Keep the cows out of the cabbages with this

ELECTRIC FENCE

Mains or battery powered, this electric fence controller is both inexpensive and versatile. Based on an automotive ignition coil, it should prove an adequate deterrent to all manner of livestock. Additionally, its operation conforms to the relevant clauses of Australian Standard 3129.

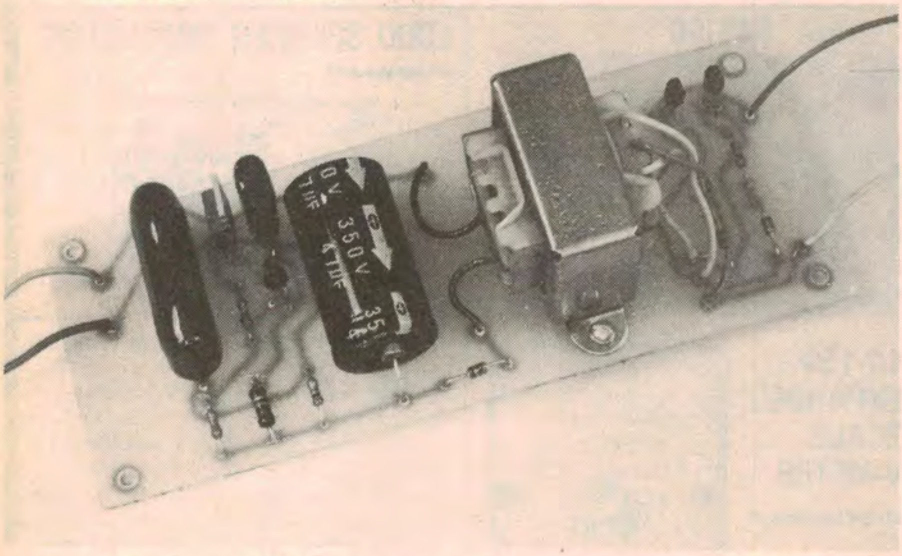
by COLIN DAWSON

Over the past few years we have received a steady stream of requests to describe an electric fence controller, plus a number of contributions to our "Circuit and Design Ideas" section describing such controllers. For a number of reasons – including legal ones, which we will deal with shortly – we have hesitated to publish these contributions, or offer a design of our own.

More recently, we received a CDI contribution from Mr R. Graham of Gerringong, NSW, describing a mains powered electric fence controller which he felt would interest our readers. Prompted by Mr Graham's suggestion, we took another look at the whole electric fence situation – including technical standards and legal obligations – and decided to publish a design, based partly on Mr Graham's, but modified to make it suitable for either battery or mains operation, and checked to ensure that it comes within safety specifications.

Most readers will probably be aware of the broad concept of an electric fence. The power supply, or controller, is designed to apply a short high voltage impulse, at regular intervals, to a single bare wire supported by insulators on either existing fence posts or on temporary stakes driven into the ground. This type of deterrent is remarkably effective against even the most stubborn "fence breaking " animals and the fact that a temporary fence can be so effective is a very valuable aid to farmers wishing to control the grazing of their stock.

By far the most important single aspect of electric fence design and application is that of safety; there is not much point in producing an effective fencing system if it carries a risk of killing or injuring either human beings or the animals it is intended to merely control. We cannot emphasise too strongly the need for extreme care and commonsense in all matters concerning electric fences.



The control circuit is built on a PC board and can be used with any standard automotive ignition coil. Unit can be either mains or battery operated.

The safety aspect, and with it the legal responsibilities, can be best presented as two broad categories; the technical specifications of the equipment, which are designed to minimise any risk of injury in the event of accidental contact, and the application constraints and precautions which should be exercised to minimise the risk of accidental contact in the first place.

Design considerations

The technical aspect is really the simpler of the two, because adequate and quite stringent specifications have been laid down by the Standards Association of Australia as AS3129. These specifications are derived from the broad concept that regular short duration pulses are quite effective as an animal deterrent, but do not constitute the danger inherent in a continously energised wire.

But this is not enough in itself. How long should these pulses be? How often should they occur? At what voltage and with what current capability? These, and similar questions, need to be answered specifically and this is the purpose of AS3129.

In detail, it sets out the following

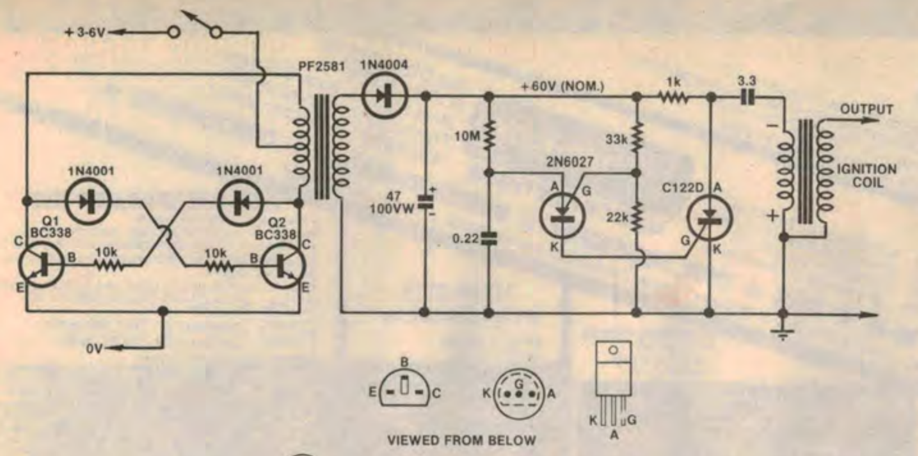


Fig. 1 ELECTRIC FENCE CONTROLLER 3/MS/-

The circuit diagram for the Electric Fence Controller. Note that the +60V rail is obtained with +6V into the inverter (with the PUT operating), and the ignition coil connected.

PARTS LIST

1 Printed circuit board, code 82ef9, 163 × 65mm
1 Transformer, 240V/12V centre tapped (PF2851 or equiv.)
1 Automotive ignition coil (see text)
1 Box to suit plus batteries as required

SEMICONDUCTORS
1 C122D silicon controlled rectifier (SCR)
1 2N6027 programmable unijunction transistor (PUT)
2 BC338 NPN transistors
1 1N4004 diode
2 1N4001 diodes

CAPACITORS
1 47μF/100VW electrolytic
1 3.3μF metallised polyester (greencap)
1 0.22μF greencap

RESISTORS (¼W, 5%)
1 × 10MΩ, 1 × 33kΩ, 1 × 22kΩ, 2 × 10kΩ, 1 × 1kΩ

MISCELLANEOUS
Copper-cored automotive ignition cable, screws, nuts, hook-up wire, insulators for fence, etc.
NOTE: components with ratings higher than specified may be used, provided they are physically compatible.

specifications and limits. The maximum output voltage, with a load impedence of 1MΩ, is 5kV. The pulse width must not exceed 0.1s, with a repetition rate of not less that 0.75s. Output current must not exceed 300mA for more than 0.3ms with a 500Ω load; current between pulses – not to exceed 0.7mA RMS with a 500Ω load; quantity of electricity – not to exceed 2.5mC with a 500Ω load. There are numerous other clauses relating to mechanical strength and accessibility of live parts, which would need to be consulted in order to build a unit to S.A.A. standards.

The unit which we are about to describe comes well within all these limits. For example, the voltage across a 1MΩ load is around 2.5kV, the pulse length is a mere 3ms, and other values are similarly conservative. Yet is can still deliver quite a jolt, as two incautious EA staff members can confirm!

The second safety aspect, the manner in which the device is used, is not quite so easily defined, but must be considered nevertheless. First, it should be realised that these devices are intended for use in rural areas where they will usually be set up well within the boundaries of private property and well away from public access. Even so, if there is a risk that members of the public may come in contact with it, AS3129 specifies that signs bearing the words "ELECTRIC FENCE" in letters not less that 50mm high, should be erected every 90m or less.

In no circumstances, for any reason whatsoever, should these devices be set up within the ordinary suburban domestic block. The risk of accidental contact, particularly by small children, is so much greater, that the possibility of injury becomes very real. It is not so much the actual shock which may be the danger, but rather the possibility of sometimes violent physical reaction which may injure either the victim, or someone standing nearby.

Significantly, some shire councils have banned the use of electric fences completely within their area and, equally significantly, some insurance companies have stated that injury incurred by reason of an electric fence would not be covered by household liability insurance.

So much, then, for the legal and technical constraints which need to be observed in any operation involving an electric fence. Having clarified those aspects, let us look at the practical design.

Mains or battery power?

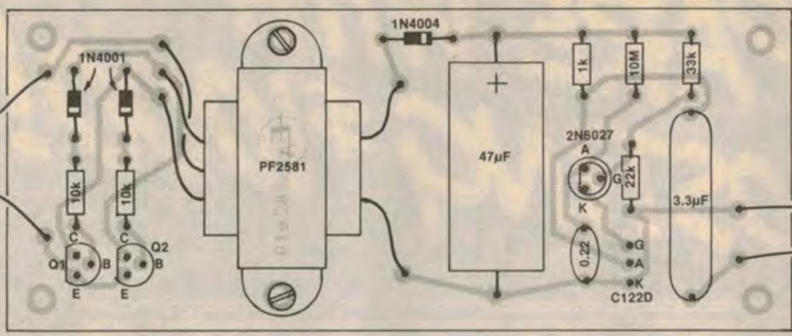
One of the first points to be decided in such a design is the source of power; batteries or mains. In some locations one may have little choice – mains power may simply not be available. It is one thing to have mains power at the homestead, but quite another at the other end of a 40 acre paddock. (Err, sorry; 16.19 hectare paddock.)

In such cases, battery power is the only answer, even though it is more expensive and usually less convenient. Then again, there is the question of which battery type to use. In the event, we decided to cater for all situations. Our controller can be built as a mains only device, a battery only device, or a combination unit which can be powered by either source, simply by connection to the appropriate leads. It can also operate from a range of battery types.

More exactly, we are describing a battery operated version as the basic unit, with the mains transformer as an "add-on" concept. Even if mains power is envisaged at the moment, we imagine a lot of readers would want to include the battery power supply anyway. It costs only about $5.00 extra and greatly improves the versatility of the unit.

Battery operation is via an inverter which consists of a conventional free running multivibrator driving a 12V centre-tapped transformer. In this case, what is normally the secondary of the transformer is driven so that it has a step-up action. Each half of the centre-tapped winding provides the collector load for a BC338 NPN transistor. The base of each transistor is cross connected to the collector of the other via a 10kΩ resistor and a diode. Due to slight differences in the transistors' operating characteristics and in the impedances of the transformer primary windings, one side of the multivibrator is activated first when power is applied.

As one transistor switches on – let us say Q1 – there is a rapid increase in current through the associated primary winding. This increase in current, by transformer action, produces a stepped up positive voltage at the Q2 collector end of the winding and this voltage is applied to the base of Q1 to turn it on still harder. Eventually, due to magnetic saturation and other factors, the current ceases to rise, transformer action ceases, Q1 is no longer biased on and it switches off. When this happens the collector



Parts overlay diagram for the control circuit. For mains-powered operation, delete the inverter circuit and substitute a 240V/12V transformer (see text).

voltage of Q1 rises and biases on the base of Q2. Current then rises in the other half of the primary winding, and the whole cycle is repeated.

These oscillations in the primary windings (at about 25kHz) cause about 60V to appear across the secondary winding. This voltage is fed to a half wave rectifier with a 47µF filter capacitor. This capacitor stores sufficient charge for a number of discharge cycles. As a result, the discharge circuitry can continue to function (with decreasing power) for some time after the power is switched off. This should not be a problem, provided that you are aware of it.

This rectified voltage charges a 3.3µF metallised polyester capacitor, via a 1kΩ resistor. This is the discharge capacitor – it cannot be an electrolytic type as they are not capable of the discharge rate required. This capacitor is connected in series with the primary of an automotive ignition coil via an SCR.

A 2N6027 programmable unijunction transistor (PUT) initiates a discharge cycle by supplying a brief pulse to the gate of the SCR. This causes the SCR to turn on, discharging the capacitor through the coil. The SCR will remain on until the discharge current falls below its "hold-on" current.

The rate at which the PUT supplies trigger pulses to the SCR depends on two factors – a reference voltage set on its own gate by the ratio of the 33kΩ and the 22kΩ resistors and the time constant of the 10MΩ resistor and the 0.22µF capacitor. When the 0.22µF capacitor – and hence the PUT's anode – reaches a voltage 0.6V higher than the reference voltage the device switches on. This allows the 0.22 µF capacitor to discharge into the gate of the SCR, thereby supplying a trigger pulse.

From the foregoing it is apparent that, to alter the trigger rate, we simply change this time constant. Increasing the value of either the 10MΩ resistor or the 0.22µF capacitor will increase the time constant, and vice versa. With the values shown the trigger rate is about 1s.

As indicated on the circuit, the inverter will operate from between three to six volts. In fact it will work quite well from two "D" size cells and could energise a small fence quite effectively in an emergency. Current consumption is quite reasonable, being a fraction under 20mA at 3V and around 45mA at 6V. (These figures as measured on our prototype.)

Even so, we don't recommend regular use from dry cells, particularly if the system has to run for long periods – 12 to 24 hours – continuously. If dry cells are contemplated for 6V operation, we suggest something like a lantern battery. Long term, a small accumulator, such as a motorcycle type, or even a set of nickel cadmium cells, "D" size, 2Ah to 4Ah, would be a much better proposition.

For mains operation the whole of the inverter circuit up to, but not including, the 1N4004 diode may be omitted. In its place we use a small power transformer delivering about 40V to the diode. This transformer must meet the relevant clauses of Australian Standard C126 and the Ferguson PL40/20VA is the recommended choice. The few simple connections are shown in Fig 2, the active side of the transformer secondary going to the 1N4004 diode.

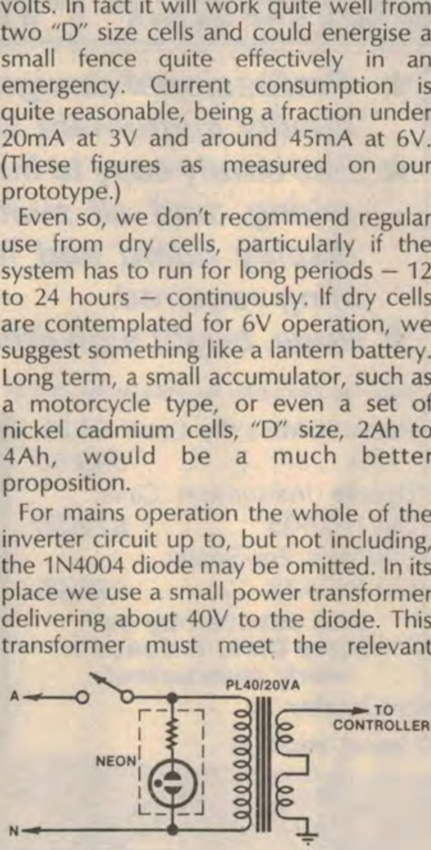


Fig. 2

Fig. 2: This simple circuit lets you power the controller from the mains.

> We estimate the current cost of components for this project to be approximately
>
> **$15**
>
> This does not include a suitable case, 40V mains transformer or ignition coil.

To make a combined battery/mains unit, simply fit a second diode between the transformer secondary lead and the positive terminal of the 47µ capacitor. Each diode will then effectively isolate each power supply from the other, and no switching is required.

Construction

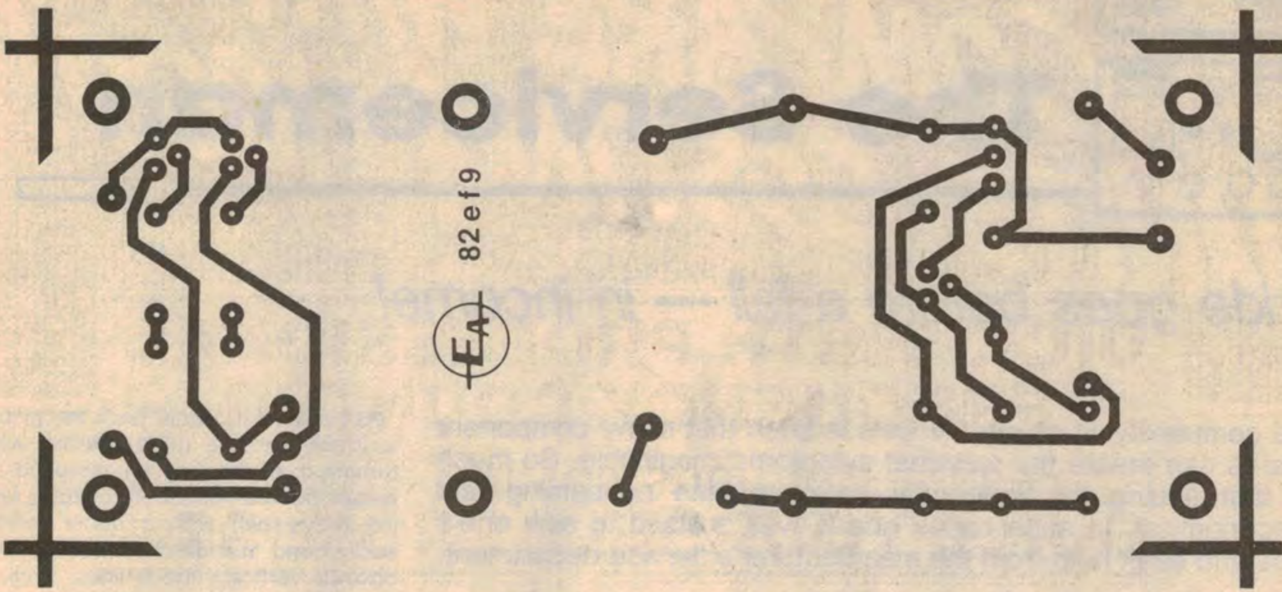
To begin construction, mount the PC board components. We are assuming that most constructors will include the inverter. If this is not the case, simply delete the inverter components, including the step-up transformer. Mount the resistors first, then – taking care with their polarity – the semiconductors. Also note the polarity of the electrolytic when mounting it. Lastly, mount the inverter transformer, fastening it with a pair of screws and nuts. To connect the PC board to the coil, use automotive type hook-up wire.

Any standard automotive ignition coil, either a 7V or 12V type, may be used. You could purchase one for less than $10 from K-mart stores or pick up a secondhand one from a wrecker's yard.

Next, it will be necessary to terminate the two high tension leads. If you can aquire a pre-terminated coil-to-distributor lead, this should prove ideal for the coil output. Otherwise, it will be necessary to fit a boot type connector yourself, since the coil output terminal is not adaptable to any other type of connector. The other lead requires a lug which fits the coil earth terminal. Both leads will need a heavy duty clip fitted to their free end.

To test the unit, position the output clips about a millimetre from each other and (with your hands clear of the leads) switch the power on. Within a few seconds, a spark should jump between the clips about once every second. If the inverter is working properly, there will be 30 to 60V across the 47µF filter capacitor. A properly functioning discharge circuit will cause a faint click in the coil with each discharge. Remember that the circuit will continue to discharge for some time after the power is switched off.

A suitable box to house the project will depend on the type of power supply used. For mains powered units, it is necessary to use a metal box so that it can be effectively earthed. Note that all leads should pass through grommetted holes and be anchored inside the case. The box should be weather-proof and



Actual size artwork for the PC board. Finished boards are available from the usual retailers.

have the words "Electric Fence" clearly marked on it.

The coil is connected to the fence via the two lengths of ignition lead already mentioned. One connects the coil to the fence wire and the other connects to a metal stake driven into the soil. Ideally, solid, copper-cored lead should be used. Carbon composite (noise suppression) type leads – as used almost exclusively on modern cars – will reduce the effectiveness of the electric fence. The copper leads also have the advantage of being more robust than the composite types and are easier to terminate. You should be able to obtain this type of lead from an auto-electrician or accessory shop.

For an electric fence to be effective, it must be insulated (preferably by at least 1MΩ) from earth. This applies not only to a fence, but also to any other item which you may wish to electrify. Wet weather can be expected to significantly reduce the length of fence which can be protected, as can long grass or overhanging shrubbery.

Note that the price estimate for this project includes only the printed circuit board, and the components mounted on it, for a battery powered unit. Although an ignition coil will be needed for both mains and battery powered units, there is a wide variation in the cost of coils available. Additionally, there is a ready supply of low-cost second hand coils. When required, the 40V mains transformer should cost approximately $16. Added to these expenses will be a box to mount the project in, hook-up wire (including two high tension leads) and, where applicable, batteries.