsec2 Pd	500.0 mW	Power	Secondary Diode Power Dissipation
21.	IC Pd	65.61 mW	Power	IC power dissipation
22.	M1 Pd	762.15 mW	Power	M1 MOSFET total power dissipation
23.	Paux	4.415 mW	Power	Power Dissipation in Raux and Daux
24.	Pd Rstartup	2.67 mW	Power	Power Dissipation in Rstartup1 and Rstartup2
25.	Rdrv Pd	34.26 mW	Power	Power Dissipation in Gate Drive Resistor
26.	Rfb Pd	8.324 mW	Power	Rfb Power Dissipation
27.	Rsns Pd	626.03 mW	Power	Current Limit Sense Resistor Power Dissipation
28.	Snubber Pd	368.658 mW	Power	Snubber Power Dissipation
29.	T1 Copper Loss	425.33 mW	Power	Transformer Copper Loss Power Dissipation
30.	T1 Core Loss	425.33 mW	Power	Transformer Core Loss Power Dissipation
31.	T1 Pd	850.65 mW	Power	Estimated Losses in Transformer
32.	Total Pd	2.712 W	Power	Total Power Dissipation
33.	Pd Rstartup	2.67 mW	Resistor	Power Dissipation in Rstartup1 and Rstartup2
34.	Rdrv Pd	34.26 mW	Resistor	Power Dissipation in Gate Drive Resistor
35.	Rfb Pd	8.324 mW	Resistor	Rfb Power Dissipation
36.	Rsns Pd	626.03 mW	Resistor	Current Limit Sense Resistor Power Dissipation
37.	BOM Count	46	System Information	Total Design BOM count
38.	Duty Cycle	57.381 %	System Information	Duty cycle
39.	Efficiency	89.847 %	System Information	Steady state efficiency
40.	FootPrint	3.094 k mm^2	System Information	Total Foot Print Area of BOM components
41.	Frequency	97.403 kHz	System Information	Switching frequency
42.	Iout	2.0 A	System Information	Iout operating point
43.	Iout_DCM	1.464 A	System Information	Approximate Current below which DCM mode of operation will begin
44.	Mode	CCM	System Information	Conduction Mode

#	Name	Value	Category	Description
45.	Pout	24.0 W	System Information	Total output power
46.	Tdead	0.0 ns	System Information	Approximate Dead Time of the Regulator
47.	Toff	3.858 us	System Information	Approximate Converter Off Time
48.	Ton Act	5.891 us	System Information	Approximate Converter On Time
49.	Total BOM	NA	System Information	Total BOM Cost
50.	Tsw	10.267 us	System Information	Switching Time Period
51.	Vin	24.0 V	System Information	Vin operating point
52.	Vout	12.0 V	System Information	Operational Output Voltage
53.	Vout Actual	11.99 V	System Information	Vout Actual calculated based on selected voltage divider resistors
54.	Vout Tolerance	1.926 %	System Information	Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
55.	Vout p-p	92.727 mV	System Information	Peak-to-peak output ripple voltage
56.	Vout pp percentage	772.721 m%	System Information	Output Voltage ripple percentage
57.	Vsnub	52.457 V	System Information	Voltage Across the Snubber
58.	Ipri Avg	1.257 A	Transformer	Average Current in Primary Winding over the complete Switching Period
59.	Ipri ripple	2.727 A	Transformer	Ripple Current in the Primary Winding
60.	Ipri ripple pk-pk percentage	124.453 %	Transformer	Primary Current pk-pk ripple percentage(of Ipri avg during ton only)
61.	Isec Ripple	6.623 A	Transformer	Ripple Current in the Secondary Winding
62.	Paux	4.415 mW	Transformer	Power Dissipation in Raux and Daux
63.	T1 Copper Loss	425.33 mW	Transformer	Transformer Copper Loss Power Dissipation
64.	T1 Core Loss	425.33 mW	Transformer	Transformer Core Loss Power Dissipation
65.	T1 Iprim RMS	1.764 A	Transformer	Transformer Primary RMS Current
66.	T1 Iprim pk	3.555 A	Transformer	Transformer Primary Peak Current
67.	T1 Is1 RMS	3.692 A	Transformer	Transformer Secondary1 RMS Current
68.	T1 Is1 pk	8.634 A	Transformer	Transformer Secondary1 Peak Current
69.	T1 Pd	850.65 mW	Transformer	Estimated Losses in Transformer
70.	Vaux	10.714 V	Transformer	Auxiliary Voltage

Design Inputs

Name	Value	Description
Iout	2.0	Maximum Output Current
VinMax	265.0	Maximum input voltage
VinMin	24.0	Minimum input voltage
Vout	12.0	Output Voltage
base_pn	UCC2813-0-Q1	Base Product Number
source	DC	Input Source Type
Ta	60.0	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

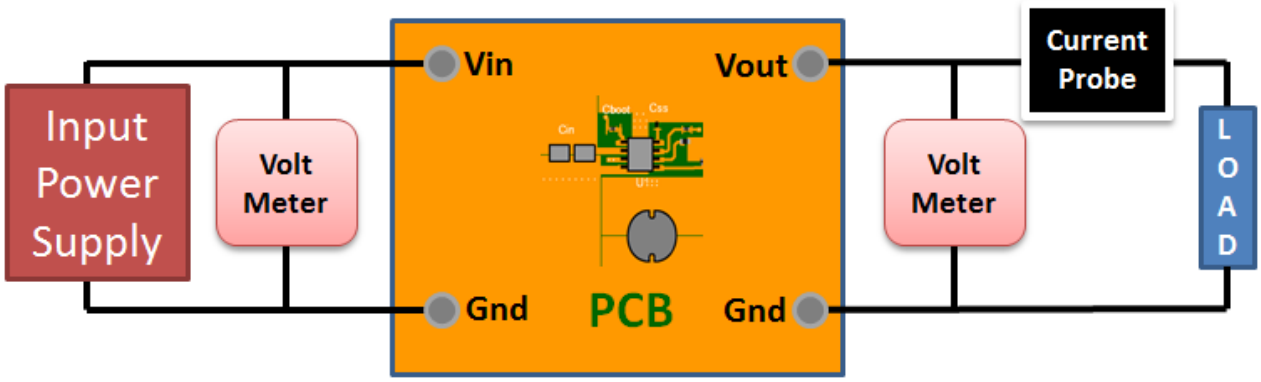
If board assembly is done in house it is best to tack down one terminal of a component on the board then solder the other terminal. For surface mount parts with large tabs, such as the DPAK, the tab on the back of the package should be pre-tinned with solder, then tacked into place by one of the pins. 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 24.0V 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

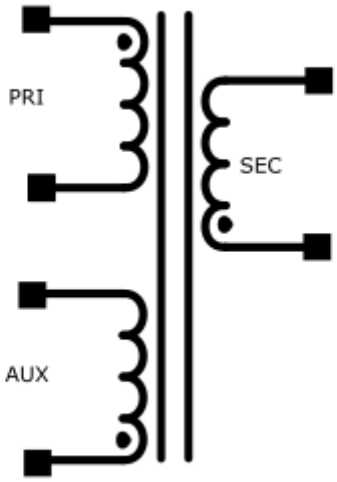
Transformer Electrical Diagram

Primary

Turns	17.0
AWG	27.0
Layers	2.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire

Auxiliary

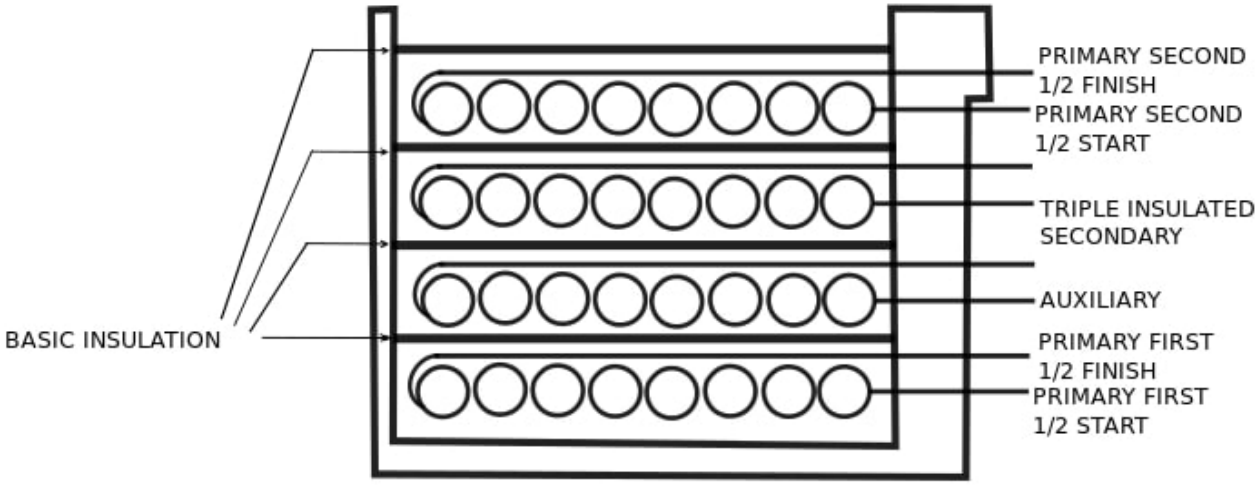
Turns	6.0
AWG	28.0
Layers	1.0
Strands	4.0
Insulation Type	Heavy Insulated Magnet Wire



Secondary

Turns	7.0
AWG	27.0
Layers	1.0
Strands	3.0
Insulation Type	Triple Insulated

Transformer Construction Diagram



Winding Instruction

Winding	AWG	Turns	Winding Orientation
Primary First 1/2.0	27.0	9	Clockwise

Winding	AWG	Turns	Winding Orientation
Auxiliary	28.0	6.0	Counter Clockwise
Triple Insulated Secondary	27.0	7.0	Counter Clockwise
Primary Second 1/2.0	27.0	8	Clockwise

Transformer Parameters

#	Name	Value
1.	Lpri	5.0E-5H
2.	Inductance Factor(Al)	175.0nH
3.	Npri	17.0
4.	Nsec	7.0
5.	Naux	6.0
6.	Core Type	E25/13/7
7.	Core Material	N87
8.	Bmax	0.19T
9.	Switching Frequency	97.40kHz
10.	DMax	0.6
11.	Ipk(Primary)	3.44A
12.	Irms(Primary)	1.68A
13.	Ipk(Secondary)	8.36A
14.	Irms(Secondary)	3.34A

Design Assistance

1. Feature Highlights: This device provides the features that are necessary to implement off-line or dc-to-dc fixed-frequency current-mode control schemes, with a minimum number of external components.

2. The UCC2813-0-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 : D51FA5CEBDB6905D[v1]

4. **UCC2813-0-Q1** Product Folder : http://www.ti.com/product/UCC2813%2D0%2DQ1 : contains the data sheet and other resources.