

Getting Started in Electronics

An Introduction

Tim Hazel – M9WWA
M9WWA@wavewizards.org
Www.wavewizards.org



Who am I?

- I am Tim – M9WWA/2E0TPH/M3TPH) Member of Somerset Wallys
- Experienced in Electronic Engineering and Embedded Systems Architecture X86-64/32/16/8
- Experienced in IPC Soldering Standards THT/SMT
- Fiber Optic Processing White Room experience
- Ex Forensics Data Analyst

Getting Started

- What you think you need is not WHAT you need.
- Cost effectiveness – Buy Smart and according to your skill set
- Ease of use is an important consideration.
- Lets dive in with the first thing you need.

Multimeter

- It can be confusing buying a multimeter for the first time
- A myriad of options are available – do you need them?
- Samples per second, Counts, Accuracy, Resolution, hand held or Bench?, Burden Voltage (what even is that)? Lo-Z?
- There are many issues surrounding CAT Ratings
- Hi-Voltage? Do you need it?

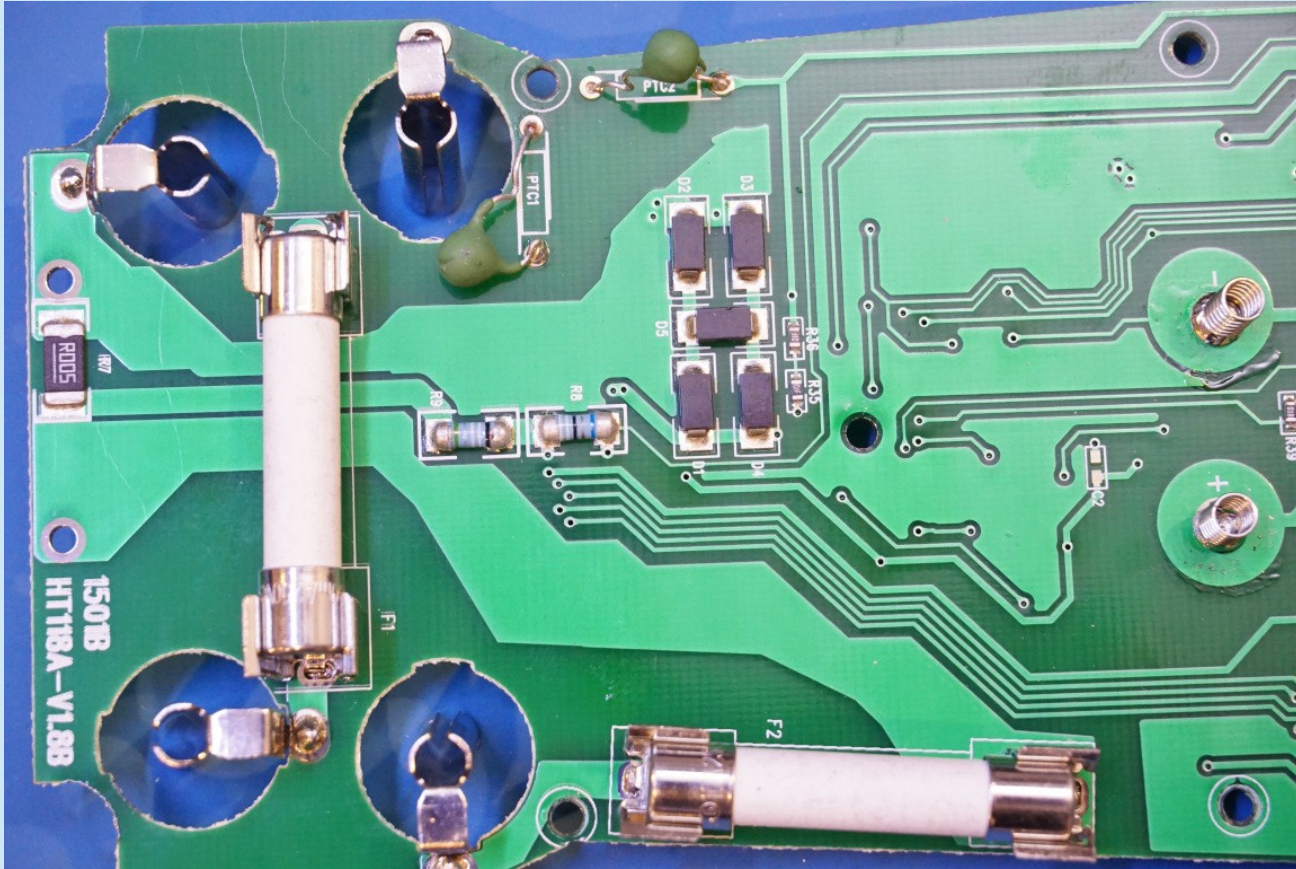
Low Voltage Readings

- It is generally acceptable to use a cheaper meter if you are restricting your measurements to below 30V DC
- Current Measurements up to 5/10 Amps is fine.
- You should consider TWO meters. Voltage and Current!
- You must consider the Probes – this also applies to Oscilloscopes
- Contact point material is also to be considered

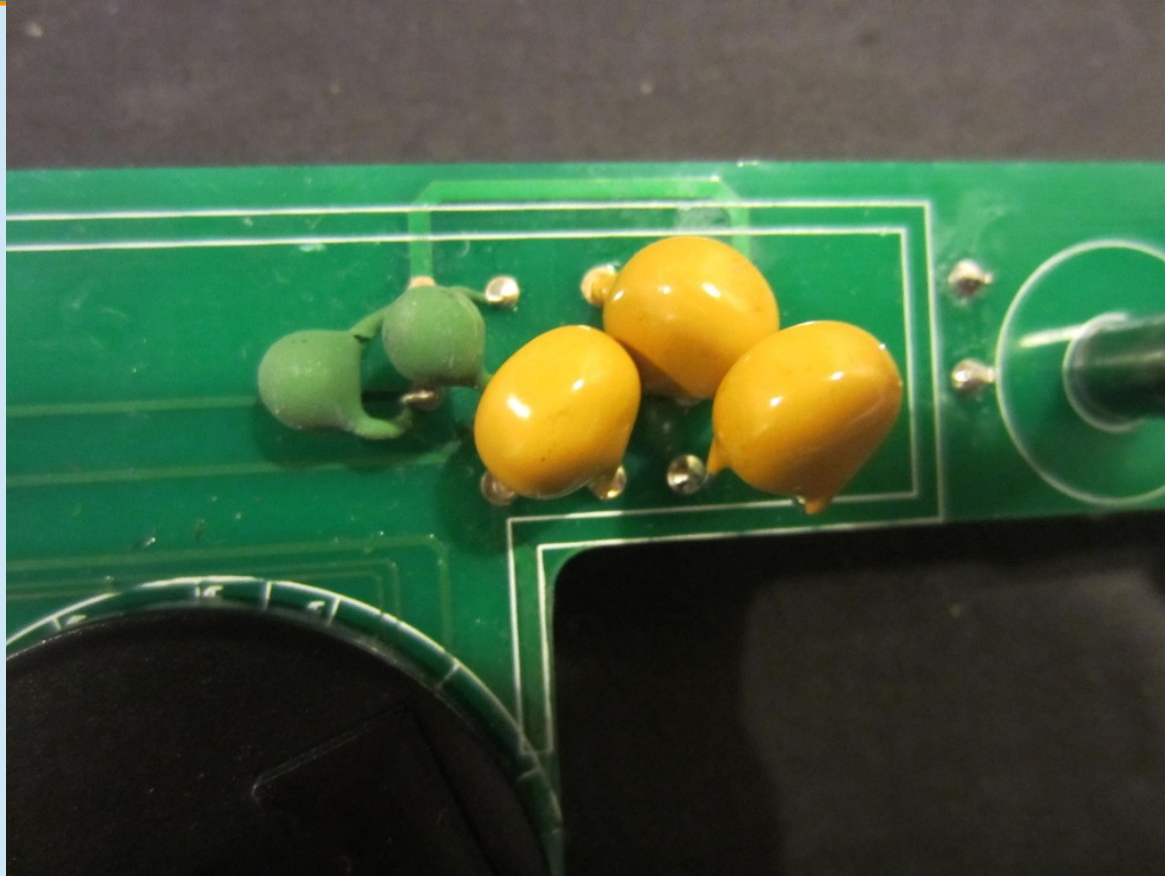
High Voltage Readings

- High Voltage readings should be made on a much better Meter
- Big names such as Fluke, Agilent, Keithley to name just three.
- Meter protection is Key
- MOV and PTC protection is a MUST not an option.
- You will find “UL TESTED” logos on suitable equipment
- CAT Ratings are also better
- Probe leads are silicone and larger cross section (Skin Effect)

Input Protection (Cheap)



Input Protection (Better)



Input Protection (Awesome)



Cat Ratings (Briefly)

CAT ratings

Category	Voltage	Transient Voltage	Impedance in ohm
CAT I	150	800	30
CAT I	300	1500	30
CAT I	600	2500	30
CAT I	1000	4000	30

CAT II	150	1500	12
CAT II	300	2500	12
CAT II	600	4000	12
CAT II	1000	6000	12

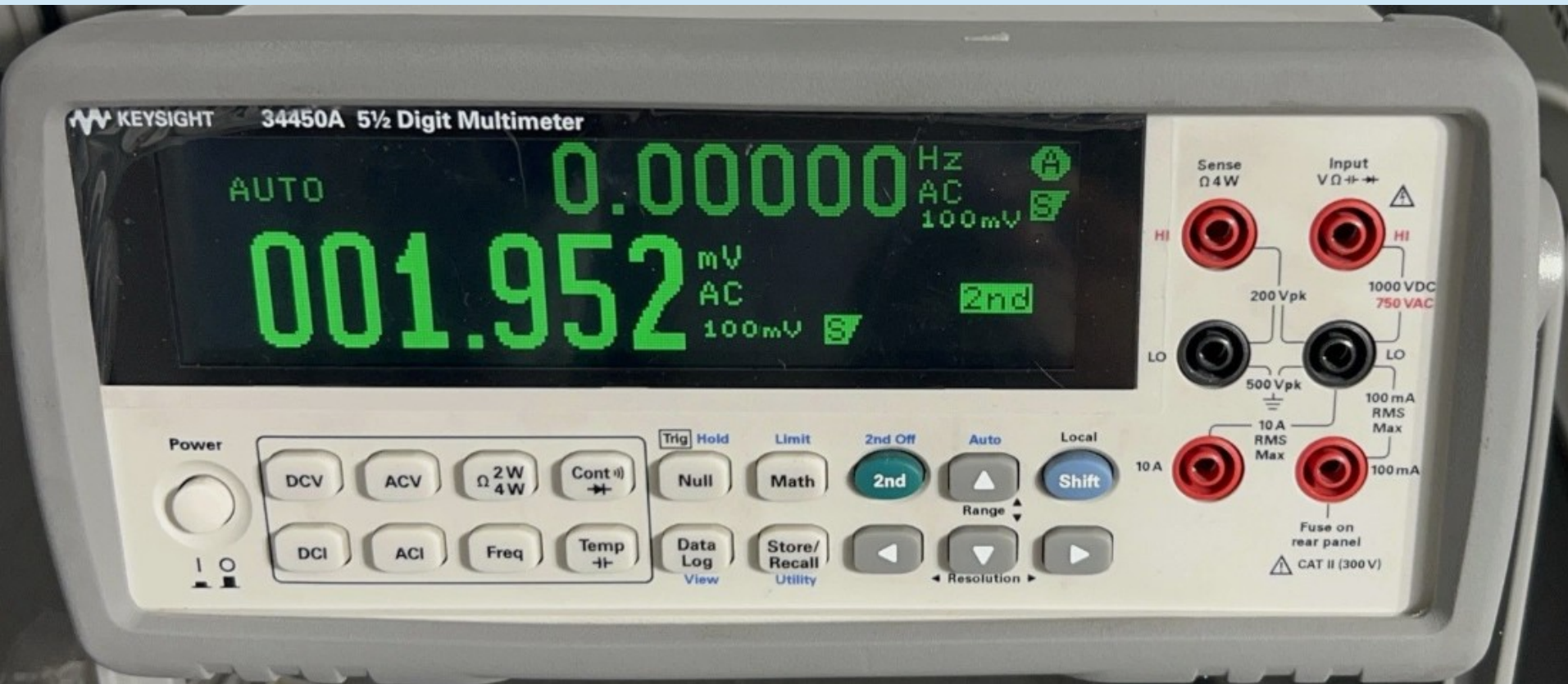
Category	Voltage	Transient Voltage	Impedance in ohm
CAT III	150	2500	2
CAT III	300	4000	2
CAT III	600	6000	2
CAT III	1000	8000	2

CAT IV	150	4000	2
CAT IV	300	6000	2
CAT IV	600	8000	2
CAT IV	1000	12000	2

Bench or Hand?

- It can be advantageous to have a “Bench” multimeter for more serious or long term use.
- Most Bench style Meters are designed and built a lot better

Bench Multimeter (£500 Upwards)



Bench Multimeter (£100 ish)



What is a “Digit”?

- Digits in a multimeter refer to the number of digits displayed on its screen, indicating the resolution—the level of detail it can measure
- The "½" digit is the most significant digit and can only display 0 or 1, which limits the maximum value the meter can show
- A 5 ½-digit multimeter can display values from 0 to 199,999, meaning it has 200,000 resolution counts.
- An 8 ½-digit multimeter can display values from 0 to 1,999,999,999, offering 2 billion resolution counts, making it suitable for ultra-high-precision measurements, such as in metrology labs or calibration standards.

Counts and Digits

Display digits	Actual measurement range	Resolution counts
3 ½ digits	+/- 1999	2,000
4 ½ digits	+/- 19999	20,000
5 ½ digits	+/- 199999	200,000
6 ½ digits	+/- 1999999	2,000,000

8 ½ Digit – Only £15,860



Analogue Meters

- Analogue meters are the “go to” standard for voltages that swing from rail to rail (Think Op Amps or Audio)
- Quick Response times give a massive advantage over Digital
- Can display incredibly fast changing levels
- Very often limited to certain swings of voltage unlike Digital

Analogue Multi Meter

A Typical Analogue Meter

Faster response to voltage swings

Also used to “Peak” RF Transformers



Probes.....

- Most cheap meters are supplied with inferior probes
- PVC and very low quality conductor
- Nickel plated tip (if you are lucky)
- Incorrectly Rated. Probe claims 1000v Cat4 – cable says 300 volt
- High resistance leads give inaccurate results

Good Probes

- Sharp gold plated tip
- Excellent Silicone Cable with suitable probe
- Extra Flexible Multiple cores (.2\80)
- Surface area gives excellent velocity factoring
- Skin Effect is deeper – gives better current rating
- More Expensive but very worth it.

What else do we need?

- We have covered Multimeters and Probes
- How about a Soldering Station?

Your First Soldering Station

- Loads of choice leads to confusion
- What features do you ACTUALLY require?
- What is your budget?
- What else do we need? Solder? Flux? Tips?
- Are we using THT or SMT, maybe both?

Don't Skimp



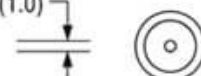
Through Hole - THT

- Easy to gain experience
- Massive choice of Tips and Accessories
- More “Forgiving” than SMT
- Cheaper entry level stations

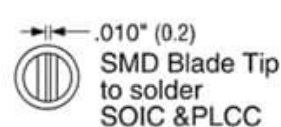
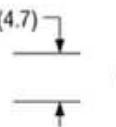
Tips



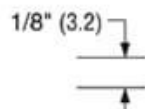
Pointed or Conical



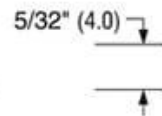
Blade or Knife



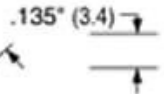
Screwdriver or Chisel



Bevel

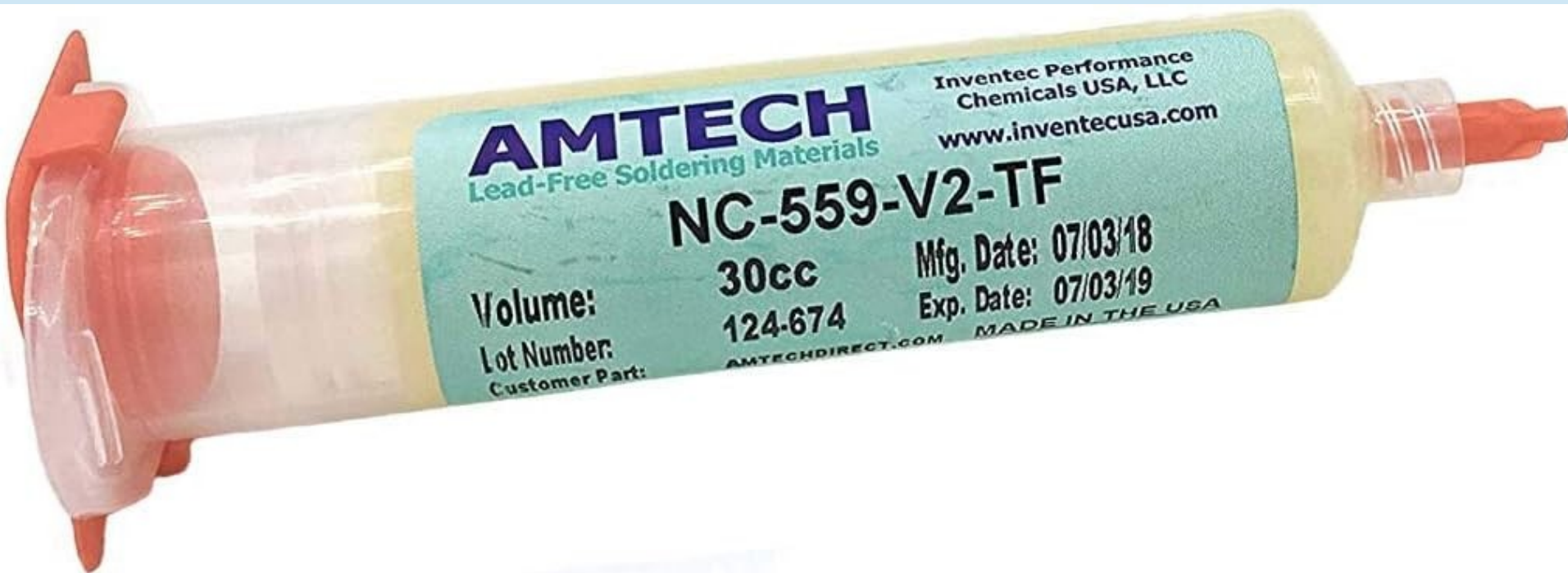


Flow



Plato® SMD
Flow Tip

Flux



Solder

- For the hobbyist, nothing beats 60/40. This is a ratio between elements that make up the alloy. Different alloy blends have different melting points and different “plastic” ranges.
- 63/37 is also called “Eutectic” and exhibits a very unique characteristic.
- Other “exotic” alloy blends are on the market for more specialised applications.

Melting Points

60/40	60%Tin 40%Lead	180°C to 190°C (General purpose)
63/37 (Eutectic)	63%Tin 37%Lead	183°C Low plastic range
58/42	58% Bismuth 42%Tin	138°C Avoids Tin Whiskers
80/20	80%Gold 20%Tin	Varies (Aerospace / Mil)
S.A.C	Tin Silver Copper	217°C to 240°C Reflow / Wave Soldering
Lead Free (Typical)	99.3%Tin 0.6%Copper 0.5%Nickel	217°C to 230°C

Flux cored solder





L= SE1

EHT= 4.00 KV

WD= 32

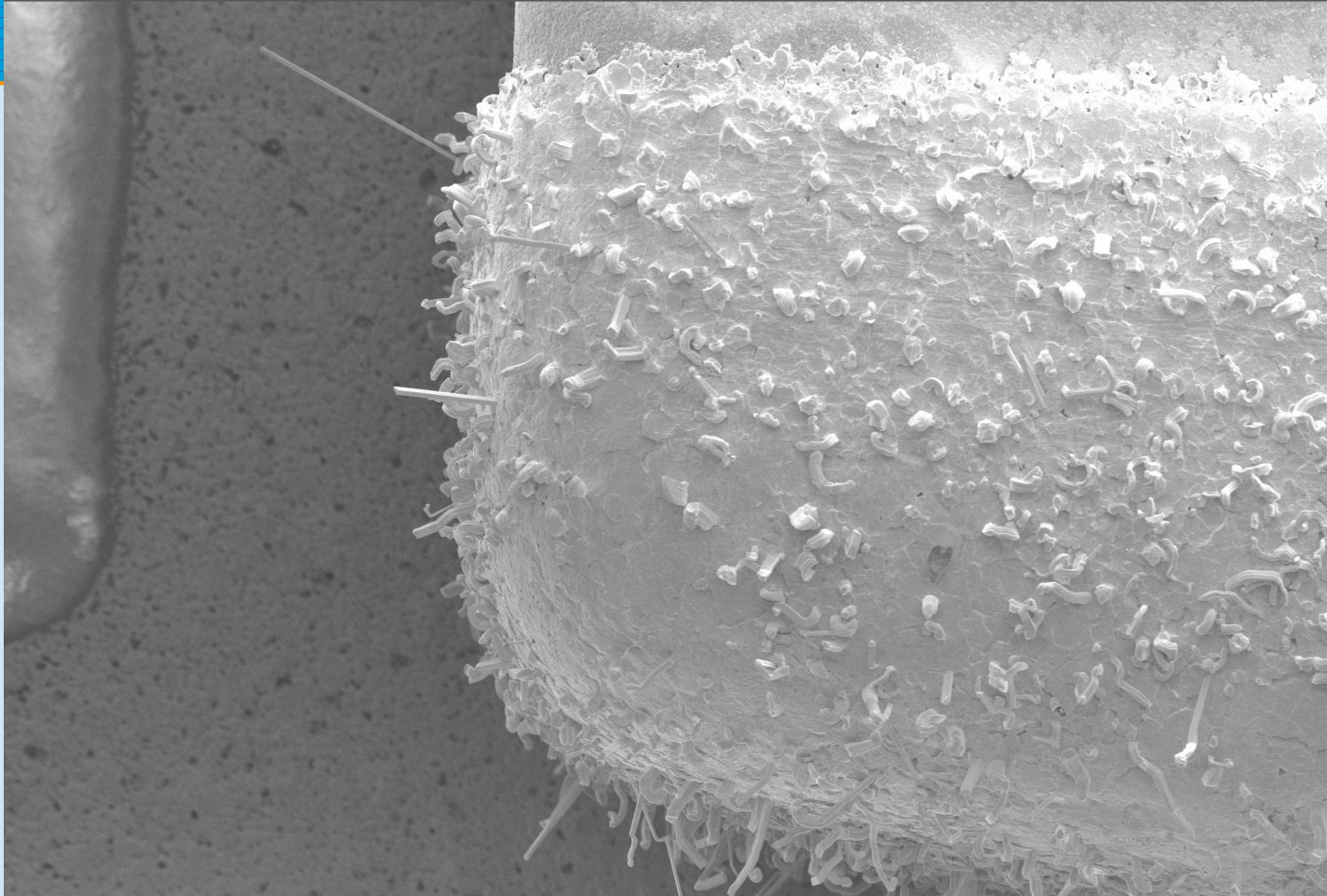
mm

MAG= X 120.

PHOTO= 16

200 μ m

10/08/02 CAP#3



No Clean Flux

- Always clean “No Clean” flux residues
- Use Alcohol (Lab Grade >80%)
- Reduces Corrosion and Resistance Bridges.
- Ignore it at you peril!

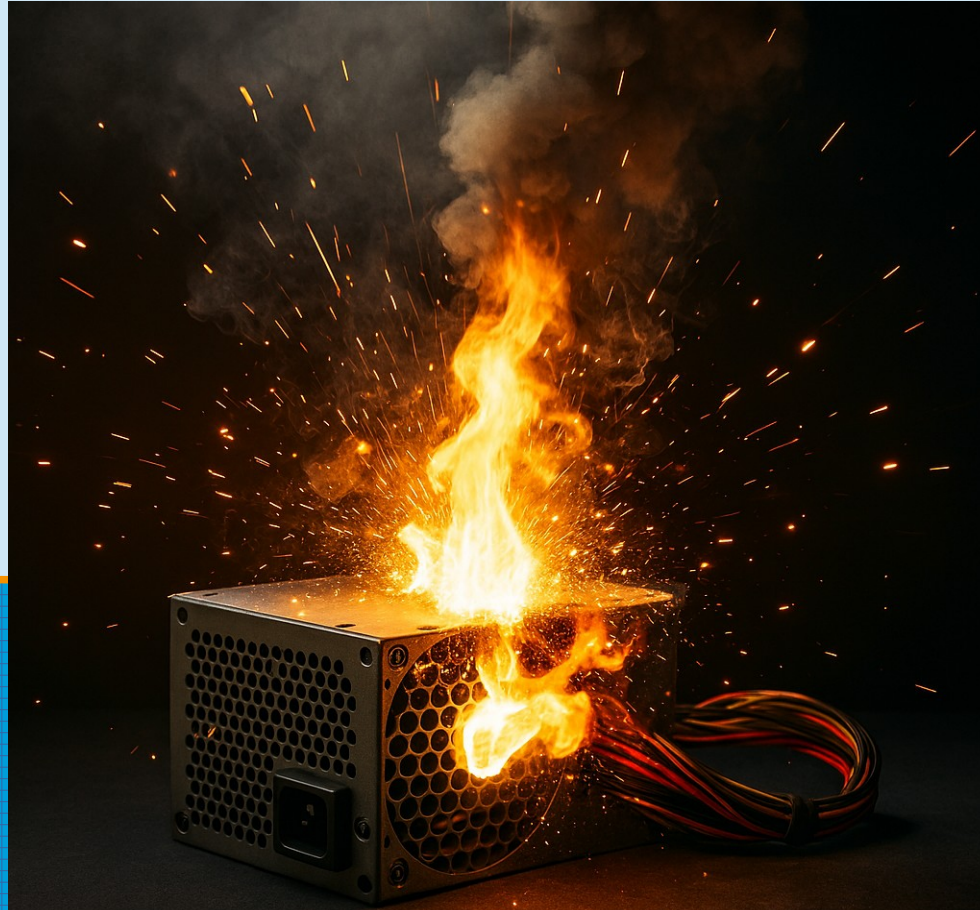
Moving on

- We have a Multimeter
- We have a Soldering Station with Tips / Flux and Solder
- What else do we need?
- Definitely a Power Supply

Power Supplies 101

Part 1

Tim Hazel – M9WWA
Tim@wavewizards.org



Use Case

- What do you want to power?
- Voltage and current requirements
- Variable or fixed?
- Mains powered or Battery powered?

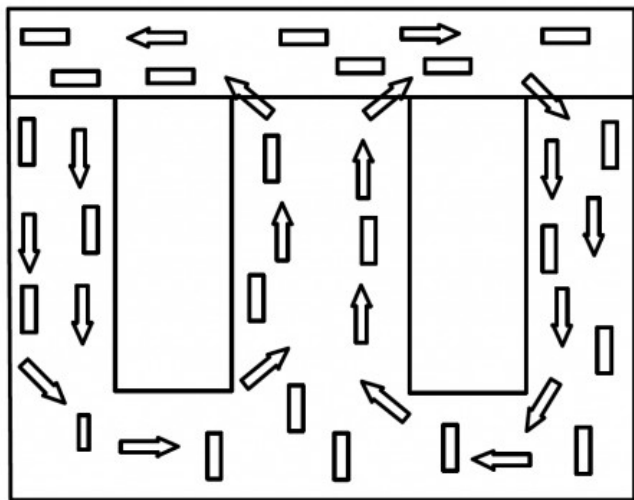
Linear Vs S.M.P.S

- Linear supplies are less efficient
- Switch Mode Power Supplies create “Noise”
- Switch Mode power supplies are much lighter
- Linear supplies are easier to repair (and safer)!

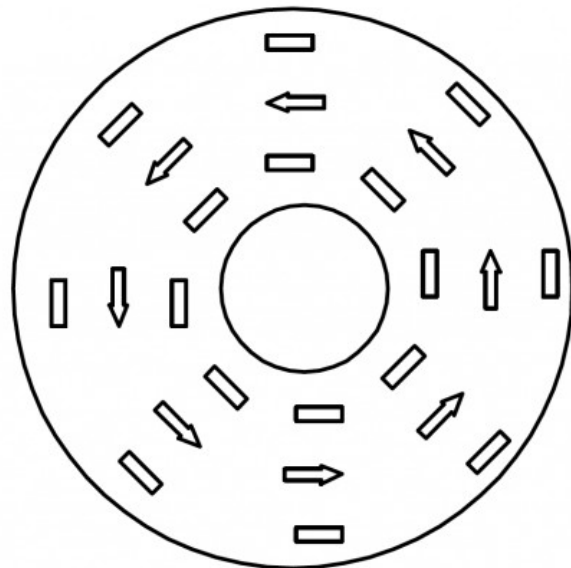
Which Transformer?

- Old skool – E I Transformer Core
- New Age - Toroidal

E I Transformer Core



E-I Laminated Flux



Toroid Flux

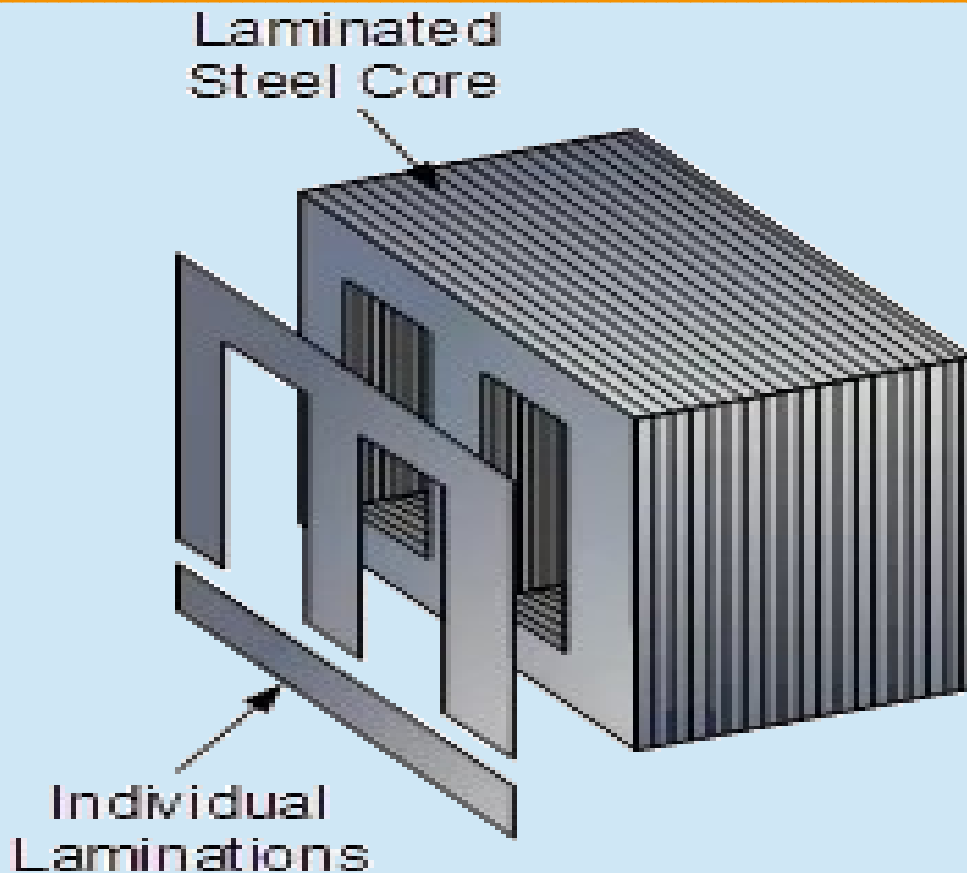


Steel Grain

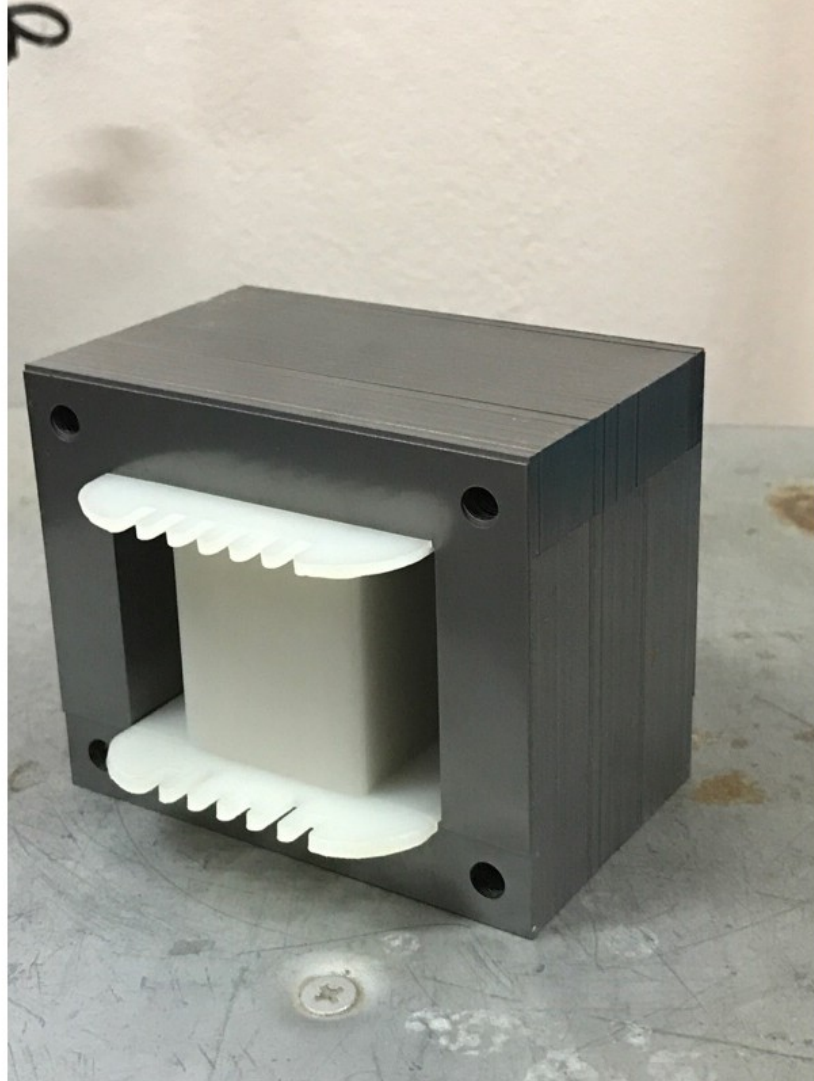


Flux Direction

E I Transformer Core



E I Bobbin



Toroidal



Use what you have!

- Check old “wallwarts” for Voltage and Current ratings.
- Old laptop charger is good for 19V 5A !
- Salvage from old equipment
- Ebay “Spares or Repairs” can prove very handy.
- Charity shops often hold back broken electronics if you ask nicely and you get to donate something back!

Next :- Bridge Rectification

- We need to rectify the AC voltage at the secondary.
- This gives us something to use at DC
- We often use Full Wave Rectification instead of Half Wave
- Full Wave offers better Bang for Buck

Next :- Bridge Rectification



Standard Recovery Diode, 1 kV, 1 A, Single, 1 V, 30 A - 1N4007-T



Manufacturer:	DIODES INC.
Manufacturer Part No:	1N4007-T
Order Code:	SC14911
Product Range 	1N4007
Technical Datasheet:	 1N4007-T Datasheet

 [Add to compare](#)

[See all Technical Docs](#)

 254 In stock

£0.05 (£0.06 Inc. VAT)

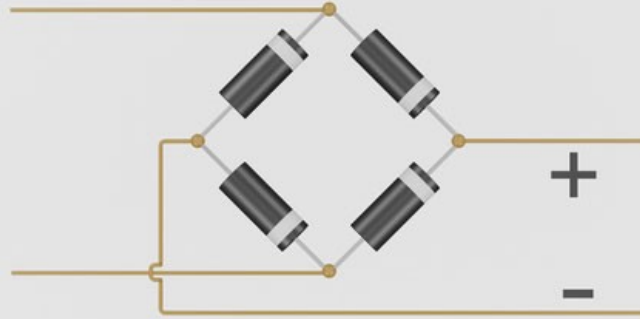
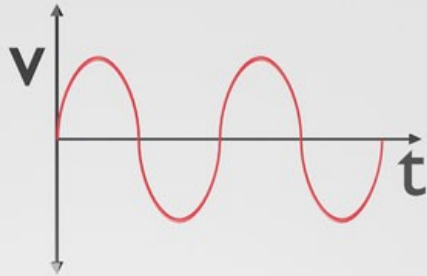
Price for: **Each**

Multiple: **10** Minimum: **10**

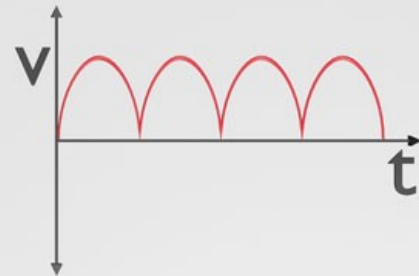
Quantity	Price
10+	£0.05 (£0.06)
100+	£0.03 (£0.04)
1000+	£0.02 (£0.02)

What IS Rectification?

AC
Alternating current



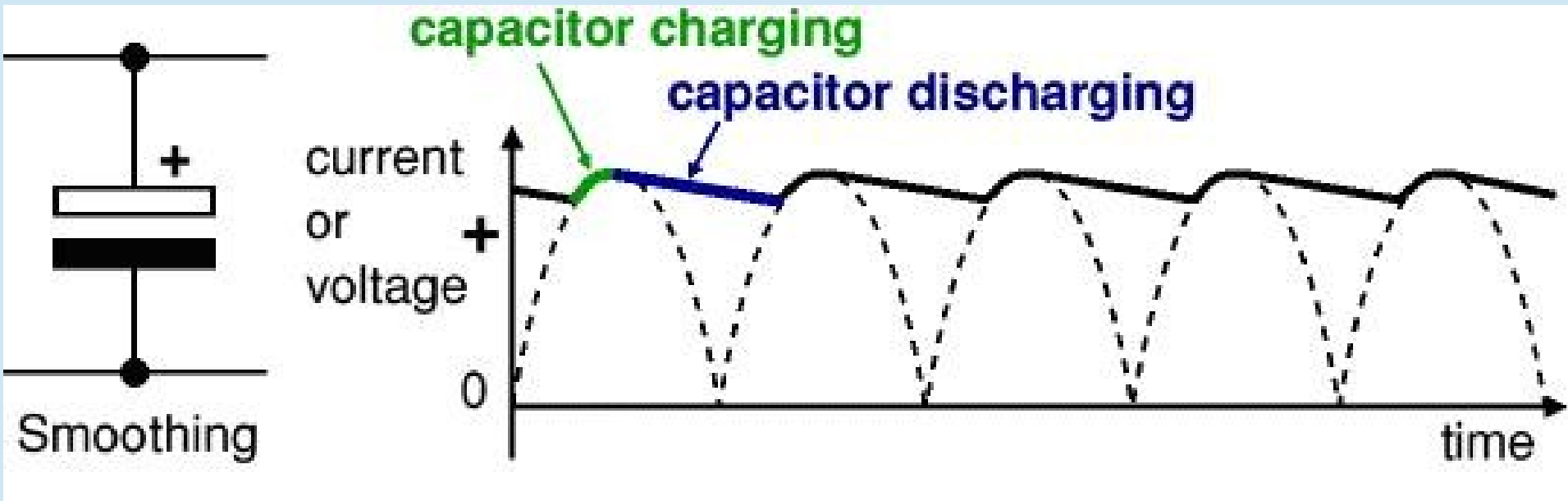
DC
Direct current



Ripple / Smoothing Cap

- A reasonable amount of voltage drop is apparent when the AC changes state from peak to fall.
- We need a Smoothing capacitor to “Smooth” the voltage output. This Capacitor will also be used to remove voltage spikes, Transients and Ripple.
- The better the DC, the less Noise will be in your circuit.

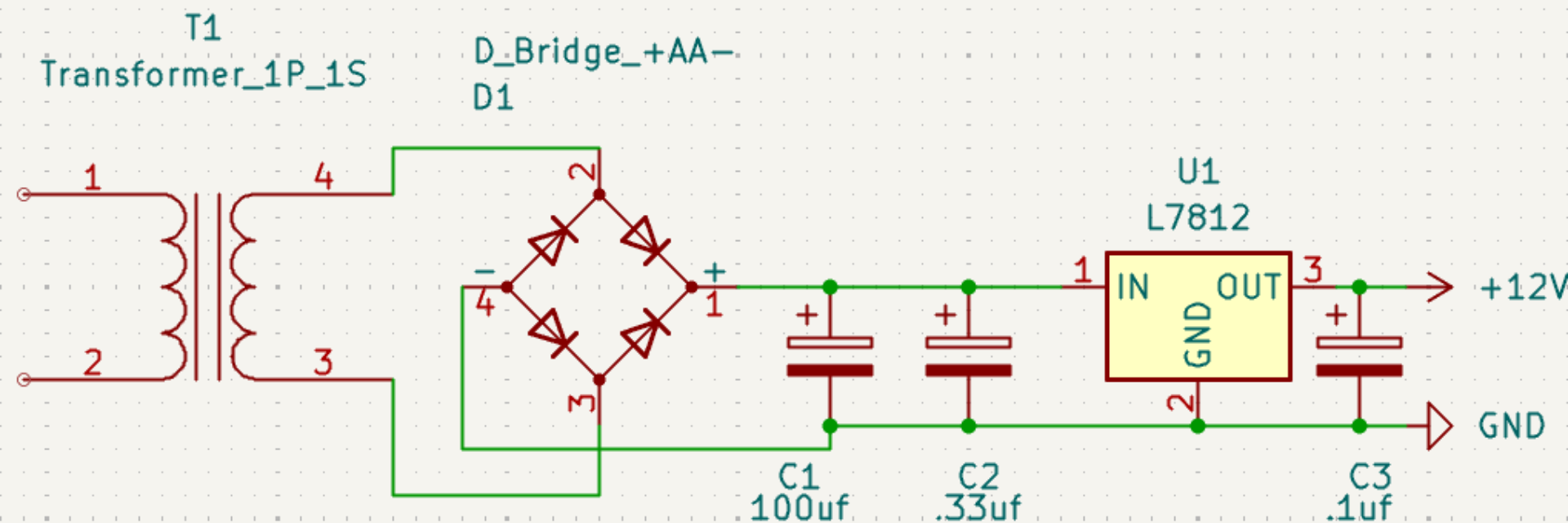
Ripple / Smoothing Cap

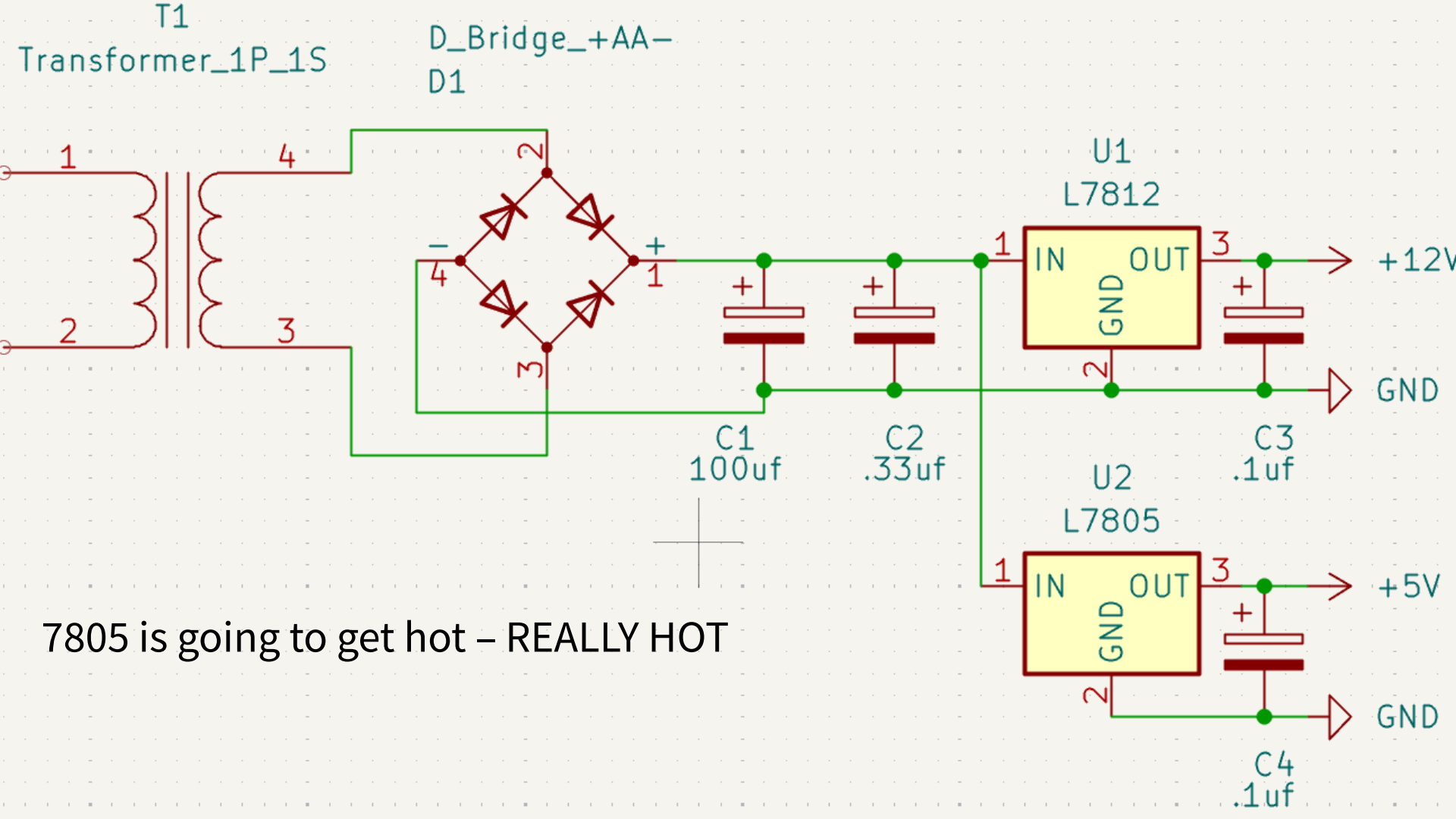


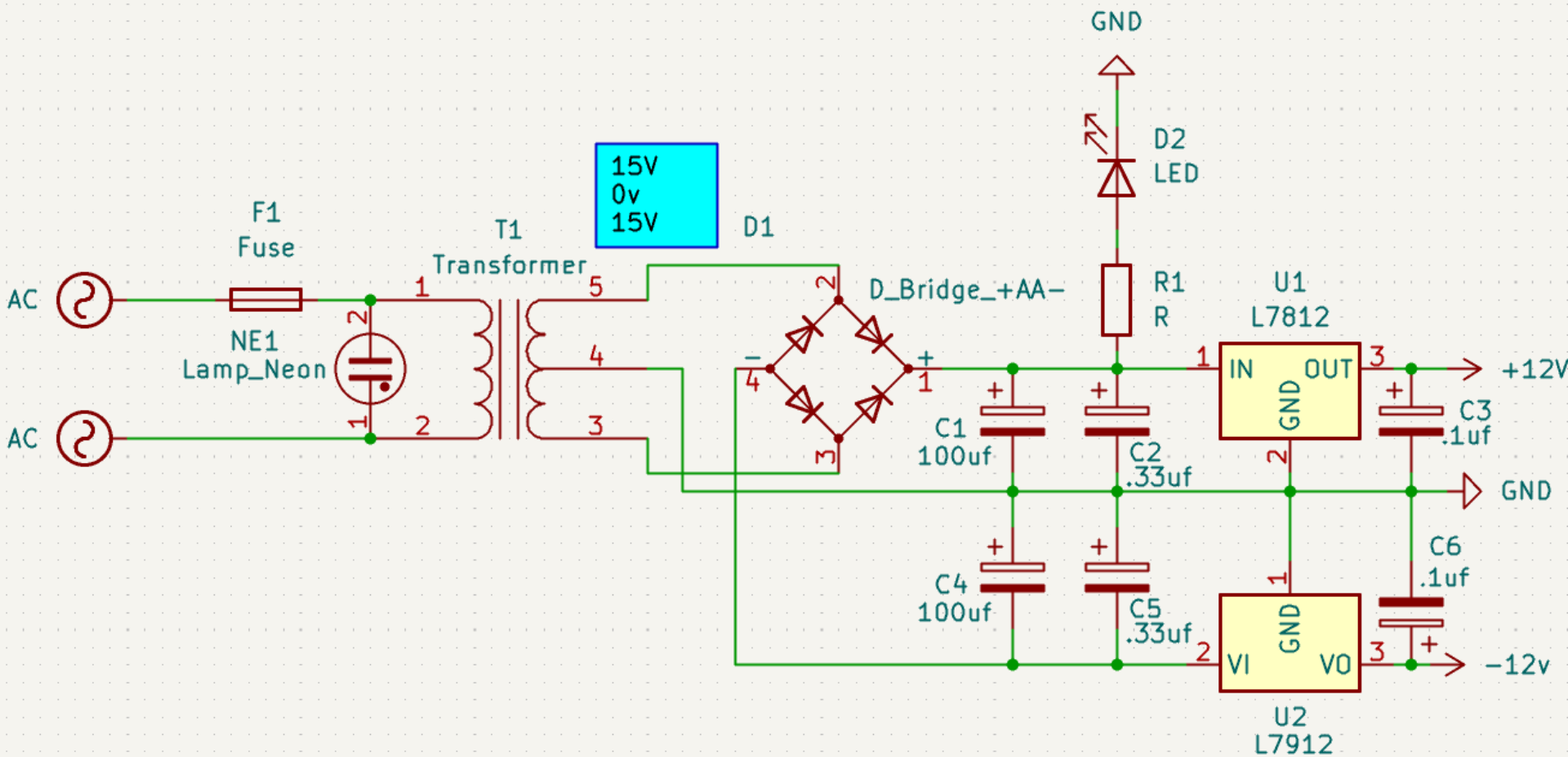
Regulation....

- We now have a good voltage conversion from AC to DC.
- How do we maintain a constant voltage?
- We need a Voltage Regulator

The simple 12v 1A supply



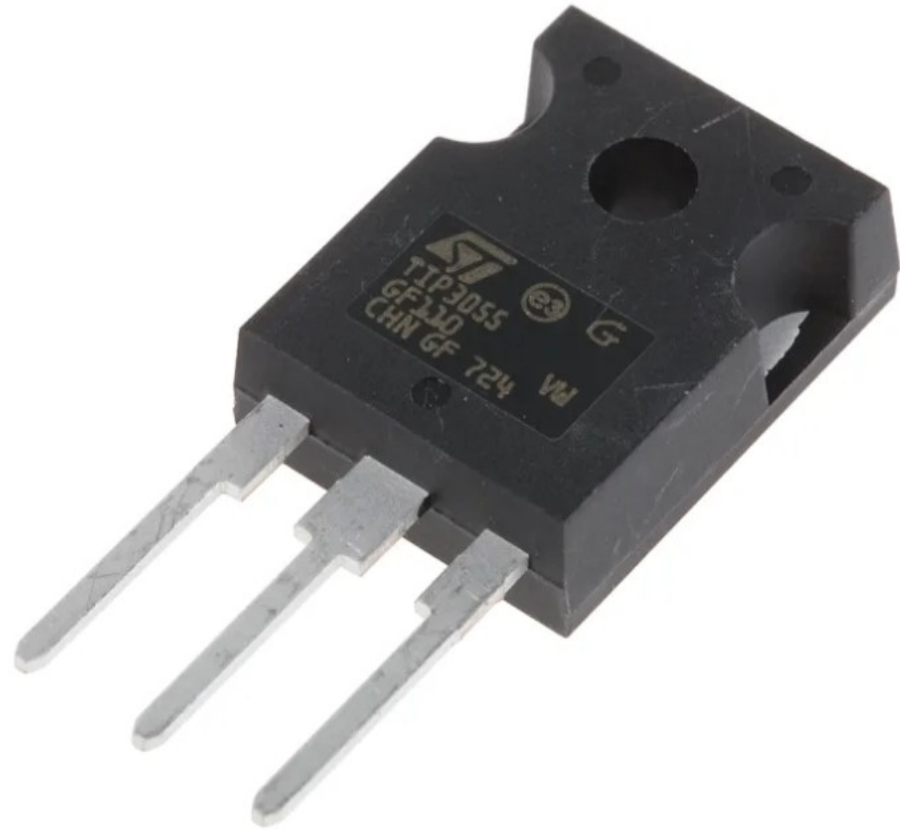




Re Cap

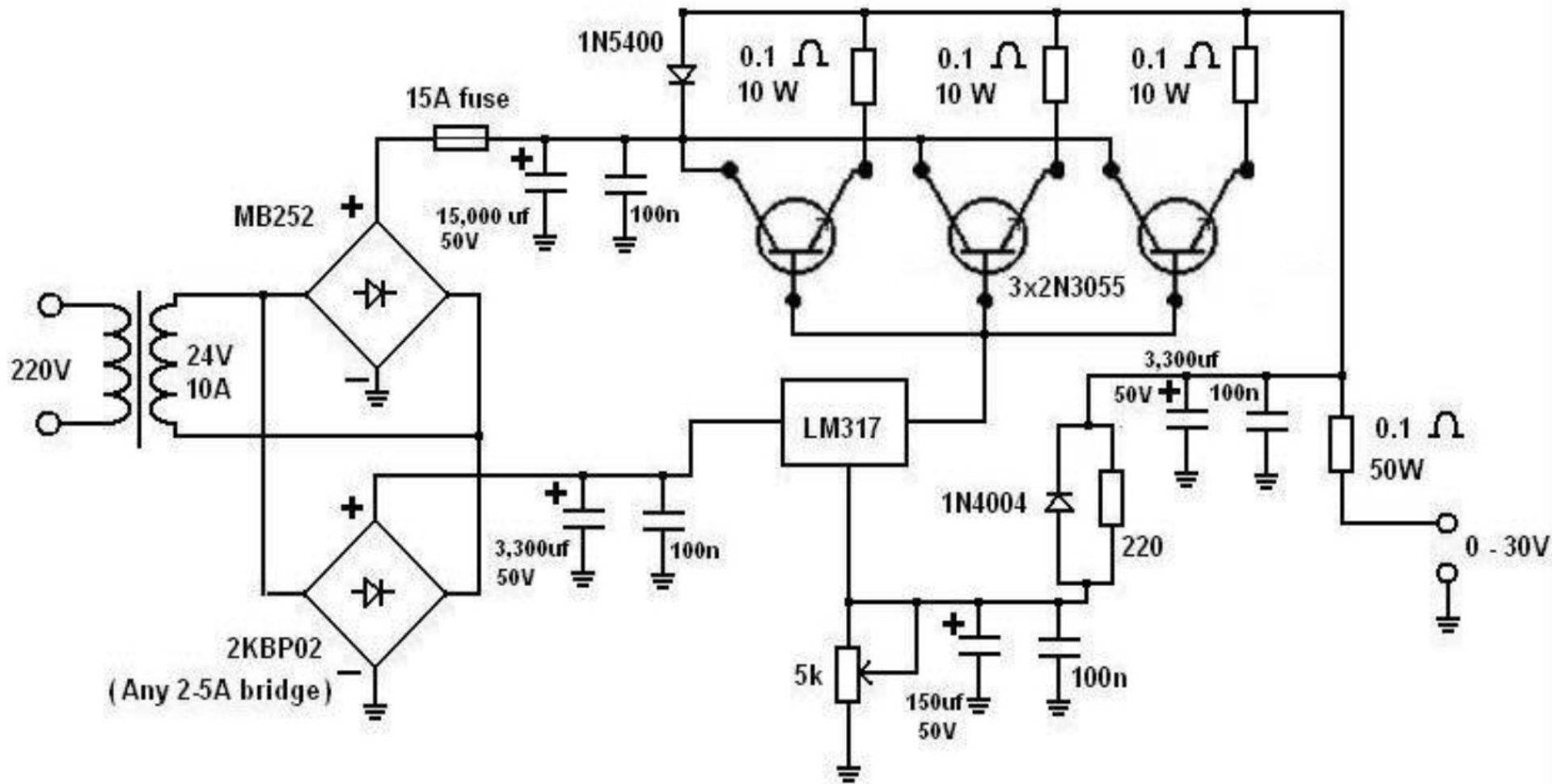
- We had some examples of PSU circuits
- None of them were capable of more than 1 Amp
- All of them would get hot when nearing current limit
- I forgot some of the series pass transistor circuits....

2n3055



Absolute Maximum Ratings (T_A = 25 °C)

Description	Symbol	Value	Units
Collector Base Voltage	V _{CBO}	100	V
Collector Emitter Voltage	V _{CEO}	60	
Collector Emitter Voltage(R _{BE} =100Ω)	V _{CER}	70	
Emitter Base Voltage	V _{EB0}	7	
Collector Current Continuous	I _C	15	A
Base Current	I _B	7	
Power Dissipation @ T _c =25°C Derate Above 25°C	P _{TOT}	115 0.657	W W/°C
Operating and Storage Junction Temperature Range	T _J , T _{STG}	- 65 to +200	°C



How about protection?

- Most Voltage Regulators will have:
- Over Voltage shutdown
- Brown Out Protection
- Thermal Protection
- Current Overload Shutdown
- Some have feedback watchdogs!

Rifa Madness



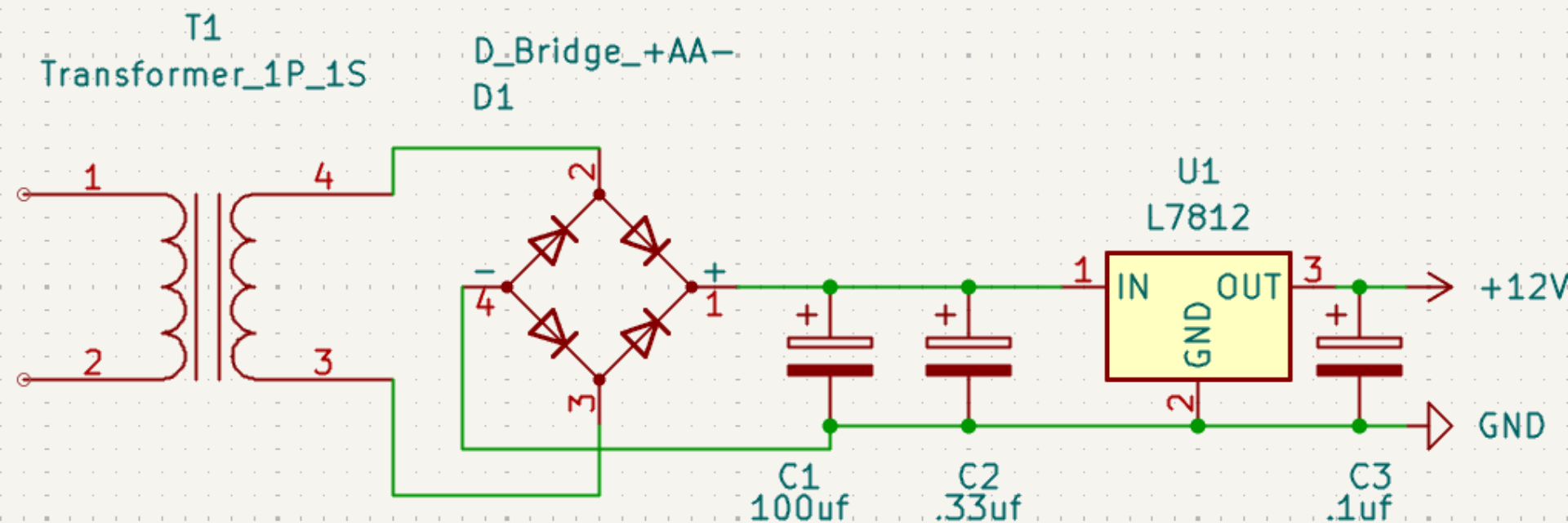
RIFA

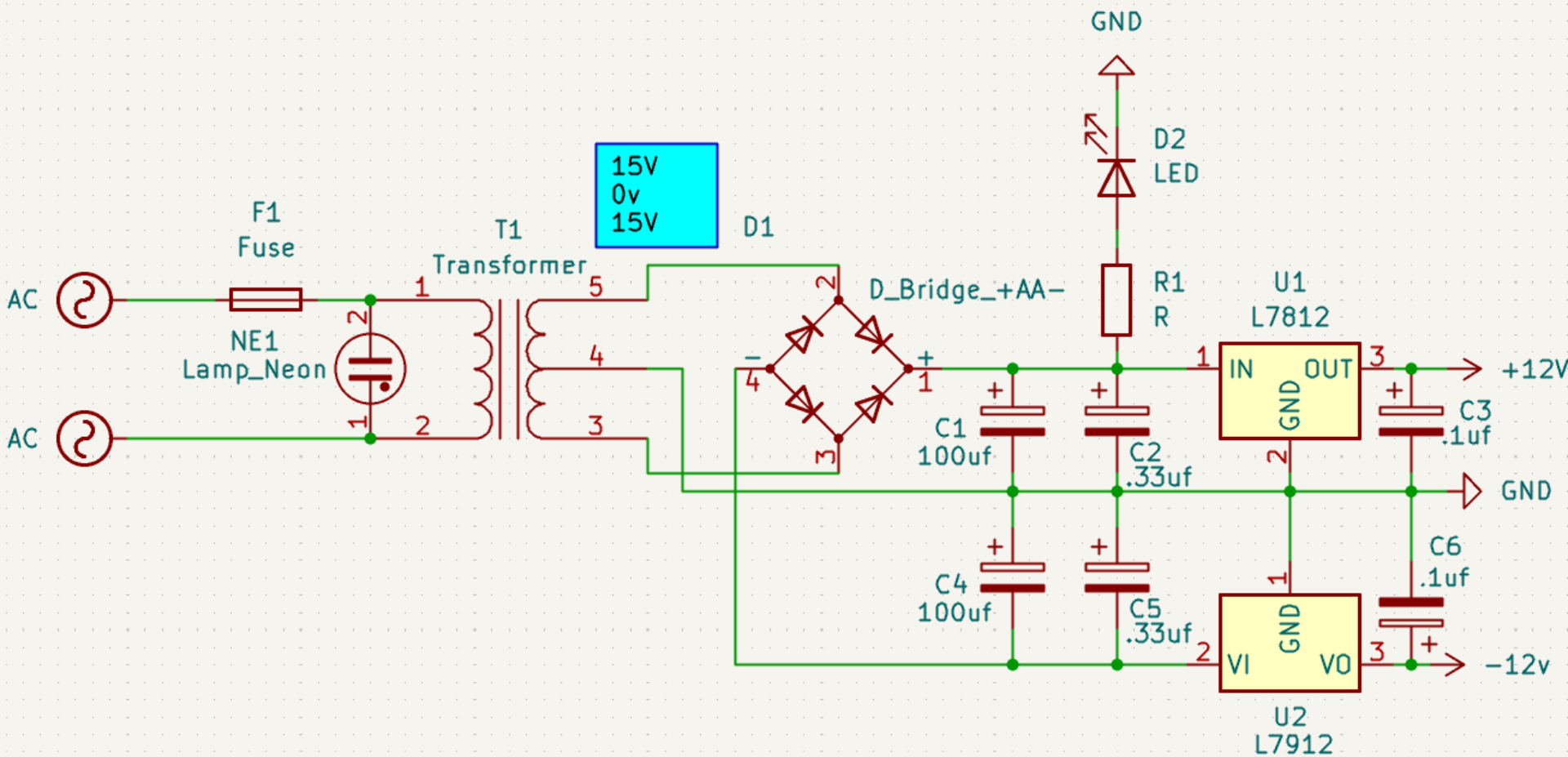


Class X and Y Capacitors

- Class X (X1 X2 X3) Line to Line
- Class Y (Y1 Y2 Y3) Line to Earth
- Class X can fail SHORT!
- Class Y are designed to Fail OPEN
- Required for consumer grade electronics to meet RFI or EMC regulations.
- A hobbyist can choose to ignore at your peril.
- Class 2 is desired over the others

The simple 12v 1A supply





Mains Earth Referencing

- What the hell is that I hear you say



Mains Earth Referencing

- Earth leads on your device may be connected to NEUTRAL
- Mains earth referenced designs can blow your oscilloscope
- Your supply is no longer “Floating”
- Be careful, I speak from experience.



So thats the power supply sorted

- We have the Multimeter
- We have the ability to Solder
- We have the POWER! (Sounds like a He-Man advert)
- The only “Essential” bit of kit left is the humble Oscilloscope
- Maybe a Frequency Counter too

What the heck is a “Scope”

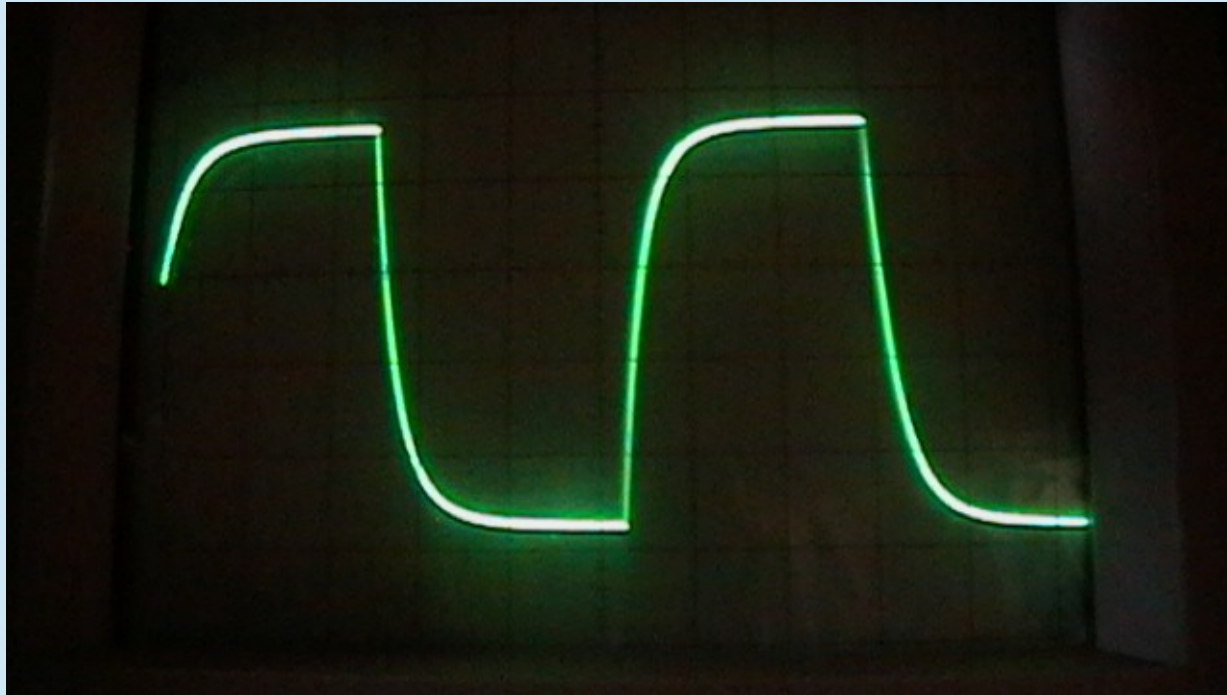
- An Oscilloscope can measure and display waveforms
- Voltage over Time (Time Domain)
- Frequency over Time (Frequency Domain)
- A MSO (Mixed Signal Oscilloscope) can display both!
- So, what do we need?

Oscilloscopes

- I designed a 1750Hz Toneburst board many years ago
- I needed to ensure that the tone was on frequency and that the waveform was good enough to open a repeater
- You can find a cheap scope at a Ham Rally – sometimes you can pick one up for free – just convince them that you can take it off their hands rather than them taking it home :)
- Most Scopes have a minimum bandwidth of 20Mhz

A Test Capture

- The Waveform photographed on my Scope



[illegible]

Budgets?

- Budget Brands: Owon, Siglent
- Mid Tier: Rigol, Hameg
- Top Tier: Agilent (Keysight), Keithley, Fluke

Always shop around



Rigol 1052 digital Oscilloscope
Pre-owned · RIGOL

£104.70



Gould OS300 Digital Oscilloscope 20mHz Dual Trace 100V-220V
Pre-owned

£50.00

or Best Offer
£20.00 P&P

Check for Sales!



Rigol DS1054Z 4CH, 50MHz, 1GSa/s, 24Mpts Digital Oscilloscope

(179 customer reviews)



£292.00 (£350.40 inc VAT)

RIGOL MARCH SALE

Save £££ On Select Rigol Units! Offer ends 1st Apr 2026

10+ In UK Stock

Availability: Stock models delivered next working day (UK only) for orders placed before 16:30 (Mon - Fri)



1

Add To Basket

Extra's

- Make sure you get a good quality probe
- Look for a scope with a Frequency Counter (most new ones are ok)
- Automatic probe detection is not critical
- Is the device Mains Earth Referenced?
- If it is, avoid measuring certain circuits (Ask Tim)

Auto Probe Detection



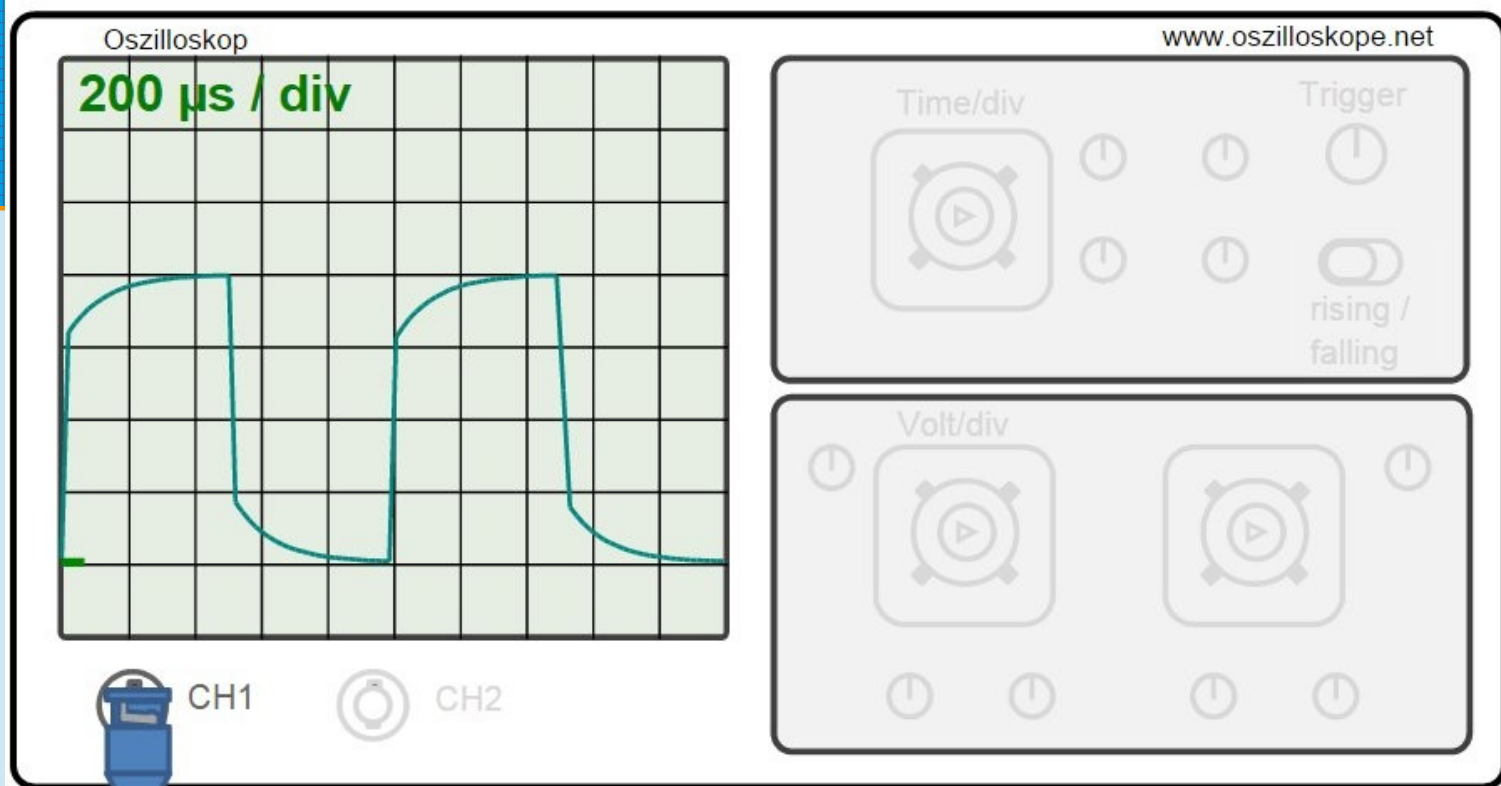
Probe Compensation



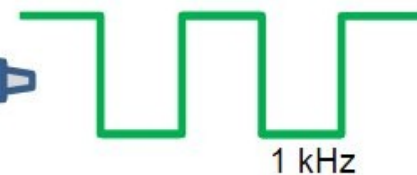
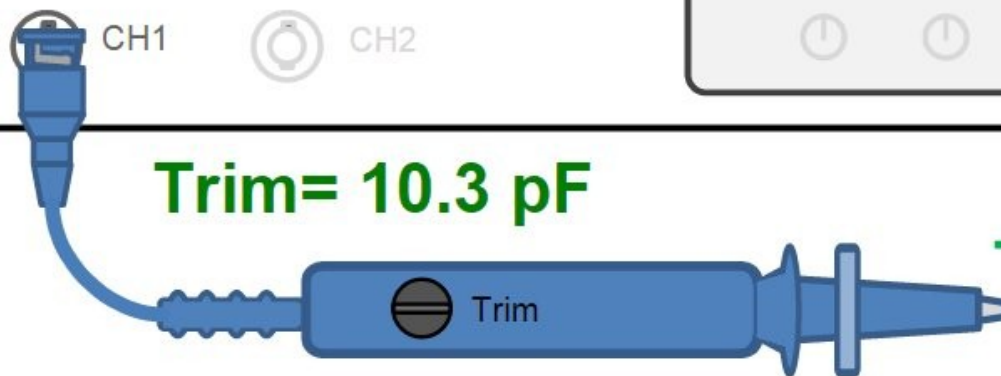
Probe Compensation



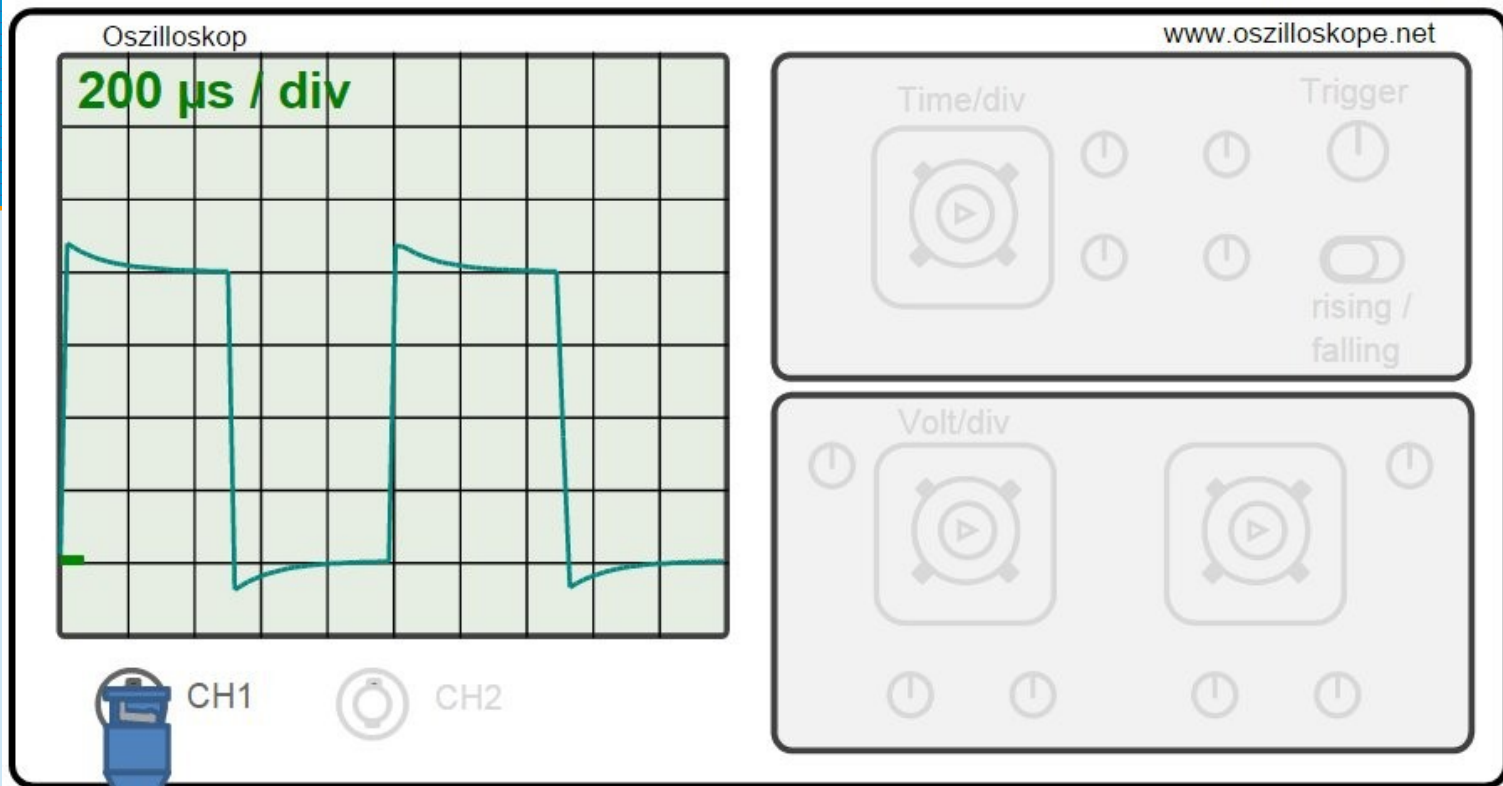
Under



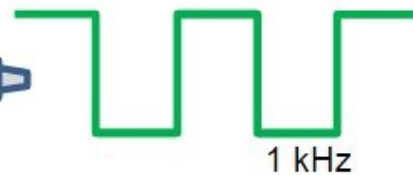
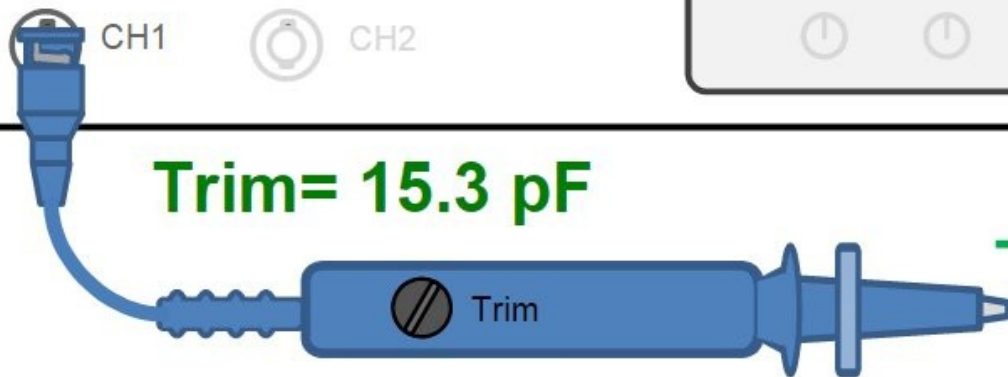
Trim = 10.3 pF



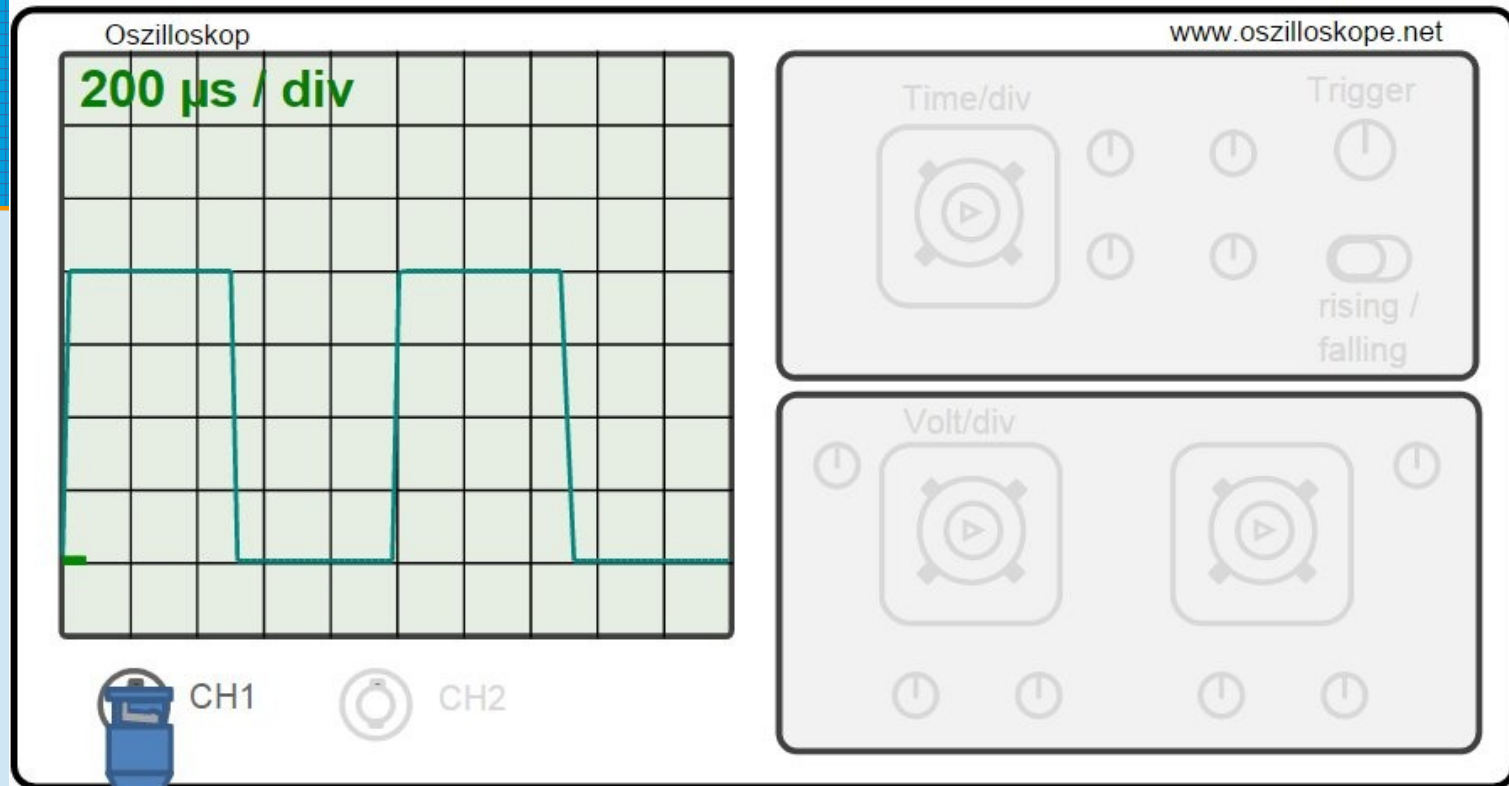
Over



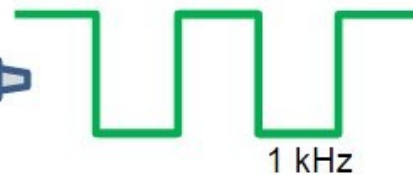
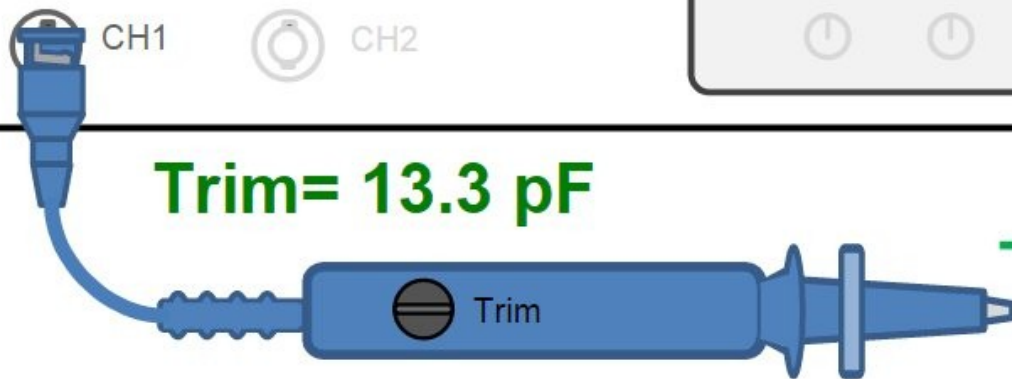
Trim = 15.3 pF



Correct



Trim = 13.3 pF



Frequency Counters

- Most “Newer” Oscilloscopes and Multi Meters have them built in
- Stand alone counters are easy to obtain
- Check Ebay for Quality second hand items
- Check suppliers for New Items – Get the Warranty!

Handheld FC-130

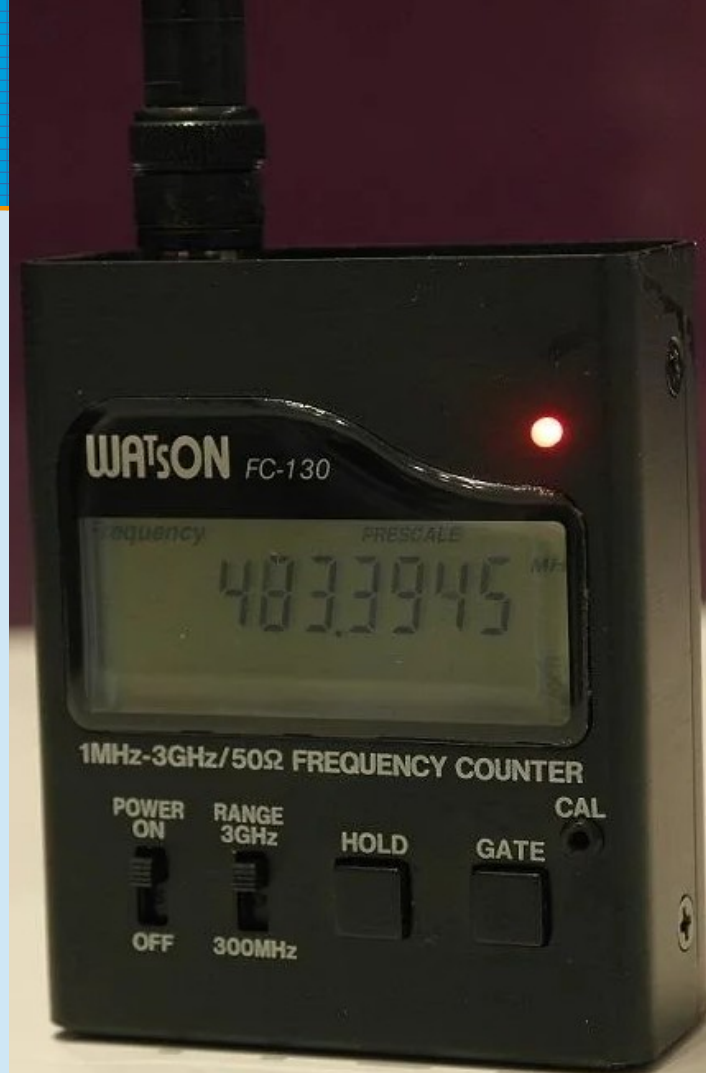
1MHz to 3GHz

Adjustable Gate

Hold Display Feature

Obtained for £10

Battery Powered



Thandar TF-200

- Thandar – Previously Sinclair – Cost me £15 – Battery Powered



Features

- Adjustable Gate Time (For accuracy)
- The more digits the better
- Mains or Battery Powered (Field use)
- Multiple input Ports for different sensitivities
- External Reference in

Optional Test Equipment

- RF Generator – Nice to have but not a “Getting Started” essential
- Function Generator – I would suggest you get one
- Waveform Generator – for the more experienced tech
- Spectrum Analyser – Good ones are expensive – RF use only
- Logic Probe – Essential for Digital Electronics
- Logic Analyser – Advanced Diagnostics – not for the faint of heart
- Digital Microscope – Give them a demo then time to go!

Final Note

- Your experience will take time to build
- It does NOT have to be an expensive Hobby
- Enjoy the challenge of building your own test equipment
- The Newsletter this Autumn will have more!