EXTERNAL DUAL 5.25 FLOPPY DRIVES FOR A CP/M COMPUTER – CONSTRUCTION ARTICLE.

(H. Holden. August. 2019).

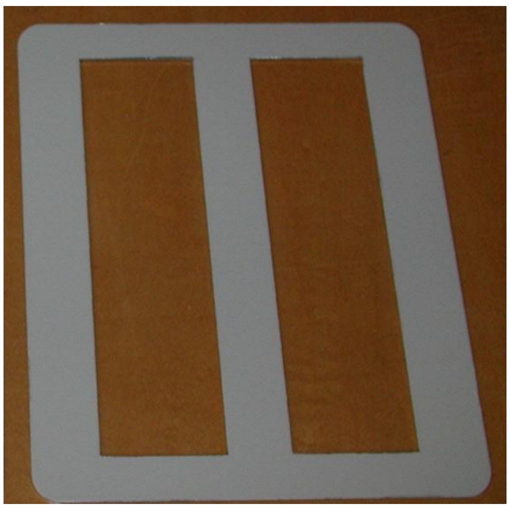
Background:

I acquired a vintage SOL-20 computer but did not have the original Processor Technology Helios Floppy Disk drive, or the controller. So, instead I acquired a North Star MDS-AD3 floppy disk controller card for the computer. I then assembled two 5.25" floppy disk drive units inside an enclosure, along with a multi-input voltage switch-mode PSU and Mike Douglas's VSG (virtual sector generator) so that soft sectored disks could be used. This article describes the construction of the twin drive unit and includes the dimensions of the cut-outs and drill holes and items required for the task.

Construction- Front Panel:

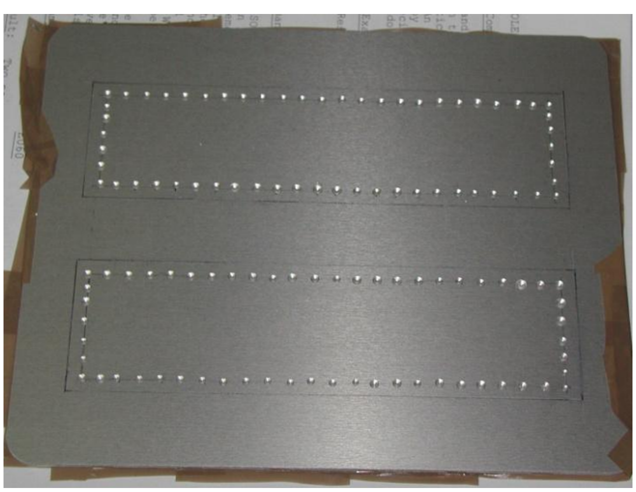
The enclosure is a Takachi model UC-15-18-28-GG. These are readily available on mail order from the Takachi factory in Japan. These are very high quality, with a tough coating and made from extruded aluminium.

Takachi offer a machining service. For this unit, the second one I have constructed, I opted for Takachi to cut out the two large rectangular holes for the drive units. These large rectangular holes are very time consuming to cut out perfectly by drilling and hand filing.

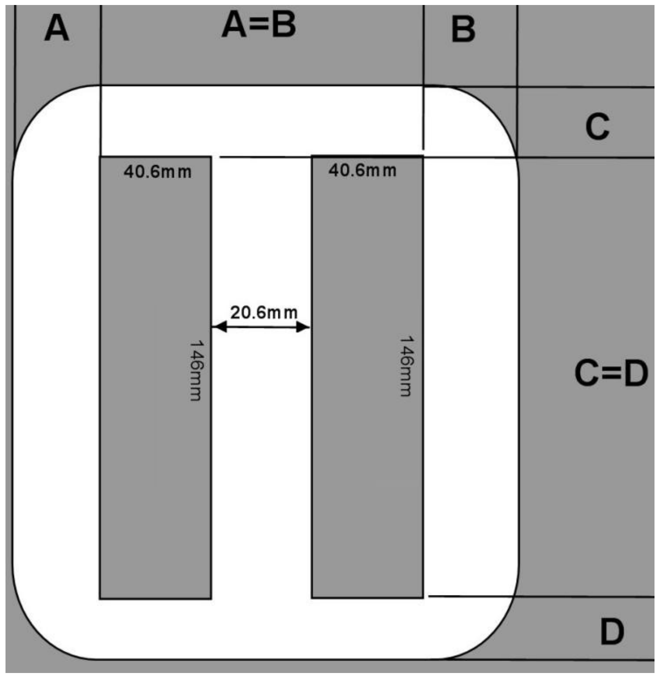


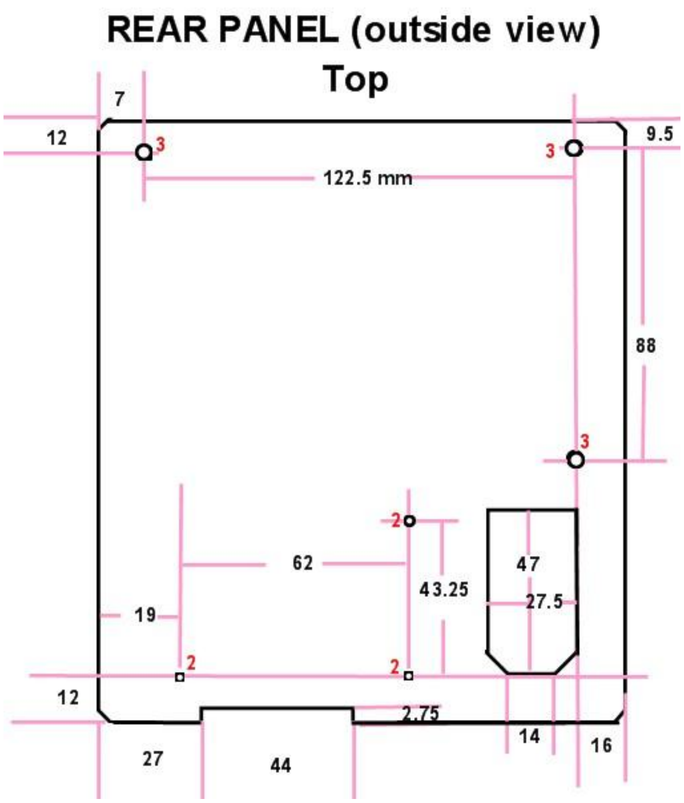
Takachi used a rectangular edged punch to make these holes on the panel seen to the left. They will also CNC mill them if you request it. This gives a slightly smoother edge. No difference is seen with the drives mounted because the escutcheons cover the punched edges.

This panel on the right is from the first unit I made. It was drilled initially then filed out by hand. If you do this be sure to protect the surfaces with liberal plastic tape to prevent the panel being scratched and marked in the process:



The geometry of the holes (which suited the YD-580 5.25” disk drives) is shown below. Likely these would be similar for most brands of 5.25” disk drive:





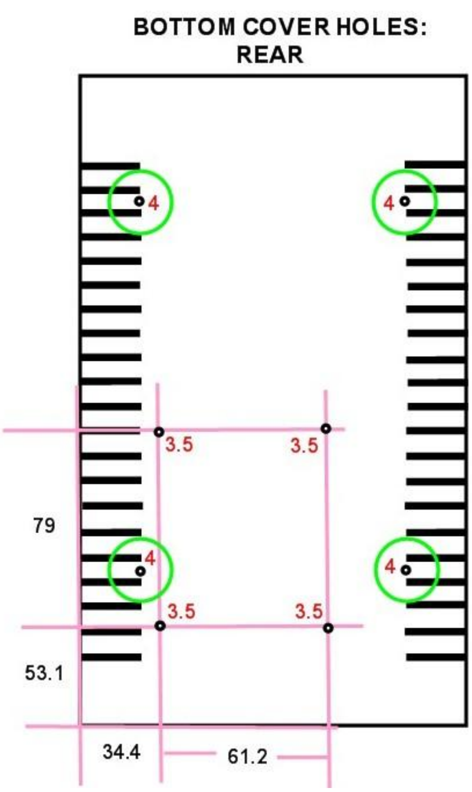
Drill hole diameters for the rear panel are shown in red. If you are not used to methods for exactly marking and starting a drill hole location you can increase the 2mm holes to 2.2mm and the 3mm holes to 3.3 mm for some additional clearance if the holes are not perfectly centred.

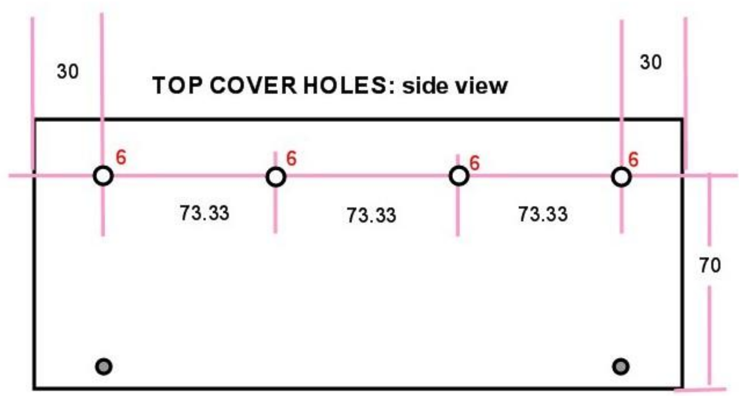
The rear panel is shown to the left, with a cut out for the mains/line IEC power connector.

Ensure the drilled holes are de-burred. I use a small countersink tool in the drill press with just a light touch. The inner edges of the hole for the IEC connector are smoothed with a diamond file and 1000 grade paper. Then the panel washed with water and detergent.

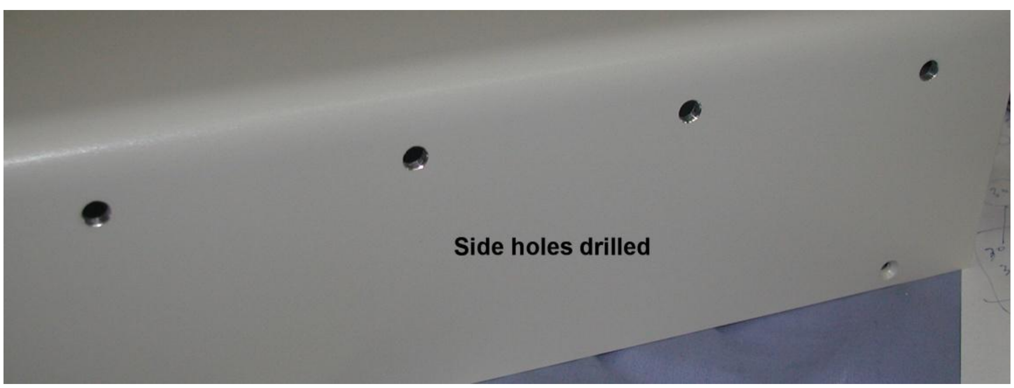
Case Bottom:

The case bottom requires 8 holes. I select the case half that has the pre-existing punched rectangular ventilation holes to be the “bottom half”. The reason for this is that if these holes are on top, then more dust would enter the case. Instead, as shown below, some holes are drilled in the side of the top half of the case, to allow air convection currents through the case and these let in very little dust.



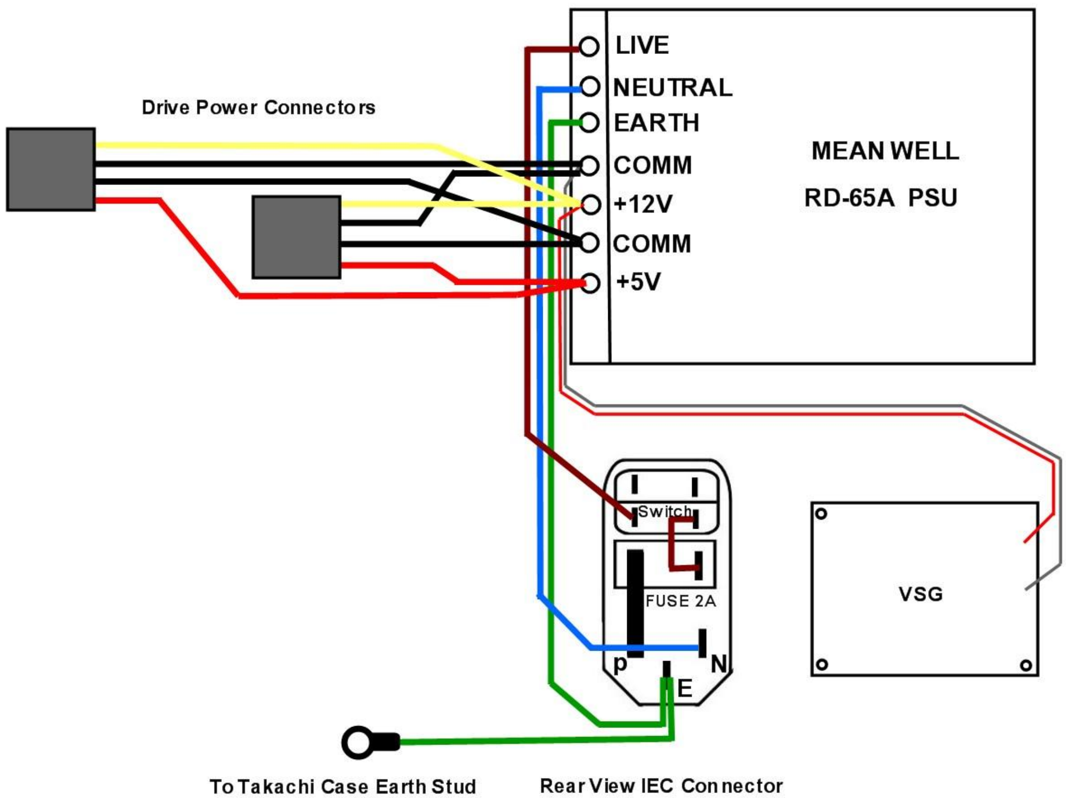


It is important when drilling the top cover side holes to protect the surrounding surface with tape. I drilled the holes (after marking with a pointed scribe and starting with a 1mm drill in a hand pin chuck) with an initial 1.5mm pilot hole, increased it in steps to 5.5mm. The final pass was with a 6mm diameter step drill which leaves a very smooth surface on the hole cut edges. The reason for this is that the hole's edge is visible as the material is around 3mm thick. Finally, the hole edge is painted with some flat off white paint to best match the case color. This makes it look as though the case was manufactured with these holes:

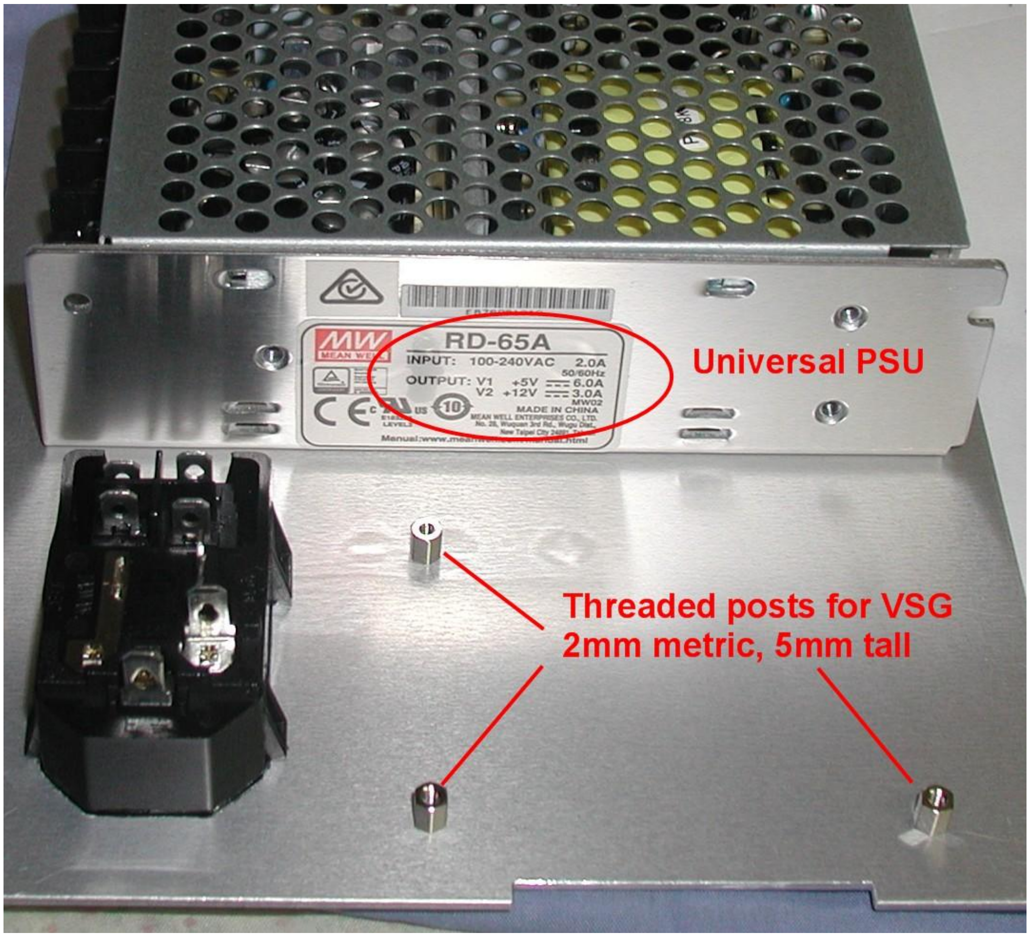


Assembling the rear panel:

NOTE : The diagram below shows the “basic wiring”. It is only a diagram. There are important considerations; with the terminating lugs on the wiring, the wire quality & insulation requirements. So also see the photos & text that follow.

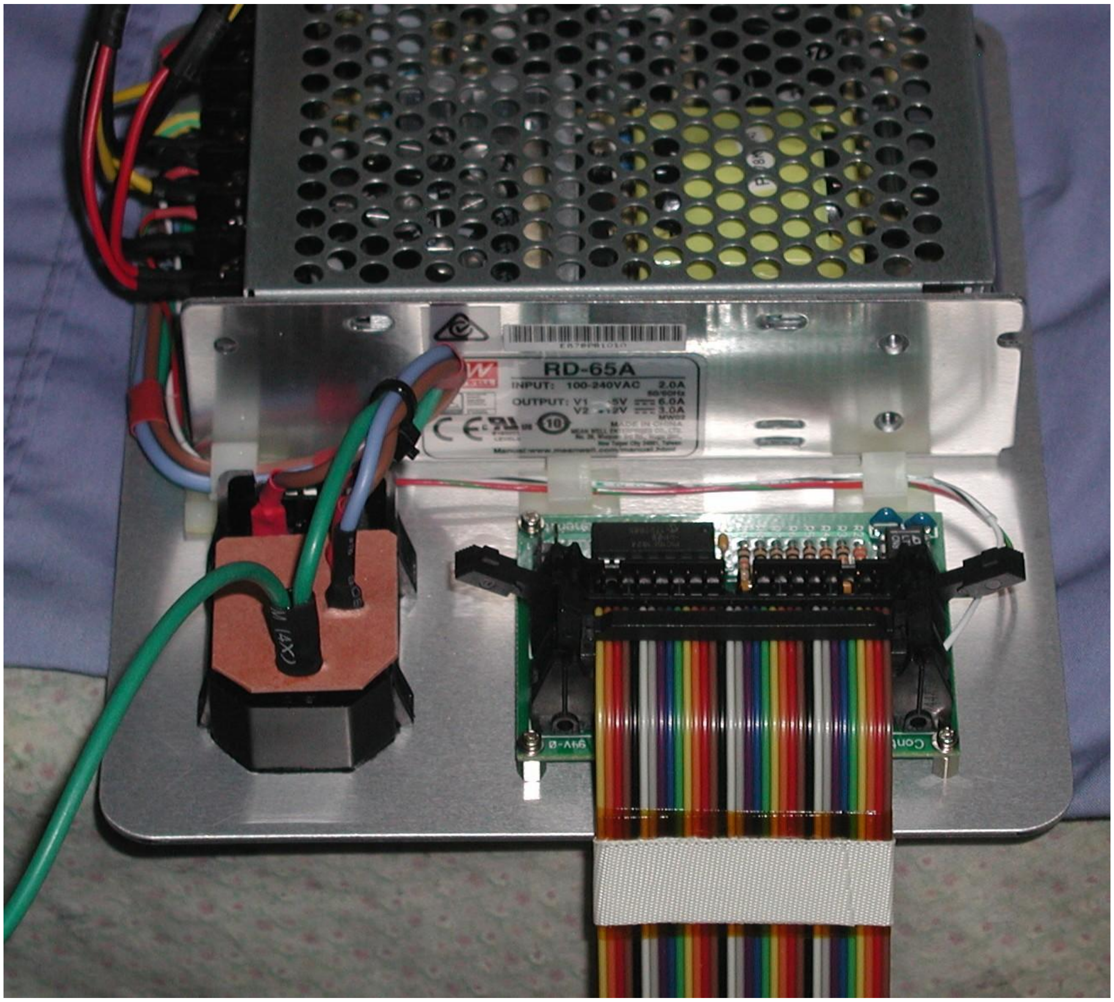


The components on the rear panel include the mains(line) input fused & switched IEC connector , the VSG and its mounting posts and the Mean Well RD-65A switch-mode PSU. This PSU has 5V @ 6A and 12V @3A rated outputs, well in excess of what is required for the two disk drives.



The VSG’s PCB has no mounting holes. However it is easy to add 2mm diameter holes on three of the corners. Their centres spaced 2mm from each edge of the PCB.

The next image shows a number of wiring details:



The VSG is secured to its mounting posts by three 2mm metric screws with spring-lock & flat washers. The VSG is powered from the PSU’s +12V output. In this case the wiring to the VSG is Teflon covered, but standard PVC wire for this is more than satisfactory.

Where the ribbon cable passes under the slot in the bottom of the rear panel, it is covered initially with three layers of polyamide taped and two layers of Scotch 27 glass cloth tape.

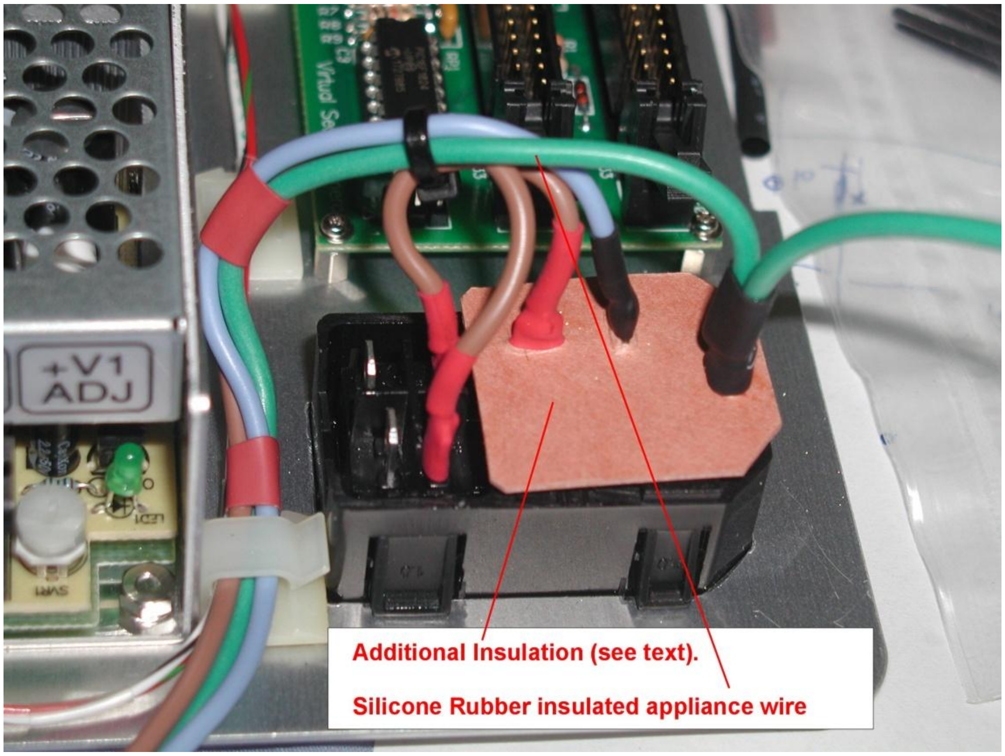
As can be seen, two Earth connection wires are soldered to the line power IEC connector, one passes to the PSU which grounds the PSU body and rear panel it is attached to. The other Earth connection passes to a terminating lug and ground stud on the enclosure (this is provided by Takachi, see below).

Most fused IEC mains power connectors leave the connection between the active pin of the connector, which passes to the fuse assembly, exposed on the rear of the connector. Sometimes insulation boots are available, but mostly not for the longer & switched assemblies with fuses. Some authorities (Silicon Chip in their mains operated projects) recommend covering this exposed metal strip with Silicone rubber. That is a little messy and it could fall off. So I simply add electrical grade high dielectric strength transformer card (available from Jaycar Electronics part number HG9985) to cover that area. This helps avoid inadvertent finger or hand contact with the Live (active) connection, when working on or servicing the inside of the unit.

You may notice that many supposed professionally factory made instruments you open for inspection, have a paucity of insulation over the line IEC connector pins, but I regard that as poor practice.

Also note that heat-shrink sleeving should be used over the soldered connections on the IEC connector.

Small rectangular stick down nylon wire retainers are used to keep the wiring orderly.



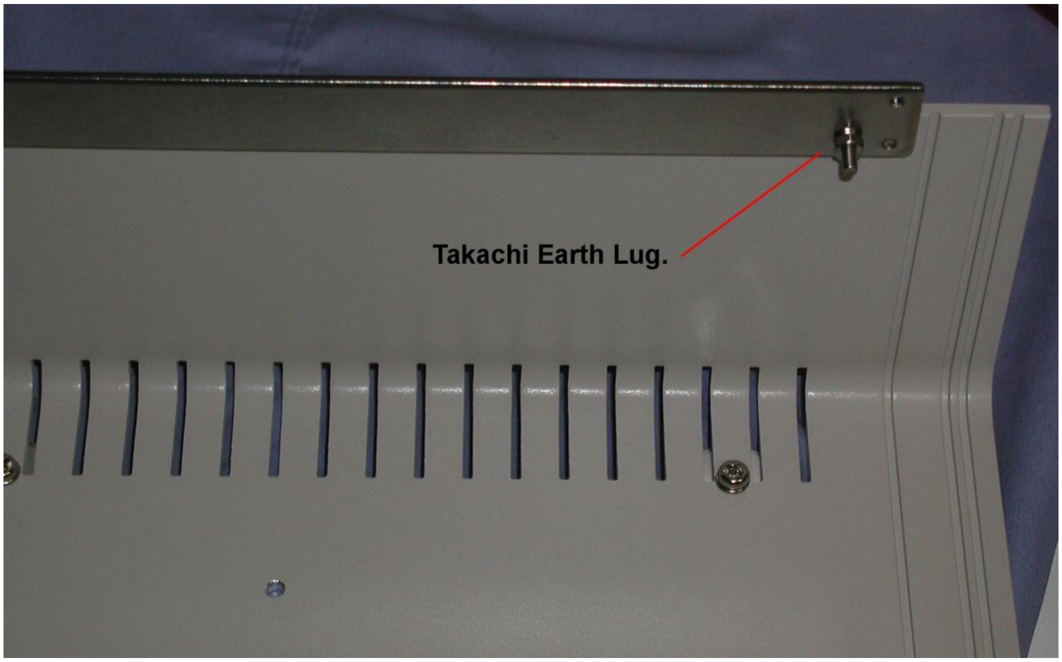
I prefer to use high quality silicone rubber insulated heat resistant appliance wire for all of my projects which have any internal mains wiring. It is more expensive than ordinary PVC covered wire. This particular wire has insulation rated at 180 Deg C, 750V and being $\mathbf{0.5}\boldsymbol{mm^2}$ wire it can carry 5A easily with a temperature rise of only 30 degrees C above ambient. The line fuse rating for this unit is 2A (see notes on fuse selection below). This wire is called “harsh environment wire” the RS Components part number for the green is 359-712 for one example.

So why use harsh environment wire when it is not a harsh environment ?

The silicone insulation does not retract with soldering, unlike PVC which is poor in this respect. Higher range soldering iron temperatures can be used when soldering the wire to ferrules or other solder lugs. This increases the activity of the flux in the multi-core solder and results in an excellent solder join. Also, Silicone rubber is very long term stable and resistant to most chemicals and does not give off toxic fumes if heated (unlike PVC). Once you have used superior wire like this it is very hard to go back to common garden PVC for internal instrument mains wiring. Also, this insulation is immune to damage when the heat-shrink sleeving is shrunk around it.

Ordinary PVC covered mains rated appliance wire can be safely used too, but this Silicone insulated wire is so much better.

The output terminal from the fuse passes to one pole of a two pole switch, then on to the PSU’s Live (Active) input connection. It is optional to switch the Neutral connection too, not done in this instance, so as can be seen; two of the switch contacts on the IEC connector are not used. (However if Neutral is switched, the Active must also be switched as well. Neutral should never be switched on its own).



As noted Takachi provided a solid Earth lug system which accommodates a 3mm CS screw, so as to be able to properly earth the case covers.

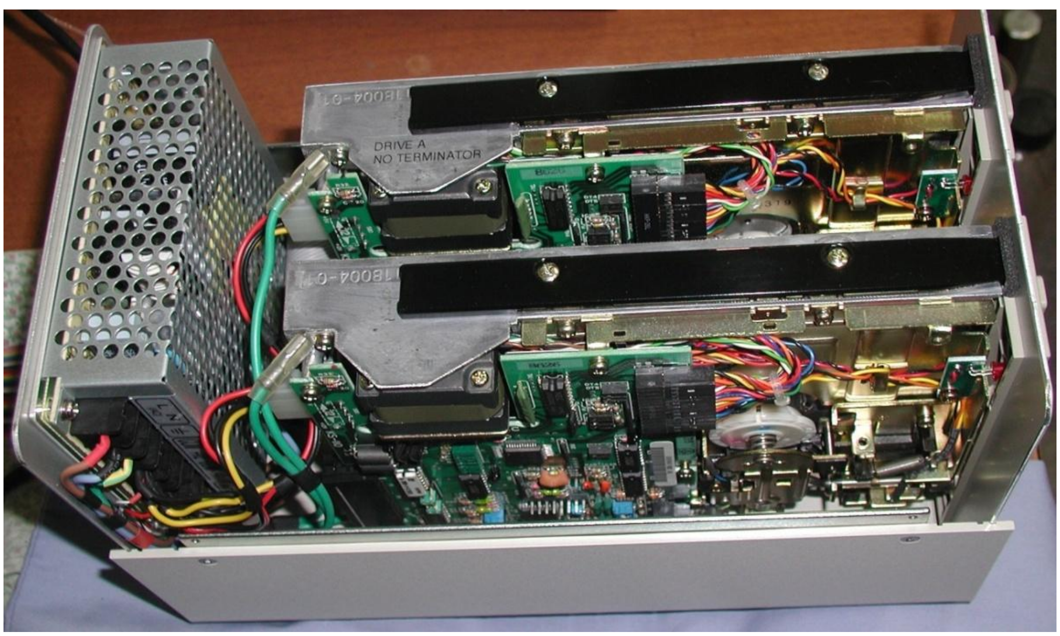
Note: There are major advantages of an all metal enclosure, versus a plastic one, for a mains operated appliances.

Firstly the metal enclosure reduces fire risk. Smoke may leak out but flames are mostly contained in the enclosure and it won't melt or catch fire like plastic can. Components within Switch-mode PSU's, despite their internal safety features, have been known to smoke and cause fires.

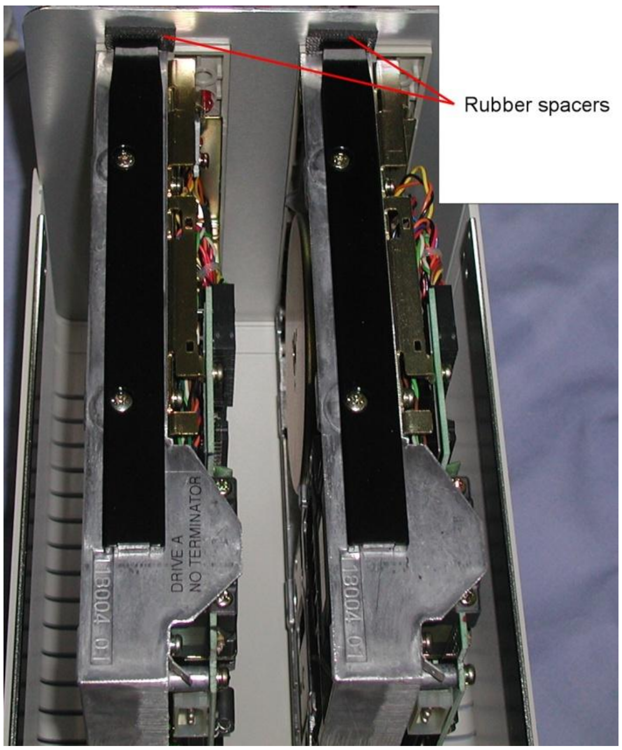
In addition with a plastic enclosure, when metal objects pass through it to the outside world and if mains powered, it then requires Earthing of each metal part, which can be quite inconvenient if there are a number of screws and connectors etc.

In short, a plastic enclosure is cheaper, nastier and not as safe (unless it's a double insulated supply with no metal-work passing through its walls). A metal enclosure also provides electrostatic screening and is much longer lasting and less of a pollution threat than plastic. Plastic enclosures are probably better suited to battery operated and portable equipment.

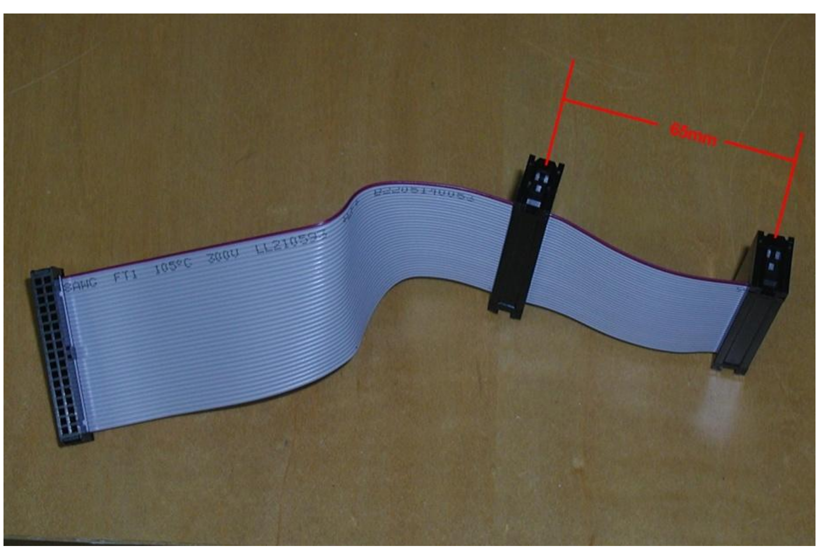
The photo below shows two additional Earth wires, these connect with spade terminals to the Earth points on the Drive bodies and they pass to the Takachi Earth screw on the enclosure along with the Earth wire & lug from the IEC connector. The lugs are retained with a 3mm nut and lock washer.

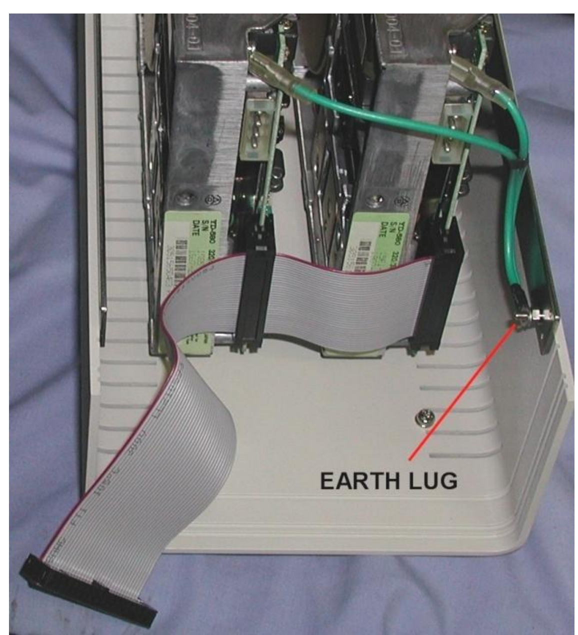


The photo bellow also shows that the black plastic guides on the sides of the drive are used with some 4mm thick rubber to help retain the drives to the front panel. The metal feet with the “O” ring rubber inserts are 25mm diameter and secured by 4mm screws are also supplied as an accessory from Takachi. (I avoid the usual stick on rubber feet because sooner or later the adhesive always fails and they fall off. They are what I have come to call a “lazy solution” to an instrument’s feet requirements)



The two photos below show the details of the drive’s data cable**.**





Mounting the drives to the Enclosure:

The front panel is merely cosmetic and does not hold the drives in place in the enclosure. The drive bodies themselves are mounted to the lower half of the enclosure by 3mm diameter metric machine screws & spacers, two for each drive.

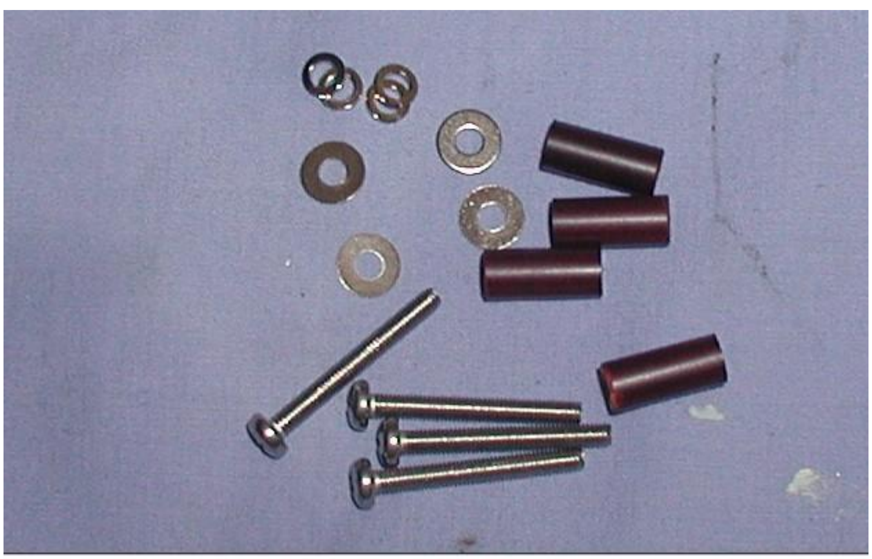
Due to the fact these drives are Japanese made, the screw threads in the alloy bodies of the drive are 3mm iso metric, not UNC.

On the lower side of the drive bodies, out of view in the photos, the black plastic drive tray slides are removed and the spacers approximate the alloy surface of the drive body. The removed black drive tray slides turned around on their long axis and used on the top of the drive body with the rubber spacers to help reduce any movements/rattling of the front panel.

Measurement and calculation indicated that the correct spacer height was 13.8mm, however a 14mm spacer is close enough.

Still, most metric spacers come in sizes such as 10,mm or 15mm length. So it may be necessary to trim 15mm spacers down, to get the four of them close the 14mm high.

I used phenolic rather than metal spacers, with an internal 3mm hole and a 6mm external diameter:



DRIVE MOUNTING HARDWARE

3mm x 25mm long screws, spring + flat washers.

13.8mm tall spacers (or 14.0mm)

Terminating Connections for the Earth lugs and PSU:

Simply because there is a “screw down connection” such as the screws on the Mean Well PSU, which could be used to clamp down the exposed core of a multi-strand wire, I would advise: don’t do that.

The local forces damage and break the strands. It is far better to use a terminating lug or ferrule. With a flat lug, the wire can be passed through the small end hole in the lug, folded around for mechanical security and then soldered. After that, the flux cleaned away with CO Contact Cleaner and heat-shrink sleeving applied on the solder end of the lug:

I have seen some imported appliances with CE logos on them where the strands of wire were simply placed under an Earth screw’s nut & washer and most of the wire’s strands there were broken. Or wires placed directly into screw down block connectors, where the compression of the screw’s end damages the wire strands.

Take the time to fit the lugs. It is important that the Earth lugs are very secure and that the soldering is impeccable too. Crimp connector lugs could also be used and crimping *can work well,* only provided it is done properly with *the correct tooling for the type of lug and wire used*. If not correct, the wire can have a high resistance to the lug (encouraging heating) or fall free of the lug, which can make for a very bad outcome.

A well soldered join, where the wire is also folded around a small flat lug hole, to mechanically secure it, prior to soldering and with the residual flux removed after soldering, is a very hard system to beat.

The same solder lugs, which can accommodate the 4mm screws on the Mean Well supply connector strip, are used on the connections for the +5V +12V and common return wires for the drive's power connections.

Selection of the line (mains) Fuse Current Rating:

This is always more tricky than it seems. A fuse exists inside most line powered switch-mode PSU's on the circuit board, however it alone cannot be relied on and there must be a separate external fuse to the supply. This is why a switched & fused IEC connector is suited for this application.

Various methods have been used to select a fuse value for an appliance. The general principle is that the fuse or circuit breaker device protects the wiring (and sometimes other components) inside the instrument from failure or burnout in a fault condition and has a lower current rating than the current carrying capacity of the wiring external to it.

For example, the application of the fuses or "circuit breakers" on a dwelling's mains power board is to protect the house wiring, not the appliances plugged onto the general purpose outlets. The fuse burns out (or the breaker trips) before the house wiring heats up excessively risking fire. The same general principle applies in the environment inside an instrument.

Inside a mains powered instrument the fuse protects the wiring there and sometimes components in the power supply & other circuitry. Ideally, in a fault condition, the fuse fails before excessive heat is developed or evolved in any wiring or components. So the fuse must always have a lower current rating than the current carrying capacity of the wiring leading to and from it, is a general safe guide.

Unfortunately it is not a foolproof system and the power dissipation in some failing circuit board component can still be too high and cook the component up, while still being within the fuse's current rating. This is another reason why switch-mode PSU's themselves are better off being built inside metal enclosures than plastic ones and why any mains or line powered project, that is home built, is better built into a grounded metal enclosure and not a plastic one.

However, metal enclosures require good Earthing/ Grounding. Many plastic enclosed PSU's don't have earthing (hence only the 2 prong plug) and are designed as double insulated or "isolated" units. Such as the many "wall wart" supplies that have become so popular. These are not without their hazards though, if the internal insulation breaks down or they are of bad internal construction quality. Fortunately now, most dwellings are fitted with RCD's which have improved safety significantly.

In the instance of the switch-mode PSU, the initial turn on current surges can be much higher than an Analog power supply as the main filter capacitors in the switch-mode PSU charge up directly from the rectified line power and not via a transformer (which limits the current) as in the case of the Analog supply. Not all small capacity switch-mode PSU supply designs contain inrush current limiting circuits. Most large supplies for computers fortunately do. The Mean Well RD-65A supply has a max power output of (12 x 3) + (5 x 6) = 66 Watts. Assuming a very rough 80% efficiency, then one would expect 80 Watts power consumption taken from the mains (supply on full load) and for a 230V supply, that is about 0.35A or about 0.7A running from a 115V line source. An experiment with the RD-65A supply, with a standard speed fuse, connected to two YD-580 disk drives, shows that to avoid nuisance fuse failures, from the turn on current surge, the fuse needs to be 2A rated.

Is there a very rough rule of thumb for selecting a fuse for a switch-mode PSU which does not have inrush current limiting? One method that "works" is to start with a low fuse value, with a fast blow fuse, which will blow on turn on (the PSU also being loaded with whatever it normally supplies). Work up in value until the fuse starts to survive turn on for at least a few attempts. Then use double that value to avoid nuisance fuse blows or 1.5 times that value if a slow blow fuse is used. If the selected fuse current value is too low, or borderline for the application, over time it will be found that the fuse fatigues and after some hundreds of turn off-on cycles it will go open circuit, not due to a fault condition.

The power consumption from the two YD-580 Disk Drives is significantly lower (well below 15W most of the time) than the 66W the RD-65A supply is capable of. However, using a larger robust supply is likely to have better longevity as the light loads result in less heating within the supply unit's transformer's windings and inductor windings and less heat evolution in the rectifiers and lower ripple currents in the capacitors too. With a cooler running supply, the electrolytic capacitors in it will also be longer lasting.

Some other remarks:

When equipment is powered by a double insulated or isolated power supplies, there is no definite voltage reference for its interface connections to other apparatus, if it has them. The equipment's common and signal/data connections can "float" above ground and hover at some significant voltage and with moderate capacitance storing charge. If the equipment is then connected (hot swapped- better avoided) to another appliance which is Earthed (say in this case the SOL-20 computer and the Disk drive card there) transient discharge currents can flow in the Data cable the moment they are plugged together. This has a higher risk of damaging IC's either on the drive card or in the drive itself. It is better, for apparatus that are 1) both mains powered and 2) both connected together at times, that they are both Earthed and their common signal lines have the same Earth potential. In the case of the SOL-20 computer, the power supply common for all the logic circuitry/cards is connected to the computer body and mains Earth.

In the case of the RD-65A power supply, the common and +5V and +12V connections on it, that feed the power to the Disk drive units are isolated or floating free with respect to the power supply's body and Earth connection. However, the makers of the YD-580 Disk Drives have made a connection between the common or return connection on the power input socket of the Drive and the metal body(frame) of the Drive, with a resistor. So the common or return power supply connection of the Drive assumes the same potential the Drive's metal body (which is Earthed in this instance). So therefore, with the Drive body Earthed, the Drive's Data cable common and the Disk Drive card's common (also Earthed) in the computer, assume the same voltage. The resistor though, limits any Earth loop currents if the Drive unit and the Computer itself are on two different Earths, say on two different general purpose outlets which shouldn't, but might have, some potential difference.

Electrical safety note- Mains Wiring:

Since this project uses mains wiring, then it behoves the constructor (if they are not licensed themselves) to have the work inspected & checked by a licensed Electrician to ensure the work has been completed correctly, prior to powering the unit.

On the topic of good Earthing of the enclosure, it is important that the Earth screw (provided by Takachi) is secured by one nut and lock washer and that the lugs that attach to that are secured by another nut and lock washer on top of the first nut. Ideally the Earth connection to the enclosure surface will carry at least 10A to the Earth pin on the IEC connector. Some authorities suggest 15A is better. The reasoning being that if the live wire came adrift in the enclosure and touched the internal metalwork, the main power-box circuit breaker will trip (or fuse fail) before the Earth connection fails. You cannot assume that an RCD will always be present in a dwelling to trip under this circumstance.

Another option, for those not wishing to perform (and have checked) any mains wiring, is to power this drive unit from an external approved double insulated dual voltage output PSU. In that case the mains IEC connector and the Mean Well PSU would not be used and a low voltage power connector would be fitted to the rear panel of the enclosure.

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