The “Felpham” Measurement Unit for Home Brew Valve Tester

Note on the name. Felpham is where I live, a small village in Sussex. Since one of the principle applications of this measurement pcb will be in the Sussex valve tester the name “Felpham” seemed appropriate.

PCB assembly.

It is highly recommended that the i.c.s are fitted in sockets.

The Ver 1 pcb has two missing components, see the Errata sheet.

Principle of operation.

The key element is a high voltage differential amplifier constructed using closely matched resistors to translate the voltage across a 100 ohm resistor in the anode circuit (hence floating at HT) to a voltage referenced to 0V.

This is followed by two stages of bandpass filter to remove the 50 and 100Hz noise.

Additional circuits have been added to measure Anode and Screen volts.

Compensation has been added to null out errors due to loading by the measurement circuits themselves.

GM is measured by injecting a 100mV 1kHz Sine wave to the grid of the valve under test. I have included an oscillator for this is on the measurement board.

The ac Anode current is sensed across the same 100 ohm resistor and is amplified and filtered to eliminate 50Hz and precision rectified. The output is a dc voltage of 2V (or 200mV) for a reading of gm=20

Circuit Description.

DC Anode Current.

The input to the Anode dc current circuit is J1. This is to be connected across a 100ohm resistor in the Anode HT line.

The Anode current measurement circuit is measured by the high voltage differential amplifier formed by R1 to R7, R14 to R21 and U2, a TL071 op amp.

R2 to R7, R14 to R16 and R18 to R20 are closely matched 390k, 2W resistors. The resistors dissipate nothing like 2W but were chosen for their voltage rating. The tolerance with respect to the value of 390k is not critical but the matching is. I purchased a quantity or resistors on a bandolier so I could be sure they were from the same batch and then measured them all. I then chose the closest matching 12 resistors for the project. R17 and R21 should be similarly matched.

TP1 allows the raw measured current to be probed, this is scaled at -100mV per mA.

RV3 allows the zero to be set under no current conditions.

The downstream arm of the high voltage differential amplifier and the voltage measuring circuits will draw current and unless compensated for will cause a permanent standing current to be displayed. Compensation for this effect is provided by U3A, this subtracts a voltage proportional to the Anode voltage from the measured current. RV4 allows the error current to be nulled.

U3B is a low pass filter to remove any 50Hz ac on the measured current.

Both filtered and unfiltered Anode dc current are available, again scaled at 100mV per mA.

The unfiltered output is provided for use in a possible curve tracer.

All measured outputs are available on J13

<u>Anode and Screen Voltage</u>

U1A and U1B are the voltage measuring devices for Anode and Screen volts respectively. The output is scaled as 1V per 100V of HT, this can be set by RV1 and RV2.

gm measurement

As noted GM is measured by injecting a 100mV 1kHz Sine wave to the grid of the valve under test and measuring the resultant ac current in the Anode.

The measurement board has a sine wave oscillator on it for maximum flexibility. If using this board in the Sussex tester the oscillator components may be omitted as the Sussex has its own oscillator. (although I prefer the oscillator on this board, but then I would say that wouldn't I?)

The oscillator is a diode stabilised Wein Bridge design. The output is scaled by R37 and RV5 and buffered by U5B. RV5 is used to set 100mV output.

The ac anode current during gm tests is measured by the same high voltage differential amplifier as for the dc current. The voltage at TP1 is now 10mv for a gm of 1mA/V.

U4A and U4B form a 4th order Sallen key band pass filter to only allow the 1kHz signal through thus rejecting any 50 or 100Hz ripple.

These are followed by a precision full wave rectifier with low pass filter. The output can be selected as 200mV equals a gm of 20 or 2V equals a gm of 20 byy selecting two resistor values (see the note on the schematic.

RV6 sets the final scale of the gm output.

<u>Power Supply</u>

The board is powered by plus and minus 15V on J5.

Testing and calibration

HV tests

1. Once the board is populated and visually checked testing can start by applying the +/- 15V to J5.
2. Temporarily link across J1. Allow a short time for the board to stabilise and measure on TP1 (J6) with respect to 0V. Adjust RV3 to give zero volts.
3. Remove the temporary link on J1 and connect a 100ohm resistor in its place, preferably the one you will use in the actual valve tester.
4. Pass a current of 10mA through the 100ohm resistor, + to pin 2 of J1, 0V to pin 1 of J1. You should get a voltage of -1V on TP1.
5. Because pin 1 of J1 is 0V the compensation circuit will not be needed at this stage.
6. Check that the filtered anode current on pin 5 of J13 is +1V.
7. Remove the current source from J1, leave the 100ohm in place.

WARNING the next tests require applying several hundred volts to the pcb, all the usual precautions need to be taken to avoid shock. The high voltage section of the board is marked by cross hatching.

8. Apply an HT voltage of say 200V to pin 2 of J1, 0v HT to 0V of the board.
9. Measure the voltage on J2 and adjust RV1 so that the read voltage is the applied HT scaled down by 100 (200V will read 2V).
10. Measure the filtered anode current and adjust RV4 to null the error current due to the measuring circuit.
11. Move the HT (switch off the HT first!) from J2 to J3 (screen voltage). Measure the output on J4. Apply the HT and set RV2 to again read the applied HT scaled down by 100 (200V will read 2V).

That completes the HT voltage tests.

Gm tests

It will be a great help to have a multimeter capable of measuring ac volts at 1kHz for the following tests.

12. Using a scope check the waveform on TP4, J10. This should be a 1kHz sine wave.of 0.43 V rms (1.2 V p-p) amplitude.
13. With the 100 ohm resistor still across J1 connect J1 pin 1 to 0v. Connect a further 100 ohms from the output of the oscillator, TP4, J10 to J1 pin 2.
14. Measure the ac voltage across J1 pins 1 to 2, (across the 100 ohm) this should read approximately 200mV rms (0.57 V p-p) This represents a gm of 20mA/V.
15. Measure the DC voltage on J13 pin 1 with respect to 0V.
16. Adjust RV6 to give a voltage of either
    a) 10 X the ac voltage measured on J1 in 4) above (approx. 2V) OR
    b) the same as the ac voltage measured on J1 in 4) above (approx. 200mV)
    depending on the output range selected by the values of R43 and RV6 (see the note on the schematic)
17. Remove the 100 ohms connected to TP4, J6.
18. Measure the ac voltage on J14. Set RV5 to give an output of 100mV rms.

That completes the measurement pcb setup.

Faultfinding

The following notes may assist you if the pcb fails to work for some reason.

Oscillator

R32 sets the gain of the oscillator, this needs to be just over 3. However if the gain is too high the waveform will be distorted. R32 ideally should be 4.9K. 4k7 is the nearest standard value and gives an acceptable waveform. If you like, try using a 5K6 in parallel with 39K giving a gain of 3.04. If there is no oscillation reduce the 39K, if the waveform is distorted increase it

Bandpass filters and Full wave rectifier.

These tests use the oscillator section as a signal source to test the Bandpass filters and Full wave rectifier

1. Remove U2
2. Add a temporary link from J14 pin 1 to J6.
3. Switch on the +/- 15V supply and probe the following points

Test Point	Test Instrument	Result
J6	Scope	1kHz ac, 100mV rms, 283v pk-pk
J7	Scope	1kHz ac, 345mV rms, 950v pk-pk
J12	Scope	1kHz ac, 1.174V rms, 3.24v pk-pk
U6b pin 7	Scope	Full wave rectified ac waveform 3.46V pk
R43/ RV6 junction	Meter	1.3V dc
J13 pin 1	Meter	Adjust RV6 for 1V dc (represents a gm of 10)
The next two tests are part of the Offset compensation and low pass filter circuit tests		
J13 pin 1	Scope	1kHz ac, 100mV rms, 283v pk-pk (as per J6)
J13 pin5	Scope	0V dc – no 1 kHz ac signal

Possible modifications / other uses

The anode current is sensed across a 100 ohm resistor. The Mullard HSVT has a 100 ohm resistor in the Anode line. The Sussex for example uses a lower value resistor, 10 ohms.

I have used a 100 ohm in my Sussex but if the constructor wishes to reduce the sensing resistor to 10 ohms the following changes should be made, I have not tried these and the values are based on theory, it is up to the constructor to experiment.

It should be noted that the signals being measured will be reduced by a factor of 10 and noise as a proportion will increase. **The "Felpham" Measurement Unit for Home Brew Valve Tester**

1. R1 should also be reduced to 10 ohms to avoid common mode errors.

2. R43 should be 15k and RV6 20k, the gm output will be 200mV for a gm of 20. A 2V output will not be possible without extensive mods.
3. The gain of U3A will need to be increased by changing R27 from 1k to 10k and R24 from 56k to 560k – this resistor is connected to the Anode Current zero pot, some experimentation may be necessary to get an acceptable range on the pot. With the gain of U3A increased the dc Anode current output remains at 100mV/mA

Curve Tracer

Having all the outputs positive voltages referenced to ground means that the pcb could form the measurement part of a curve tracer. I have provided the unfiltered anode current on J13 pin 3 for this purpose as it will have a much faster response than the filtered output.

To complete the curve tracer a circuit will have to be constructed to step the grid volts and sweep the Anode volts with a sawtooth waveform.

Appendices

The Sussex valve tester

The Sussex uses a 10 ohm resistor to sense the anode current for gm and a 1 ohm to sense the anode current at dc.

For my Sussex I simply replaced the 10ohm with a 100ohm and omitted the 1ohm since dc current is also sensed across the 100 ohm.

If it is desired to retain the original 10 ohm then the mods described at the end of the main article will need to be implemented.

The Mullard High Speed Tester

In the MHSVT there is a resistor, R89 (100R), always in the Anode circuit. This can be utilised as the sensing resistor for the measurement pcb. However accuracy will be improved if this is changed to a 1% component.

I added a 10K resistor in the grid circuit so as to prevent the existing grid bias supply loading the 100mV 1kHz sine wave inserted via an isolating capacitor.

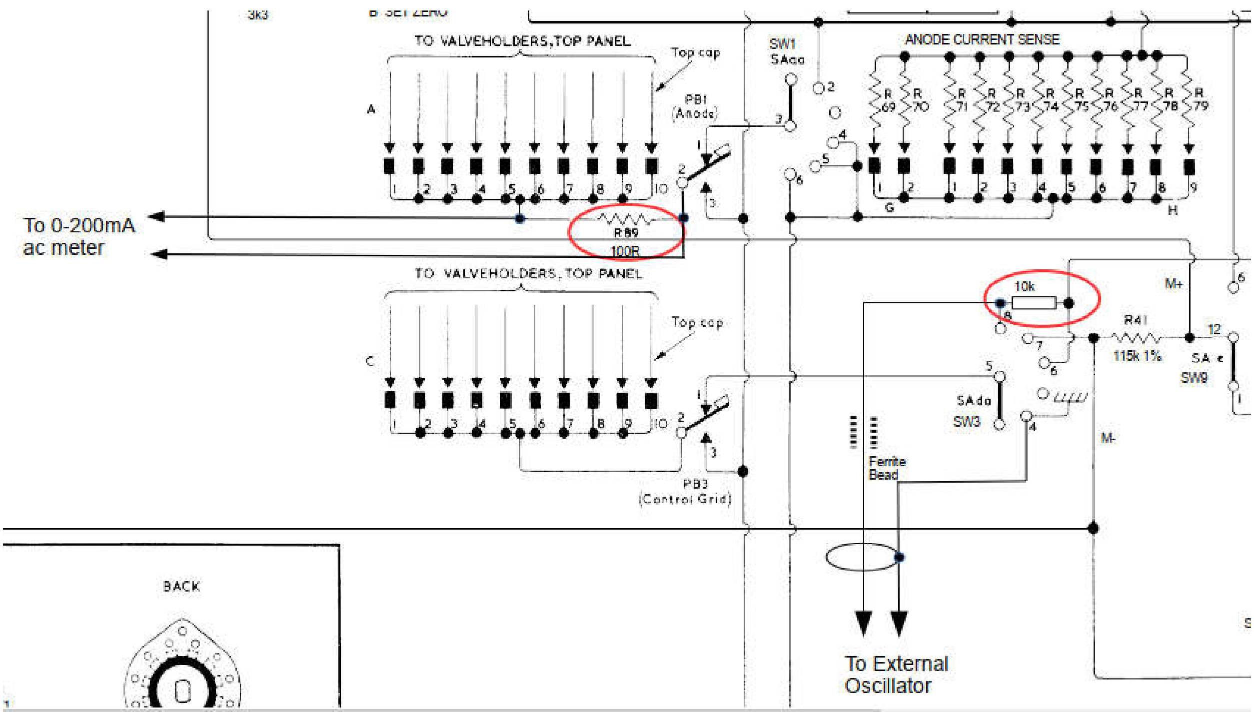
The mods

R89 needs to be changed to a tighter tolerance component and a couple of wires attached, one to each end. The measurement pcb will be attached to these wires. It should be borne in mind that these will have HT volts on them during testing so the insulation has be chosen appropriately. I used double insulated 2 core mains wire for this. I also put a ferrite on each wire. I also used 4 resistors in series/ parallel to give the same value but increase the power and voltage rating, not needed in normal conditions but possibly under fault conditions. The original resistor was a 4W component.

The second mod is to cut a link on the main selector switch and replace it with a 10K resistor, a co-ax cable is then attached to the switch to inject the 1kHz signal.

The switch segment is SAda (/4 version) / SW3 (/3 version).

In position 6, (marked 8 on the schematic but equates to position 6 as you rotate the switch), this segment connects the grid bias volts to the grid, it is upstream of the gate switches that select the valve pins. This connection is only used during emission testing and the 10K resistor has no effect on this test.



Schematic showing the mods. The reference to a 0-200mA meter should read “To the measurement pcb.”

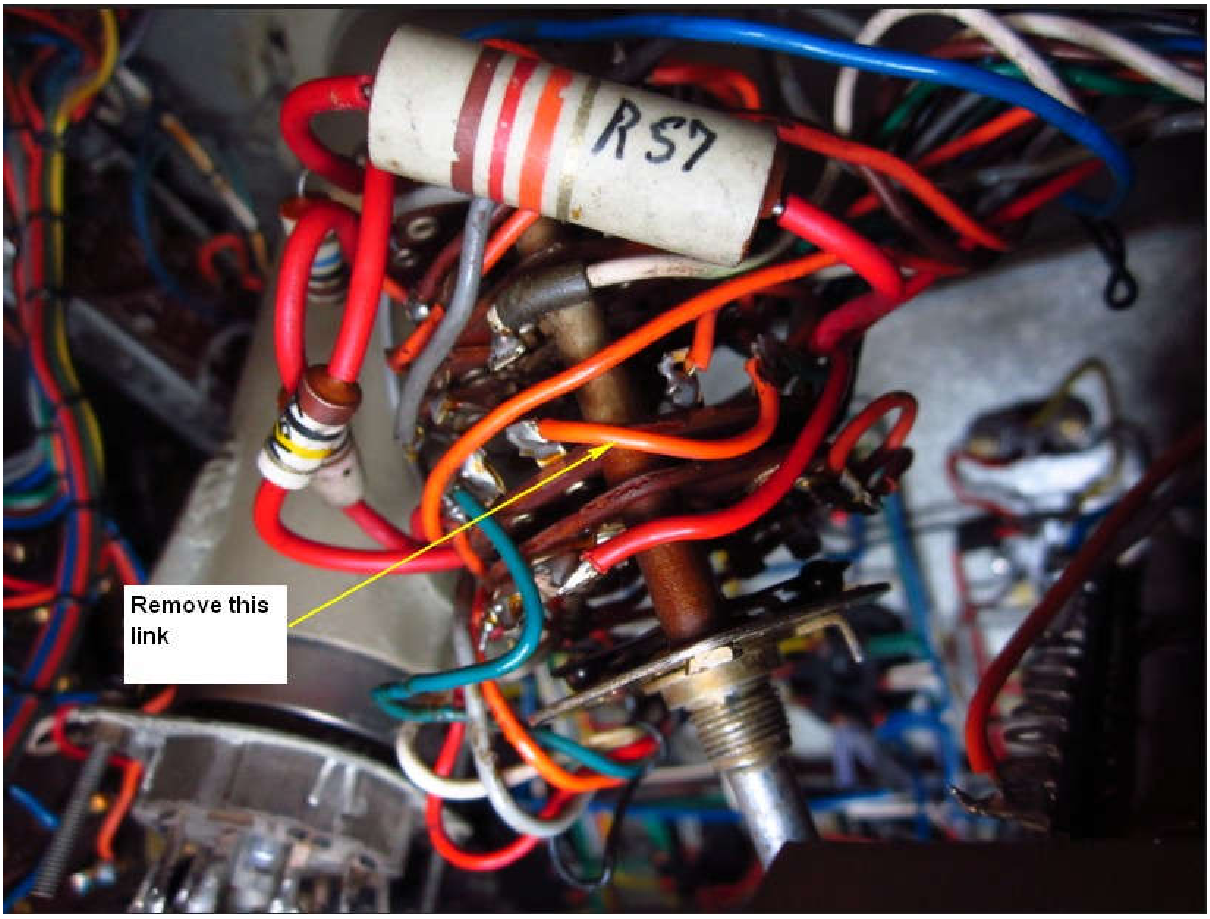
The link between the tags marked 6 and 8 on the schematic (position 4 and 6) is cut and the 10K resistor connected in its place. In my tester there was a green wire attached to tag 8, this had to be moved to tag 6

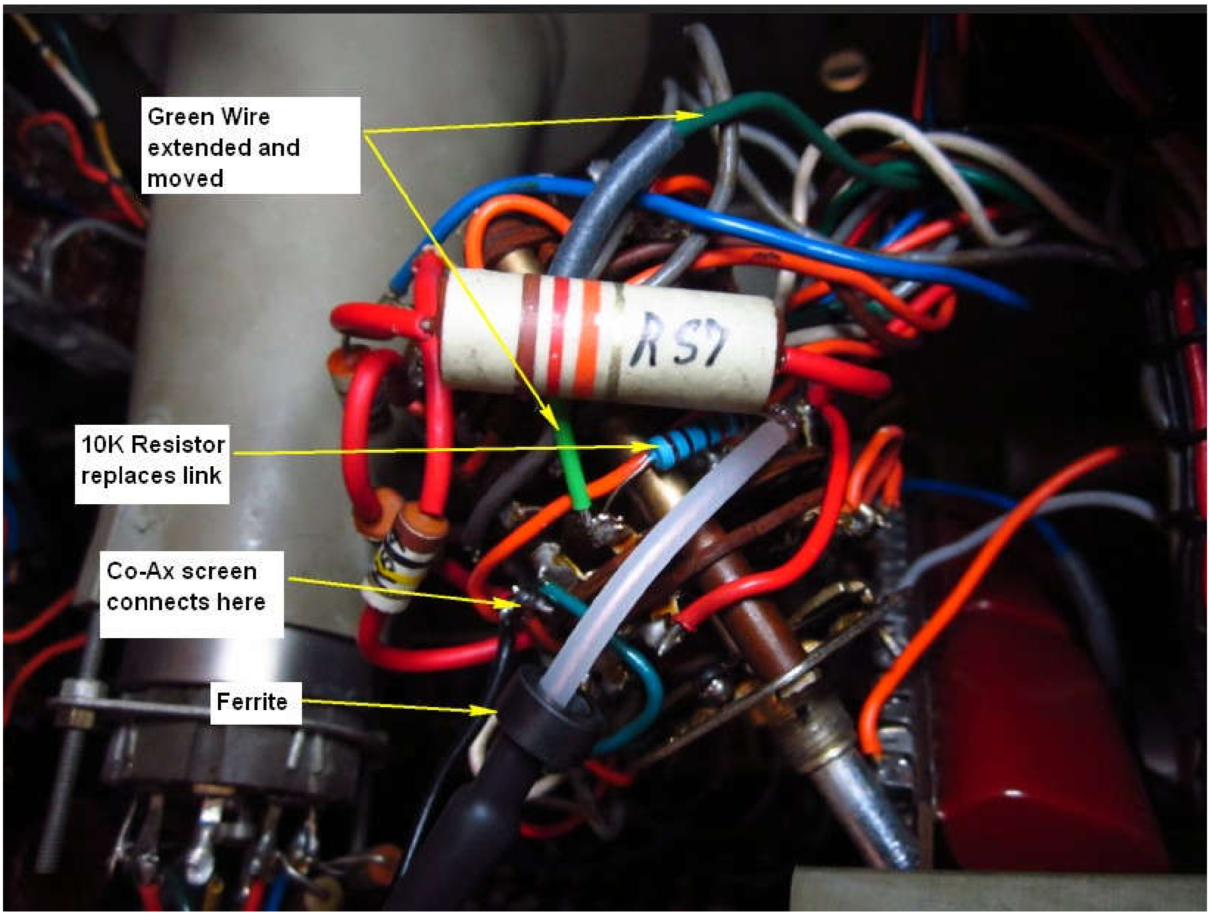
The Screen of the co-ax is connected to position 2 (marked 4 on schematic) which is 0V.

During testing the Cathode of the valve is held at 0V except when push button 3 (PB3) is pressed.

I added a small ferrite to the inner of the co-ax to minimise the possibility of parasitic oscillation

Additionally the mains may need to be brought out to provide power to the power supply for the measurement pcb, the switched Live can be picked up from the fuse holder, the switched Neutral can be picked up from the wiper of the mains selector switch, SW12 and the Earth from a convenient point on the chassis.





Green Wire
extended and
moved
10K Resistor
replaces link
Co-Ax screen
connects here
Ferrite
RS7