# POWER SUPPLY FOR NATIONAL 1-10A RADIO.

**(REPLACES THE NATIONAL 5886 SUPPLY. H. Holden Jan, 2020)**

**Background:**

I acquired a National 1-10A radio. It was well made in my opinion & interesting too, with two Acorn valves, type 954 & 955. A super-Regenerative set, covering 1 to 11 meters, it also contained a 6J5 and a 6V6 for the audio. I did not have a power supply and could not lay my hands on ones easily. So I decided to design & build one as a replacement:



**Power Supply design & construction task - "simple or not ?"**

On the face of it the specifications are very simple: 6.3V AC heater supply at 1.6 Amps and 180V DC supply at 35 mA, *running from the line voltage* (in this case 230V AC rms in Australia). There is a "big clue" right there, highlighted in red. There are important physical construction, earthing and safety consideration thrown into the mix.

It pays to remember that any line powered equipment that you build for yourself (even if you do not propose to sell it) will one day very likely fall into the hands of others.

Therefore the construction standard of wiring, earthing & fuse arrangements must be impeccable.

In other words what you create must ideally be better designed & built and be safer, than any equivalent commercial product. Or at a bare minimum equal for safety qualities.

Obviously a supply of these simple specifications in some form or other could be cobbled together in less than 1 hour with parts from the junk box and it could take the form of a transistor regulated supply, or a switch mode supply. I've seen a lot of power supplies like this, on internet published projects, when people are in a hurry to get something up & running fast. Sometimes a hazardous mess of dangling wires, exposed connections & components, with poor physical layout and poor mechanical construction.

One problem we are seeing these days in commercial line powered apparatus, especially in plastic enclosures, is that they are being so poorly made from the electrical & mechanical engineering perspective, that it poses safety hazards (both electrocution & fire risk). A lot of this equipment is imported wall wart and USB supplies made in the Far East. One person in Australia has been killed by an imported faulty design USB supply.

Also, looking at the National 1-10A radio itself, it is very well engineered on all fronts, both the mechanical engineering and the electronic design. So this would mean the power supply companion to it should be of "suitable quality & appearance" or bluntly, it would look like a "lame effort" sitting beside the National radio on a bench.

Therefore the main design parameters for the replacement supply became:

*1) Crinkle Black painted steel housing, fully enclosed (reduces fire risk).*

*2) Labelled switches & connectors (alert user to the voltages present).*

*3) Earthing & Fusing & Switching on the line power input side (reduces fire & electrocution risks).*

*4) No access of prying fingers to line connections (Chassis fully enclosed, reduces electrocution risk).*

*5) All components, transformers, wiring & capacitors run well inside their ratings (improves reliability).*

*6) Furnishes outputs that match the original National 5886 supply (suits the 1-10A radio).*

So now the supply design is not looking quite so “simple” is it ?

Other design parameters of less importance relate to the hardware. I tend to prefer stainless steel as it keeps its finish over time. Also for anything requiring a thread in sheet metal, I generally use press in captive machine nuts, rather than self threading screws. These can be undone hundreds of times with no thread damage.

For hookup wire, I use high temperature silicone rubber covered Harsh Environment Appliance wire. This wire has the advantage that the insulation does not melt or shrink back with any applied soldering temperature. It also has the appearance of vintage rubber covered wire. It is resistant to nearly all forms of chemical attack and far superior to PVC covered wire in every respect. It is more expensive though. It is sold by RS Components. The part number for the green wire is 359-712 for one example. It comes in Brown, Blue, Black, Red & Green.

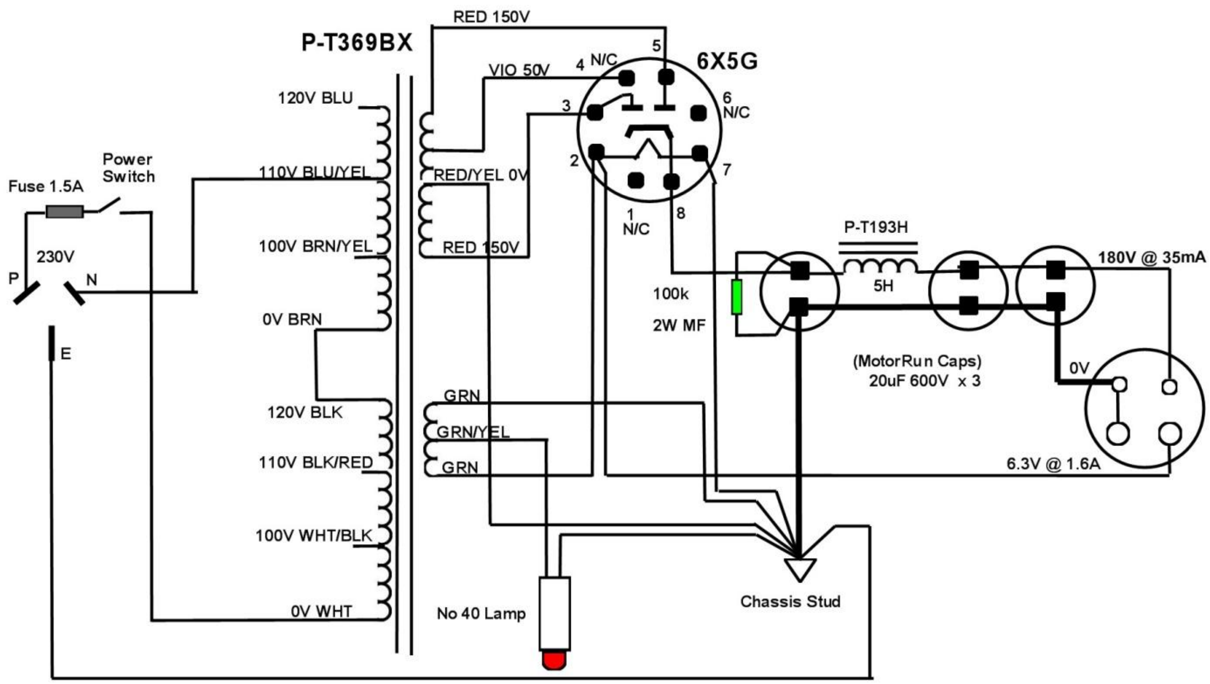
One issue though, with any high voltage power supply (> 70V), it is difficult to protect against stupidity. For example if a person is insistent on acquiring an electric shock they could poke conductors into the power supply’s output connector, while the supply was switched on. This applies to National’s original 5886 power supply too. Over the years, with some appliances like vintage TV’s, attempts have been made to deal with this with complex mechanical interlock systems to disable the power, if a plug is removed from a socket exposing it. But rarely are they practical and they often get disabled by users.

One important thing is to have a bleeder resistor across the filter capacitors, so that when the supply is turned off, the stored charge dissipates in some seconds. This is especially so if the capacitors are high quality low leakage types (MKP) as used in this supply version and driven by a high vacuum rectifier. Otherwise these capacitors could store charge for weeks or months. Oddly, National did not have a bleeder resistor in their 5886 supply, however, the leakage in their Electrolytic capacitors probably served the task.

Photo below of National's wonderful 1-10A Radio undergoing some repairs:


**Power Supply Circuit Design:**

I decided to go for a conventional transformer based 50/60Hz operated supply and avoid any RFI issues of a switch-mode supply. And since it was for a tube radio application, why not use a tube rectifier too. The original 5886 power supply used an 80 rectifier. After looking around for suitable power transformers, the closest one I could find for the application was a Hammond P-T369BX. Also I used a Hammond 5H choke of the same physical size. Since there was no 5V winding on this transformer, rather then using the 80 rectifier I used a 6X5G. The schematic:




I made use of the centre tap connection on the filament winding to run the power lamp off half voltage. Due to the fact this lamp has a clear glass lens (yes real glass for this one) the filament temperature a yellow-orange color which is easy to see, but not too bright. This way the lamp will likely never require replacing.

Of note: **This power supply version does not contain any electrolytic capacitors**.

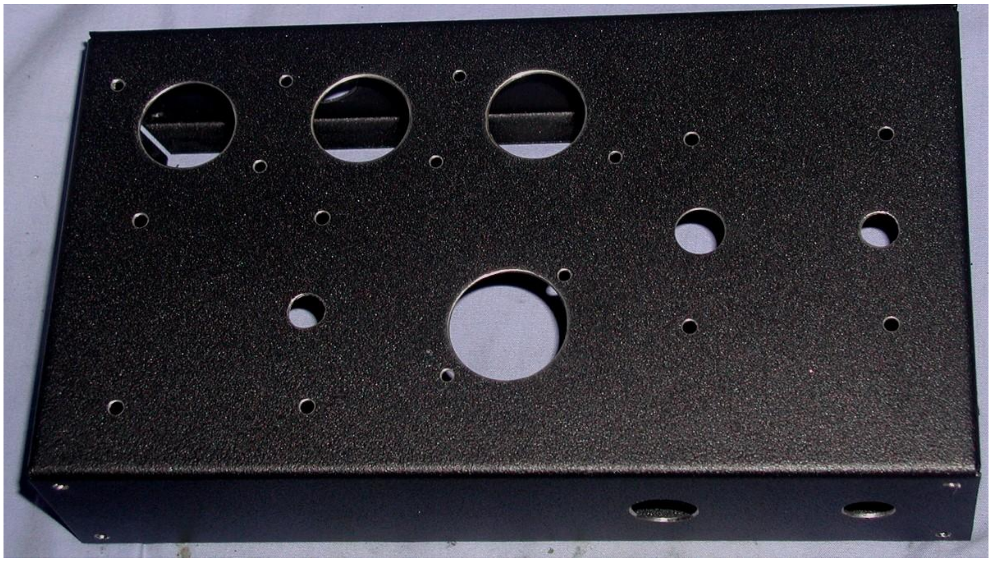
Over the years having many bad experiences with the electrolytic capacitors and forensic examination of the many failure modes & opening them for inspection, I prefer to use non-electrolytic capacitors where possible. The capacitors used here are 20uF 450V AC rated (over 600v DC rated) MKP motor run types, which from the chassis top physically resemble an electrolytic capacitor, but these components are far superior and likely they will never fail in the application, unlike the electrolytic. The maximum voltage they are exposed to in this design is about 220V DC off load. They have extremely low leakage and hence the requirement for some bleeder resistance that was not present in National's original circuit.

On testing this supply, with a 231V rms line power input, powering a normally working (restored) 1-10A radio, with NOS tested tubes, the HT measures 181V DC and the heater supply, at the tube sockets in the radio, 6.37V AC rms. The radio draws a little less than 35mA from the HT supply. 35mA must have been a nominal value.

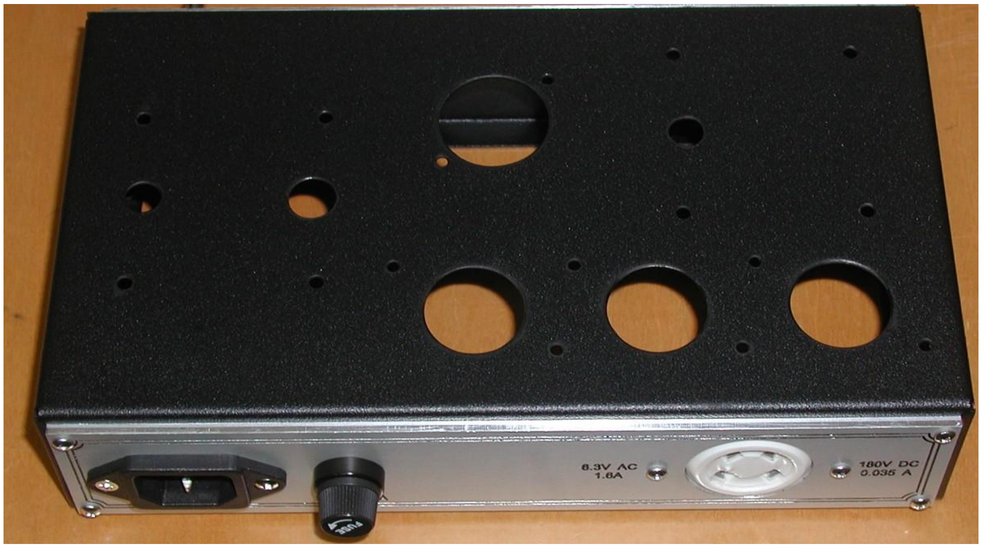
**Photos during construction:**

I decided to go with a pre-painted 2” x 5” x 9” Hammond Steel chassis. These come with a bottom plate (which is required for safety reasons) and a top ventilated cover.

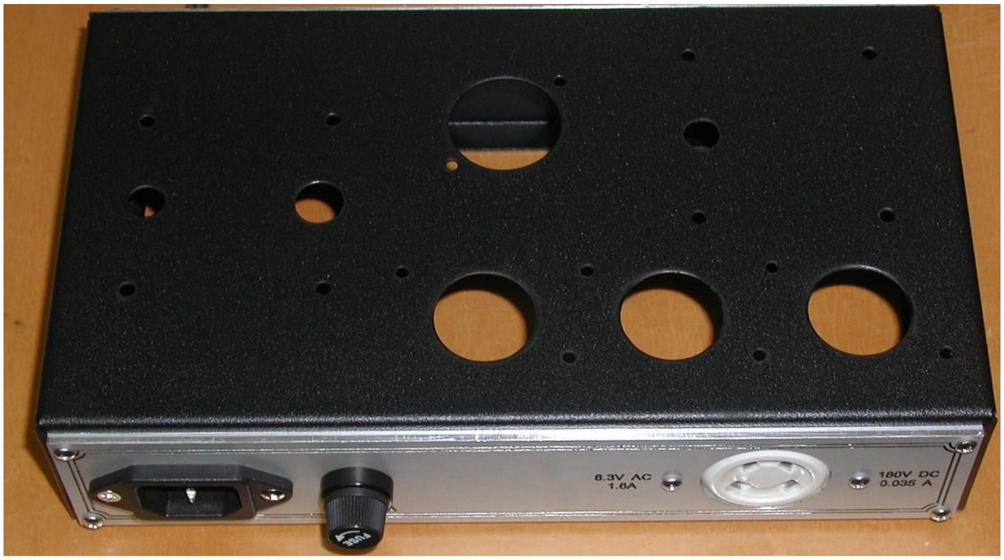
When working with pre-painted chassis the paintwork must be protected with tape and the cut hole edges smoothed and then painted to prevent rusting. The photos below show the construction process along the way. Holes cut & smoothed ready for painting:



Hole edges painted with satin black paint:



Also, I had the local engraving store make silver satin finish 3mm thick (close to 1/8”) front and rear panels, engraving filled with gloss black paint. This shows the rear panel fitted.




I have never been particularly happy with self threading screws into steel or aluminium sheet metal. I prefer pressed in nut inserts, so I abandoned Hammond’s base screws and fitted 4-40 UNC stainless steel captive nuts for both the base plate & the top cover:

It is important, where wires pass through chassis holes to use rubber grommets:

The underside view shows the wiring. The most important point here is the earth stud which needs a double nut locking arrangement and should be a separate fitting unrelated to any other hardware.

The earth pin on the IEC connector’s connection to the chassis should support at least 10 to 15 Amps. The paint must be cleaned off the chassis in the region of the earth stud (I have a tool for doing this) and locking star washers must be used. The first nut is done up securely with a socket wrench. Another nut and star washer is added to the stud to make sure the first nut cannot loosen. Ideally nobody has access to the stud’s head (if it is a screw) as they might loosen it by mistake. In this case the top chassis cover is helpful to keep out prying hands, although there is nothing dangerous on the chassis top, except perhaps the hot glass of the 6X5G rectifier. Some manufacturers have a riveted in chassis earth stud, which is helpful.

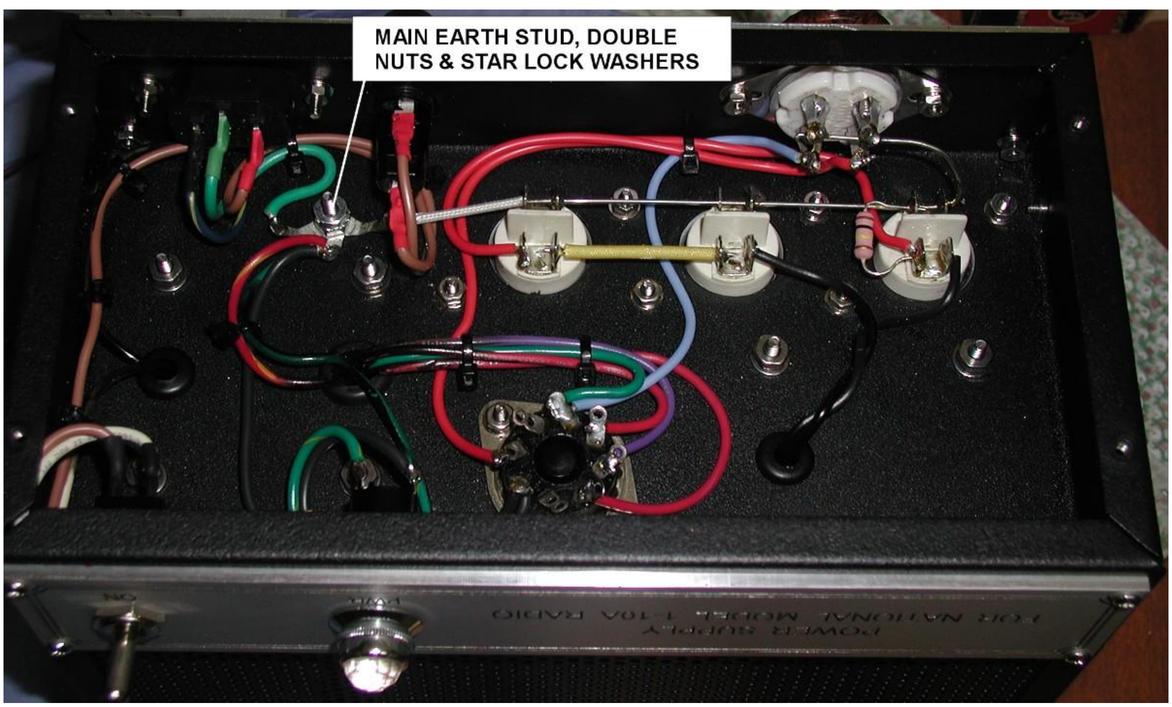
The purpose of the fuse is to protect the wiring inside the instrument and possibly the transformer in events of shorts or severe over-current. So the important factor is that the fuse has a lower current rating than the wiring around it. Higher current rated fuses reduce the possibility of nuisance fuse blows with turn on current surges. Lower range current rated fuses can provide additional protections for other components, the transformer windings etc. In all cases the fuse must have a lower current rating than the wiring around it. In this design, if the 6.3V winding is shorted out, the primary current goes over 1.5A and the fast blow fuse blows. However, the turn on current surge, with cold tubes, is below 1.5A and there is no possibility of nuisance fuse blows.

Two advantages of a metal enclosure (compared to plastic) is that if any of the components catch fire, it is contained most likely inside the enclosure. Also a good earth to the enclosure body is easy to achieve with an all metal enclosure.

Many plastics, even “approved types” it seems make an excellent hydrocarbon fuel for a fire and I’m not very keen on them for enclosures for line powered applications, but they are cheap & lightweight and therein lis the common use of them.

All the wiring on the line power side is high temperature appliance wire. It is also helpful to have heat shrink insulation on the line wiring connections in the unit. This can avoid accidents if a technician is working inside the unit while it is powered. In many appliances these are often left bare and are a hazard because of that.

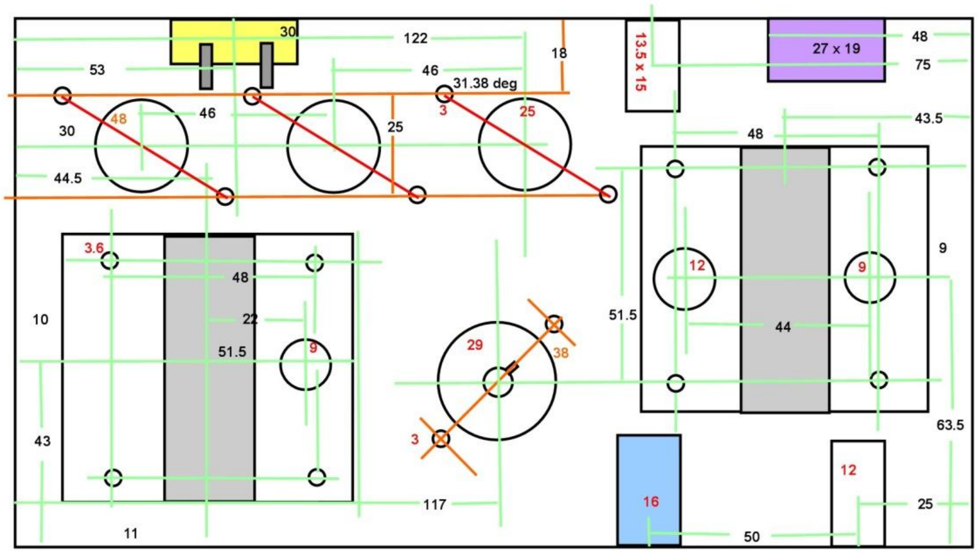
The hole for the main earth stud was drilled last and the surrounding paint removed (not painted like the other holes). The lugs used are also a star washer type.

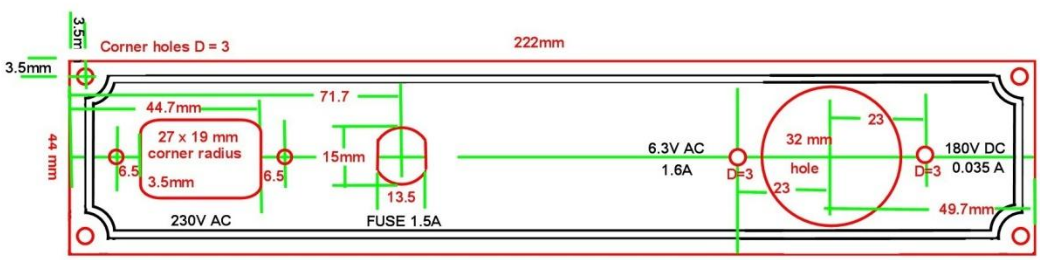


Rubber feet were fitted to the base. I machine brass sleeves or a bush so the rubber is slightly compressed when the screws & nuts tighten them, but they do not work loose as they always will if a metal bush is not used. I never use stick on rubber feet, because they nearly always fall off and are “hopeless”. Mind you we have a hot climate in Australia and it is good at melting the adhesives.


The following photos show the front and rear panel views, it pays to have everything labelled, especially that there is 180V at the output socket, exactly the same as National’s 5886 power supply :


The following diagrams show the geometry (in mm) of the assembly in case anyone wants to replicate it, the Hammond chassis is 2” x 5” x 9”:




3mm thick engraved silver surface aluminium panel with black ink.

3 mm dia corner holes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