BIOFEEDBACK MONITOR

With the free PCB and your free components, you can build a basic GSR monitor or read on and find out how to build and use a more advanced version.

The circuit of the basic GSR monitor (see Fig. 1) is an oscillator whose frequency varies inversely with the resistance across the input terminals. The output can be connected to a crystal earpiece or an amplifier and loudspeaker to produce an audible tone.

At their most basic, the electrodes could be the bared ends of some stranded wire stuck to your palms with tape. You will achieve better results by soldering a large washer to the end of each lead and, with a strip of felt, some Velcro and a little foam rubber and glue, you can make yourself a pair of strap-on electrodes (Fig. 2).

The component overlay is shown in Fig. 3. The circuit will run from a 9V PP3 battery — it could be dangerous to use a mains power supply, so don't.

The circuit was designed to work over a wide range to accommodate the possible variations in skin resistance between one person and another. Around 90% of individuals will have a skin resistance in the range 50k to 200k, but the monitor will be responsive to them at the cost of sensitivity to small resistance changes. It is, in any case, difficult to be sure whether the tone has risen or fallen over a period of time.

To produce a more sensitive and effective monitor, the basic circuit can be extended (see Fig. 1). Room has been allowed for this on the PCB.

The input from the electrodes still drives an oscillator but the resulting signal is now processed to give an output suitable for connecting to a meter. The circuit will adapt itself to any resistance, while giving a clear indication of variations.

An analogue multi-meter is the best choice for the display — it is easy to take in at a glance whether the needle has moved to left or right, and the sensitivity of the instrument can be adjusted by switching meter ranges. A 50μA range should be suitable — it gives a clear indication of small changes without pushing the meter needle off the scale for large variations.

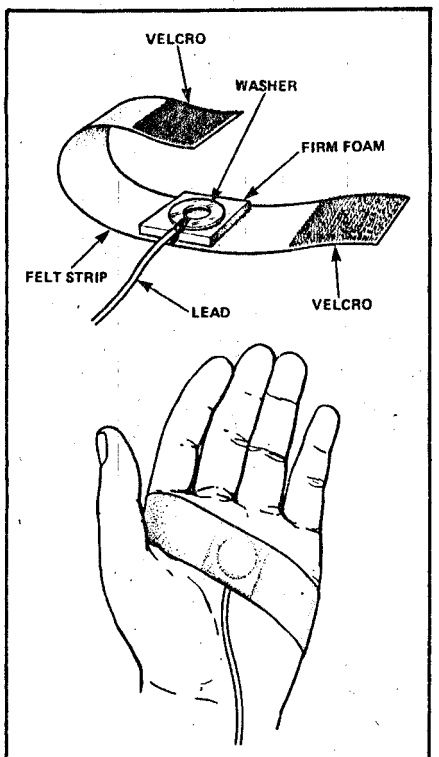


Fig. 2 Home made electrodes — the foam gives pressure to the contact.

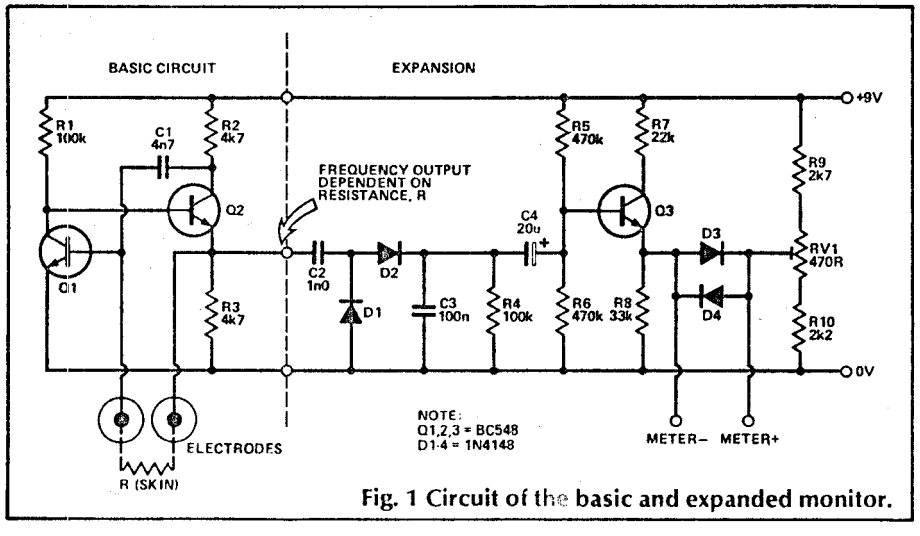


Fig. 1 Circuit of the basic and expanded monitor.

Construction

Figure 3 shows the component overlay for the extended circuit and Fig. 4 and the photograph show the internal layout of a suitable case (the one supplied by our Readers Service). Self-adhesive pads hold the PCB in place — they have more than enough strength for such a light

PCB and save drilling the case. You will find a hole at the bottom of the battery compartment for the connector leads. Remember to thread them through before soldering. Soldering the components should present no problems.

The 4mm plugs for the electrodes have an insulated cover which pushes down over the metal terminal. It is quite a tight fit. The trick of getting it on easily is to solder the wire to the tag neatly, without excess solder, and to make sure the tag is standing upright. Hold the metal part of the plug (don't try to pull it through by the wire), apply firm pressure, and the cover will slip on without fuss.

The case should be screwed together after setting up the circuit. On the case supplied, you will find holes for self-tapping screws at the bottom of the battery compartment. The front of this case just snaps into place. The internal layout is quite straightforward, so you should have no trouble using almost any case.

Setting Up

Connect a 47k resistor temporarily between the two electrode plugs. Turn your meter to the 1mA range and connect it to the terminal posts. Now, switch on. The meter needle should read about 100μA. If it tries to swing to

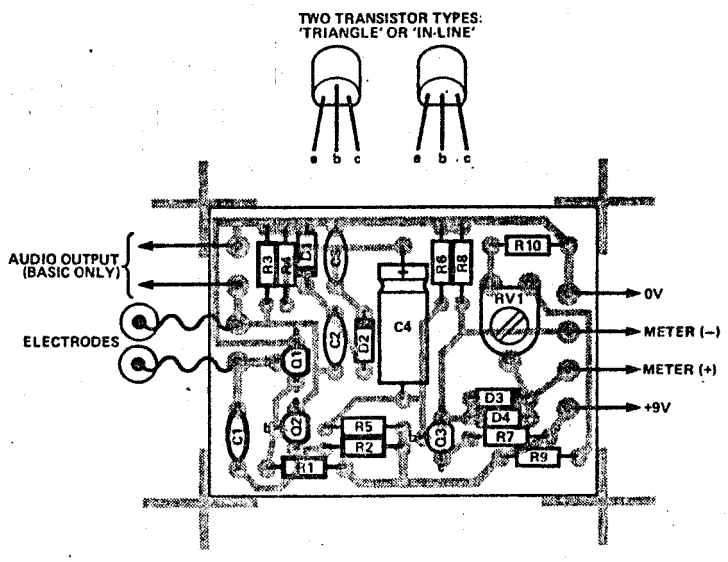


Fig. 4 Component overlay for both the basic monitor and the expanded version.

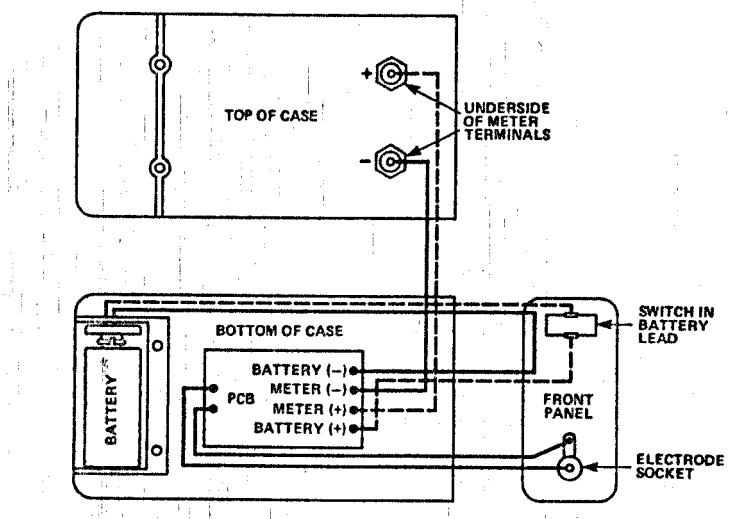


Fig. 5 Casing the unit.

HOW IT WORKS

Q1 and Q2 (Fig. 1) form an oscillator whose frequency depends on the resistance between the electrodes. In the basic circuit, biofeedback is obtained by listening to the output of the oscillator at the emitter of Q2.

In the extended circuit, C2, D1, D2, C3 and R4 form a non-linear charge pump circuit which produces a voltage across R4 dependent on the oscillator frequency. The charge pump has been made non-linear to accommodate a wide range of frequencies, and because it must give an indication of the percentage change in frequency, rather than the number of Hz by which the frequency changes.

A bridge is formed by R5, R6, R9, R10 and RV1. Q3 is included to give one arm of the bridge a high input resistance and low output resistance. R7 and R8 are chosen to limit the maximum output current to 100μA or so; D3 and D4 give further protection to the meter if it is set to the wrong range.

Normally, the bridge is balanced by RV1 (strictly speaking, it is offset to give a mid-scale reading on the meter, to avoid the need for a centre-zero meter). The bridge can be pushed out of balance by a voltage applied to C4 from the charge pump. If the charge pump output voltage rises or falls, the bridge will indicate this. If the voltage remains steady, the bridge will return to the balanced condition after twenty seconds or so.

The result is that the output responds with great sensitivity to *changes* in skin resistance, and can accommodate a wide range of inputs without adjustment.

PARTS LIST

RESISTORS (all ¼ W 5%)

R1*	100k
R2*	4k7
R3*	4k7
R4	100k
R5	470k
R6	470k
R7	22k
R8	33k
R9	2k7
R10	2k2
RV1	470R

CAPACITORS

C1*	4n7
C2	1n0
C3	100n
C4	20μ electrolytic

SEMICONDUCTORS

Q1*, 2*, 3	BC548 or equivalent
D1, 2, 3, 4	1N4148

MISCELLANEOUS

Switch, case, PCB*, phono plug and socket, terminal posts, PP3 battery connector*, connecting wire*, 4mm plugs, electrodes (see text)*, conductive gel*, crystal earpiece (basic monitor only)*.

(* Items necessary to basic monitor)

the left, turn off the monitor and check that the connections to the terminal posts are the right way round. After about ten seconds, the needle will gradually fall back of its own accord to a lower reading. If it goes off the scale at this stage, adjust RV1 to bring it back. When it has settled, adjust RV1 so that the meter reads just a little over zero, then switch to the 50μA range (or the nearest range to this that your meter offers). Adjust RV1 to give a centre-scale reading and leave for a minute or so to be sure the circuit has settled. Adjust RV1 again if necessary. Now disconnect the meter, switch off the monitor, screw the case together, and you are ready to begin.

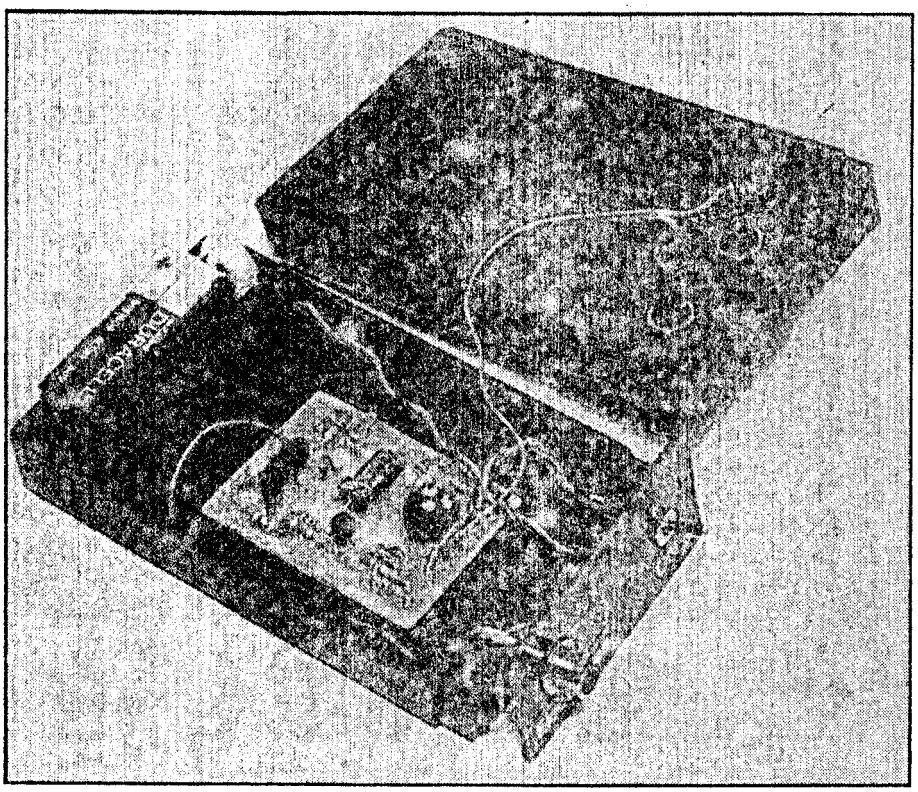
The circuit contains components to protect the meter from overload, but it is a sensible precaution in any case to turn to a less sensistive range each time you power up the monitor (the peak current will be about 100μA) or make any changes to the electrodes. In use, a leftward swing of the meter needle corresponds to a rise in pitch on the basic GSR monitor (and vice versa).

Getting Started

Take a little conductive gel on your fingertip and fill the recess in each electrode pad with it. If you bend your hand slightly, you will see that there is a part of your palm that moves very little — this is the best place for the pads (see Fig. 2)

Make sure your hands are clean. If you really want to be thorough, rub your palms lightly with a pumice stone to remove any loose dead cells. Remove the covering from the adhesive on the rim of the pads and attach them firmly to your palms — one on each hand.

Find a comfortable place to sit, and rest your hands with the palms facing inwards or upwards so as not to put pressure on the electrodes. Find a hand position that feels natural and unstrained. When the meter needle has settled try taking a few deep breaths. After a second or so, the needle should move to the left and then, if you breathe normally again, should move back towards the centre. You can produce a similar effect by tensing your muscles — try it with your leg muscles — or by biting your lip (not too hard!).



The GSR monitor installed in the recommended case.

In each case, you will notice that the needle does not move instantly — it responds a second or two after the cause. This is not a characteristic of the meter, but of your body. It takes that long to respond and produce the resistance change. Another thing you will notice is that the recovery takes much longer than the initial response. The needle moves smartly to the left, but only gradually back to the right again.

Producing a change without any of the physical aids is almost as easy — just think of a worrying or exciting situation. Unless you have a vivid imagination, a real situation will probably produce a much greater response than an imaginary one.

While you are experimenting with the monitor, you may see the needle move for no particular reason. Your body is constantly affected by your surroundings and responds to things you are hardly aware of. Many people produce quite large resistance changes in response to traffic noise, even if they claim not to notice it!

An interesting adaptation the body makes is to habituate to events that happen regularly. If you can produce a regular click, for instance, notice that the GSR reading becomes less and less on each successive click until eventually there is no visible response at all. A metronome is too fast for this experiment — it won't allow time for the needle to return between successive clicks — but it shouldn't be beyond ETI readers to make a circuit which gives a slow, regular beat.

Relaxation

The GSR monitor can be a valuable aid to stress control, relaxation and meditation. Find a quiet situation where you will not be disturbed. Traffic noise should be avoided if possible, but more important is to be out of sight of anything that may remind you of things that need to be done. Find a comfortable chair to sit in (if you lie down, you may become drowsy, which is not the point of the exercise).

Relaxation is not something you do, it is something you let happen. The repetition of a nonsense word, or mantra, may help this along.

Keep your eyes open, but don't stare at the meter needle. Just allow yourself to notice it every now and again. If you concentrate on it, it will almost certainly swing over to the left and you'll lose the mood. After a while, the needle should deflect to the right; it may began to swing freely about the central position, or a little to the right of it. Both are signs that you are on the right track. After ten or fifteen minutes, you should in any case stop.

Lie Detection

Lie detection depends on the observation that a person's autonomic nervous system reacts more strongly when telling a lie than when telling the truth. It's big business in the USA, but thankfully has not caught on here yet. The instrument used commercially — a 'polygraph' — consists of a number of pieces of bio-monitoring equipment in the same box — a GSR monitor, blood pressure meter, heart rate detector, and so on. The output usually drives a chart recorder so that the results can be analysed later.

Lie detection works well with neutral topics. When used to pry into someone's personal affairs, the results can be very misleading since responses can be caused by all manner of things. Don't ask personal questions of anyone connected to the GSR monitor — at best it can only cause embarrassment.

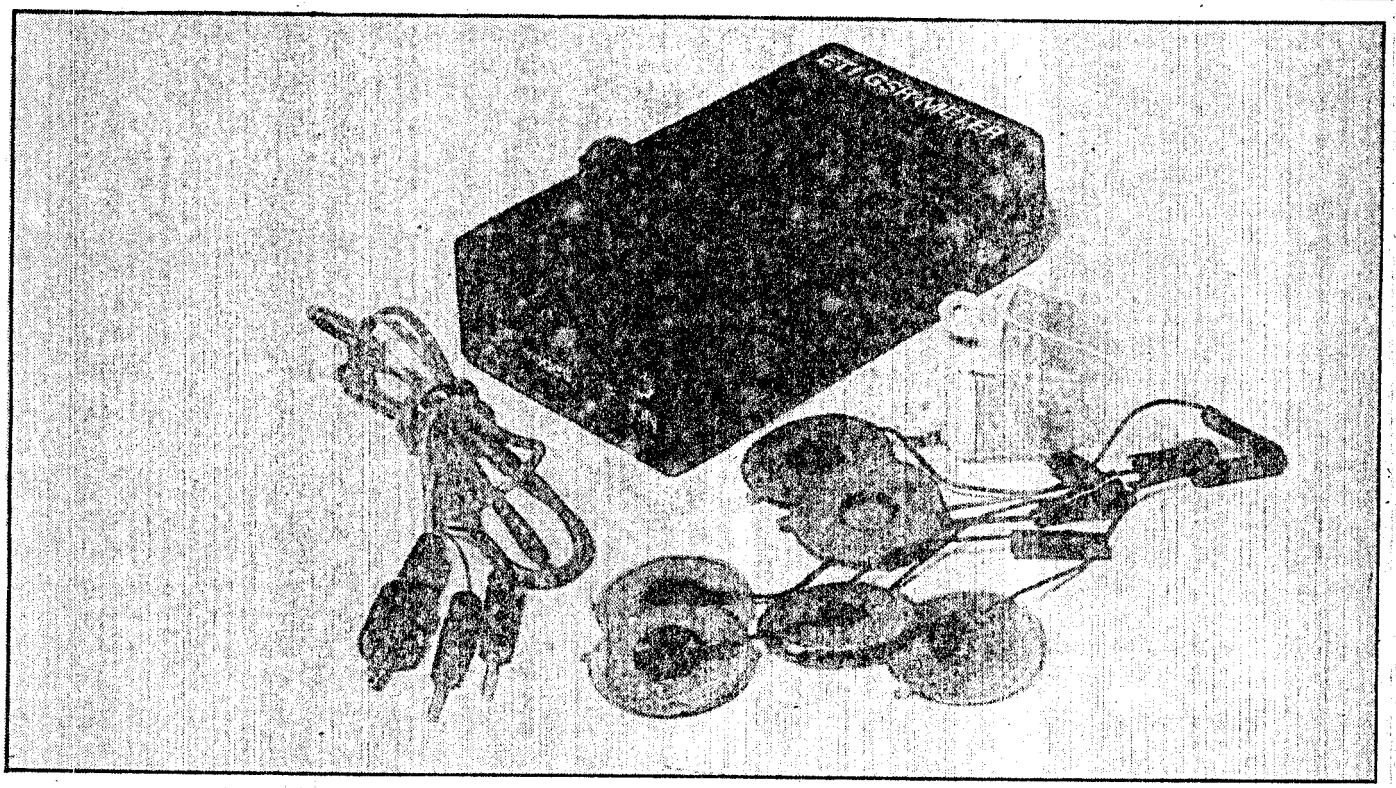
Ask someone to pick a card from a set of ten (if you use more, the test will take too long!) and memorise it. Now, show the cards one at a time and ask 'Is this the card you picked?' Each time, the person must answer 'No, it isn't'. When the selected card appears, the answer will be a lie and the meter needle should swing to the left, so you will be able to identify the chosen card. Remember to allow enough time between each card for the meter needle to return to the central position — it will probably move slightly after each answer.

Biofeedback can strengthen the results. If the person connected to the monitor can see the needle move, the deflection should be greater than if they can't. A more devious method is to give false biofeedback — let the subject beleive that the meter they see is measuring their responses when what they are really looking at is a meter under your control (a multimeter on ohms range connected to a pot, for instance). Ask a few questions and if the answers are untrue, tweak the pot to give a huge swing of the needle! This should cause the genuine GSR response to be more pronounced.

Cheating the lie detector is easy, since there are so many ways to produce a GSR response at will. More difficult is to try to cancel your GSR response to a lie, but relaxation techniques can help here.

BUYLINES

A complete set of parts, including case, electrodes, conductive gel, leads, etc. to convert the basic GSR monitor to the advanced version is available from our Readers' Service department. See the special offer in this issue. If you would prefer to seek out the components for yourself, the only items likely to cause any problem are the electrodes and gel. Most medical suppliers are only prepared to sell the electrodes in large quantities, so we have arranged for supplies to be available from: Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. They will supply a set of ten electrode pads and a sachet of conductive gel for £2.90, inclusive of postage. If you would prefer to make the strap-on electrodes, materials will be available from any good haberdashery shop! All the electronic components are entirely non-critical.



The completed monitor.