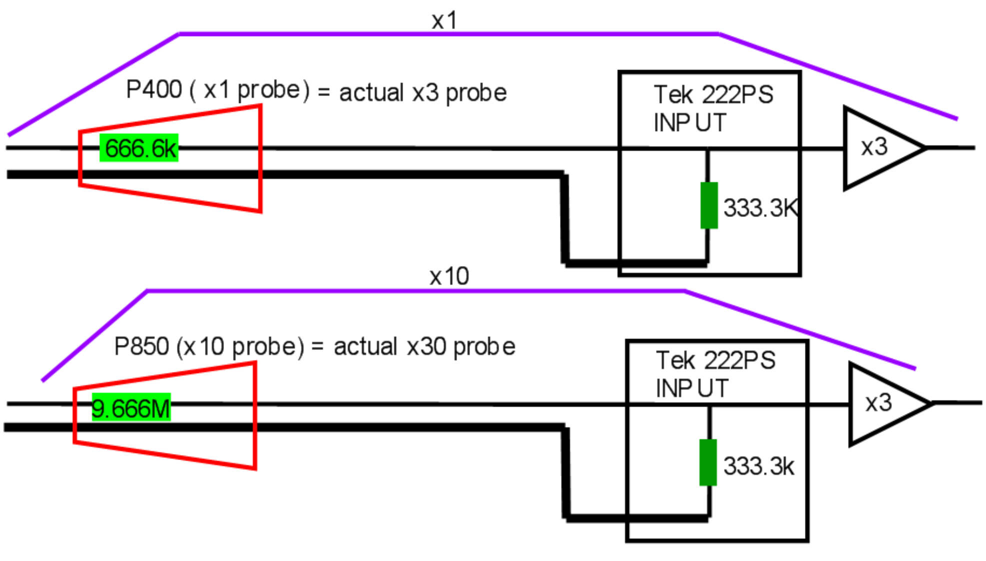
USING STANDARD x1 and x10 OSCILLOSCOPE PROBES WITH THE TEKTRONIX 222PS OSCILLOSCOPE:

& REPLACING the 222PS Battery

Dr. H. Holden 2013.

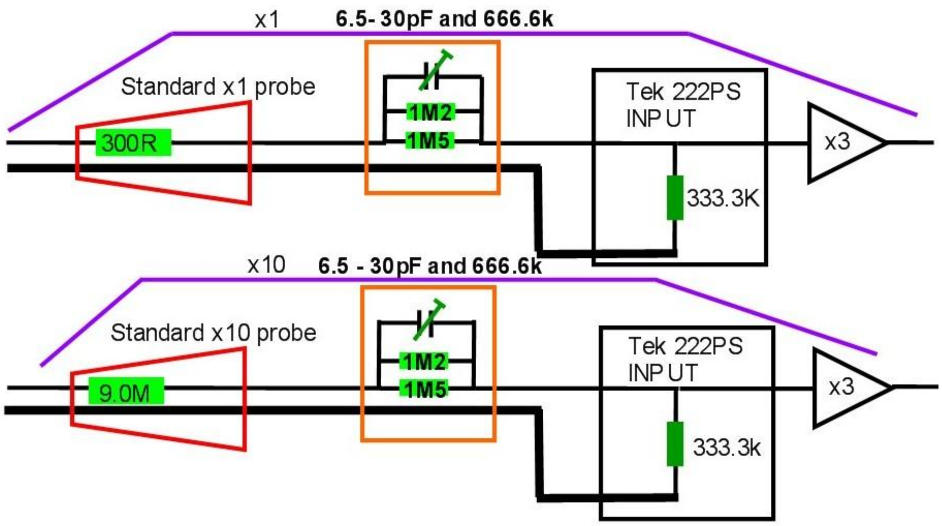
WARNING: The original Tektronix P850 and P400 probes(now hard to get) supplied with the 222PS were intended for connection to high voltage mains power circuitry and isolated with no exposed parts to 600VAC (or 850V DC + peak AC) and 1200V AC rms between channels and the probes were made with special insulation. This conversion is to use standard scope probes not for that particular application. The standard x10 probe is only 300V CAT II(DC + peak AC).So be mindful of the input voltage limitations and the exposed probe earth connectors using standard probes. In x1 mode a standard probe is only rated to 300V CAT I and 150V CAT II. So the use of the standard probes renders the 222ps for mains voltage testing only as safe as a standard oscilloscope (which is not perfect) with the exception that the input grounds are isolated which can sometimes be very helpful. Probe voltage ratings need to be de-rated with increasing frequency so observe the manufacturer's recommendations. So the modification described here is only recommended for safe low voltage work and not for working with mains power testing. A x 100 standard probe will add a huge safety margin even over the original x 30 provided the adapter surface is well insulated.

The 222ps differs from a standard oscilloscope in that its input resistance is 333.3K rather than the typical 1meg Ohms. This was done to divide the input voltage down to 1/3 of what it normally is to be presented to the first stage input amplifiers of the scope. This helps to increase the voltage range that can be measured to 3 times that of a normal probe. The P850 probe in conjunction with the 333.3k input resistance creates x30 attenuation and the P400 probe x3 attenuation. The gain is simply recovered later in the overall scope calibration. This is summarised in the following diagram:



Tek 222PS scope has a 333.3k input resistance unlike most scopes which have a 1M input resistance.

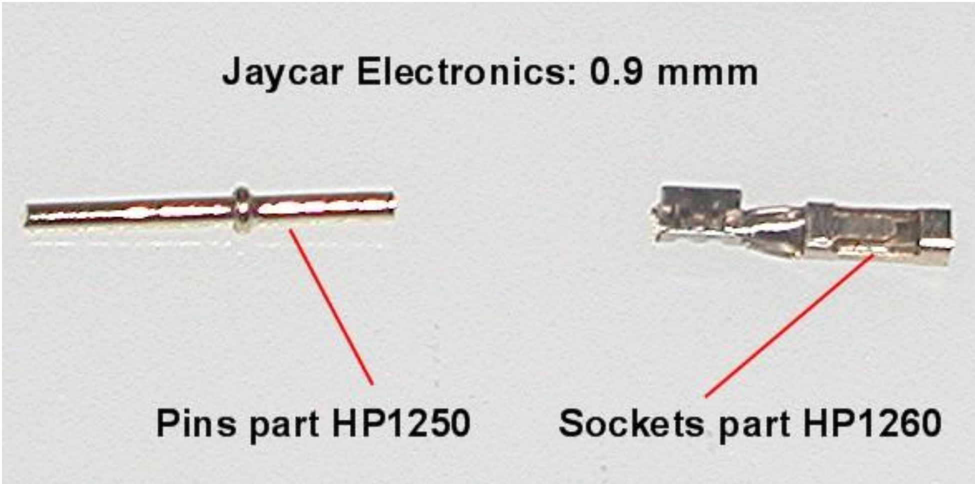
To obtain the correct overall resistance so stanadrd probe has the correct calibration a 666.6K series resistor is required. It also requires a high frequency compensation capacitor to maintain a flat response across the scope's 10 MHz bandwith. The following diagram summarizes the adapter (in the orange box) that needs to be placed in series with the standard probes:



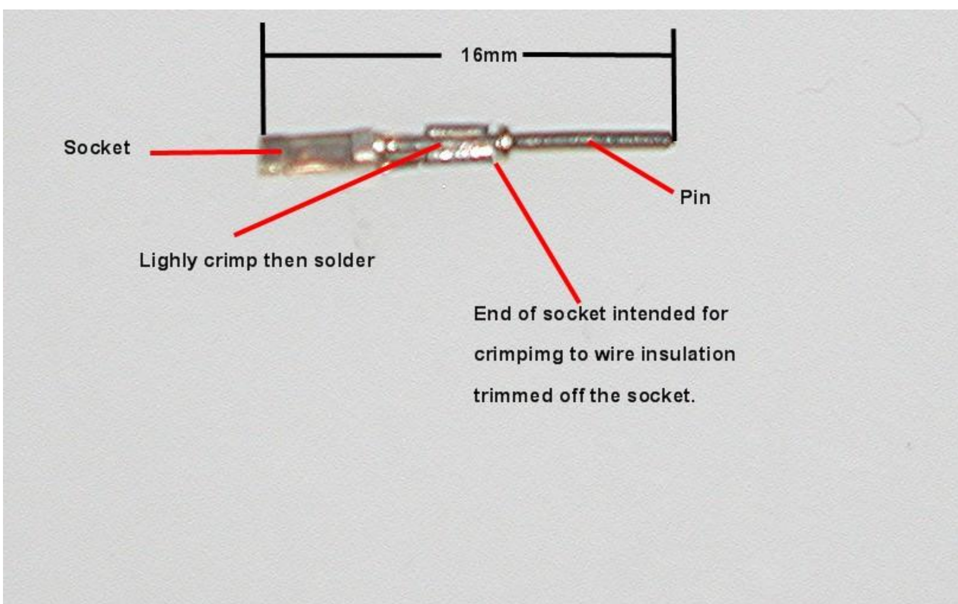
This arrangement ensures that not only do the probes see the correct impedance they were designed for, but the voltage calibration is correct on the scope's display.

Firstly is is necessary to gain a connection to the scopes input connectors. It turns out that a BNC adapter part (often supplied with standard probe kits) slides perfectly on to the outer "ground" connection of the scope's input connector.

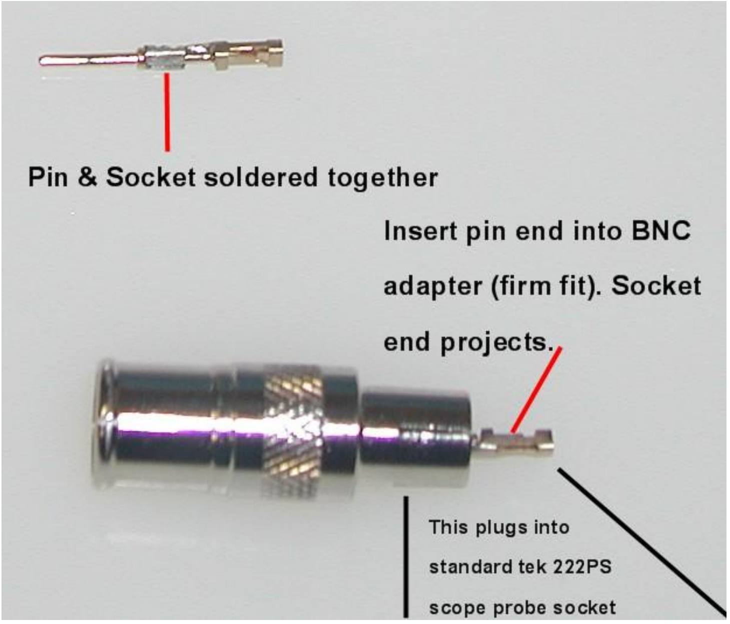
A central pin and socket link is fabricated from some Jaycar pin & socket parts:



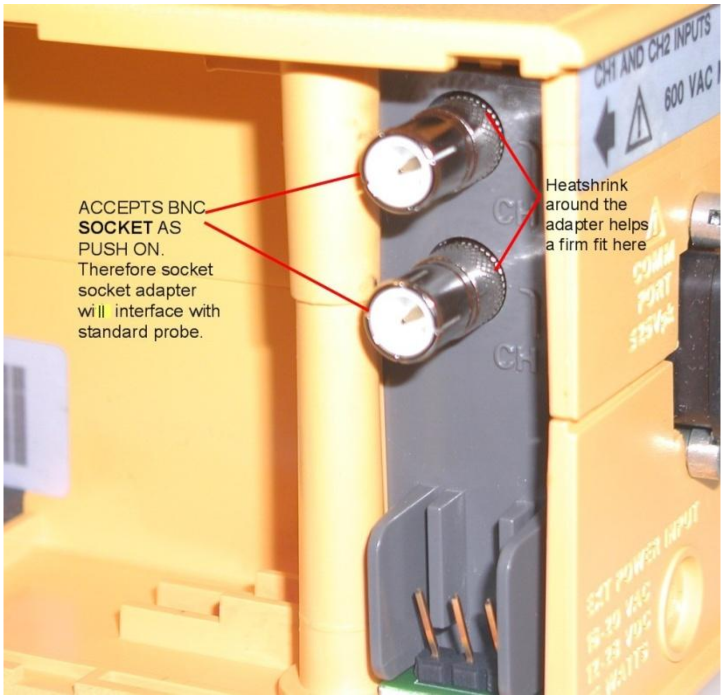
These are crimped and soldered together:



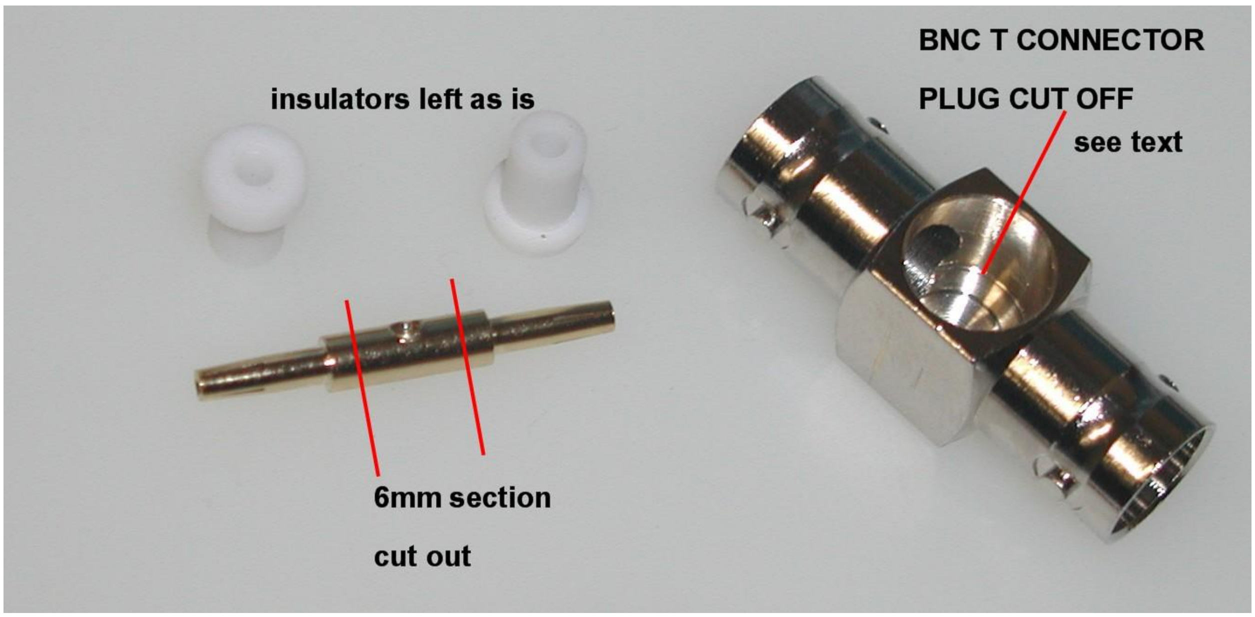
The pin end which is 0.9mm diameter is a tight fit and is inserted into the BNC adapter:



A single piece of heat-shrink sleeve around the right hand half of this adapter also helps make an interference fit with the plastic socket hole in the 222ps probe socket area. The photo below shows these adapters plugged into the side of the standard 222ps probe socket area:



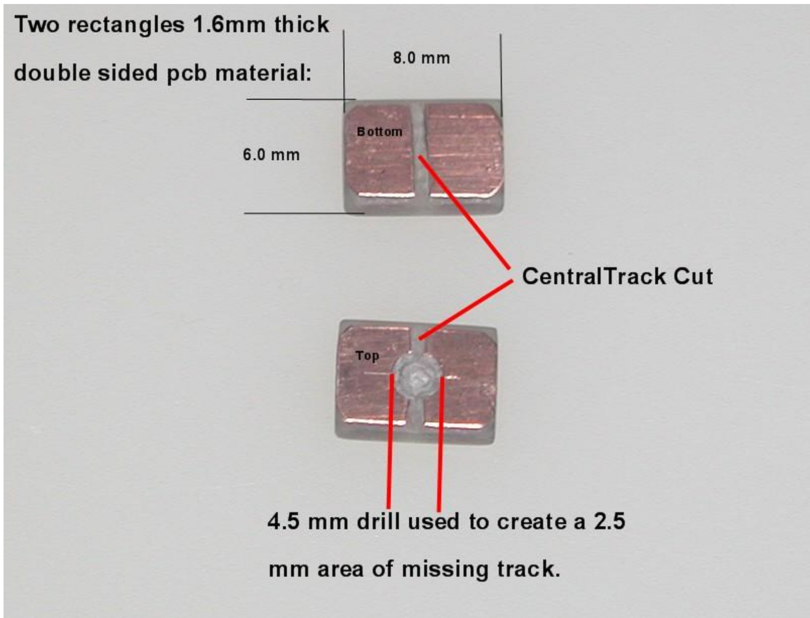
A female – female (BNC socket – socket) adapter now will adapt a standard probe to these fittings. However the 666.6k series resistor and HF compensation capacitor is still required in series. Therefore these can be put inside the socket-socket adapter. This is done by starting with a socket to socket adapter with a T style BNC plug. RS components part number 546-4948. The plug is cut off and just the straight section used. The central hole is bored out just a little to 9mm diameter:



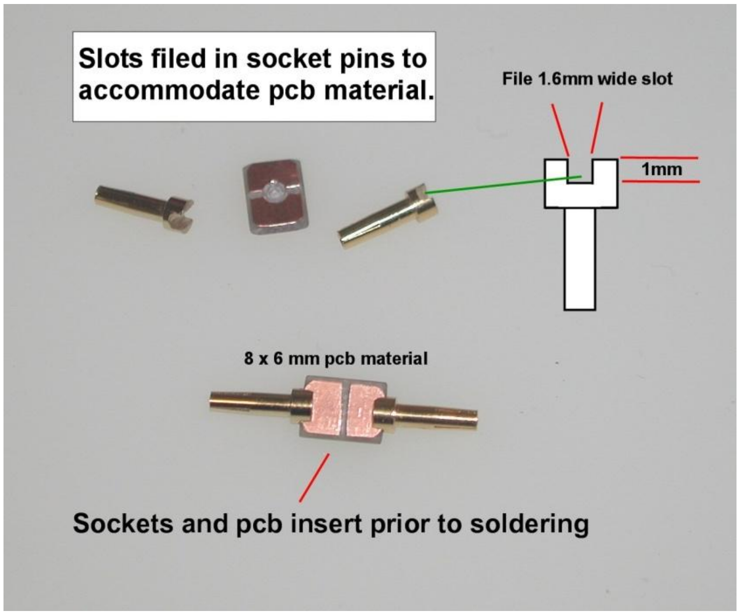
The central pin and insulators are pressed out (they are retained by a small serrated edge press fit washer at one end. A 6mm length is cut out of the central pin area, leaving a 2.0mm base on the socket pin because the central section is exactly 10mm wide.

Two small 6 x 8mm rectangles of double side pcb material are prepared. Rather than etching the tracks were cut with a fine needle file.

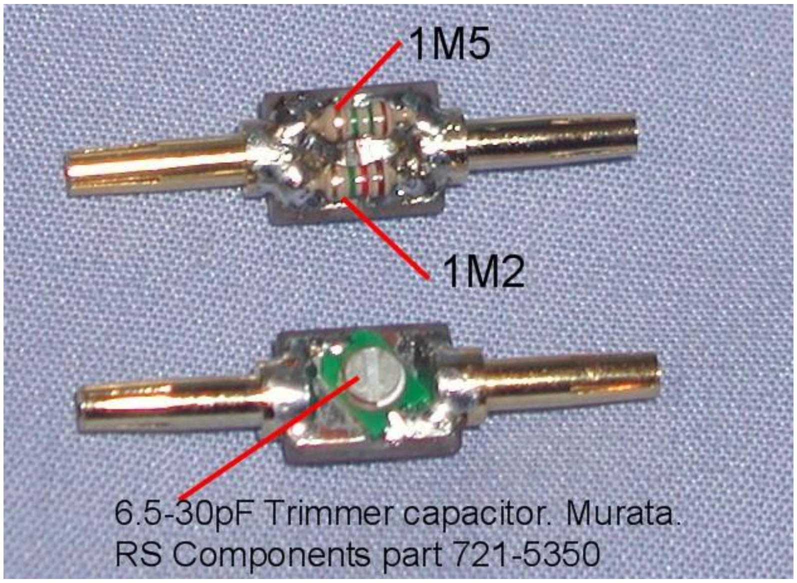
The diagram below shows the details. On one side a round area of track is removed so as to accommodate the underside of the surface mount trimmer capacitor:



Slots are filed in the cut down socket pin to a depth of 1mm and a width of 1.55 to1.6mm so they are a snug fit on the pcb. This is done by hand with needle files:



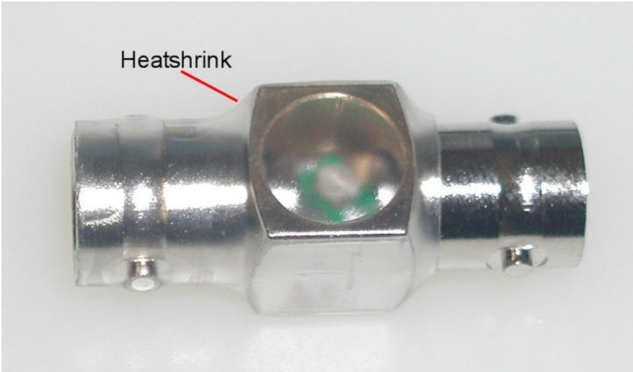
The pins are aligned on the pcb and spun in a drill chuck or lathe to ensure they are on the same axis. After that the assembly is soldered together and the resistors added on one side and the trimmer capacitor on the other:



The photo below shows the parts before reassembly:

A small piece of tube is used to press in the locking washers and reassemble the connector.

Some heat shrink sleeve is placed over the connector to keep out dust and a small hole can be made in it to adjust the capacitor.

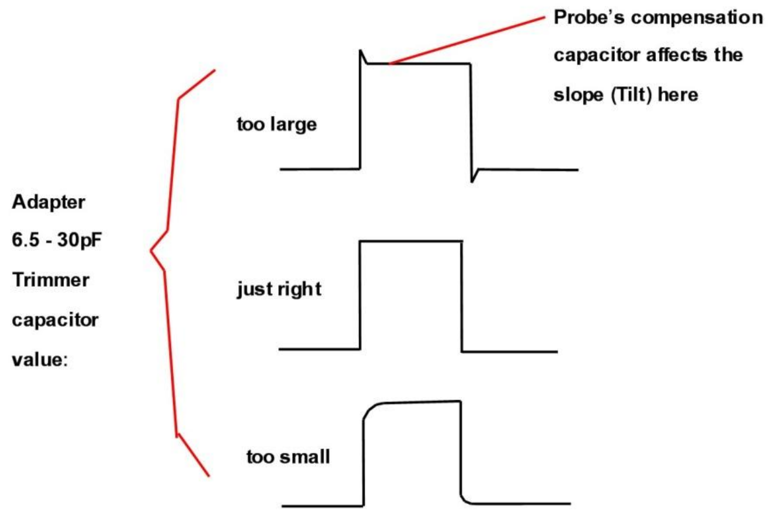


The following photo shows these adapters pushed on to the BNC adapters that were fitted to the 222ps probe sockets. A small anount of plastic is remove from the battery compartment cover to accommodate the lower adapter.

Adjusting the 6.5 to 30pF trimmer capacitor and the probe's own trimmer capacitor:

This is best done with a 1kHz square wave, the adapter trimmer affects the leading and falling edges and the probe's compensation capacitor affects the tilt on the top of the waveform. When these are set correctly as shown, a levelled sine wave generator test shows the scope has it correct flat bandwidth to 10MHz.

1kHz fast rise square wave signal from 50 Ohm source impedance & x 10 probe:



REPLACING (BUILDING) A REPLACEMENT BATTERY FOR THE 222PS:

The original 222ps battery, like the probes, is now not available. Nor in fact is the original virtual instrument CAT200 software. Looking back through history Tek did make the world's best oscilloscopes and each was once supported by complete and detailed manuals with schematics parts lists and parts backup. Printed on many of the manuals was the statement: "Committed to Excellence". This was not marketing hype it was true and admirable. Any well trained electronics engineer would grade the design work and instrument build 10/10 and the instruments were something to aspire to own and the quality something to aspire to emulate. The circuitry was also very clever & elegant, reflecting the extraordinary level of achievement and experience of Tek's design engineers in the field of oscilloscope and laboratory instrument design. Tek also mastered the design of special IC's for their instruments and CRT design. They also made the required test instruments, pulse generators, calibrators etc to support their equipment. Their instruments were so beautiful, they would with care, potentially last a lifetime which is not consistent with modern business models.

In any event if there are no parts/accessory backup it falls to the owner to find spare used parts or find a way make a substitute part, that is if they want to keep their beloved instrument running.

The original 222ps battery was composed of 4 lead acid gel-cell giving a nominal voltage of 8V. But the battery voltage varies with state of charged a resting well charge battery would have about 8.5V terminal voltage. Lead acid batteries are often charged with a fixed voltage. In automotive alternator charging systems is 14.3 V typically, which is 2.38V/cell. For 4 cells this is 9.52V. Tek recommended a 9.8Volt 1 amp current limited supply to charge their battery. They also recommended the usual -0.01V/DegreeC negative temperature coefficient (to allow for the battery's change in internal resistance with temperature) So at 50 degrees C the charging voltage should be 9.50V.

Attempts have been made by some to replace the battery with a rectangular gel cell, but some plastic needs to be cut away and it's a shame to damage the casing like that. Another option is to use 4 Cyclon brand gel cells in series.

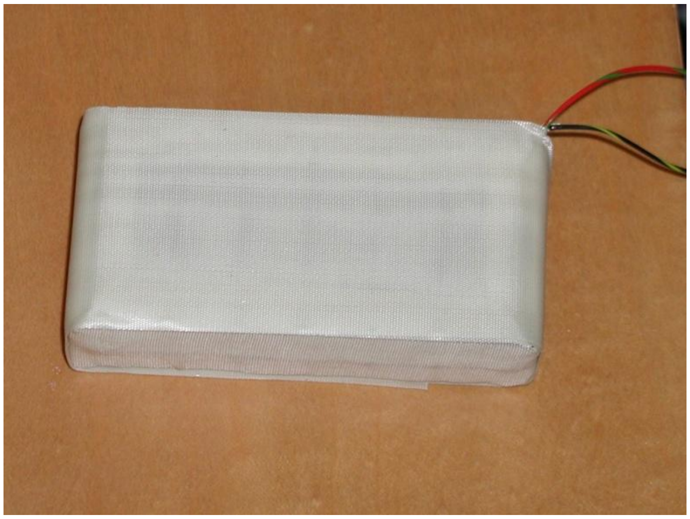
The method described here replaces the battery with nickel metal hydride batteries. A total of 14 AA sized 2000mAH batteries are used (in 7 parallel pairs). These batteries are also available in 2400mAh versions.

Paralleling batteries for additional A.H capacity, although not generally recommended, is ok *provided all the batteries are new and of the same manufacturing batch and same brand and the same terminal voltage*. I have done this over many years and had no difficulty when those rules are obeyed. The battery pack is created to fit in the battery housing area without having to modify it. The photo below shows the pairs of batteries with their tags soldered together:

It is important to insulate the tags from the battery tops as shown with a strong heat resistant insulator such as thin (0.2mm) fibreglass which is a tight fit under the terminals as the edge of the batteries casing (negative terminal) is nearby and the insulation around these modern batteries s very thin and not very temperature resistant either. Additional polyamide tape was also wrapped around each pair to improve the insulation between adjacent pairs of cells. The resting voltage is around 1.25 to 1.28V /cell in a charged cell yielding about 8.75 to 8.96 V for the 7 pairs, versus the 8.5V of the original 4 gel cells.

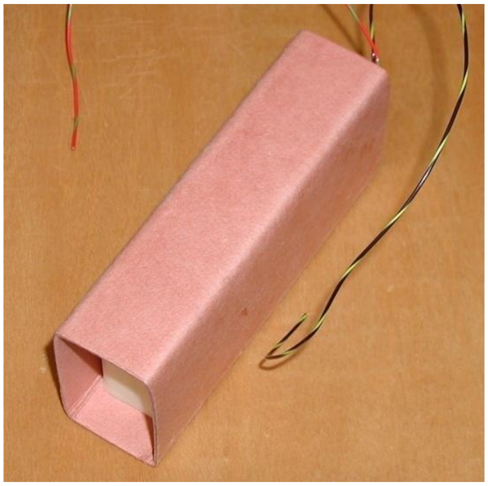
The cells are then taped together in a stack of seven:

The cells are linked together with 0.15 thick x 5mm wide brass strips as shown. This assembly has the connecting wires added and is covered in fibreglass tape:



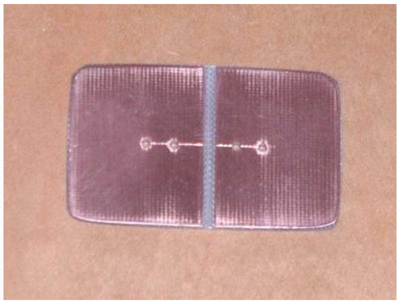
The connecting wires have Teflon insulation. One thing to be aware of is that these batteries have a very low internal resistance. If shorted out the current climbs quickly to very high values and the wires catch fire. The battery can also deliver very high currents with a fault condition in the instrument or possibly with reverse polarity, so a fuse is very helpful. I think for any battery pack of this nature there needs to be a fuse of one type or another, 1.6A is a safe value. The 222ps scope draws about 480 mA when running but there is the turn on rush current that the fuse must support.

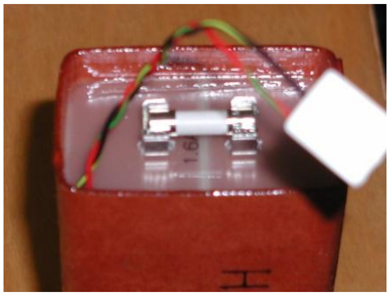
The battery assembly then requires some sort of housing to protect it, hold the fuse and give it the correct geometry to fit in the space in the side of the 222ps scope. A good material, albeit old fashioned, is electrical grade cardboard. This is a high density card and is available from Jaycar Electronics, part HG9985: It is wrapped around the cells. Scoring the inside fold surface helps the folds to be straight and regular. 5 minute epoxy adhesive is useful here as it can be easily held while the glue sets:



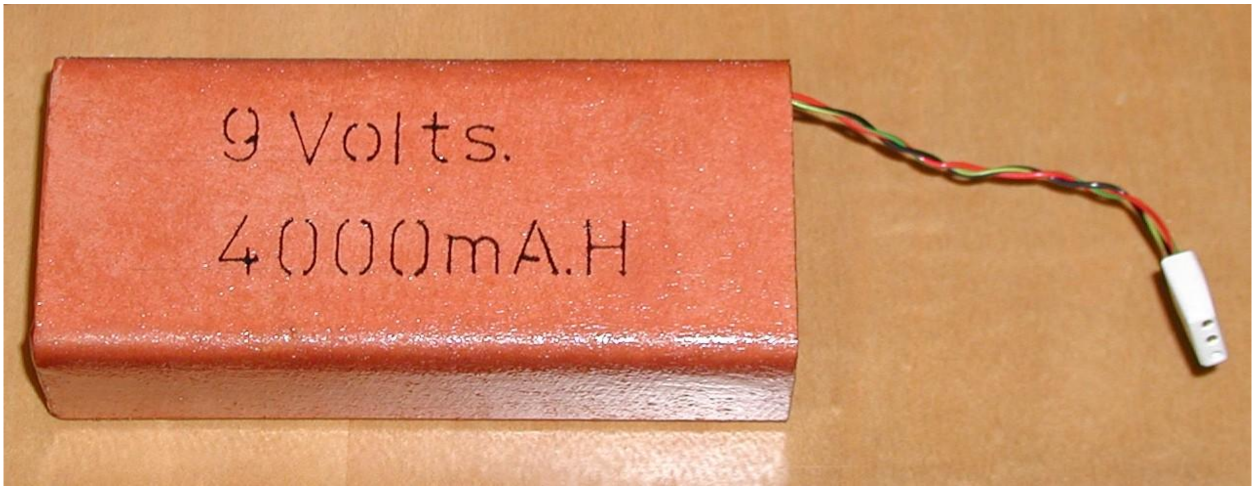
An end cap is placed in one end. The whole case is also varnished to seal the electrical card.

A pcb insert is prepared for the battery top, so as to mount 2 pcb fuse clips:





The pcb panel is glued over another layer of card with 24 hr epoxy resin. The connector had unusual pin spacing at 4mm. So a connector body was crafted from some white Bramite (similar to Garolite) and Jaycar 0.9mm socket pins fitted inside it. The external dimensions are 34 x 55 x 125mm.



Fitted into the 222ps: A small piece of additional black foam is added on the left hand side (not shown in the photo) to take up the small gap between the battery base and the case.