Objective:

Create a linear power supply that converts 220v AC and 50Hz frequency to variable 0 to 15v DC (3A max)

Process questions:

Is the voltage AC of Tunisia Vrms 220V or Vpeak 220 ?

220v is the Vrms and Vpeak is 311 V

How much optimal voltage AC do I need after the transformer to minimize heat ?

- LM317 needs Vin = Vout + 3 ➔ Vin = 15 + 3 = 18v
- Bridge rectifier drop 1 each diode so 2V for 1b4b42
- After rectifier + capacitor, the voltage is **not constant.**

So LM317 does **not** see only the peak.
It sees a waveform like:

Top = Vpeak

Bottom = Vpeak – V ripple

Vmin=Vpeak(after bridge)−Vripple ≥ 18V

Vac is RMS voltage at transformer so We need to calculate it:

Vmin >= (1.414 * Vac – 2) – Vripple

1.414 * Vac = Vmin + Vripple + 2

Vac = (Vmin + Vripple + 2) / 1.414

Vac = (18 + 2 + Vripple) / 1.414

Vac >= (20 + Vripple) / 1.414

So lets choose a filter capacitor for a maximum load of 3A

F = 100 Hz = 50 * 2 because of bridge rectifier

Vripple = I (max) / (f * C)

Vripple = 3 / (100 * C)

(100 * c) * Vripple = 3

100 * C = 3 / Vripple

C = 3 / 100 * Vripple

We gonna Allow a Vripple of 1-2 Vpp!!!

So minimum value of C is

Cmax = 3 / 100 * Vripple(min) = 3 / 100 = 0.03 F

Cmin = 3 / 100 * Vripple(max) = 3 / 200 = 0.015 F

So we need a capacitor between 0.03F and 0.015F

We can get capactiors in parallel becase Ctotal = C1 + C2 + …. + Cn

So let's choose a 0.03F capacitor with a Vripple 1V

So our **Vac >= (20 + Vripple) / 1.414**

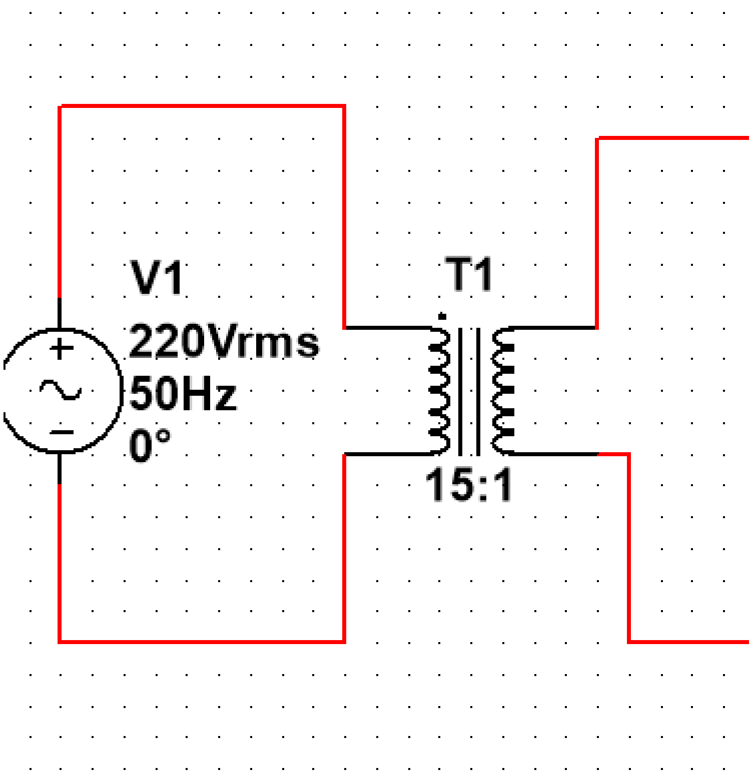
Vac >= (20 + 1) / 1.414

Vac >= 14.85 V

So we need at least a 15VAC transformer

So the ratio = Vin / Vout = Nin / Nout = 220 / 15 = 14.6

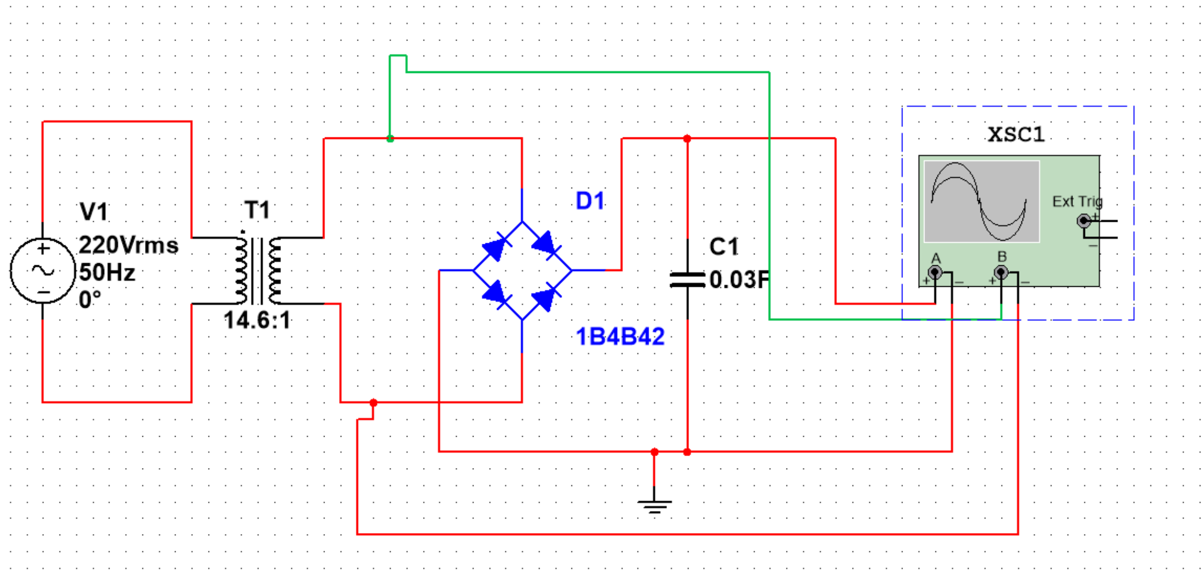
Nin = 14.6 Nout=1

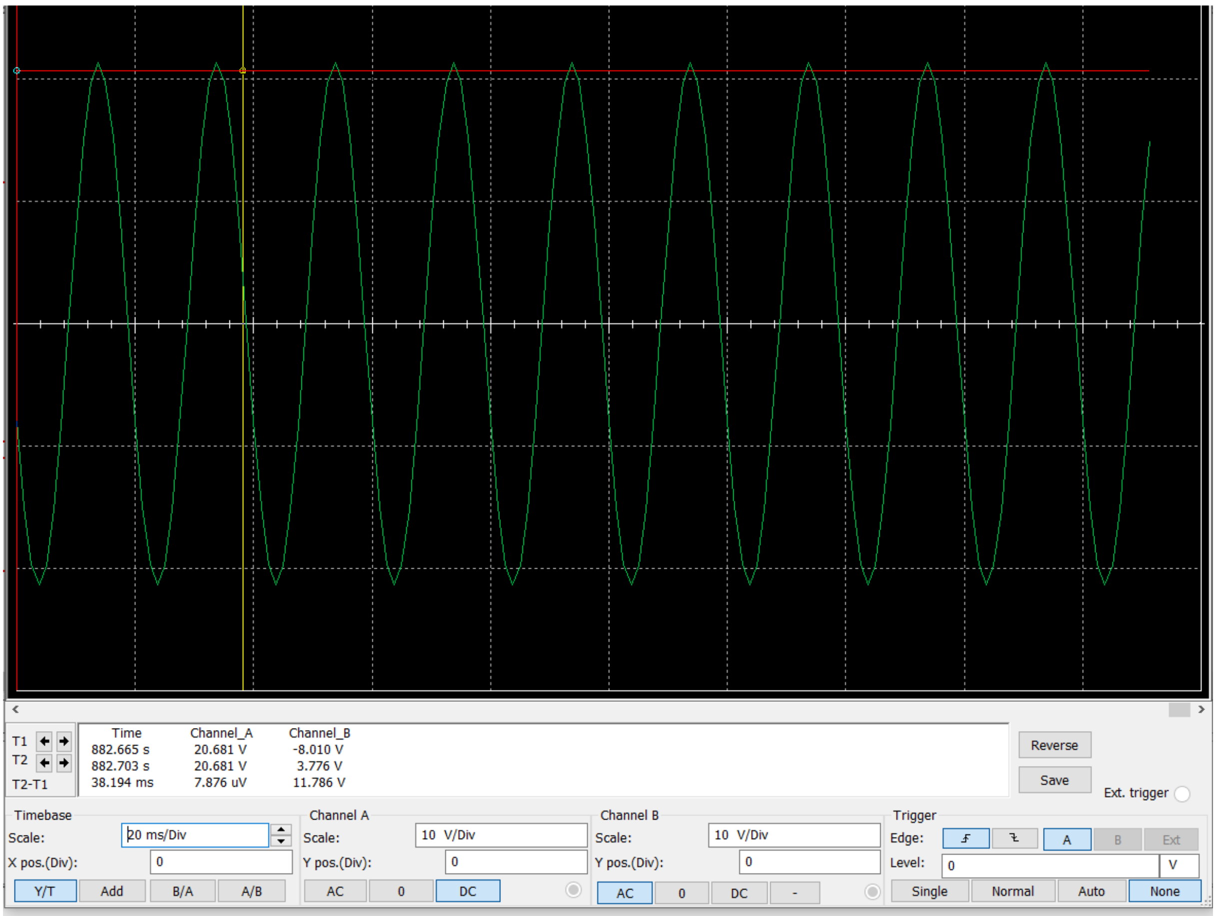


Choose a bridge rectifier for AC-DC

So I choose 1B4B42 full wave rectifier

Maximum Instantaneous Forward Voltage per element at IF = 1.0 A => 1V

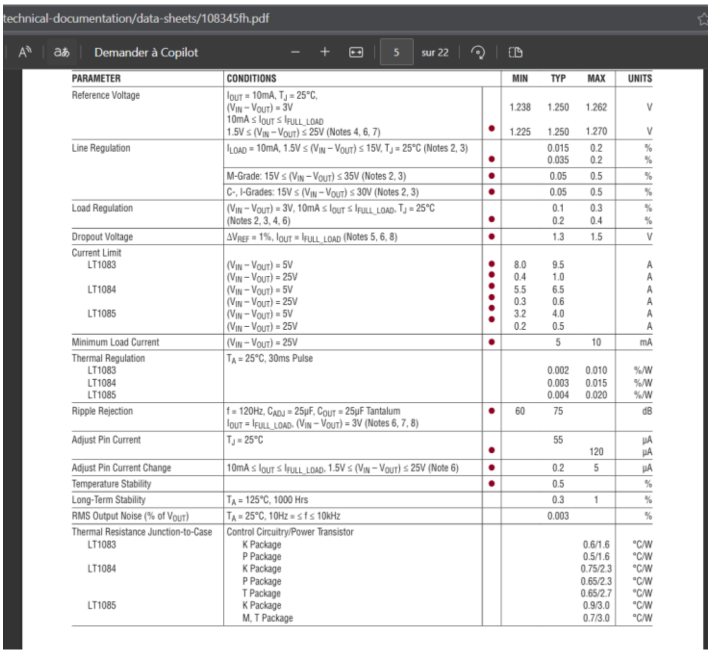




after the capacitor and bridge rectifier the voltage around capacitor is around 20V As expected in calculations

Variable voltage regulator choose?

So I choose a LT1083 because It can output 7.5 A and can handle 20v in datasheet



technical-documentation/data-sheets/108345fh.pdf

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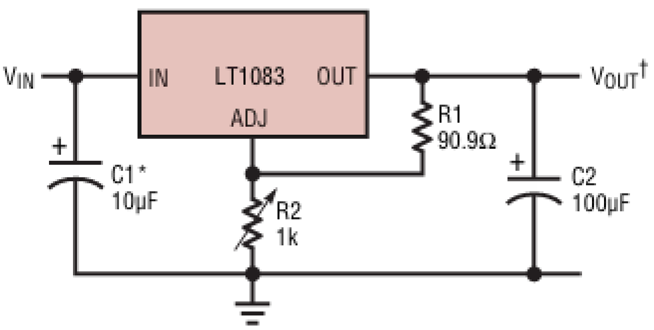
PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
Reference Voltage	I_{OUT} = 10mA, T_J = 25°C, ($V_{IN} - V_{OUT}$) = 3V		1.238	1.250	1.262	V
	10mA ≤ I_{OUT} ≤ I_{FULL_LOAD} 1.5V ≤ ($V_{IN} - V_{OUT}$) ≤ 25V (Notes 4, 6, 7)	●	1.225	1.250	1.270	V
Line Regulation	I_{LOAD} = 10mA, 1.5V ≤ ($V_{IN} - V_{OUT}$) ≤ 15V, T_J = 25°C (Notes 2, 3)			0.015	0.2	%
		●		0.035	0.2	%
	M-Grade: 15V ≤ ($V_{IN} - V_{OUT}$) ≤ 35V (Notes 2, 3)	●		0.05	0.5	%
	C-, I-Grades: 15V ≤ ($V_{IN} - V_{OUT}$) ≤ 30V (Notes 2, 3)	●		0.05	0.5	%
Load Regulation	($V_{IN} - V_{OUT}$) = 3V, 10mA ≤ I_{OUT} ≤ I_{FULL_LOAD}, T_J = 25°C			0.1	0.3	%
	(Notes 2, 3, 4, 6)	●		0.2	0.4	%
Dropout Voltage	ΔV_{REF} = 1%, I_{OUT} = I_{FULL_LOAD} (Notes 5, 6, 8)	●		1.3	1.5	V
Current Limit						
LT1083	($V_{IN} - V_{OUT}$) = 5V	●	8.0	9.5		A
	($V_{IN} - V_{OUT}$) = 25V	●	0.4	1.0		A
LT1084	($V_{IN} - V_{OUT}$) = 5V	●	5.5	6.5		A
	($V_{IN} - V_{OUT}$) = 25V	●	0.3	0.6		A
LT1085	($V_{IN} - V_{OUT}$) = 5V	●	3.2	4.0		A
	($V_{IN} - V_{OUT}$) = 25V	●	0.2	0.5		A
Minimum Load Current	($V_{IN} - V_{OUT}$) = 25V	●		5	10	mA
Thermal Regulation	T_A = 25°C, 30ms Pulse					
LT1083				0.002	0.010	%/W
LT1084				0.003	0.015	%/W
LT1085				0.004	0.020	%/W
Ripple Rejection	f = 120Hz, C_{ADJ} = 25µF, C_{OUT} = 25µF Tantalum I_{OUT} = I_{FULL_LOAD}, ($V_{IN} - V_{OUT}$) = 3V (Notes 6, 7, 8)	●	60	75		dB
Adjust Pin Current	T_J = 25°C			55		µA
		●			120	µA
Adjust Pin Current Change	10mA ≤ I_{OUT} ≤ I_{FULL_LOAD}, 1.5V ≤ ($V_{IN} - V_{OUT}$) ≤ 25V (Note 6)	●		0.2	5	µA
Temperature Stability		●		0.5		%
Long-Term Stability	T_A = 125°C, 1000 Hrs			0.3	1	%
RMS Output Noise (% of V_{OUT})	T_A = 25°C, 10Hz = ≤ f ≤ 10kHz			0.003		%
Thermal Resistance Junction-to-Case	Control Circuitry/Power Transistor					
LT1083	K Package				0.6/1.6	°C/W
	P Package				0.5/1.6	°C/W
LT1084	K Package				0.75/2.3	°C/W
	P Package				0.65/2.3	°C/W
	T Package				0.65/2.7	°C/W
LT1085	K Package				0.9/3.0	°C/W
	M, T Package				0.7/3.0	°C/W

I found the circuit in LT1083 datasheet so lets use it

1.2V to 15V Adjustable Regulator

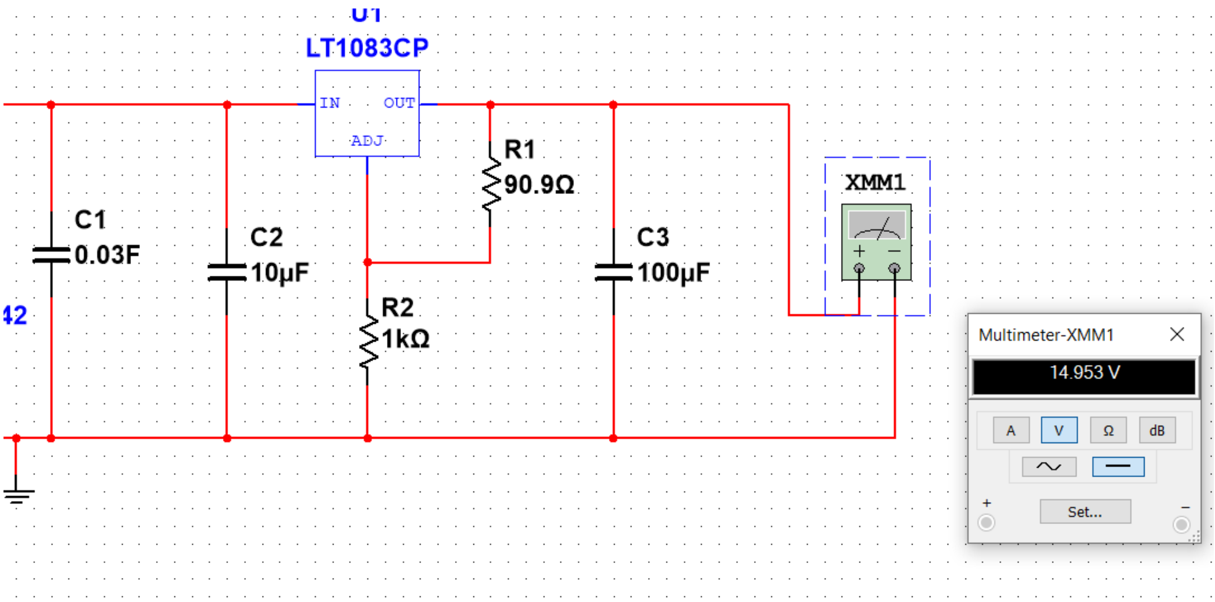


*NEEDED IF DEVICE IS FAR FROM FILTER CAPACITORS

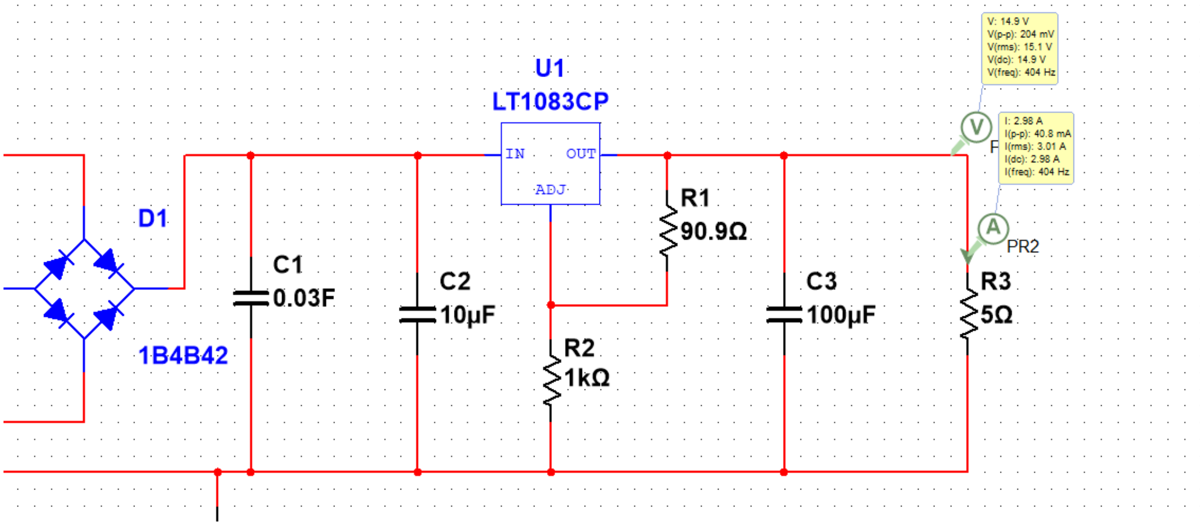
$$^{\dagger}V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right)$$

1083/4/5 ADJ TA08

Vout = 1.25 (1 + (1000 / 90.9)) = 15V

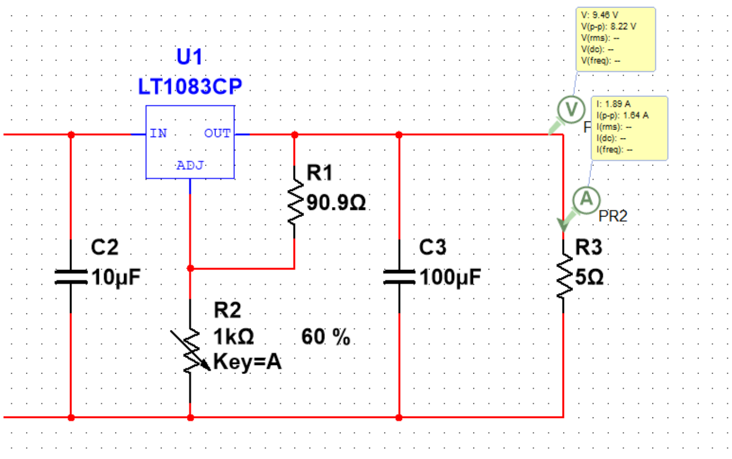


After verification the result is as exepted in Multisim



So here a load using a 3A and 15V

We can now make a variable resistor on R2 instead of fixed



Ok now let's check if there is any security issue with this circuit

Security Concern

Human Safety

The transformer have a inductive isolation which is good

- We need to add a fuse on the primary
- We need MOV / surge protection
- We need double insolation

Choose Primary fuse:

Pmax of load = V * I = 15 V * 3 A = 45 WATT

Linear supplies are only ~50-80% efficient overall (worse at low output voltages because more voltage is "dropped" as heat in the regulator).

Input power at transformer ≈ P_dc / efficiency.

Optimistic (80% eff): 45 W / 0.8 = 56.25 W.

Pessimistic (50% eff, e.g., at low V_out like 5 V where dropout is high): 45 W / 0.5 = 90 W.

This gives a rough input power range of ~56-90 W.

Standard rule for bridge rectifier + large cap filter (from sources like the National Semiconductor Handbook and Elliott Sound Products):

Secondary RMS current (I_sec_rms) ≈ 1.5-2 × I_dc (3 A).

The cap charges in short bursts (high peak current) near the AC peaks, but discharges steadily to the load. This "form factor" raises RMS by ~1.57 ideally, but 1.6-1.8 is common in practice; some guides use up to 2 for safety/margin.

I_sec_rms ≈ 1.5 × 3 A = 4.5 A (low end)

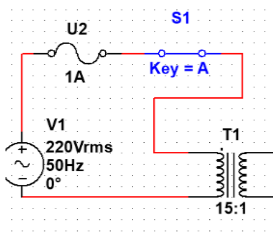
to 2 × 3 A = 6 A (high end).

Transformer VA = V_sec_rms × I_sec_rms ≈ 14.6 V × 4.5-6 A = 66-88 VA. Oversize (100- 132)

I_primary_rms = VA / V_primary_rms = VA / 220 V.

For 66-88 VA: 66 / 220 ≈ 0.3 A to 88 / 220 ≈ 0.4 A.

If oversized to 100-132 VA (common for margin/heat): 100 / 220 ≈ 0.45 A to 132 / 220 = 0.6 A.



Safety checklist:

Define Worst-Case Conditions

Ambient temp | 40 °C Load current | MAX continuous Load type | Resistive / inductive

Good insulation transformer and slow blow fuse

Worst-case secondary voltage

220V +10% = 242V

242 / 15 = 16.1 Vrms

Vpeak = 16.1 × 1.414 ≈ 22.8V

Bridge drop ≈ 2V

Vdc ≈ 20.8V

IN-RUSH CURRENT CHECK

Inrush current at power-on

Worst case: capacitor initially = 0V

I_inrush ≈ Vpeak / (Rsecondary + Rbridge)

If C > 10,000 µF and transformer > 30 VA → inrush protection required

Add NTC thermistor (e.g. 5–10 Ω cold)

How to SELECT the NTC (STEP BY STEP)

We need 3 parameters:

Cold resistance (R25)

Current rating

Energy rating (Joules)

Decide acceptable inrush current

I_inrush ≤ 2 × Inominal

10A

Calculate required cold resistance

R_ntc = V / I

R_ntc = 22 / 10 ≈ 2.2 Ω

2–5 Ω @ 25°C

NTC must survive continuous RMS current:

$I_{ntc} \geq 1.5 \times I_{load}$

$I_{ntc} \geq 7.5$ A

Energy stored in capacitor:

$E = \frac{1}{2} C V^2$

$E = 0.5 \times 0.03 \times 22^2$

$E \approx 7.3$ Joules

NTC must handle **≥ 2× this** (safety margin): > 15J

Ametherm SL32 2R025

Parameter	Value
R25	**2 Ω**
Continuous current	**25 A**
Energy rating	**150 J**
Diameter	32 mm

⇨ We add it before generic diode

RECTIFIER CHECK

Current rating

$I_{rectifier} \geq 1.8 \times I_{load}$ (5)

$I_{rectifier} \geq 9$A

Heat check

$P \approx 2 \times V_f \times I$

$P \approx 2 \times 0.9 \times 5 \approx 9$ W

Needs airflow or PCB copper area.

Capacitor C1 rating

$V_{cap} \geq 1.5 \times V_{dc}$

$21.4 \times 1.5 \approx 32$V

Ripple current rating (CRITICAL)

Iripple ≈ Iload≈ 5 A

Iripple_cap ≥ 1.3 × Iload ≥ 6.5 A

If not → capacitor overheats → dries → explodes.

Ripple voltage check

$\Delta V = I / (f \times C)$

$\Delta V = 5 / (100 \times 0.03) \approx 1.63$ V

REGULATOR THERMAL CHECK (MOST IMPORTANT)

$P = (V_{in} - V_{out}) \times I$

$P = (21.4 - 15) \times 5$

$P \approx 32$ W

VERY HIGH

REVERSE PROTECTION OF REGULATOR SO WE ADD A DIODE

Thermal resistance calculation

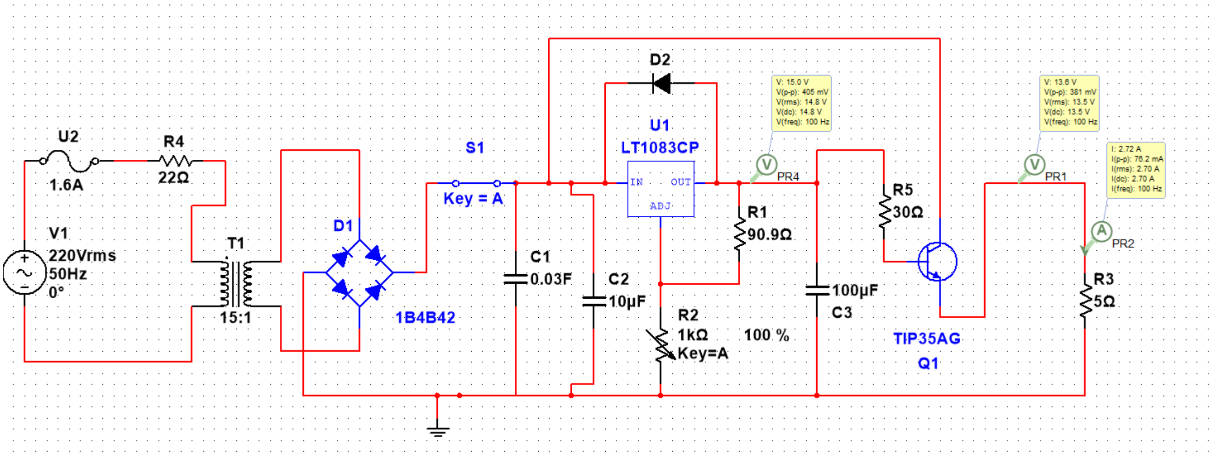
Max junction temp = 125°C
Ambient = 40°C

$\theta_{total} \le (125 - 40) / 22.7$

$\theta_{total} \le 3.7$ °C/W

Junction-case ≈ 1°C/W   Case-sink ≈ 0.5°C/W Remaining for heatsink:

$\theta_{sink} \le 2.2$ °C/W **This is a BIG heatsink,**



SO I added a tip35 transistor to reduce heat from voltage regulator

A 22ohm after fuse acting like NTC thermistor

Also a a diode to protect regulator from reverse current