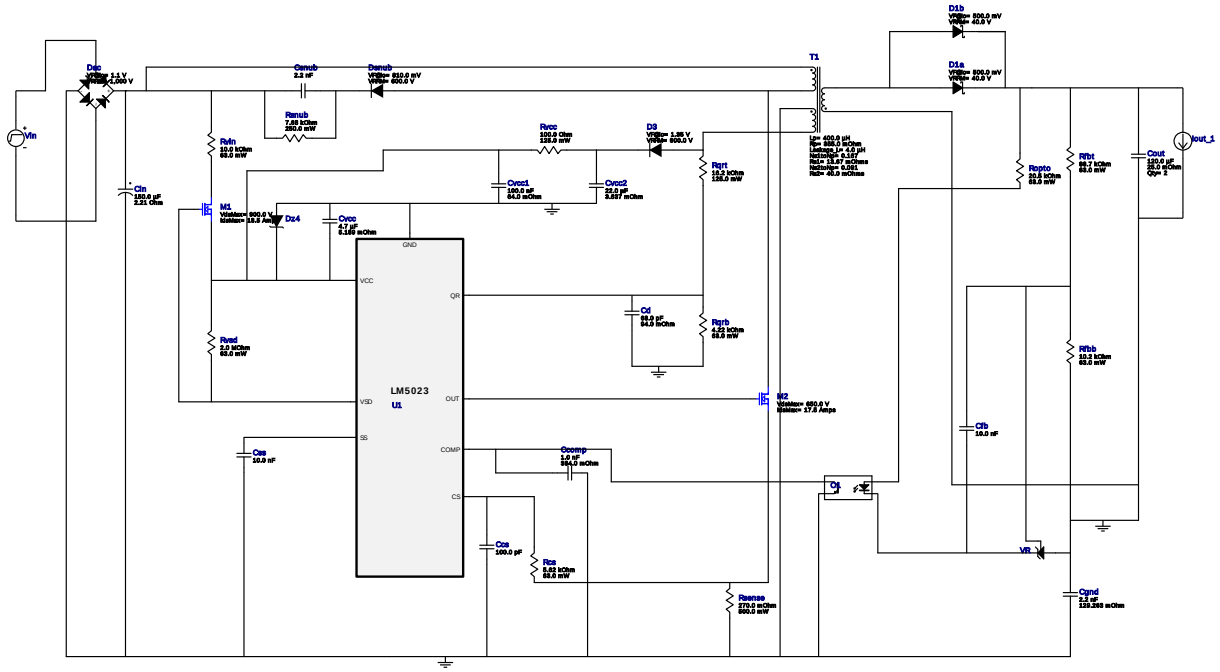
VinMin = 85.0V
VinMax = 220.0V
Vout = 24.0V
Iout = 2.0A

Device = LM5023MM-2/NOPB
Topology = Flyback
Created = 7/29/16 1:15:32 AM
BOM Cost = $0.00
BOM Count = 36
Total Pd = 3.39W

WEBENCH® Design Report

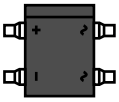
Design : 1996644/6 LM5023MM-2/NOPB
LM5023MM-2/NOPB 85.0V-220.0V to 24.19V @ 2.0A

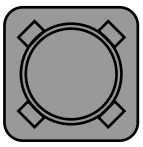


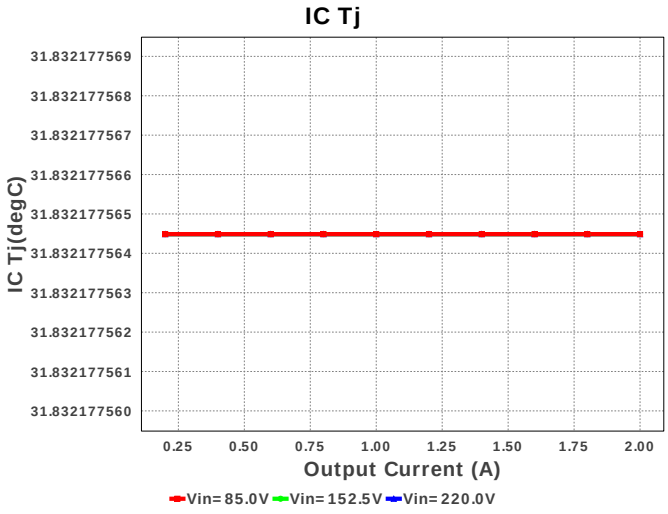
1. Rbld is a starting point, but may need to be experimented with in order to get minimum current needed to hold Vout at no load. Rlc and the feedback resistors may also need adjustment based on the actual transformer used. For more information please click the design assistance button.

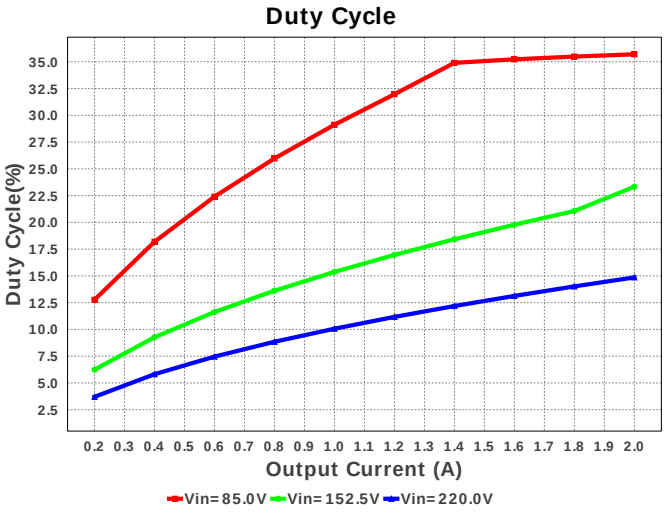
Electrical BOM

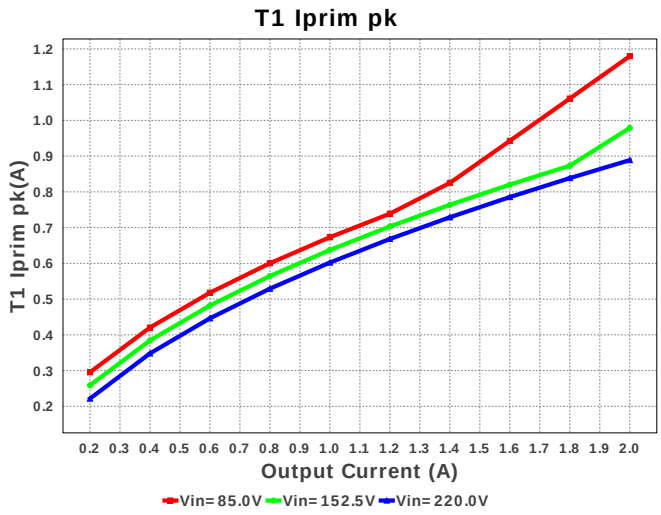
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
1.	Ccomp	Kemet	C0805C102K5RACTU Series= X7R	Cap= 1.0 nF ESR= 384.0 mOhm VDC= 50.0 V IRMS= 214.0 mA	1	$0.01	0805 7 mm^2
2.	Ccs	Kemet	C0201C101K3GACTU Series= C0G/NP0	Cap= 100.0 pF VDC= 10.0 V IRMS= 0.0 A	1	$0.01	0201 2 mm^2
3.	Cd	Kemet	C0805C680J5GACTU 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	C4532JB3D222K Series= JB	Cap= 2.2 nF ESR= 129.263 mOhm VDC= 2.0 kV IRMS= 0.0 A	1	$0.16	1812 23 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	20SVPF120M Series= ?	Cap= 120.0 uF ESR= 25.0 mOhm VDC= 20.0 V IRMS= 3.2 A	2	$0.43	CAPSMT_62_F61 74 mm^2

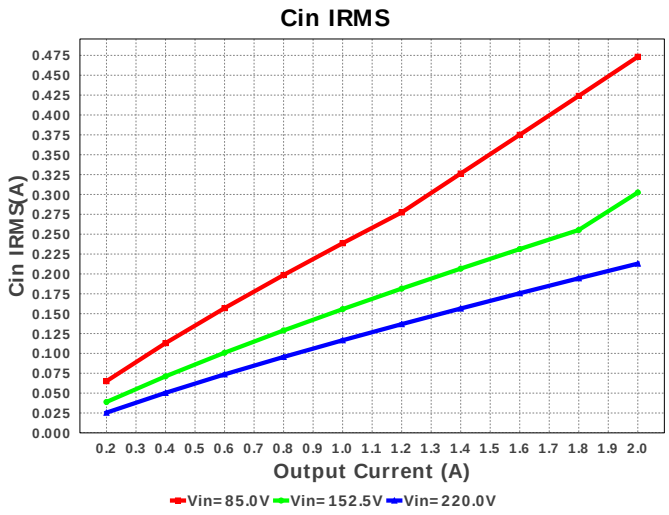
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
8.	Csnub	MuRata	GRM21AR72E222KW01D Series= X7R	Cap= 2.2 nF VDC= 250.0 V IRMS= 0.0 A	1	$0.02	 0805 7 mm²
9.	Css	MuRata	GRM155R71E103KA01D Series= X7R	Cap= 10.0 nF VDC= 25.0 V IRMS= 0.0 A	1	$0.01	 0402 3 mm²
10.	Cvcc	MuRata	GRM21BR61E475KA12L Series= X5R	Cap= 4.7 uF ESR= 5.189 mOhm VDC= 25.0 V IRMS= 2.03531 A	1	$0.02	 0805 7 mm²
11.	Cvcc1	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 mm²
12.	Cvcc2	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 mm²
13.	D1a	Vishay-Semiconductor	SS14-E3/61T	VF@Io= 500.0 mV VRRM= 40.0 V	1	$0.08	 SMA 37 mm²
14.	D1b	Vishay-Semiconductor	SS14-E3/61T	VF@Io= 500.0 mV VRRM= 40.0 V	1	$0.08	 SMA 37 mm²
15.	D3	Micro Commercial Components	ES1J-TP	VF@Io= 1.35 V VRRM= 600.0 V	1	$0.08	 SMA 37 mm²
16.	Dac	Vishay-Semiconductor	DF10SA	VF@Io= 1.1 V VRRM= 1,000.0 V	1	$0.24	 DF-S 99 mm²
17.	Dsnub	ON Semiconductor	MURS360T3	VF@Io= 810.0 mV VRRM= 600.0 V	1	$1.12	 SMC 83 mm²
18.	Dz4	NXP Semiconductor	BZX585-C22,115	Zener	1	$0.02	 SOD-523 5 mm²
19.	M1	STMicroelectronics	STW21N90K5	VdsMax= 900.0 V IdsMax= 18.5 Amps	1	$3.94	 TO-247 123 mm²
20.	M2	Infineon Technologies	IPP65R190CFD	VdsMax= 650.0 V IdsMax= 17.5 Amps	1	$2.34	TO-220 0 mm²
21.	O1	California Eastern Laboratories	PS2811-1	Optocoupler	1	$0.38	 SSOP-4 111 mm²
22.	Rcs	Vishay-Dale	CRCW04025K62FKED Series= CRCW..e3	Res= 5.62 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
23.	Rfbb	Vishay-Dale	CRCW040210K2FKED Series= CRCW..e3	Res= 10.2 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
24.	Rfbt	Vishay-Dale	CRCW040288K7FKED Series= CRCW..e3	Res= 88.7 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
25.	Ropto	Vishay-Dale	CRCW040220K5FKED Series= CRCW..e3	Res= 20.5 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²
26.	Rqrb	Vishay-Dale	CRCW04024K22FKED Series= CRCW..e3	Res= 4.22 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	 0402 3 mm²

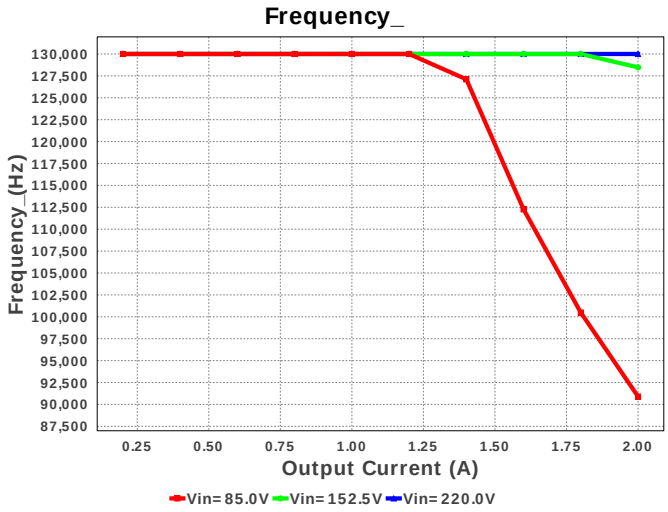
#	Name	Manufacturer	Part Number	Properties	Qty	Price	Footprint
27.	Rqrt	Panasonic	ERJ-6ENF1622V Series= ERJ-6E	Res= 16.2 kOhm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
28.	Rsense	Rohm	MCR25JZHFLR270 Series= MCR25	Res= 270.0 mOhm Power= 500.0 mW Tolerance= 1.0%	1	$0.03	1210 15 mm²
29.	Rsnub	Panasonic	ERJ-8ENF7681V Series= ERJ-8E	Res= 7.68 kOhm Power= 250.0 mW Tolerance= 1.0%	1	$0.01	1206 11 mm²
30.	Rvcc	Vishay-Dale	CRCW0805100RFKEA Series= CRCW..e3	Res= 100.0 Ohm Power= 125.0 mW Tolerance= 1.0%	1	$0.01	0805 7 mm²
31.	Rvin	Vishay-Dale	CRCW040210K0FKED Series= CRCW..e3	Res= 10.0 kOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
32.	Rvsd	Vishay-Dale	CRCW04022M00FKED Series= CRCW..e3	Res= 2.0 MOhm Power= 63.0 mW Tolerance= 1.0%	1	$0.01	0402 3 mm²
33.	T1	Wurth 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 mm²
34.	U1	Texas Instruments	LM5023MM-2/NOPB	Switcher	1	$0.38	 MUA08A 24 mm²
35.	VR	Texas Instruments	TL431AIDBVR	Voltage References	1	$0.07	 R-PDSO-G3 16 mm²

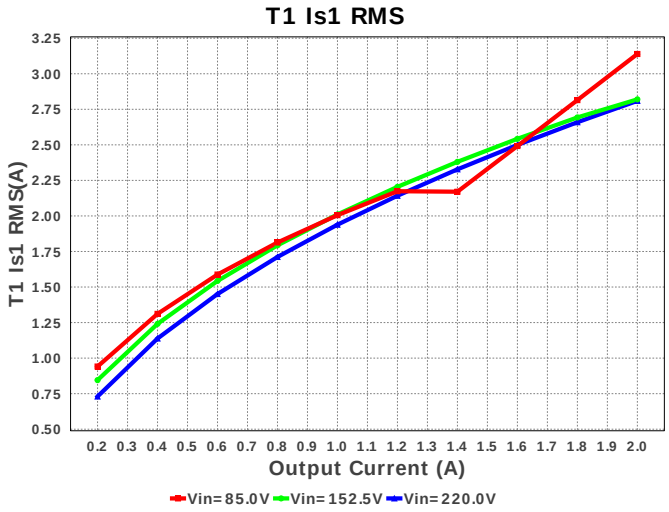


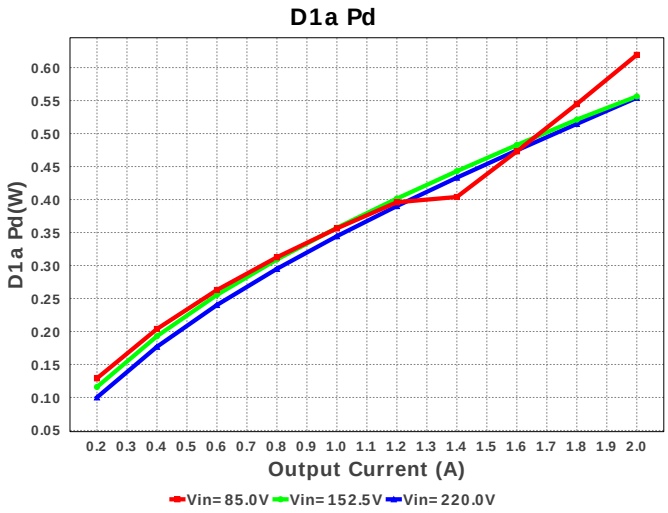


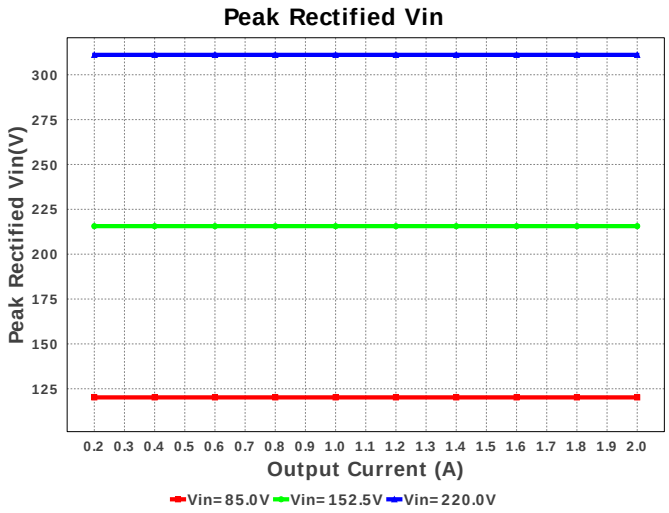


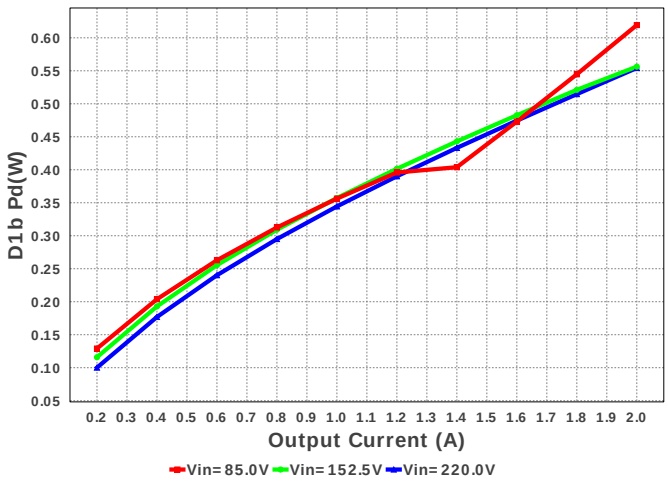


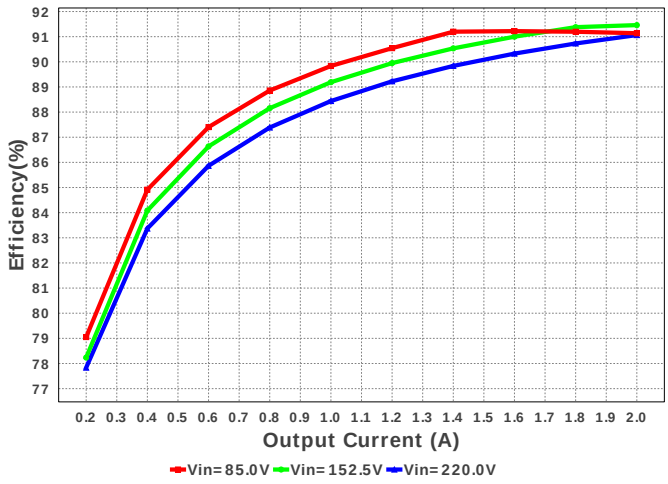


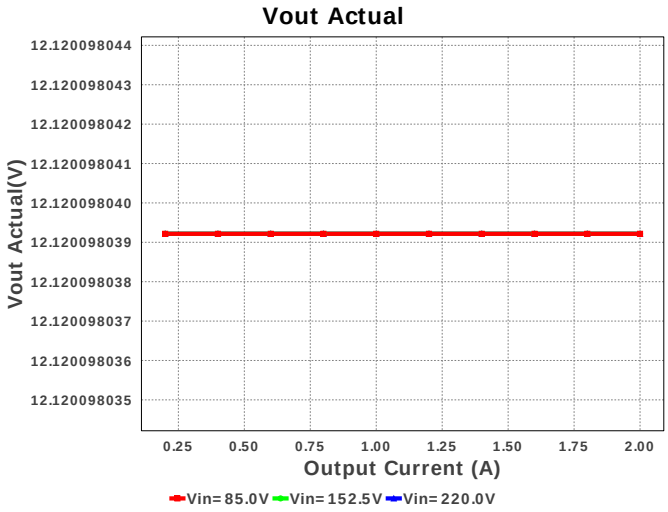


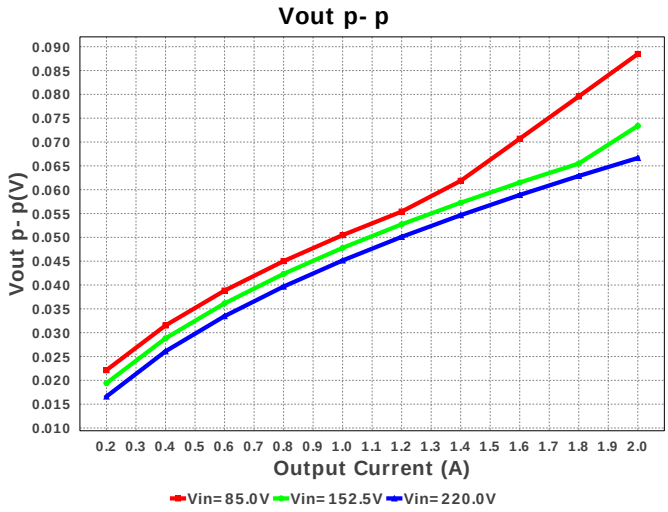


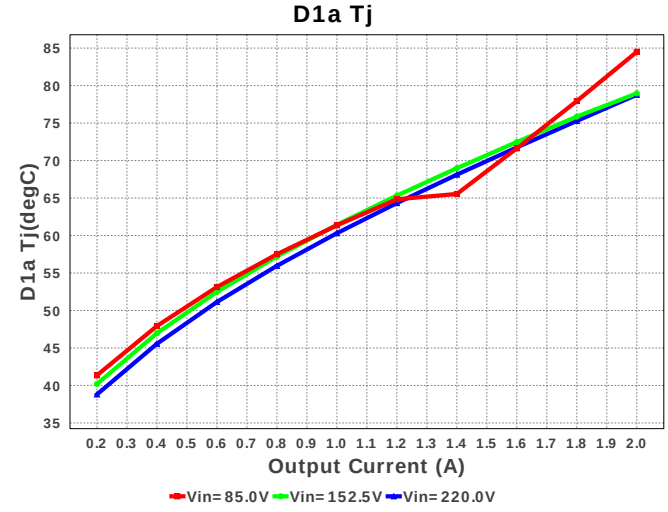


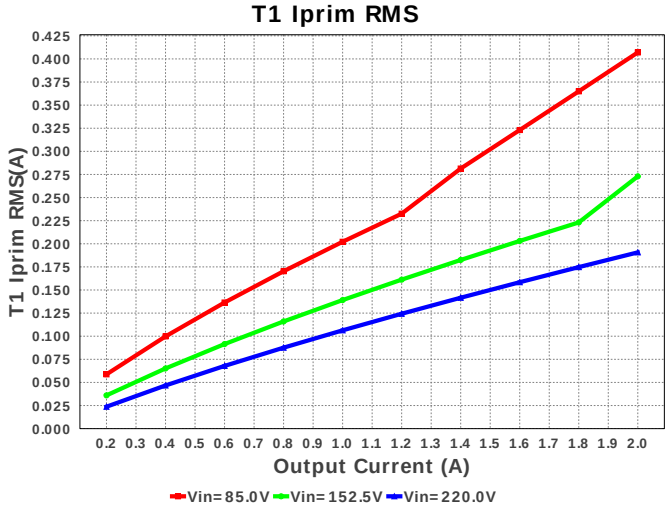


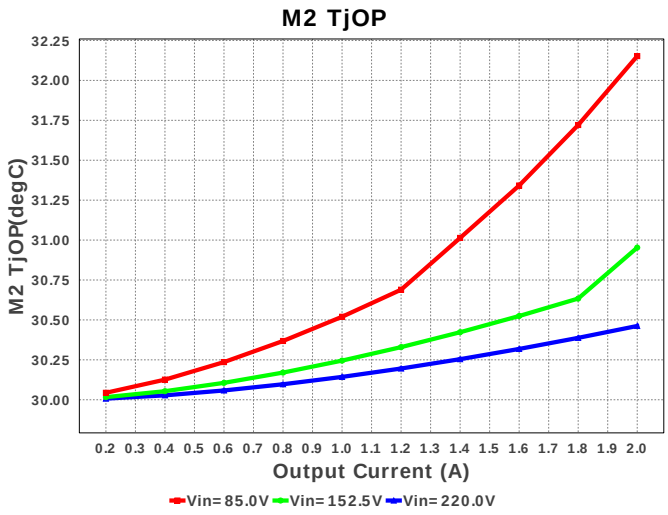


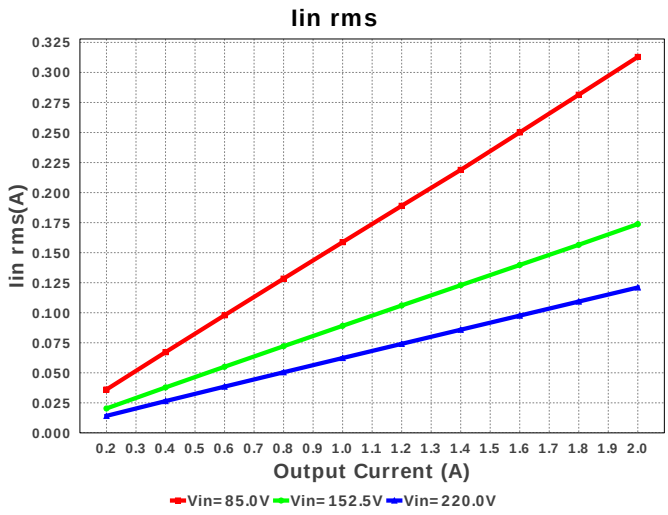


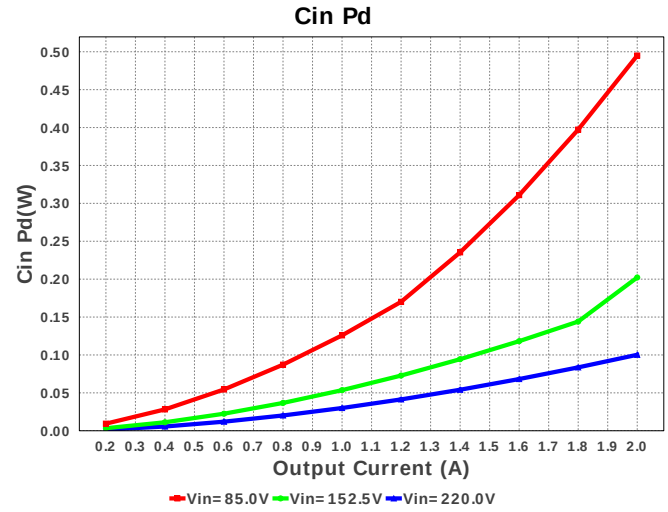


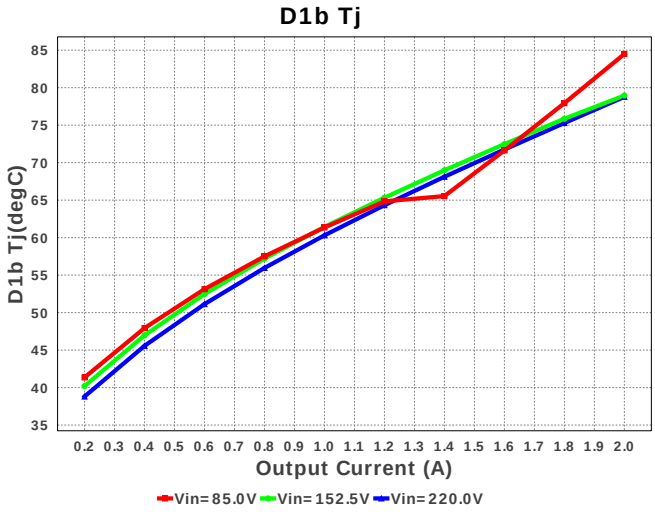


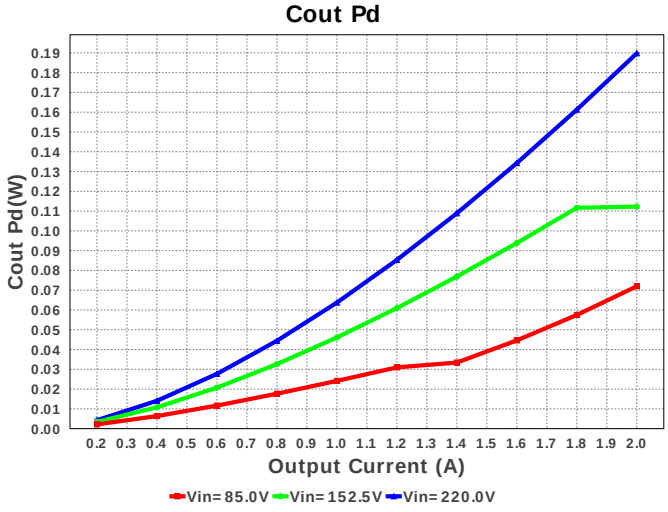


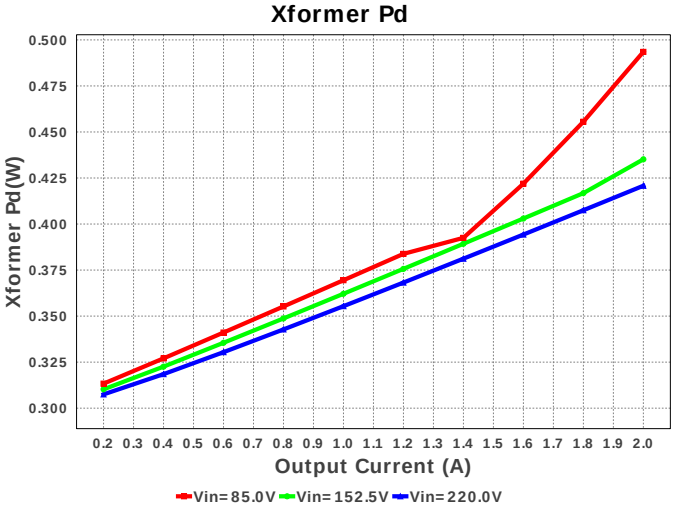

M2 TjOP
M2 TjOP(degC)
32.25
32.00
31.75
31.50
31.25
31.00
30.75
30.50
30.25
30.00
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 85.0V
Vin= 152.5V
Vin= 220.0V

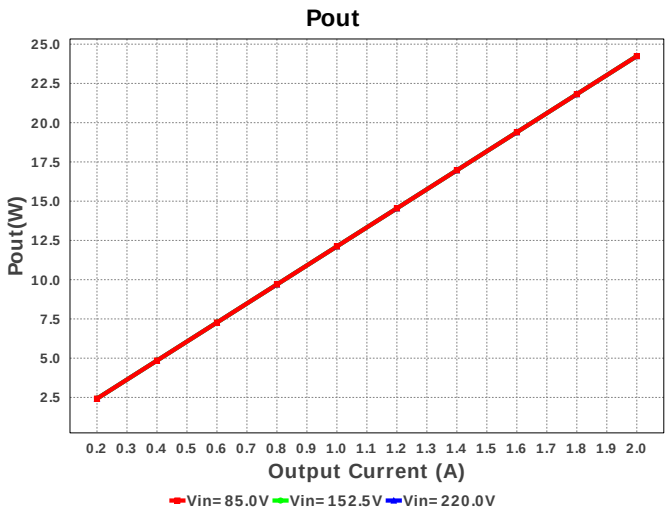

Iin rms
Iin rms(A)
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 85.0V
Vin= 152.5V
Vin= 220.0V

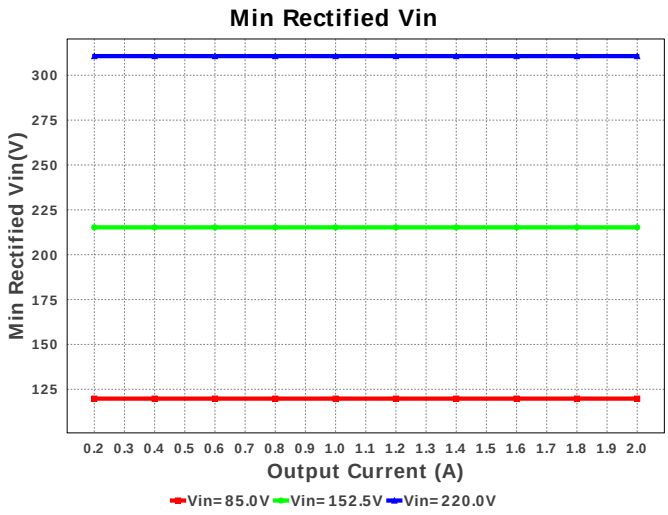

Cin Pd
Cin Pd(W)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 85.0V
Vin= 152.5V
Vin= 220.0V

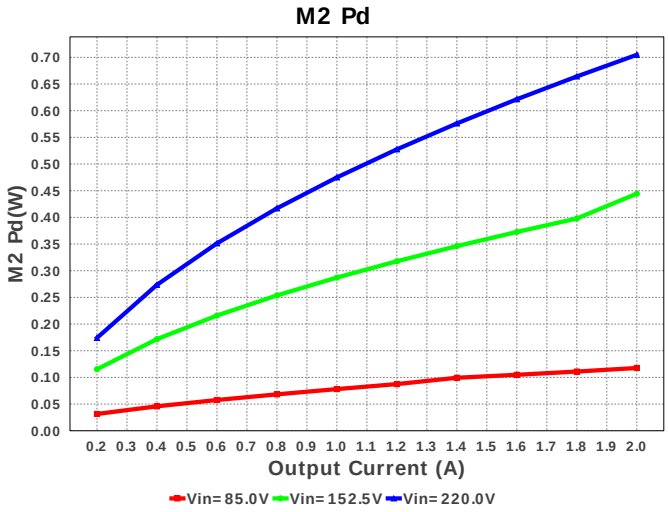

D1b Tj
D1b Tj(degC)
85
80
75
70
65
60
55
50
45
40
35
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 85.0V
Vin= 152.5V
Vin= 220.0V

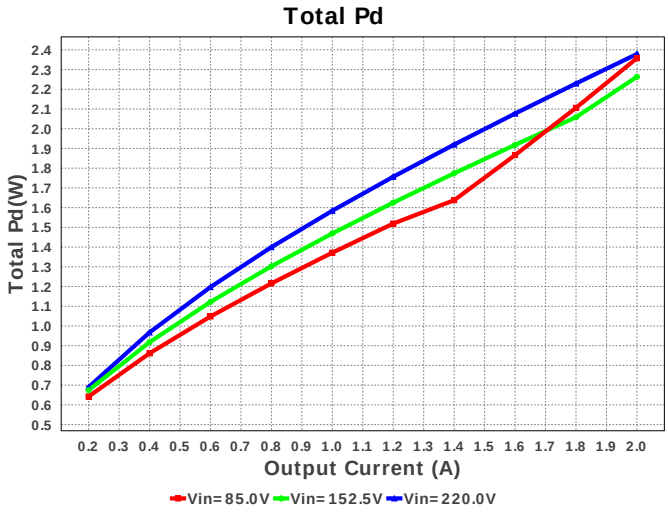

Cout Pd
Cout Pd(W)
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 85.0V
Vin= 152.5V
Vin= 220.0V

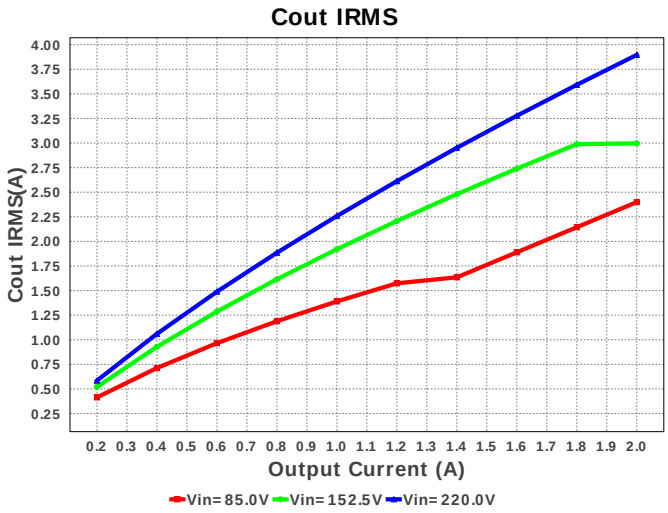

Xformer Pd
Xformer Pd(W)
0.500
0.475
0.450
0.425
0.400
0.375
0.350
0.325
0.300
0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Output Current (A)
Vin= 85.0V
Vin= 152.5V
Vin= 220.0V

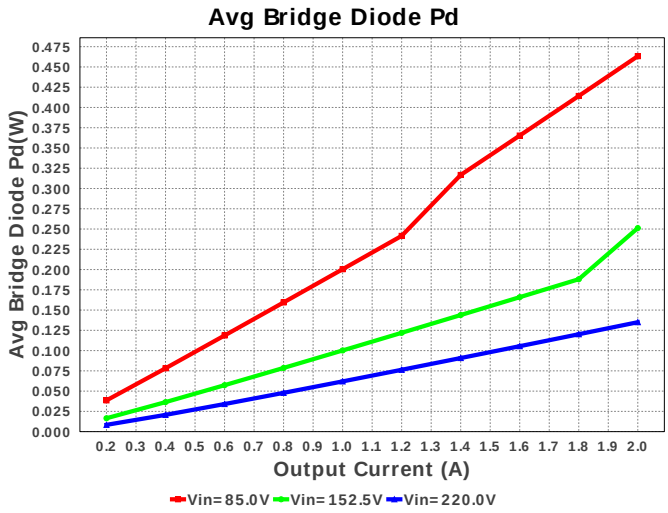


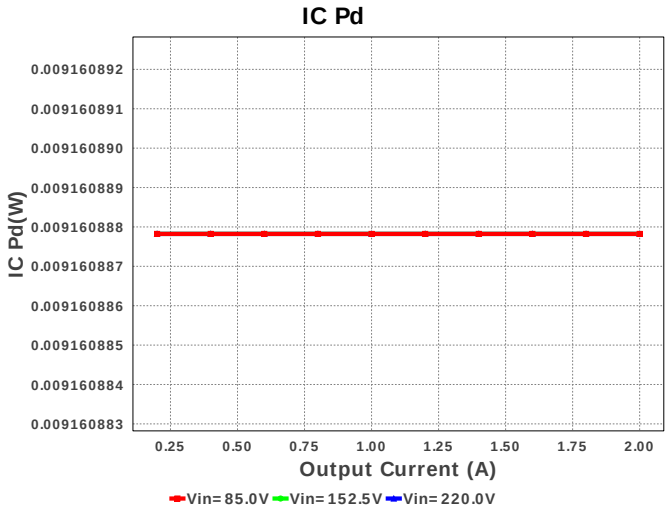


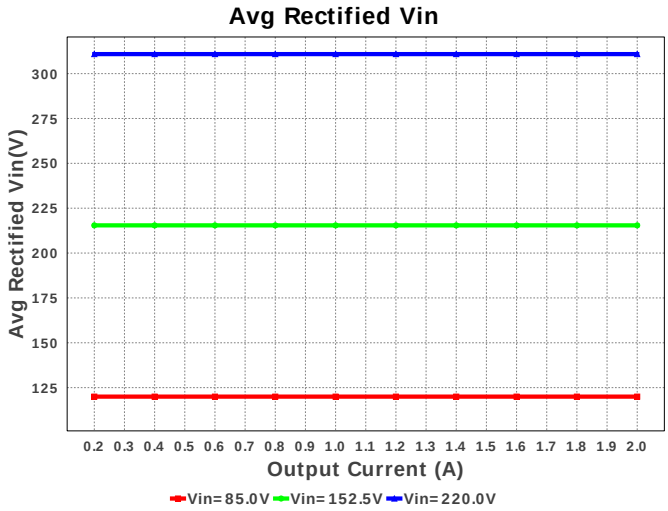


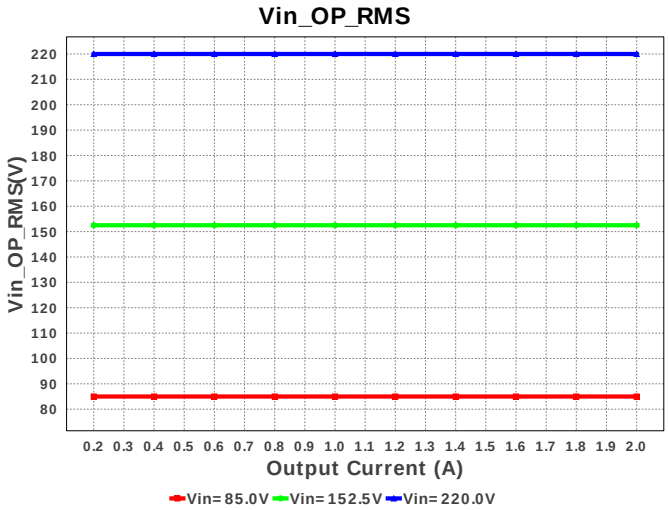


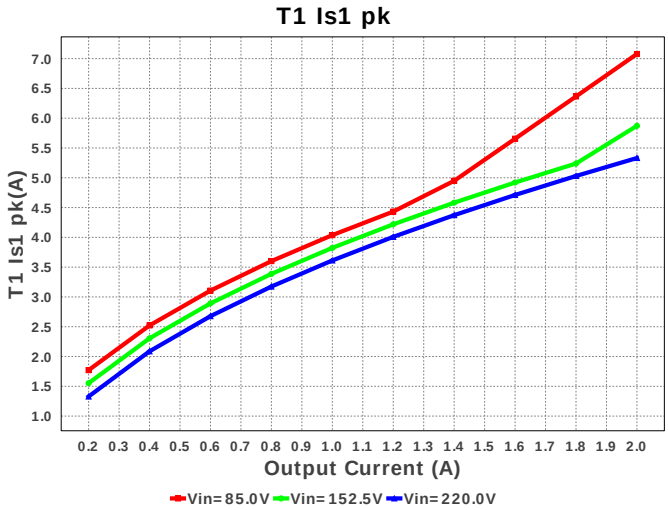












Operating Values

#	Name	Value	Category	Description
1.	Cin IRMS	667.519 mA	Current	Input capacitor RMS ripple current
2.	Cout IRMS	1.671 A	Current	Output capacitor RMS ripple current
3.	Iin rms	235.35 mA	Current	RMS Input Current
4.	T1 Iprim RMS	536.0 mA	Current	Transformer Primary RMS Current
5.	T1 Iprim pk	1.289 A	Current	Transformer Primary Peak Current
6.	T1 Is1 RMS	3.967 A	Current	Transformer Secondary1 RMS Current
7.	T1 Is1 pk	7.734 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	36	General	Total Design BOM count
10.	FootPrint	1.567 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	98.872 degC	Op_Point	D1 junction temperature
14.	D1 Tj	98.872 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	55.78 %	Op_point	Duty cycle
18.	Efficiency	93.445 %	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	33.814 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	96.676 mV	Op_point	Peak-to-peak output ripple voltage
28.	Avg Bridge Diode Pd	503.77 mW	Power	Average Power Dissipation in the Bridge Diode over the AC Line Period
29.	Cin Pd	984.735 mW	Power	Input capacitor power dissipation
30.	Cout Pd	34.899 mW	Power	Output capacitor power dissipation
31.	Diode1 Pd	782.631 mW	Power	Diode1 power dissipation

#	Name	Value	Category	Description
32.	Diode1 Pd	782.631 mW	Power	Diode1 power dissipation
33.	IC Pd	19.369 mW	Power	IC power dissipation
34.	M2 Pd	630.081 mW	Power	M2 MOSFET total power dissipation
35.	Total Pd	3.394 W	Power	Total Power Dissipation
36.	Xformer Pd	617.135 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	85.0	Minimum input voltage
4.	Vout	24.0	Output Voltage
5.	line_fsw	0.0	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 fined 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.