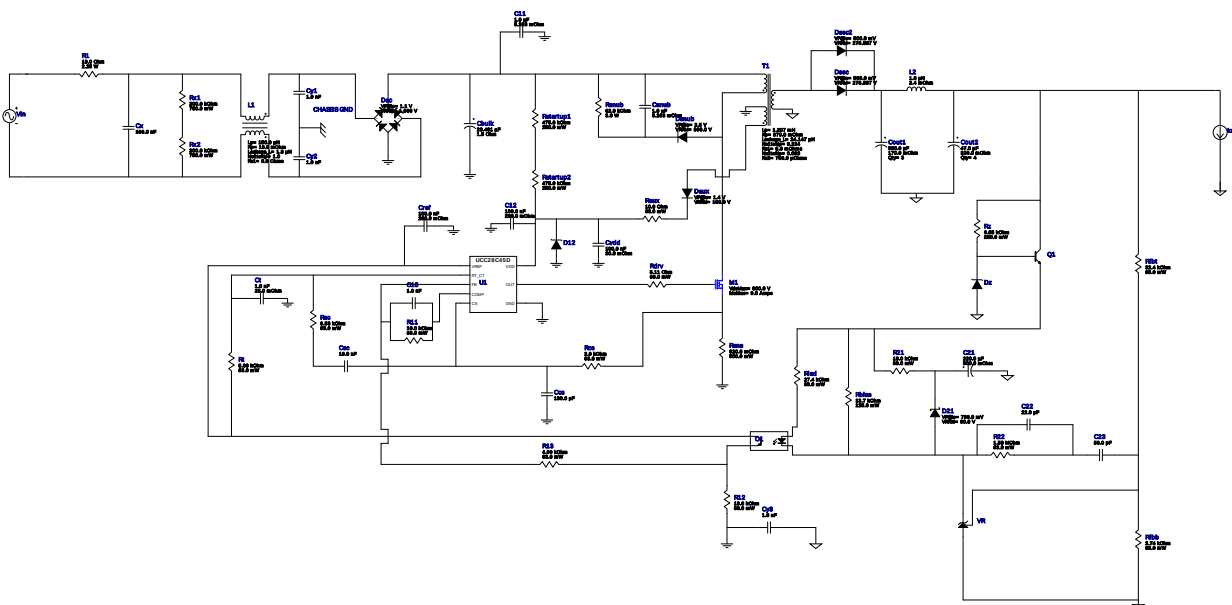


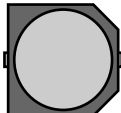
WEBENCH® Design Report

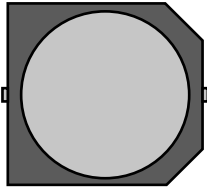
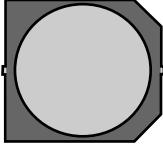
Design : 4738744/12 UCC28C45DR
UCC28C45DR 220.0V-250.0V to 32.00V @ 2.0A

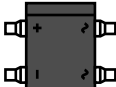
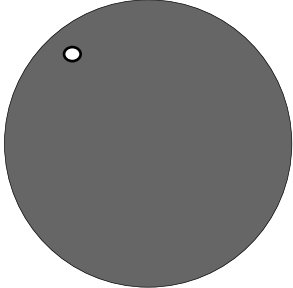


1. The EMI filter selected here contains the estimated values. The real numbers will depend on the attenuation needed at a particular frequency.

Electrical BOM

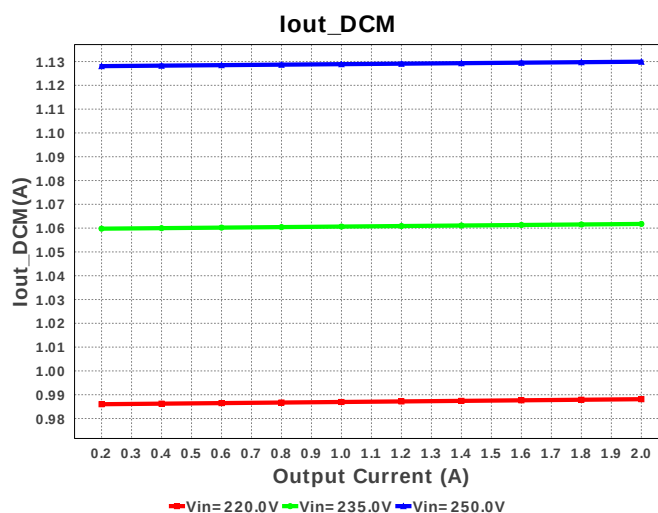
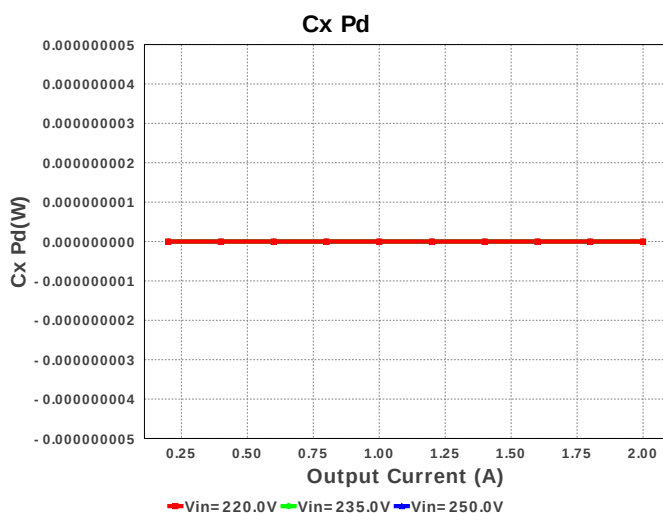
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	C11	TDK	C5750X6S2W105K Series= X6S	Cap= 1.0 uF ESR= 5.263 mOhm VDC= 400.0 V IRMS= 0.0 A	1	\$1.19	 2220 54 mm ²
2.	C12	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²
3.	C13	Samsung Electro-Mechanics	CL21C102JBCNFNC Series= C0G/NP0	Cap= 1.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²
4.	C21	Chemi-Con	EMVY500ADA221MJA0G Series= MVY	Cap= 220.0 uF ESR= 300.0 mOhm VDC= 50.0 V IRMS= 500.0 mA	1	\$0.28	 CAPSMT_62_JA0 151 mm ²
5.	C22	Kemet	C0805C220K3GACTU Series= C0G/NP0	Cap= 22.0 pF VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²
6.	C23	Yageo America	CC0805JRNPO9BN560 Series= C0G/NP0	Cap= 56.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²
7.	Cbulk	CUSTOM	CUSTOM Series= ?	Cap= 28.481 uF ESR= 1.5005 Ohm VDC= 424.26 V IRMS= 705.91 mA	1	NA	CUSTOM 0 mm ²
8.	Ccs	Kemet	C0805C181K5GACTU Series= C0G/NP0	Cap= 180.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²

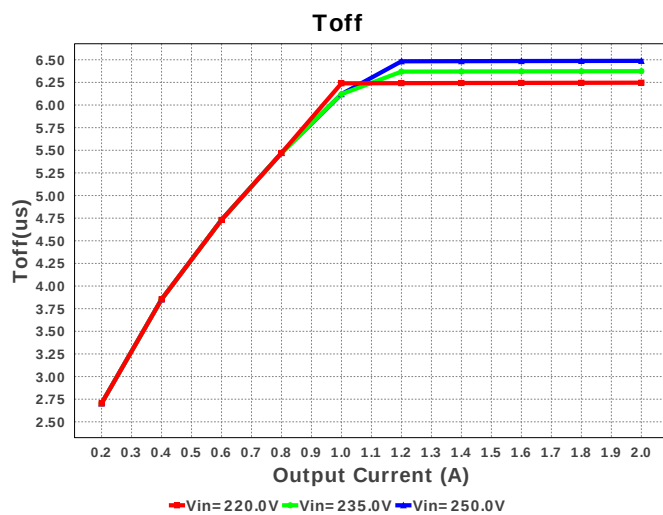
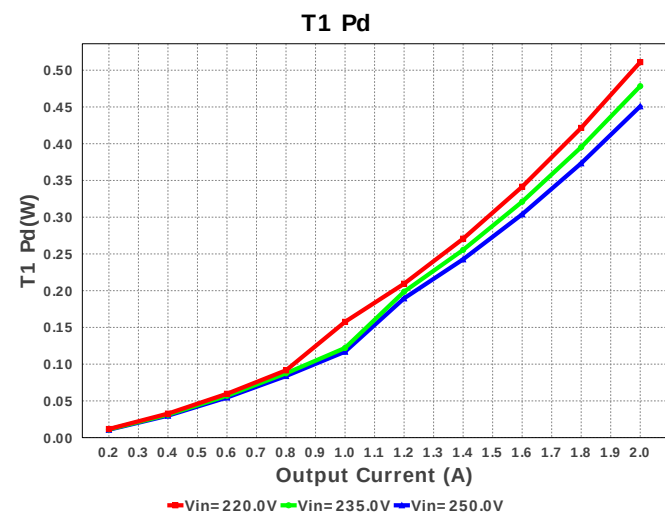
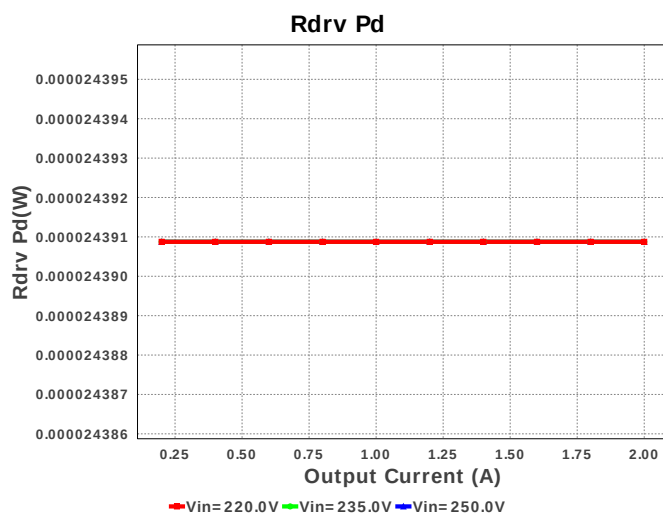
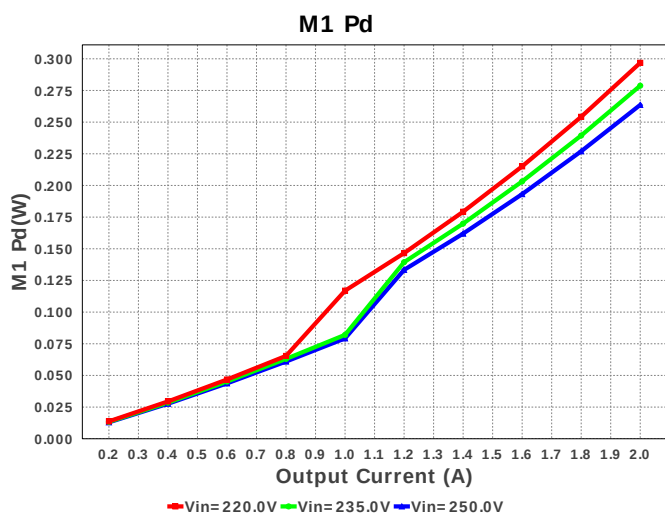
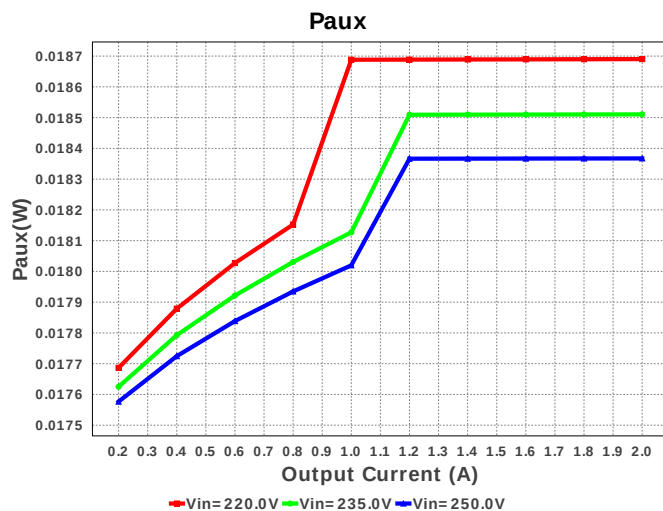
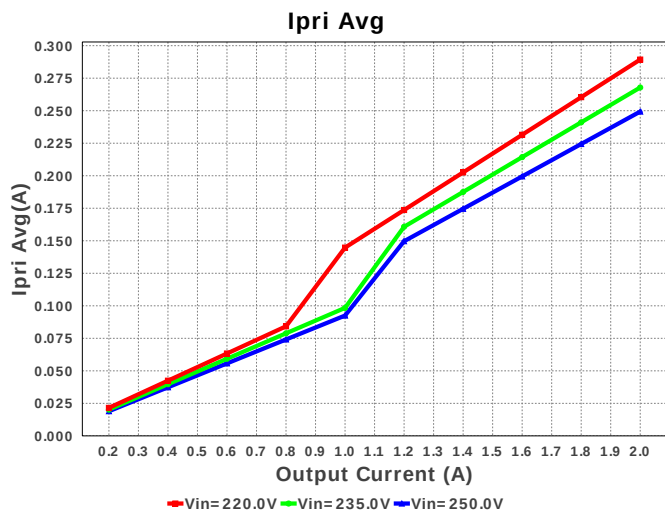
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	Cout1	Panasonic	EEV-FK1K331M Series= FK	Cap= 330.0 uF ESR= 170.0 mOhm VDC= 80.0 V IRMS= 793.0 mA	3	\$0.78	 SM_RADIAL_J16 399 mm ²
10.	Cout2	Panasonic	EEV-FK2A470Q Series= FK	Cap= 47.0 uF ESR= 320.0 mOhm VDC= 100.0 V IRMS= 500.0 mA	4	\$0.51	 SM_RADIAL_H13 264 mm ²
11.	Cref	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²
12.	Csc	MuRata	GRM216R71H103KA01D Series= X7R	Cap= 10.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²
13.	Csnub	TDK	C5750X6S2W105K Series= X6S	Cap= 1.0 uF ESR= 5.263 mOhm VDC= 400.0 V IRMS= 0.0 A	1	\$1.19	 2220 54 mm ²
14.	Ct	Kemet	C0805C102J5GACTU Series= C0G/NP0	Cap= 1.0 nF ESR= 25.0 mOhm VDC= 50.0 V IRMS= 1.71 A	1	\$0.01	 0805 7 mm ²
15.	Cvdd	MuRata	GRM188R71E104KA01D Series= X7R	Cap= 100.0 nF ESR= 30.0 mOhm VDC= 25.0 V IRMS= 1.51 A	1	\$0.01	 0603 5 mm ²
16.	Cx	TDK	B32913A5104M000 Series= 2231	Cap= 100.0 nF VDC= 1000.0 V IRMS= 0.0 A	1	\$0.46	 B32913_2650x600x1500 228 mm ²
17.	Cy1	TDK	B81123C1102M Series= B81123	Cap= 1.0 nF VDC= 3.0 kV IRMS= 0.0 A	1	\$0.22	 B81123_1800x500x1050 140 mm ²
18.	Cy2	TDK	B81123C1102M Series= B81123	Cap= 1.0 nF VDC= 3.0 kV IRMS= 0.0 A	1	\$0.22	 B81123_1800x500x1050 140 mm ²

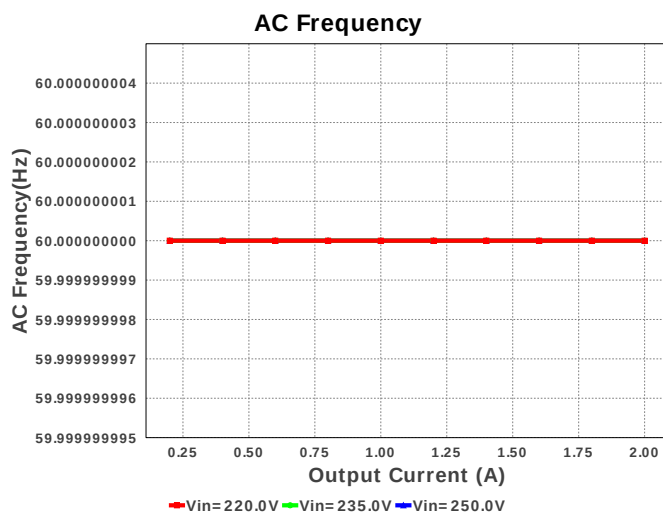
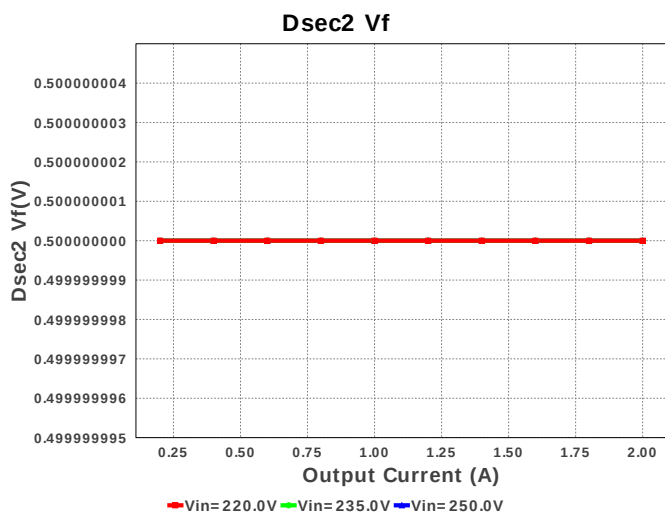
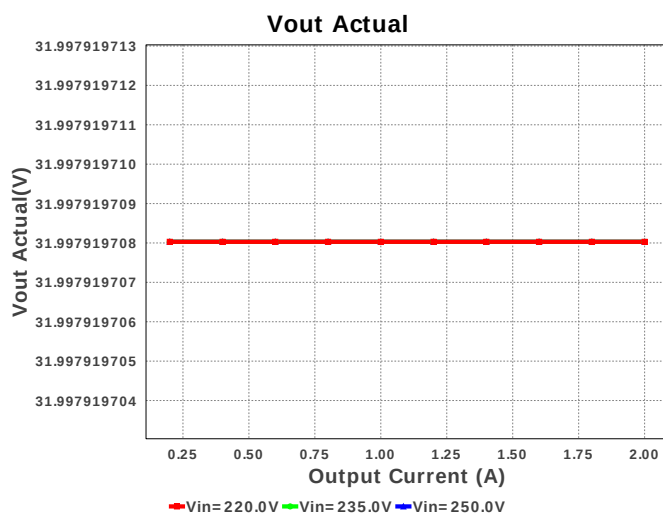
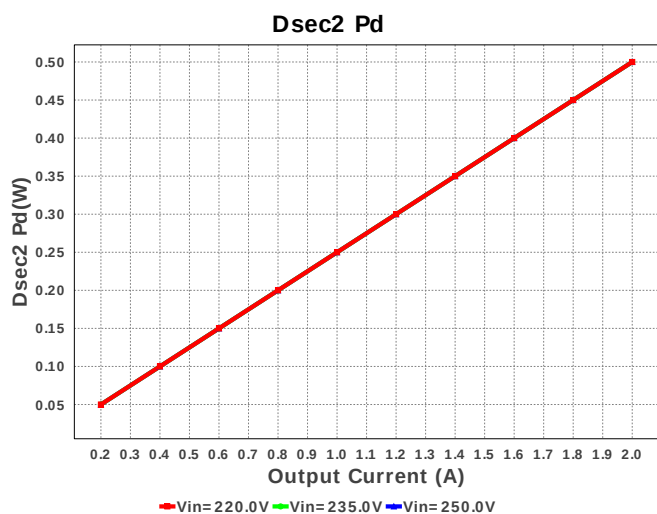
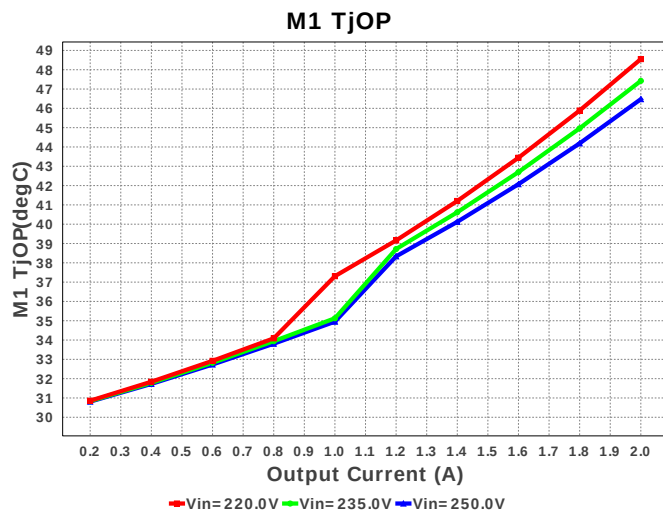
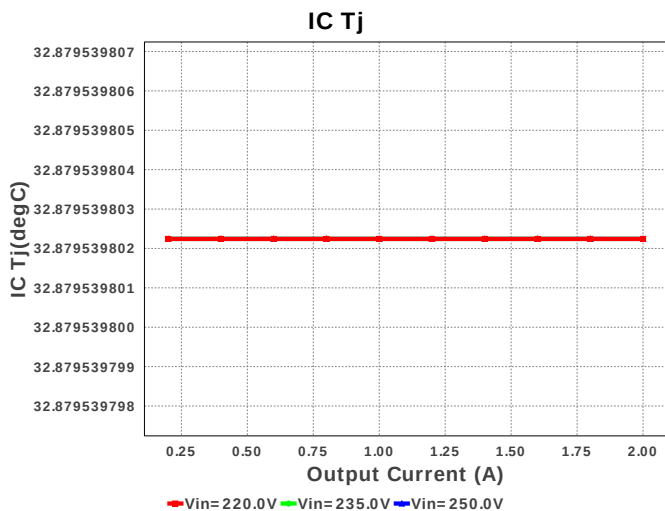
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
19.	Cy3	TDK	B81123C1102M Series= B81123	Cap= 1.0 nF VDC= 3.0 kV IRMS= 0.0 A	1	\$0.22	 B81123_1800x500x1050 140 mm ²
20.	D12	Diodes Inc.	MMSZ5248B-7-F	Zener	1	\$0.04	 SOD-123 13 mm ²
21.	D21	Diodes Inc.	B260A-13-F	VF@Io= 700.0 mV VRRM= 60.0 V	1	\$0.09	 SMA 37 mm ²
22.	Dac	Vishay-Semiconductor	DF10SA	VF@Io= 1.1 V VRRM= 1,000.0 V	1	\$0.24	 DF-S 99 mm ²
23.	Daux	NXP Semiconductor	BAS316,115	VF@Io= 1.4 V VRRM= 100.0 V	1	\$0.02	 SOD-323 9 mm ²
24.	Dsec	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 278.387 V	1	NA	CUSTOM 0 mm ²
25.	Dsec2	CUSTOM	CUSTOM	VF@Io= 500.0 mV VRRM= 278.387 V	1	NA	CUSTOM 0 mm ²
26.	Dsnub	Bourns	CD1408-FU1800	VF@Io= 2.5 V VRRM= 800.0 V	1	\$0.13	 Diode_1408 13 mm ²
27.	Dz	Diodes Inc.	MMSZ5250B-7-F	Zener	1	\$0.03	 SOD-123 13 mm ²
28.	L1	API Delevan	CM6296R-154	Lp= 150.0 µH Rp= 16.0 mOhm Leakage_L= 1.8 µH Ns1toNp= 1.0 Rs1= 0.0 Ohms	1	\$5.95	 CM6296 833 mm ²
29.	L2	Coilcraft	SER1360-182KLB	L= 1.8 µH DCR= 2.4 mOhm	1	\$0.72	 SER1360 225 mm ²
30.	M1	STMicroelectronics	STF10N80K5	VdsMax= 800.0 V IdsMax= 9.0 Amps	1	\$2.52	 TO-220FP 79 mm ²
31.	O1	Vishay-Semiconductor	TCMT1107	Optocoupler	1	\$0.21	 SOP-4 44 mm ²
32.	Q1	ON Semiconductor	BC846BLT1G	Bipolar Transistor	1	\$0.02	 SOT-23 14 mm ²
33.	R1	Vishay-Dale	AC03000001009JACCS Series= F_RES	Res= 10.0 Ohm Power= 2.25 W Tolerance= 5.0%	1	\$0.30	 AC03 158 mm ²

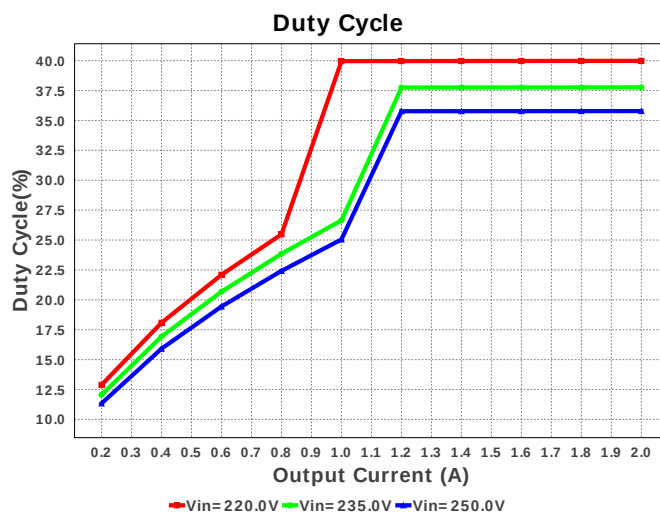
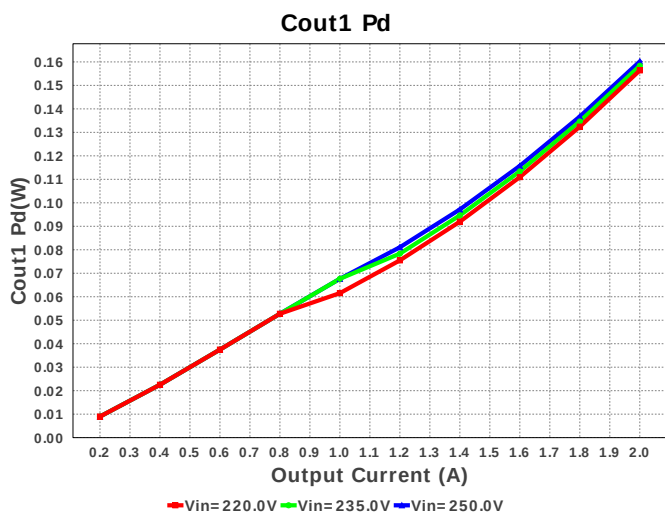
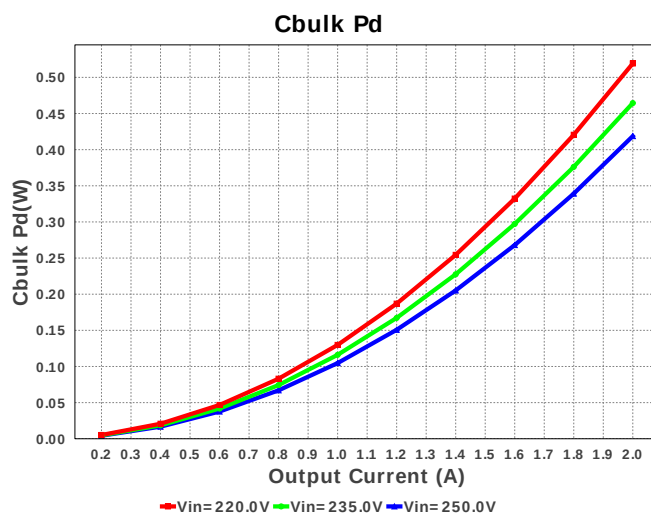
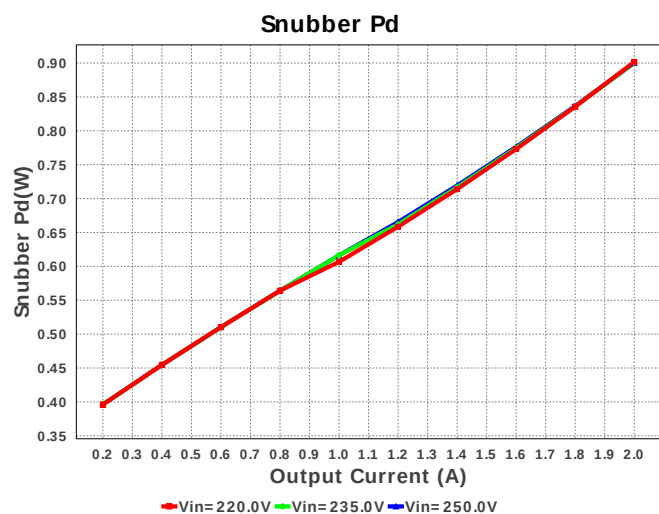
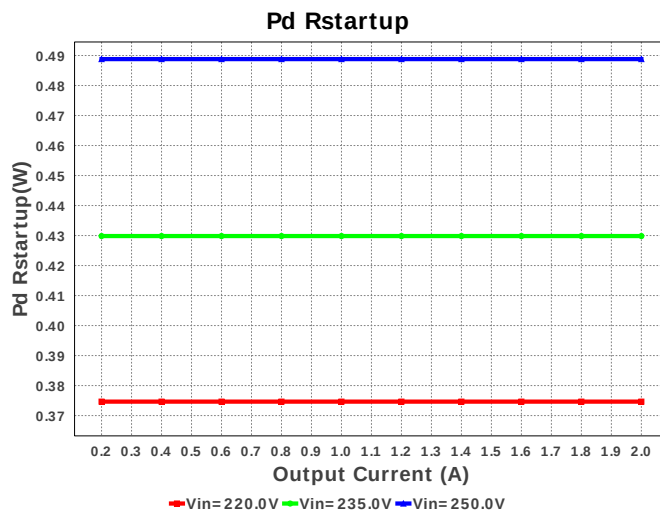
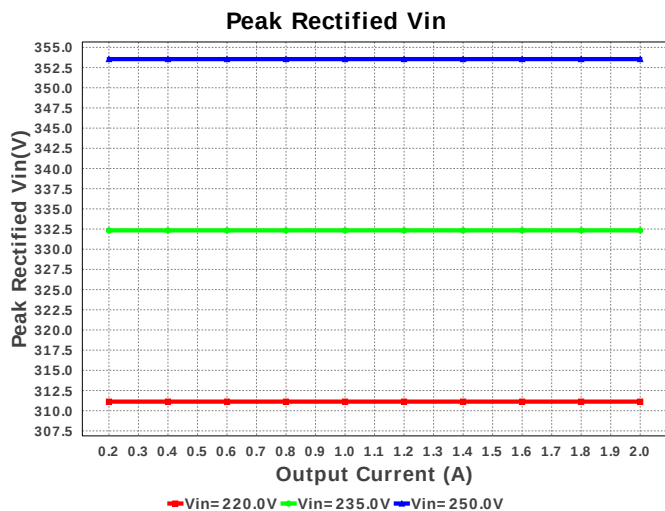
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
34.	R11	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
35.	R12	Vishay-Dale	CRCW040219K6FKED Series= CRCW..e3	Res= 19.6 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
36.	R13	Vishay-Dale	CRCW04024K99FKED Series= CRCW..e3	Res= 4.99 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
37.	R21	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
38.	R22	Vishay-Dale	CRCW04021M58FKED Series= CRCW..e3	Res= 1.58 MOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
39.	Raux	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
40.	Rbias	Panasonic	ERJ-6ENF1372V Series= ERJ-6E	Res= 13.7 kOhm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 mm²
41.	Rcs	Vishay-Dale	CRCW04022K00FKED Series= CRCW..e3	Res= 2.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
42.	Rdrv	Vishay-Dale	CRCW04025R11FKED Series= CRCW..e3	Res= 5.11 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
43.	Rfbb	Vishay-Dale	CRCW04022K74FKED Series= CRCW..e3	Res= 2.74 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
44.	Rfbt	Vishay-Dale	CRCW040232K4FKED Series= CRCW..e3	Res= 32.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
45.	Rled	Vishay-Dale	CRCW040227K4FKED Series= CRCW..e3	Res= 27.4 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
46.	Rsc	Vishay-Dale	CRCW04029K53FKED Series= CRCW..e3	Res= 9.53 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
47.	Rsns	Rohm	MCR25JZHFLR620 Series= MCR25	Res= 620.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	\$0.03	 1210 15 mm²
48.	Rsub	Vishay-Bcomponents	PR03000206202JAC00 Series= ?	Res= 62.0 kOhm Power= 3.0 W Tolerance= 5.0%	1	\$0.19	 PR03 0 mm²
49.	Rstartup1	Panasonic	ERJ-8ENF4753V Series= ERJ-8E	Res= 475.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm²
50.	Rstartup2	Panasonic	ERJ-8ENF4753V Series= ERJ-8E	Res= 475.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm²
51.	Rt	Vishay-Dale	CRCW04028K66FKED Series= CRCW..e3	Res= 8.66 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
52.	Rx1	Vishay-Semiconductor	CRCW2010200KFKEF Series= ?	Res= 200.0 kOhm Power= 750.0 mW Tolerance= 1.0%	1	\$0.03	 2010 32 mm²
53.	Rx2	Vishay-Semiconductor	CRCW2010200KFKEF Series= ?	Res= 200.0 kOhm Power= 750.0 mW Tolerance= 1.0%	1	\$0.03	 2010 32 mm²

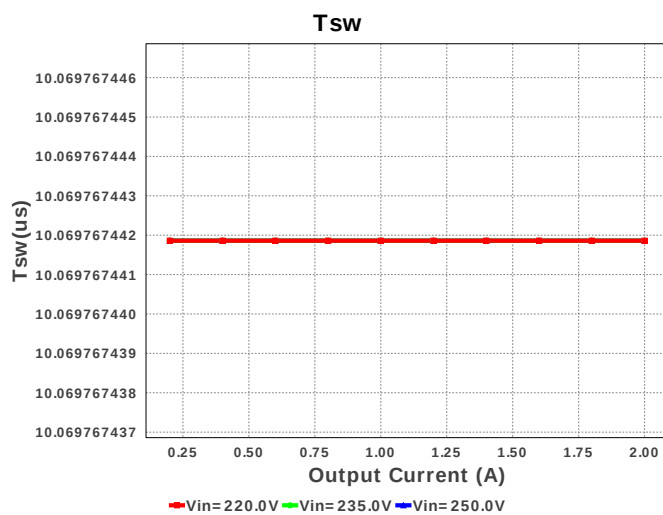
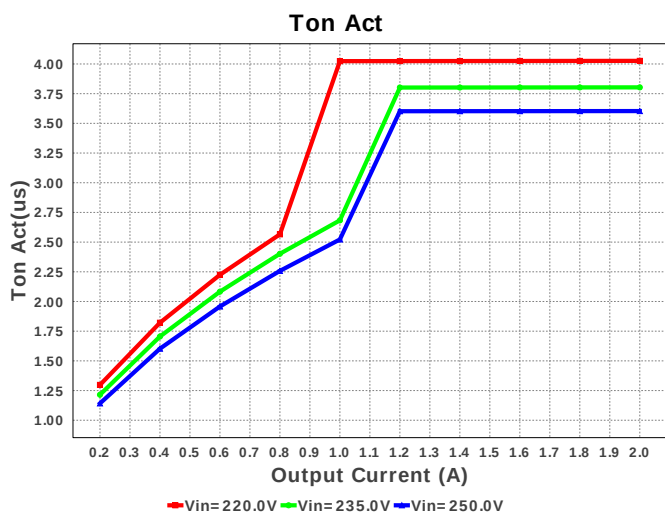
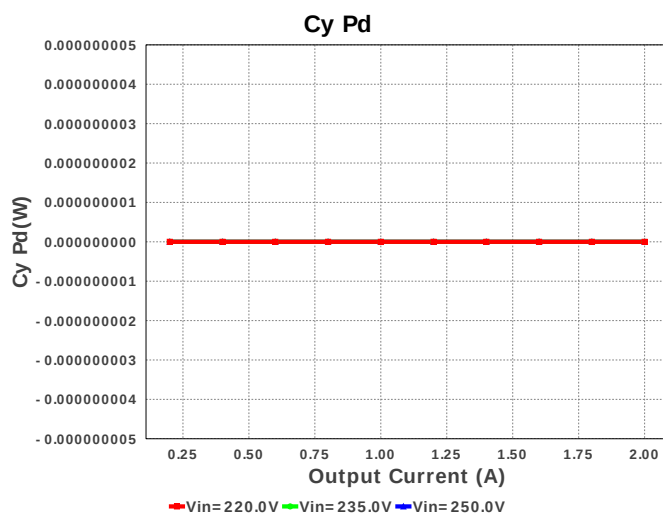
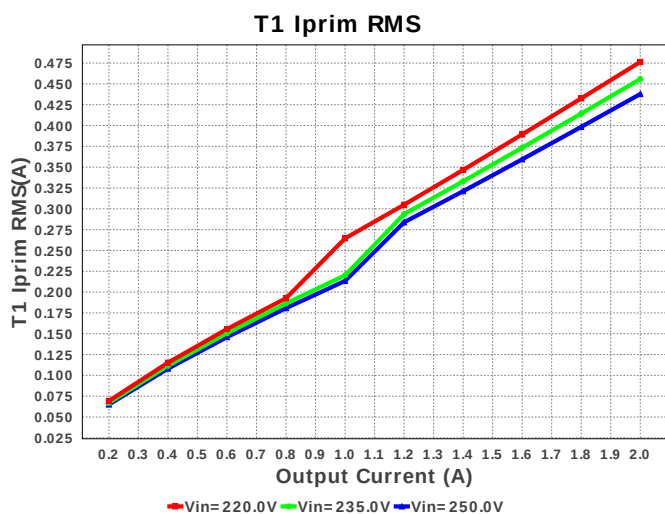
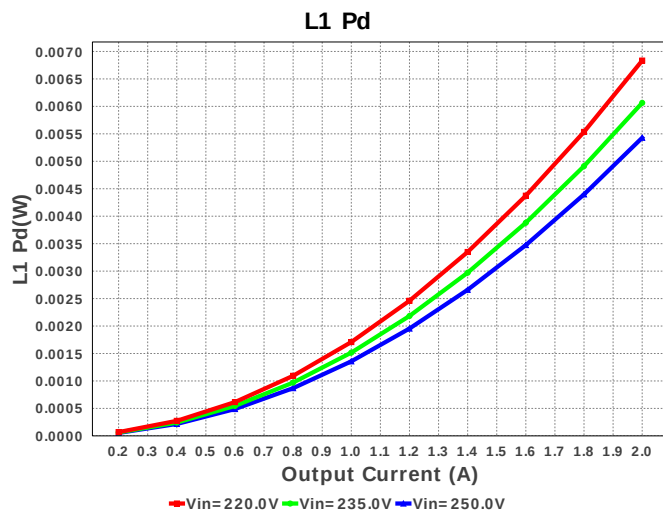
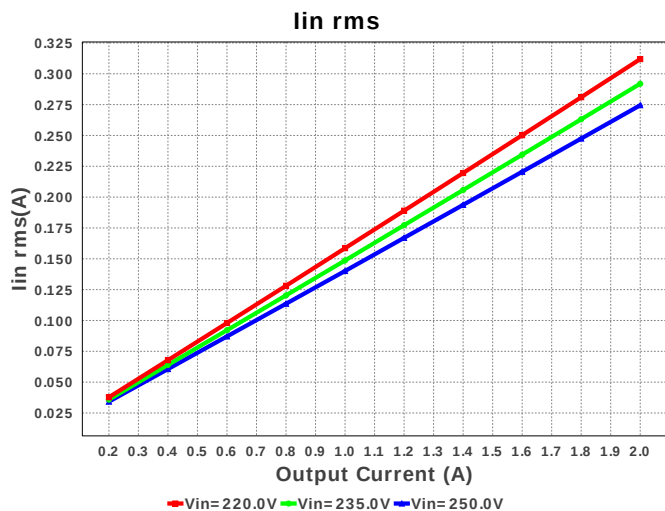
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
54.	Rz	Panasonic	ERJ-8ENF6651V Series= ERJ-8E	Res= 6.65 kOhm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm ²
55.	T1	CUSTOM	CUSTOM	Lp= 1.207 mH Rp= 870.0 mOhm Leakage_L= 24.147 μH Ns1toNp= 0.224 Rs1= 8.6 mOhms Ns2toNp= 0.083 Rs2= 700.0 μOhms	1	NA	CUSTOM 0 mm ²
56.	U1	Texas Instruments	UCC28C45DR	Switcher	1	\$0.60	
57.	VR	Texas Instruments	TL431AIDBVR	Voltage References	1	\$0.07	 D0008A 57 mm ² R-PDSO-G3 16 mm ²

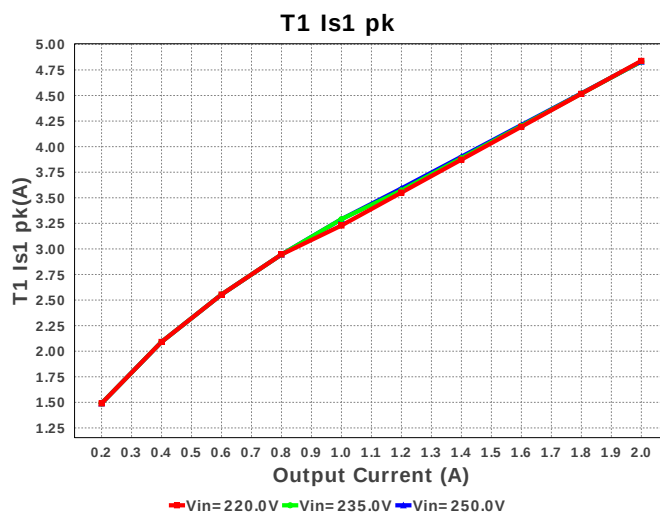
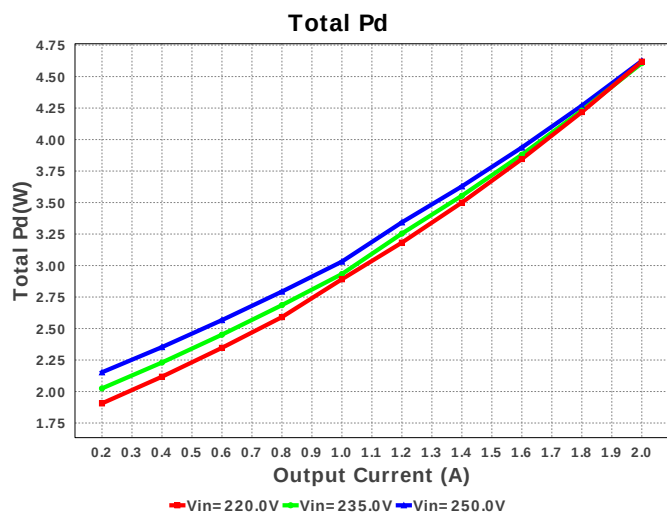
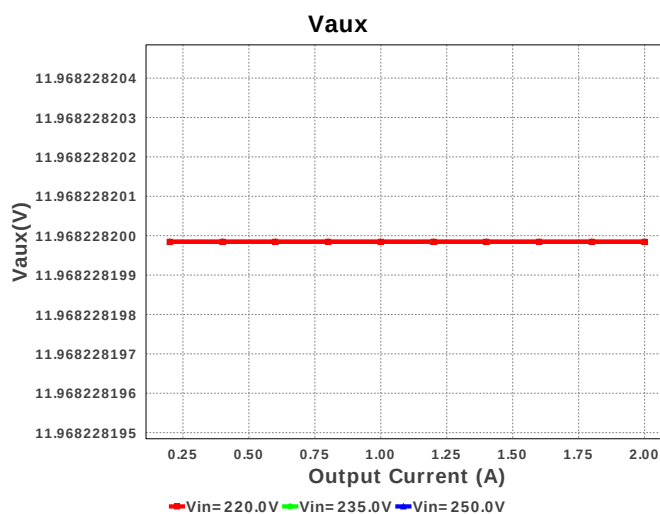
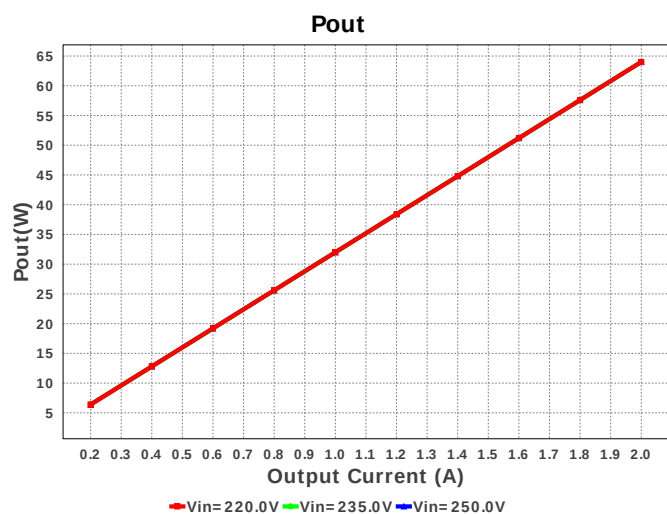
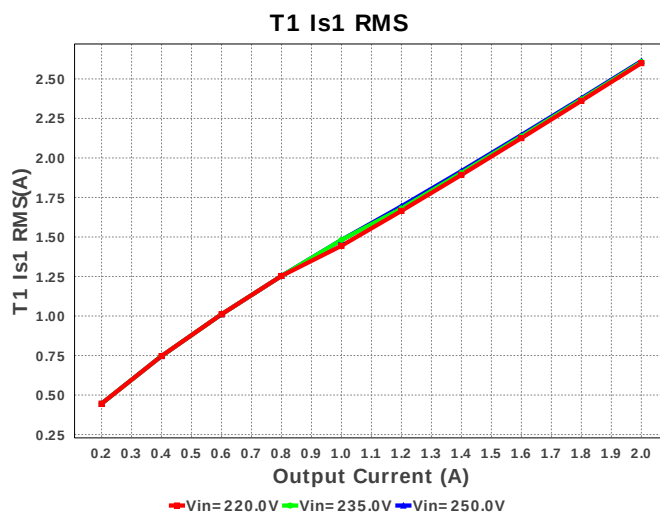
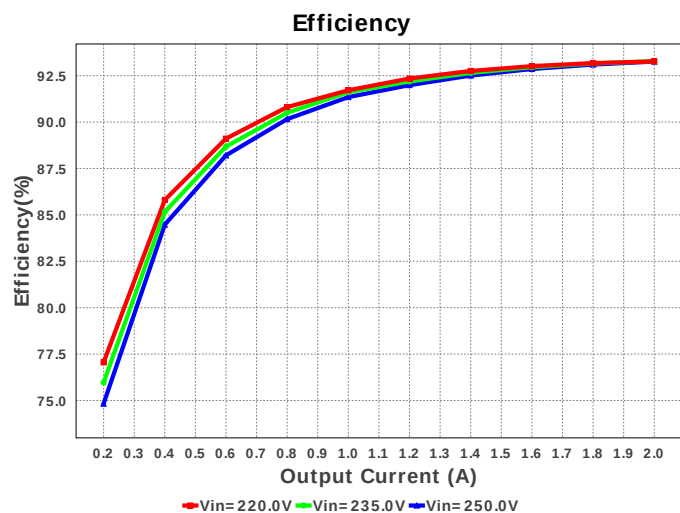


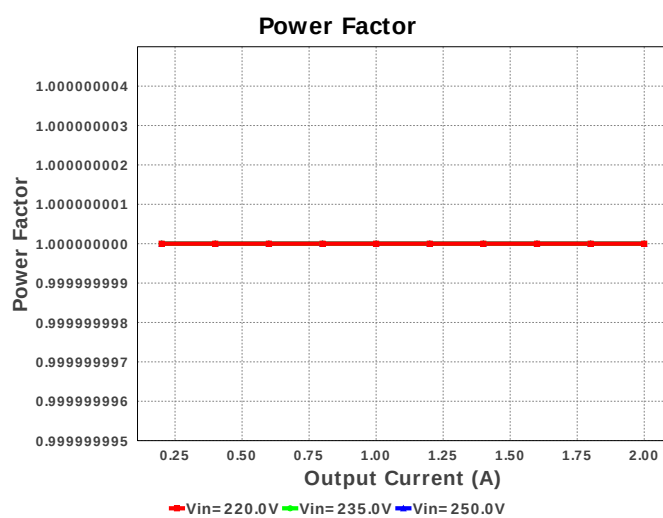
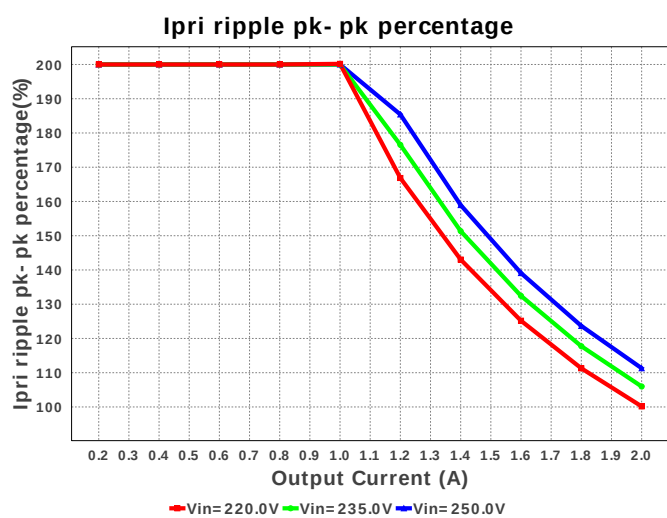
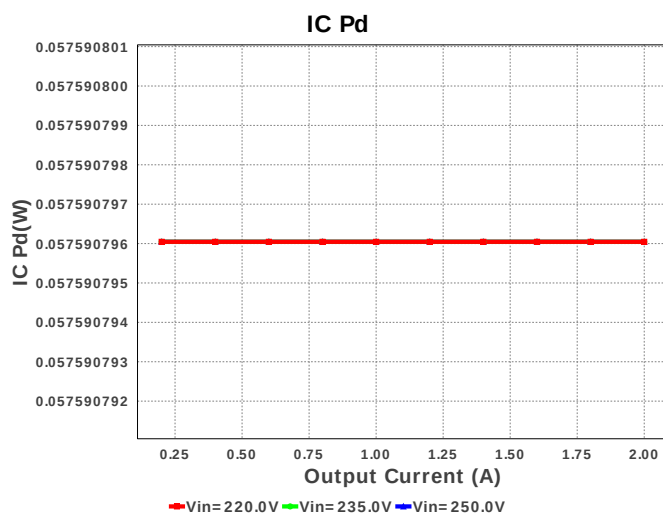
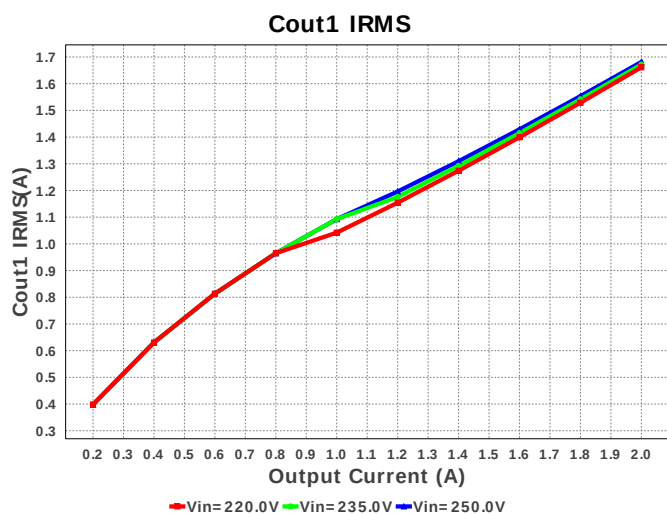
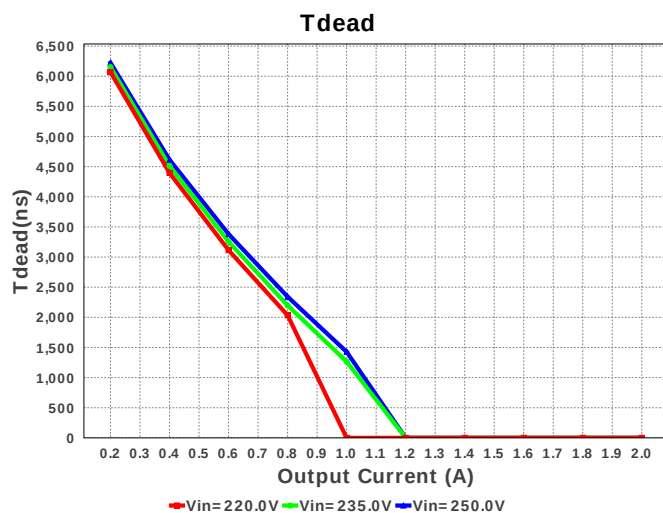
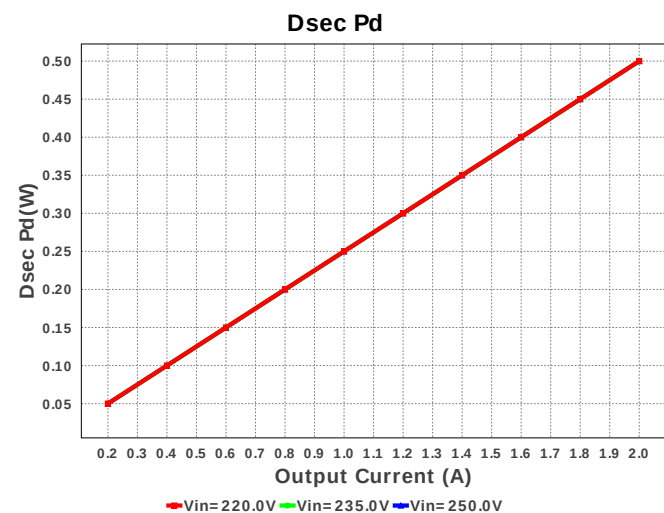


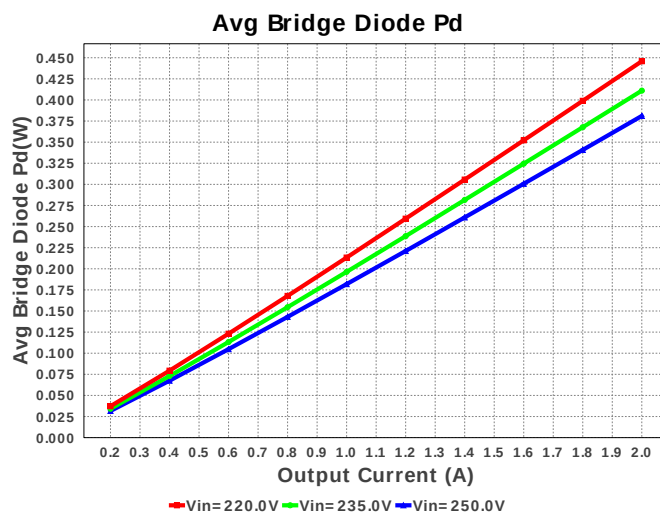
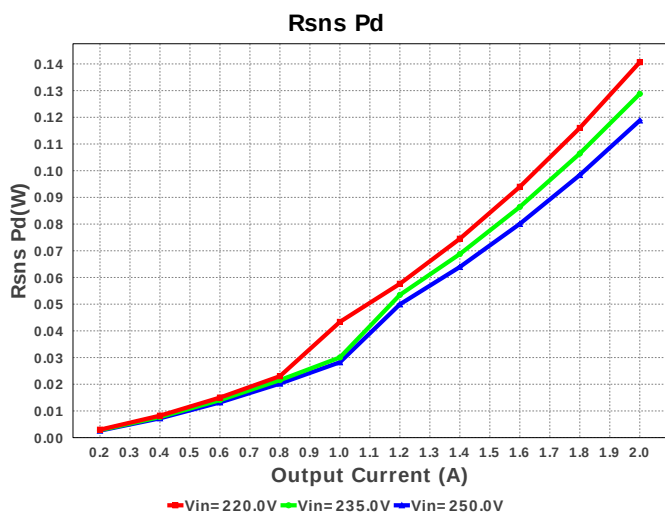
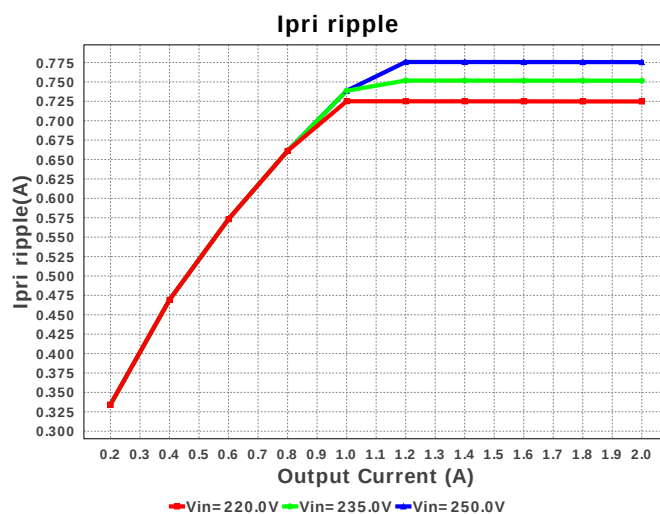
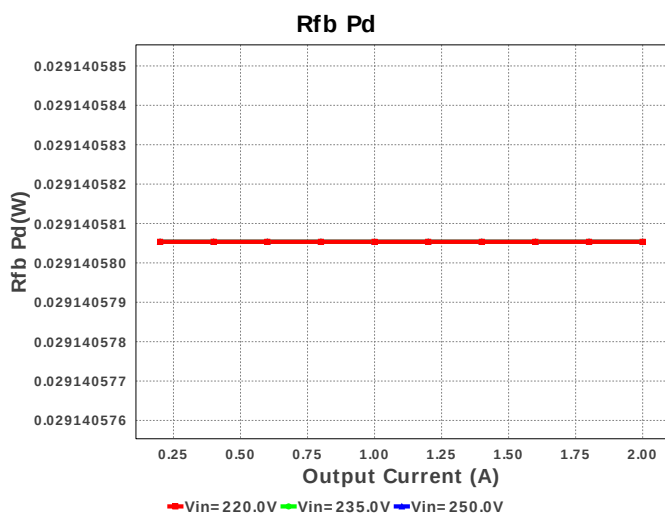
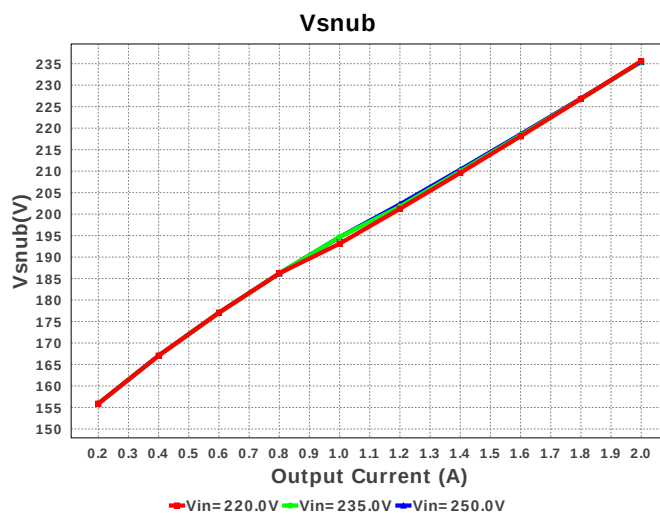
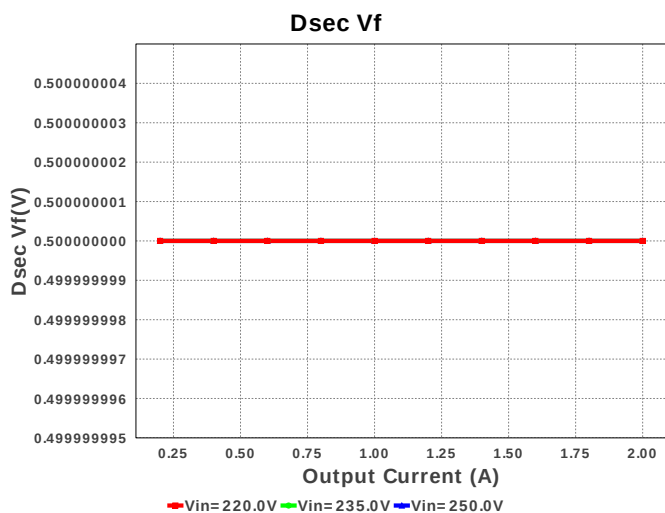


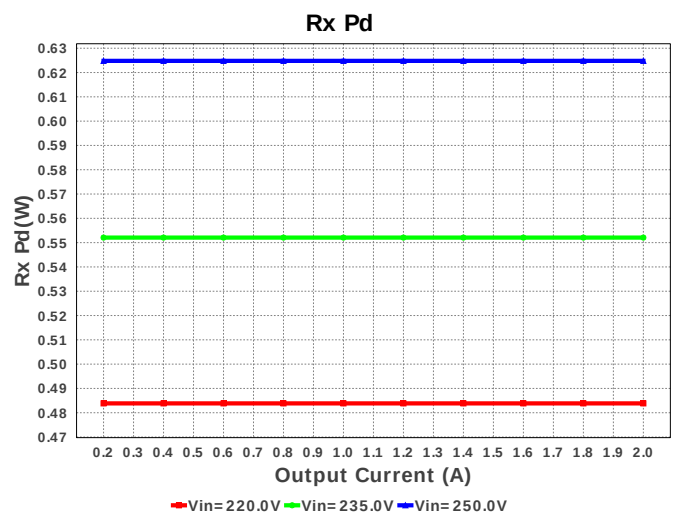
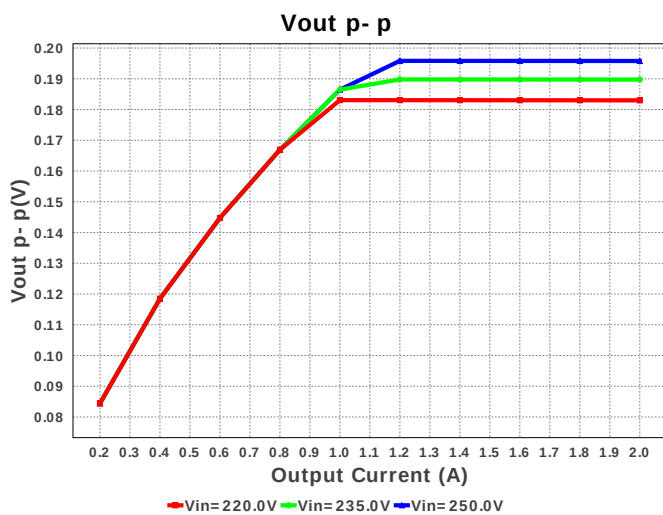
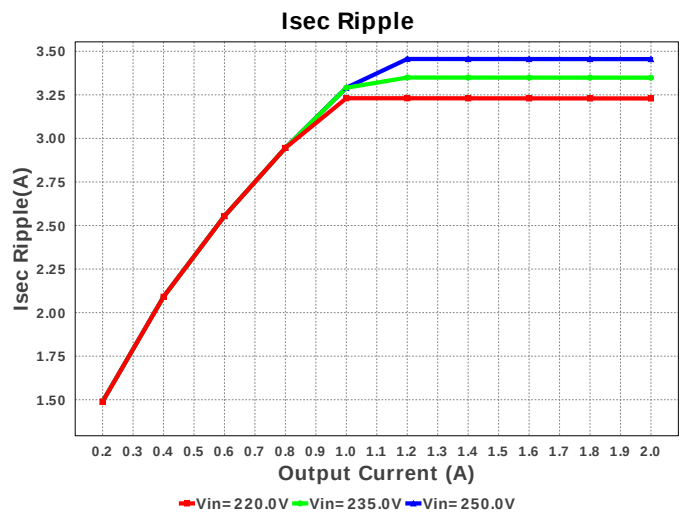
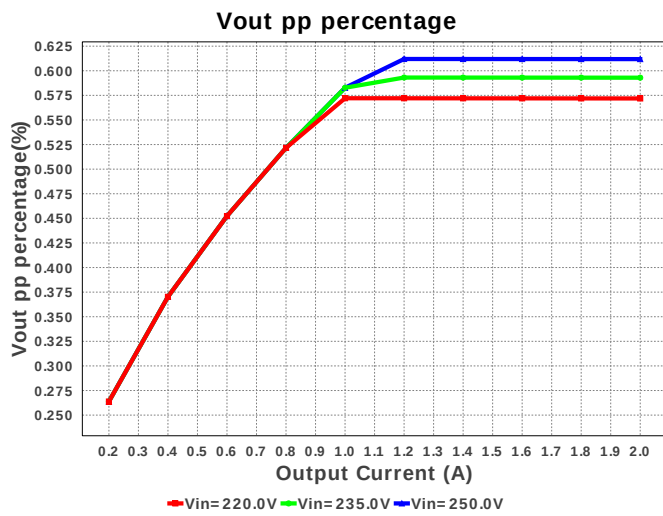
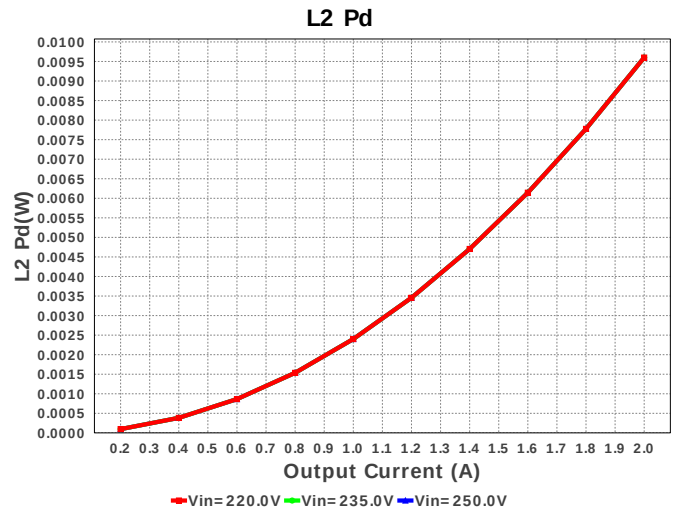
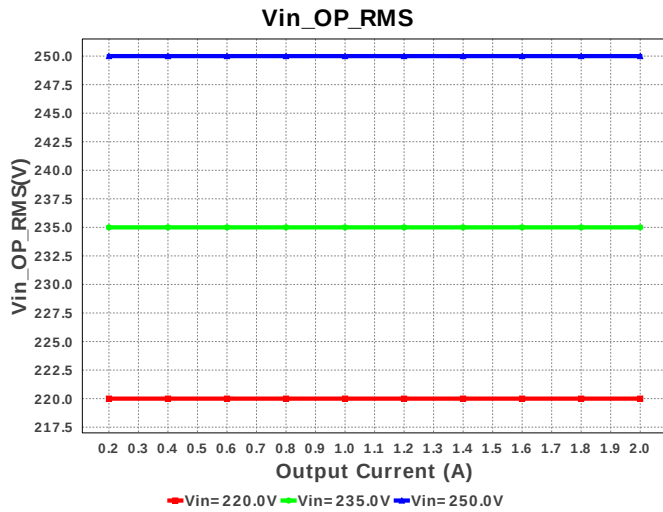


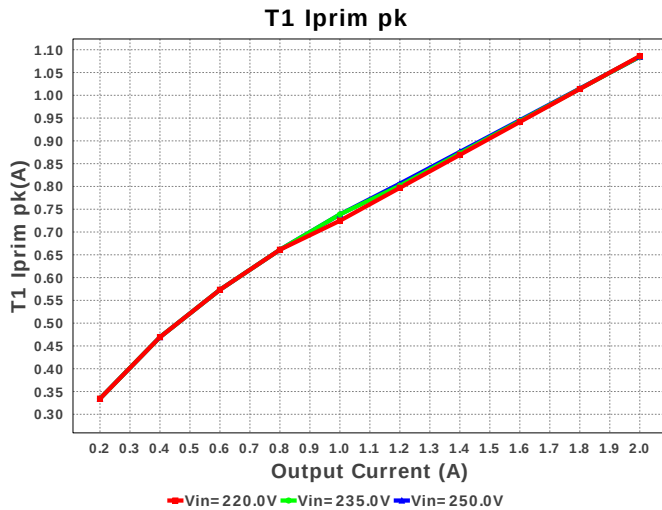












Operating Values

#	Name	Value	Category	Description
1.	Cout1 IRMS	1.661 A	Current	Output capacitor1 RMS ripple current
2.	Iin rms	311.9 mA	Current	RMS Input Current
3.	Iout_DCM	988.116 mA	Current	Approximate Current below which DCM mode of operation will begin
4.	Ipri Avg	289.322 mA	Current	Average Current in Primary Winding over the complete Switching Period
5.	Ipri ripple	724.814 mA	Current	Ripple Current in the Primary Winding
6.	Ipri ripple pk-pk percentage	100.165 %	Current	Primary Current pk-pk ripple percentage(of Ipri avg during ton only)
7.	Isec Ripple	3.229 A	Current	Ripple Current in the Secondary Winding
8.	T1 Iprim RMS	476.303 mA	Current	Transformer Primary RMS Current
9.	T1 Iprim pk	1.086 A	Current	Transformer Primary Peak Current
10.	T1 Is1 RMS	2.6 A	Current	Transformer Secondary1 RMS Current
11.	T1 Is1 pk	4.839 A	Current	Transformer Secondary1 Peak Current
12.	AC Frequency	60.0 Hz	General	Input AC frequency
13.	BOM Count	62	General	Total Design BOM count
14.	Daux trr	4.0 ns	General	Auxiliary Diode Reverse Recovery Time
15.	Dsec Vf	500.0 mV	General	Effective Forward Voltage Drop at the Operating Current
16.	Dsec trr	60.0 ns	General	Output Diode Reverse Recovery Time
17.	Dsec2 Vf	500.0 mV	General	Effective Forward Voltage Drop at the Operating Current
18.	Dsnub trr	35.0 ns	General	Snubber Diode Reverse Recovery Time
19.	FootPrint	5.008 k mm ²	General	Total Foot Print Area of BOM components
20.	Frequency	99.307 kHz	General	Switching frequency
21.	Pout	64.0 W	General	Total output power
22.	Power Factor	1.0	General	Assumed Power Factor for the Application
23.	Tdead	0.0 ns	General	Approximate Dead Time of the Regulator
24.	Toff	6.247 us	General	Approximate Converter Off Time
25.	Ton Act	4.026 us	General	Approximate Converter On Time
26.	Total BOM	\$0.0	General	Total BOM Cost
27.	Tsw	10.07 us	General	Switching Time Period
28.	Vaux	11.968 V	General	Auxiliary Voltage
29.	Vsnub	235.605 V	General	Voltage Across the Snubber
30.	Vout Actual	31.998 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
31.	Vout OP	32.0 V	Op_Point	Operational Output Voltage
32.	Duty Cycle	39.982 %	Op_point	Duty cycle
33.	Efficiency	93.269 %	Op_point	Steady state efficiency
34.	IC Tj	32.88 degC	Op_point	IC junction temperature
35.	ICThetaJA	50.0 degC/W	Op_point	IC junction-to-ambient thermal resistance
36.	IOUT_OP	2.0 A	Op_point	Iout operating point
37.	M1 TJOP	48.551 degC	Op_point	M1 MOSFET junction temperature
38.	Peak Rectified Vin	311.124 V	Op_point	Peak voltage seen at rectified input
39.	Vin_OP_RMS	220.0 V	Op_point	AC Input RMS Voltage
40.	Vout p-p	182.992 mV	Op_point	Peak-to-peak output ripple voltage
41.	Avg Bridge Diode Pd	445.862 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
42.	Cbulk Pd	519.239 mW	Power	Bulk capacitor power dissipation
43.	Cout1 Pd	156.388 mW	Power	Output capacitor1 power dissipation
44.	Cx Pd	0.0 W	Power	X-cap Power Dissipation
45.	Cy Pd	0.0 W	Power	Y-caps Power Dissipation
46.	Dsec Pd	500.0 mW	Power	Secondary Diode Power Dissipation
47.	Dsec2 Pd	500.0 mW	Power	Secondary Diode Power Dissipation
48.	IC Pd	57.591 mW	Power	IC power dissipation
49.	L1 Pd	6.834 mW	Power	Power Dissipation in the Inductor
50.	L2 Pd	9.6 mW	Power	Average Power Dissipation in the Inductor Over the AC Line Period

#	Name	Value	Category	Description
51.	M1 Pd	296.814 mW	Power	M1 MOSFET total power dissipation
52.	Paux	18.69 mW	Power	Power Dissipation in Raux and Daux
53.	Pd Rstartup	374.653 mW	Power	Power Dissipation in Rstartup1 and Rstartup2
54.	Rdrv Pd	24.391 μ W	Power	Power Dissipation in Gate Drive Resistor
55.	Rfb Pd	29.141 mW	Power	Rfb Power Dissipation
56.	Rsns Pd	140.656 mW	Power	Current Limit Sense Resistor Power Dissipation
57.	Rx Pd	483.845 mW	Power	Total Power Dissipation in Rx1 and Rx2
58.	Snubber Pd	901.568 mW	Power	Snubber Power Dissipation
59.	T1 Pd	511.013 mW	Power	Estimated Losses in Transformer
60.	Total Pd	4.619 W	Power	Total Power Dissipation
61.	Vout Tolerance	2.189 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
62.	Vout pp percentage	571.851 m%		Output Voltage ripple percentage

Design Inputs

#	Name	Value	Description
1.	Iout	2.0	Maximum Output Current
2.	Iout1	2.0	Output Current #1
3.	Iout2	3.0	Output Current #2
4.	Iout3	2.0	Output Current #3
5.	VinMax	250.0	Maximum input voltage
6.	VinMin	220.0	Minimum input voltage
7.	Vout	32.0	Output Voltage
8.	Vout1	32.0	Output Voltage #1
9.	Vout2	5.0	Output Voltage #2
10.	Vout3	5.0	Output Voltage #3
11.	acFrequency	60.0	Light Output in Lumen
12.	base_pn	UCC28C45	Texas Instruments Base Part Number
13.	source	AC	Input Source Type
14.	ta	30.0	Ambient temperature

Design Assistance

1. UCC28C45 Product Folder : <http://www.ti.com/product/UCC28C45> : contains the data sheet and other resources.

Texas Instruments' WEBENCH simulation tools attempt to recreate the performance of a substantially equivalent physical implementation of the design. Simulations are created using Texas Instruments' published specifications as well as the published specifications of other device manufacturers. While Texas Instruments does update this information periodically, this information may not be current at the time the simulation is built. Texas Instruments does not warrant the accuracy or completeness of the specifications or any information contained therein. Texas Instruments does not warrant that any designs or recommended parts will meet the specifications you entered, will be suitable for your application or fit for any particular purpose, or will operate as shown in the simulation in a physical implementation. Texas Instruments does not warrant that the designs are production worthy.

You should completely validate and test your design implementation to confirm the system functionality for your application prior to production.

Use of Texas Instruments' WEBENCH simulation tools is subject to [Texas Instruments' Site Terms and Conditions of Use](#). Prototype boards based on WEBENCH created designs are provided AS IS without warranty of any kind for evaluation and testing purposes and are subject to the terms of the [Evaluation License Agreement](#).