Repair of probes for HP 8405A Vector Voltmeter

by Richard L. Carey, W6RLC, August 12, 2010

The Hewlett-Packard model 8405A Vector Voltmeter is a wide-range voltmeter and phasemeter that measures over the 1 to 1000 MHz frequency range. The unit features two channels with Channel A accepting voltages from about 1 mV to 1 V rms and Channel B measuring voltages from 100 uV to 1V rms. (an input to Channel A is required for B to work).

Probes: The instrument uses two probes that are not removable. The probes each contain a four-diode sampling gate followed by a FET transistor buffer/amplifier. The probes have a maximum voltage limit of +/- 50 VDC or 2 Volts peak. The probes are easily damaged if connected to higher DC or RF voltages.

The Problem: My 8405A was working fine and was bought as a new instrument from Fair Radio Sales. It came in an unopened box with all manuals and accessories. While probing an RF circuit I touched probe B on a line with about 7 Watts RF power on it. This is about 19 V rms and is way above the maximum rating. The probe went dead right away. This note documents repairs I made to get it working again.

Probe Types: There were three types of probes. My instrument had the later type “C” probes. I think the differences are mostly mechanical and the repairs I describe should apply to the circuits of the older probes.

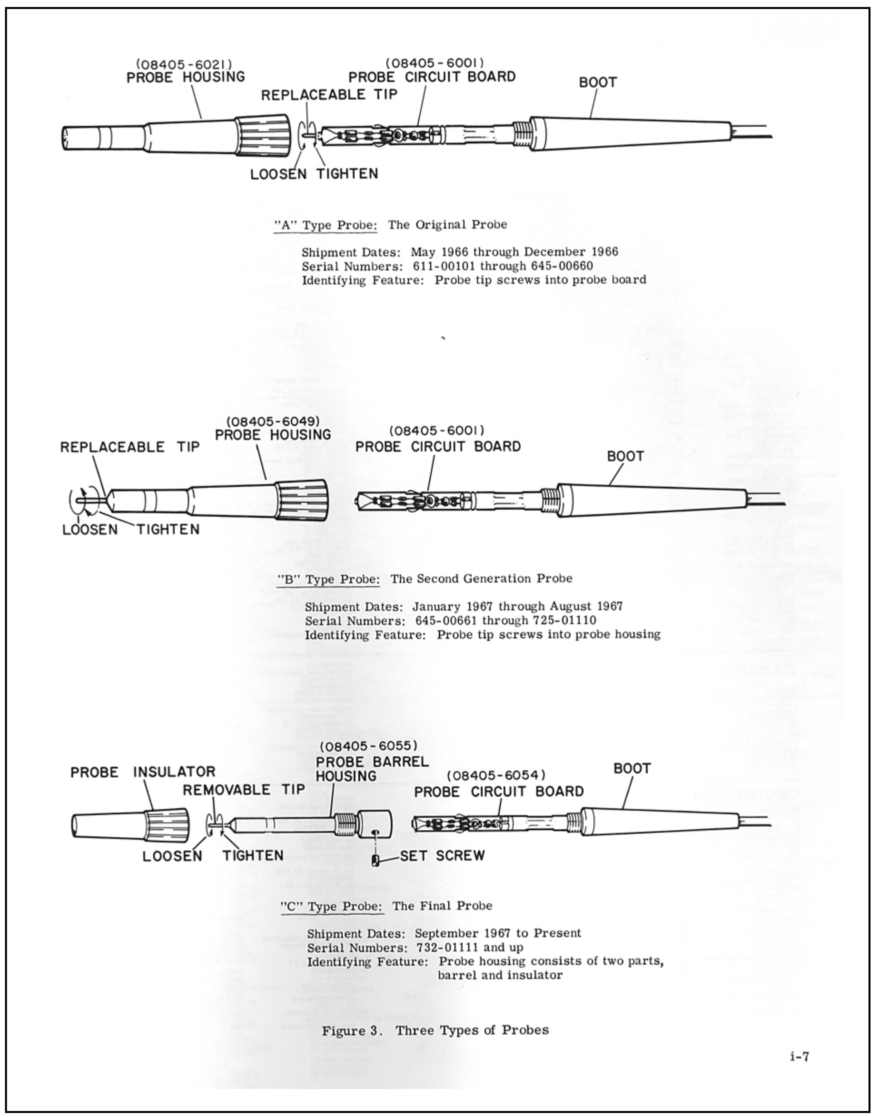
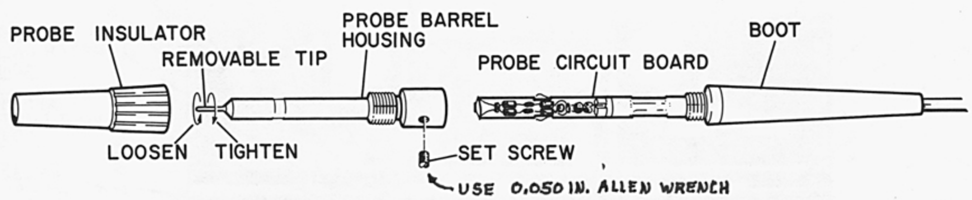


Figure 3. Three Types of Probes

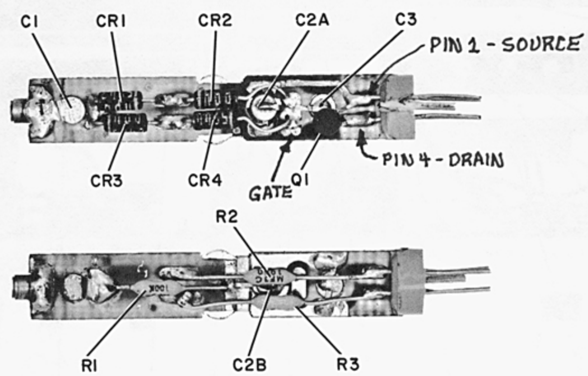
Disassembly of the Probe: Start by unscrewing the insulator. If you have an “A” or “B” type probe the circuit board will be visible. For the “C’ type probe use a 0.050 inch hex wrench to loosen the locking screw then undo the metal probe housing.

Diode Checks: The board can be pulled out of the body and clamped in a vise to check the four diodes. Using a DVM on the diode range check each of the diodes. I found the left pair, CR1 and CR3 to be OK and the right pair, CR2 and CR4 to be shorted. See the diagram on the next page for probe components.

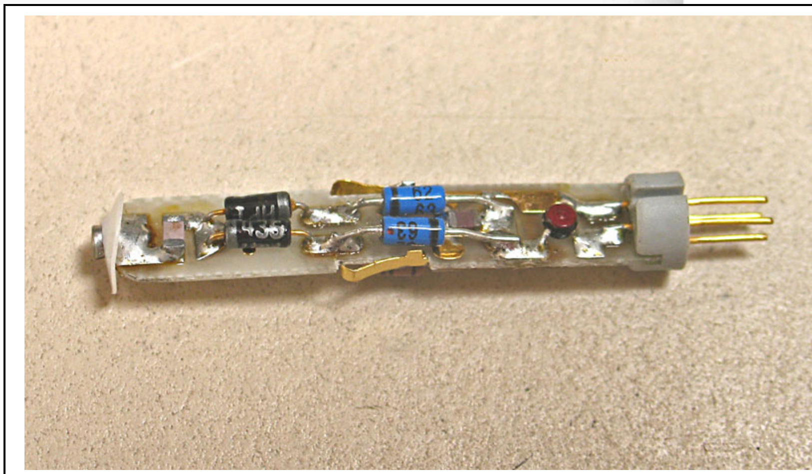
The diodes were labeled HP1517 and I wasn’t able to find any specs on these. I substituted 1N6263 Schottky diodes which are the same size and seem to work fine.



(a.) Probe Housing Assy



(b.) Probe Board Assy



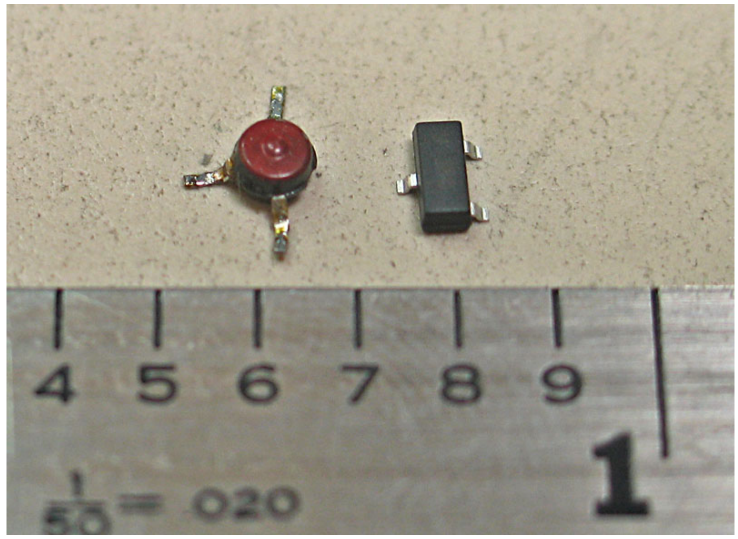
The photo to the right is the probe board with diodes CR2 and CR4 replaced by 1N6263's.

FET Checks:
On the right side note the small FET transistor Q1. In this photo the original HP transistor is there.

I recommend plugging the board back into the cable and clamping the unit in a vise by the end of the flexible cable next to the board. A small clip lead should be used to clamp to the gold fingers at the middle of the board and ground those to the metal shell to the right of the board. Be careful not to damage these since they ground parts of the circuit when it is inserted back into the metal housing. Note on the drawing above that I have labeled the FET source on pin 1 and the drain on pin 4. The schematic shows that the source should be -2.3 V and the drain at -17 V. Measure these voltages with a DVM with no signal applied.

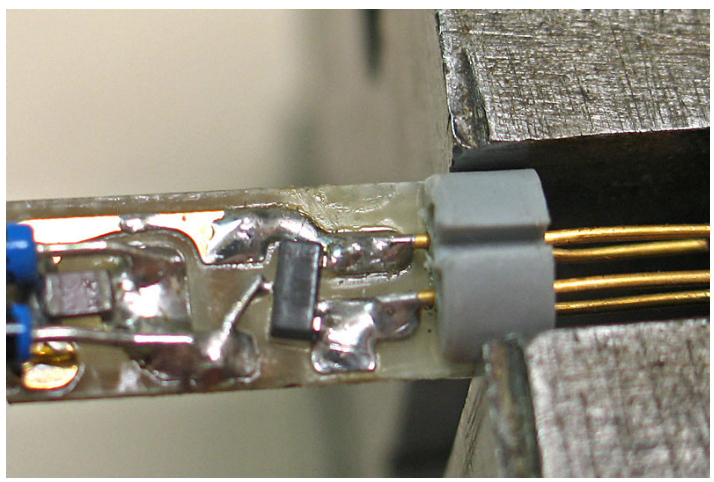
Q1 Pins	Schematic voltages	Probe A (good)	Probe B (bad)
FET source, pin 1	-2.3 V	-1.4 V	-3.1 V
FET drain, pin 4	-17 V	-17.1 V	-15.9 V

Another check of the FET can be done by applying a signal to the probe input. I suggest about 1 V rms at say 1 MHz. Look at the source (pin 1) with an oscilloscope and you should see a fairly clean sine wave of about 3 V peak-to-peak at 20 KHz. If you are checking probe A the signal can be applied there. If you are checking probe B there needs to be a signal on probe A at the same time for the instrument to phase lock.



FET Replacement: If the source voltage is off as it was in my case or the 20 KHz signal is bad then the FET needs to be replaced. The photo to the right shows the HP FET which is in a small circular package that is no longer available. The replacement to the right is a modern FET in an SOT23 package used in many surface mount applications. It is small enough to fit on the board.

The replacement P-channel FET I used is a Philips PMBFJ176. There are four FET's in this family with different IDSS values which affect the biasing of the device in the circuit. The PMBFJ176 has an IDSS range of 2 to 35 mA. This is quite a spread so if one doesn't seem to work, try another one. I tried the -174 and -175 models and they didn't seem to work right. This FET is also made by Fairchild and is available from Digi-Key for about 49 cents each.



The photo to the right shows the new FET installed. The source and drain match up OK with the board, but the gate does not so I used a fine wire to connect the gate. Use Solder-Wick to clean up the traces and use a very small tip on the soldering iron.

Note: Watch that there is not a sharp edge of solder or conductor extending off the board where the gate lead is. This could short out when the unit is slid into the housing. I also put a small piece of clear Scotch tape over this terminal before sliding into the housing. Here is a table of voltages after the repair. Probe B voltages are much better and close to normal.

Q1 Pins	Schematic voltages	Probe A (good)	Probe B (new FET)
FET source, pin 1	-2.3 V	-1.4 V	-1.7 V
FET drain, pin 4	-17 V	-17.1 V	-16.9 V

Instrument Checks: After repair I suggest doing the adjustment that minimizes the sampling signal at the probe tips. This was on page 5-21 in my manual. This requires taking the top cover off and also removing the left side shield plate over the A and B channel input boards. Connect an oscilloscope to the probe tip set to about 10 mV/ cm. Adjust the symmetry pot, A3R15 or A4R15 for a minimum signal which should be less than 5 mV. Check both channels.

Another check is to apply the same RF signal to both inputs and check the meter readings. If the gain is off in the repaired channel adjust A3R5 or A4R5 as needed. The adjustment should be only a slight amount. These potentiometers are on top of the boards and are labeled.

Below is the schematic for the probe and front end of the instrument for reference.

Good luck with your repairs!