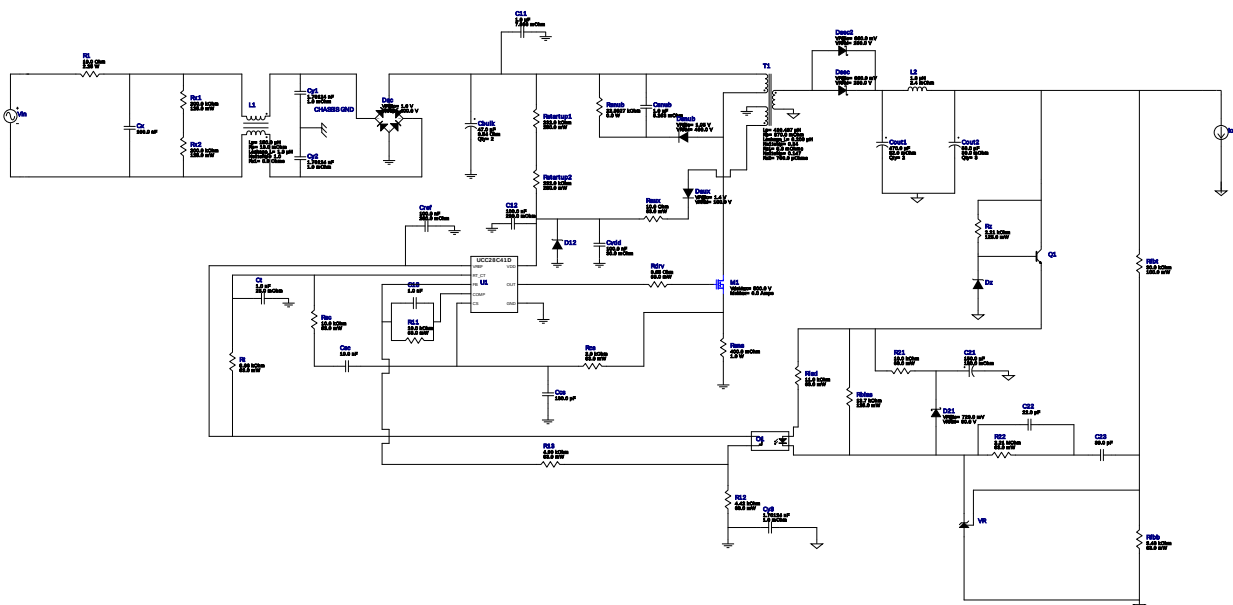


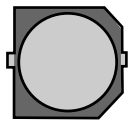
WEBENCH® Design Report

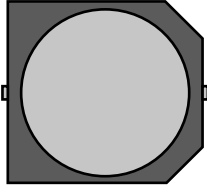
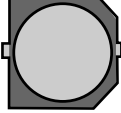
Design : 906020/2239 UCC28C41DR
UCC28C41DR 110.0V-130.0V to 24.00V @ 2.0A

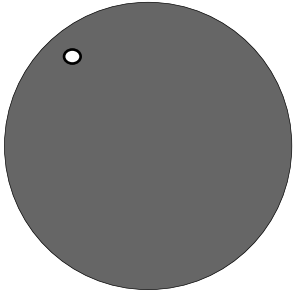


1. The EMI filter selected here contains the estimated values. The real numbers will depend on the attenuation needed at a particular frequency.

Electrical BOM

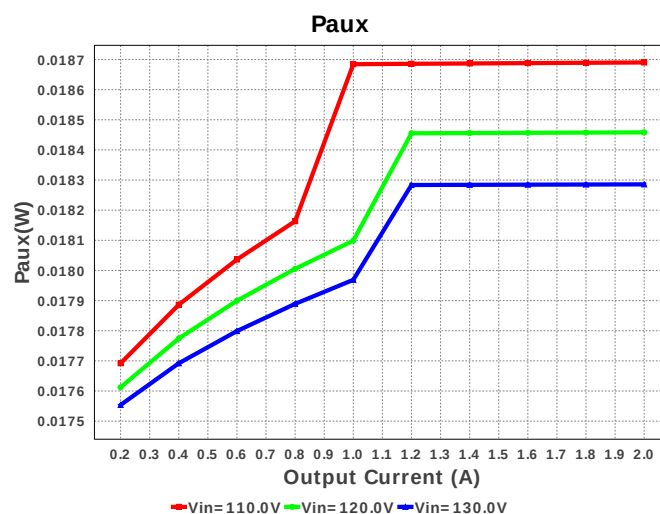
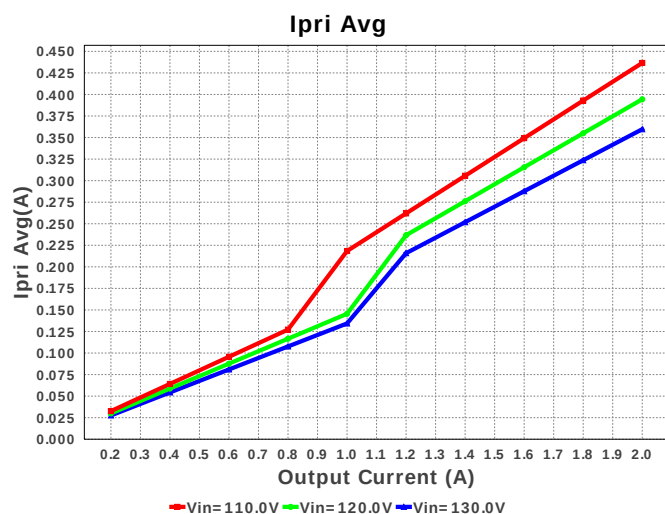
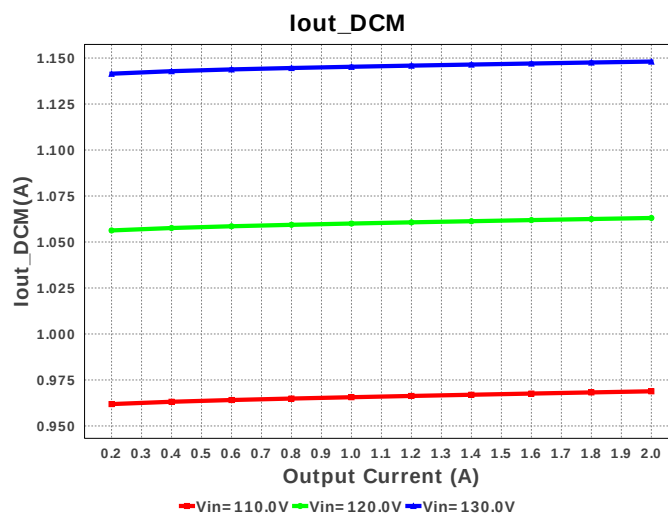
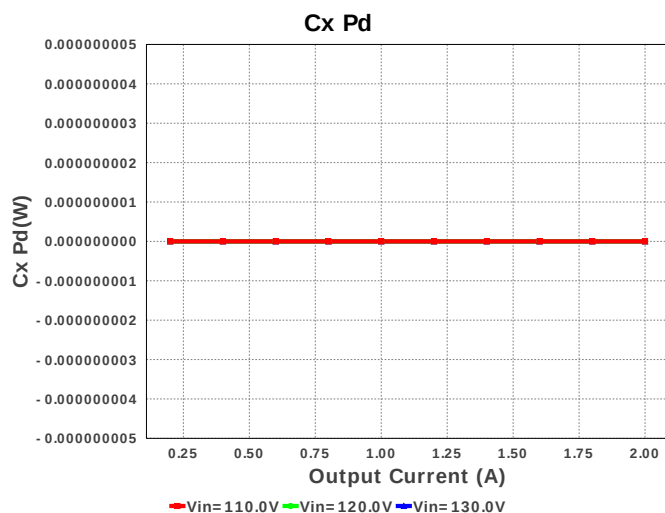
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	C11	MuRata	GRM55DR72E105KW01L Series= X7R	Cap= 1.0 uF ESR= 7.086 mOhm VDC= 250.0 V IRMS= 2.0605 A	1	\$0.26	 2220_200 54 mm ²
2.	C12	AVX	08053C104KAT2A Series= X7R	Cap= 100.0 nF ESR= 280.0 mOhm VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm 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	Nichicon	UUD1H151MNL1GS Series= uD	Cap= 150.0 uF ESR= 180.0 mOhm VDC= 50.0 V IRMS= 670.0 mA	1	\$0.26	 SM_RADIAL_10BMM 160 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	CC0805JRNPO9BN390 Series= C0G/NP0	Cap= 39.0 pF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm ²
7.	Cbulk	Vishay-Bccomponents	MAL215759479E3 Series= 2239	Cap= 47.0 uF ESR= 3.54 Ohm VDC= 500.0 V IRMS= 680.0 mA	2	\$2.68	157PUM-SI_2200x2500 576 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

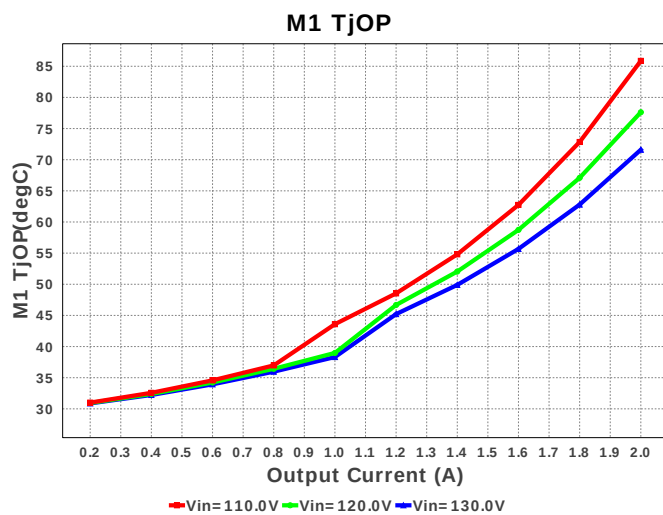
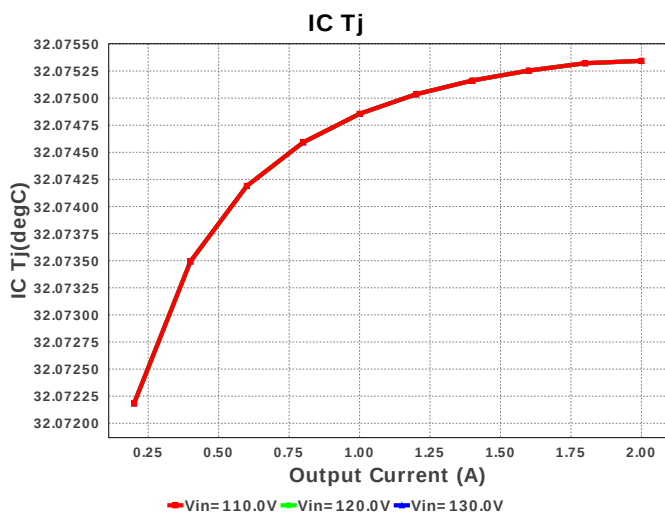
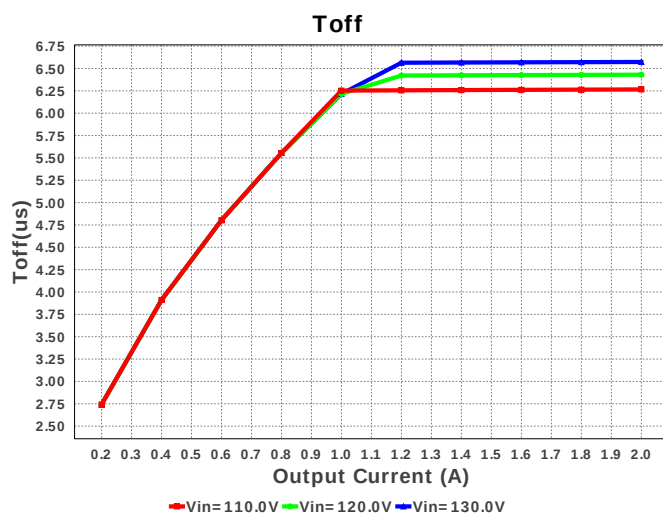
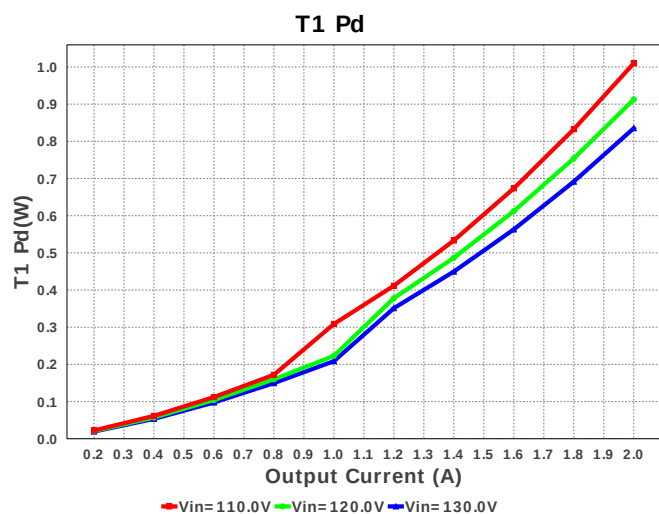
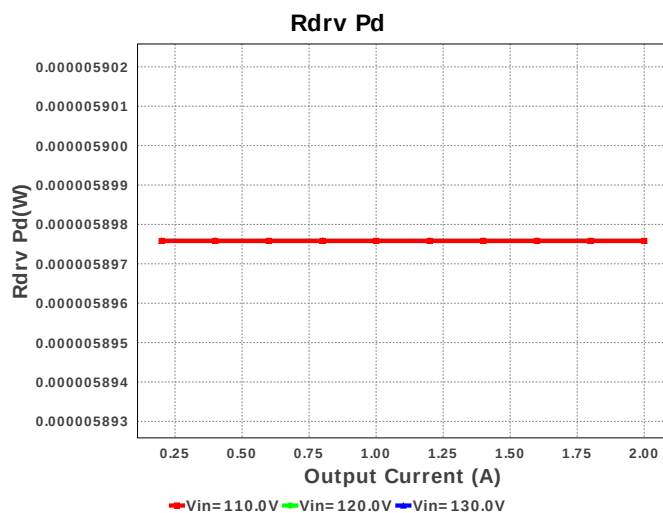
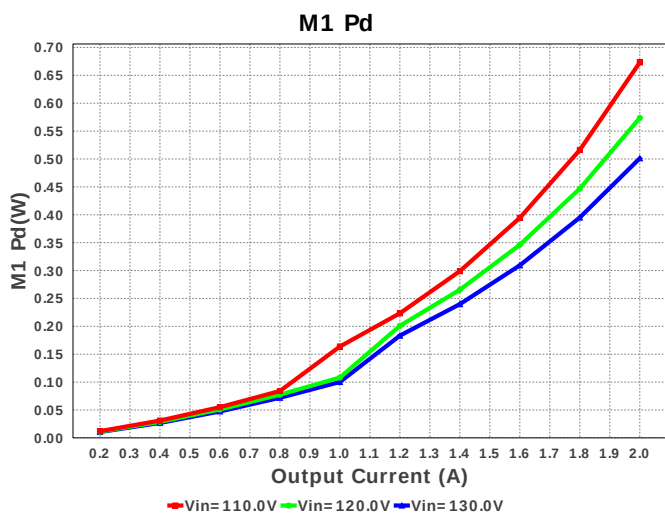
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
9.	Cout1	Panasonic	EEV-FK1J471M Series= FK	Cap= 470.0 uF ESR= 82.0 mOhm VDC= 63.0 V IRMS= 1.41 A	2	\$0.78	 SM_RADIAL_J16 399 mm²
10.	Cout2	Panasonic	EEHZA1J560P Series= ?	Cap= 56.0 uF ESR= 30.0 mOhm VDC= 63.0 V IRMS= 1.8 A	3	\$1.05	 SM_RADIAL_10BMM 160 mm²
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 mm²
12.	Csc	MuRata	GRM216R71H103KA01D Series= X7R	Cap= 10.0 nF VDC= 50.0 V IRMS= 0.0 A	1	\$0.01	 0805 7 mm²
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 mm²
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 mm²
15.	Cvdd	MuRata	GRM188R71C104KA01D Series= X7R	Cap= 100.0 nF ESR= 30.0 mOhm VDC= 16.0 V IRMS= 1.7 A	1	\$0.01	 0603 5 mm²
16.	Cx	TDK	B32913A5104M000 Series= 2231	Cap= 100.0 nF VDC= 1000.0 V IRMS= 0.0 A	1	\$0.46	 B32913_2650x600x1500 228 mm²
17.	Cy1	CUSTOM	CUSTOM Series= ?	Cap= 1.70124 nF ESR= 1.0 mOhm VDC= 220.62 V IRMS= 500.0 uA	1	NA	CUSTOM 0 mm²
18.	Cy2	CUSTOM	CUSTOM Series= ?	Cap= 1.70124 nF ESR= 1.0 mOhm VDC= 220.62 V IRMS= 500.0 uA	1	NA	CUSTOM 0 mm²
19.	Cy3	CUSTOM	CUSTOM Series= ?	Cap= 1.70124 nF ESR= 1.0 mOhm VDC= 220.62 V IRMS= 500.0 uA	1	NA	CUSTOM 0 mm²
20.	D12	Diodes Inc.	MMSZ5248B-7-F	Zener	1	\$0.04	 SOD-123 13 mm²
21.	D21	ON Semiconductor	SS16T3G	VF@Io= 720.0 mV VRRM= 60.0 V	1	\$0.08	 SMA 37 mm²
22.	Dac	Diodes Inc.	HD04-T	VF@Io= 1.0 V VRRM= 400.0 V	1	\$0.12	 MiniDIP 62 mm²
23.	Daux	NXP Semiconductor	BAS316,115	VF@Io= 1.4 V VRRM= 100.0 V	1	\$0.02	 SOD-323 9 mm²

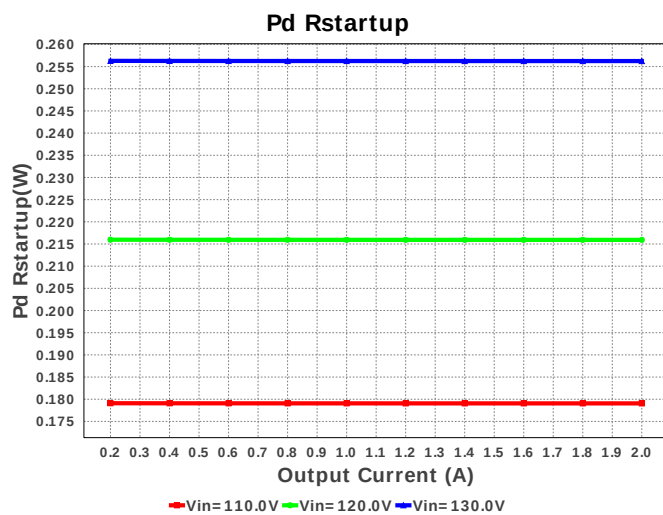
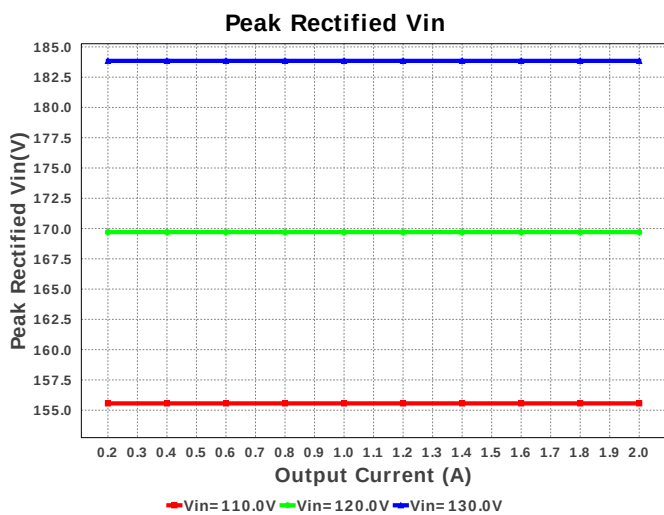
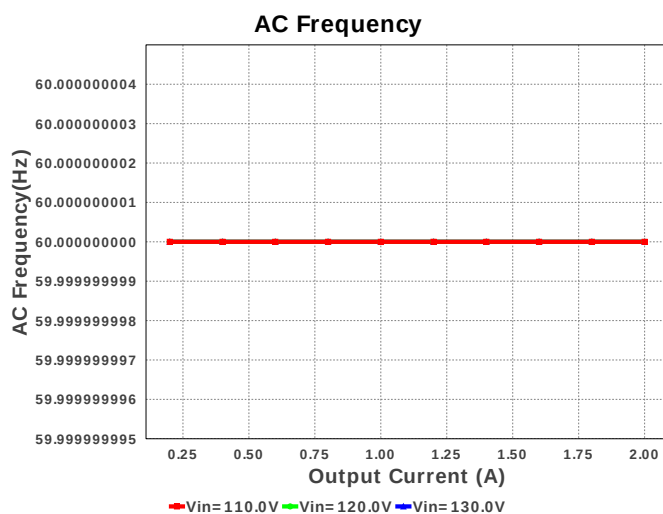
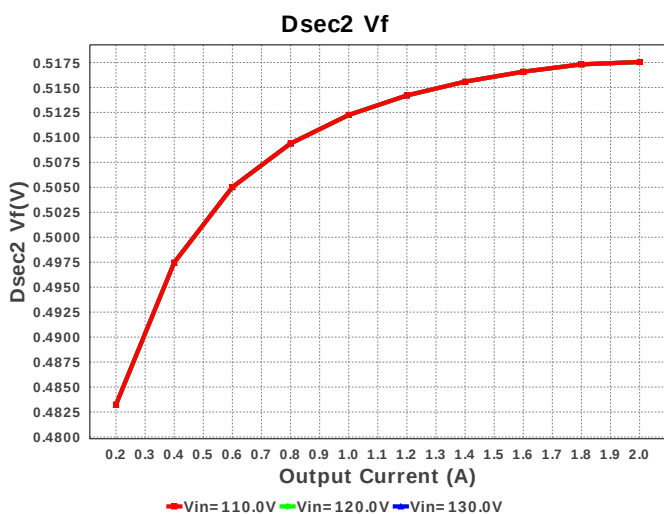
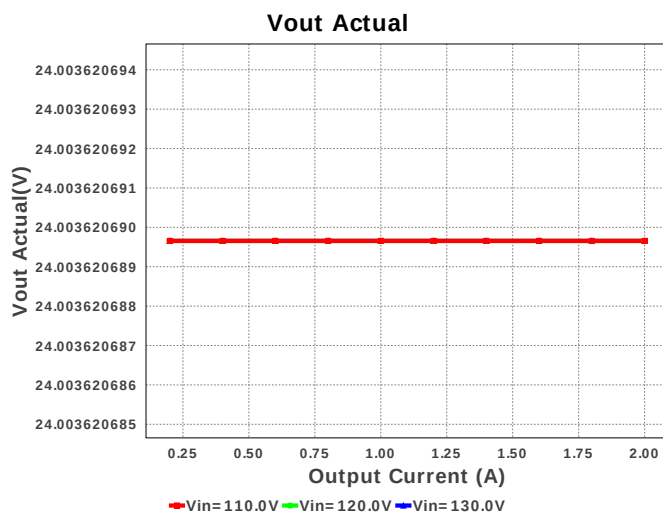
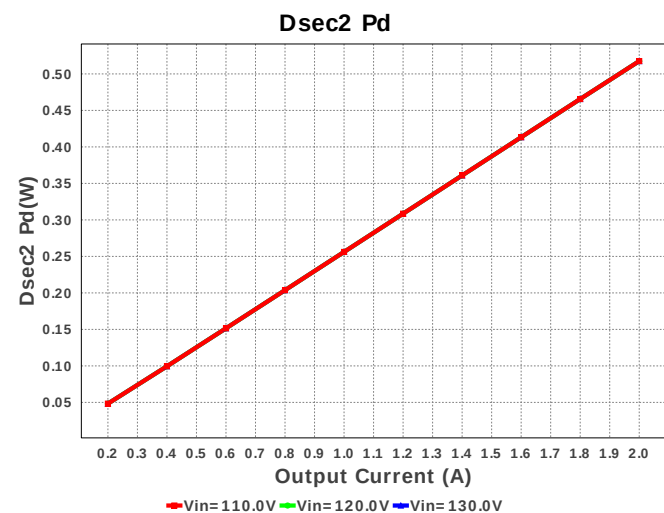
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
24.	Dsec	ON Semiconductor	MBRB40250TG	VF@Io= 860.0 mV VRRM= 250.0 V	1	\$0.94	 DDPAK 210 mm²
25.	Dsec2	ON Semiconductor	MBRB40250TG	VF@Io= 860.0 mV VRRM= 250.0 V	1	\$0.94	 DDPAK 210 mm²
26.	Dsnub	Bourns	CD1408-FU1400	VF@Io= 1.05 V VRRM= 400.0 V	1	\$0.13	 Diode_1408 13 mm²
27.	Dz	Diodes Inc.	MMSZ5250B-7-F	Zener	1	\$0.03	 SOD-123 13 mm²
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 mm²
29.	L2	Coilcraft	SER1360-182KLB	L= 1.8 µH DCR= 2.4 mOhm	1	\$0.72	 SER1360 225 mm²
30.	M1	Fairchild Semiconductor	FDD6N50TM	VdsMax= 500.0 V IdsMax= 6.0 Amps	1	\$0.47	 DPAK 102 mm²
31.	O1	Vishay-Semiconductor	TCMT1107	Optocoupler	1	\$0.21	 SOP-4 44 mm²
32.	Q1	ON Semiconductor	BC846BLT1G	Bipolar Transistor	1	\$0.02	 SOT-23 14 mm²
33.	R1	Vishay-Dale	AC03000001009JACCS Series= F_RES	Res= 10.0 Ohm Power= 2.25 W Tolerance= 5.0%	1	\$0.30	 AC03 158 mm²
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	CRCW04024K42FKED Series= CRCW..e3	Res= 4.42 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	CRCW04022M21FKED Series= CRCW..e3	Res= 2.21 MOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²

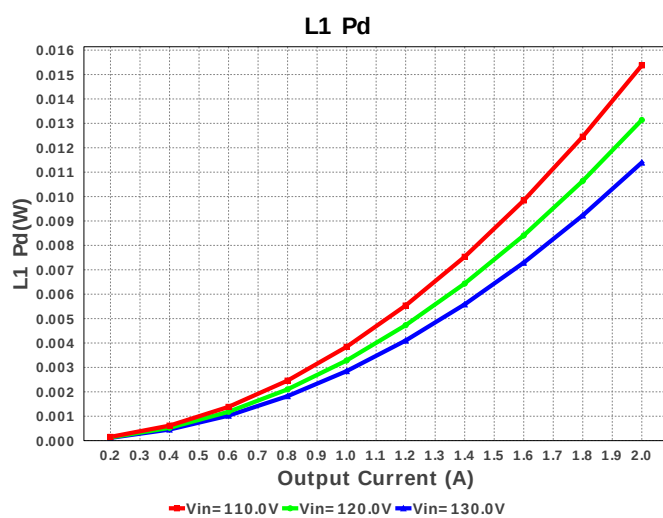
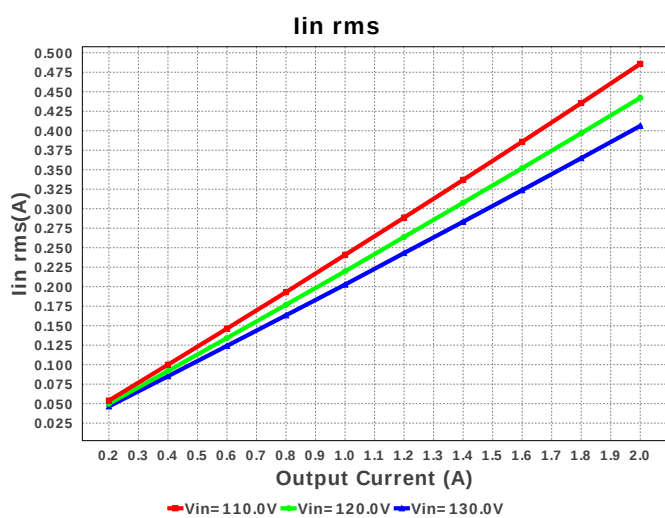
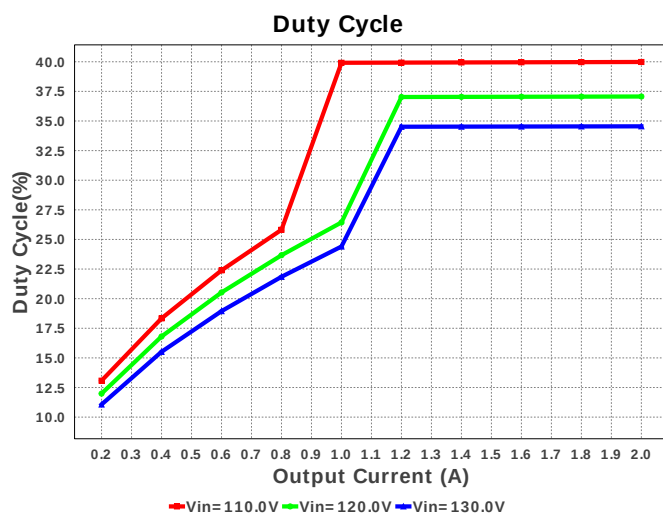
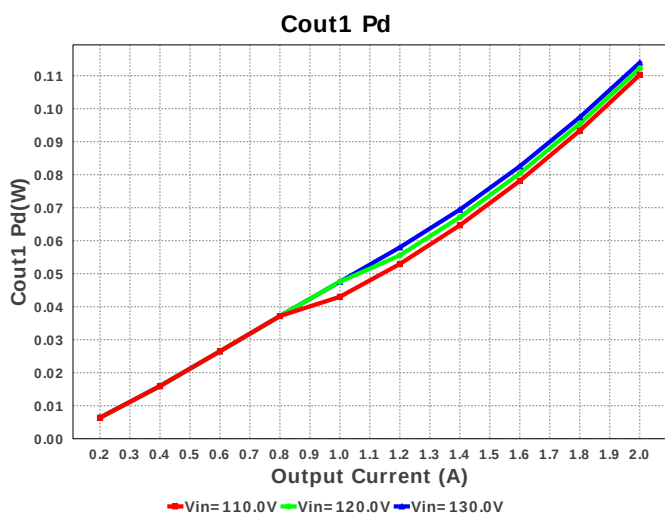
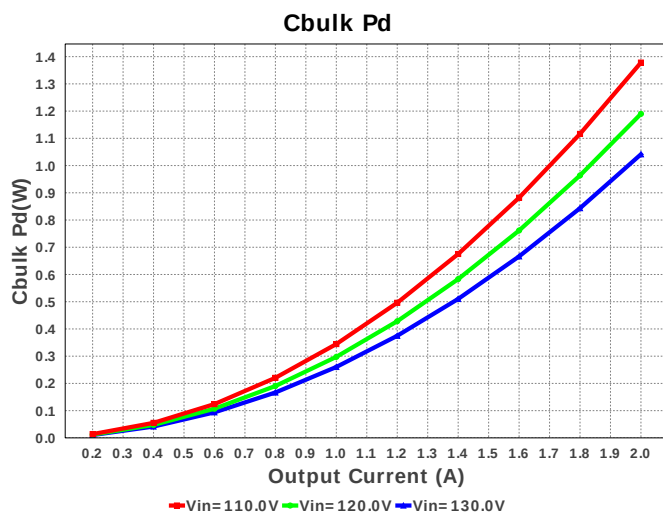
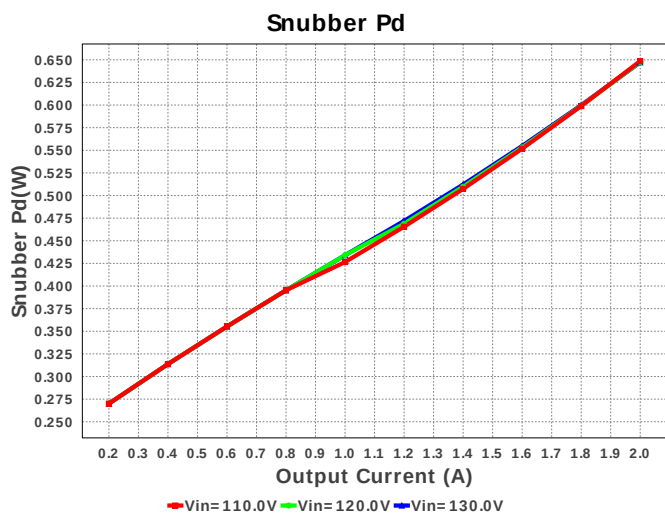
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
39.	Raux	Vishay-Dale	CRCW040210R0FKED Series= CRCW..e3	Res= 10.0 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
40.	Rbias	Panasonic	ERJ-6ENF1372V Series= ERJ-6E	Res= 13.7 kOhm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 mm²
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	CRCW04023R65FKED Series= CRCW..e3	Res= 3.65 Ohm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
43.	Rfbb	Vishay-Dale	CRCW04023K48FKED Series= CRCW..e3	Res= 3.48 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
44.	Rfbt	Yageo America	RC0603FR-0730KL Series= ?	Res= 30.0 kOhm Power= 100.0 mW Tolerance= 1.0%	1	\$0.01	 0603 5 mm²
45.	Rled	Vishay-Dale	CRCW040211K0FKED Series= CRCW..e3	Res= 11.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
46.	Rsc	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm²
47.	Rsns	Stackpole Electronics Inc	CSRN2010FKR400 Series= ?	Res= 400.0 mOhm Power= 1.0 W Tolerance= 1.0%	1	\$0.11	 2010 32 mm²
48.	Rsnu	CUSTOM	CUSTOM Series= ?	Res= 22.8827 kOhm Power= 0.0 W Tolerance= 0.0%	1	NA	CUSTOM 0 mm²
49.	Rstartup1	Panasonic	ERJ-8ENF2323V Series= ERJ-8E	Res= 232.0 kOhm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm²
50.	Rstartup2	Panasonic	ERJ-8ENF2323V Series= ERJ-8E	Res= 232.0 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	Panasonic	ERJ-6ENF2003V Series= ERJ-6E	Res= 200.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 mm²
53.	Rx2	Panasonic	ERJ-6ENF2003V Series= ERJ-6E	Res= 200.0 kOhm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 mm²
54.	Rz	Panasonic	ERJ-6ENF2211V Series= ERJ-6E	Res= 2.21 kOhm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 mm²
55.	T1	CUSTOM	CUSTOM	Lp= 410.437 µH Rp= 870.0 mOhm Leakage_L= 8.209 µH Ns1toNp= 0.34 Rs1= 8.6 mOhms Ns2toNp= 0.147 Rs2= 700.0 µOhms	1	NA	CUSTOM 0 mm²
56.	U1	Texas Instruments	UCC28C41DR	Switcher	1	\$0.75	 D0008A 57 mm²

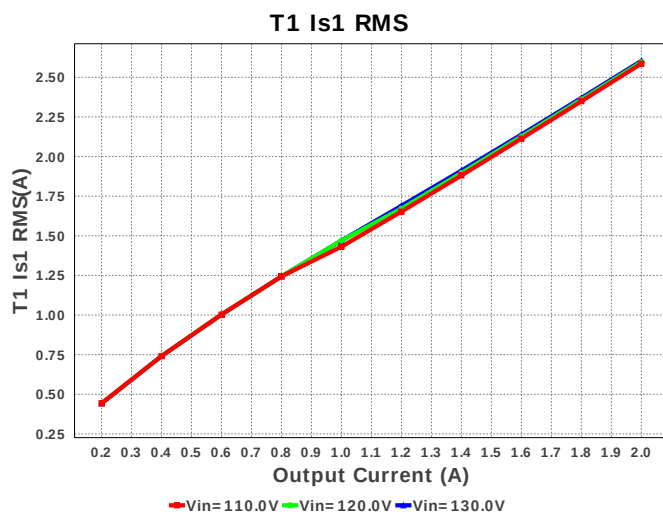
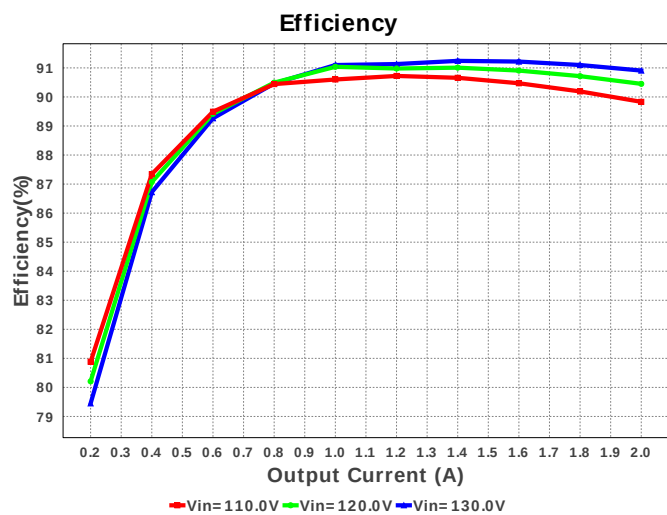
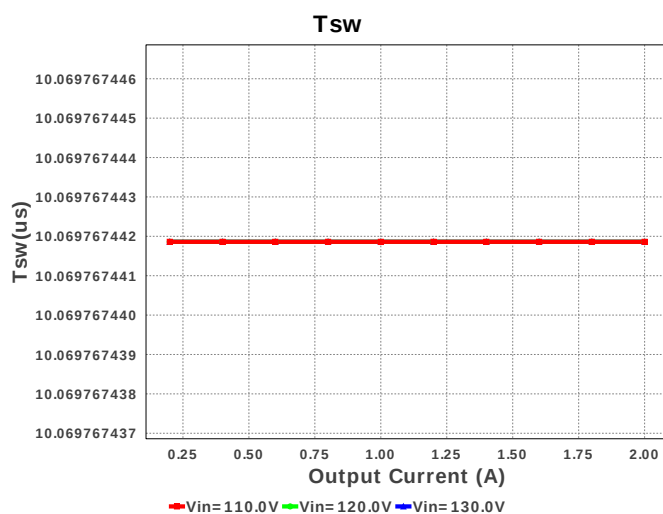
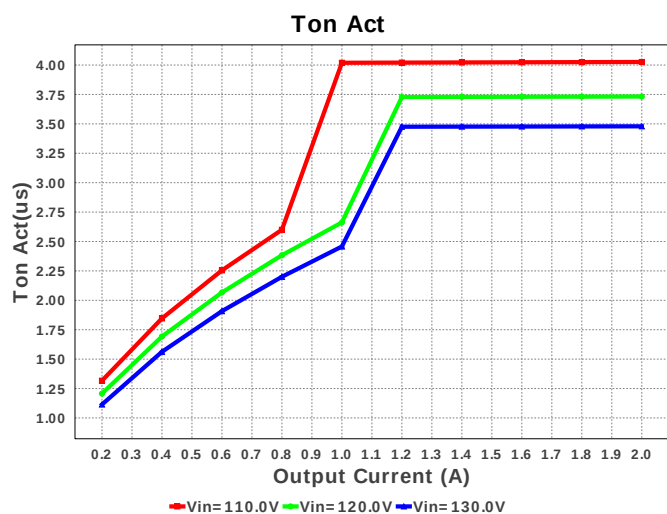
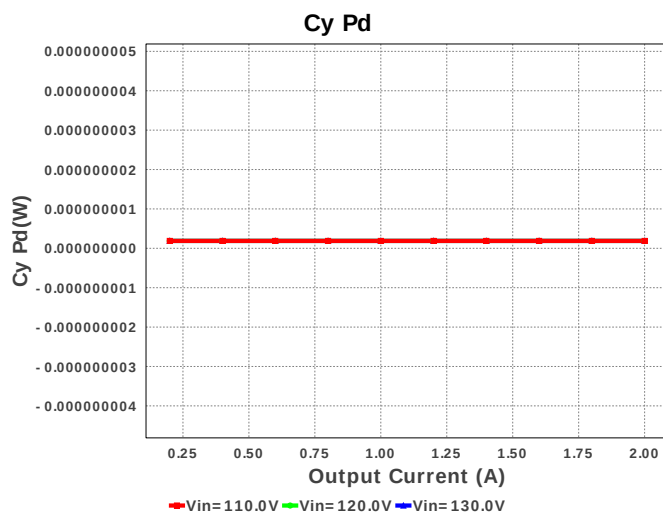
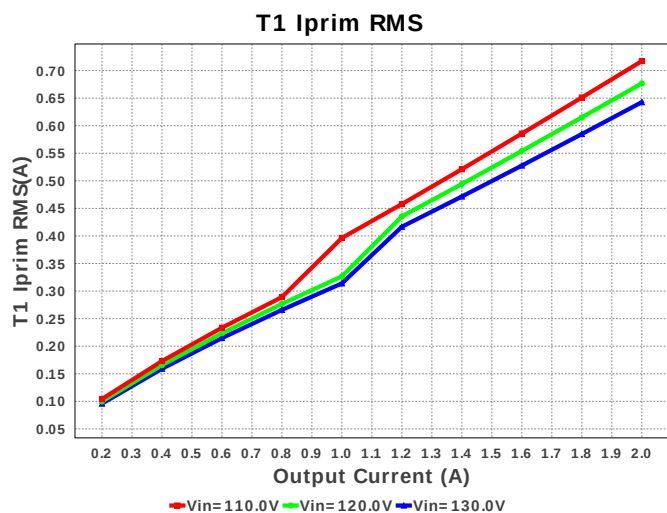
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
57.	VR	Texas Instruments	TL431AIDBVR	Voltage References	1	\$0.07	 R-PDSO-G3 16 mm ²

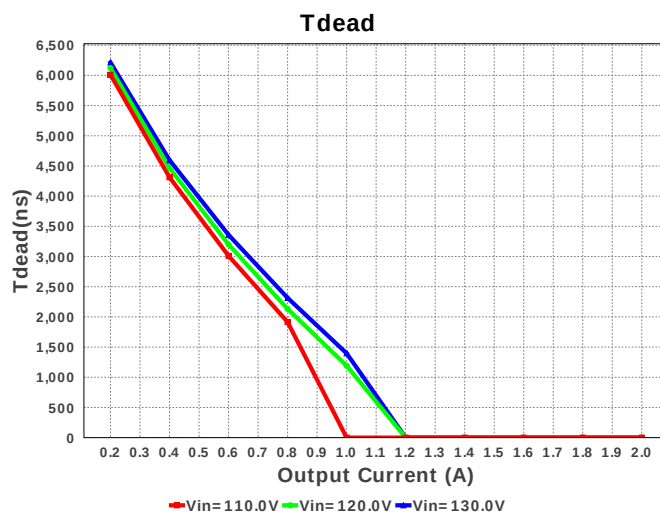
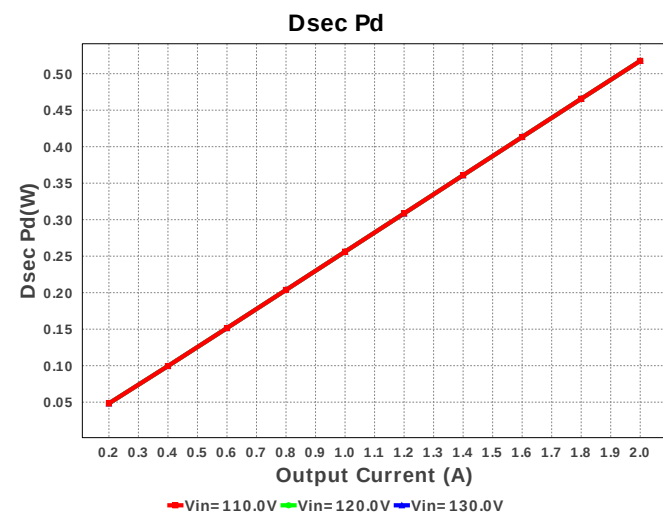
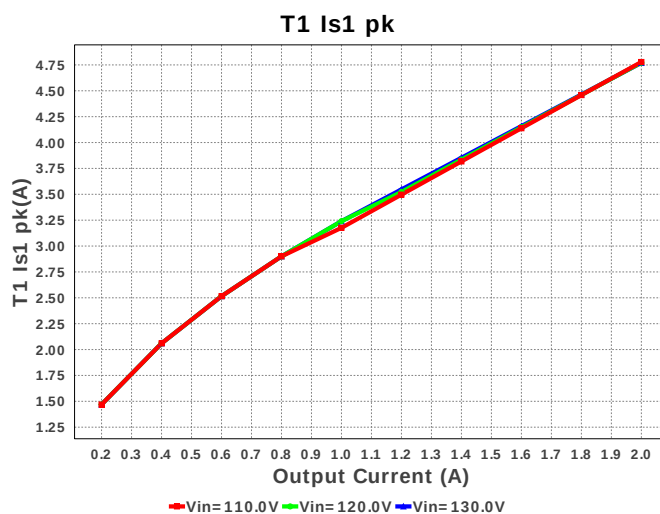
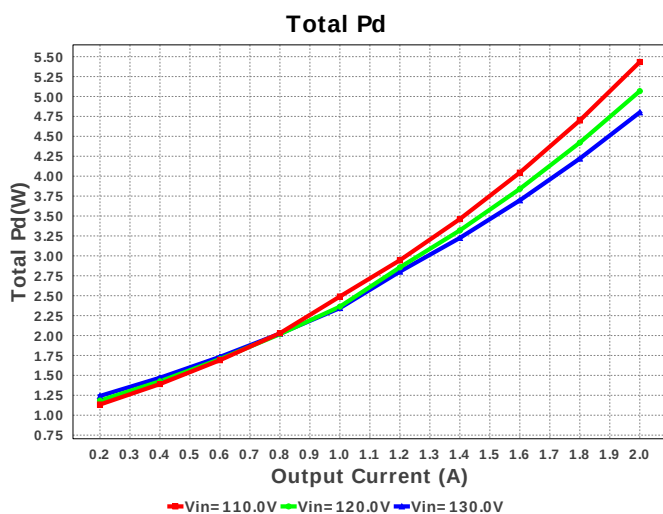
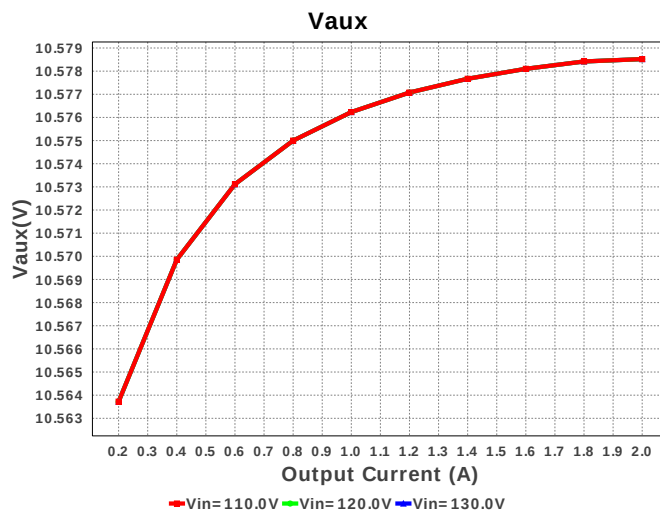
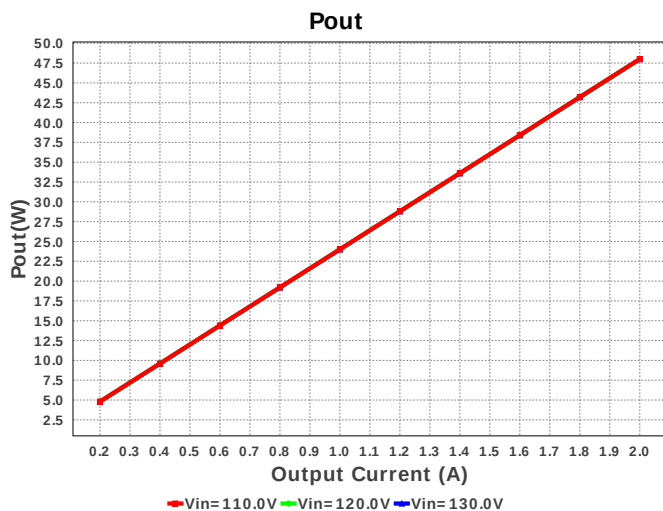




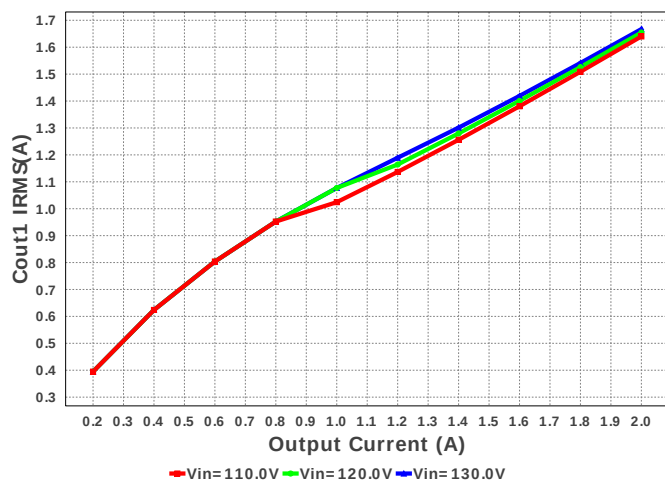




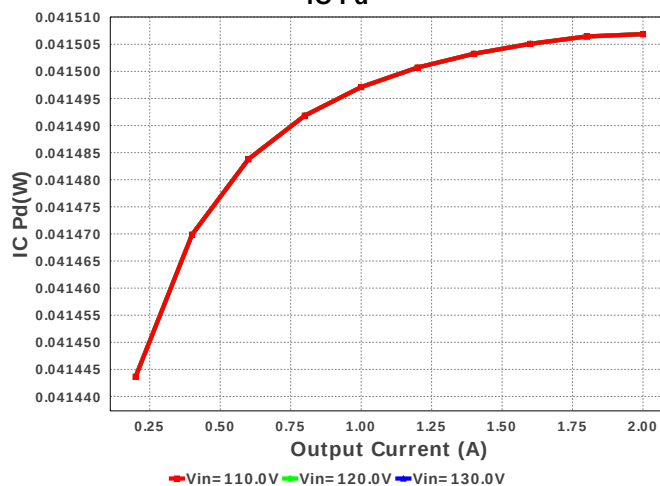




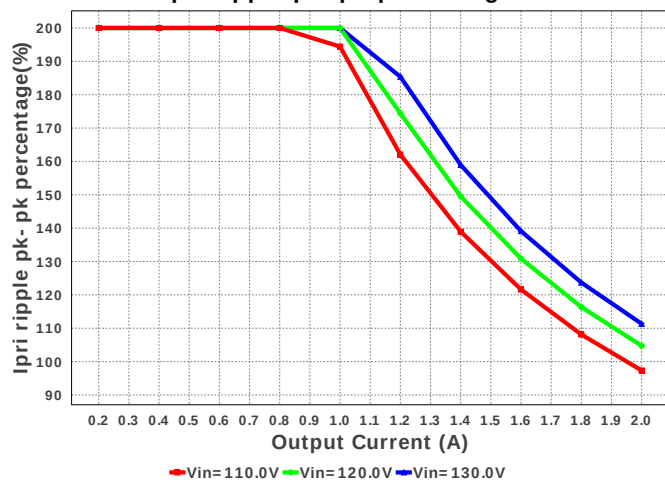
Cout1 IRMS



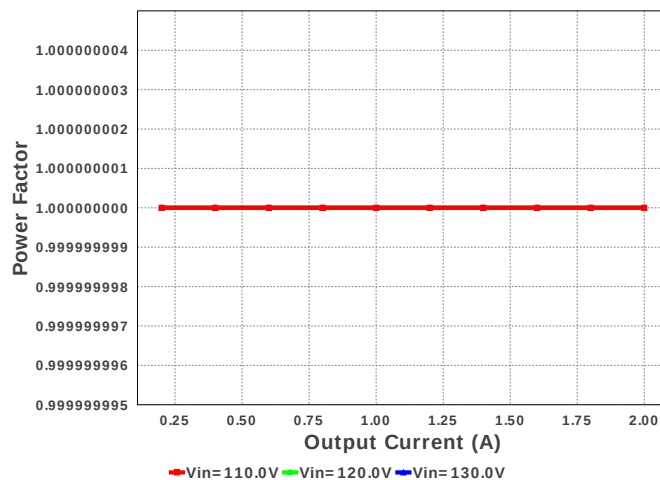
IC Pd



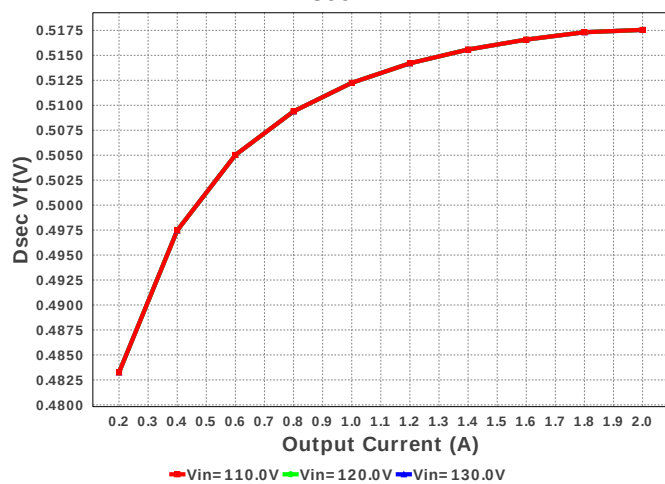
Ipri ripple pk- pk percentage



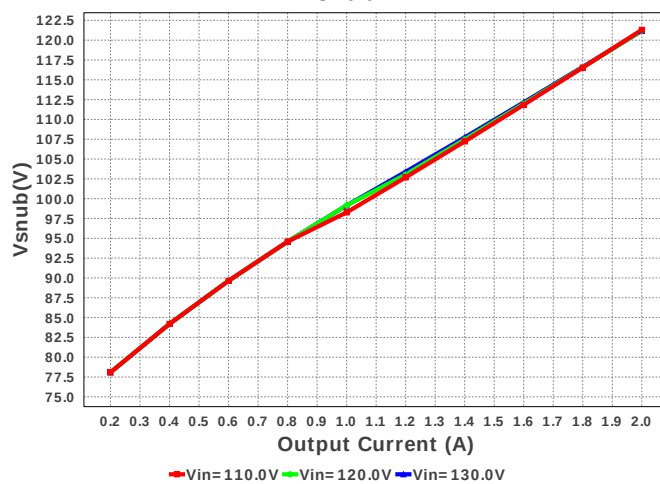
Power Factor

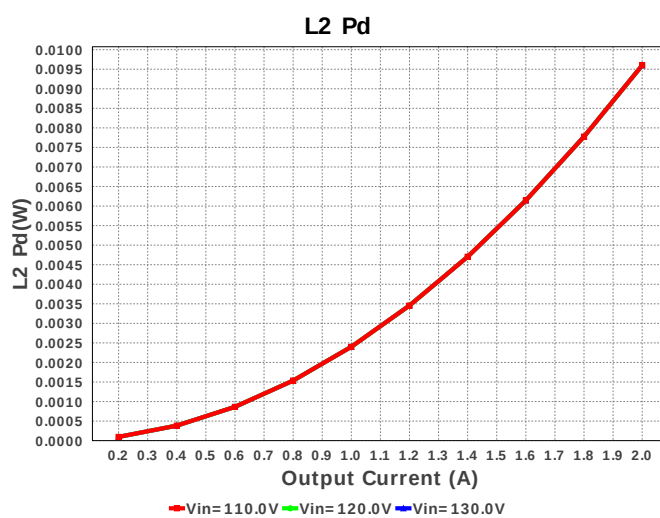
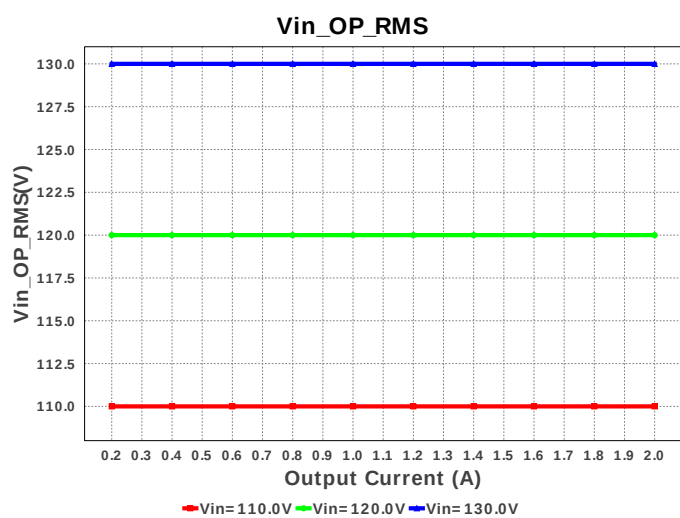
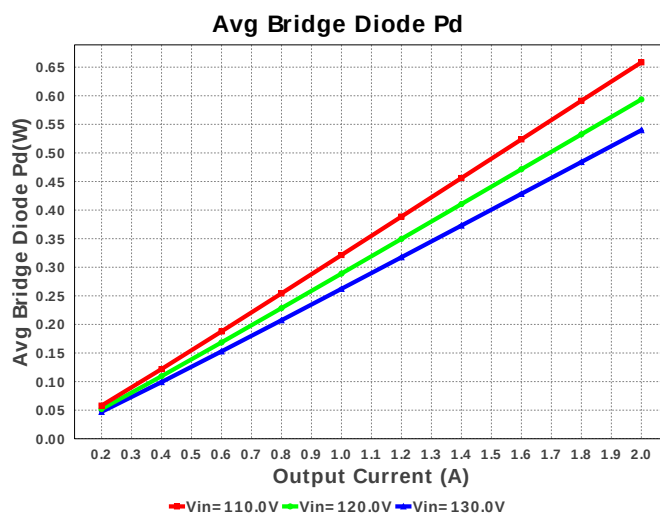
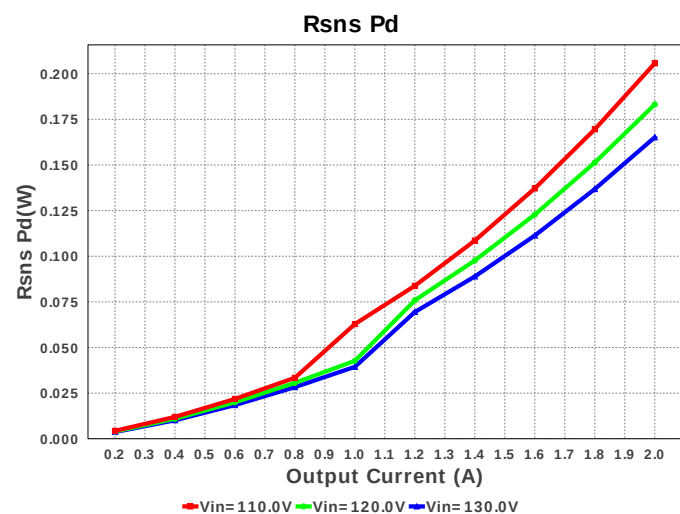
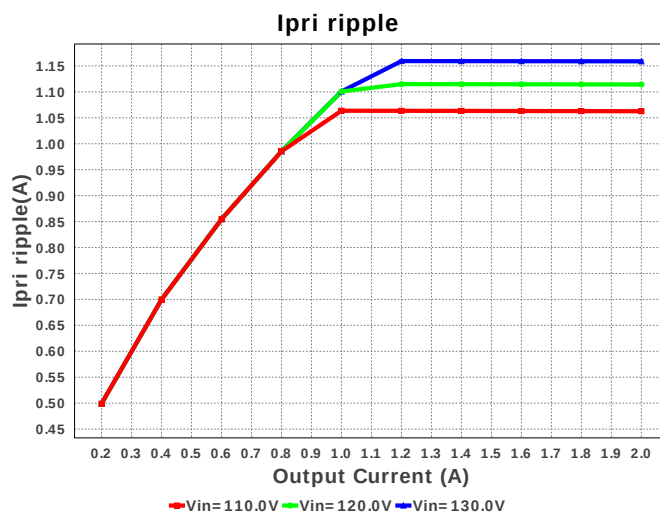
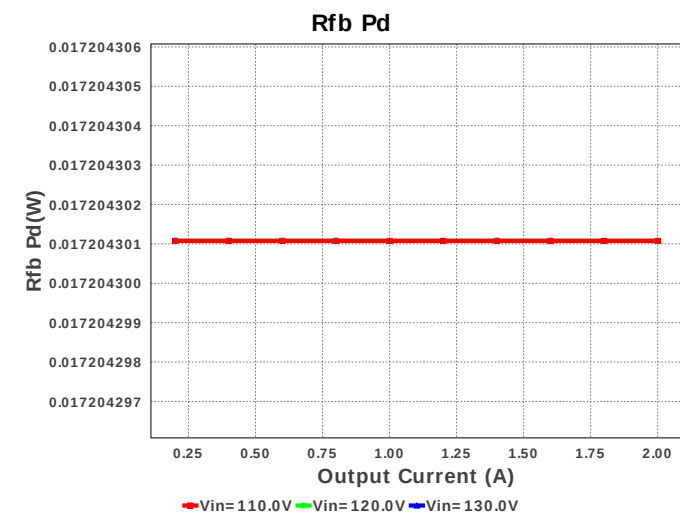


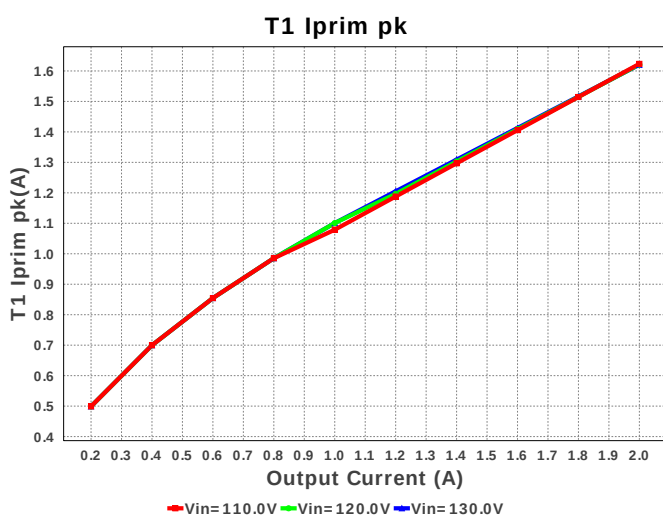
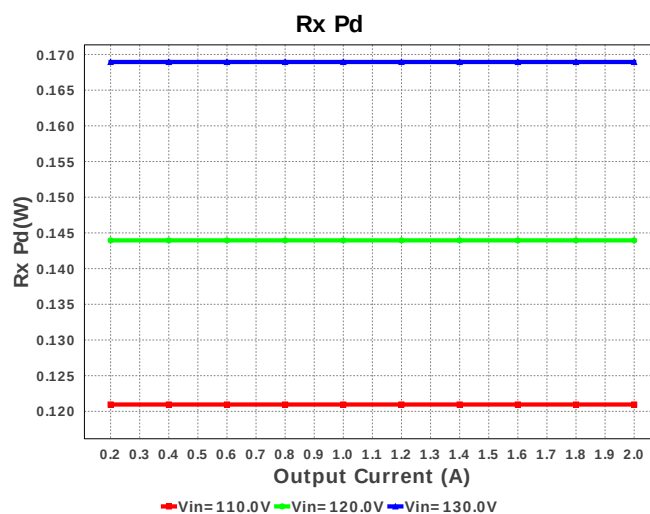
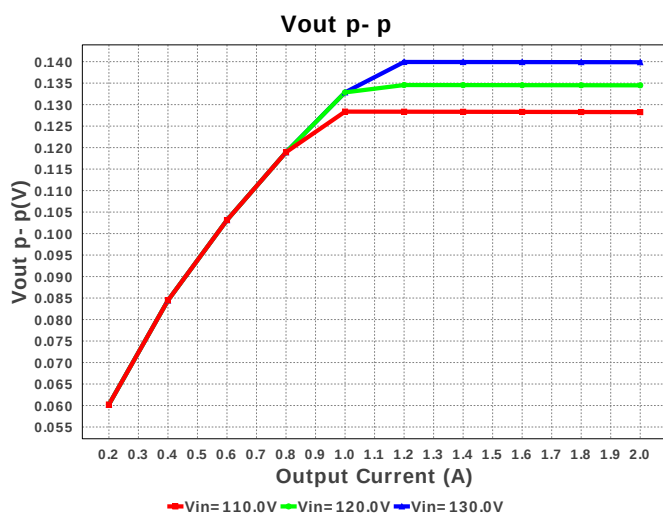
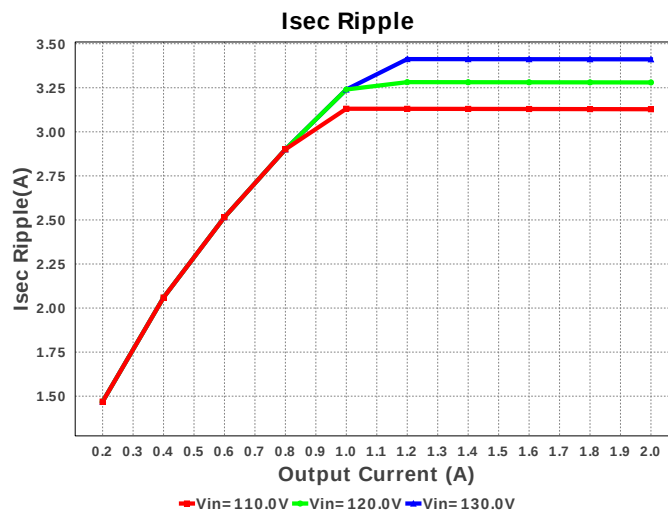
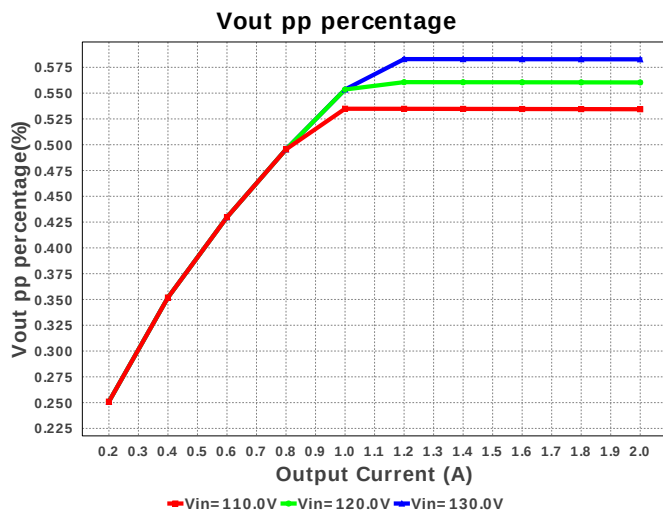
Dsec Vf



Vsub







Operating Values

#	Name	Value	Category	Description
1.	Cout1 IRMS	1.64 A	Current	Output capacitor1 RMS ripple current
2.	Iin rms	485.75 mA	Current	RMS Input Current
3.	Iout_DCM	968.84 mA	Current	Approximate Current below which DCM mode of operation will begin
4.	Ipri Avg	436.563 mA	Current	Average Current in Primary Winding over the complete Switching Period
5.	Ipri ripple	1.063 A	Current	Ripple Current in the Primary Winding
6.	Ipri ripple pk-pk percentage	97.326 %	Current	Primary Current pk-pk ripple percentage(of Ipri avg during ton only)
7.	Isec Ripple	3.128 A	Current	Ripple Current in the Secondary Winding
8.	T1 Iprim RMS	717.159 mA	Current	Transformer Primary RMS Current
9.	T1 Iprim pk	1.623 A	Current	Transformer Primary Peak Current

#	Name	Value	Category	Description
10.	T1 Is1 RMS	2.586 A	Current	Transformer Secondary1 RMS Current
11.	T1 Is1 pk	4.778 A	Current	Transformer Secondary1 Peak Current
12.	AC Frequency	60.0 Hz	General	Input AC frequency
13.	BOM Count	61	General	Total Design BOM count
14.	Daux trr	4.0 ns	General	Auxiliary Diode Reverse Recovery Time
15.	Dsec Vf	517.55 mV	General	Effective Forward Voltage Drop at the Operating Current
16.	Dsec trr	0.0 ns	General	Output Diode Reverse Recovery Time
17.	Dsec2 Vf	517.55 mV	General	Effective Forward Voltage Drop at the Operating Current
18.	Dsnub trr	35.0 ns	General	Snubber Diode Reverse Recovery Time
19.	FootPrint	5.145 k mm ²	General	Total Foot Print Area of BOM components
20.	Frequency	99.307 kHz	General	Switching frequency
21.	Pout	48.0 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	6.266 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	10.579 V	General	Auxiliary Voltage
29.	Vsnub	121.299 V	General	Voltage Across the Snubber
30.	Vout Actual	24.004 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
31.	Vout OP	24.0 V	Op_Point	Operational Output Voltage
32.	Duty Cycle	39.981 %	Op_point	Duty cycle
33.	Efficiency	89.832 %	Op_point	Steady state efficiency
34.	IC Tj	32.075 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	85.867 degC	Op_point	M1 MOSFET junction temperature
38.	Peak Rectified Vin	155.562 V	Op_point	Peak voltage seen at rectified input
39.	Vin_OP_RMS	110.0 V	Op_point	AC Input RMS Voltage
40.	Vout p-p	128.257 mV	Op_point	Peak-to-peak output ripple voltage
41.	Avg Bridge Diode Pd	658.467 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
42.	Cbulk Pd	1.378 W	Power	Bulk capacitor power dissipation
43.	Cout1 Pd	110.285 mW	Power	Output capacitor1 power dissipation
44.	Cx Pd	0.0 W	Power	X-cap Power Dissipation
45.	Cy Pd	187.5 pW	Power	Y-caps Power Dissipation
46.	Dsec Pd	517.55 mW	Power	Secondary Diode Power Dissipation
47.	Dsec2 Pd	517.55 mW	Power	Secondary Diode Power Dissipation
48.	IC Pd	41.507 mW	Power	IC power dissipation
49.	L1 Pd	15.376 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
51.	M1 Pd	673.1 mW	Power	M1 MOSFET total power dissipation
52.	Paux	18.69 mW	Power	Power Dissipation in Raux and Daux
53.	Pd Rstartup	179.064 mW	Power	Power Dissipation in Rstartup1 and Rstartup2
54.	Rdrv Pd	5.898 μW	Power	Power Dissipation in Gate Drive Resistor
55.	Rfb Pd	17.204 mW	Power	Rfb Power Dissipation
56.	Rsns Pd	205.727 mW	Power	Current Limit Sense Resistor Power Dissipation
57.	Rx Pd	120.961 mW	Power	Total Power Dissipation in Rx1 and Rx2
58.	Snubber Pd	648.56 mW	Power	Snubber Power Dissipation
59.	T1 Pd	1.01 W	Power	Estimated Losses in Transformer
60.	Total Pd	5.433 W	Power	Total Power Dissipation
61.	Vout Tolerance	2.137 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable
62.	Vout pp percentage	534.404 m%		Output Voltage ripple percentage

Design Inputs

#	Name	Value	Description
1.	Iout	2.0	Maximum Output Current
2.	VinMax	130.0	Maximum input voltage
3.	VinMin	110.0	Minimum input voltage
4.	Vout	24.0	Output Voltage
5.	acFrequency	60.0	Light Output in Lumen
6.	base_pn	UCC28C41	Texas Instruments Base Part Number
7.	source	AC	Input Source Type
8.	ta	30.0	Ambient temperature

Design Assistance

1. UCC28C41 Product Folder : <http://www.ti.com/product/UCC28C41> : 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](#).