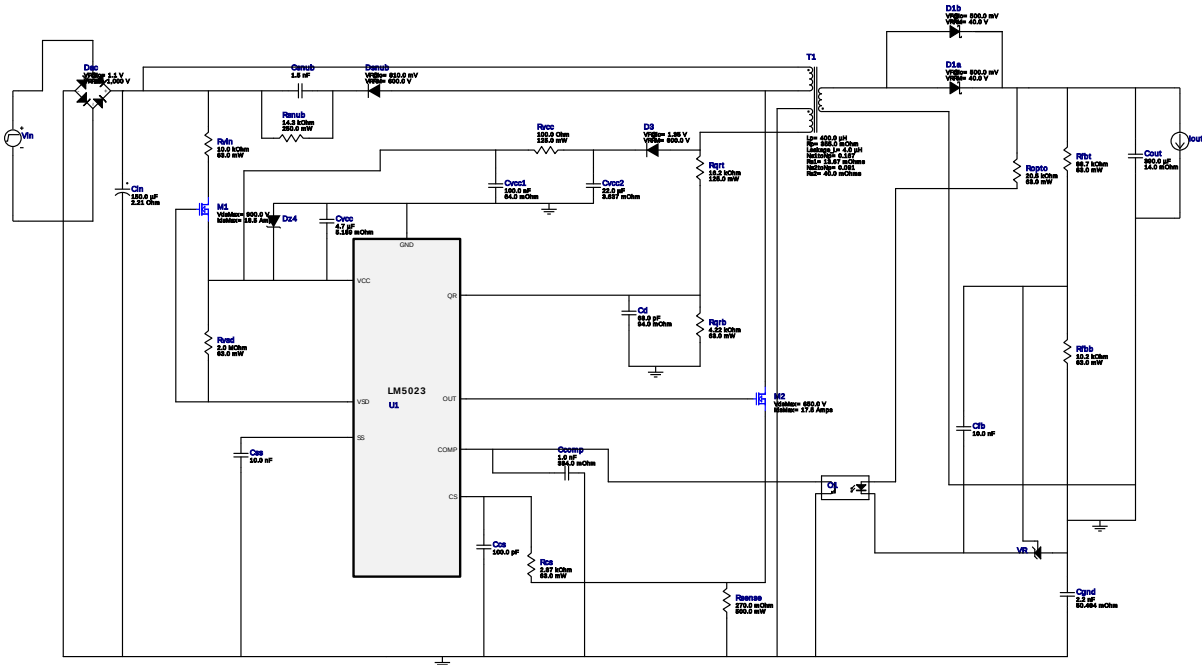


WEBENCH® Design Report

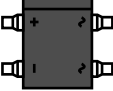
Design : 4077713/35 LM5023MM-2/NOPB
LM5023MM-2/NOPB 110.0V-220.0V to 24.19V @ 2.0A

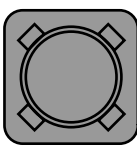


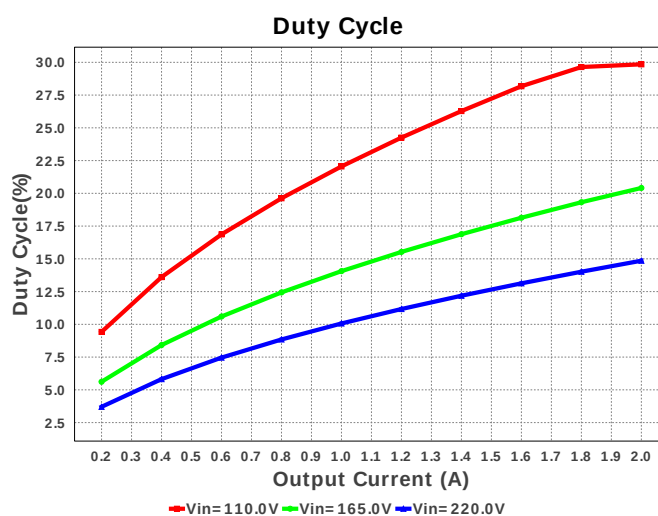
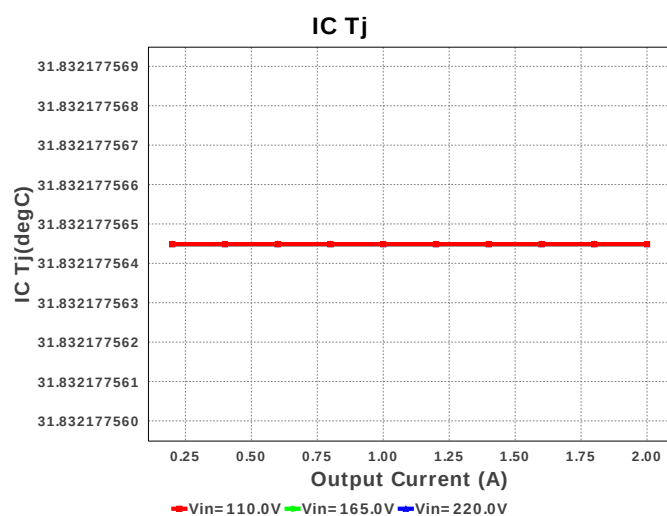
1. Rbld is a starting point, but may need to be experimented with in order to get minimum current needed to hold Vout at no load. Rlc and the feedback resistors may also need adjustment based on the actual transformer used. For more information please click the design assistance button.

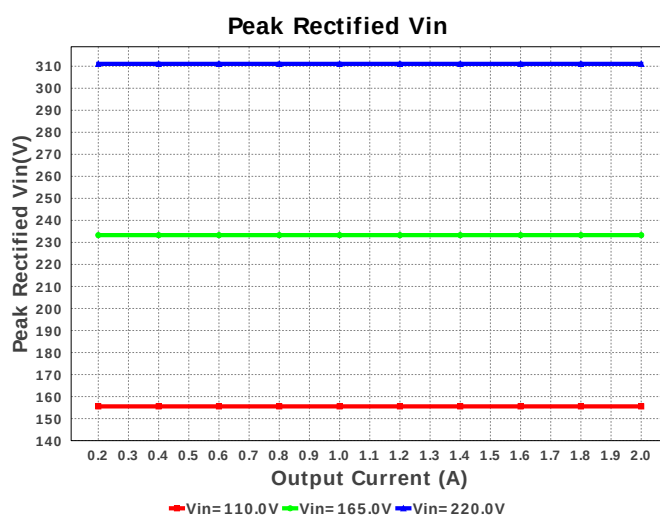
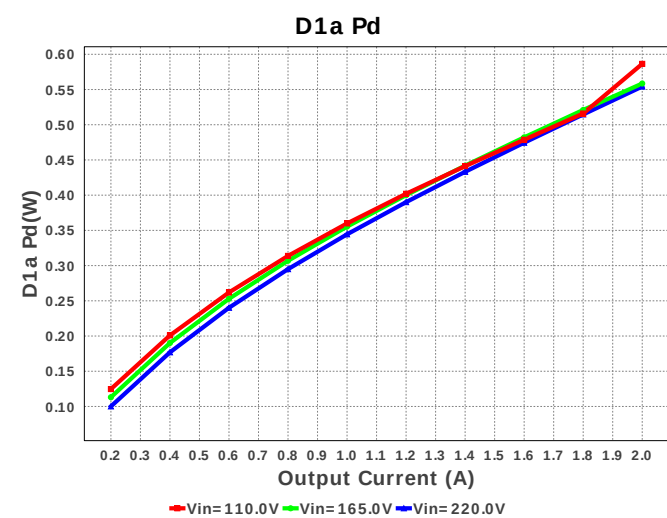
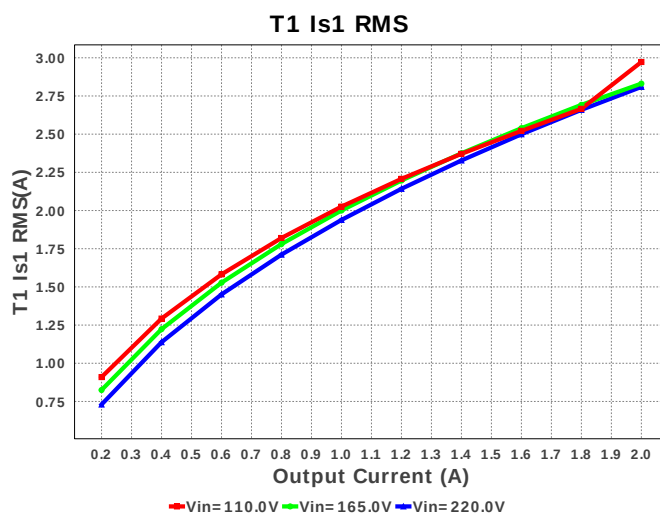
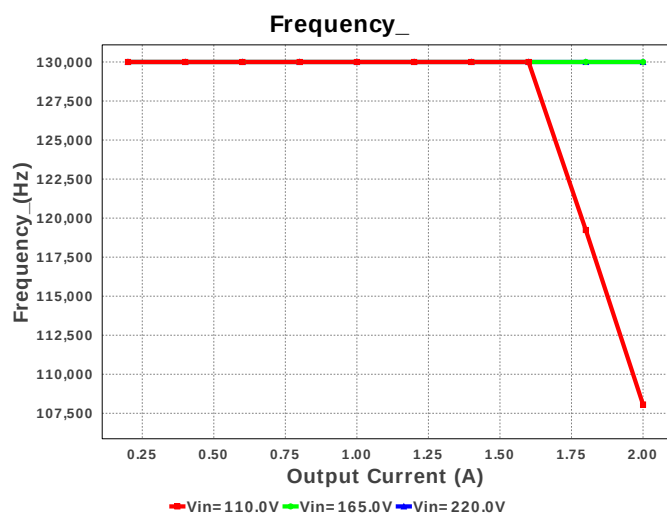
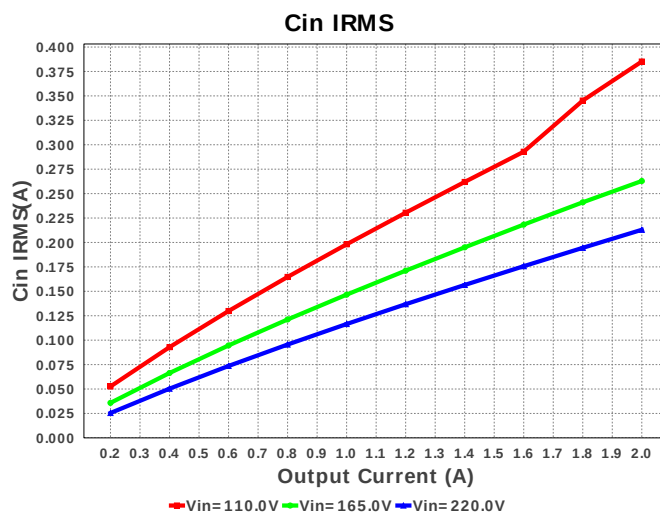
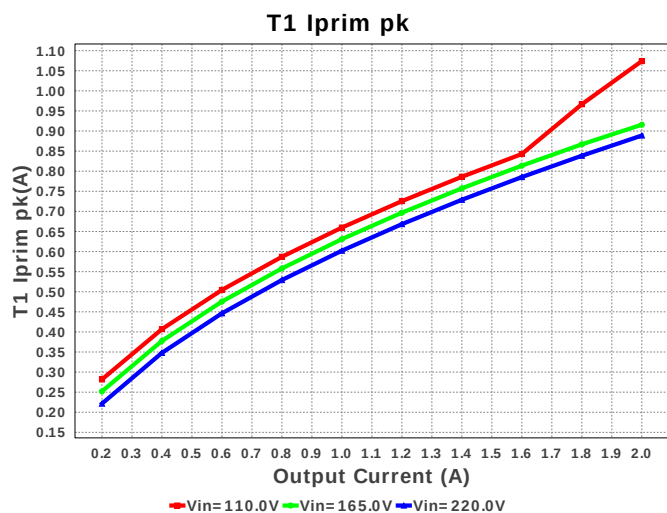
Electrical BOM

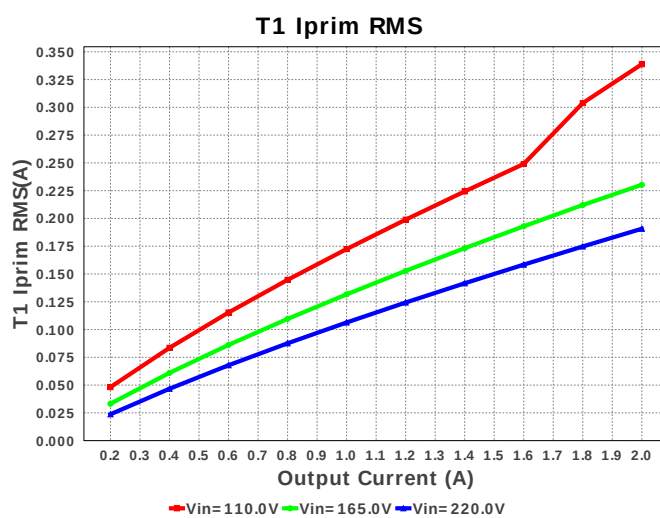
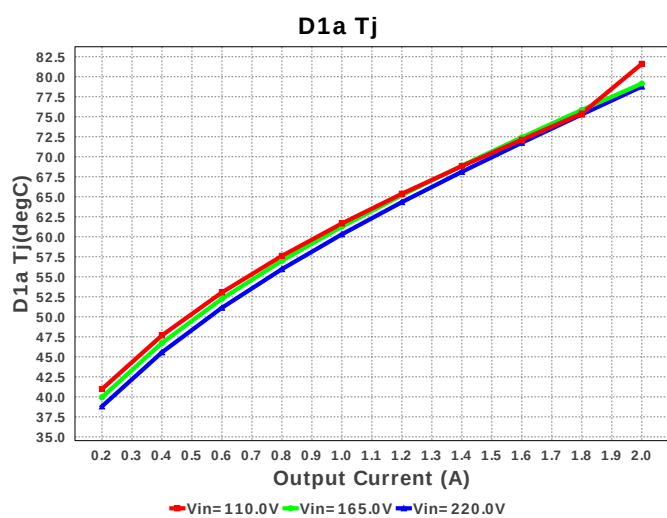
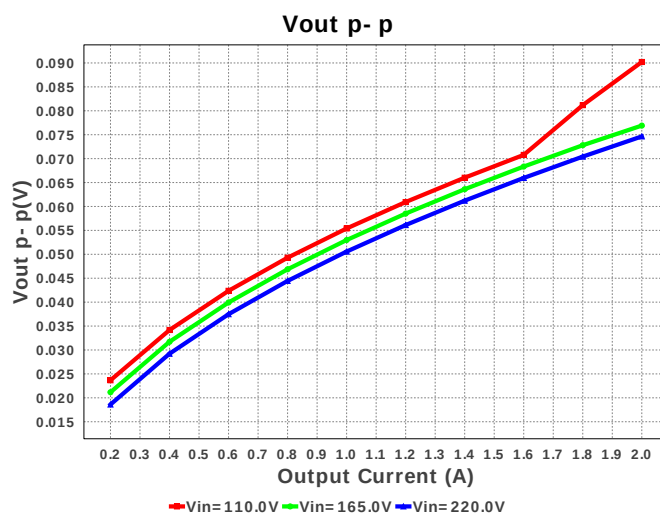
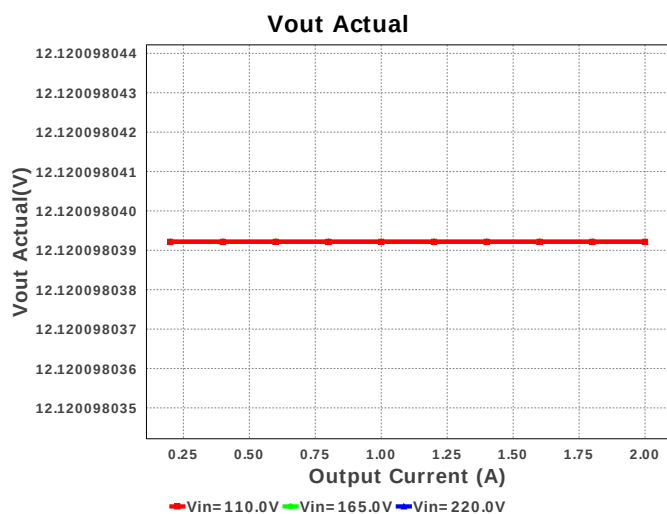
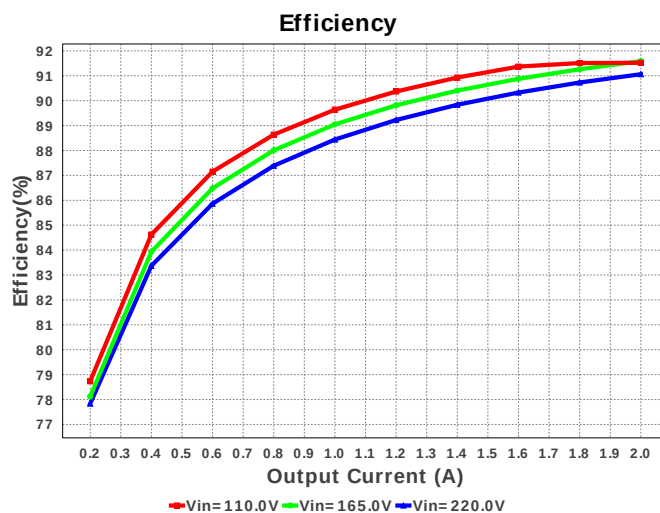
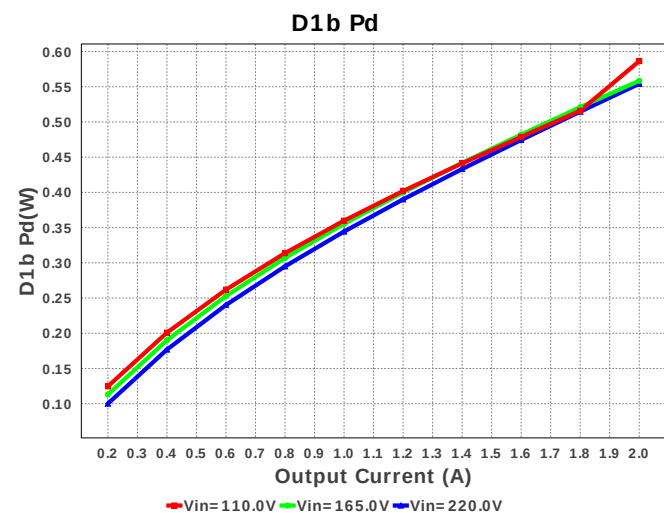
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Ccomp	Kemet	C0805C102K5RACTU Series= X7R	Cap= 1.0 nF ESR= 384.0 mOhm VDC= 50.0 V IRMS= 214.0 mA	1	\$0.01	0805 7 mm ²
2.	Ccs	Kemet	C0201C101K3GACTU Series= C0G/NP0	Cap= 100.0 pF VDC= 10.0 V IRMS= 0.0 A	1	\$0.01	0201 2 mm ²
3.	Cd	Kemet	C0805C680J5GACTU Series= C0G/NP0	Cap= 68.0 pF ESR= 94.0 mOhm VDC= 50.0 V IRMS= 603.0 mA	1	\$0.01	0805 7 mm ²
4.	Cfb	MuRata	GRM155R71E103KA01D Series= X7R	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	0402 3 mm ²
5.	Cgnd	TDK	C3225X7S3D222K Series= X7S	Cap= 2.2 nF ESR= 50.484 mOhm VDC= 2.0 kV IRMS= 0.0 A	1	\$0.22	1210 15 mm ²
6.	Cin	Rubycon	450BXW150MEFC18X45 Series= BXW	Cap= 150.0 uF ESR= 2.21 Ohm VDC= 450.0 V IRMS= 800.0 mA	1	\$1.29	BXW_1800x4500 400 mm ²
7.	Cout	Panasonic	20SVPF390M Series= ?	Cap= 390.0 uF ESR= 14.0 mOhm VDC= 20.0 V IRMS= 4.95 A	1	\$0.63	CAPSMT_62_E12 106 mm ²

#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
8.	Cs _{sub}	MuRata	GRM21AR72E152KW01D Series= X7R	Cap= 1.5 nF VDC= 250.0 V IRMS= 0.0 A	1	\$0.02	 0805 7 mm ²
9.	C _{ss}	MuRata	GRM155R71E103KA01D Series= X7R	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	\$0.01	 0402 3 mm ²
10.	C _{vcc}	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 mm ²
11.	C _{vcc1}	Kemet	C0805C104K5RACTU 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
12.	C _{vcc2}	MuRata	GRM31CR61C226ME15L Series= X5R	Cap= 22.0 uF ESR= 3.637 mOhm VDC= 16.0 V IRMS= 3.4771 A	1	\$0.13	 1206_190 11 mm ²
13.	D _{1a}	Vishay-Semiconductor	SS14-E3/61T	V _F @I _o = 500.0 mV V _{RRM} = 40.0 V	1	\$0.08	 SMA 37 mm ²
14.	D _{1b}	Vishay-Semiconductor	SS14-E3/61T	V _F @I _o = 500.0 mV V _{RRM} = 40.0 V	1	\$0.08	 SMA 37 mm ²
15.	D ₃	Micro Commercial Components	ES1J-TP	V _F @I _o = 1.35 V V _{RRM} = 600.0 V	1	\$0.08	 SMA 37 mm ²
16.	D _{ac}	Vishay-Semiconductor	DF10SA	V _F @I _o = 1.1 V V _{RRM} = 1,000.0 V	1	\$0.24	 DF-S 99 mm ²
17.	D _{snub}	ON Semiconductor	MURS360T3	V _F @I _o = 810.0 mV V _{RRM} = 600.0 V	1	\$1.12	 SMC 83 mm ²
18.	D _{z4}	NXP Semiconductor	BZX585-C22,115	Zener	1	\$0.02	 SOD-523 5 mm ²
19.	M ₁	STMicroelectronics	STW21N90K5	V _{ds} Max= 900.0 V I _{ds} Max= 18.5 Amps	1	\$3.94	 TO-247 123 mm ²
20.	M ₂	Infineon Technologies	IPP65R190CFD	V _{ds} Max= 650.0 V I _{ds} Max= 17.5 Amps	1	\$2.34	TO-220 0 mm ²
21.	O ₁	California Eastern Laboratories	PS2811-1	Optocoupler	1	\$0.38	 SSOP-4 111 mm ²
22.	R _{cs}	Vishay-Dale	CRCW04022K87FKED Series= CRCW..e3	Res= 2.87 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
23.	R _{fb}	Vishay-Dale	CRCW040210K2FKED Series= CRCW..e3	Res= 10.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
24.	R _{fbt}	Vishay-Dale	CRCW040288K7FKED Series= CRCW..e3	Res= 88.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
25.	R _{opto}	Vishay-Dale	CRCW040220K5FKED Series= CRCW..e3	Res= 20.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
26.	R _{qrb}	Vishay-Dale	CRCW04024K22FKED Series= CRCW..e3	Res= 4.22 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²

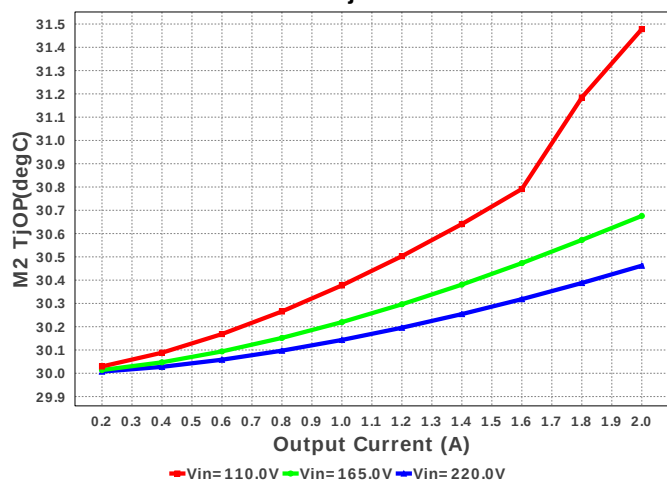
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
27.	Rqrt	Panasonic	ERJ-6ENF1622V Series= ERJ-6E	Res= 16.2 kOhm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 mm ²
28.	Rsense	Rohm	MCR25JZHFLR270 Series= MCR25	Res= 270.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	\$0.03	 1210 15 mm ²
29.	Rsnuh	Panasonic	ERJ-8ENF1432V Series= ERJ-8E	Res= 14.3 kOhm Power= 250.0 mW Tolerance= 1.0%	1	\$0.01	 1206 11 mm ²
30.	Rvcc	Vishay-Dale	CRCW0805100RFKEA Series= CRCW..e3	Res= 100.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	\$0.01	 0805 7 mm ²
31.	Rvin	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
32.	Rvsn	Vishay-Dale	CRCW04022M00FKED Series= CRCW..e3	Res= 2.0 MOhm Power= 63.0 mW Tolerance= 1.0%	1	\$0.01	 0402 3 mm ²
33.	T1	Würth Elektronik	750313417	Lp= 400.0 µH Rp= 355.0 mOhm Leakage_L= 4.0 µH Ns1toNp= 0.167 Rs1= 13.67 mOhms Ns2toNp= 0.091 Rs2= 40.0 mOhms	1	NA	 WE-DD-L 210 mm ²
34.	U1	Texas Instruments	LM5023MM-2/NOPB	Switcher	1	\$0.38	 MUA08A 24 mm ²
35.	VR	Texas Instruments	TL431AIDBVR	Voltage References	1	\$0.07	 R-PDSO-G3 16 mm ²



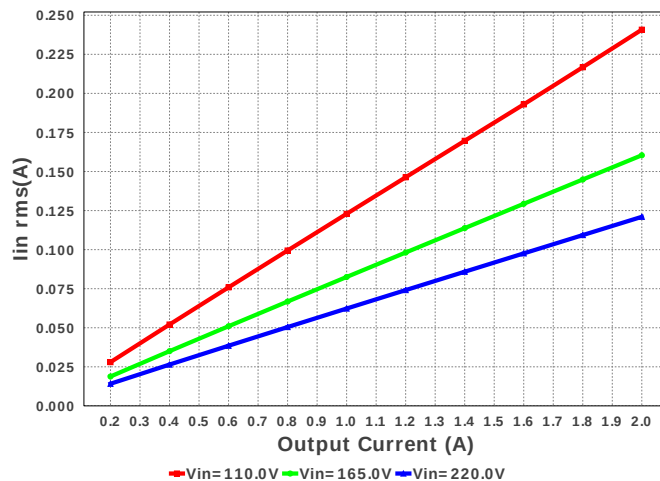




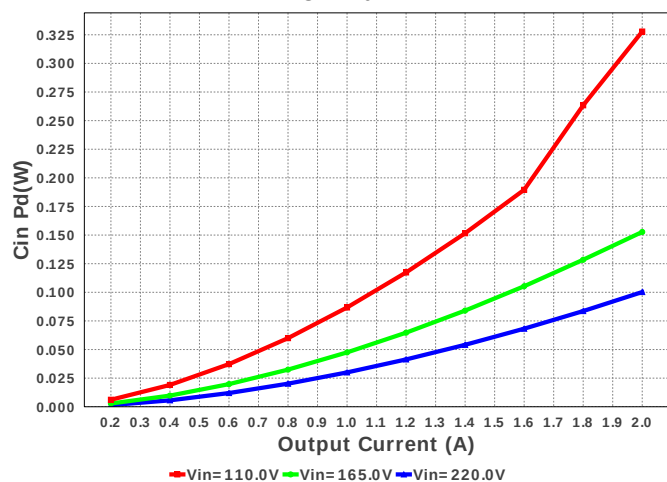
M2 TjOP



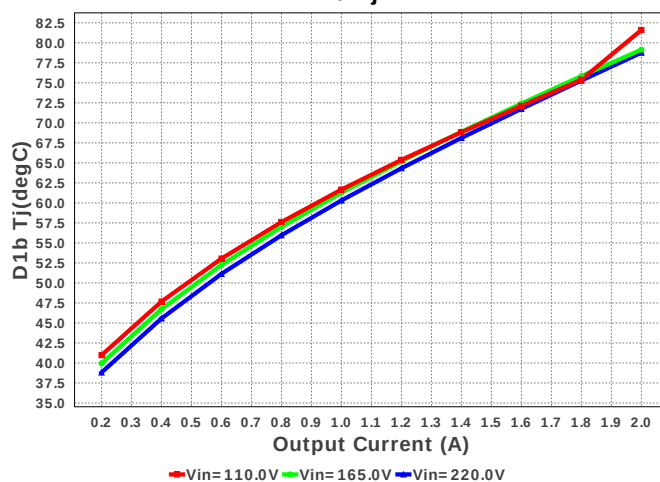
lin rms



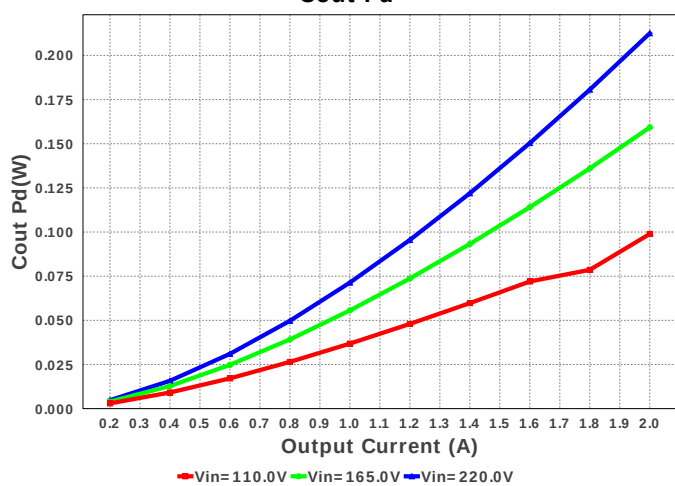
Cin Pd



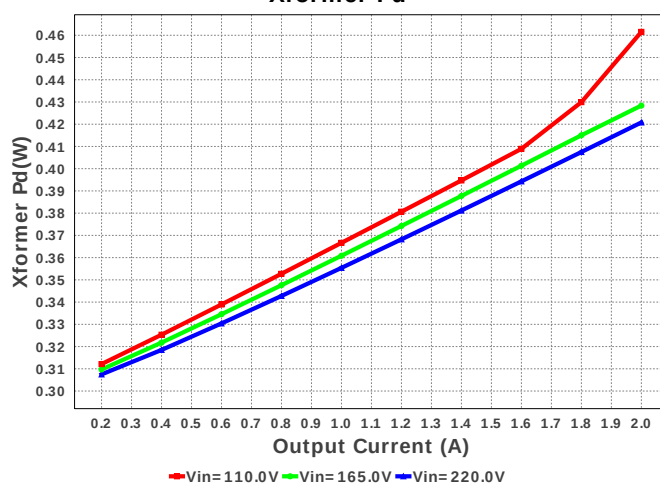
D1b Tj

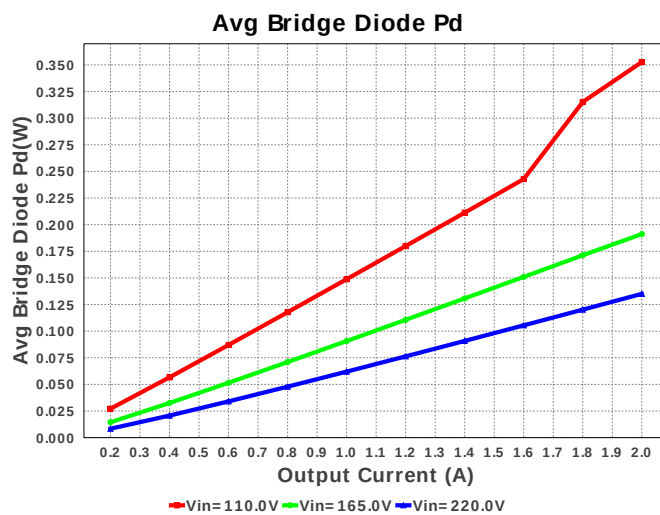
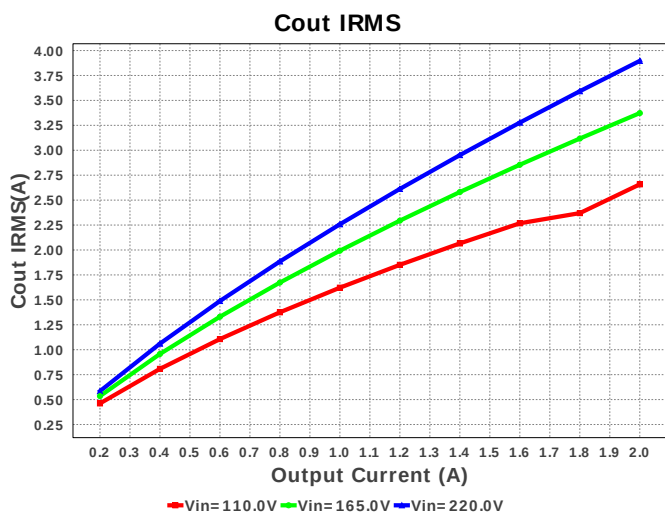
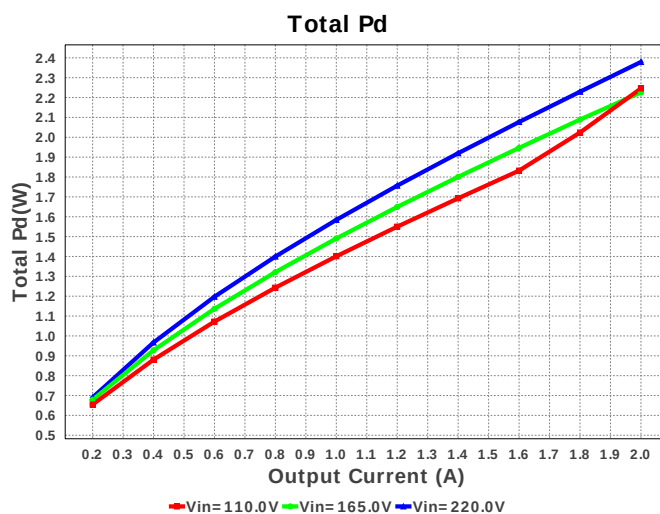
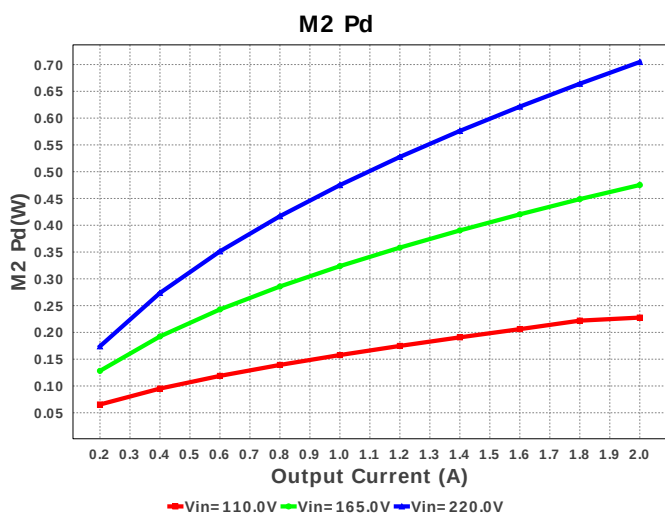
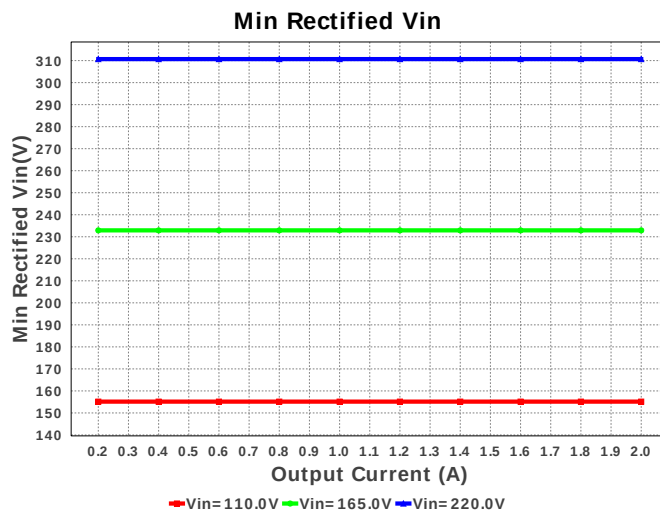
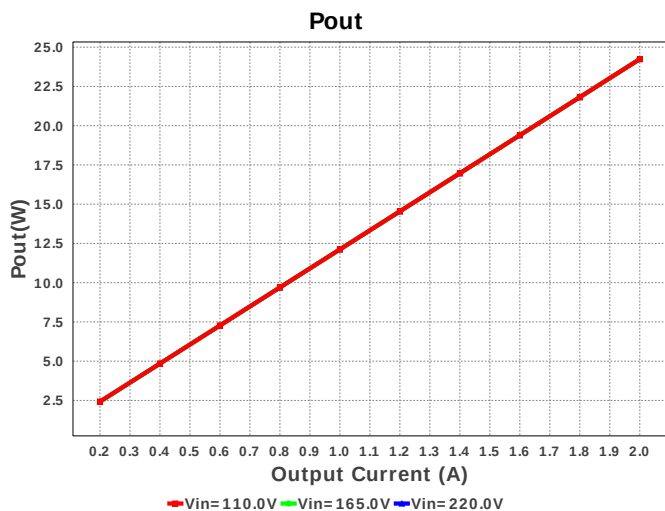


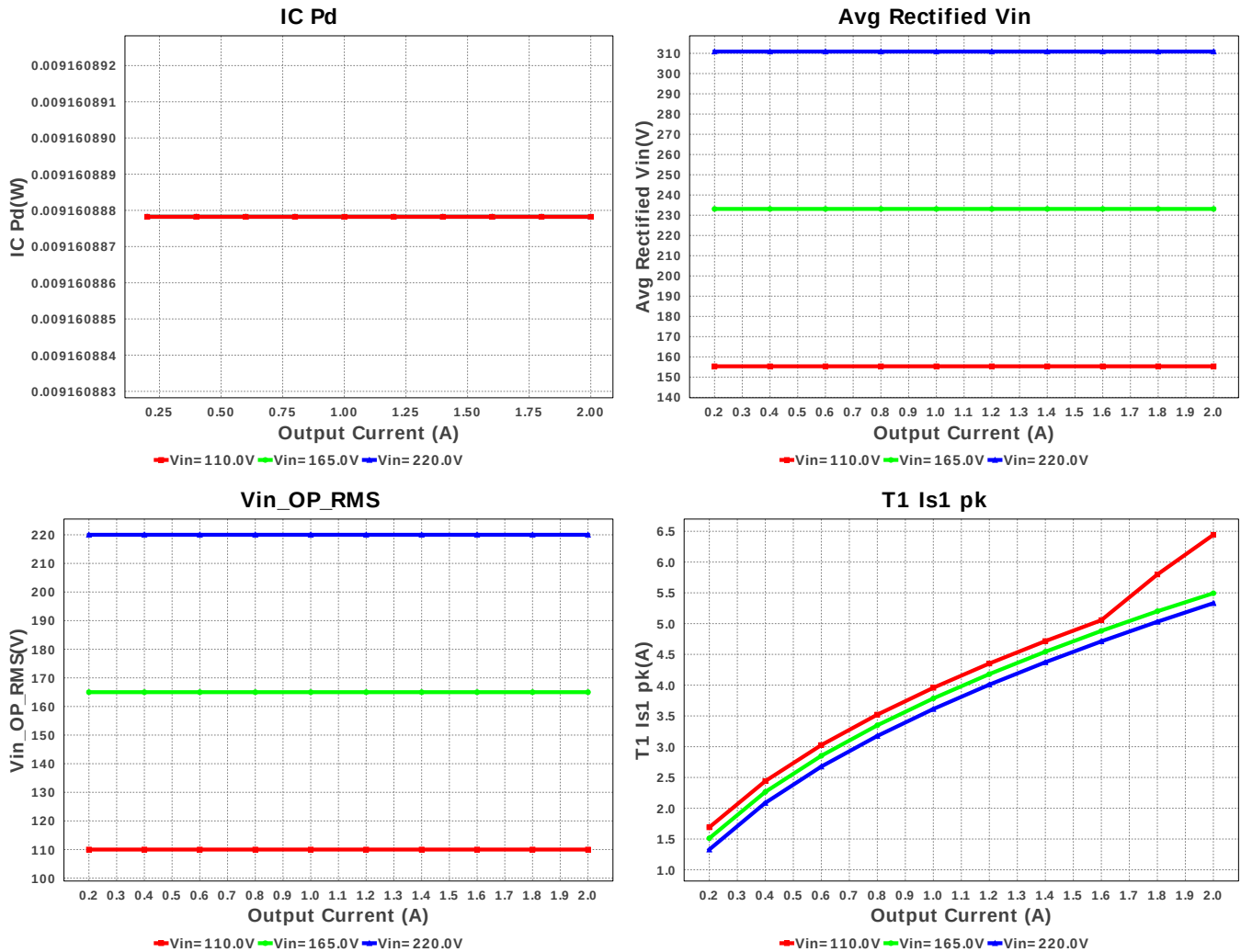
Cout Pd



Xformer Pd







Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	566.739 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	2.123 A	Current	Output capacitor RMS ripple current
3.	Iin rms	234.56 mA	Current	RMS Input Current
4.	T1 Iprim RMS	469.786 mA	Current	Transformer Primary RMS Current
5.	T1 Iprim pk	1.287 A	Current	Transformer Primary Peak Current
6.	T1 Is1 RMS	3.96 A	Current	Transformer Secondary1 RMS Current
7.	T1 Is1 pk	7.719 A	Current	Transformer Secondary1 Peak Current
8.	Avg Rectified Vin	310.88 V	General	Average Rectified Voltage for the AC Line Period
9.	BOM Count	35	General	Total Design BOM count
10.	FootPrint	1.517 k mm ²	General	Total Foot Print Area of BOM components
11.	Pout	48.383 W	General	Total output power
12.	Total BOM	\$0.0	General	Total BOM Cost
13.	D1 Tj	98.749 degC	Op_Point	D1 junction temperature
14.	D1 Tj	98.749 degC	Op_Point	D1 junction temperature
15.	Vout Actual	24.192 V	Op_Point	Vout Actual calculated based on selected voltage divider resistors
16.	Vout OP	24.192 V	Op_Point	Operational Output Voltage
17.	Duty Cycle	43.018 %	Op_point	Duty cycle
18.	Efficiency	93.762 %	Op_point	Steady state efficiency
19.	Frequency	130.0 kHz	Op_point	Switching frequency
20.	IC Tj	33.874 degC	Op_point	IC junction temperature
21.	ICThetaJA	200.0 degC/W	Op_point	IC junction-to-ambient thermal resistance
22.	IOUT_OP	2.0 A	Op_point	Iout operating point
23.	M2 TjOP	32.895 degC	Op_point	M2 MOSFET junction temperature
24.	Min Rectified Vin	310.68 V	Op_point	Minimum voltage seen at rectified input
25.	Peak Rectified Vin	311.08 V	Op_point	Peak voltage seen at rectified input
26.	Vin_OP_RMS	220.0 V	Op_point	AC Input RMS Voltage
27.	Vout p-p	108.064 mV	Op_point	Peak-to-peak output ripple voltage
28.	Avg Bridge Diode Pd	387.753 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
29.	Cin Pd	709.836 mW	Power	Input capacitor power dissipation
30.	Cout Pd	63.072 mW	Power	Output capacitor power dissipation
31.	Diode1 Pd	781.234 mW	Power	Diode1 power dissipation

#	Name	Value	Category	Description
32.	Diode1 Pd	781.234 mW	Power	Diode1 power dissipation
33.	IC Pd	19.369 mW	Power	IC power dissipation
34.	M2 Pd	616.3 mW	Power	M2 MOSFET total power dissipation
35.	Total Pd	3.219 W	Power	Total Power Dissipation
36.	Xformer Pd	592.725 mW	Power	Transformer power dissipation
37.	Vout Tolerance	2.138 %		Vout Tolerance based on IC Tolerance (no load) and voltage divider resistors if applicable

Design Inputs

#	Name	Value	Description
1.	Iout	2.0	Maximum Output Current
2.	VinMax	220.0	Maximum input voltage
3.	VinMin	110.0	Minimum input voltage
4.	Vout	24.0	Output Voltage
5.	line_fsw	60.0	Light Output in Lumen
6.	base_pn	LM5023	Base Product Number
7.	source	AC	Input Source Type
8.	Ta	30.0	Ambient temperature

Design Assistance

1. The feedback resistors will set the output voltage of the circuit. The values chosen may need to be fine tuned based on the final Transformer turns ratios and the voltage across the output diode at close to zero current. Please see the datasheet for further design guidance. <http://www.ti.com/lit/ds/symlink/lm5023.pdf>

2. **LM5023 Product Folder** : <http://www.ti.com/product/LM5023> : 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](#).