Electric fence tester

This project was developed to take some of the guesswork out of testing or checking an electric fence. Many factors can influence the operation of an electric fence energiser and fence, reducing its effectiveness. A common method of testing a fence is to hold a blade of grass near the wire and get the 'feel'. Get it wrong and you'll find yourself dusting off the seat of your pants!

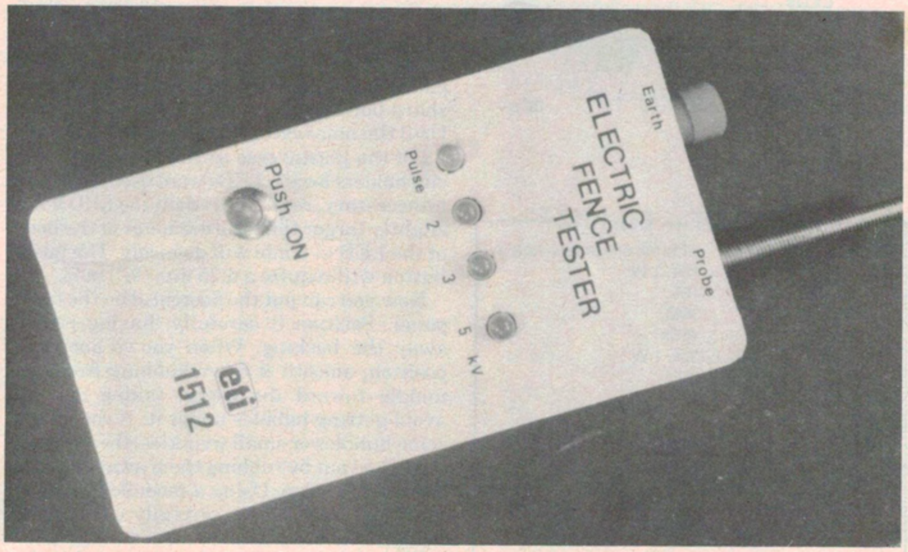
Graeme Teesdale

ELECTRIC FENCES are now a common 'tool' of farm management. Cattle which escape from an enclosure can cause considerable injury to themselves and other property. An electric fence is an effective, non-injurious barrier when properly erected and maintained. But they have to be maintained! Checking if an electric fence is operating by grabbing it is one method to prove it's working — but few relish the substantial 'jolt' delivered. Another method is to hold a blade of grass near the fence wire. At a few centimetres distant, you should feel a 'tickle'. But, that's dependent on the moisture in the grass, your contact with the ground, etc. If you fail to feel the tickle and approach more closely, you're liable to receive quite a jolt! None of these methods is quantitive, nor can results be compared day-to-day or along the length of a fence.

This project was devised to provide a more quantitive indication of fence/energiser operation and avoid the pitfalls of the 'grass roots' methods.

The unit indicates the presence of each pulse from the energiser and shows when the pulse voltage on the fence wire exceeds an amplitude of 2 kV, 3 kV and 5 kV, once calibrated. If used in an uncalibrated mode, the unit will indicate pulse amplitudes on the fence of 40%, 60% and 100% of energiser output.

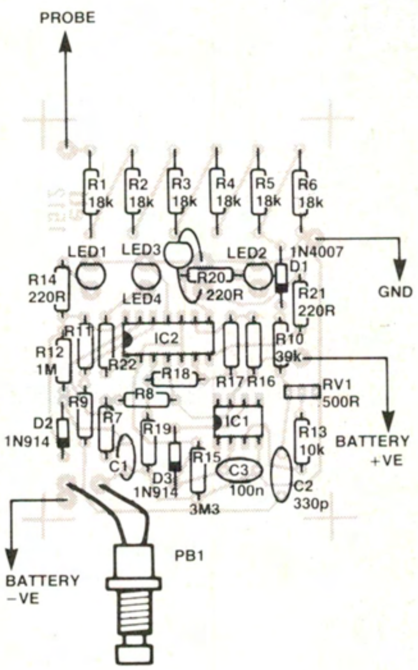
The electronics for this project has been deliberately kept simple, so that the cost is low and reliability good. Construction, too, is simplified. Only two ICs, a handful of resistors and capacitors, four LEDs and very little else is used. The LEDs are used as indicators. So that they can be readily seen in sunlight, we recommend you use the common yellow LEDs or the recently introduced 'high brightness' types.

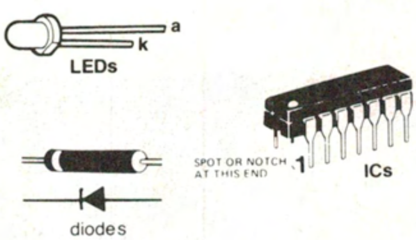


Our tester was housed in an all-plastic case — so that you can't possibly come in contact with anything carrying the high voltage pulses! The case is held in one hand and the probe protruding from the end touched on the live wire from the fence after the 'ground' probe or lead is literally 'earthed'. Pressing the pushbutton on the front panel turns the unit on. One LED indicates the presence of a pulse. The '2 kV' LED lights to indicate the unit is on and goes out when a voltage pulse exceeding 2 kV is present. When the voltage pulse exceeds 5 kV, the 2 kV LED goes out and the '3 kV' and '5 kV' LEDs flash on. If there is a problem with the fence or the energiser, and the voltage does not exceed 2 kV, the 'pulse' LED only will flash, indicating that the energiser is working but that the voltage is low. More details on checking out a fence are given later.

Construction

For ease of assembly and reliability, it is recommended you use our pc board design. This board will fit in a standard, commonly stocked plastic case measuring at least 60 mm wide by 30 mm deep by 110 mm long. A number of models have been made, but the one shown in the photograph measured 65 x 36 x 121 mm (w-d-l). The front panel was dressed up with a *plastic* Scotchcal label. Don't use a metal type as pulses from the fence probe may 'track' across the case to the panel and you may receive a little surprise. You can make your own pc board using our artwork or buy one ready made, that's up to you. ▶





PARTS LIST — ETI-1512

Resistors .... all ½ W, 5% unless noted

R1-6	18k, 1 W
R7, R12	1M
R8, R15	3M3
R9	100k
R10	39k 1 W
R11	2M2
R13	10k
R14, 20, 21, 22	220R
R16	4k7
R17, R19	2k2
R18	1k2
RV1	500R min. vertical mount trimpot.

Capacitors

C1, C3	100n greencap
C2	330p ceramic

Semiconductors

D1	1N4007
D2, D3	1N914, 1N4148
IC1	CA3140
IC2	LM324, uA324
LED1-4	TIL220Y yellow LEDs

Miscellaneous

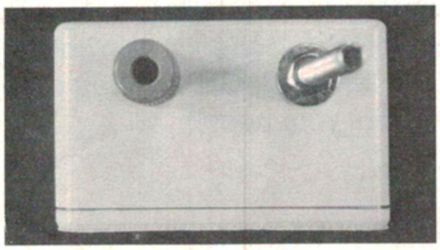
PB1	pushbutton

ETI-1512 pc board; all plastic zippy box 121 x 65 x 36 mm or similar; No. 216 9 V battery and clip lead; Scotchcal front panel; wire, alligator clip etc.

Price estimate
$18 — $22

When you've gathered all the components together, first thing to do is check the pc board. See that all the holes are drilled the correct size and that there are no broken tracks or shorts between tracks — particularly between the IC pins. Commercially made boards don't suffer such problems in general, but do check the hole sizes. If you mount the pushbutton switch on the pc board, like I did, then see that the holes where it mounts are of the right diameter. Leads on the LEDs on the trimpot are usually of greater thickness than most other components and their mounting holes should be checked too.

At the 'top' of the case, mark out and drill two holes for the fence and ground probes. The fence probe shown on the model in the photographs was a 50 mm long 2 BA bolt. The ground probe was plugged into a standard 'banana' socket.



Top. Fence probe and ground socket.

If, or when, all's well with the pc board, mark out and drill the case. Tackle the front panel first. You can use the Scotchcal artwork as a template to mark out the front panel, pricking through the artwork with a sharp-pointed instrument such as a scriber. Drill the holes carefully. It's easier to use the lid of the plastic case as the front panel. No clip holders for the LEDs were used as they're unnecessary, really. Just drill the LED holes slightly larger than the diameter of the body of the LED — 5 mm will do nicely. The pushbutton will require a 6.25 mm (¼") hole.

Now you can put the Scotchcal on the front panel. Position it carefully, having peeled away the backing. When you've got it in position, smooth it down rubbing from the middle toward the edges, taking care to avoid getting bubbles under it. If you do get some bubbles or small wrinkles, these can be smoothed out by rubbing them away towards the nearest edge. Using a modeller's scalpel or other sharp blade, carefully cut out the holes in the Scotchcal.

With the case prepared, you can tackle the pc board assembly. Refer to the accompanying overlay. Solder all the resistors and capacitors in place first, including RV1. Then solder all the diodes in place, making sure you get them the right way round. Note that D1 is a 1N4007 and D2, D3 are 1N914s or 1N4148s. Solder the two ICs in place next, taking care to orient them correctly. Solder the pushbutton to the board next, making sure it sits perpendicular to the board. Last of all come the LEDs. Place them in their positions, making sure you get them the right way round, but don't solder the leads yet. Temporarily mount the board to the panel using the pushbutton. Then, pushing each LED into place in turn, solder their leads to the board. Disassemble the board from the front panel and solder flying leads of adequate length from the fence probe and ground probe pads on the board and attach the battery clip lead. Use heavily insulated wire for the probe leads and space them well away from each other.

Assemble the board to the panel once again and terminate the two probe leads from the board. Plug in a No. 216 9 V battery and you're ready to test and calibrate the unit.

Testing it

This method is guaranteed non-dangerous as you don't get anywhere near an electric fence or fence energiser! For this test you will need one 470 ohm resistor. Solder one lead to the battery positive pad on the board. Set RV1 so that its wiper is at the R10 end of its travel (toward IC1). Press the pushbutton. The '2 kV' LED should come on. Now touch the other end of the 470 ohm resistor to the junction of R10 and RV1. The '2 kV' LED should go out, the '3 kV — 5 kV' LEDs should light and the 'pulse' LED should give a flash. When you disconnect the 470 ohm resistor, the '3 kV — 5 kV' LEDs should go out in reverse order (5 kV LED first) and the 2 kV LED light briefly. If you don't get these indications, look for an error in component orientation or placement. Check that you're getting the supply to the circuit when you press the pushbutton, too.

Correct any errors and try again.

Calibration

You can go about this in several ways. The display can be calibrated to read fence voltage as a percentage of energiser voltage output or it can be calibrated to read directly in volts.

If you're going to calibrate the display to show percentage of energiser output then this should be done with the energiser connected to either a 'known good' fence or to a ▶

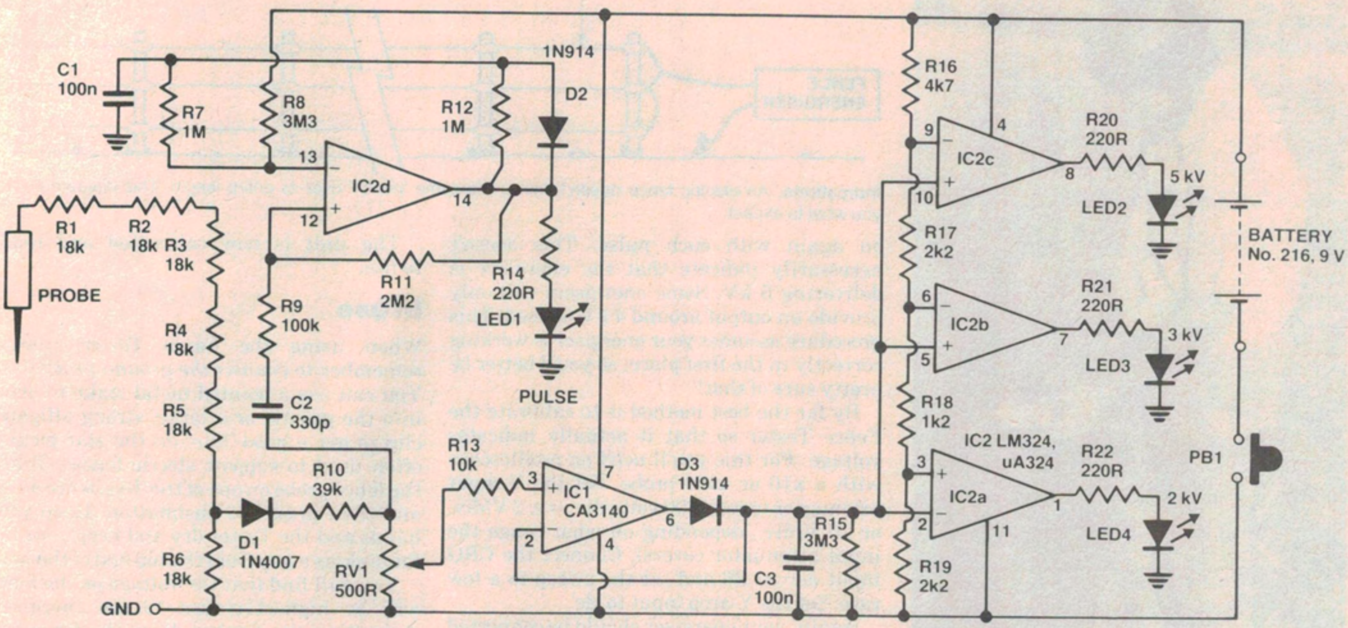
RESISTORS R1 TO R6 AND R10

These seven resistors require special mention. In use, they will experience a pulse voltage across them of around 800 to 1000 volts. Power dissipation will never be a problem as the pulse duration is too short and pulse timing too long to cause any significant dissipation.

However, all resistors have a voltage stress rating for both continuous operation (max. dc working voltage) and for pulse operation. The reaction of resistors to voltage stresses is almost instantaneous. Carbon film resistors — commonly stocked by component suppliers — can withstand about twice to 2.5 times their rated dc working voltage under pulse conditions. A 1 W carbon film resistor generally has a dc working voltage of 500 V and thus will withstand 1 kV to 1.25 kV under pulse conditions. Thus, we recommend resistors of 1 W rating for R1 to R6 and R10.

At a pinch, ½ W resistors could be used. These generally have a dc working voltage rating of 350 V and, at best, will withstand 875 V under pulse conditions.

(For more information, see *Resistors* and *Film Resistors*, by Roger Harrison, ETI September '76 page 90 and November '76 page 15, respectively.)



HOW IT WORKS — ETI 1512

The circuit can be divided into four sections: the input divider, the peak voltage detector, the display and the pulse indicator.

INPUT DIVIDER

The input divider comprises R1 to R6, plus R10 and RV1. Diode D1 is for protection, and I'll get around to that shortly. Assuming a positive-going input pulse of 5 kV peak, the voltage appearing across R6 will be about 830 V. This will be conducted to R10/RV1 via D1 and a pulse of about 10 V peak will appear across RV1. When calibrated to indicate voltage on the display LEDs, RV1 will be set to about mid-travel and a pulse of about 5 V peak will appear on the wiper of RV1. What happens to that, I'll get around to in a minute, but first, what's the reason for D1?

Should the input pulse on the fence probe be negative-going, as it sometimes is, then D1 will not conduct as it will be reverse-biased. This prevents a large negative-going pulse being conducted to the rest of the circuit. If the peak pulse voltage developed across R6 in this situation should be greater than 1000 volts, D1, which is rated at 1 kV PIV, will likely go into reverse, or 'zener', breakdown the current passed through it being limited by R10. The voltage across RV1 will be very low, thus ensuring the rest of the circuit is still protected.

PEAK VOLTAGE DETECTOR

IC1 and D3 are arranged as a peak voltage detector. The positive-going input pulse from RV1 is applied to the non-inverting input of IC1, pin 3, via R13. As the input impedance of IC1 is very high, R13 does not drop the input voltage and simply provides input current limiting. The output of IC1 will be driven toward the positive supply rail and D3 will conduct. Negative feedback from the cathode of D3 to the inverting input of IC1, pin 2, ensures that IC1 has only unity gain (x1). The output of IC1 charges C3 to the same value as the peak voltage applied to the input. If the peak pulse voltage on the fence probe is 5 kV, and the voltage on the wiper of RV1, when calibrated, is 5 V then C3 will be charged to 5 V.

When the input pulse falls to zero, C3 will discharge slowly via R15 and the combined input impedance of op-amps IC2a, b and c.

THE DISPLAY

The display circuitry consists of IC2a, b and c arranged as voltage comparators, LEDs 2, 3 and 4 and resistors R16 to R22.

The resistive divider formed by R16, 17, 18 and 19 provides three fixed voltage points. The junction of R16-17 will be at 5 V (with respect to the common rail), the junction of R17-18 will be at 3 V and the junction of R18-19 will be at 2 V. Thus the inverting input of IC2c will be held at 5 V, the inverting input of IC2b will be held at 3 V, but the non-inverting input of IC2a will be held at 2 V.

With the non-inverting input of IC2a (pin 3) held at 2 V, the output, pin 1, will be driven high (toward +9 V) and LED4 will light, the current through it being limited by R22. That is, assuming PB1 is pressed! LED4 thus acts as an 'ON' indicator, one part of its dual role.

If the voltage on C3 reaches a little over 2 V, the inverting input (pin 2) of IC2a will cause the output to go low and LED4 will go out, indicating that the peak pulse voltage on the fence probe has reached 2 kV.

As the inverting inputs of IC2b and c are held at a lower voltage than their non-inverting inputs, the outputs of these two op-amps will be low and LEDs 3 and 4 will be off.

When the voltage on C3 reaches a little over 3 V, the non-inverting input of IC2b will be at a higher voltage than its inverting input and its output, pin 7, will be driven high, lighting LED3. Note that LED4 will remain off. Thus, LED3 lighting indicates that the peak pulse voltage on the fence probe has reached 3 kV.

When the voltage on C3 reaches a little over 5 V, the non-inverting input of IC2c will be higher than its inverting input and LED2 will be turned on, in the same way as LED3 was turned on. Thus, when LED2 lights, you know the peak pulse voltage on the fence is at least 5 kV. Note that, in this case, LED4 will be out and LEDs 2 and 3 will be lit.

The pulse from the fence falls to zero very rapidly, but the charge on C3 will be maintained, slowly leaking away via R15 and the combined input impedances of the op-amps IC2a, b and c. Thus, the display will 'hold' for longer than the duration of the fence energiser pulse, allowing you to see the action more readily.

THE PULSE INDICATOR

This circuit comprises IC2d, LED1 and associated components. The input pulse is used to trigger IC2d which is connected as a one-shot multivibrator. The output of IC2d drives LED1 which will flash, indicating the presence of a pulse, regardless of the amplitude, so that if the pulse has insufficient amplitude to drive LED4 off, you can still check that the energiser is supplying pulses to the fence.

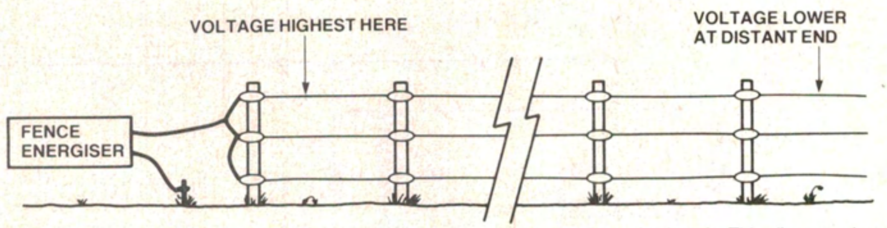
In the absence of an input pulse, resistor R8 keeps the output of IC2d in a low state (0 V) as it holds the inverting input (pin 13) at a higher voltage than its non-inverting input (pin 12). Thus, LED1 will be off.

When an input pulse arrives, it is coupled to the one-shot via C2, and R9. The positive-going pulse drives the non-inverting input of IC2d (pin 12) more positive than its inverting input (pin 13), driving the output (pin 14) high. LED1 will turn on and positive feedback via R11 will cause IC2d to 'latch' in this state. At this time, C1 will charge from virtually zero volts towards the supply rail, via R7-R8. When the voltage across C1 reaches the value on pin 12, the op-amp will switch back to its previous state with the output low. LED1 will then go out. This action takes a few hundred milliseconds, time enough for you to see LED1 light.

So that the one-shot reacts to rapid pulses, diode D2 is included to discharge C1 quickly, so that IC2d rapidly resets to its quiescent state, ready to receive the next incoming pulse.

If the energiser provides a negative-going pulse to the fence, reverse the energiser connections, NOT the Fence Tester connections or you'll be applying the fence pulse to the common rail of the Tester and you might get a wee surprise via PB1 when you try to test the fence.

Shock. Horror. Probe! Gentleman about to receive shock from incorrectly connected Fence Tester (note ground lead going to live fence wire!).



Indications. An electric fence doesn't deliver the same 'punch' over its entire length. This diagram shows you what to expect.

dummy fence'. A dummy fence can be made up quite simply. You'll need two 10n/3 kV ceramic capacitors, which are widely available. These should be connected in series and then connected directly across the energiser output along with the Fence Tester, thus placing a load of about 5 nF on the energiser. Nothing else should be connected across the energiser output. Make sure all the connections are well above the bench top, or whatever. Set the energiser going, then press the pushbutton on the Fence Tester. Adjust RV1 back until the '5 kV/100%' LED just goes out, then advance it until it comes on again with each pulse. This doesn't necessarily indicate that the energiser is delivering 5 kV. Some energisers will only provide an output around 4 kV on load. This procedure assumes your energiser is working correctly in the first place, so you'd better be pretty sure of that!

By far the best method is to calibrate the Fence Tester so that it actually indicates voltage. For this you'll need an oscilloscope with a x10 or x100 probe. Set the Y-input attenuator to read 200 volts/div. (i.e: 2 V/div. or 20 V/div., depending on what range the input attenuator covers). Connect the CRO input across R6 and set the sweep to a low rate. Set the Y-amp input to 'dc'.

Again, your energiser should be connected either to a known good fence or a dummy fence. Connect the Fence Tester to the energiser's output, set the energiser going, and measure the pulse amplitude directly from the oscilloscope's face. At 200 V/div., multiply by six to give the energiser's output directly in volts. Say you get a pulse amplitude of 4½ divisions on the CRO. The energiser's output is 4.5 x 200 x 6 = 5400 volts.

Note the polarity of the pulse. Generally, it will be positive-going. However, some energisers give a negative-going pulse. If such is the case, you'll need to reverse the energiser output leads for the next step.

This time, connect the oscilloscope across C3. (Don't use a x1 probe or you'll upset the C3-R15 time constant.) Set the Y-input to read, say, 1 V/div. on the screen (taking the probe division into account). Turn on the energiser and adjust RV1 so that the peak pulse voltage on the screen is 1000th that previously determined. If the energiser output was determined to be 5400 volts, then the peak pulse amplitude across C3 should be 5.4 volts when RV1 is correctly adjusted.

The unit is now calibrated and ready to use.

In use

When using the Fence Tester, *always* remember to *connect the ground probe first.* You can use a pointed metal stake to drive into the ground or a large, strong alligator clip to get a good 'bite' on the star pickets often used to support elecric fences. Touch the fence probe on one of the 'live' fence wires and then press the pushbutton. Keep your hands and the Tester dry and keep your big fat pinkies away from the top end of the box.

You will find that the voltage on the fence will be highest closest to the energiser, decreasing the further down the fence you move from the energiser end. If the fence is 'shorting to ground' somewhere, then the voltage will fall off rapidly as you approach the fault. If the live wire is open (i.e: broken) at some point, the voltage will remain high within the vicinity of the break, but disappear on the side of the break away from the energiser.

To be effective, the fence voltage should be generally no lower than 3 kV at its distant end. ●

BATTERY CHOICE

As this project will probably experience considerable periods of idleness, a battery having a long shelf life is recommended. Alkaline batteries have by far the longest shelf life, being about two years, and are thus recommended. Standard carbon-zinc batteries have a shelf life somewhat less than half that of Alkaline types and would need replacing at six to eight month intervals — if you could remember!

Artwork. Full size reproductions of panel and pc board artwork.