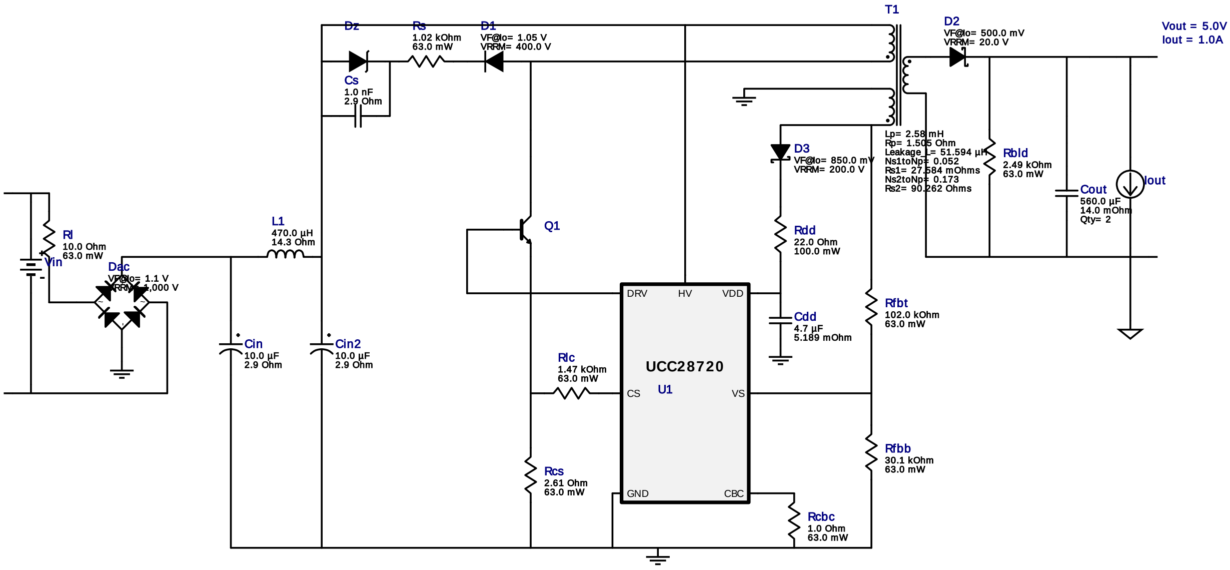
TEXAS INSTRUMENTS

WEBENCH ® Design Report

VinMin = 110.0V
VinMax = 220.0V
Vout = 5.0V
Iout = 1.0A

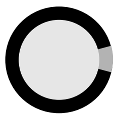
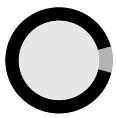
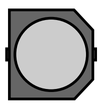
Device = UCC28720DR
Topology = Flyback
Created = 9/27/16 7:46:17 PM
BOM Cost = $0.00
BOM Count = 24
Total Pd = 1.3W

Design : 4412135/40 UCC28720DR
UCC28720DR 110.0V-220.0V to 5.37V @ 1.0A

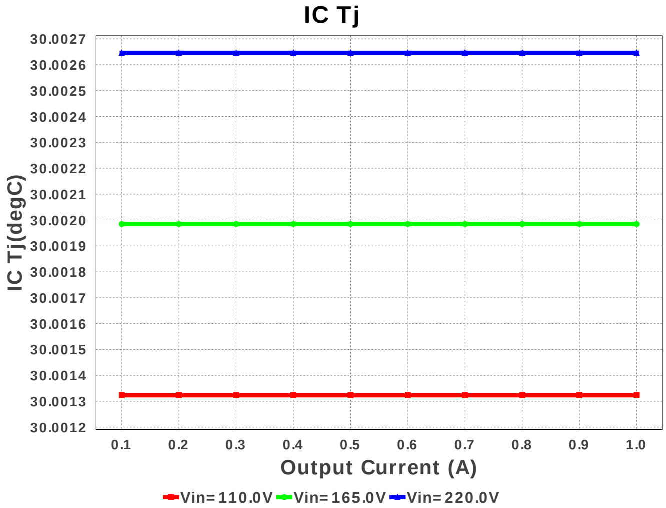


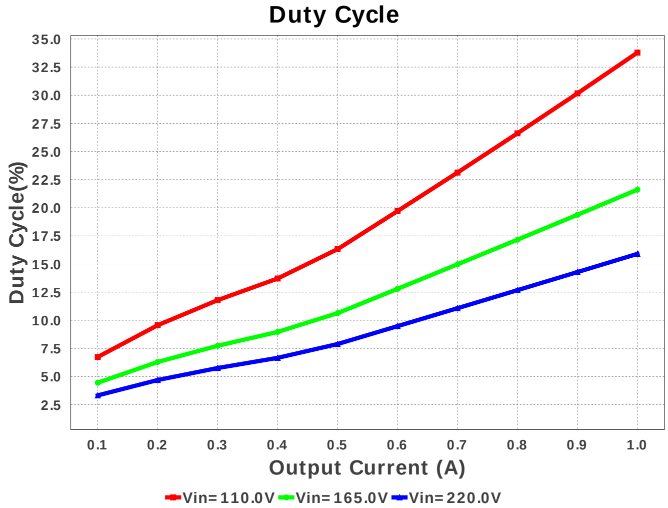
1. Rbld is a starting point, but may need to be experimented with in order to get minimum current needed to hold Vout at no load. Rlc and the feedback resistors may also need adjustment based on the actual transformer used. For more information please click the design assistance button.

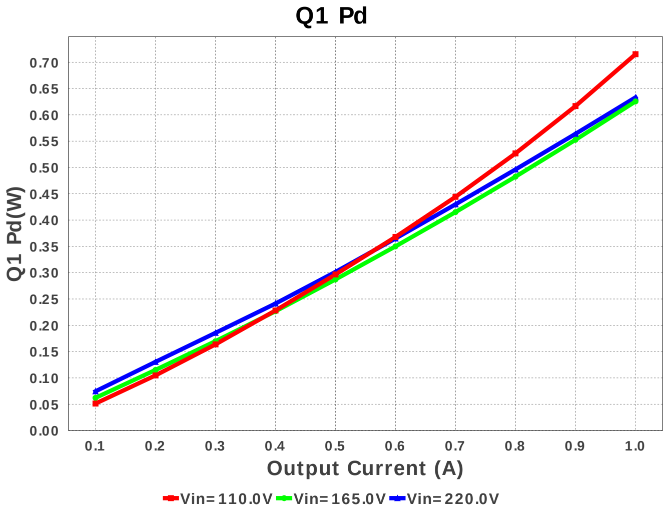
Electrical BOM

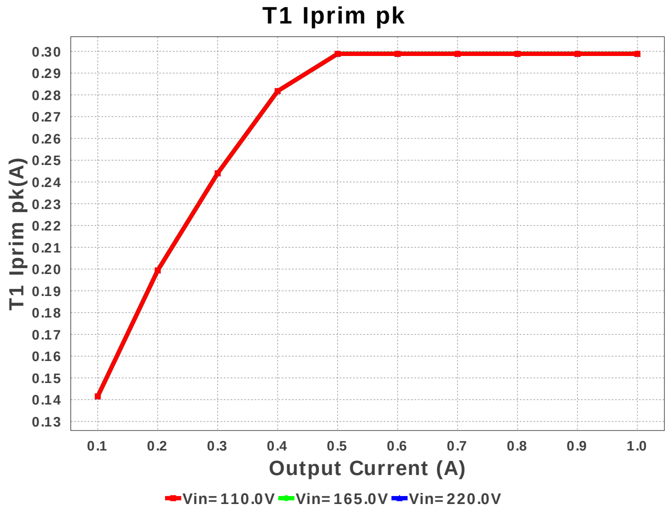
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Cdd	MuRata	GRM21BR61E475KA12L Series= X5R	Cap= 4.7 uF ESR= 5.189 mOhm VDC= 25.0 V IRMS= 2.03531 A	1	$0.02	0805 7 mm²
2.	Cin	Kemet	ESG106M400AH4AA Series= 2334	Cap= 10.0 uF ESR= 2.9 Ohm VDC= 400.0 V IRMS= 100.0 mA	1	$0.19	 ESG106 144 mm²
3.	Cin2	Kemet	ESG106M400AH4AA Series= 2334	Cap= 10.0 uF ESR= 2.9 Ohm VDC= 400.0 V IRMS= 100.0 mA	1	$0.19	 ESG106 144 mm²
4.	Cout	Panasonic	16SVPF560M Series= ?	Cap= 560.0 uF ESR= 14.0 mOhm VDC= 16.0 V IRMS= 4.95 A	2	$0.61	 CAPSMT_62_E12 106 mm²
5.	Cs	MuRata	GRM188R72E102KW07D Series= X7R	Cap= 1.0 nF ESR= 2.9 Ohm VDC= 250.0 V IRMS= 90.0 mA	1	$0.01	0603 5 mm²
6.	D1	Bourns	CD1408-FU1400	VF@Io= 1.05 V VRRM= 400.0 V	1	$0.13	 Diode_1408 13 mm²
7.	D2	Diodes Inc.	B220-13-F	VF@Io= 500.0 mV VRRM= 20.0 V	1	$0.08	 SMB 44 mm²

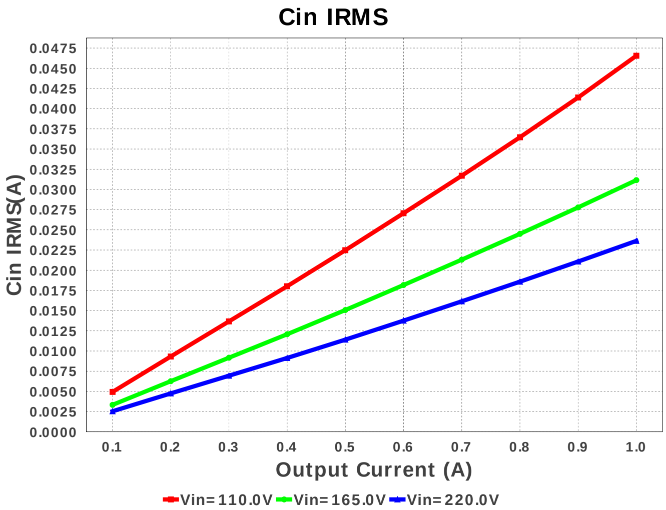
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
8.	D3	Diodes Inc.	DFLS1200-7	VF@Io= 850.0 mV VRRM= 200.0 V	1	$0.21	PowerDI123 13 mm^2
9.	Dac	Vishay-Semiconductor	DF10SA	VF@Io= 1.1 V VRRM= 1,000.0 V	1	$0.24	DF-S 99 mm^2
10.	Dz	ON Semiconductor	1SMB5951BT3G	Zener	1	$0.10	SMB 44 mm^2
11.	L1	Bourns	SDR0302-471KL	L= 470.0 µH DCR= 14.3 Ohm	1	$0.18	SDR0302 15 mm^2
12.	Q1	STMicroelectronics	STN2580	Bipolar Transistor	1	$0.19	SOT-223 76 mm^2
13.	Rbld	Vishay-Dale	CRCW04022K49FKED Series= CRCW..e3	Res= 2.49 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
14.	Rcbc	Vishay-Dale	CRCW04021R00FKED Series= CRCW..e3	Res= 1.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
15.	Rcs	Vishay-Dale	CRCW04022R61FKED Series= CRCW..e3	Res= 2.61 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
16.	Rdd	Yageo America	RC0603FR-0722RL Series= ?	Res= 22.0 Ohm Power= 100.0 mW Tolerance= 1.0%	1	$0.01	0603 5 mm^2
17.	Rfbb	Vishay-Dale	CRCW040230K1FKED Series= CRCW..e3	Res= 30.1 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
18.	Rfbt	Vishay-Dale	CRCW0402102KFKED Series= CRCW..e3	Res= 102.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
19.	Rl	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
20.	Rlc	Vishay-Dale	CRCW04021K47FKED Series= CRCW..e3	Res= 1.47 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
21.	Rs	Vishay-Dale	CRCW04021K02FKED Series= CRCW..e3	Res= 1.02 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm^2
22.	T1	CUSTOM	CUSTOM	Lp= 2.58 mH Rp= 1.505 Ohm Leakage_L= 51.594 µH Ns1toNp= 0.052 Rs1= 27.584 mOhms Ns2toNp= 0.173 Rs2= 90.262 Ohms	1	NA	CUSTOM 0 mm^2
23.	U1	Texas Instruments	UCC28720DR	Switcher	1	$0.40	R-PDSO-G7 55 mm^2

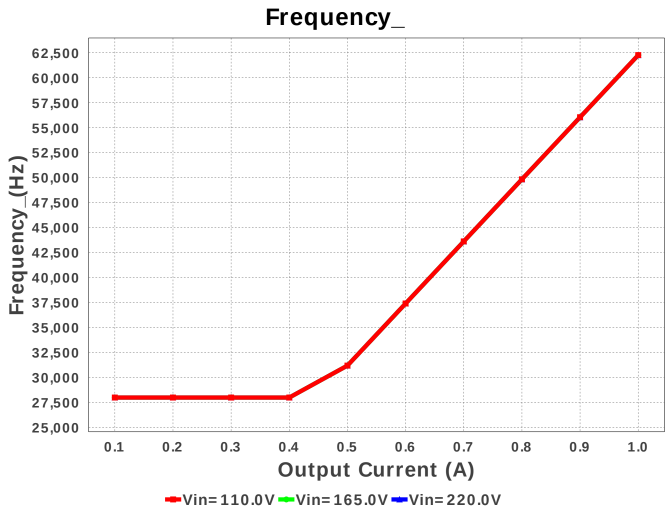

IC Tj
IC Tj(degC)
30.0027
30.0026
30.0025
30.0024
30.0023
30.0022
30.0021
30.0020
30.0019
30.0018
30.0017
30.0016
30.0015
30.0014
30.0013
30.0012
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=110.0V Vin=165.0V Vin=220.0V


Duty Cycle
Duty Cycle(%)
35.0
32.5
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=110.0V Vin=165.0V Vin=220.0V

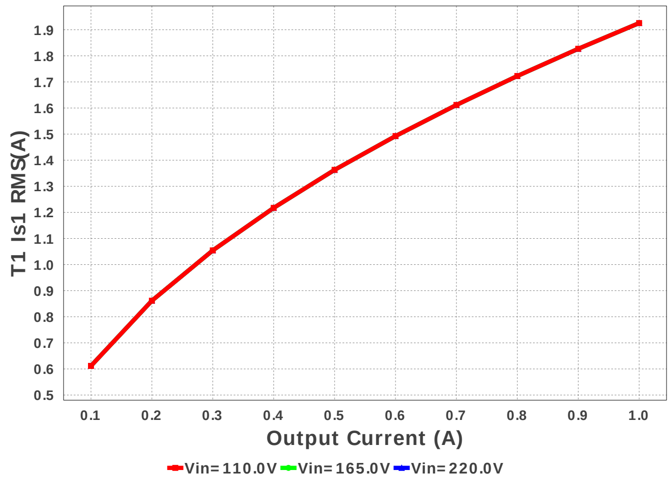

Q1 Pd
Q1 Pd(W)
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=110.0V Vin=165.0V Vin=220.0V


T1 Iprim pk
T1 Iprim pk(A)
0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=110.0V Vin=165.0V Vin=220.0V

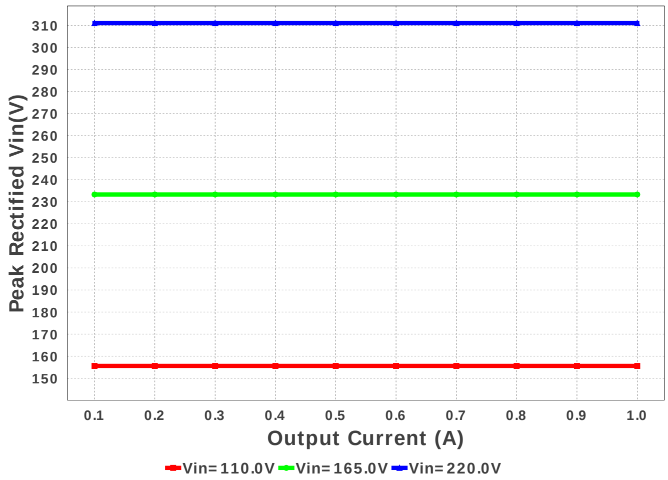

Cin IRMS
Cin IRMS(A)
0.0475
0.0450
0.0425
0.0400
0.0375
0.0350
0.0325
0.0300
0.0275
0.0250
0.0225
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=110.0V Vin=165.0V Vin=220.0V


Frequency_
Frequency_(Hz)
62,500
60,000
57,500
55,000
52,500
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin=110.0V Vin=165.0V Vin=220.0V

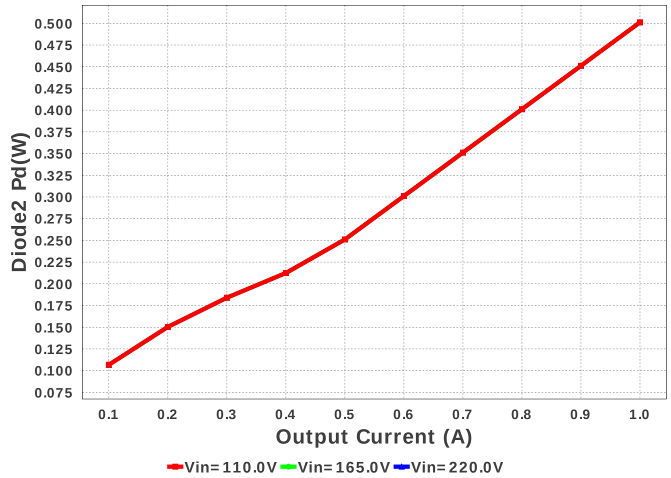
T1 Is1 RMS



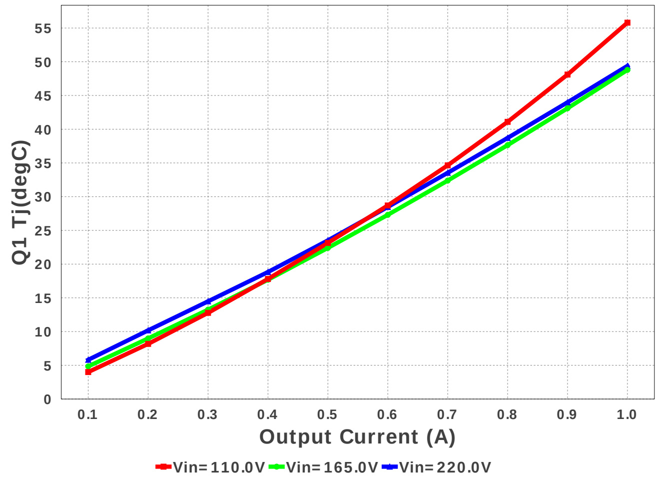
Peak Rectified Vin



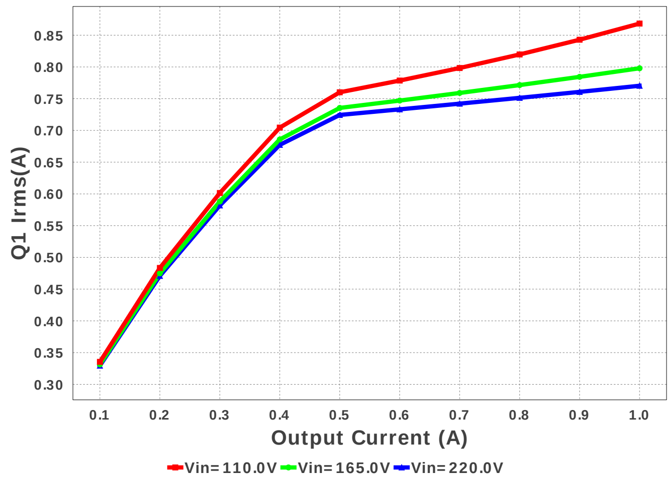
Diode2 Pd



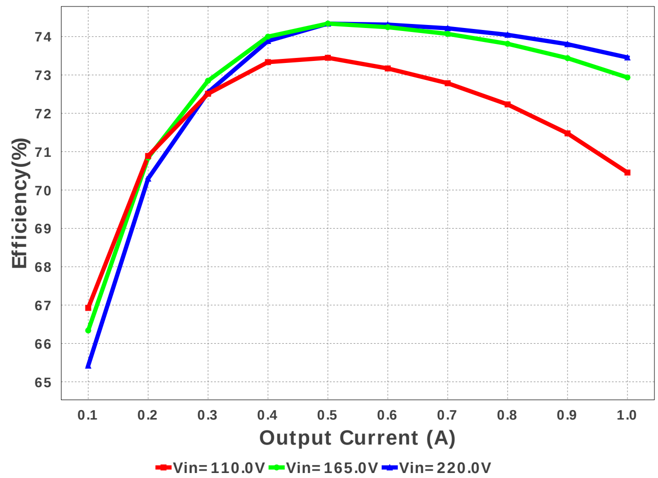
Q1 Tj



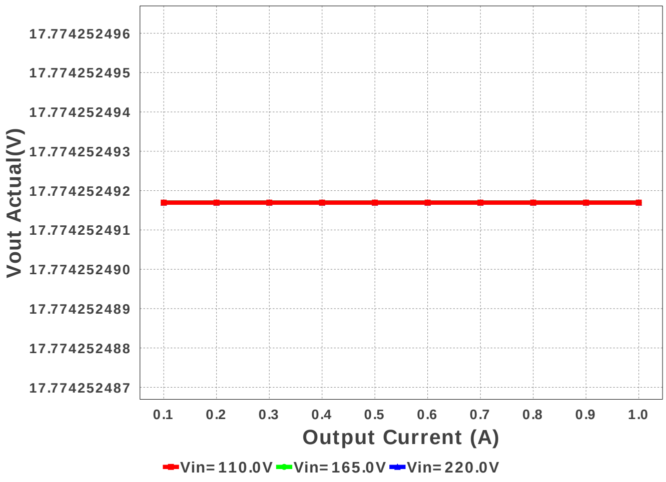
Q1 Irms



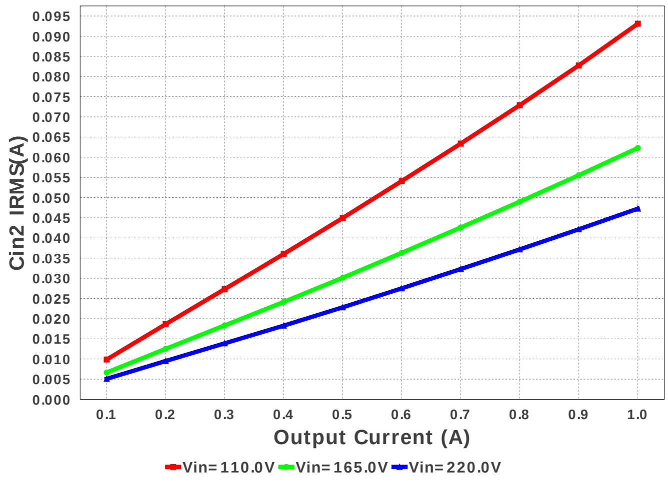
Efficiency



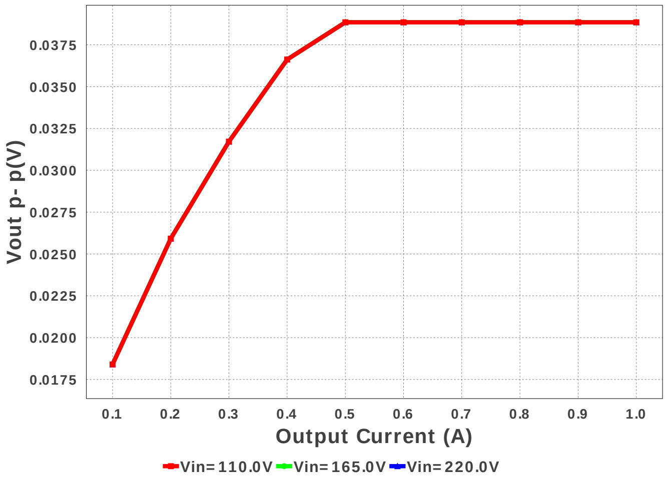
Vout Actual



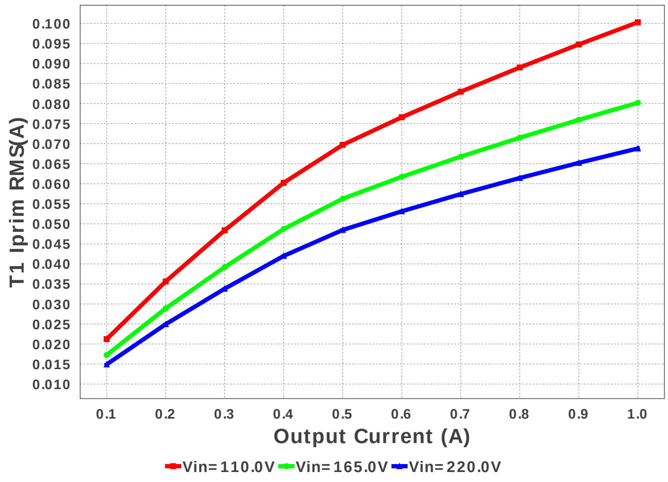
Cin2 IRMS



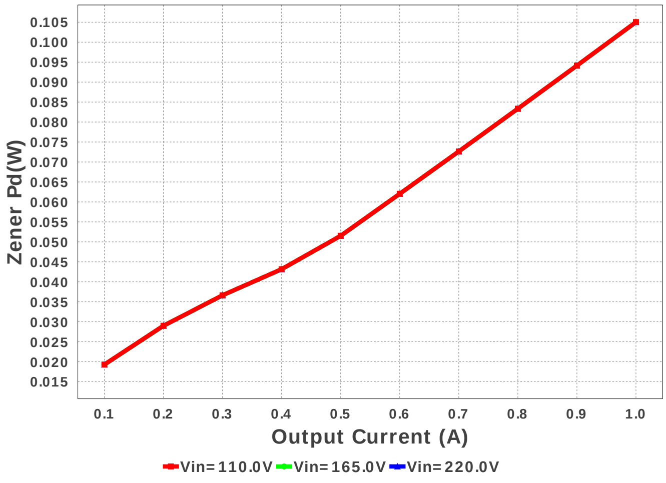
Vout p-p



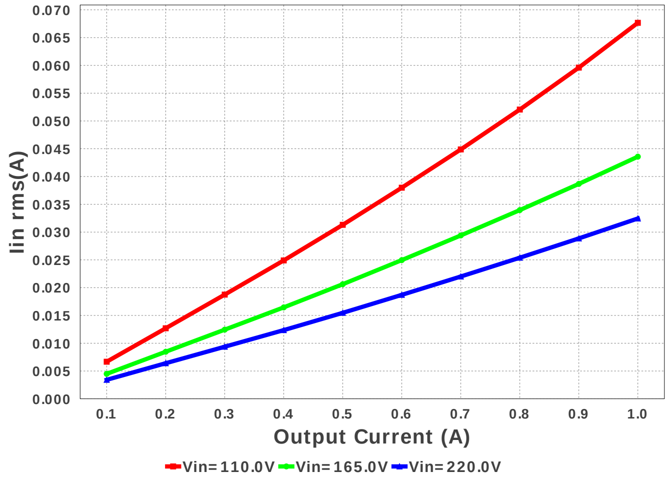
T1 Iprim RMS

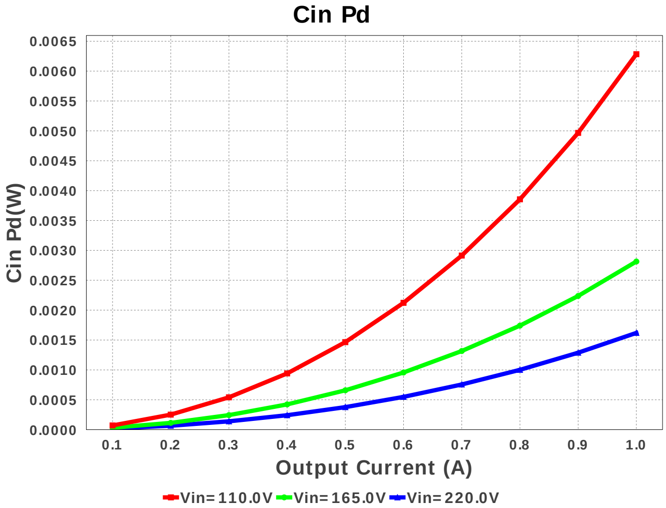


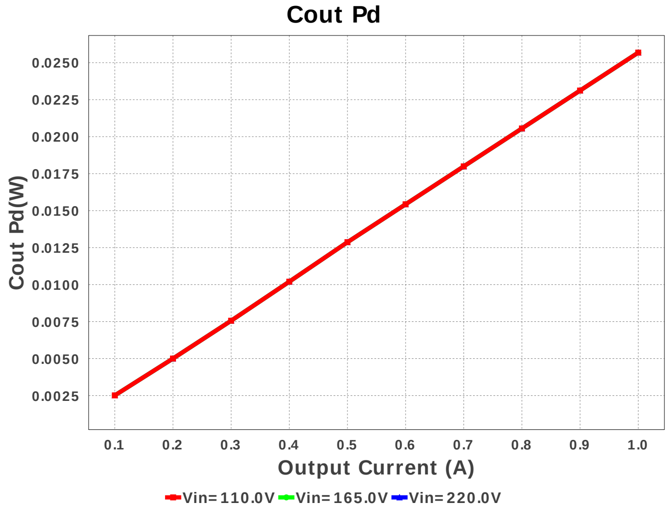
Zener Pd

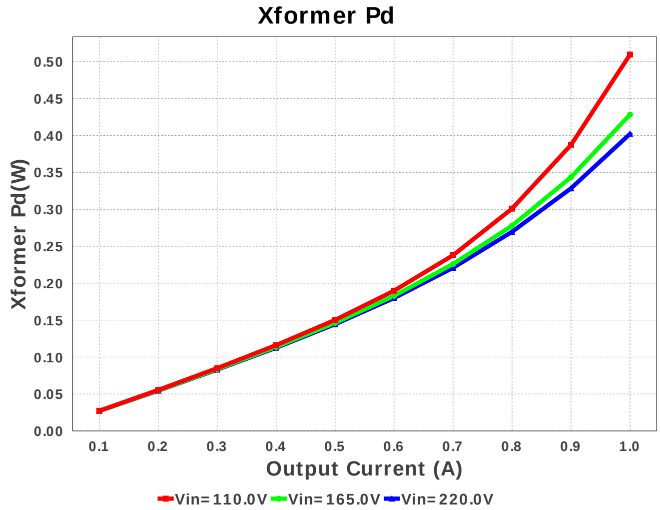


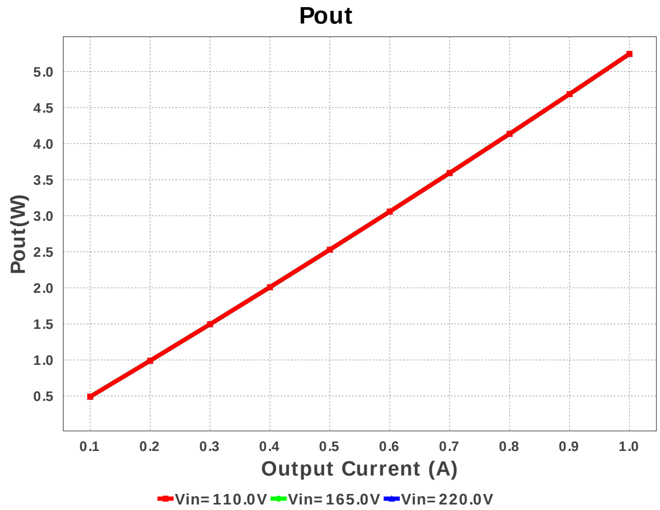
Iin rms

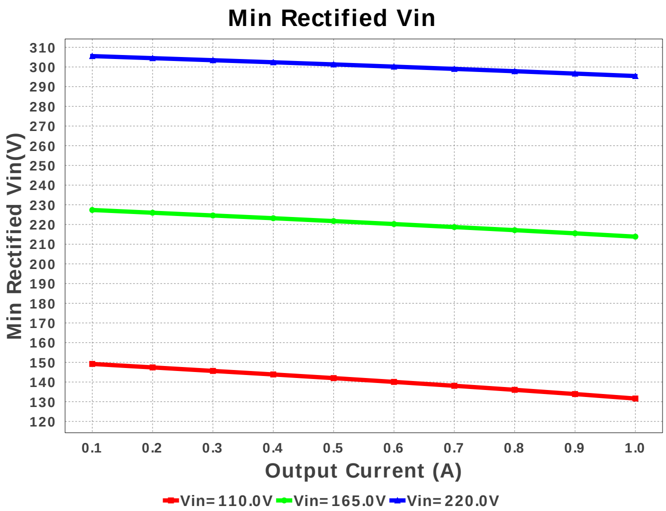


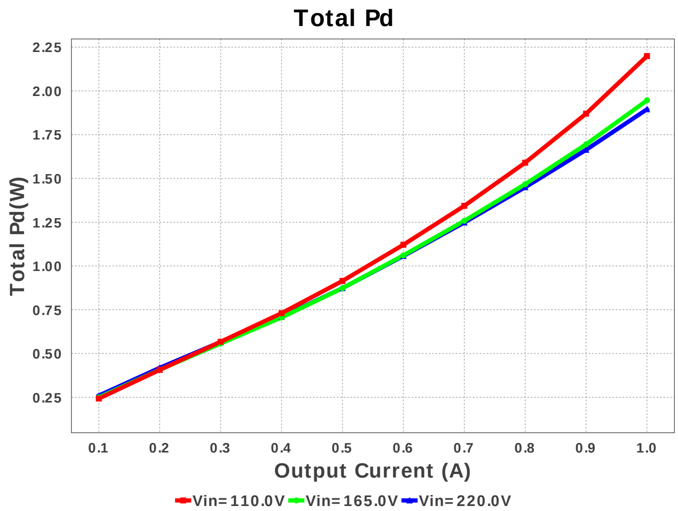

Cin Pd
Cin Pd(W)
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

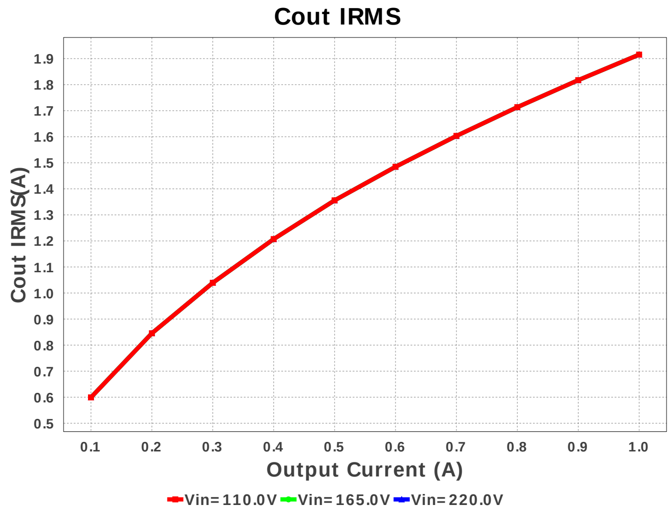

Cout Pd
Cout Pd(W)
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

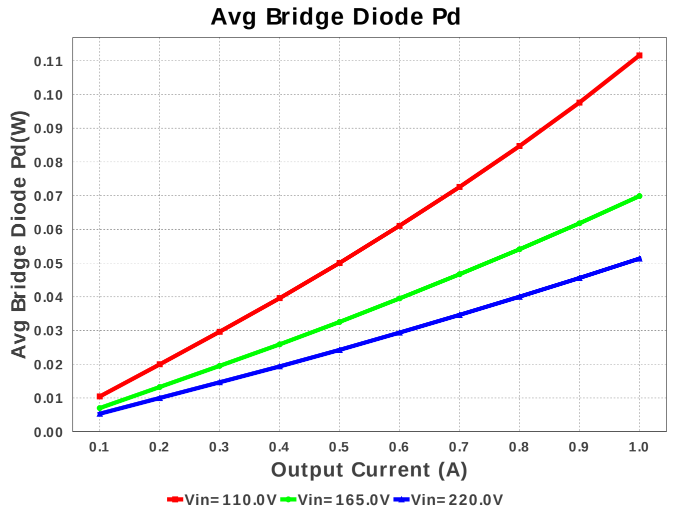

Xformer Pd
Xformer Pd(W)
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

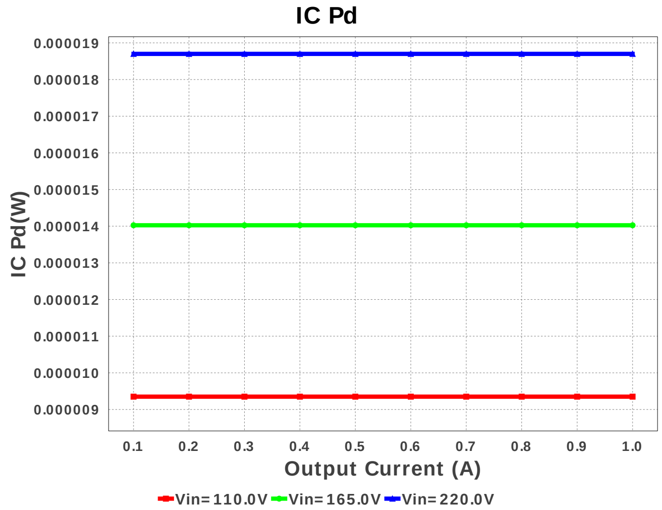

Pout
Pout(W)
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

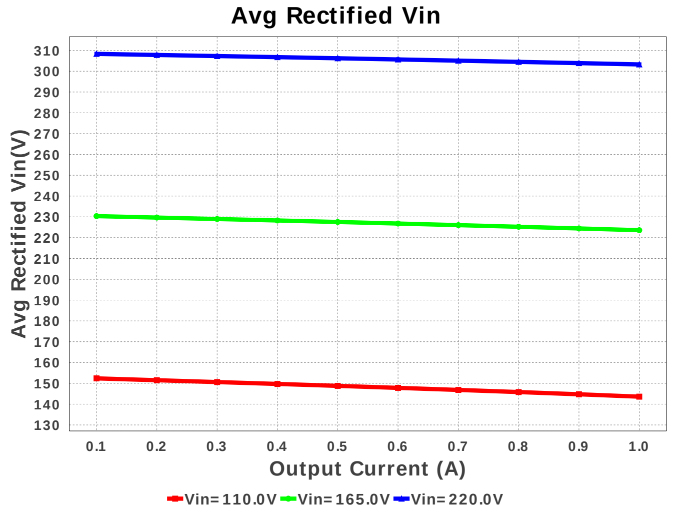

Min Rectified Vin
Min Rectified Vin(V)
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

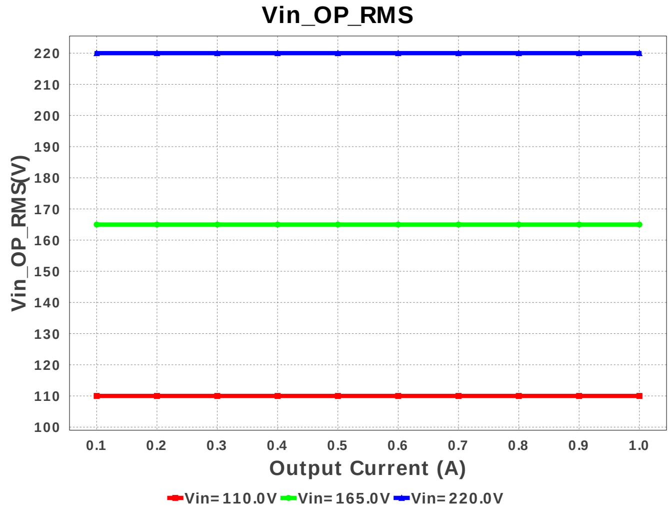

Total Pd
Total Pd(W)
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

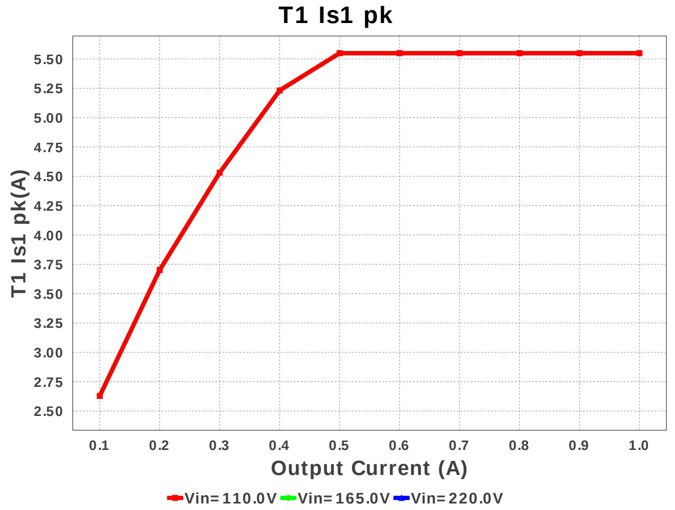

Cout IRMS
Cout IRMS(A)
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

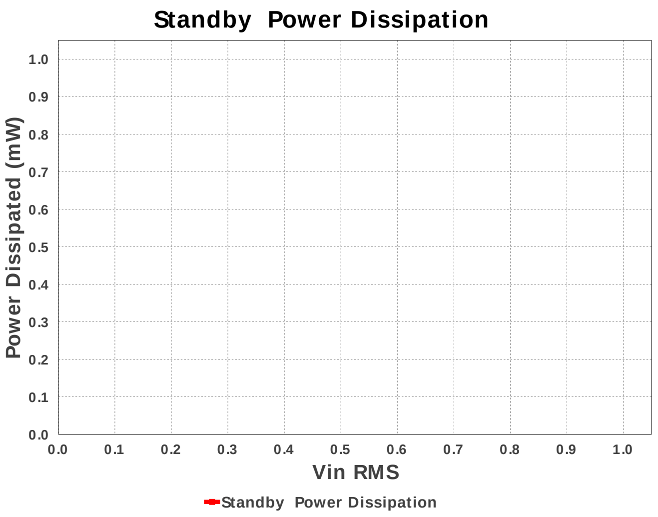

Avg Bridge Diode Pd
Avg Bridge Diode Pd(W)
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V

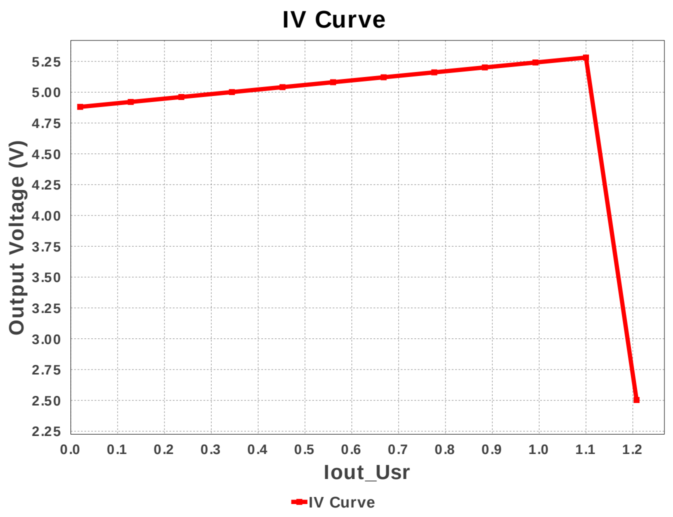

IC Pd
IC Pd(W)
0.000019
0.000018
0.000017
0.000016
0.000015
0.000014
0.000013
0.000012
0.000011
0.000010
0.000009
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V


Avg Rectified Vin
Avg Rectified Vin(V)
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V


Vin_OP_RMS
Vin_OP_RMS(V)
220
210
200
190
180
170
160
150
140
130
120
110
100
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V


T1 Is1 pk
T1 Is1 pk(A)
5.50
5.25
5.00
4.75
4.50
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
Output Current (A)
Vin= 110.0V Vin= 165.0V Vin= 220.0V





Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	22.076 mA	Current	Input capacitor RMS ripple current
2.	Cin2 IRMS	121.388 mA	Current	Input Capacitor Cin2 RMS Ripple Current
3.	Cout IRMS	1.923 A	Current	Output capacitor RMS ripple current
4.	Iin rms	30.316 mA	Current	RMS Input Current
5.	Q1 Irms	789.915 mA	Current	Q1 RMS current
6.	T1 Iprim RMS	67.473 mA	Current	Transformer Primary RMS Current
7.	T1 Iprim pk	298.851 mA	Current	Transformer Primary Peak Current
8.	T1 Is1 RMS	1.934 A	Current	Transformer Secondary1 RMS Current
9.	T1 Is1 pk	5.596 A	Current	Transformer Secondary1 Peak Current
10.	Avg Rectified Vin	303.714 V	General	Average Rectified Voltage for the AC Line Period
11.	BOM Count	24	General	Total Design BOM count
12.	FootPrint	905.0 mm^2	General	Total Foot Print Area of BOM components
13.	Mode	DCM	General	Conduction Mode
14.	Pout	5.369 W	General	Total output power
15.	Total BOM	$0.0	General	Total BOM Cost
16.	Q1 Tj	33.627 degC	Op_Point	Q1 Junction Temperature
17.	Vout Actual	17.774 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
18.	Vout OP	5.369 V	Op_Point	Operational Output Voltage
19.	Duty Cycle	15.292 %	Op_point	Duty cycle
20.	Efficiency	80.499 %	Op_point	Steady state efficiency
21.	Frequency_	59.958 kHz	Op_point	Switching frequency
22.	IC Tj	30.001 degC	Op_point	IC junction temperature
23.	ICThetaJA	70.0 degC/W	Op_point	IC junction-to-ambient thermal resistance
24.	IOUT_OP	1.0 A	Op_point	Iout operating point
25.	Min Rectified Vin	296.304 V	Op_point	Minimum voltage seen at rectified input
26.	Peak Rectified Vin	311.124 V	Op_point	Peak voltage seen at rectified input
27.	Vin_OP_RMS	220.0 V	Op_point	AC Input RMS Voltage
28.	Vout p-p	39.17 mV	Op_point	Peak-to-peak output ripple voltage
29.	Avg Bridge Diode Pd	29.186 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
30.	Cin Pd	1.413 mW	Power	Input capacitor power dissipation
31.	Cout Pd	25.893 mW	Power	Output capacitor power dissipation
32.	Diode2 Pd	376.286 mW	Power	Diode2 power dissipation
33.	IC Pd	9.35 μW	Power	IC power dissipation
34.	Q1 Pd	431.117 mW	Power	Q1 Power Dissipation
35.	Total Pd	1.301 W	Power	Total Power Dissipation
36.	Xformer Pd	310.246 mW	Power	Transformer power dissipation
37.	Zener Pd	27.812 mW	Power	Zener power dissipation
38.	Vout Tolerance	1.76 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	1.0	Maximum Output Current
2.	VinMax	220.0	Maximum input voltage
3.	VinMin	110.0	Minimum input voltage
4.	Vout	5.0	Output Voltage
5.	acFrequency	60.0	Light Output in Lumen
6.	base_pn	UCC28720	Texas Instruments Base Part Number
7.	source	AC	Input Source Type
8.	ta	30.0	Ambient temperature

Design Assistance

1. Application Hints 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. Rcbc Rcbc is used to set the amount of output voltage compensation to offset cable resistance. Connecting this resistor from the CBC pin to GND will program a current that is summed into the VS feedback divider, increasing the regulation voltage as Iout increases. 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. Part Description The UCC28700 family of flyback power supply controllers 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/ucc28720.pdf

2. UCC28720 Product Folder : http://www.ti.com/product/UCC28720 : contains the data sheet and other resources.