# Detecting acupoints electrically

## *Methods and equipment used*

By Fletcher Kovich

### The electrical current used

To be able to measure the skin resistance or impedance, it is necessary to pass an electrical current into the skin. Technically, a direct current would provide the simplest solution. However when this was tried, it was found that the acupoints tended to charge up (presumably due to the capacitance of the skin and the matter beneath it), which produced unreliable results. Therefore an alternating current (AC) was used. Another problem with passing a current into an acupoint is that the current may stimulate the acupoint and thereby change the qualities being measured.

After much experimentation, it was decided to use a 400 mv sine wave of 5 kHz. In short sessions (when merely locating an acupoint), the subject is unaware of the current, and the process does not appear to change the impedance at the acupoint, nor affect the organ function.

In the design of equipment to continuously monitor an acupoint's impedance, it was found that a 200 mv sine wave of 40 kHz worked best. This equipment is described elsewhere.

### The electrodes

From the literature, it seemed that an acupoint's centre is generally thought to be only around 1mm in diameter. Therefore an electrode was designed with a tip diameter of around 1mm. It was decided to use a pair of electrodes, set at a fixed distance of 6mm from one another, so that the monitoring could be switched between the two electrodes to aid the detection process.

Such specialist equipment needs to be custom built. Engineering services may be used to do this, but a quicker and cheaper option is to build the electrode assembly yourself. The following are detailed instructions of the steps necessary to do this.

**Building the electrodes yourself**

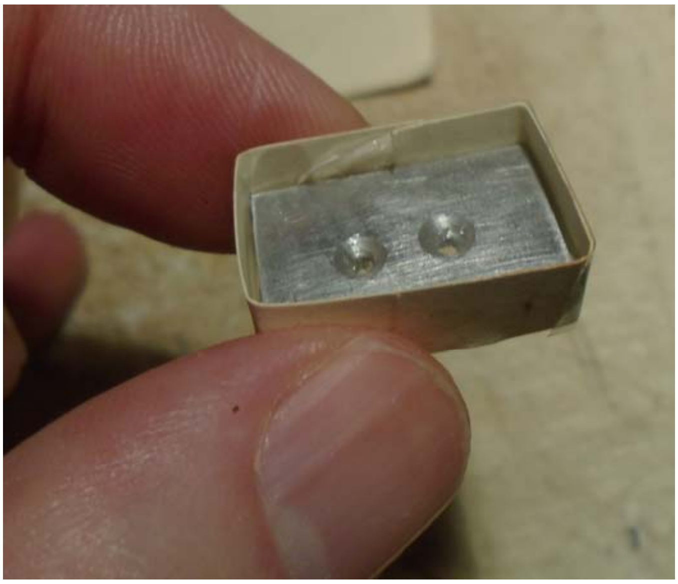
The tools needed.

- copper coated panel pins with a conical head,
- insulated electrical wire in two colours (red and blue were used in the experiment),
- hot melt glue gun,
- a small plate of polished metal,
- the means to drill holes,
- soldering iron,
- cork from a wine bottle,

- bench vice,
- junior hacksaw.

## Method

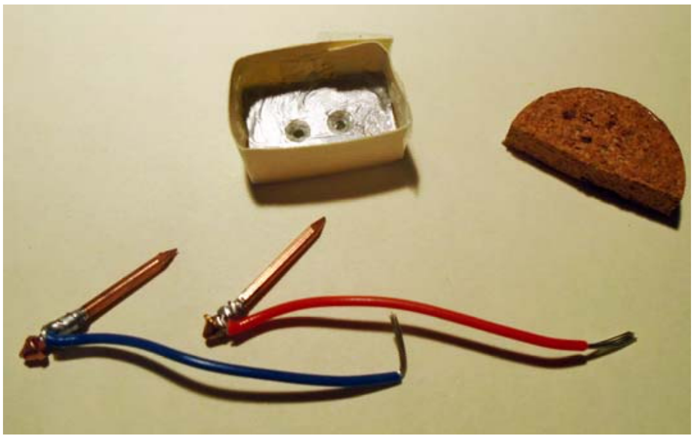
**Figure 1. The drilled metal plate**



Any piece of smooth metal of a suitable size may be used. In this case, cast aluminium was used, measuring approximately 20 x 12 x 2mm. Cylindrical metal of around 18mm diameter would be more suitable, but this was not available.

Drill two pilot holes in the metal, 6mm apart. Then countersink the holes so that the conical heads of the panel pins sit in the metal to a depth of around 1.5mm. This is the depth that the electrode head will protrude from the electrode assembly.

**Figure 2. Metal plate and soldered electrodes**

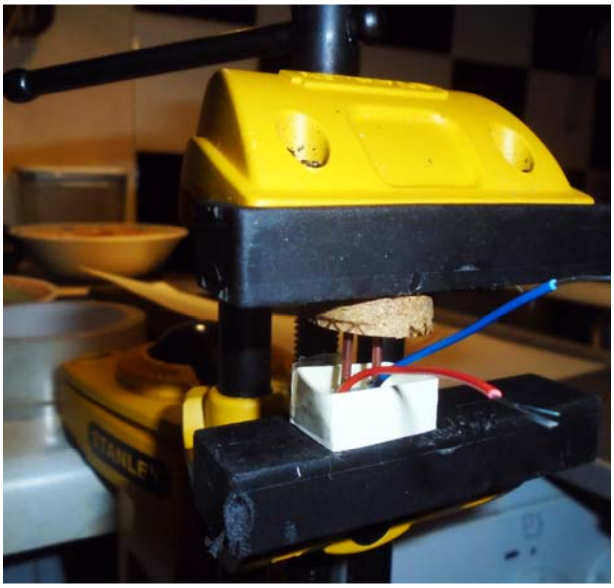


Select two panel pins. The heads should be uniform and as complete as possible (in the panel pins available for the experiment, there was only a small percentage that was suitable).

Strip the insulation from two pieces of electrical wire, leaving around 8mm of wire to wrap around the panel pins. Just beneath the head, wrap this exposed wire around each pin, and solder to fix it in place.

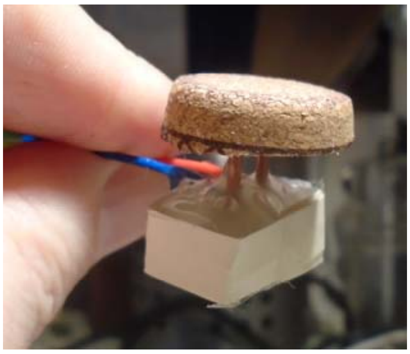
It is necessary to place either card or plastic around the metal, to hold the hot melt glue in place. The metal surface, and the inside surface of the card or plastic should be smeared with gel, to prevent the hot melt glue from adhering to these surfaces.

**Figure 3. The assembly held in a horizontal vice**



This assembly should then be placed in horizontal vice jaws; the panel pins placed in position, with the heads resting in the countersunk holes; place the cork in position and press it into the sharp ends of the panel pins. The pins should first be position, so that they are parallel, and at 6mm distance. The vice may then be tightened to hold the panel pins securely in place. A hot melt glue gun should then be used to fill the card or plastic container.

**Figure 4. The assembly after the glue has set**



Once the glue has set, the cork, card or plastic, and the metal base may be removed, and the protruding ends of the panel pins sawn off. Care should be taken not to damage the electrode wires or their insulation.

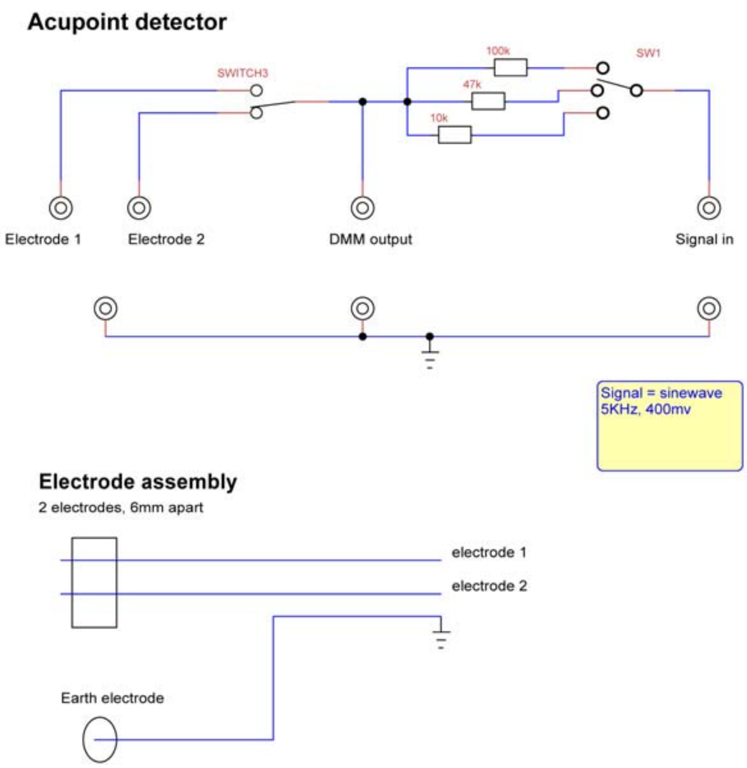
At this stage, further hot melt glue may be used to build up the assembly to a larger size, if needed.

Any suitable wiring and connectors may be used to connect the electrodes to the monitoring equipment.

## The voltage divider

To determine a variable impedance, a simple "voltage divider" circuit is used, where the test signal (of known voltage) is placed across a known resistor that is in series with the impedance being measured. Since the impedance is the only unknown factor, a simple equation can be used to calculate it, using the voltage drop across the impedance, the signal voltage and the known resistor.

**Figure 5. The voltage divider circuit**

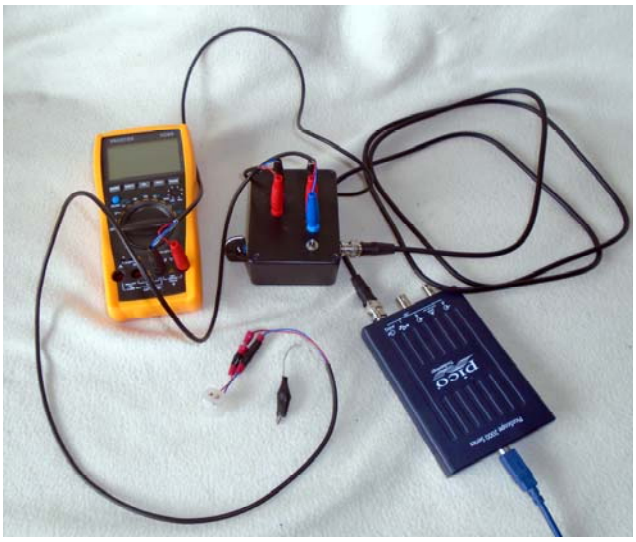



The above circuit was used to create the voltage-divider unit. A switch selects between a choice of three series resistors, of 10 kΩ, 47 kΩ and 100 kΩ. This is to allow for the fact that the skin impedance differs between people, and to provide the ability to use a higher value series resistor if this provides a more suitable range of voltage readings. However, the 10 kΩ resistor is probably suitable for most subjects.

The “DMM” sockets connect to a digital multi-meter. And a switch selects which electrode is monitored. Switching between the two electrodes provides two readings in any location. This assists in the process of locating acupoints and also provides the opportunity to gather readings of the impedance gradient in that location.

A standard ECG gel-coated electrode may be used for the earth electrode.

**Figure 6. The equipment used in the experiment**




The above photo shows the equipment used in the experiment. The DMM was a Proster VC99, but any suitable DMM could be used. To generate the test signal, a PicoScope 2204A was used, but again, any suitable signal generator could be used. The black box houses the voltage divider components, as shown in Figure 5 above.

**Note on earthing**

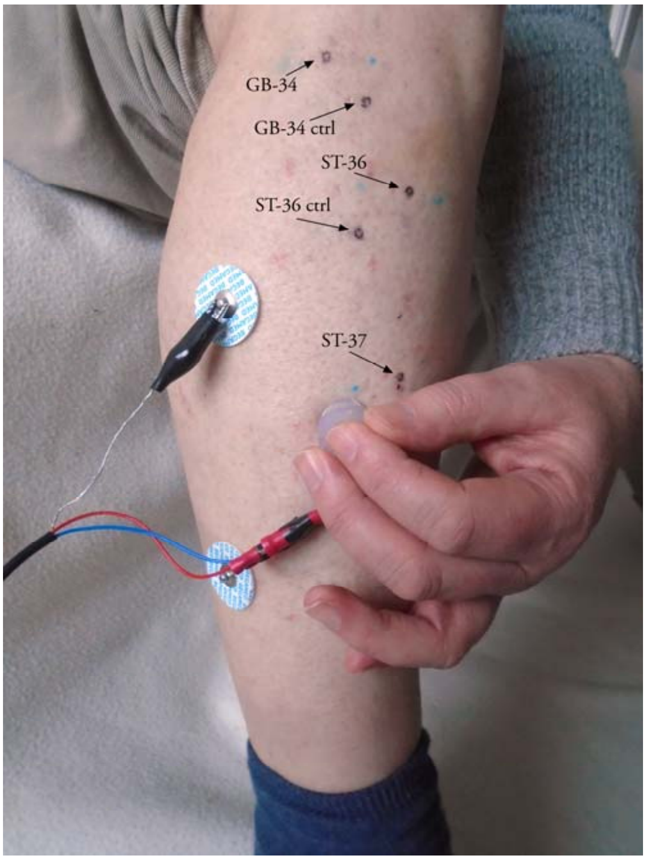
If a laptop is used to drive the signal generator, then a separate earth lead should be connected to any of the earth connections; either the signal generator, or the earth connection on the DMM or the black box. If the equipment is not referenced to earth, the readings may be unreliable.

## Point location technique

In the experiment, each acupoint was first located by an experienced Chinese Medicine acupuncturist and that location marked with a felt tip pen. The electrical survey of that point could then begin. The technique may take several days practice to acquire reliably. Therefore this skill should be separately practised before it is needed in any experiment. The technique used in the experiment is described below.

The earth electrode should be placed a few cm away from the test acupoints (around 6-10cm). In the experiment, crocodile clips were used to then secure the earth wire to that electrode.

**Figure 7. The subject’s marked-up leg with the electrodes in place**




A thin smear of gel was made across the marked acupoint. In this case, “Spectra 360 Electrode Gel” was used, but any suitable electrode gel could be used.

The electrode assembly was then placed, with its “blue-wired” electrode on the marked location, and the “red-wired” electrode being placed perpendicular to the meridian in a lateral direction. The DMM reading from the “blue” electrode was then noted, and the electrode assembly moved about 1mm in a medial direction. If the new reading was lower than the previous, even by 1mv, then the electrode assembly was again moved a further 1mm in a medial direction. However, if the reading was higher than the original, then the electrode assembly was moved in a lateral direction. At each position, the switch on the voltage divider black box could be switched to change between electrodes. This is another method to confirm that the “blue” electrode is reading a lower value than the “red”, and can help to quickly locate the point of lowest impedance.

In this way, the point of lowest impedance is located in the plane that is perpendicular to the meridian. Once located, the same technique can then be repeated in the plane parallel to the meridian, to ensure that the acupoint has been accurately located on the meridian.

In the experiment, this positioning was always unambiguous, once the correct location had been found, so that a movement of around 1mm in any direction would produce a higher value of impedance.

**Checking the connections**

In the experiment, the locator signal was a 400 mv sine wave at 5 kHz. If the DMM reads an RMS value, and the voltage divider resistor is the 10 kΩ value, then the meter should show a reading of around 209mv when the electrodes are not in contact with the skin. To then check the wiring, the earth electrode may be touched to each of the two electrodes in turn (with the "black box" selector switch positioned for each electrode), which should reduce the reading to around 3mv for each electrode.

When the earth electrode is attached, and connected to the subject, and the electrode assembly placed on the gelled skin location, an initial reading may be in the region of 100 to 150 mv. If the reading is above this value, then one of the following issues may be present.

**Problems to watch out for**

The same acupoints will be easier to locate on some patients than on others.  With each patient, when a particular organ is significantly stressed, its key acupoints would tend to have a steep impedance gradient and hence be relatively easy to locate. But when an organ is not stressed, its acupoints would tend to have a shallow impedance gradient and hence be difficult to locate. This should be considered when selecting a suitable patient to use to monitor a particular organ.

Once familiar with the technique, it becomes quickly apparent if the readings do not make sense. Sometimes, when switching between the two electrodes, the DMM reading was the same, or within about 2-3 mv. This usually indicated shorting across the electrodes, which can occur if too much gel has been used. In this case, wiping the face of the electrode assembly and replacing it, often clears the problem. If this does not, then wiping the gel from the acupoint and replacing it with a fresh thin smear of gel, may resolve the problem.

Another, less common, cause of this situation, can be that acupoints sometimes seem to change their width. In the experiment, this was sometimes found with GB-34. Its trough of lowest impedance, rather than being around 1mm in diameter, would sometimes apparently extend to be almost 6mm, which would hence provide the same impedance reading on both electrodes. A solution to this was to switch the electrode assembly around, so that the "red" electrode was now reading the medial edge of the acupoint's centre (i.e. the location where the "blue" electrode was previously placed), and the "blue" electrode would then be reading a point 6mm medial to this.

Another problem that sometimes arose was in the seating of the electrode assembly. When this does not make good contact, the readings may not make sense; often they would be unexpectedly high. This can sometimes be resolved by lifting the electrode assembly and replacing it, but slightly rotating it in either direction as the electrodes make contact with the skin.

The amount of gel applied, and the pressure that the electrode assembly is held to the skin with, can both heavily affect the reading, and practice is required to ensure these factors are as uniform as possible.

It is also important that the same amount of gel is applied to both electrodes, otherwise any readings used to calculate the impedance gradient between the two electrodes would produce misleading results.

The gel tends to evaporate quickly if the electrode assembly is not in place on the skin, therefore it was found that it was best to apply the gel to only one acupoint at a time, just prior to taking the reading.

To become familiar with all these techniques can take several days practice. And the knowledge of an experienced Chinese Medicine acupuncturist is useful to safeguard against mislocating acupoints. If the electrically located acupoint is more than around 5mm from the location initially indicated by the practitioner, they should be consulted again to examine the new location and confirm that it makes sense as the location of that particular acupoint.

## Conversion of readings

The millivolt readings are converted to Ohms with the following formula

$$\text{Ohms} = (V/707)*10/(0.4-(V/707))$$

where V = the reading, in millivolts.

The "707" value converts the RMS millivolt reading to peak volts. And the equation assumes that the series resistor used is the 10 kΩ value. The "0.4" value equates to the 400mv sine wave signal.

If other values are used for either the signal or the series resistor, the equation should be adjusted accordingly. The DMM used should also be checked to find out if it provides an RMS reading. If a reading of the 400 mv signal is made, this should provide a value of around 282 mv RMS.