Notes on Maintenance of Tektronix 492 Spectrum Analyser

Some years ago I bought a Tektronix 492 SA on e-Bay, and have been living with its faults since then. Basically the CRT is fine, and the mixer seems to be in good condition. The attenuator was faulty (10 db pad OK, 20 db pad had 14 db attenuation, and the 30 db pad was blown , attenuation close to infinite). That meant careful level setting was needed together with the use of external attenuators from time-to-time. In addition to that fault, the signal level “varied” sometimes, and after I added a TR502 Tracking generator (modified to work as a TR503 according to the data in KO4BB’s wiki by Bruce, KG6OJI, much thanks to both) I found that the level shifting behaviour also had a frequency dependent behaviour, when in the “bad” state.

So it was time to look at this seriously and really fix it for once and for all.

1. The signal level variability and frequency dependency.

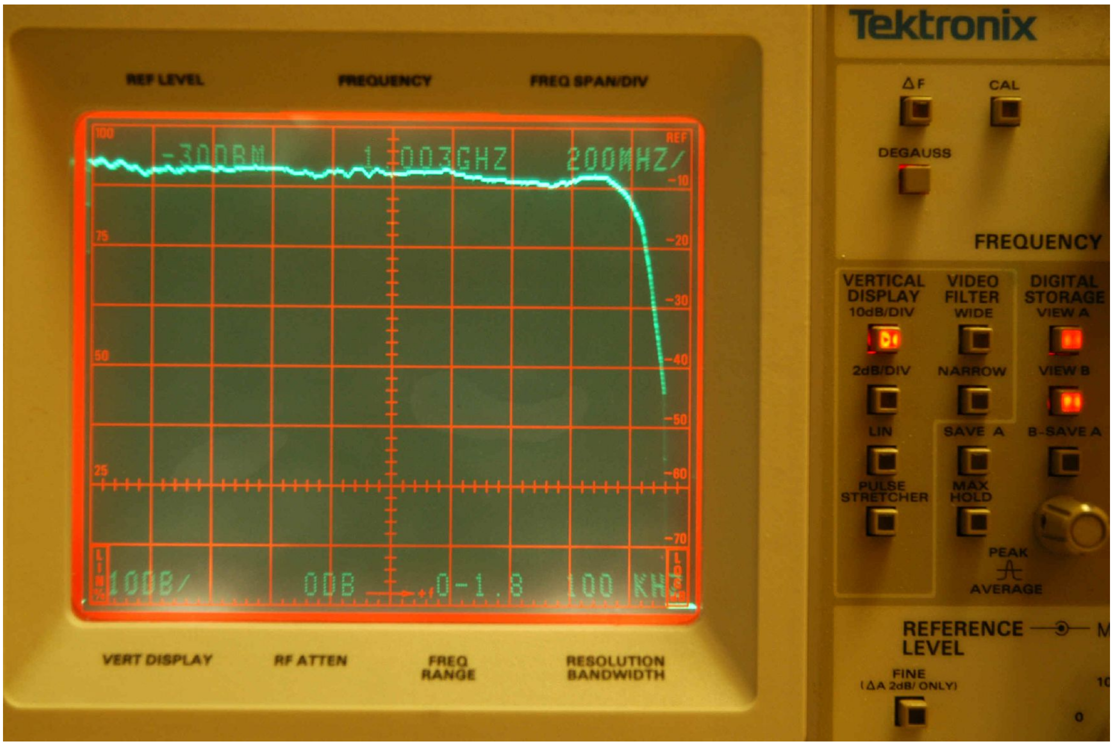


Figure 1. Spectrum Analyser showing TR502(3) output when in “good” state.

Figure 1 shows the response (10db/division) obtained using the tracking generator when the SA was behaving. About as it should be.

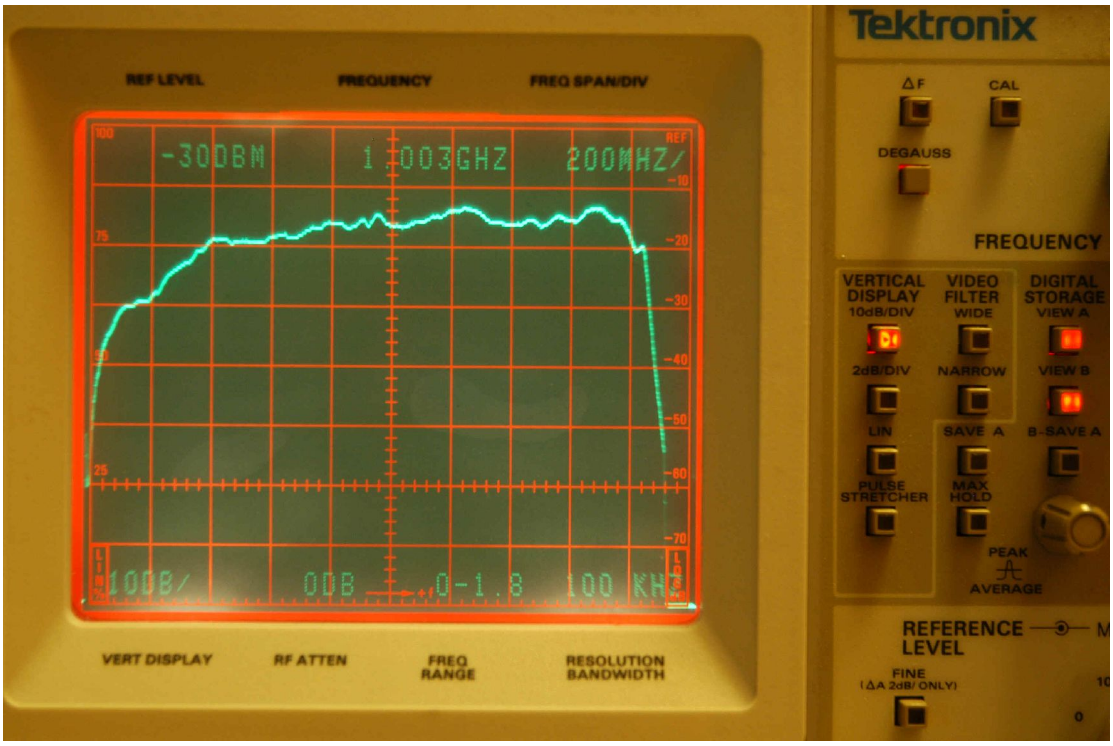
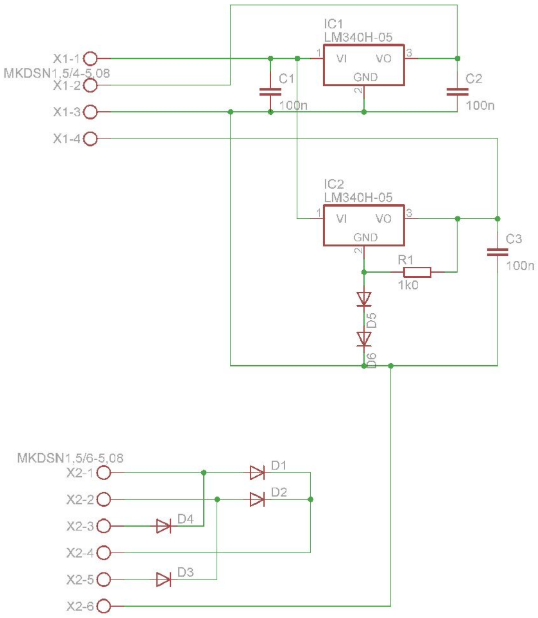


Figure 2. Spectrum Analyser showing TR502(3) output when in "failed" state.

Figure 2 shows the same response when it was "misbehaving". Clearly there is a low frequency loss, looks like an open circuit somewhere in the RF path, with a small capacitance across it. The level is reduced as well. Judicious "tapping" of the various components in the RF path led to the conclusion it was somewhere in the vicinity of the co-axial relays associated with switching in the pre-selector filter for the high bands (This was an SA with Option 1 and 2). Repeated switching of the band from the 0-1.8 GHz to the next one up and back again caused the fault to clear and/or appear again. This band-switching causes the transfer relays to operate. Well, I have to remove the attenuator anyway, so lets get the relays out to check them (please remember to buy a couple of 5/16 inch or 8mm open-ended spanners or even a special SMA torque wrench to protect the SMA connectors and cables when undoing and re-connecting, don't use pliers !).

It turned out that one of the relays had one faulty contact. DC wise it would measure open circuit, or anything between about 0 and a few tens of ohms, depending on what was done to it, like cycling it, tapping it etc. The other near RF components (Limiter, Filters etc seemed to be stable, at least for present. Running the analyzer for some hours without the relays seemed to confirm the situation. So it was decided this fault would be repaired by replacing the two relays by a couple of second-hand but new, unused Agilent 26.5 GHz relays, with 15V coils. This required extensive modification of the RF interconnect cables in the front end, as these relays are larger as well as having better isolation with internally terminated unused ports. And a small interface using diodes was made to allow the Agilent relays to operate from the original Tektronix driver circuit.

The schematic for the relay interface and a small power supply used for the attenuator driver is shown in figure 3. I used the SA 9 volt power rail to power the substitute attenuator, it was the easiest to physically access without making any modifications to the SA.



Relay Driver:

X2-1 and X2-2 connect to the pins in P3038, where the original relays were connected. If standard Agilent latching relays are used as replacements, X2-4 connects to the common + terminal, and X2-3 and X2-5 connect to the select port 1 and select port 2 terminals respectively.

Power:

X1-3 and X2-6 are grounded to the SA chassis. X1-1 is connected to the +9v internal power rail. X1-2 provides +5v regulated to the relay driver board. X1-4 provides +6.3v for the relay coils in the replacement attenuator (if needed).

Figure 3. Replacement relay interface and power supply for replacement attenuator driver.

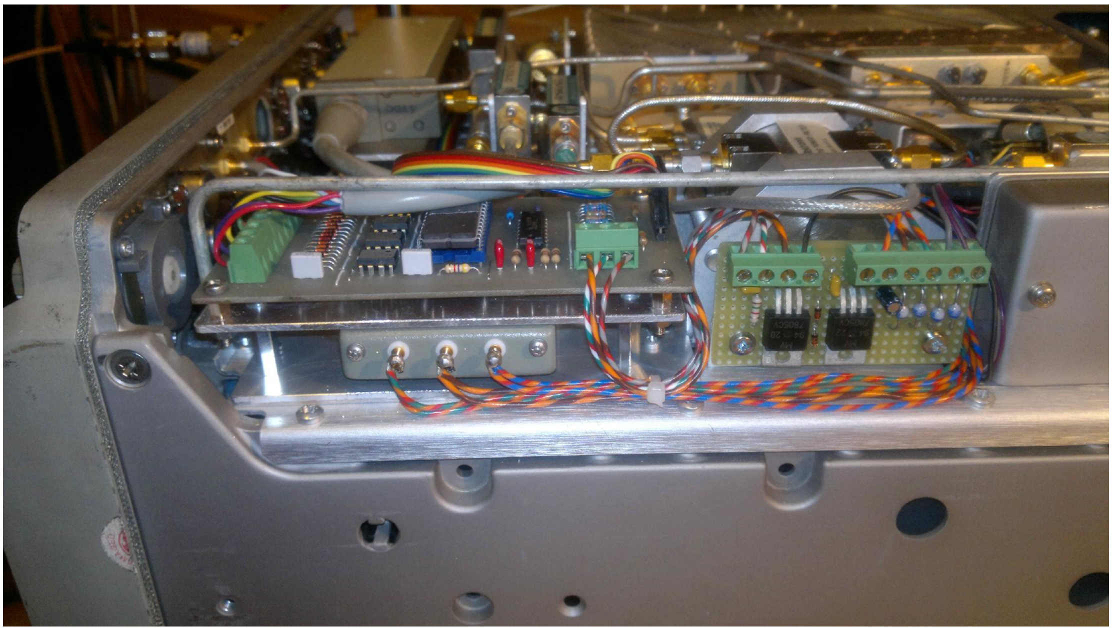
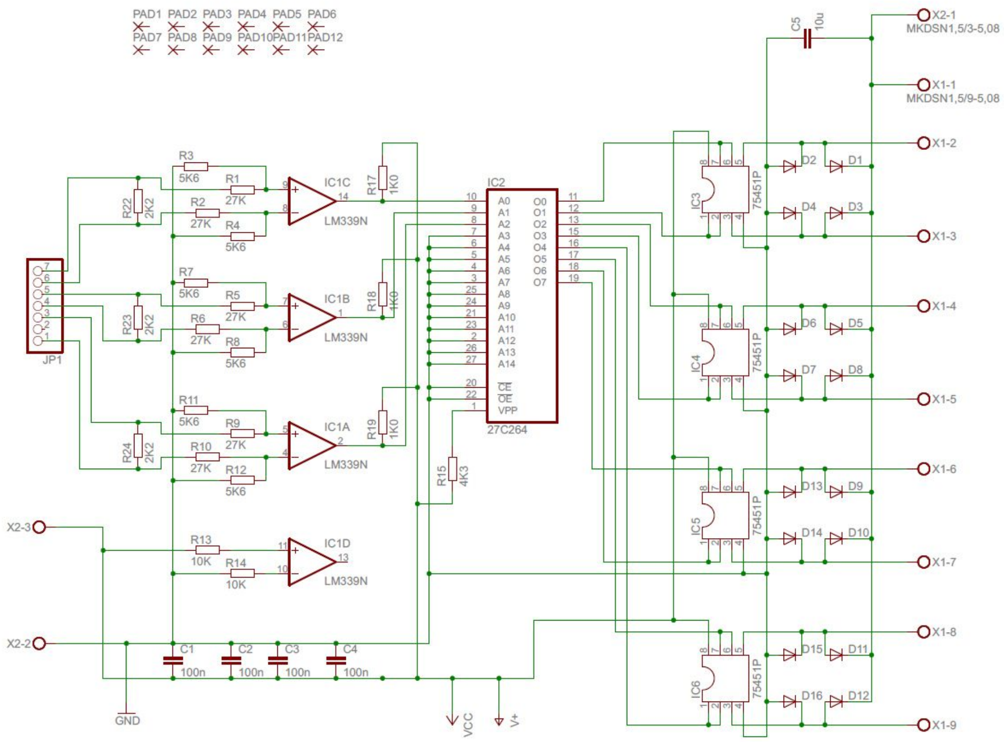


Figure 4. Showing the final placement of the Attenuator Driver, one of the replacement changeover relays and the power supply and relay interface board.

2. The faulty attenuator.

Initially I tried to locate new pads for the Tektronix attenuator, but it seemed they are not really easy to find, despite contacting supposed sources of these components. There are sometimes similar Tek. attenuators on e-Bay, but not often. And the condition is often a bit suspicious. So there was nothing else to do except to see what could be done with more easily available programmable attenuators, e.g. the 3332xx series from Agilent/HP. The Tektronix attenuator has 10db, 20db and 30db sections. Most “standard” attenuators have 10db, 20db and 40db sections. There are a few attenuators with the same 10, 20, 30 sections, generally spec’t for use up to 40 GHz. But they are rare. So some kind of logic was going to be required to handle the conversion, and provide the needed drivers to handle the different logic.

I finally decided to use a EPROM to handle the look-up, as it could easily be changed depending what replacement attenuator would be available. Figure 3 shows the schematic of the resulting interface design. I chose not to use a PIC or other processor, as no re-timing would be needed and putting yet another oscillator near the front-end of a SA didn't seem a fundamentally good idea.The interface is connected directly to J4018 of the SA, in place of the existing attenuator, with a 1:1 cable to its input connector, JP1. R22 (and 23, 24) replace the relay coils, and the comparators in IC1 reflect the state of the 3 original attenuators in the SA. The state is valid both during the switching time for the original attenuator (when the supply is +17V) and the steady state time (when the supply is +9V). Tek. switched the supply to the attenuator coils dynamically during selection of each section, as well as reversing its polarity to switch a section in or out.



The EPROM used is a 27c256, totally far too large. But they can be obtained fairly easily, compared to smaller devices. So why not use it ?. After translating the needed states in the look-up table, the outputs provide both true and complementary signals to turn on one of the relay drivers for each section of an Agilent/HP attenuator (the attenuators have a common positive supply terminal, and you must ground only one of the bypass (= 0bd) or select pad (= 10, 20, 40 db) terminals. Enough outputs are provided to drive a four section attenuator, even though only 3 sections are needed. You never know what you can get cheap and in good condition ! And a 4 section attenuator is more easily mounted in the space available than a 3 section attenuator. See later. I ended up using a HP 33322H attenuator, with 5 volt coils and 0 to 110 db attenuation.

Connector JP1 is mentioned above.

Connector X1 is used to connect the attenuator to the drivers, Pin 1 is the common positive supply voltage, Pin 2 is connected to 10db section bypass, Pin 3 to 10 db section enable, and so on for the 20 db, 40 db and second 40db sections if used. The Output pins therefore are in a logical order

Connector X2 is used to connect the supply voltages to the card. Pin 1 is connected to the relay supply voltage (+5v, or +17v etc.) Pin 2 is connected to Chassis Ground. Pin 3 is connected to the +5v digital supply in the SA. It's probably easier to use attenuators with 5 volt or 15 volt coils than the more common 24 volt coil versions.

The usage of output pins and the bits in the EPROM is not totally logical, but it made a single sided PCB with minimum number of links possible. Fixing the bit usage is done in the program in the EPROM. Figure 7 shows the EPROM contents, in an Excel table.

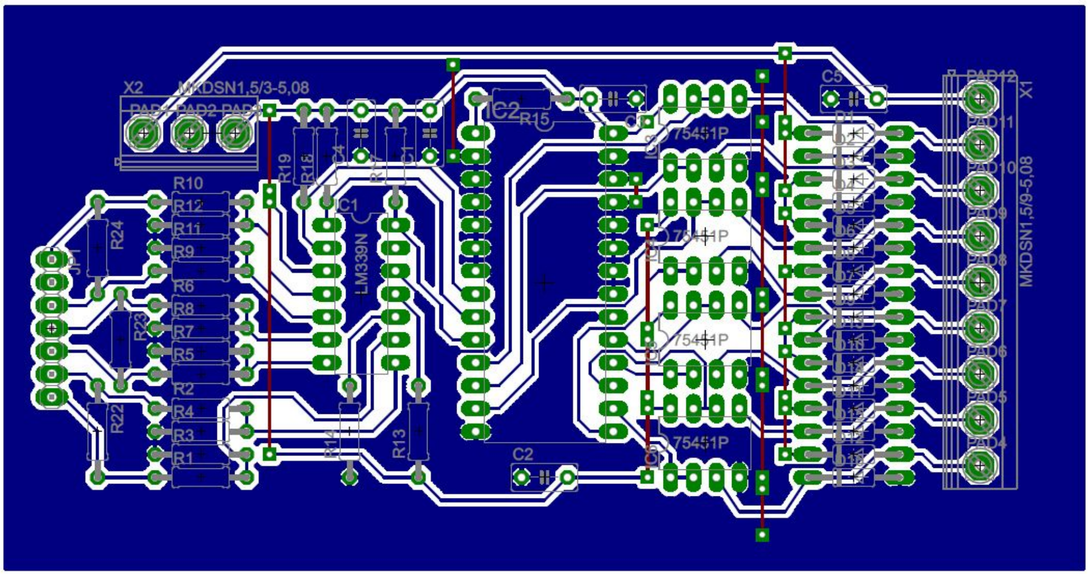


Figure 5. PCB Top View with Component Overlay

Figure 5 is a PCB layout overlay, and Figures 6 and 7 show the empty and populated PCB. The board was designed using Eagle CAD SW, and made by printing a positive image onto glossy photo paper with a laser printer, then transferring the toner to the PCB with a very hot iron. Low cost and fast turn-around for a single sided board.

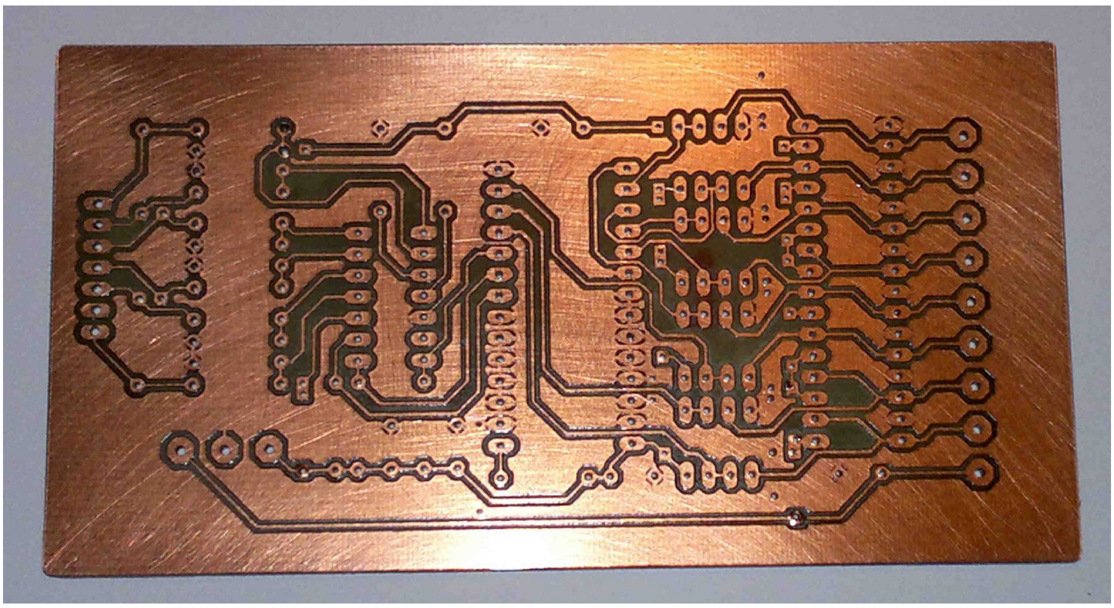


Figure 6. Etched and drilled PCB for Attenuator Interface

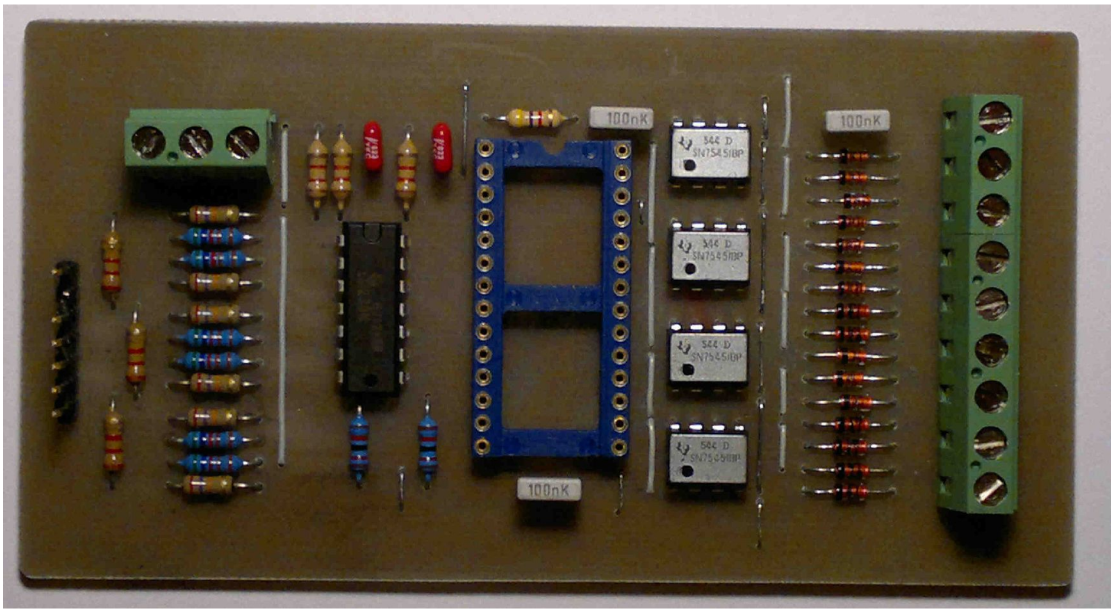


Figure 7. Assembled Attenuator Interface

	Tek. Section Select			Prom Address State				EPROM Output bit state									
Tektronix Attenuator Value	30	20	10	A2	A1	A0	HP Attenuator Driver State	O7	O6	O5	O4	O3	O2	O1	O0	**Prom Location**	**Prom Contents**
							Section	3	3	4	4	2	2	1	1		
							Value	N40	40	N40	40	20	N20	10	N10		
0	0	0	0	TRUE	TRUE	TRUE		0	1	0	1	1	0	1	0	**7**	**5A**
10	0	0	1	TRUE	TRUE	FALSE		0	1	0	1	1	0	0	1	**6**	**59**
20	0	1	0	TRUE	FALSE	TRUE		0	1	0	1	0	1	1	0	**5**	**56**
								(Unused state, define so no attenuator drivers are on)								**4**	**FF**
30	1	0	0	FALSE	TRUE	TRUE		0	1	0	1	0	1	0	1	**3**	**55**
40	1	0	1	FALSE	TRUE	FALSE		1	0	0	1	1	0	1	0	**2**	**9A**
50	1	1	0	FALSE	FALSE	TRUE		1	0	0	1	1	0	0	1	**1**	**99**
60	1	1	1	FALSE	FALSE	FALSE		1	0	0	1	0	1	1	0	**0**	**96**

Figure 8. EPROM Contents Definition

Where to mount it all ?

These Tektronix guys were quite clever (maybe !) in designing the RF deck of the 492 analyser. When you try to fit in other parts, there isn't much room. A big problem with the readily available Agilent/HP attenuators is that their RF connections come out the side. The attenuators are too high to mount "vertically" in the available height (Attenuator + Right Angle Connector needs about 66mm, only about 50mm is available). If you use a 4 section Agilent/HP you can fit it in amongst the Mixer connectors if you mount it 20mm above the chassis. The bracket shown in Figure 9 mounts using the original mounting holes for the Tek. attenuator, and holds the replacement attenuator. It is made from a section of 20mm x 50mm square tube, with one side cut away as required. The height is critical if you are to avoid the cables and connectors to the mixer.

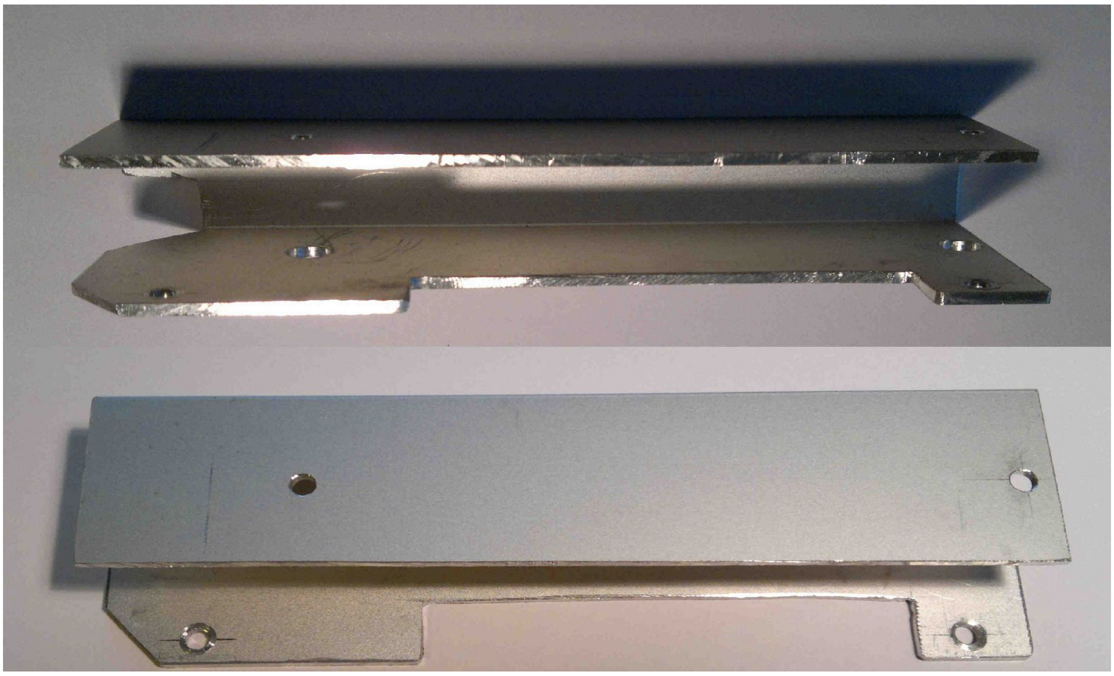


Figure 9. The aluminium bracket fashioned to hold the replacement attenuator.

The final disposition of the replacement attenuator and other associated parts is shown in Figures 10, 11 and 12. If you have an analyzer with the Phase-Lock option, you won't have this space.

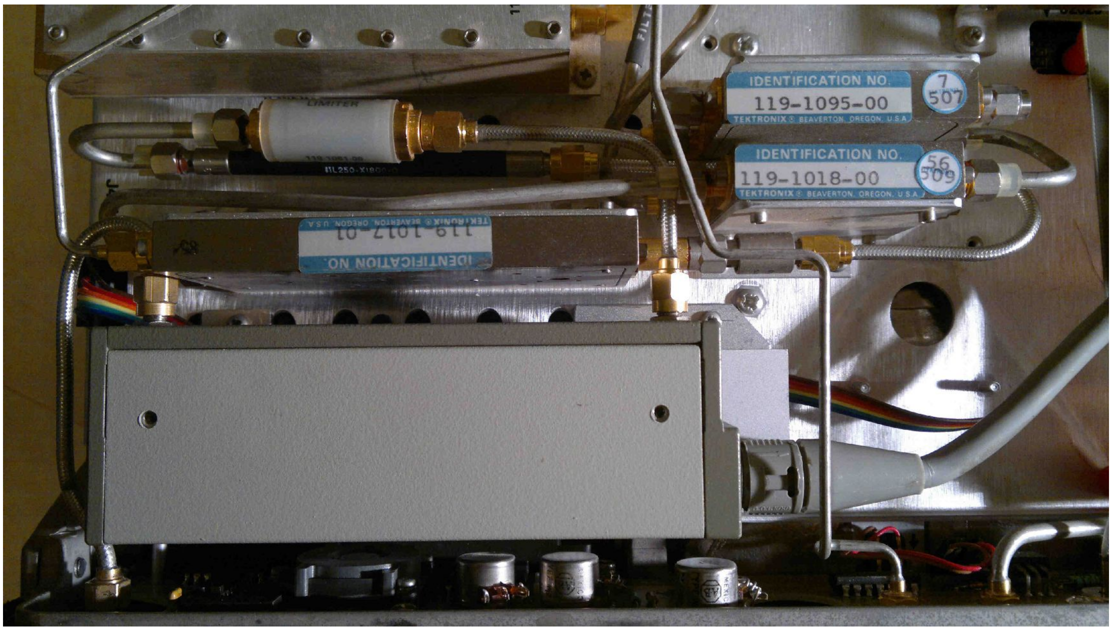


Figure 10. Agilent attenuator mounted in place of Tek. original.

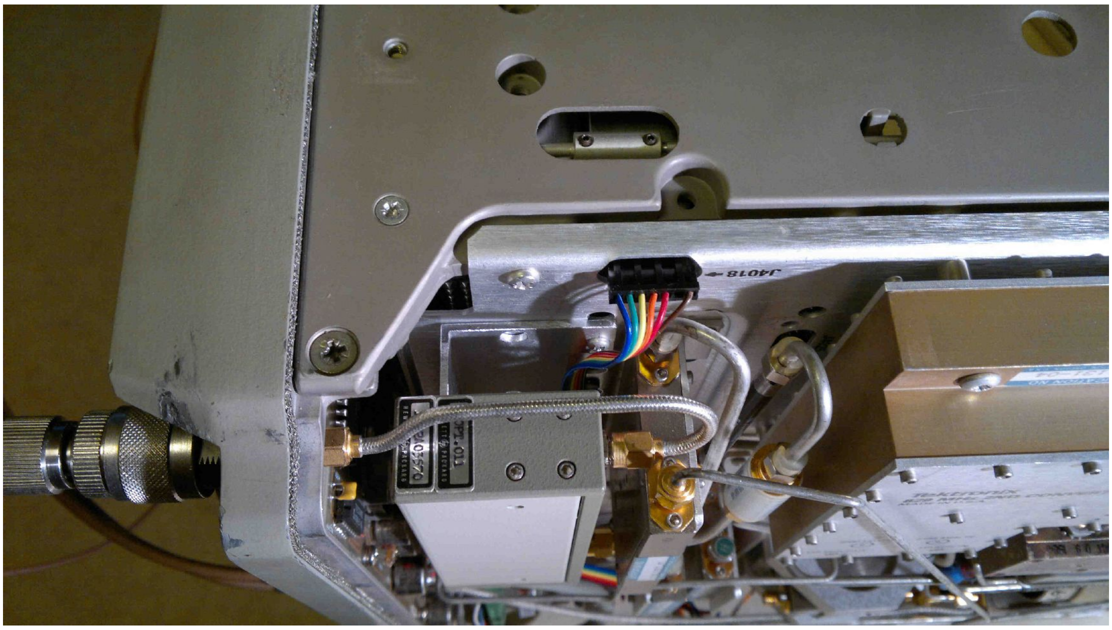


Figure 11. Side view of the replacement attenuator

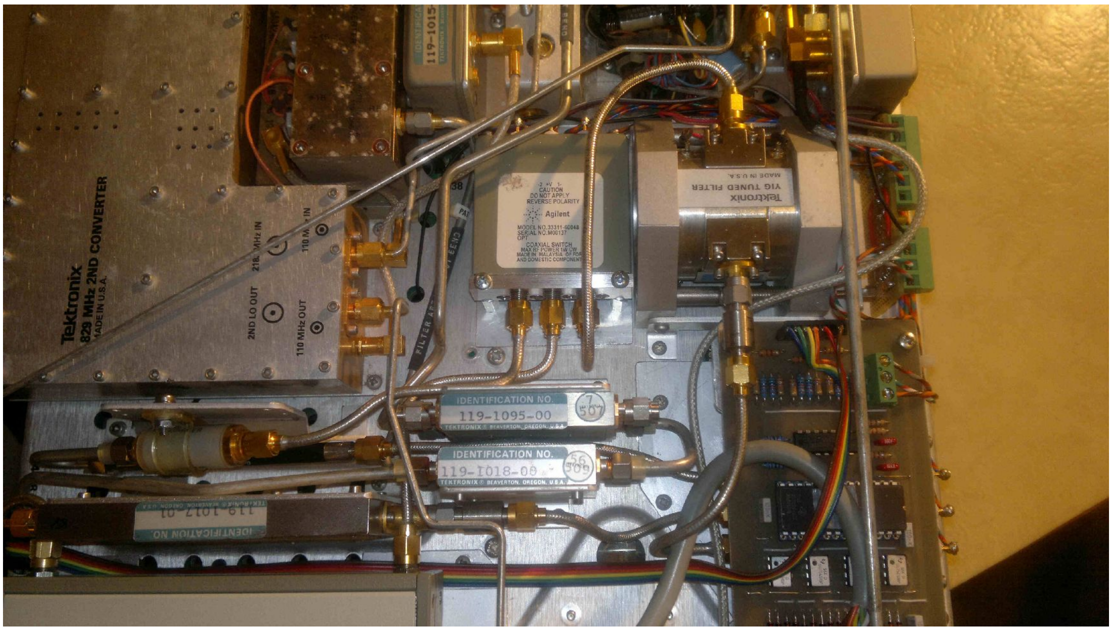


Figure 12. View of the replacement attenuator, one of the relays (other is hidden under the attenuator driver board) and the new co-axial cables in the front-end. As my 492 does not have the phase lock option, no attempt was made to minimize the space taken by the replacements.

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