# Digital Panel Meter – Jaycar QP5570

(also designated as model CX101B)

by Guy Fletcher VK2KU

These notes address the use of the Jaycar QP5570 Digital Panel Meter (DPM) for the measurement of low differential voltages up to 2V with neither input grounded. Although its use on a 2V range is actively discouraged in the application note for an external divider board offered as QP5575, nevertheless this use was found to be perfectly feasible provided certain precautions are observed.

The DPM is often used with a fully floating and independent 5V power supply, but most amateurs will probably find it more convenient to power it from the same supply as the circuit to be measured.

It will be helpful if I explain briefly one of my intended uses of the DPM, so that you can understand what I wanted to achieve. My DPM is required to monitor the Electronic Frequency Control (EFC) line of an Oven Controlled Crystal Oscillator (OCXO) at a frequency of 10MHz, locked to a GPS-based reference. The continuous monitoring of  this line is desirable as one of several checks that the OCXO remains locked to the GPS reference. It is also of interest in showing the gradual drift of the natural OCXO frequency with crystal ageing. I judge that a resolution of 1mV is needed for this.

The EFC voltage is derived from a phase-locked loop which compares the OCXO with the GPS reference at a frequency of 10kHz, and lies in the range 0 to +8V. The DPM has a 3.5-digit display, so if it is used to measure up to the full 8V, it will need to be on a 20V range with only 10mV resolution. A resolution of 1mV can be realized on a 2V range, by comparing the EFC voltage with a reference voltage of around 4V (adjustable to suit the actual initial EFC voltage, at present unknown). Thus both sides of the DPM input are above ground, though only by a few volts. None of the circuits given in the application notes actually address this situation. The circuit used is shown in Figure 1 and is very similar to one of those in the notes.

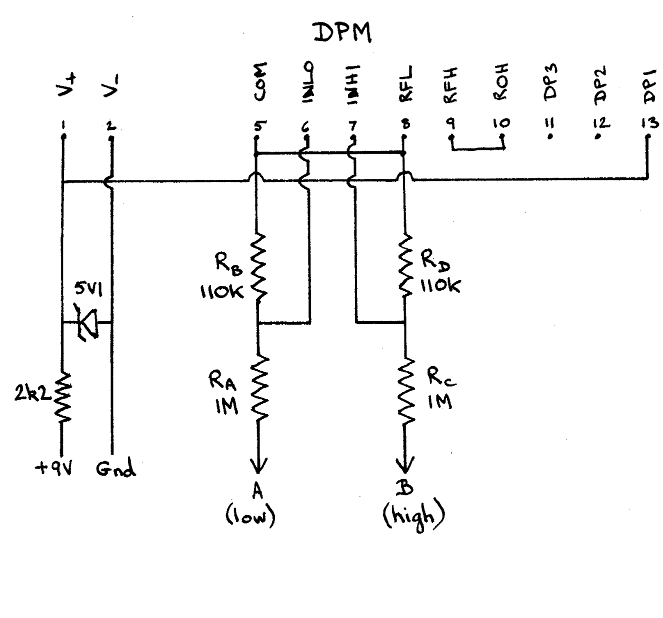

Fig.1. Circuit used for DPM with floating input

The 2 inputs A and B each feed a potential divider which sets the range.
Values for the 4 resistors in the potential dividers are suggested in the notes: 10MΩ for $R_A$ and $R_C$, and values from 100kΩ downwards for $R_B$ and $R_D$ depending on the range (20V, 200V or 500V). No values are suggested for a 2V range. High values for $R_A$ and $R_C$ are needed to isolate the inputs from the DPM (more on this below), but $R_B$ and $R_D$ must clearly be no greater than 100kΩ so as to be low compared with each input impedance of 10MΩ. This is probably why a 2V range is not recommended with the external PCB QP5575 - it would not be compatible with the 10MΩ resistors used for $R_A$ and $R_C$.
I opted to use 110kΩ for $R_B$ and $R_D$, and 1MΩ for $R_A$ and $R_C$.

The notes suggest 0.5% tolerance for the 4 resistors, but my initial feasibility tests were done with 5% 1MΩ resistors because they were to hand! I set up a simple string of six 1kΩ resistors across a 9V supply (with a ground which was shared with the 5V supply to the DPM), to give me several potential differences each of about 1.5V at various levels above ground. The results were quite disappointing, and led me to measure the DPM zero reading with both A and B inputs linked together to the various voltage points available (0V, 1.5V, 3V, 4.5V, 6V, 7.5V and 9V). There was a linear dependence of the DPM zero reading on the common potential of the two inputs, and a plot of this showed that the DPM only showed the correct reading of zero at a common input potential of 1.9V, with a maximum error of about 0.3V when the common input potential was 9V. It is very important to understand this because it indicates how the DPM measures the voltage difference between its two inputs.

I had initially believed that if I connected A to a potential of 4V and B to 6V, then the potential at the COM midpoint of the two dividers must be 5V, and this caused me considerable worry – consider the situation with A at 0V and B at 200V! It is important to understand that the DPM does not directly measure the voltage difference between its two inputs at all. Rather it seems to measure each input against a reference of about 1.9V, and then subtract these from each other. The COM point is clamped at 1.9V to protect the DPM circuit from damage.

So if A and B are both held at 1.9V, the DPM is bound to read zero, no matter what the values of the 4 resistors in the potential dividers. But if both A and B are held at, say, 6V, then the DPM will only read zero if the two potential dividers are identical so that INLO and INHI each have the same potential.

A quick check of the 1MΩ resistors showed that one was very close to 1MΩ but the other was nearly 6% high! Armed with this knowledge, I took a bunch of 1% resistors for each value, and selected identical pairs with my DMM (to 0.01%). I also tried to select for an accurate division ratio of 10 (i.e. resistors of ratio 9 to 1), but was unable to achieve that. This proved not to matter since the full-scale reading can be adjusted with a trimpot on the back of the DPM. With these resistors in place, results were excellent.

In summary, you can certainly use this DPM on a 2V range (or any other), but it is very important to match the resistors in the two potential dividers. This should be sufficient for most applications, but if you want to measure the voltage difference between two points one of which is always floating at, say 8V above ground, then there would be some small additional benefit in using zener diodes to float the power supply at about 6V above ground (i.e. from +6V to +11V), so that the 8V input level is sitting about 2V above the power supply "negative".

Postscript:
Rather than bring 9 leads from the DPM to your PCB it is probably more convenient to mount the potential dividers (and other connections) on a small sub-PCB mounted directly on the back of the DPM. The DPM connections are in the form of a 13-pin PCB-type header, so a 13-way PCB header socket would be convenient. Unfortunately PCB headers seem to be mostly male, with the female socket in the form of a cable termination. No doubt a suitable part is available somewhere, but in the absence of this the simplest (but not the cheapest) way forward is to buy the Jaycar board QP5575 (with its integral female header), remove its 4 resistors, and mount your own on it. I think one or more tracks will also need to be cut.