AN ELECTRONICS AUSTRALIA PUBLICATION

EASY TO BUILD ELECTRONICS PROJECTS FOR YOUR CAR

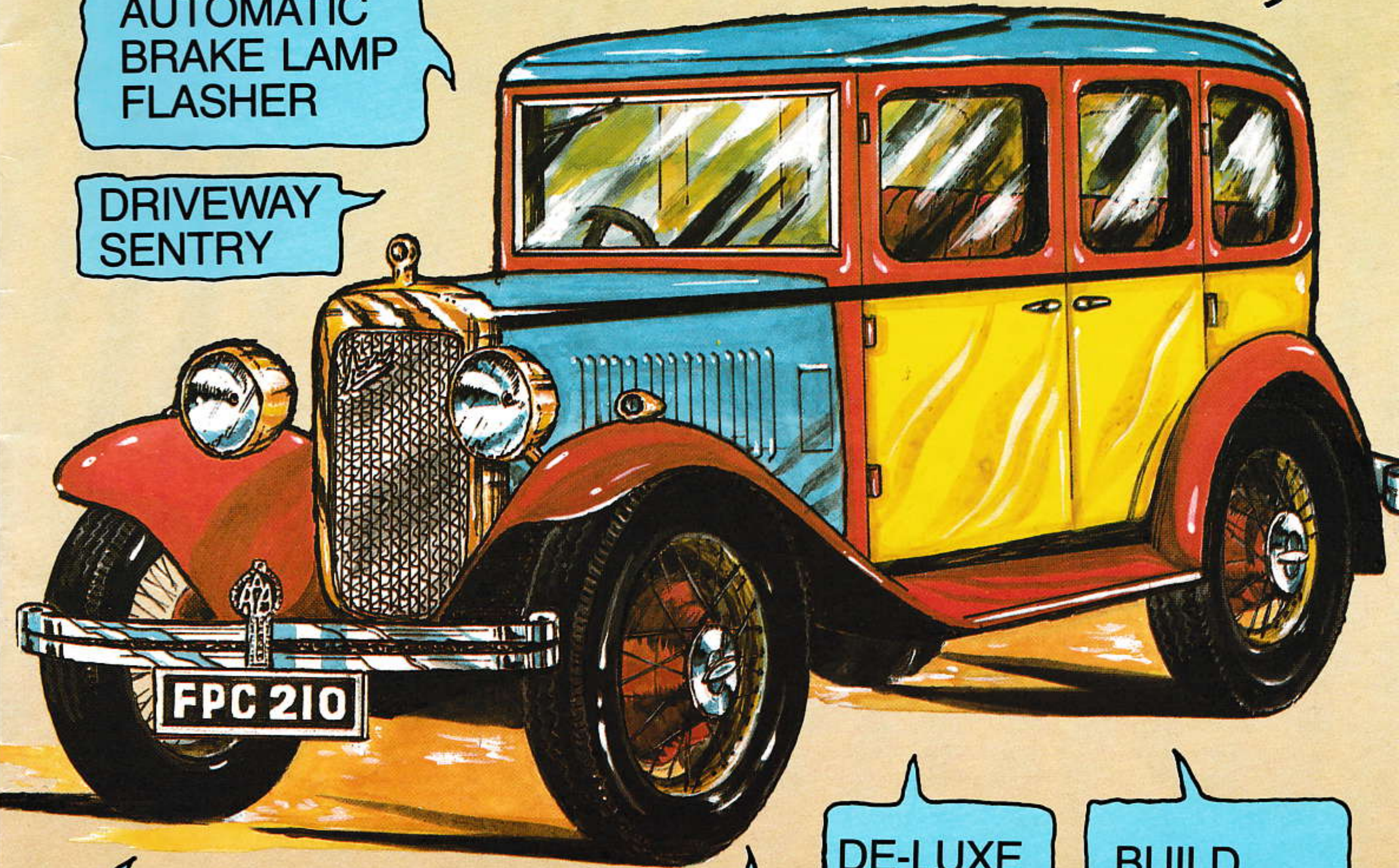
LOW FUEL WARNING INDICATOR FOR CARS

AUDIBLE REVERSING ALARM!!!

COURTESY LIGHT DELAY SYSTEM FOR CARS

AUTOMATIC BRAKE LAMP FLASHER

DRIVEWAY SENTRY



ULTRASONIC MOVEMENT DETECTOR

CAR IGNITION KILLER

DE-LUXE CAR BURGLAR ALARM

BUILD OUR REACTION TIMER

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EASY TO BUILD ELECTRONICS PROJECTS FOR YOUR CAR

NOTE: The estimated cost of parts for each project was accurate when they were originally published. However, we suggest you check current prices before starting a project.

An Electronics Australia Publication

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Keep thieves at bay: install our new

Deluxe Car Burglar Alarm

Stop your car from being stolen. This new state-of-the-art car burglar alarm features keyswitch operation, delayed entry and exit, automatic reset, and provision for an auxiliary battery.

by JOHN CLARKE and GREG SWAIN

We shouldn't really have to sell you on the concept of a car burglar alarm. Car theft is a growth industry in Australia, with more than 70,000 cars stolen last year. Small wonder that the Ignition Killer featured on page 16 has proven so popular — it provides a useful measure of protection at relatively low cost.

But the Ignition Killer does have drawbacks. It will not protect stereo equipment or other contents in the car, nor does it have an alarm to frighten the thief away. And while it will fool most joyriders, it will not stop a determined "professional" for too long.

By contrast, a properly designed and fitted car burglar alarm provides "front line" defence. It will sound an alarm if an attempt is made to gain access to the vehicle and this by itself is usually sufficient to deter the thief. Common practice is to add to the deterrent effect by fitting the vehicle with prominent warning stickers and a flashing dash panel lamp.

When we described the Ignition Killer project, we were quick to point out the drawbacks of many commercial car burglar alarms. In particular, we pointed out that many could be disabled simply by cutting the horn wires from underneath the vehicle or by disconnecting the battery.

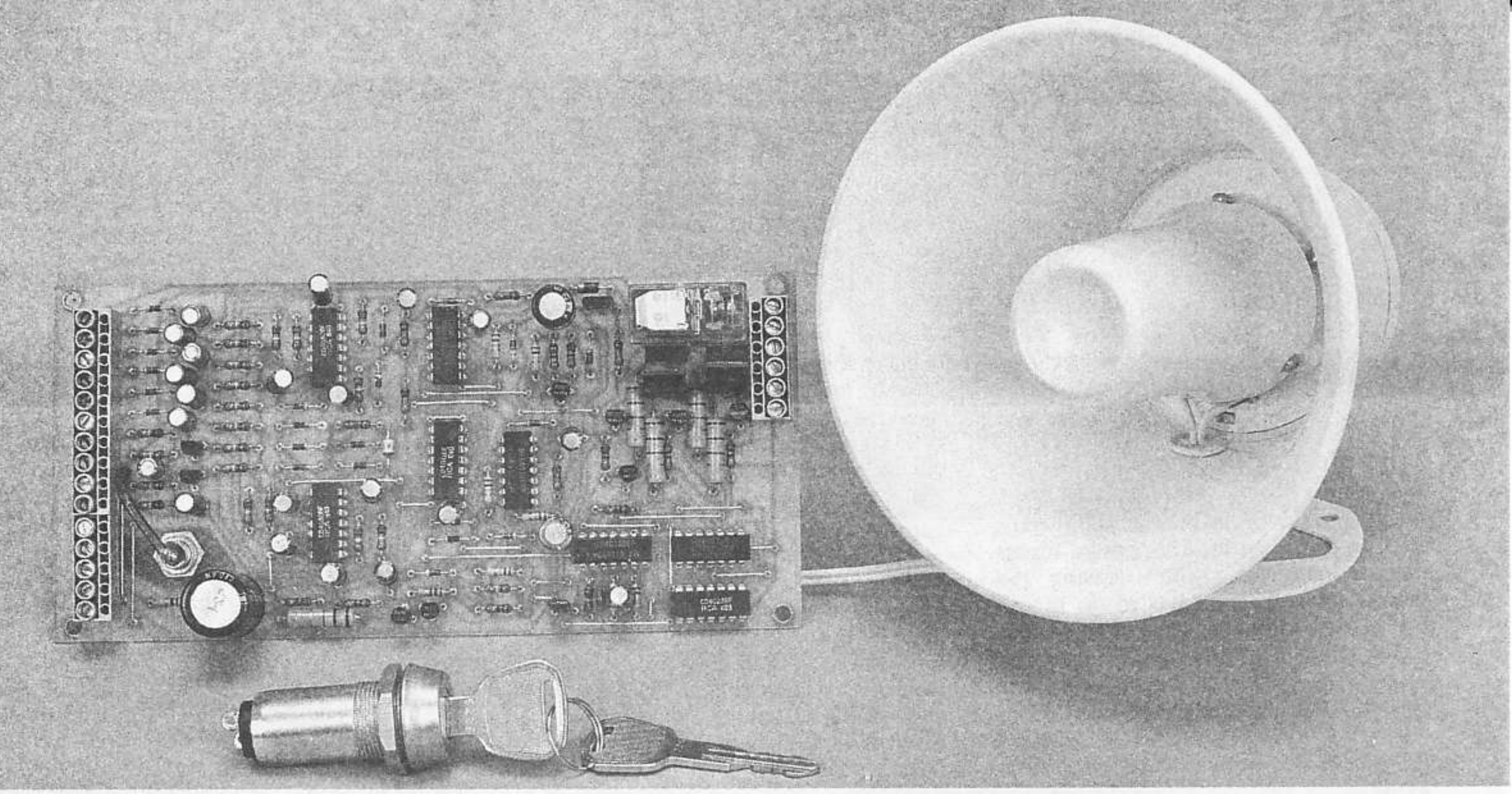
For sure, it's possible to install commercial alarms that will frustrate all but the most professional thief. The trouble is, they usually cost an arm and a leg. Most sell for between $200 and $400 fitted although there are units that you install yourself for around the $100 mark.

The unit described here will set you back no more than about $70 but that's not to say that it's a cheap and nasty design. On the contrary. It includes a range of features normally found only on expensive commercial units and has a few more tricks besides.

Ten commandments

What features should be included to produce an effective car burglar alarm? In the "Open Road" for December 1983, the NRMA briefly surveyed a number of commercial units and gave a list of "Ten commandments". Let's take a look at these:

1. The alarm should protect all doors, bonnet and boot at least.
2. It should operate instantly when the boot is opened and when the bonnet lock is released.
3. Air horns or a siren should be used, rather than the car's horn.
4. The alarm should be set from inside the vehicle or by an electronic key – not by a key or tumbler switch from outside the vehicle.
5. Entry delay should be between five and 10 seconds.
6. The alarm should cut out the ignition system.
7. If the alarm obtains its power from the battery, the wiring should be direct



and should be positioned so that it cannot be reached from under the vehicle.

8. Horns or sirens, and the wiring to them, should be placed so that they cannot be tampered with through the grille or from under the vehicle.

9. The alarm duration should be about two minutes, with automatic cut-out and reset.

10. Window stickers should indicate that the vehicle is carrying an alarm system, but not the make or type.

The NRMA survey covered some 27 different alarm systems. Of these, the best units only complied with the first eight conditions.

By contrast, this new EA design can meet all the above requirements except for the sixth. We'll have more to say about that later. Other features include a flashing dash panel lamp, keyswitch operation, an auxiliary battery (optional), and provision for tow-away protection. It can protect external driving lights and will instantly trigger if the ignition is switched on or if the leads to the car's battery are cut (provided, of course, that an auxiliary battery is fitted).

Inputs and options

The key to the versatility of this alarm is that the inputs are designed to detect a change of state. It does not matter whether an input is normally pulled low or tied high, or whether the input is open circuit. If there is any change on the input (ie, from 0V to +12V or vice versa), the alarm will trigger.

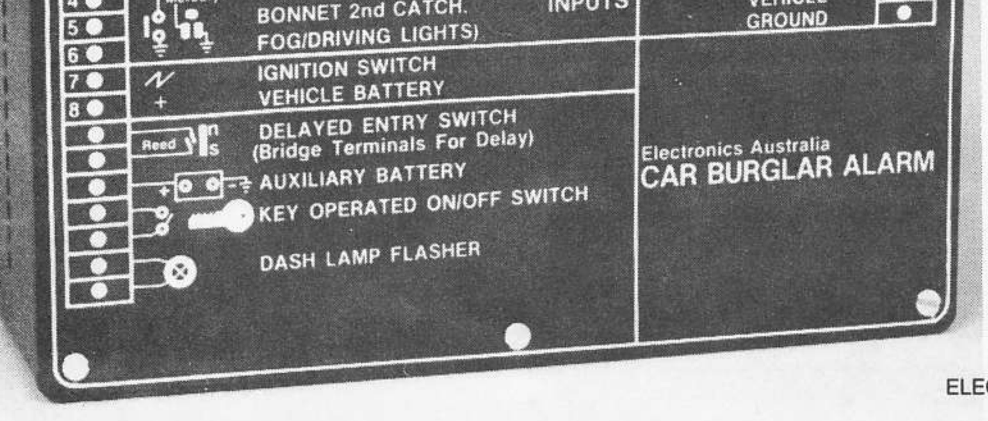
There are eight inputs in all, two providing 10-second delayed triggering and six providing instantaneous triggering. The delayed inputs monitor the doors and an optional ultrasonic movement detector (to be described later), while the six instant inputs monitor the boot, bonnet, external driving lights, ignition system and the vehicle battery.

When triggered, the alarm drives a separate horn-type loudspeaker for a period of two minutes and causes the hazard lights to flash on and off. At the end of the two minute alarm period, the unit automatically resets and rearms itself.

Several different techniques are used to trigger the alarm. The doors are protected by monitoring the courtesy light switches, the bonnet by fitting a spring-loaded switch adjacent to the bonnet catch, and the boot by fitting a mercury switch to the bootlid (a measure that also provides protection against tow-away). The ignition and battery inputs simply detect the presence or absence of voltage, while the driving lights are protected by monitoring the filaments.

There are other options. For example, some readers may prefer to forget about tow-away protection and monitor the bootlid by making a connection to the switched side of the bootlight. Other readers might prefer to protect the bonnet using a reed switch and magnet assembly. It's really up to the individual as to just how inputs 1-6 are used.

Below is the prototype alarm, ready for installation.



Deluxe Car Burglar Alarm

What about the ignition cutout requirement referred to earlier? While we did not fit this feature directly to our car burglar alarm, we do recommend that readers also install the Ignition Killer. In fact, we believe this to be a far better scheme since the Ignition Killer can act independently as a last line of defence should the alarm be disabled.

Easy operation

While it's nice to have a lot of fancy features, a good car burglar alarm must also be easy to use. This design meets that requirement. When leaving the vehicle, all the driver has to do is turn the alarm on using the key operated on/off switch. He then has 10 seconds to leave the vehicle during which time the dash panel lamp remains fully lit to indicate that all inputs are disabled.

At the end of the exit period, the dash panel lamp flashes to indicate that the alarm is armed.

Entering the vehicle is just as easy – for the driver, that is – although we have included a rather clever "wrinkle" in the delayed entry input circuitry. Essentially, the reader has two options.

The first option is to bridge two terminals on the alarm to provide for normal delayed entry. This gives the driver 10 seconds to open the car door and switch off the alarm. As before, the dash panel lamp remains fully lit during this procedure.

The second option is to fit a reed switch across the two terminals instead of linking them. The delay circuitry will now operate only if the reed switch is momentarily closed. If the switch is not closed, the alarm will trigger instantly when the car door is opened.

In practice, the reed switch can be glued to the inside of the windscreen immediately adjacent to the pillar or the dashboard. Or it could be hidden in the external mirror surround or some other suitable location. To enter the car, the driver simply uses a small magnet to momentarily close the reed switch. He then has 10 seconds to open the car door and switch off the alarm as before.

How it works

At first glance, the circuit may seem quite complicated, comprising as it does eight CMOS ICs, 14 transistors, 25 diodes and associated components. But while there may seem to be quite a few components, the circuit can be simplified by breaking it down into six basic sections: input circuitry, alarm timer, delayed exit timer, delayed entry timer, dash lamp flasher, and horn speaker driver circuitry.

The action starts with the eight inputs at the lefthand side of the circuit. As can be seen, these all have a fairly similar circuit configuration with each input circuit built around an exclusive-OR gate, or XOR gate for short.

Basically, the output of an XOR gate is high only when one input is high and the other is low, and is low otherwise. We have used this characteristic to derive a positive-going pulse whenever there is a change in the input state.

To achieve this, one input of each XOR gate is connected to the other input via an RC delay circuit consisting of a 100kΩ resistor and a 10μF capacitor. Thus, when the input signal changes state, one input of the XOR gate changes state immediately while the other is delayed from making this change until the 10μF capacitor charges to about 8V. The result is a positive-going 100ms output pulse.

Note that some of the 10μF capacitors are tied to the positive supply rail while the remainder are tied to ground. This was done to simplify the printed circuit board (PCB) layout and in no way alters the operation of the circuit.

Inputs 1-6 are all tied to the +12V rail via 100kΩ pullup resistors, while the 1μF capacitors provide decoupling to prevent false triggering. Normally, the trigger switches are open circuit and inputs 1-4 are held high. If a switch closes (as when a door is opened), the input is pulled low and the corresponding XOR gate produces a 100ms pulse.

Inputs 5 and 6 function in similar manner except that they are normally held low by the driving light filaments and are pulled high if the ground connection is broken. The corresponding XOR gate then produces a 100ms pulse as before. Diodes D1-D6 prevent damage to the XOR gates in the event that a positive voltage higher than their own supply is applied to the inputs.

Voltage sensing inputs 7 and 8 use transistors Q1 and Q2 to switch the inputs of XOR gates IC2d and IC2b between the high and low states. In the case of the ignition input (7), Q1 is normally off and the inputs to IC2d are high. When the ignition is switched on, Q1 turns on and pulls the input signal to IC2d low.

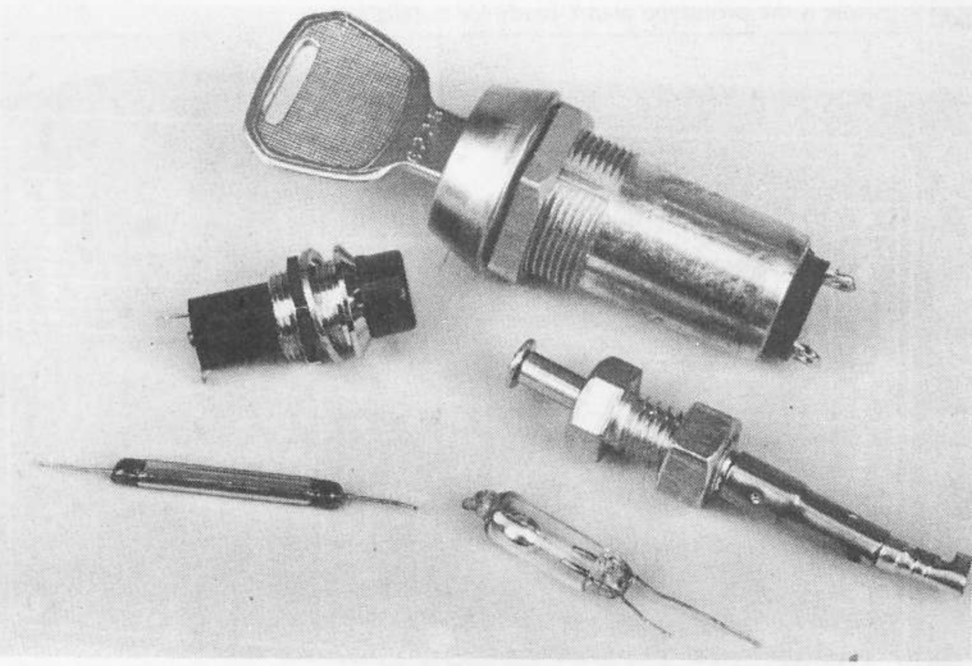
Q2 works in reverse fashion. It is normally biased on by the battery voltage but turns off if the battery leads are cut.

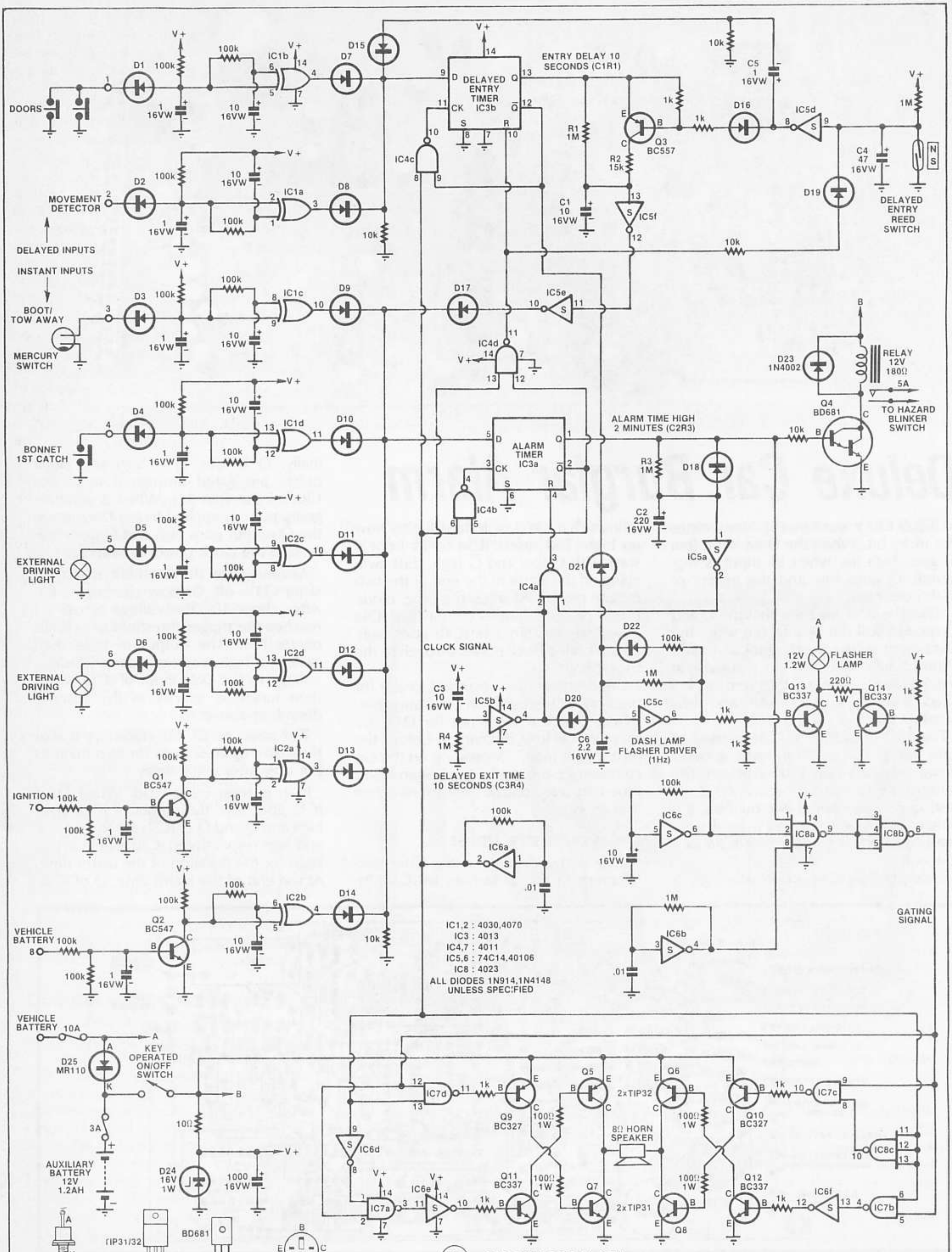
The outputs of IC1a and IC1b are fed to diode OR gate D7 and D8, and then applied to the data input of D-type flipflop IC3b. Likewise, the outputs IC1c-IC2d are connected to the data input of IC3a via diodes D9-D14. Note that both data inputs are normally tied low via a 10kΩ resistor.

Here's how this circuitry works. A D-type flipflop has two complementary outputs designated Q and $\overline{Q}$. When the Reset input is low, the Q output will follow the Data input at the positive edge of the clock waveform. In other words, if the Data input goes high, the Q output will also go high when the next positive going clock pulse is received.

IC3a is the alarm timer. Its clock signal is gated by IC4b which has its pin 5 input connected to $\overline{Q}$. Thus, when $\overline{Q}$ is high, IC4b inverts the clock signal and passes it

Alarm accessories (clockwise from top): barrel-type keyswitch, spring-loaded automotive switch, mercury switch, reed switch and bezel lamp.





CAR BURGLAR ALARM

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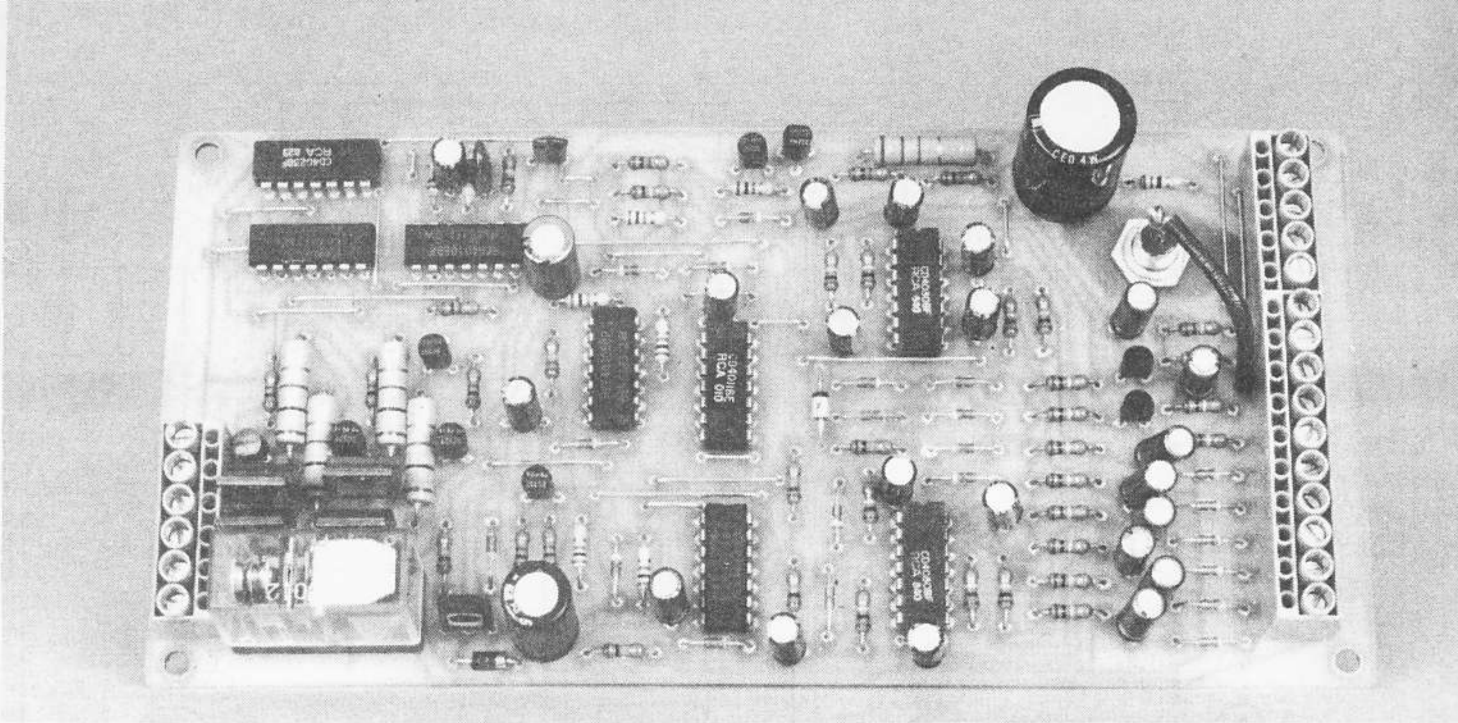

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to IC3a's Clock input (pin 3). Now comes the tricky bit. When the Data input (pin 5) goes high (ie, when an input is triggered), $\overline{Q}$ goes low and the output of IC4b goes high.

What this now means is that the Q and $\overline{Q}$ outputs will not be affected when the Data input subsequently goes low after 100ms, since no further clock pulses can reach IC3a. The flipflop thus remains latched with Q and $\overline{Q}$ high and low respectively.

The high Q output of IC3a is used to gate on (via IC8a) the horn speaker driver circuit to sound the alarm. At the same time, it charges capacitor C2 via resistor R3. After about two minutes, the voltage across C2 reaches a level sufficient to switch Schmitt trigger IC5a to a low output.

Since pin 2 of IC4a is normally high, it follows that pin 3 of IC4a will also now go high. This resets IC3a to its normal state with Q low and $\overline{Q}$ high, thus switching off the alarm at the end of the two minute period. At the same time, diode D18 rapidly discharges C2, pin 3 of IC4a goes low, and pin 5 of IC4b goes high, thus allowing clock pulses through to the Clock input.

The circuit is now re-armed, ready for the next 100ms pulse on the Data input.

Note that if it were not for D18, C2 may not be fully discharged before the next trigger input. Depending on the circumstances, this could result in an alarm time that was considerably shorter than two minutes.

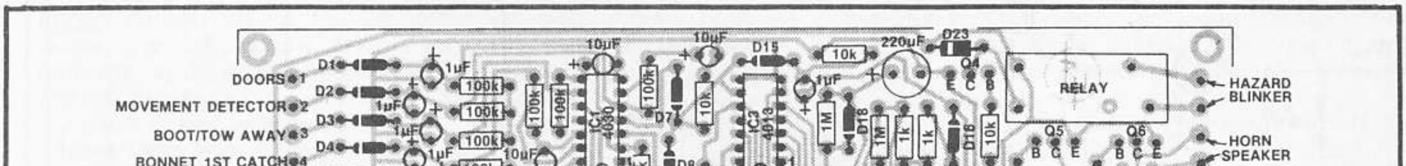
Delayed entry timer

IC3b is the delayed entry timer and functions in similar fashion to IC3a. Initially, Q is low, $\overline{Q}$ is high and clock pulses are gated through IC4c to the Clock input (pin 11). When a positive-going pulse is applied to the Data input, the Q output goes high and $\overline{Q}$ goes low to stop the clock pulses as above.

Assuming for the moment that transistor Q3 is off, C1 now charges via R1. After about 10s, the voltage across C1 reaches the trigger threshold of Schmitt trigger IC5f. The output of IC5e then switches high and applies a positive voltage to the Data input of IC3a which then functions exactly in the manner described above.

The result of all this chicanery is that the alarm again sounds for two minutes but only after a 10s delay.

IC3b is reset using IC4d. When $\overline{Q}$ of IC3a goes low, the output of IC4d goes high and Q and $\overline{Q}$ of IC3b are forced low and high respectively. IC3b is held in this state for the duration of the alarm time. At the end of the alarm time, $\overline{Q}$ of IC3a



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switches high again and the output of IC4d goes low. IC3b is now re-armed and ready to accept the next input to its Data pin.

If that's all a bit too much for you, consider it this way. The delayed entry inputs trigger IC3b which in turn triggers IC3a after a 10s delay. During the following two-minute alarm period, IC3b is held in the reset state by IC4d and the $\overline{Q}$ output of IC3a. Finally, at the end of the alarm period, both Reset inputs go low and the alarm is re-armed ready for the next trigger input.

Delayed entry switch

So much for the basic operation of the delayed entry timer. But just when you think you've got it all figured out, we now inject a complicating factor: the delayed entry switch circuit. This comprises C4, IC5d, Q3 and associated components.

Let's first assume that the switch contacts are shorted to provide for normal delayed entry. It follows that the output of IC5d will be high and thus transistor Q3 will be off. In this case, the delayed entry timer functions exactly as described above to provide a 10s entry delay.

Now suppose that we substitute a normally open reed switch as shown on the circuit diagram. Furthermore, let's initially assume that the reed switch is left open circuit. The delayed entry switch circuit now comes into play. Here's how it works.

When power is first applied, the Reset input of IC3b goes high for 10s (we'll explain why later) and quickly charges C4 to +12V via the 10kΩ resistor and D19. Thus, the output of IC5d goes low. Now when the Q output of IC3b goes high, Q3 is biased on and charges C1 via R2.

We estimate that the cost of parts for this project is approximately

$70

This includes the horn speaker but not the cost of an auxiliary battery or extra switches.

We've now got a whole new ballgame. Whereas it previously took 10s for C1 to charge via R1 (1MΩ), it now only takes about 150ms to charge via Q3 and R2 (15kΩ). So, as far as the thief is concerned, the alarm triggers instantly if a door is opened.

The 10s entry delay can be activated by momentarily closing the reed switch. This action rapidly discharges C4, forcing the output of IC5d high and turning Q3 off. C1 can now charge only via R1 and so the 10s delay is restored.

But that's not the end to the electronic skullduggery. When the output of IC5d switches high, a short positive-going pulse is applied to the Data input of IC3b via C5 and D15. This triggers the delayed entry timer which means that the alarm will sound 10s after the reed switch is closed.

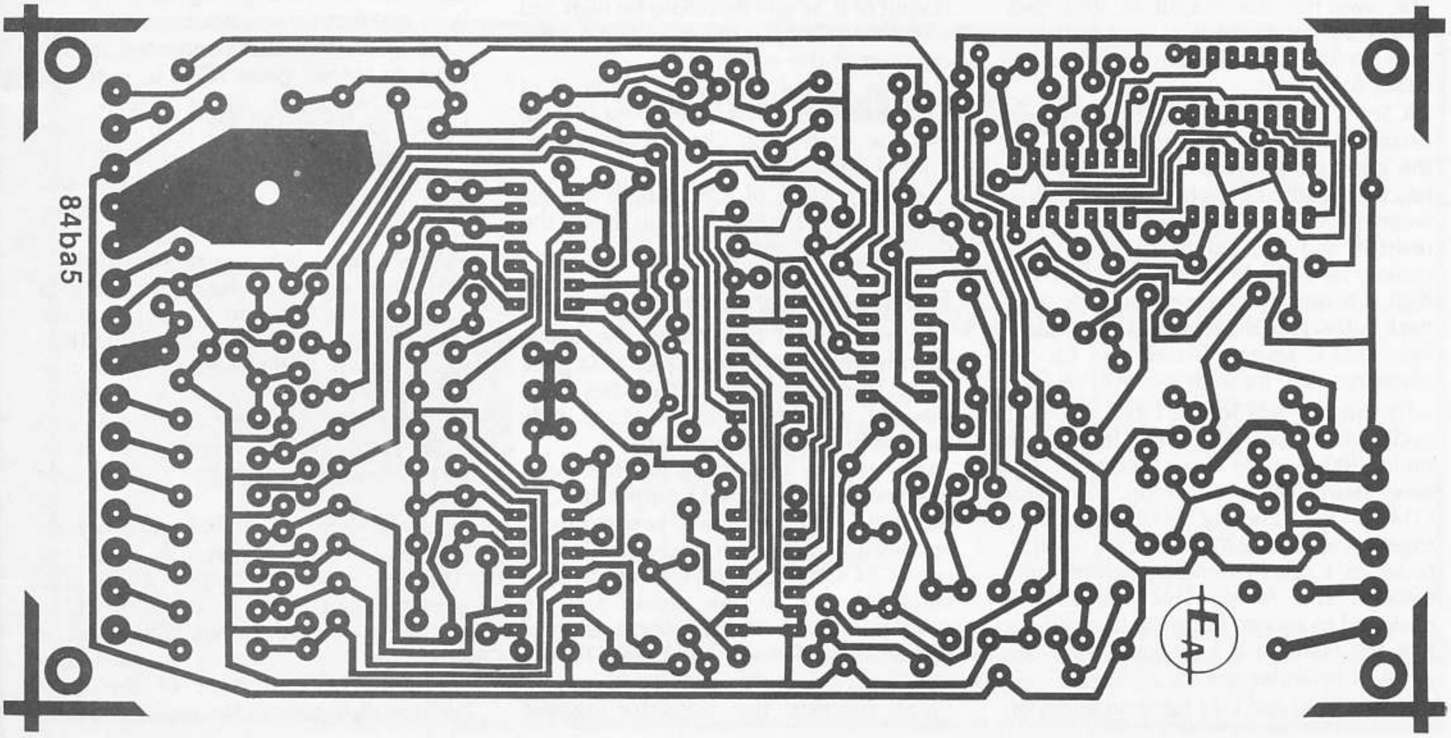
So it doesn't matter whether or not a door is opened after the reed switch is closed. The alarm will still sound after a 10s delay (unless, of course, the driver enters the car and switches the alarm off).

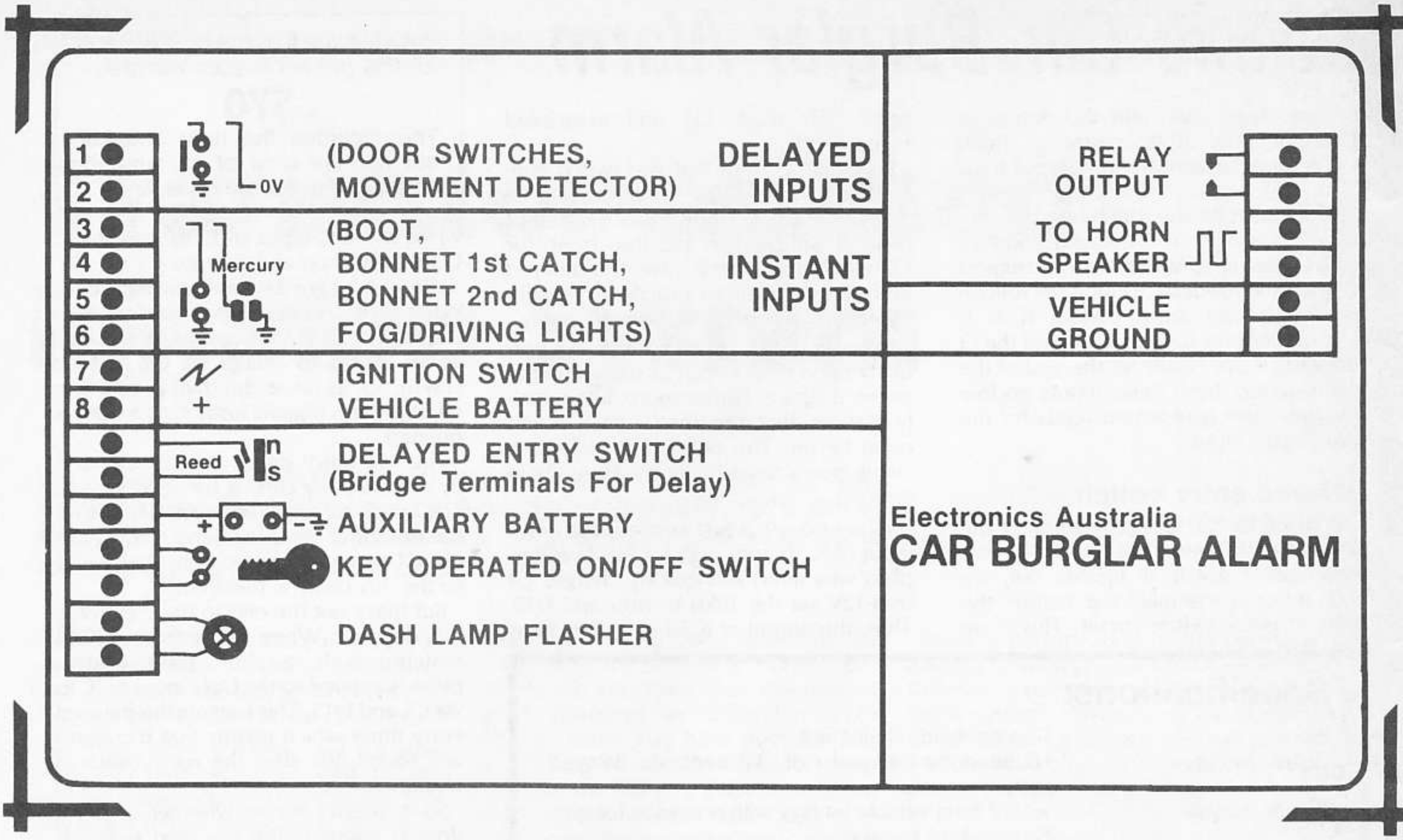
Delayed exit timer

Schmitt trigger IC5b forms the delayed exit timer. When power is first applied, C3 pulls pin 3 high and the output (pin 4)

Specifications:

Inputs	Two delayed, six instant
Delay times	10 seconds delayed exit, 10 seconds delayed entry
Power supply	+12V from vehicle battery with provision for auxiliary battery backup
Alarm time	Two minutes with automatic re-arming at end of alarm time
Alarm output	1kHz tone modulated at 100Hz and 1Hz driving an 8Ω horn speaker
Current consumption	13mA standby mode, 500mA when alarm is triggered
Miscellaneous	Flashing dash panel lamp, key-operated on/off switch, provision for tow-away protection





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goes low. Pin 2 of IC4 and pin 13 of IC4d are thus also pulled low, which means that the Reset inputs of IC3a and IC3b are held high.

C3 now charges via R4 and, after about 10s, switches the output of IC5b low. The Reset inputs of IC3a and IC3b also now go low and the alarm is armed and ready for action.

IC5c is wired as a Schmitt trigger oscillator and drives transistor Q13 and the dash panel lamp. Notice that IC5c has two feedback paths connected between pins 5 and 6: one via the 1MΩ resistor and the other via the 100kΩ resistor and diode D22. When pin 6 is high, C6 quickly charges via both feedback paths. However, when the output is low, D22 is reverse biased and C6 can discharge only through the 1MΩ resistor.

The output of IC5c thus has a 1:10 duty cycle which means that the lamp turns on for 100ms once every second (ie, the lamp flashes at a 1Hz rate). Transistor Q14 is permanently biased on and, together with its 220Ω collector resistor, provides a 50mA standing current path through the lamp. This measure is designed to extend lamp life by ensuring that the filament is kept just above the point of incandescence.

Diodes D20 and D21 have no effect on the circuit except during the delayed entry and exit times. During the delayed exit time, for example, the output of IC5b is low and thus pin 5 of IC5c is held low by D20 which is now forward biased. The output of IC5c will therefore be high and so the dash lamp remains fully lit for the duration of the exit time.

At the end of the exit time, pin 4 of IC5b goes high, D20 is reversed biased, and the dash lamp circuit commences normal operation.

Similarly, pin 5 of IC5c is held low via D21 and the $\overline{Q}$ output of IC3b during the delayed entry time.

Horn speaker driver

As mentioned previously, the alarm sounds when the Q output of IC3a goes high. The horn driver circuit has been devised so that it draws very little current in the quiescent state.

Let's assume that the alarm has been triggered and that the Q output of IC3a has gone high. This does two things: it applies a gating signal to 3-input NAND gate IC8a and it turns on Darlington transistor Q4. Q4, in turn, drives a single pole relay with output contacts connected in parallel with the hazard flasher switch.

D23 protects the transistor against back EMF from the coil when the relay turns off.

The remaining two inputs of IC8a are connected to the outputs of Schmitt trigger oscillators IC6b and IC6c. The first oscillator operates at about 100Hz while the latter has a nominal output of 1Hz. When Q of IC3a is high, their outputs are gated through to the output of inverter IC8b and form the gating signal for the horn speaker driver circuit.

This gating signal is connected to one input of NAND gates IC7a, b, c and d. When the gating signal is low, the NAND gate outputs are high and transistors Q7, Q8, Q9 and Q10 are off. IC6e and IC6f invert the outputs of IC7a and IC7b, and so Q5, Q6, Q11 and Q12 are also off.

When the gating signal goes high, a 1kHz tone signal for the horn speaker is gated through to the transistor driver stages by the IC7 NAND gates. This 1kHz tone signal is generated by Schmitt trigger oscillator IC6a which, incidentally, also provides clock signals for IC3a and IC3b. Note that the 1kHz signal is inverted before it is applied to IC7a and IC7c.

The transistor driver stage operates in push-pull mode. When the output of IC6a goes high, the output of IC6f also goes high and turns on transistors Q12 and Q6. At the same time, the output of IC7d goes low and turns on transistors Q9 and Q7. One side of the horn speaker thus goes to the positive supply rail while the other goes to ground.

Similarly, when the output of IC6a goes low, Q6, Q7, Q9 and Q12 all turn off and Q10, Q8, Q11 and Q5 turn on. In this manner, each side of the horn speaker is switched at a 1kHz rate from one polarity to the other.

This 1kHz tone is modulated at 100Hz by IC6b, while IC6c switches the tone on and off at a 1Hz rate (ie, on for 0.5s and off for 0.5s). The result is an ear-piercing alarm tone that's sure to attract attention.

Power supply

Power for the alarm circuit is derived from the vehicle battery and also from the optional auxiliary battery. Note that the auxiliary battery is charged via D25. This diode prevents the auxiliary battery from discharging into the vehicle battery should the latter go "flat".

Supply line decoupling is provided by a 10Ω resistor and a 1000μF capacitor, while zener diode D24 protects the circuit from voltage spikes. Short circuit protection is provided by fusing the vehicle and auxiliary battery supply lines to 10A and 3A respectively.

PARTS LIST

- *1 PCB, code 84ba5, 88 x 181mm*
- *1 plastic zippy case, 190 x 110 x 60mm*
- *1 12V single pole relay, 180Ω*
- *1 8Ω horn speaker*
- *1 Scotchcal front panel, 190 x 108mm*
- *1 10-way PCB-mounting terminal block*
- *2 6-way PCB-mounting terminal blocks*
- *1 barrel-type keyswitch*
- *1 12V bezel lamp (red)*
- *1 reed switch and magnet set*
- *4 12mm standoffs*
- *1 mercury switch*
- *1 spring-loaded automotive switch*
- *1 12V motorcycle battery, 1.2Ah capacity or greater (optional)*
- *1 3A fuse*
- *1 10A fuse*
- *2 in-line fuseholders*

Semiconductors

- *2 4011 quad 2-input NAND gates*
- *1 4013 dual D flipflop*
- *1 4023 triple 3-input NAND gate*
- *1 4030, 4070 quad 2-input XOR gate*
- *2 74C14, 40106 hex Schmitt triggers*
- *1 BC557 PNP transistor*
- *2 BC547 NPN transistors*
- *4 BC337 NPN transistors*
- *2 BC327 PNP transistors*
- *1 BD681 NPN Darlington transistor*
- *2 TIP31 NPN transistors*
- *2 TIP32 PNP transistors*
- *1 1N4002 100V diode*
- *1 MR110 10A 100V diode*
- *1 16V 1W zener diode*
- *22 1N914, 1N4148 diodes*

Capacitors

- *1 1000μF/16VW PC electrolytic*
- *1 220μF/16VW PC electrolytic*
- *1 47μF/16VW PC electrolytic*
- *11 10μF/16VW PC electrolytic*
- *1 2.2μF/16VW PC electrolytic*
- *9 1μF/16VW PC electrolytic*
- *2 .01μF metallised polyester*

Resistors *(¼W, 5% unless stated)*
6 x 1MΩ, 23 x 100kΩ, 1 x 15kΩ, 5 x 10kΩ, 10 x 1kΩ, 1 x 220Ω 1W, 4 x 100Ω 1W, 1 x 10Ω

Miscellaneous
Hookup wire, tinned copper wire, automotive connectors, machine screws and nuts, shakeproof washers, warning stickers, solder, etc.

Construction

Construction of the Car Burglar Alarm is a heck of a lot easier than understanding how it works. All the parts are mounted on a PCB coded 84ba5 (88 x 181mm) and this is housed in a plastic zippy case measuring 190 x 60 x 110mm. A Scotchcal front panel gives the unit a professional appearance as well as providing a legend for all the external wiring connections.

Begin construction by installing the 22 wire links, then mount the diodes, resistors and capacitors. Note that the diodes and electrolytic capacitors must be mounted with due regard to polarity so check your work carefully as you proceed. The diode type numbers can be gleaned from the circuit diagram.

Diode D25 is a 10A stud-mounting type and should be screwed securely to the PCB using the nut and lockwasher supplied. The anode terminal is then connected to the PCB using 1mm-thick tinned copper wire. This lead should be insulated with spaghetti tubing.

The transistors can be mounted next and should be pushed down onto the PCB as far as they will comfortably go. As with the diodes, you will have to refer to the circuit diagram for the type numbers. Make sure that you install the transistors the right way round.

External connections to the alarm are handled by PCB-mounting terminal blocks. A 6-way section is installed adjacent to the relay while 5-way and 10-way sections are mounted at the other end of the PCB adjacent to the input diodes.

Assembly of the PCB can now be completed by installing the CMOS ICs and the relay. Note that all the ICs are CMOS devices so solder the supply pins (7 and 14) first to enable the internal static protection diodes. The hazard flasher relay can be regarded as optional – if you want to save a few dollars it can be deleted from the circuit along with Q4 and D23.

Finally, the Scotchcal label can be affixed to the lid, the various holes drilled in the case, and the PCB mounted on 12mm standoffs. Use shakeproof washers under all mounting nuts, as this project will be subject to a good deal of vibration.

Testing

The test procedure is as follows:

- switch on the alarm and check that the dash panel lamp remains fully lit for 10s. Check that none of the inputs can trigger the alarm during this 10s exit time.
- check that the dash panel lamp flashes at the end of the exit time and that all inputs now instantly sound the alarm. Inputs 1-6 can be test triggered by momentarily shorting them to ground; input 7 by applying +12V to the input; and input 8 by shorting the base of Q2 to ground.
- check that the alarm sounds for about two minutes when triggered and that the relay closes.
- check that the alarm sounds after a 10s delay if the reed switch terminals are momentarily shorted.
- short the reed switch terminals permanently and check that the delayed trigger inputs sound the alarm after a 10s delay (the entry time). Check that the dash panel lamp is fully lit during the 10s delay.

Finally, make sure that you install the alarm in a professional manner. Use 10 x 0.2mm (or thicker) hookup wire for all external connections and terminate all leads in suitable connectors. In fact, it is a good idea to purchase an assortment of automotive quick connectors, bullet connectors and lugs before commencing installation.

The alarm can be mounted in any convenient location but, for most cars, the best place will be under the rear parcel shelf inside the boot. The auxiliary battery can also be mounted in the boot and should be securely clamped. Run leads to the front of the vehicle alongside existing wiring looms and don't omit the in-line supply fuses or you could get a fire in the event of a short.

The horn speaker can be mounted in the engine bay, but make sure that neither it nor the wiring to it is accessible from outside the vehicle. In fact, the effectiveness of this alarm ultimately depends on just what sort of a job you make of the installation.

Ultrasonic movement detector

for the Car Burglar Alarm

Designed to mate with the Deluxe Car Burglar Alarm on page 2, this ultrasonic movement detector provides added protection against illegal entry. It will trigger the alarm if a window is broken or if there is any movement inside the vehicle.

by JOHN CLARKE

Judging by the interest shown in the Car Burglar Alarm, this ultrasonic movement detector is sure to be popular. While the alarm, in its original form, will guard against entry via a door or interference to the ignition, it cannot protect against entry through a broken window.

It is thus possible for a thief to enter your car through a broken window and to abscond with your expensive sound system without triggering the alarm. Alternatively, having gained access, the thief could possibly disable the alarm and disappear with the vehicle. This circuit overcomes those problems.

In fact, when you think about it, an ultrasonic movement detector is an ideal add-on for a car burglar alarm. The metal and glass construction of a car means that the ultrasound is kept within the confines of the vehicle. The detector is thus unaffected by external movements and sounds.

Reference to the circuit on p.2 will show that we made provision for this latest unit by including a second delayed entry (the first monitors the doors). This means that the alarm will not sound until 10s after movement has been detected, a necessary feature to allow for authorised entry to the vehicle.

A feature of the circuit is that it is very easy to build. Apart from two ultrasonic transducers, the circuit uses just two ICs, three transistors and a handful of other parts. These are mounted on a small printed circuit board (PCB) and accommodated in a plastic zippy case which mounts out of sight under the dash.

A small red LED on the front of the plastic case flashes on and off when movement is detected. This is used during the setting up procedure and allows the circuit to be adjusted for correct operation without actually setting off the alarm (which makes an unholy ruckus).

How it works

The basic concept is really very simple. Essentially, we have two ultrasonic transducers, a receiver and a transmitter. The latter emits a continuous 40kHz signal which is reflected from surfaces inside the car and picked up by the receiver.

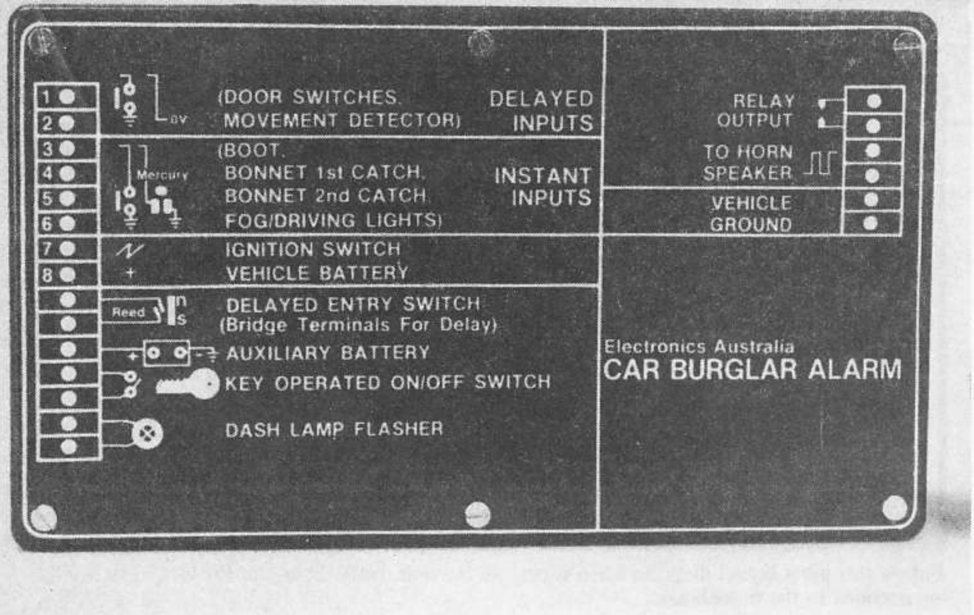
Provided all reflecting surfaces are stationary, the phase of the received signal will remain constant with respect to the transmitted signal. However, as soon as one of the reflecting surfaces moves, or a new surface is introduced, the phase of the received signal will change. This phase change is detected by the circuit and used to trigger the main alarm.

At the heart of the circuit is IC1 which is a 4046 phase lock loop (or PLL for short). Among other things, this IC contains a voltage controlled oscillator (VCO) and a phase comparator. The phase comparator compares the incoming signal frequency (on pin 14) with the VCO signals and produces a square wave output at pin 1, the duty cycle of which is dependent upon the degree of phase mismatch.

When the signals are in phase, the output of pin 1 is permanently low (ie, zero duty cycle). When the signals are 180° out of phase the output is high. If the signals are 90° or 270° out of phase, the duty cycle is 50%.

VR1 and the .001μF capacitor on pins 6 and 7 set the internal VCO to 40kHz. Note that the VCO input is permanently tied low so that it operates simply as a fixed oscillator. The output appears at pin 4 and drives the ultrasonic transmitter via inverters IC2f and IC2e.

The two inverters provide complementary outputs to the transmitter. This technique ensures that the transmitter is driven by the full supply voltage during each half cycle of the 40kHz signal and



The Ultrasonic Movement Detector mates with the EA Car Burglar Alarm at left. It can also be used with some commercial alarms.

thus increases the output power. The 1.2kΩ resistor limits the surge current through the transmitter when the inverter outputs change state.

Note that the VCO output of IC1 is also connected to the pin 3 comparator input. This enables the phase comparator to compare the VCO signal with the received (reflected) signal.

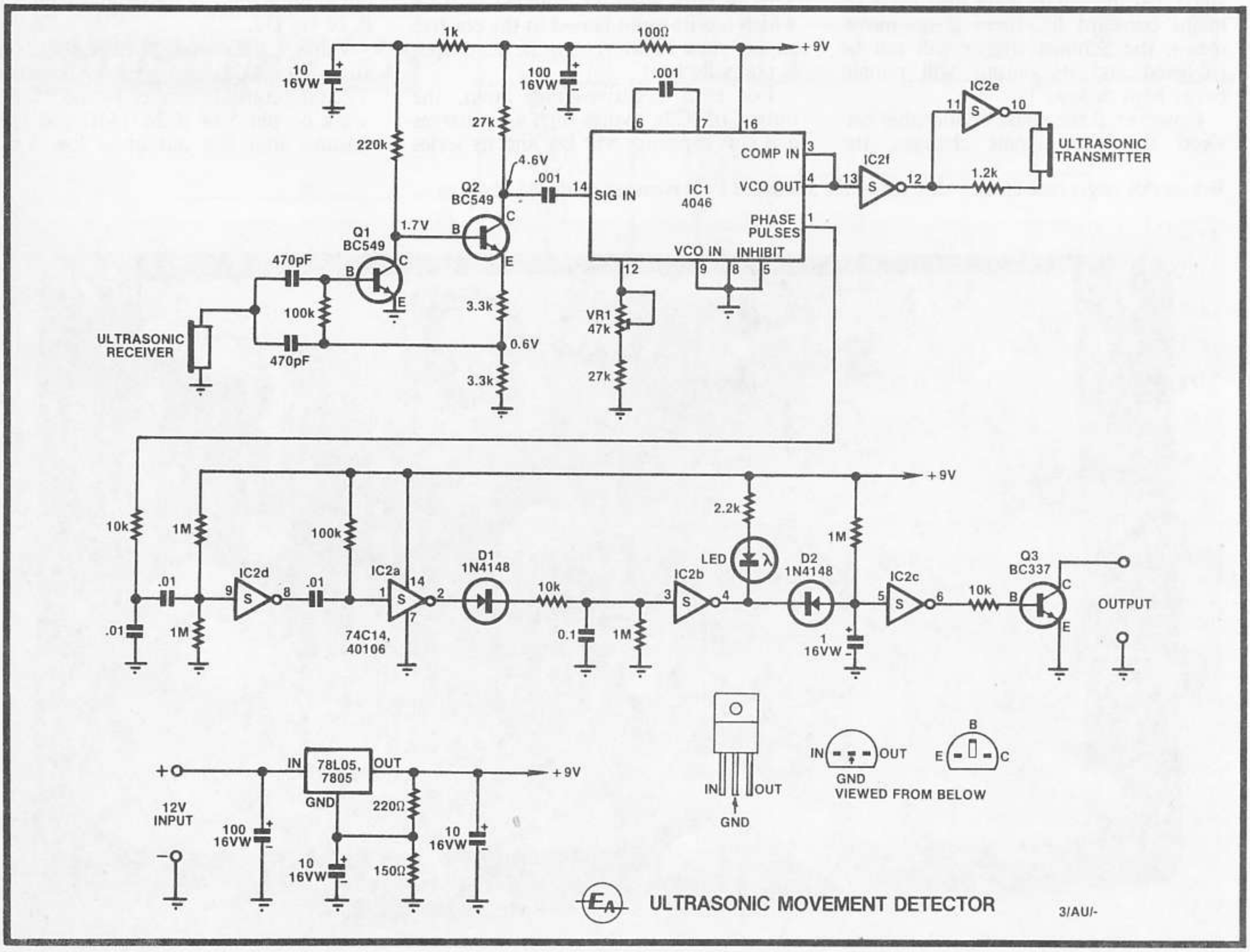
The receiver

The reflected signal is picked up by the ultrasonic receiver and fed via a 470pF capacitor to a two-stage amplifier consisting of transistors Q1 and Q2. These transistors operate as common emitter amplifiers and provide an overall gain of 100. The output is taken from the collector of Q2 and AC-coupled to the PLL via a .001μF capacitor.

As well as providing signal gain, Q1 and Q2 also function as a bandpass filter. If you look closely at the circuit, you will notice that DC bias for Q1 is derived from a voltage divider network (2 x 3.3kΩ) at the emitter of Q2. At the same time, part of Q2's emitter signal is fed back to the input via a second 470pF capacitor.

So the circuit has two feedback paths: a DC feedback path which provides bias for Q1, and an AC negative feedback path which feeds part of Q2's emitter signal back to the input.

In greater detail, the upper 470pF capacitor on Q1's input functions as a high pass filter which progressively attenuates all signals below 40kHz. Signals above 40kHz are similarly attenuated by reason of the AC-feedback path via the lower 470pF capacitor, the amount of



Ultrasonic movement detector

feedback increasing with rising frequency.

Because of the high sensitivity of the amplifier, it is necessary to decouple the power supply to each transistor. A 10μF capacitor and 1kΩ resistor decouple Q1, while a 100μF capacitor and 100Ω resistor decouple Q2.

The amplified signal at Q2's collector is AC-coupled to pin 14 of the PLL and compared with the VCO signal. As previously mentioned, this comparison results in a square wave signal output from pin 1, the duty cycle depending upon the degree of phase mismatch. These phase pulses are then filtered to a DC level and AC-coupled to the input of Schmitt trigger IC2d.

In this case, the input of IC2d is biased to half supply by two 1MΩ resistors. Provided that the square wave duty cycle remains constant (ie, there is no movement), the Schmitt trigger will not be triggered and its output will remain either high or low.

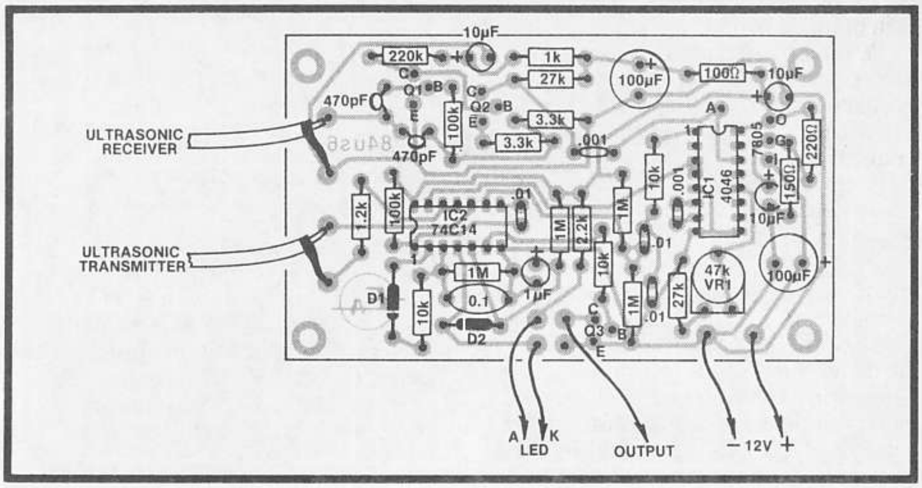
However, if the phase relationship between the two signals changes, the filtered DC level shifts and a pulse is applied to the input of IC2d. The greater the phase change, the greater the voltage pulse applied to the Schmitt trigger.

When this pulse exceeds the hysteresis level of the Schmitt trigger its output will change state. Note that if a continuous movement is detected, the output of IC2d will be a continuous pulse train. This signal is then AC-coupled to IC2a which has its input biased to the positive supply via a 100kΩ resistor (ie, its output is normally low).

For each negative-going input, the output of IC2a swings high and charges a 0.1μF capacitor via D1 and its series 10kΩ resistor. Note that D1 is reversed biased when the output of IC2a is low; the only discharge path for the capacitor is via the parallel 1MΩ resistor.

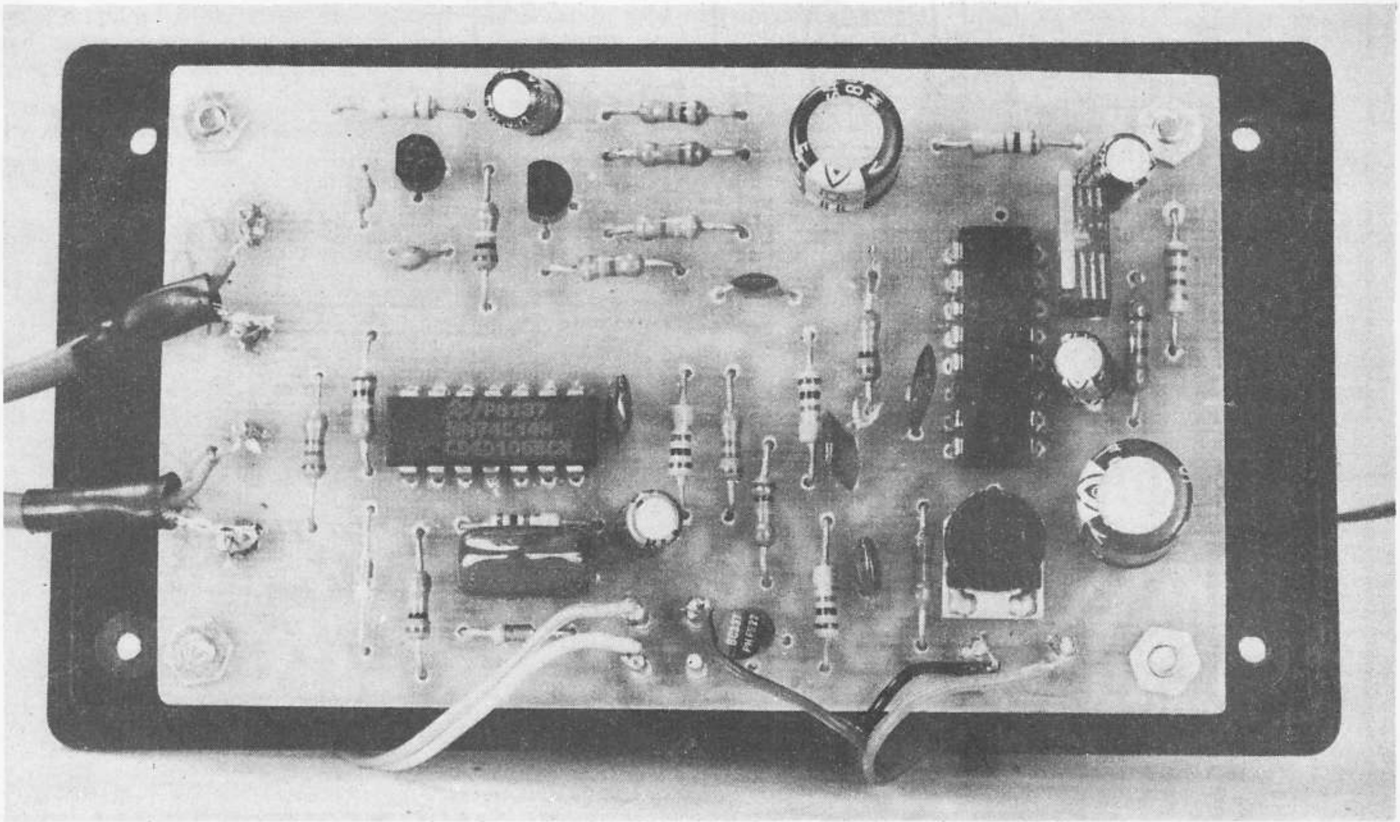
Provided it receives sufficient pulses from IC2a, the 0.1μF capacitor quickly charges to the upper trigger voltage of IC2b. The output of IC2b then switches low, lighting the indicator LED and discharging the 1μF capacitor on pin 5 of IC2c via D2.

Finally, the output of IC2c goes high, turning on Q3 and triggering the alarm. The time constant formed by the RC network on pin 5 of IC2c (1MΩ and 1μF) ensures that the output is low for a



Follow this parts layout diagram when wiring up the unit. Note the use of shielded cable for the connections to the transducers.

Below: this larger-than-life-size view shows the assembled PCB mounted on the lid of the case.



minimum 1s period.

Power for the circuit is derived from the vehicle battery (see construction) and regulated to +9V using a 5V 3-terminal regulator. That's not quite as silly as it sounds.

In this circuit, the GND terminal of the regulator is connected to a voltage multiplier network consisting of 220Ω and 150Ω resistors. Because the regulator produces 5V between its OUT and GND terminals, it follows that the current through the 220Ω resistor will be 23mA or thereabouts. Both this current and a 6mA current from the GND terminal flow through the 150Ω resistor which "jacks up" the GND terminal by about 4V.

Thus, the output voltage is set to around 9V. The 100μF capacitor filters the supply line while the 10μF capacitors provide decoupling to improve the transient response of the regulator.

Construction

The Ultrasonic Movement Detector is housed in a plastic case measuring 120 x 65 x 39mm, while most of the components are mounted on a PCB coded 84us6 and measuring 97 x 57mm.

Begin construction by installing the parts on the PCB according to the overlay diagram. Take extra care with the semiconductors and the electrolytic capacitors since these must be fitted with due regard to polarity. We used PC stakes to facilitate the external connections.

Once the PCB had been completed, it can be mounted on the lid of the case on 6mm spacers. The hole for the indicating LED is centrally located on one side of the case, while the external wiring passes through a grommeted hole in the opposite side of the case.

Rainbow cable can be used for the connections to the LED, while the power supply and output connections should be run using light duty hook-up wire. Connections to the ultrasonic transducers must be run in shielded cable.

The two ultrasonic transducers are housed in rightangle sparkplug covers. Feed the connecting cable through the cover first, then solder the leads to the transducer with the shield connected to the earth pin. The transducer can then be pushed into the cover to provide a neat assembly.

The ultrasonic transducers are positioned above the front windscreen, one on each side of the vehicle. Each transducer is supported by a nylon cable clamp which is wrapped around the lead exit of the sparkplug cover, which in turn is held by one of the screws that locate the sun visor.

Be careful not to get the two transducers mixed up. The transmitter is labelled SCS401A while the receiver is labelled SCM401A. The two should be mounted as far apart as possible (to avoid interference) and pointed towards the rear of the vehicle.

The ground wire for the circuit can terminate at a convenient chassis point while the positive supply lead goes to the switched side of the key operated on/off switch. The output lead goes to the spare delayed entry input, but don't make this connection until after the setting up procedure has been carried out.

Setting up

Before making any adjustments, first check that the transducers point towards the rear of the vehicle and are reasonably parallel. This done, set your multimeter to read low AC volts and connect it to the test point marked "A" on the parts layout diagram (pin 14 of IC1). Apply power and adjust VR1 for maximum reading (typically 0.5-0.6V).

There's just one hassle here — you will have to keep quite still while you make this adjustment, otherwise the reading will fluctuate.

This done, check that the LED flashes whenever there is movement in the vehicle. If the unit displays a tendency to false trigger, rotate the trimpot (either way will do) to reduce the sensitivity.

Finally, the output lead can be connected to the delayed entry input of the alarm and the unit mounted permanently under the dashboard. The leads from the transducers run down the windscreen pillars and can be fixed with contact adhesive.

That's it. If a thief can get past that lot, there's always the insurance!

We estimate the current cost of parts for this project to be approximately

$30

This includes sales tax.

PARTS LIST

1 PCB, 84us6, 97 x 57mm
1 plastic case, 120 x 65 x 39mm
1 ultrasonic transmitter, SCS401A (Dick Smith Electronics)
1 ultrasonic receiver, SCM401A (Dick Smith Electronics)
4 6mm standoffs
2 right angle spark plug covers (for lawnmowers and motor bikes)
1 5.5mm grommet
1 4-metre length of screened cable
2 cable clamps

Semiconductors

1 4046 phase lock loop
1 74C14/40106 hex Schmitt trigger
2 BC549 NPN transistors
1 BC337 NPN transistor
1 7805 5V 3-terminal regulator
2 1N4148/1N914 small signal diodes
1 3mm red LED

Capacitors

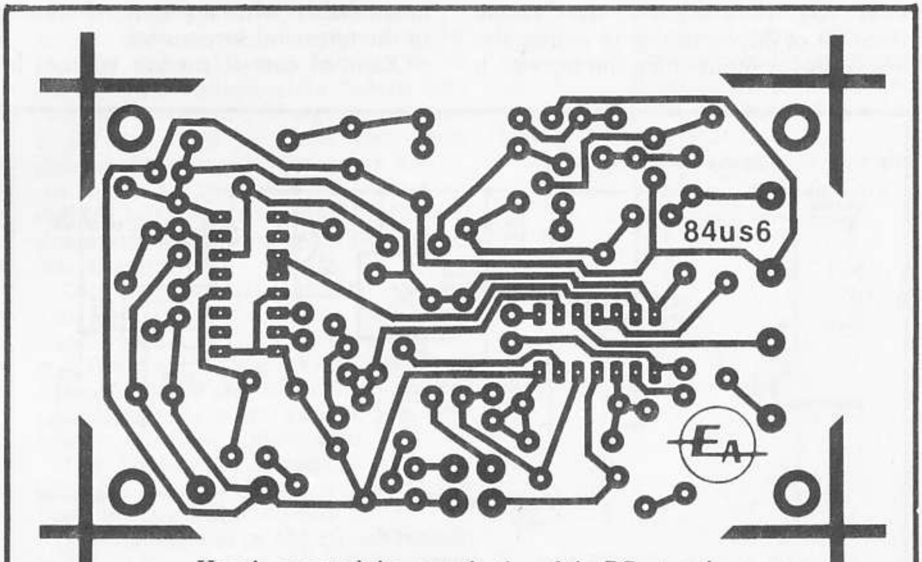
2 100μF/16VW PC electrolytic
3 10μF/16VW PC electrolytic
1 1μF/16VW PC electrolytic
1 0.1μF metallised polyester
3 .01μF metallised polyester
2 .001μF metallised polyester
2 470pF ceramic

Resistors (¼W, 5%)

4 x 1MΩ, 1 x 220kΩ, 2 x 100kΩ, 2 x 27kΩ, 3 x 10kΩ, 2 x 3.3kΩ, 1 x 2.2kΩ, 1 x 1.2kΩ, 1 x 1kΩ, 1 x 220Ω, 1 x 150Ω, 1 x 100Ω, 1 x 47kΩ miniature horizontal trimpot.

Miscellaneous

Machine screws and nuts, rainbow cable, hook-up wire, PC stakes.



Here is an actual-size reproduction of the PC artwork.

Sneaky anti-theft device to build

Car Ignition Killer

Car burglar alarms are fine except that most are easily circumvented. This cunning anti-theft device is cheap, easy to fit, and effective.

We may be in the midst of an economic recession, but no such recession has been reported in the car theft "industry". Last year, more than 70,000 cars were stolen in Australia, this despite the existence of car steering locks and the increasing use of car burglar alarms.

A problem concerning the car alarm concept is how to make it most effective. One philosophy – usually expounded by the commercial alarm manufacturers – is that the alarm is most effective if its presence is clearly advertised and made obvious. The thief will then, according to theory, bypass that vehicle and attack one whose owner has not been astute enough to fit the "Little Beaut Red and Green Flashing Car Alarm". (What would happen if everybody fitted the "Little Beaut . . . etc" is not clear).

But that question aside, the opposite alarm philosophy contends that a warning sticker only makes the thief aware that there is an alarm to be circumvented. And professional thieves are not above familiarising themselves with the various commercial alarms and how best to disable them.

In fact many car alarms can be effectively disabled by the simple measure of disconnecting or cutting the horn wires without lifting the bonnet. It is not generally realised that most horns can be reached without much effort from underneath the vehicle. An experienced thief can pull this trick in a few seconds.

Even if the alarm does sound, the thief usually has sufficient time to disable it. Surveys have shown that people tend initially to disregard a car burglar alarm, assuming that the owner has set it off accidentally. Provided he keeps his "cool", the thief has only to cut the wires to the horn or siren and drive away.

One of the worst thieves, as far as the car owner is concerned, is the "joyrider". This is the person who grabs your lovingly cared for Ford, Holden, Porsche, etc and takes it for a "spin around the block" to see for himself just how fast it will go. If the owner is lucky, the car will be found intact a day or so later, usually minus the radio-cassette player and any other valuable accessories that may have been fitted.

But even this can have a sting in the tail, with the real damage to the car often unseen. After all, the thief doesn't care two hoots about your property. The engine could well have been overheated or had the inside revved out of it. Or the car could have been used to show off innumerable "wheelies" to the detriment of the tyres and suspension.

Often, of course, the car will not be recovered or will be damaged beyond repair. Many cars are stolen by professional thieves to be stripped and used for spare parts. But whatever the circumstances, car theft causes the owner a great deal of expense and inconvenience.

Ignition killer

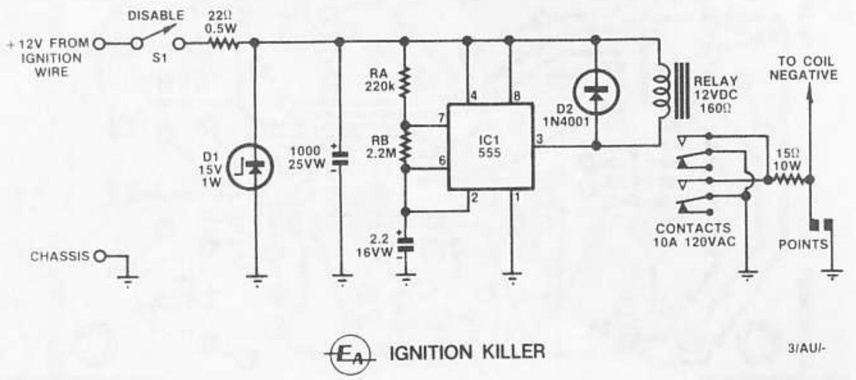
In order to protect your car against the above situations we have devised a rather cunning little circuit. We've christened it the "Ignition Killer".

It works like this: imagine a thief has just broken into your car. He starts the engine and begins to drive off. Just as he does, the engine dies. He immediately cranks the engine and a few seconds later it starts. Again he begins to drive off and again the engine dies. In desperation he tries a third time only to have the engine die again.

The above sequence of events should automatically deter any joyriders and many so-called professional thieves as well. After all, it is difficult to get any joy out of the car that only moves a few metres at a time. In this situation, most thieves will simply assume that the car has an engine problem and will abandon it for easier "game".

The simple circuit that creates this mayhem is simply an astable oscillator based on the ubiquitous 555 timer IC. The output of the 555 oscillator is connected to a relay which in turn has its normally open contacts wired in parallel with the car's points or coil switching transistor (see Fig. 1).

A few seconds after the car is started,



The circuit consists of a 555 timer IC driving a relay.

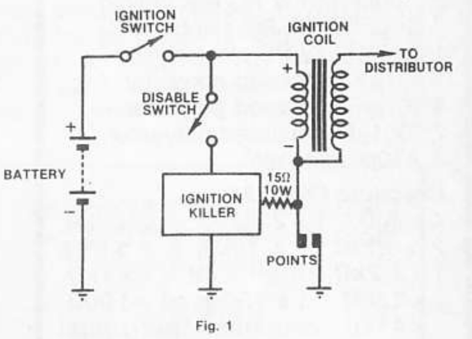
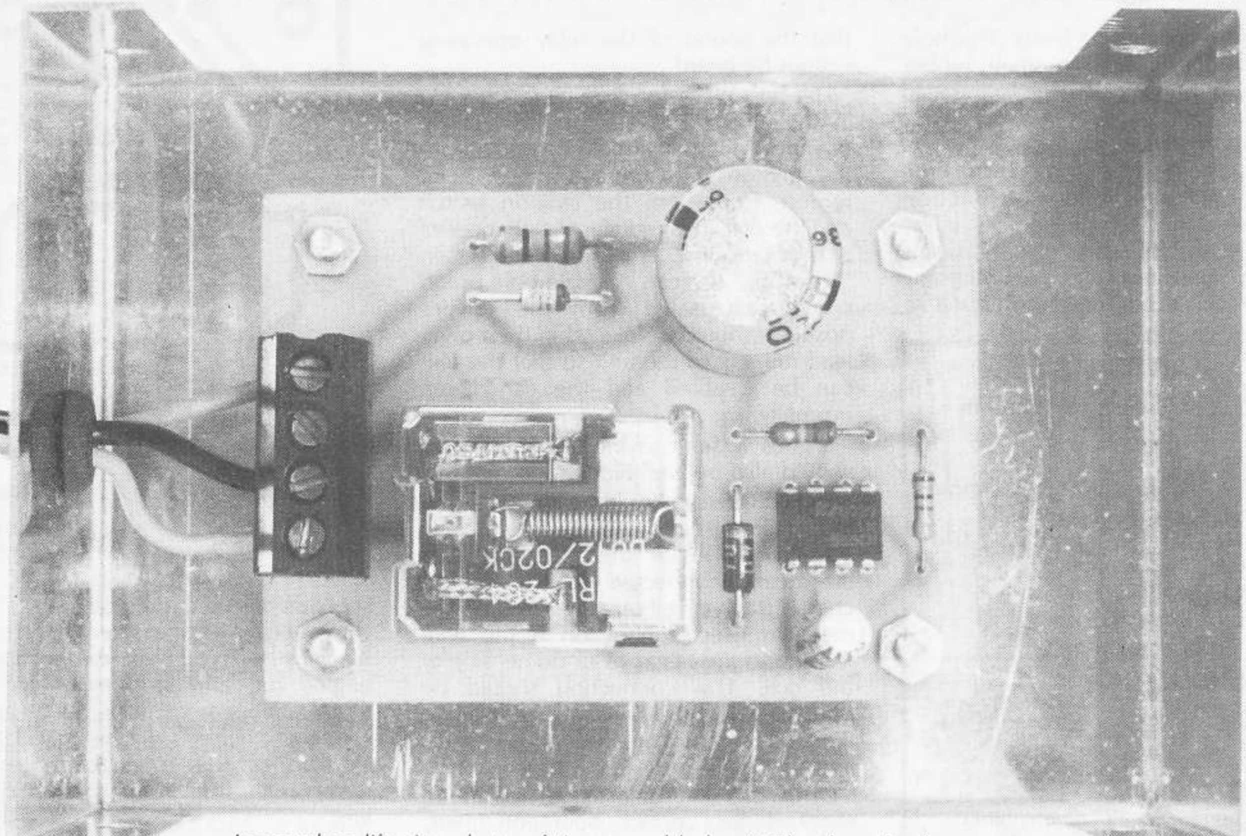


Fig. 1

The Ignition Killer is simply connected in parallel with the points (or the coil switching transistor).



Larger than life size photo of the assembled unit. The three leads go to the disable switch, chassis and coil negative.

the oscillator output goes low, causing the relay to operate and short out the car's points. With no points signal the ignition system cannot produce a spark and so the engine dies. A few seconds later the oscillator output returns to the high state, the relay turns off and the contacts open. The engine can now be started and will run for a few seconds until the next low cycle of the oscillator.

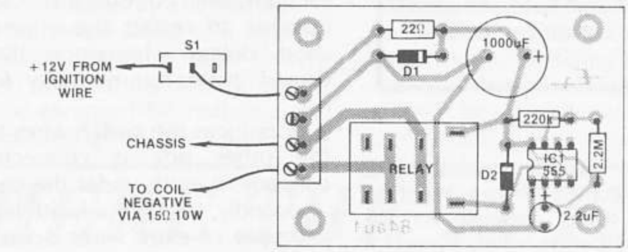
The circuit is powered from the car's ignition wire and uses no power when the ignition is not switched on. Thus it will not flatten the battery when used to protect the car for extended periods.

How it works

The circuit consists of astable oscillator IC1 (555), a relay and a handful of minor components.

Inside the 555 timer IC is a resistor divider network which sets reference voltages of 1/3 Vcc and 2/3 Vcc on internal comparators. At switch on, the pin 2 trigger input is pulled low by an external 2.2μF capacitor, while the output is high. This means that the relay will be off and so the engine can be started.

The 2.2μF capacitor immediately begins charging via the 220kΩ and 2.2MΩ timing resistors. When the voltage across it reaches 2/3 Vcc, the 555 output (pin 3) switches low and the relay turns on to short out the points (or the coil switching transistor). At the same time, pin 7 goes low (ie, the discharge transistor turns on) and the 2.2μF capacitor begins discharging.



Construction is easy – just follow this parts overlay diagram. Note component orientation.

Pin 3 will remain low, and hence the relay remains on, until the capacitor is discharged to 1/3 Vcc. At this point, pin 3 switches high again, the pin 7 discharge transistor turns off, and the 2.2μF capacitor re-charges towards 2/3 Vcc. Thus, the cycle repeats indefinitely while ever power is applied. It follows, therefore, that the car can be started only during the charging cycle and stalls immediately the voltage across the timing capacitor reaches 2/3 Vcc.

The 1N4001 diode connected across the relay contacts shorts out the relay coil back EMF to prevent damage to the output circuit of the 555. The 22Ω resistor, 15V zener and 1000μF capacitor provide supply line filtering and decoupling. The 15V zener clamps supply line transients to 15V, thus protecting the 555 from excessive voltages.

Construction

Construction is straightforward with all parts except the switch mounted on a small printed circuit board (PCB) coded 84au1 and measuring 69 × 48mm. This is housed in a metal case measuring 102 × 70 × 51mm, although any similarly-sized plastic case would also be suitable.

We mounted the PCB assembly on the lid of the case using four 6mm brass spacers and machine screws and nuts. A small hole was drilled in the end of the lid closest to the terminal block to allow

Car Ignition Killer

entry of the connecting leads. This hole should be fitted with a small rubber grommet to prevent damage to the lead insulation.

Installation of the unit is probably the most important part of the construction. To enable the unit to function effectively, it must remain undetected by the potential thief. This not only means hiding the unit itself and disguising any exposed wiring, but locating the unit so that the sound of the relay operating cannot be heard.

The best place for the unit is probably in the engine bay against the firewall. Power for the unit should be taken from the ignition wire, preferably at a point remote from both the ignition switch and the coil. This reduces the chances of a thief spotting the extra lead when "hotwiring" the car. A single-pole on-off switch, accessable from the driver's position, should be placed in the power lead running to the unit so that the unit can be disabled and the car driven normally.

It goes without saying that this switch should also be well hidden.

The earth wire should be connected to the nearest earth point, which may actually be inside the case if this is electrically connected to the vehicle chassis (say via self-tapping screws). The most exposed connection is the wire leading to the negative or points side of the coil. This connection should be disguised by using wiring similar in appearance to the existing coil leads, and by bundling the leads together.

Once the unit is installed, it can be checked for correct operation. First, switch the unit off and check that the car can be started and that the engine runs normally. Now switch the unit on – the engine should run normally for a few seconds, then cut out. It should now be possible to restart the engine after a short delay, whereupon the engine should again run normally for a few seconds before cutting out.

If your car's engine is very easy (or very hard) to start you may wish to alter the engine run and stop times we have chosen. This can be done quite easily by changing either of the two timing resistors or the timing capacitor. The formulae for the time periods in seconds are:

- Engine run time = $0.685(R_A + R_B)C$;
- Engine stop time = $0.685(R_B)C$.

In our circuit, $R_A = 220k\Omega$, $R_B = 2.2M\Omega$, and $C = 2.2\mu F$. By substituting these figures into the above equations, we get an engine run time of 3.6 seconds and an engine "kill" time of 3.3 seconds.

PARTS LIST

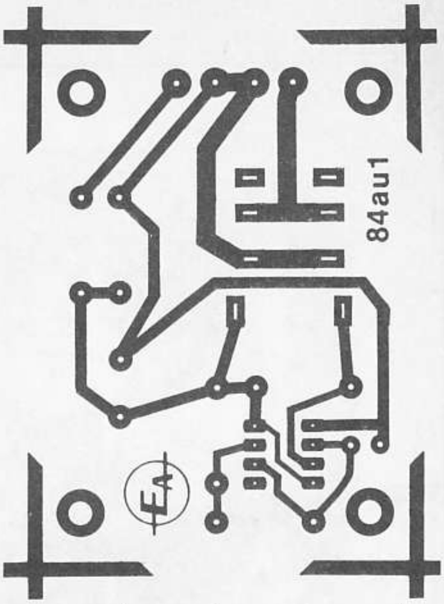
1 PCB, code 84au1, 69 × 48mm
1 aluminium case, 102 × 70 × 51mm
1 4-way PC-mounting terminal block
1 DPDT 12V relay with 10A 120VAC contacts
1 SPST toggle switch
4 6mm or 8mm spacers
1 small rubber grommet

SEMICONDUCTORS
1 555 timer IC
1 15V 1W zener diode
1 1N4001 diode

CAPACITORS
1 1000µF 25VW PC electrolytic
1 2.2µF 16VW PC electrolytic

RESISTORS (¼W, 5% unless stated)
1 x 2.2MΩ, 1 x 220kΩ, 1 x 22Ω ½W

MISCELLANEOUS
Machine screws and nuts, self tapping screws, automotive hook-up wire, solder etc.



Above is the actual size PCB artwork.

ERRATA

IGNITION KILLER There is a possibility of damage to the ignition coil in the event of the "killer" circuit being operated for an extended period. To prevent this, connect a 33Ω/5W resistor in series with the relay contacts.

FEEDBACK

IGNITION KILLER: The ignition killer project is a great idea! However, I've thought of a couple of things that could make it better.

Firstly, the "disable" switch should be taken from "reset" (pin 4) of the 555. This should be tied high via a pullup resistor so that the unit is permanently enabled, but when taken low via a switch from pin 4 to earth, the unit is disabled. This has a number of advantages over the original placement:

1. A burglar hopefully snipping this wire would only permanently enable the device (rather than disable with the original design).

2. It reduces the switch wires to one, as the other side is connected to a convenient earth under the dash.

Secondly, to any thief with half a brain, a couple of extra wires across the H/T coil leading to a box is going to look a bit suspicious – snip – no more ignition killer. This might not look so bad if the box was marked "electronic ignition" of similar.

Another possibility is to make the unit very small and mount it inside the H/T coil – there's enough room if you don't use a PCB and use a compact relay. This would only leave one extra wire (enable) to give an indication of an anti-theft system.

However, this approach is probably beyond the scope of most of your readers, not to mention a number of technical difficulties – like the H/T coil being full of transformer oil which could lead to premature component failure if not properly sealed (how well does a relay full of oil work? I suppose it would solve the problem of relay click attracting the thief's attention!). (D.C., Rosanna, Vic.)

- We agree that, at first sight, using the reset pin of the 555 as the enable/disable control is attractive. However, in the electrically noisy environment of a car, using the reset pin with a long wire to the on/off switch is asking for trouble. You would be likely to have intermittent false triggering.

It is far better to have the 555 completely disabled by removing power via the on/off switch. At least that way there can be no false tripping of the relay and no likelihood of stalling in the wrong place.

Only one wire need go directly to the coil negative and even if both wires go directly to the coil it should be possible to rout them behind the coil so that they are well nigh invisible. And if the thief does find the wires to the ignition coil you would be able to console yourself that he was really determined to pinch your vehicle. Even the best alarm will not stop a really determined thief.

As far as the suggestion of building the ignition killer inside the coil is concerned, it is just not on. The above remarks about electrical noise apply even more so here. Not to mention the physical problems of coil flashover to foreign components mounted inside the cap!

Simple circuit tells you when to "fill 'er up"!

Low fuel warning indicator for cars

If you've ever experienced the feeling of foolishness as your car splutters to a halt, fuel gauge on empty, this project is for you. When the car's fuel reserve falls below a preset minimum level, the circuit sounds a buzzer and lights a lamp to warn the driver to "fill 'er up"!

by COLIN DAWSON

Running out of petrol is inconvenient at the very least, and dangerous at worst. The trouble is, it is all too easy to get caught, especially if one is trying to squeeze an extra few kilometres from the tank during the occasional petrol strike. This circuit is presented in an effort to banish forever the stranded, jerrycan-toting motorist — at least amongst "Electronics Australia" readers.

The circuit is all contained on a small PC board, can be easily fitted to most cars, and can be set to trigger at any fuel level. When triggered, it sounds a buzzer for five seconds and a lamp remains on to remind the driver that the tank needs filling. If the tank is not filled immediately, the buzzer and lamp will come on each time the car is started (ie each time the ignition switch is turned on).

The driver would have to be both blind and deaf, or preoccupied with the blonde in the car in front to overlook these warnings!

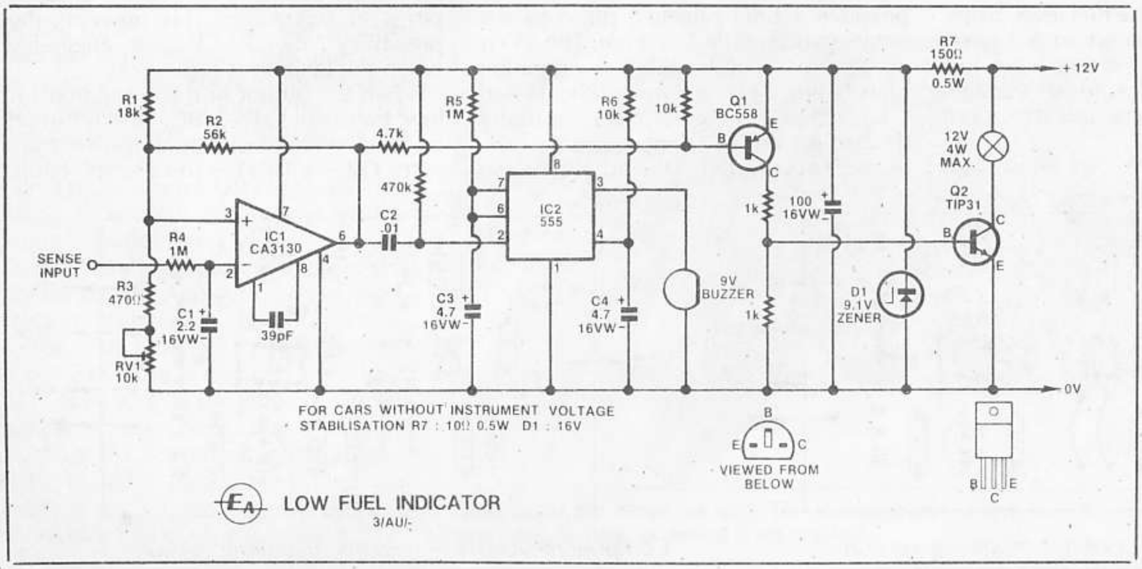
The warning circuit can be adapted for use in most cars, provided they have conventional fuel tank sensors. It should prove simple to install, requiring only connections to chassis, +12V from the ignition switch, and the fuel gauge sender unit.

Before describing the circuit, readers may find the project's background of some interest. The circuit originally suggested came from the Dick Smith Electronics technical department, who designed it for use in Dick's Bell Jet-Ranger helicopter. With the recent spate of helicopter and light aircraft accidents, perhaps such a device should be more widely used. Whilst we do not regard fuel exhaustion in a Kingswood to be as traumatic as in a Jet-Ranger, it can nevertheless prove awkward to find yourself making a "forced landing" on the Harbour Bridge during peak hour!

The helicopter low fuel warning indicator was designed to switch on a warning lamp — much the same as some late model cars do. We felt that a five-second buzzer would be a useful addition, and several other circuit modifications were incorporated to adapt the circuit to the rigours of the automotive electrical system.

While testing this project, we found that there are several different types of fuel level indicating systems used. The PC board has been designed to accommodate most systems that we know of, although a few component values will depend on the particular car. Details on finding out exactly what type of sensor is fitted to your car are given later on in the article.

Readers should note, however, that the circuit is not suitable for use with XD Ford Falcons. The XD Falcon uses a capacitance-type sensor (as used in many aircraft) in which the different dielectric values of air and fuel determine the reading. While we are not aware of any other vehicles using this system, owners of late model cars should check carefully before embarking



The circuit consists of a CA3130 comparator driving a 555 monostable timer and transistors Q1 and Q2.

on this project, otherwise you could waste your money.

Note: many late model cars are already fitted with low-fuel warning lights, although we do not know of any that also have a buzzer!

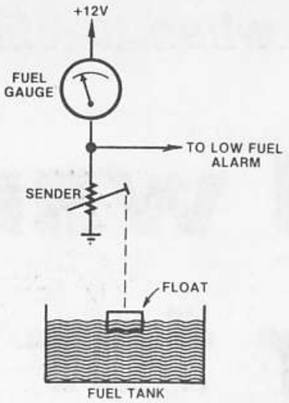


FIG. 1

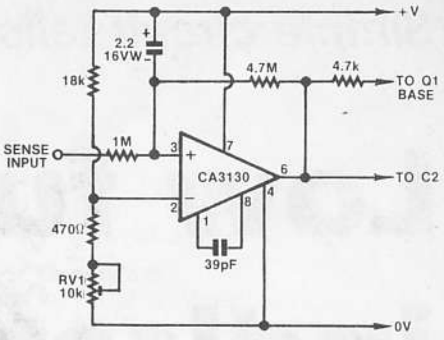


FIG. 2

Fig. 2: alternative negative triggering input stage (see text).

HOW IT WORKS

In most vehicles, the fuel-level sensor is a float-controlled rheostat wired in series with the dashboard-mounted fuel gauge and connected between chassis and +12V as shown in Fig. 1. When the tank is full, the float arm rises and the rheostat normally has minimum resistance, although a few circuits work in the opposite sense. The fuel gauge, which is actually a milliammeter, will respond with full-scale deflection.

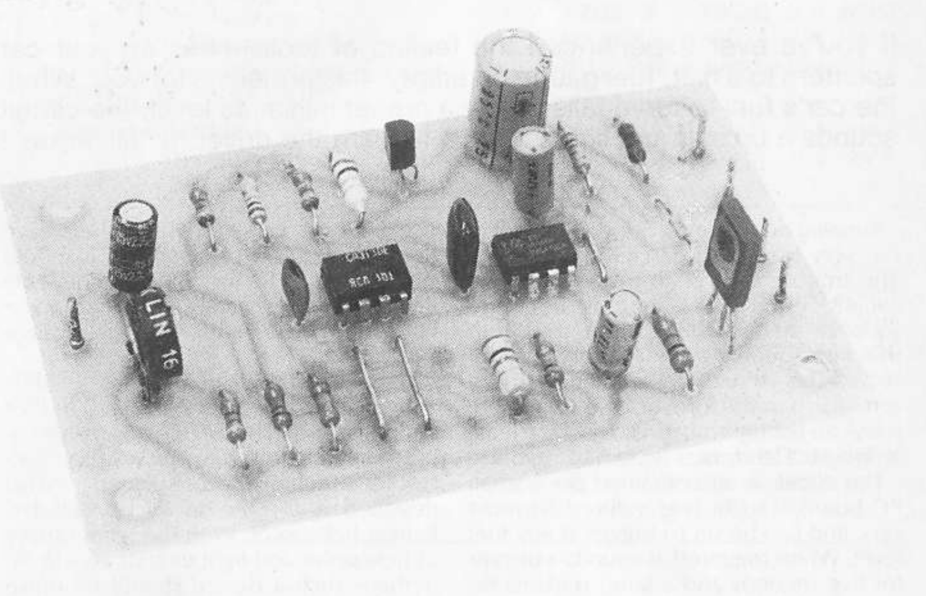
As the fuel level in the tank drops, the resistance of the rheostat increases (or decreases) and the current through the circuit varies accordingly. The voltage across the rheostat thus depends on the fuel level and, by monitoring this voltage, we can detect when a certain fuel level is reached.

The voltage generated across the fuel-level sensor is first applied to low-pass filter R4-C1 so that the voltage across C1 is the average across the sensor. This low pass filter eliminates voltage transients generated by the switching voltage regulator used in some vehicles, as well as voltage fluctuations due to fuel sloshing and a bouncing sensor float.

Heart of the circuit is IC1, a CA3130 FET input op amp capable of swinging its output to either supply rail. It is used here as a comparator with either its inverting or non-inverting input used as the sense input. When the comparator detects a low fuel condition its output goes low, switching on IC2 – a 555 timer – to drive the buzzer, and transistors Q1 and Q2 to drive the lamp.

Since the circuit may have to trigger on either a rising voltage or, in some cars, a falling voltage, the sense input may be either the inverting or non-inverting inputs. As shown in the main circuit diagram, the inverting input (pin 2) is used where the voltage across the rheostat increases as the fuel level drops. This voltage is compared to a pre-set voltage on the non-inverting input (pin 3). When it exceeds this pre-set voltage, the comparator triggers and its output goes low.

Fig. 2 shows the alternative input stage used when the voltage across the rheostat decreases as the fuel level drops. As can be seen, the non-inverting input is now used as the sense input and the pre-set voltage is on the inverting input.

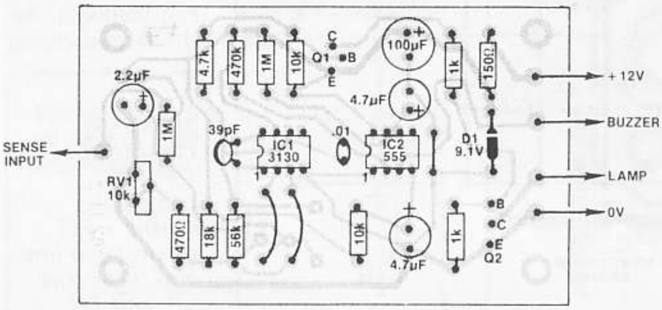


The prototype low fuel warning indicator. Note that the PC pattern for the final version differs slightly from the prototype (see below).

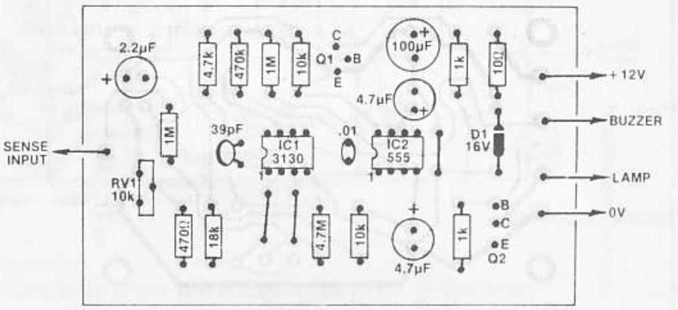
When the output of IC1 goes low, C2 provides a brief negative pulse to the trigger (pin 2) of the 555 timer. The 555 is used here as a monostable, the duration of its timing cycle determined by R5 and C3. When triggered, C3, initially discharged, begins charging towards the positive supply rail. The output of the 555 remains high for as long as pin 6 is at a voltage lower than 2/3 supply. C3 now charges via R5 and when it reaches 2/3 supply, the 555's output goes low and the timing cycle ends.

Normally the reset (pin 4) is tied high for monostable operation, but we have included a capacitor (C4) which grounds pin 4 at switch on. This prevents the possibility of false buzzer triggering when the ignition is turned on.

When the output of the comparator is low, transistor Q1 – a BC558 – is turned on. This, in turn, switches on power transistor Q2 – a TIP31 – to drive the lamp.



Component overlay – positive triggering version.



Component overlay – negative triggering version.

The lamp remains on until fuel is added to the tank. Note that the lamp rating should not exceed 4W.

The level of fuel at which the device triggers can be adjusted by means of RV1. Together with R1 and R3, this forms a voltage divider which determines the pre-set reference voltage on the comparator. If the comparator triggers on an increasing voltage, then increasing the voltage of the reference will cause the warning to trip at a higher fuel gauge reading. For a comparator which triggers on a decreasing voltage, the reference voltage is decreased to achieve the same effect. The range of adjustment provided by RV1 is approximately 2V, which should be adequate for most cars.

To prevent the comparator from continually retriggering when fuel is at a critical level, positive feedback has been provided via R2 to give the comparator a little hysteresis. This means that when the output of the comparator goes low, the voltage on pin 3 is also pulled low by about 1.5V.

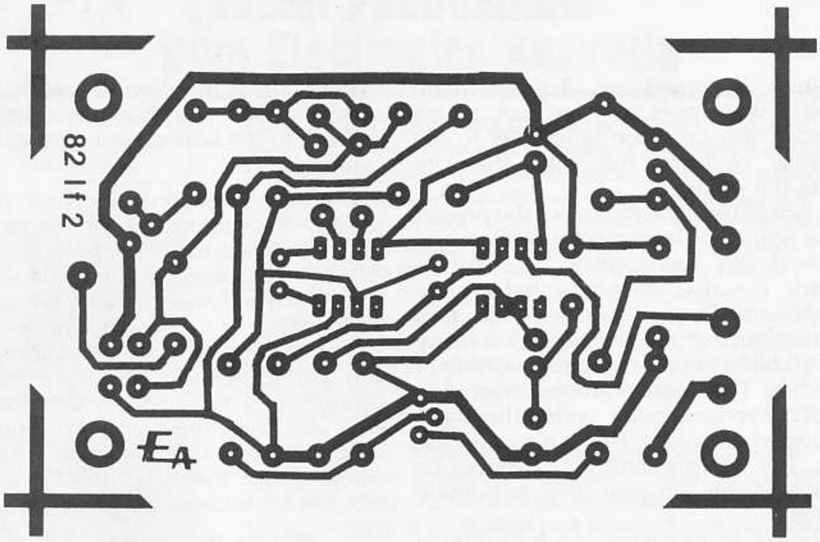
In the case of the positive triggering circuit, this prevents the voltage on the sense input (pin 2) from easily falling below the reference on the noninverting input (pin 3) and hence rearming the device. For the negative triggering circuit, it prevents the sense input (pin 3) from easily rising above the reference voltage on the inverting input (pin 2).

The circuit also includes a zener diode voiltage regulator which may be either 9.1V or 16V, depending on the particular car. Some cars have a voltage stabiliser for the instruments. If this is the case, the low fuel warning circuit would lose some accuracy if it were not also stabilised, so the 9.1V zener diode should be used. If the car does not have an instrument voltalge stabiliser, the 16V zener should be used instead.

It is important that the circuit have a zener diode to provide protection against voltage spikes which can be present on automotive electrical systems. Without protection from these spikes, the circuit may be subject to false triggering, or worse, damage to the semiconductors.

CONSTRUCTION

Before commencing construction, it will be necessary to determine what type of sender unit your car has and whether it has an instrument voltage stabiliser. To check the sender, it will be necessary to disconnect the wire running to the fuel gauge. Use this wire to short the sender side of the fuel gauge to chassis and, with the ignition turned on, observe the reading on the fuel gauge. If it shows "full", the sender has least resistance when the tank is full and the positive triggering circuit must be used. If



Above is an actual size artwork for the PC board.

PARTS LIST

1 PC board, code 82lf2, 59 × 96mm
1 9V miniature electronic buzzer
1 12V instrument lamp (4W max)
2 mounting screws for buzzer
5 PC pins

SEMICONDUCTORS
1 CA3130 op amp
1 555 timer
1 BC558 PNP transistor
1 TIP31 NPN power transistor
1 9.1V zener diode (16V zener diode)

CAPACITORS
1 100μF 16VW electrolytic
2 4.7μF 16VW electrolytic
1 2.2μF 16VW electrolytic
1 0.01μF greencap
1 39pF ceramic

RESISTORS (¼W, 5%)
2 × 1MΩ, 1 × 470kΩ, 1 × 56kΩ(4.7MΩ), × 18kΩ, 2 × 10kΩ, 1 × 4.7kΩ, 2 × 1kΩ, 1 × 470Ω, 1 × 150Ω ½W (10Ω ½W), 1 x 10kΩ 5mm vertical trimpot.

MISCELLANEOUS
2.5mm auto cable, hook-up wire, machine scres and nuts etc

the gauge shows "empty", the sender has least resistance when the tank is empty and will require the negative triggering circuit.

The simplest way of determining whether the car has an instrument voltage stabiliser is to consult the wiring diagram in the manual. If you don't have access to a manual, it is possible to determine whether the car has the stabiliser by measuring the voltage at the fuel gauge. Be sure to measure from the power supply side and not the sender side. If the voltage is two or three volts below that of the battery, this indicates the presence of a stabiliser. If this voltage does not increase when the engine is started and run at faster than idle, there is almost certainly a stabiliser in the circuit.

We built our Low Fuel Indicator on a printed circuit board coded 82lf2 and measuring 59 × 96mm. Begin construction by fitting the three wire links. The first link – adjacent to the 555 timer – is the same on all circuits. The other two links, however, determine whether the circuit is negative triggering or positive triggering, so make sure that you follow the relevant wiring diagram carefully.

Once the links have been installed, the remaining components may be soldered into position. If your car has an instrument voltage stabiliser, be sure to use a 9.1V zener for D1 and make R7 150Ω; otherwise D1 should be a 16V zener and R7 should be 10Ω. Watch the orientation of the zeners, transistors and ICs, and the polarity of the electrolytics.

INSTALLATION

All the connections needed for the circuit are available under the dashboard, so this is the logical place to mount the project. The earth connection can be made to any convenient point on the chassis while the +12V should be taken from the ignition switch, otherwise the warning may be tripped whenever the ignition is turned off. To determine which wire goes to the fuel gauge sender, you can once again refer to the manual, or failing this, trace the wire from the sender.

It would be advisable to put the project in a zippy box to protect it from prying screwdrivers and other implements which can find their way behind the dashboard. If you choose to do this, remember that the buzzer and warning lamp will have to be mounted outside of the box. The buzzer can be mounted at any convenient point under the dash, provided, of course, that it is easily audible. The warning lamp will need to be mounted on or near the instrument panel.

The connecting wires can be soldered to the PC board terminals, but to conform to automotive standards, connectors should be used to interface the circuit to the car. There are several types of connectors which are suitable. The simplest are "Scotch-lock" squeeze-on connectors which require no stripping, soldering or terminating of the wires. All that is necessary is to lay the two wires to be joined side by side in the connector and squeeze it closed!

These connectors have the added advantage that if you should accidentally connect to the wrong wire, they can be easily removed.

A more conventional approach to installing the project would be to use "bullet" connectors. Four-way female "bullet" adapters (Utilux H862 or equivalent) and male "bullet" connectors (Utilux H863 or equivalent) are needed. To fit these it is necessary to cut the wire you wish to tap into. Fit a male "bullet" connector to each end of the severed wire and insert them into the four-way adapter. If you don't have access to a crimping tool, the male "bullet" connectors can be soldered on to the wire.

To calibrate the circuit, one of two methods can be used. The most obvious is to syphon petrol from the tank until the desired "critical" quantity is reached. It is then simply a matter of adjusting RV1 until the device just triggers. Alternatively, the wire to the fuel gauge sender can be disconnected and a rheostat of about 100Ω substituted. With one side of the rheostat connected to ground, the fuel gauge can now be made to indicate any quantity. First set the fuel gauge to indicate the level of fuel at which you want the warning to be activated and then adjust RV1 until the device just triggers. Remove the 100Ω rheostat and reconnect the wire to the sender.

Some readers may find that it is not possible to get enough range of adjustment on RV1. In that case, it may be necessary to attenuate the sense input by connecting a high-value resistor across C1, eg 3.3MΩ. This resistor can be wired on the copper side of the PC board.

That's it for calibration. Provided you have done the job properly, you should never run out of petrol again. Safe motoring!

We estimate that the cost of parts for this project is approximately

$12.00

This includes sales tax.

Delay system for car courtesy lights

Build this simple circuit for your car

How about this for a neat automotive circuit? When fitted to the interior lighting circuit of your car, it will delay the turn-off of the courtesy lights for a set period after the door closes. It's easy to build, all on a small PC board, and can be fitted to most negative chassis cars.

by GREG SWAIN

Conjure up in your mind the following fantasy. You've just left an exclusive nightclub on the foreshores of beautiful Sydney harbour. Her expensive French perfume wafts balmily on the still summer night air. You open the door to the Mercedes and she slides into the imported lambswool-covered seat. You shut the door . . . and the courtesy light stays on!

You've now got all of 20 seconds to stroll suavely round to the other side of the car before the courtesy lights go out. Just think how impressed she'll be when the lights automatically fade as you drive off.

Whoa! . . . steady on. Let's get back to reality. Let's discuss some of the more down-to-earth uses of a courtesy light delay! . . .

While courtesy lights provide a welcoming sight when a car door is opened at night, the effect is spoiled immediately one enters the car and pulls the door shut. The light goes out just when you need it to find and fasten the seat belt, identify the ignition key, and locate the ignition lock. Most people (including me) have six or seven keys on the key ring, and finding the ignition key in the dark can be a "real pain".

Of course, there is an internal switch for the courtesy lights, but finding it can be just one more problem in the dark. Think how much nicer it would be if the courtesy lights stayed on long enough to get yourself settled.

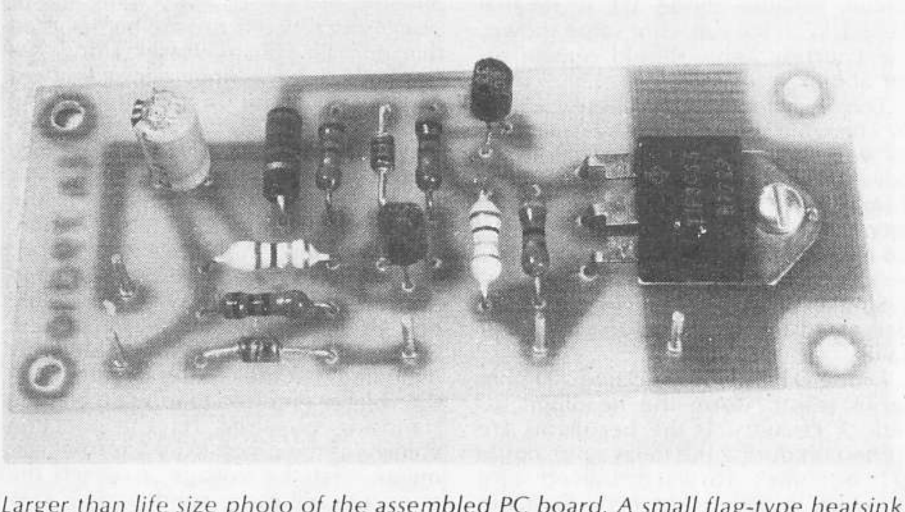
Such a feature would be even more valuable when ushering a guest into your car. The internal switch is seldom accessible from the passenger side of the car, so you have no option but to plunge the car into darkness as the door closes, leaving the guest to fumble for the seat belt in the dark until the driver's door is opened.

This simple circuit overcomes these problems by holding the courtesy lights on for a fixed period after the car door has been closed. As shown, the circuit provides a delay time of approximately 20 seconds, although this can easily be varied to suit the constructor. At the end of the delay period, the lights automatically fade out.

With a simple type of delay circuit, choosing a suitable delay time involves a compromise. If the period chosen is too short, you do not have time to settle in properly; if it is too long, the lights will still be on when you are ready to drive off. While this latter situation is of no consequence during daylight hours, it could be a problem at night.

This leads us to the next feature provided by our delay circuit. The circuit has been designed to interconnect to the headlight switch so that the courtesy lights are switched off automatically whenever the headlights or parking lights are turned on. With the headlight interlock arrangement, the delay time is no longer critical. It can be extended to one minute or more if you so wish.

We found a delay time of 20 seconds to be the best compromise. It provides ample time to get settled in the car, and yet doesn't keep the courtesy lights on for an inordinately long period after the driver leaves the vehicle. It also turns the lights off after a reasonably short period when driving off during daylight hours.



Larger than life size photo of the assembled PC board. A small flag-type heatsink should be fitted to the TIP3055 transistor for loads exceeding 30W.

We estimate that the current cost of parts for this project is approximately

$5

including sales tax. This does not include the cost of miscellaneous items.

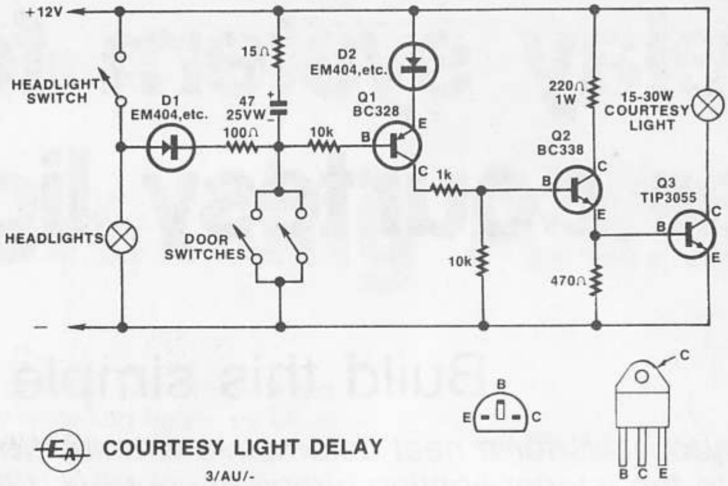
PARTS LIST

1 TIP3055 NPN transistor
1 BC338 NPN transistor
1 BC328 PNP transistor
2 IN4001 or similar silicon power diodes
1 47uF/25VW electrolytic capacitor
1 PCB, 87 x 38mm, code 79d10
5 PC pins

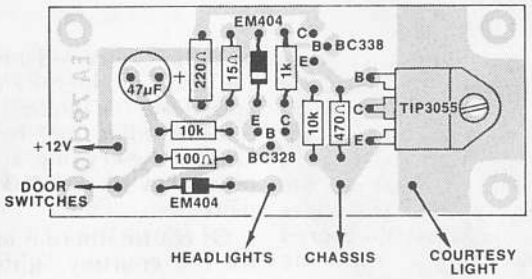
RESISTORS
¼ or ½ watt unless specified
1 x 15 ohm, 1 x 100 ohm, 1 x 220 ohms 1W, 1 x 470 ohms, 1 x 1k, 2 x 10k

MISCELLANEOUS
Hookup wire, 3A fuse and fuseholder, stand-off pillars, machine screws and nuts, automotive connectors, etc.

Note: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.



The circuit uses three low-cost transistors and provides a delay time of approximately 20 seconds. The delay time can be altered by changing the 47uF electrolytic capacitor (see text).



The component overlay diagram. Make sure that all polarised components (transistors, diodes, capacitor) are inserted the right way round.

HOW IT WORKS

Refer now to the circuit. It's really very simple, and uses just three transistors and a handful of other components. It works as follows:

Assuming initially that all switches are open and that the 47uF electrolytic capacitor is discharged, there will be no forward bias on the base of Q1 and no collector current through this transistor. This, in turn, means that both Q2 and Q3 are also held off because Q2 receives no forward bias from Q1.

The 10k and 470 ohm resistors in the base circuits of Q2 and Q3 respectively ensure that these transistors are held completely off, in these conditions.

When one of the door switches is closed (ie, the car door is opened), the 12V supply is connected to the 47uF capacitor via a 15 ohm resistor. The purpose of the resistor is simply to limit the initial charging current through the capacitor to a reasonable level and prevent damage to the door switches. In spite of it, the capacitor charges almost instantaneously.

Regardless of the time needed for the capacitor to charge, Q1 is forward biased immediately the switch closes due to the very low internal impedance of the battery. Initially, the full voltage appears across the 15 ohm resistor then, as the capacitor charges, progressively across the latter until it is fully charged.

With forward bias applied, Q1 conducts, turning on Q2 and Q3 and switching on the courtesy light. When the door switch opens the charge on the 47uF capacitor maintains the forward bias on Q1 until it is discharged. When the capacitor discharges the forward bias to Q1 is removed, Q2 and Q3 turn off, and the courtesy light goes out.

So long as the headlight switch remains open, the capacitor can discharge only through the 10k resistor and the base/emitter junction of transistor Q1. It cannot discharge through the 100 ohm resistor and the headlight circuit because diode D1 is reverse biased. With the capacitor value shown, the courtesy lights should remain on for about 20 seconds.

The delay time can be altered simply by changing the value of the capacitor. As you may expect, the relationship between capacitance and delay time is linear. To increase the delay time to 40 seconds, for example, all you have to do is double the value of the capacitor — 100uF is the nearest preferred value.

Similarly, the delay time can be decreased by decreasing the capacitor value.

Diode D1 and its associated 100 ohm series resistor form the headlight interlock circuitry. If the headlights are turned on during the delay time, diode D1 becomes forward biased and provides a low resistance discharge path for the capacitor which discharges almost instantaneously. The 100 ohm resistor limits the current through the diode to a safe value.

The reason for the inclusion of diode D2 will not be obvious at first glance. Basically, it has been included to ensure that Q1 and the other transistors turn off completely once the 47uF capacitor is discharged.

Because of the presence of D1, the headlight switch cannot discharge the 47uF capacitor below the forward conduction voltage of the diode, about 0.6V. In practice it can be higher than this due to voltage losses along the headlight lead wiring, depending on where the circuit is tapped into the car's electrical system. Thus it could be that the headlight interlock circuit may not discharge the capacitor below 0.8V or even 1V, at which level it is still capable of holding Q1 in conduction, albeit at a low level.

While the capacitor will discharge eventually the courtesy lights would not go out immediately as required. Diode D2 overcomes this problem. By including it in the emitter circuit of Q1, the voltage required to forward bias the transistor is raised by the junction voltage of the diode (0.6V approx). This means that the voltage at which the transistor will cease conducting is raised to about 1.2V.

CONSTRUCTION

Construction should present no difficulties, even for the beginner. The circuit is all contained on a small printed circuit board measuring 87 x 38mm and coded 79d10. Assemble all of the components onto the board as shown in the overlay diagram, making sure that you insert the transistors, diodes and electrolytic capacitor the right way round. We used PC stakes to facilitate external connections to the board.

No heatsink is required for the TIP3055 power transistor, at least not for loads up to 30W. The saturation voltage of Q3 is quite low at about 0.2V, so that even when connected to a 30W load the transistor only has to dissipate 0.5W. You should find that for loads of less than 30W, the TIP3055 will run slightly warm to the touch, even when the car door is held open for extended periods.

Note that Q3 should be mounted flat against the PC board and secured with a small machine screw and nut. A modest amount of heatsinking is provided by the copper pattern on the reverse side of the board.

Note also that the circuit can be operated with loads exceeding 30W, provided that Q3 is fitted with an adequate heatsink. For loads up to about 45W, a small flag-type heatsink should suffice.

Fitting an extra unit of any kind to a car often involves as much or more effort as making the unit, particularly if one is not familiar with the wiring. However, in this case the job should not be too difficult.

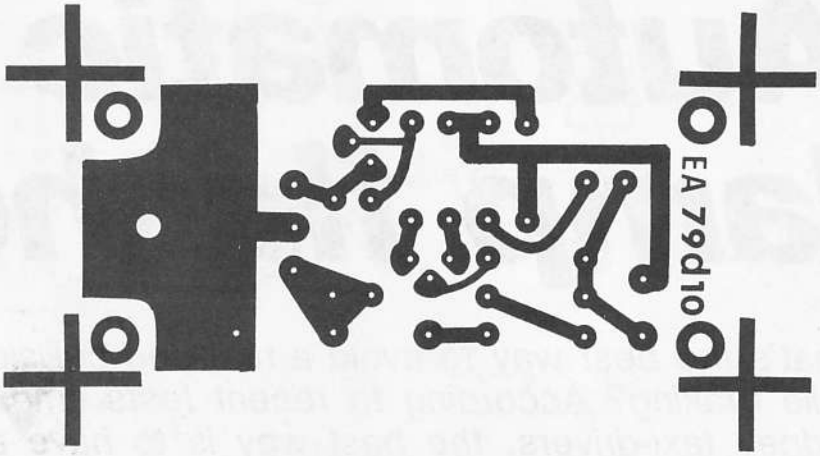
The leads from the door switches are usually found coming over the top of the trim panels forward of the front doors, while the courtesy light lead(s) are usually run up the inside of the windscreen pillar. Assuming that the headlight switch can be easily removed, connections to the headlight circuit are most logically made direct to the switch terminals.

Make sure that the +12V supply is derived from the active side of the switch.

In some cars, however, removal of the headlight switch can be a major undertaking. If this is the case, the +12V supply can be picked up from the fuse panel and the connection to D1 picked up from the headlight dipper circuit. A 3A fuse should be included in the positive supply line to provide protection in the event of circuit malfunction, and all connecting wires should be of reasonably heavy current capacity. Use 23 x 0.19mm cable or heavier.

As to the best place to mount the PC board, that will largely depend on the type of car you own. The most obvious place is somewhere under the dashboard or, alternatively, on the firewall.

Having completed the installation, the unit can be given a final checkout. Check to see that the courtesy lights go out at the end of the delay time, that they go out immediately the headlights are turned on, and that the courtesy light switch on the dashboard still functions in the normal way. You should also check the temperature of the TIP3055 power transistor after the car door has been left open for an extended period, say five or 10 minutes. If it becomes too hot to touch, it should be fitted with a heatsink.



Actual size reproduction of the PC artwork.

ERRATA

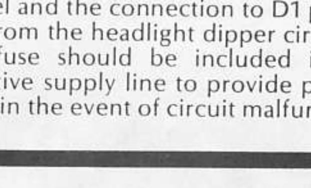
COURTESY LIGHT DELAY (January, 1980: File No. 3/AU/23): the 100 ohm resistor in series with D1 may overheat when the door switches are closed and the headlights are on. This can be remedied by substituting a 680 ohm ½W resistor.

BRIGHT IDEA

6V Car Adaptor

The requirement for a 6V supply in a car with a 12V battery is easily met with this simple discrete-component circuit. Q1 is an emitter-follower with a 6.8V reference provided by the one-watt zener diode. The base-emitter voltage of Q1 is subtracted from the reference to give a nominal output of 6.1 volts.

The 120Ω resistor feeding the zener diode limits the current available to the base of Q1 and thus sets the regulation performance. It also renders Q1 proof against momentary short circuits. Q1 will deliver about one amp or so and should be mounted on a suitable heatsink.



M. Sully,
Keilor Downs, Vic.

Add this safety feature to your car

Automatic brake lamp flasher

What's the best way to avoid a rear-end collision while braking? According to recent tests among Sydney taxi-drivers, the best way is to have an additional flashing stop-lamp installed on the parcel shelf. This project fulfils that requirement.

by COLIN DAWSON

The circuit described here will flash a set of accessory lamps three times each time the brakes are applied and hold them on after that while ever the brake pedal remains depressed.

Installation is easy. Only two connections are required to the existing wiring — one to the brake lamp line and the other to the chassis.

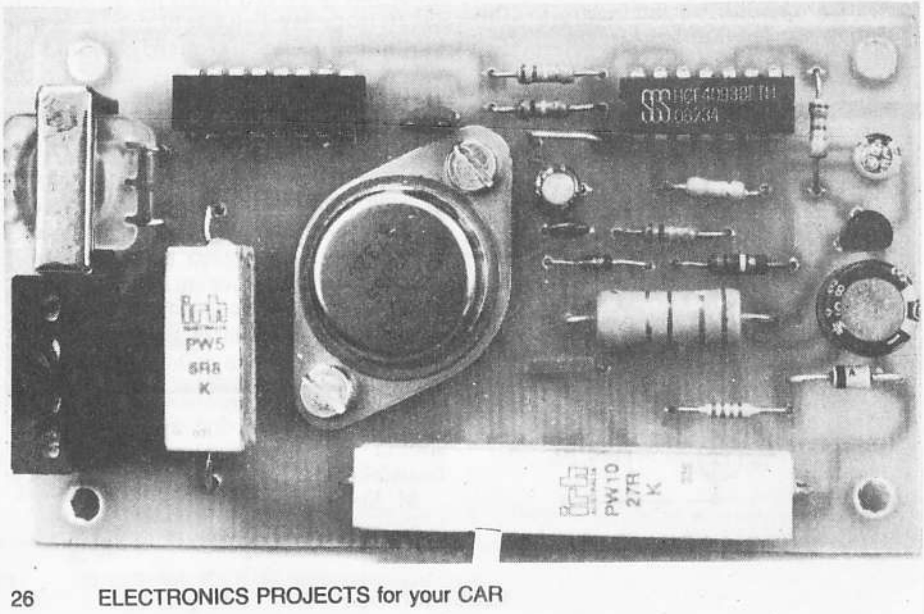
Except for the accessory lamps, the project is completely self contained on a small printed circuit board. This could easily be mounted under the rear parcel shelf of a sedan — even most hatchback cars would have some suitable "nook".

We are, of course, aware of various other schemes for flashing accessory brake lamps. Most simply flash the lamps continuously while ever the brakes are in use, although at least one has the added refinement of altering the flash rate in proportion to braking effort. The problem with this arrangement is that following motorists only need the first few flashes to attract their attention. After that, the device only serves to irritate, and an irritated driver can easily become an aggressive one.

Our circuit overcomes this problem by including a "delay" feature. This effectively causes the circuit to wait five seconds after the brakes have been released before it is re-armed. Any brake application during this period will cause the accessory lamps to operate without flashing. For bumper-to-bumper driving where brake release may only last for a few seconds, the accessory lamps will function just the same as ordinary brake lamps.

The project could, in fact, be used without any additional brake lamps. For cars with two pairs of brake lamps such as Commodores and Falcons, one pair could be modified to flash. This may not be as effective as fitting eye level lamps, but it would be cheaper.

Below is a larger-than-life size of the assembled PCB.



The circuit

The main components in the circuit are a 4093 quad NAND gate with Schmitt trigger inputs, a 4017 decade counter and three transistors. These components may be considered as three main functional elements: a clock, a counter (incorporating the delay) and the lamp driver section.

The circuit basically works as follows. When the brake pedal is pressed, the circuit is energised. This starts the clock which drives the transistor lamp driver section, flashing the accessory lamps on and off. This continues until the counter section counts up to four, after which the accessory lamps are turned on continuously, as long as the brake pedal is depressed.

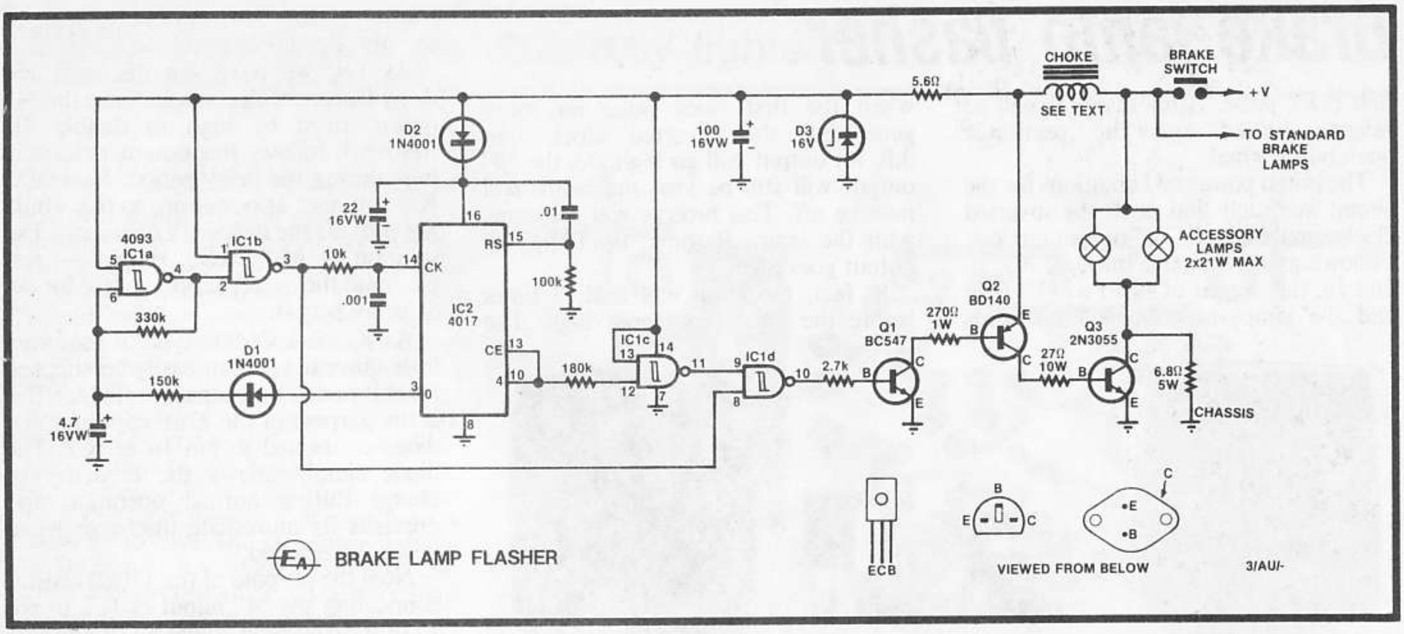
To gain a better understanding of the circuit, let's look more closely at what the 4017 does.

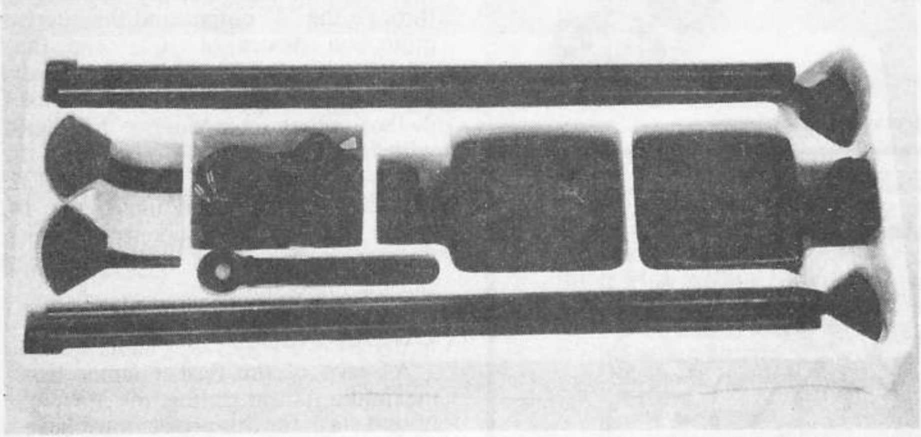
A 4017 decade counter is a device with ten outputs, numbered 0 to 9. Normally, each output goes high, in sequence, for one complete clock cycle. This mode of operation can be overridden by either Clock Enable (CE, pin 13) or Reset (RS, pin 15). CE

We estimate the current cost of parts for this project to be approximately

$16-20

This includes sales tax, but not the cost of accessory brake lamps.





This accessory brake lamp kit comes with all the necesssary hardware for installation on the rear parcel shelf. It cost us less than $20 (from BBC Hardware).

prevents further counting when it is taken to logic high and RS sets the counter outputs to zero when it is taken high.

Notice that the Reset pin has a 100kΩ resistor and a .01μF capacitor connected to it. These two components form a power-on reset circuit. Whenever power is applied to the IC, it automatically resets to the zero count. Notice also that the "4" output (pin 10) is connected to the Clock Enable input (pin 13). This means counting ceases once the "4" output goes high.

The "4" output of IC2 is also connected to pin 12 of IC1c by means of a 180kΩ resistor. For the moment, ignore the resistor and assume that the connection is direct. IC1c simply functions as an inverter so that its output (pin 11) is low only after the "4" count has been reached.

Pin 11 of IC1c is connected to pin 9 one of the inputs of IC1d. Pin 9 acts as a control for this gate — whenever it is low, the output (pin 10) will be high. While ever this condition prevails, the lamps will be permanently on.

Until the "4" output (and hence pin 9 of IC1d) goes high, the output of IC1d will be determined by the logic state of it's other input, pin 8. As pin 8 of IC1d is connected back to the inverted clock output (pin 3, IC1b), it now becomes necessary to examine the operation of the clock in detail.

The frequency of the oscillator based on IC1a is set by the 4.7μF capacitor and 330kΩ resistor at about 1.5Hz. During normal operation, the charge on the 4.7μF capacitor will swing over a range equal to the hysteresis voltage. This might typically be between + 6V and +8.5V for a 4093 made by National Semiconductor.

Unfortunately, when the circuit is first powered up, the 4.7μF capacitor must charge from 0V to the normal operating range. This, of course, would mean that the first clock cycle takes much longer than normal.

As we want the accessory lamps to begin flashing as soon as the brakes are used, an extended first clock cycle is undesirable. As a means of preventing it, the capacitor is "fast charged" by an auxiliary circuit. This consists of D1 and the 150kΩ resistor connected to the "0" output of IC2.

When power is first applied the "0" output is high and D1 permits current to flow into the capacitor. Remember, the "0" output will only be high until the

PARTS LIST

1 PCB, code 84au9, 101 × 60mm
1 4-way PCB-mounting terminal block
1 Automotive noise suppression choke (DSE Cat. L-1900)
2 21W automotive stop lamps (see text)

Semiconductors

1 4017 decade counter IC
1 4093 quad Schmitt NAND IC
1 BC547 NPN transistor
1 BD140 PNP transistor
1 2N3055 NPN transistor
2 1N4001 diodes
1 16V/1W zener diode

Capacitors

1 100μF/16V electrolytic
1 22μF/16V electrolytic
1 4.7μF/16V electrolytic
1 .01μF metallized polyester (greencap)
1 .001μF greencap

Resistors (5%, ¼W unless noted)
1 × 330kΩ, 1 × 180kΩ, 1 × 150kΩ, 1 × 100kΩ, 1 × 10kΩ, 1 × 2.7kΩ, 1 × 270Ω/1W, 1 × 27Ω/10W, 1 × 6.8Ω/5W, 1 × 5.6Ω

Miscellaneous

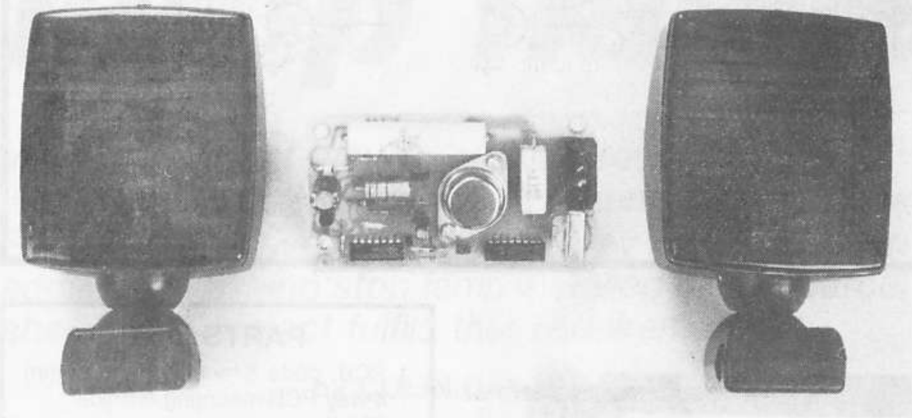
Machine screws and nuts, automotive hookup wire, solder etc.

Brake lamp flasher

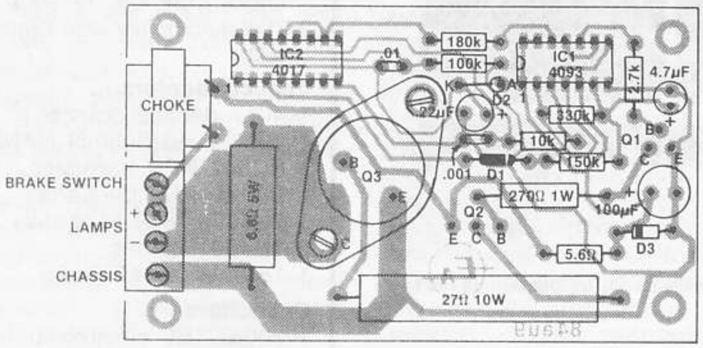
first clock pulse. After that, D1 will be reverse biased and the oscillator operation normal.

The initial power-on conditions for the circuit are such that both the inverted clock signals and the "4" output are low. Following these inputs through ICs 1b and 1c, the output of IC1d will be high and the lamps on. Shortly afterwards when the first clock pulse has been generated, the inverted clock (pin 3,IC1b) output will go high. As the "4" output will still be low, the lamps will now be off. This process will continue, with the lamps flashing, until the "4" output goes high.

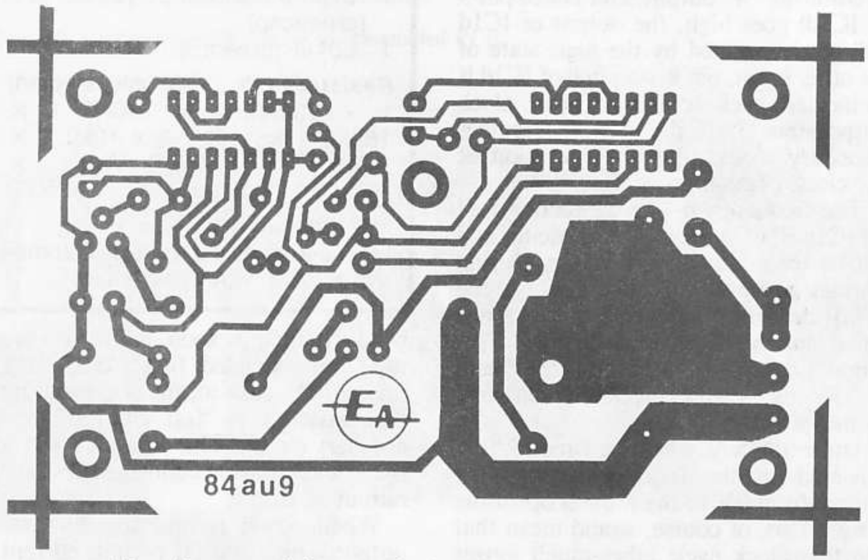
In fact, the lamp will flash 3 times before the "4" output goes high. The fourth "flash" will continue as long as the brake pedal is depressed.



This view shows the PCB together with the two accessory lamps.



Follow this parts placement diagram when wiring up the Brake Lamp Flasher. The suppression choke should be secured to the PCB using epoxy adhesive.



Above is an actual size reproduction of the printed circuit artwork.

As yet, we have not discussed the delay feature of the circuit. Since the "4" output must be high to disable the flasher, it follows this output must stay high during the delay period. Normally, IC2 will reset at power-on, so this would not provide the necessary operation. The solution is really very simple — just maintain the power supply to IC2 for the 5s delay period.

As IC2 is a CMOS type, it uses very little current and can easily be supplied for this period by a capacitor. In fact, this is the purpose of the 22μF capacitor and diode connected to pin 16 of IC2. The diode simply allows the capacitor to charge during normal operation and prevents its immediate discharge when power is removed.

Now the purpose of the 180kΩ resistor connecting the "4" ouput of IC2 to pin 12 of IC1c becomes apparent. It prevents the capacitor from rapidly discharging through the "4" output and the internal protection diodes of IC1. The time constant is virtually determined by the 22μF capacitor and the 180kΩ resistor.

Two other components associated with IC2 should also be mentioned: the 10kΩ resistor and shunt .001μF capacitor at the clock input, pin 14. These are filter components which prevent hash on the clock line from causing mis-counting.

Output stage

As each of the flasher lamps has a maximum power rating of 21W, the output stage for this project must have a nominal current rating of nearly four amps. To achieve this level of drive from the CMOS output, three stages of current gain are needed. The first consists of an NPN BC547 transistor (Q1). This drives a PNP BD140 (Q2) which drives the final stage, an NPN 2N3055.

Current through the 270Ω base resistor of Q2 is about 45mA, which means that this resistor must have a power rating of 1W. Similarly, the 450mA base current of Q3 dictates that its base resistor must have a 10W rating. For periods of extended brake usage, this resistor will become quite hot.

There is another power resistor in the circuit — a 6.8Ω/5W resistor connected across Q3. This is simply a "heater" for the lamps. It maintains a filament current of about 750mA per lamp in the period between flashes. Whenever the lamps are fully on, most of the current flows through Q3 and the 6.8Ω resistor has very little effect.

To prevent ignition and alternator noise from upsetting the logic, we found it necessary to include a noise suppression choke. This is included in the brake switch line to the circuit.

In the event that this choke should fail to suppress some high voltage spikes sufficiently, a 16V zener diode in conjunction with a 5.6Ω resistor will protect the circuit from the damage.

Construction

In contrast to most automotive projects, this one is quite simple to construct and install. We have not mounted the project in a box, so construction simply amounts to soldering the printed circuit board components in place. The PCB measures 101 × 60mm and is coded 84au9.

Location of the board will depend on the type of car, although it should be somewhere towards the rear of the vehicle. This will be close to both existing brake light wiring and the new lights.

Begin soldering with the smaller components, then move on to the larger devices. The suppression choke should be held in place with some epoxy adhesive once its leads have been soldered.

Note that the accessory brake lamps must connect back through the appropriate terminal on the PCB — they cannot simply be connected to the vehicle chassis.

On Commodores and Falcons, where one pair of standard brake lamps can be used as "flashers", a small amount of modification to the vehicle wiring will be necessary. Usually, one pair of lamps will be dual filament — one filament for the tail light and one for the brake light. The other bulb(s) will usually only be single filament types. These are the ones to use with the flasher.

The chassis connection to the single filament bulbs must be broken. A Commodore which we inspected had the single filament brake lamps mounted on a plastic "card" with pressed wiring. This card was shared with the reversing lamp. To use the brake lamp as a flasher, the pressed wiring track will have to be cut. Make sure that the chassis return to the reversing lamp is not broken — you may have to make a new connection after cutting the track.

Once the chassis connection to the single filament bulb has been broken, make a new connection from the bulb to the flasher "Bulb -ve" output on the PCB. The "Bulb +ve" output of the flasher PCB need not be used as +V will be supplied to the bulb by the brake lamp switch in the normal manner.

Testing this project is simply a matter of operating it normally. Due to components tolerances, the flash rate might not be ideal. This can easily be altered by changing the value of the 330kΩ resistor associated with IC1a. Should the initial flash be of incorrect duration, alter the value of the 150kΩ resistor connected to D1.

BRIGHT IDEA

Automatic brake lamp flasher

I constructed the Brake Lamp Flasher as described in the November 1984 issue. When tested using direct leads from the battery, it functioned as it should have although I had to reduce the 300kΩ resistor to 150kΩ to obtain the correct flash rate. The rearm period was approximately 15s which I deemed acceptable.

I then installed it in the vehicle, taking a lead from the appropriate connection to the brake light. On applying the brakes, all four lights came on, but none flashed. Back to the workbench.

It appeared that pin 16 of the 4017 did not go low enough (even overnight) to rearm the circuit — only by momentarily shorting pin 16 to ground would the lights flash. I tried a lower value (10μF) capacitor but this did not help so I simply connected a 150kΩ resistor from pin 16 of IC2 to ground. This, together with the 10μF electrolytic capacitor, gave a rearm period of approximately 10s which was quite acceptable.

The circuit was then re-installed in the vehicle where it has functioned perfectly ever since.

Not being familiar with the internal circuitry of the 4017 and IC1c, I am unable to explain why the 22μF electrolytic did not discharge sufficiently through the 180kΩ resistor to rearm the circuit as stated in the text. Nor can I explain why the circuit worked when connected directly to the battery but not when connected to the brake light.

I wonder if any other readers have encountered this problem or whether you are able to offer any explanation? (F.H., Ardross, WA.)

• Although we haven't encountered it before, we suspect a reset problem with the 4017 due to the 22μF and .01μF capacitors not discharging completely. If the .01μF capacitor is partially charged, pin 15 of the 4017 will not be pulled high enough for resetting to occur. As you have found, connecting the 150kΩ resistor between pin 16 and ground provides an effective cure.

ERRATA

BRAKE LAMP FLASHER (November 1984, File 3/AU/42): in some circuits, there may be a reset problem with the 4017 (IC2). If this happens, the accessory lamps will not flash but will stay on whenever the brake pedal is depressed. This problem may be cured by connecting a 150kΩ resistor across the 22μF capacitor.

Simple safety device for your car:

Audible Reversing Alarm

Are you worried about possible dangers to children and others when reversing your car? Do you feel that ordinary reversing lights, as fitted to most cars, are not a sufficient warning to pedestrians? If so, you may consider fitting an extra audible alarm to your car, to give a more noticeable indication that you are reversing.

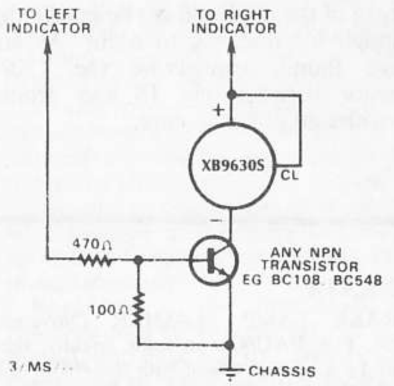
by DAVID EDWARDS

First and foremost, readers and motorists should realise that when reversing their car, the onus is on them to avoid all collisions and dangerous situations. In particular, when crossing the footpath, pedestrians have right of way. This applies whether the car is reversing or moving forward normally.

As part of the design rules for Australian cars, all new cars must be fitted with visual reversing indicators. These can be either separate white lights, or the amber indicator lights. In either case, they must come on when reverse gear is selected, and the ignition is on.

This requirement has been in force for some time, so that the majority of cars now on the road are fitted with one or other of these warning systems. In general these systems are adequate, and do not require supplementing.

However, situations do exist when some form of additional indication is warranted. Perhaps the most obvious example is that of a car reversing from a garage across the footpath and onto the



AUDIBLE REVERSING INDICATOR

Note that this circuit is suitable only for negative earth cars which use the indicator lights as reversing lights. See text for details on other types of cars.

street. The possibility exists, especially in daylight, that pedestrians may not see the reversing lights, or hear the car itself.

In these situations, the car driver may not be able to see the pedestrians either, and so there is a chance that the pedestrian may be knocked down and injured. The fact that the driver was not able to see the pedestrian does not absolve him from blame; the law requires that he exercise the necessary care required to prevent such accidents.

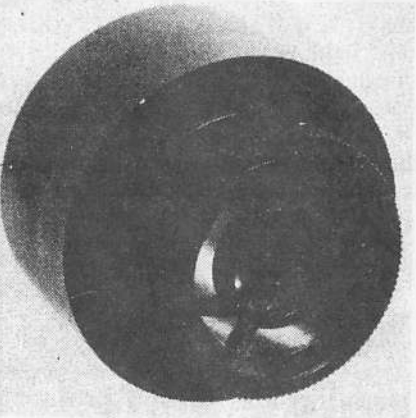
One possible solution to this problem is simply to reverse into the garage, rather than out of it. This means that when leaving the garage the driver will have much better vision, and that he has a clear, unobstructed view when reversing into the garage.

In some cases, however, this course of action is not practicable, and the car must be reversed from the garage. In these situations, a majority of pedestrians who realise that the car is about to reverse will yield right of way, even though they are not required to by law. The car driver must still be vigilant, however, as not all pedestrians may see and act upon the normal reversing light indications.

It is in these situations that it can be worthwhile to have an additional indication that the car is reversing. One quick and simple way of doing this is to operate the car horn briefly. This is a universal sound that is usually acted upon promptly by pedestrians.

Blowing the horn does require conscious action from the driver, which may not always be carried out. In addition, car horns tend to produce extremely loud sounds, which may not be appreciated by those in the vicinity. What is really required is a softer sound which will operate automatically.

This can be done quite simply by wiring a suitable sound source in parallel with the reversing lights. Such a sound source should be cheap, robust and easy to fit. Completely solid state piezoelectric transducers fit this bill completely.



Shown above is the solid state piezoelectric transducer, which forms the basis of the alarm.

A device of this type is available from C & K Electronics (Aust) Pty Ltd: the AudioLarm XB9630S continuous tone/beep unit. It operates at voltages from 5 to 30VDC, giving an output sound level of 94 to 104dB. Operating frequency is a nominal 2900Hz. The unit is sealed into a plastic case, with two tin-plated screw type terminals. Current consumption is less than 100mA.

The unit is sealed into a plastic case, with two tin plated screw type terminals. A third control lead simply emerges from the potting compound at the rear. If this lead is connected to the negative terminal, the unit operates continuously. But if it is connected to the positive terminal, the unit beeps with a duty cycle of about 70%. Current consumption is less than 100mA in both modes.

The AudioLarm has diode protection against reverse polarity. It will operate over a temperature range of −20 to +65 degrees C. It will continue to operate even when submerged in water (we tried it!), and it cannot be damaged by sharp objects entering the grill. The unit is mounted onto a panel from the rear, using a 28mm dia. hole and the supplied retaining rim.

The remaining problem then is simply how to connect the unit into the wiring system of your car. If your car is fitted with separate reversing lights, then all you have do is find the appropriate wire, and connect the AudioLarm between it and the car chassis, with appropriate polarity. If your car has a negative earth system, connect the negative lead from the unit to the chassis, and the positive and control leads to the wire.

For positive earth cars, simply reverse the leads from the AudioLarm. We should mention that the unit will only operate satisfactorily with 12V cars. With 6V systems, the sound produced is too low to be of use.

Cars which use the rear indicator lights for the reversing lights pose a slightly harder problem as far as interconnection is concerned. The AudioLarm could be connected across the reversing switch, but this would involve running additional wiring from the front of the car to the rear, where the unit is best mounted. If you feel capable of finding the switch, and sorting out which leads are the correct ones, as well as running the extra wires, go ahead by all means.

However by simply adding a single transistor it is still possible to keep all wiring in the boot area of the car. The circuit, which is shown in the diagram, functions as a simple AND gate. Any small general purpose NPN transistor can be used.

In order for the AudioLarm to be energised, both left and right indicators must be on. If either one is on alone, such as when the direction indicating system is in operation, the unit will not sound. If a disabling switch is required, it should be connected in parallel with the 100 ohm resistor. This will keep the switch contacts wetted, and ensure reliable operation.

If the car is fitted with a hazard warning system, the alarm will operate when this system is used. It will be pulsed on and off in sympathy with the hazard lights. If your car has a positive earth electrical system, use a PNP transistor, and reverse the connections to the alarm unit.

The transistor and associated components can be mounted on a small piece of tagstrip, and placed in any convenient position inside the boot. The alarm unit itself should be mounted in the vicinity of the rear bumper bar, facing downwards so as to minimise the chance of dirt or other foreign materials clogging the grill. Ideally it should be mounted so that it will not be struck by stones flung up by the road wheels, and so that it cannot be easily seen.

So there you are: a simple and easily installed audio alarm system, to supplement the normal reversing light indicators. Using a minimum of parts, it should be very reliable in operation.

Don't trip over the dog! Build the

Driveway Sentry

There's no need to trip over the family dog when you come home late at night. Activated by your car's headlights, this Driveway Sentry Mk. 2 automatically turns on an outside light so that you can make it safely into the house.

by COLIN DAWSON

Our original Driveway Sentry was described in EA (Dec. 82) and became a popular project. Unfortunately, the circuit provided readers with quite a few headaches as it was prone to false triggering. The Driveway Sentry Mk.2 employs a completely new circuit that very effectively eliminates this problem.

In developing this new circuit, our aim was to make it as easy as possible for readers to upgrade to the new design. The new Mk.2 version uses the same case, transformer, relay and sensors as the original version, so the cost of the upgrade is relatively cheap. All the constructor has to do is assemble and substitute a new PC board that uses a handful of low-cost parts.

For those readers who didn't see the original article, let's briefly recap on the basic concept. Most of us, when we arrive home late at night, are faced with the problem of negotiating our way from the garage to the house in total darkness. Along the way, there is always the chance of tripping over an unexpected toolbox, bicycle or dog before we've reached a lightswitch.

Of course, some readers may face more serious problems once inside the house but these problems are usually of a more personal nature.

The Driveway Sentry can't solve your personal problems but it can stop you from tripping over the dog. It uses a light dependent resistor (LDR) to detect your car's headlights and then it automatically switches on an exterior light. At the end of a four minute period, it switches the light off again.

Operation of the Driveway Sentry is completely automatic. A second LDR is used to sense the level of ambient light so that the circuit is inhibited during daylight hours. The circuit is powered, via a transformer, from the same supply as the exterior light and consumes minimal power in the untriggered state.

A useful feature of the circuit is the external trigger switch. This can be mounted remotely and used to turn the exterior light on so that you can walk from your door to the car. The Driveway Sentry will then automatically turn the light off after you have driven away.

The manual switch is also handy for brief nocturnal excursions to the garage, verandah or other venue. Essentially, it causes the circuit to function as a simple timer for the lamp.

Unlike the original circuit, the cancel switch has been deleted from this latest design.

How it works

Whereas the original design was based on a 555 timer IC, the Mk.2 version uses two CMOS ICs: a 4060 14-stage binary counter and a 4011 quad NAND gate. This overcomes the difficulties experienced with the earlier version which were due to reset problems within the 555.

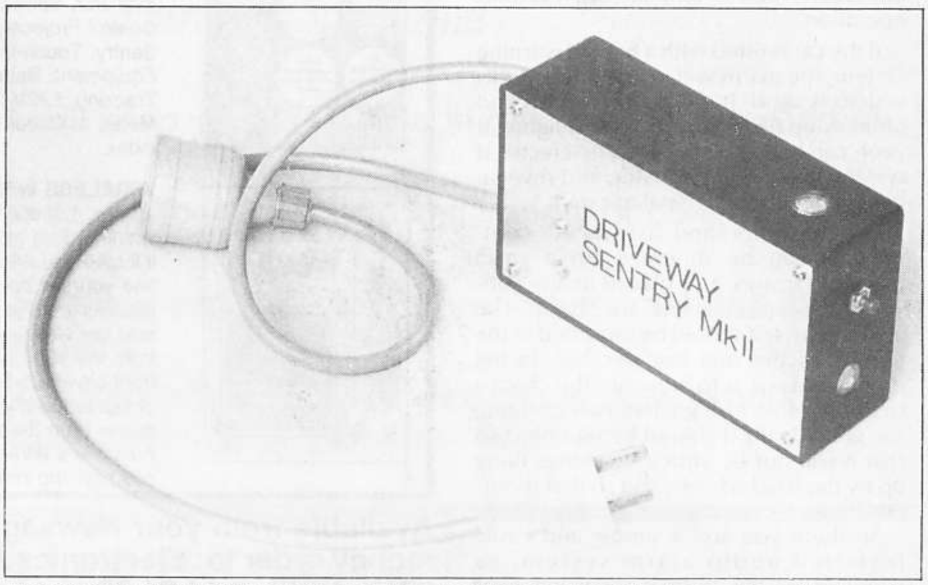
Essentially, the circuit can be broken into two distinct sections, each based on one of the two ICs. The 4011, in company with two light dependent resistors (LDRs), provides detection and control triggering while the 4060 provides the timing function.

Let's examine the timer section first. The 4060 CMOS IC is ideally suited to this role. Basically, it divides the clock pulses on its pin 11 input by 2 raised to the power of 14, or 16,384. This means that the Q14 output goes high after 8192 clock pulses and then goes low again after another 8192 pulses to complete the timing cycle.

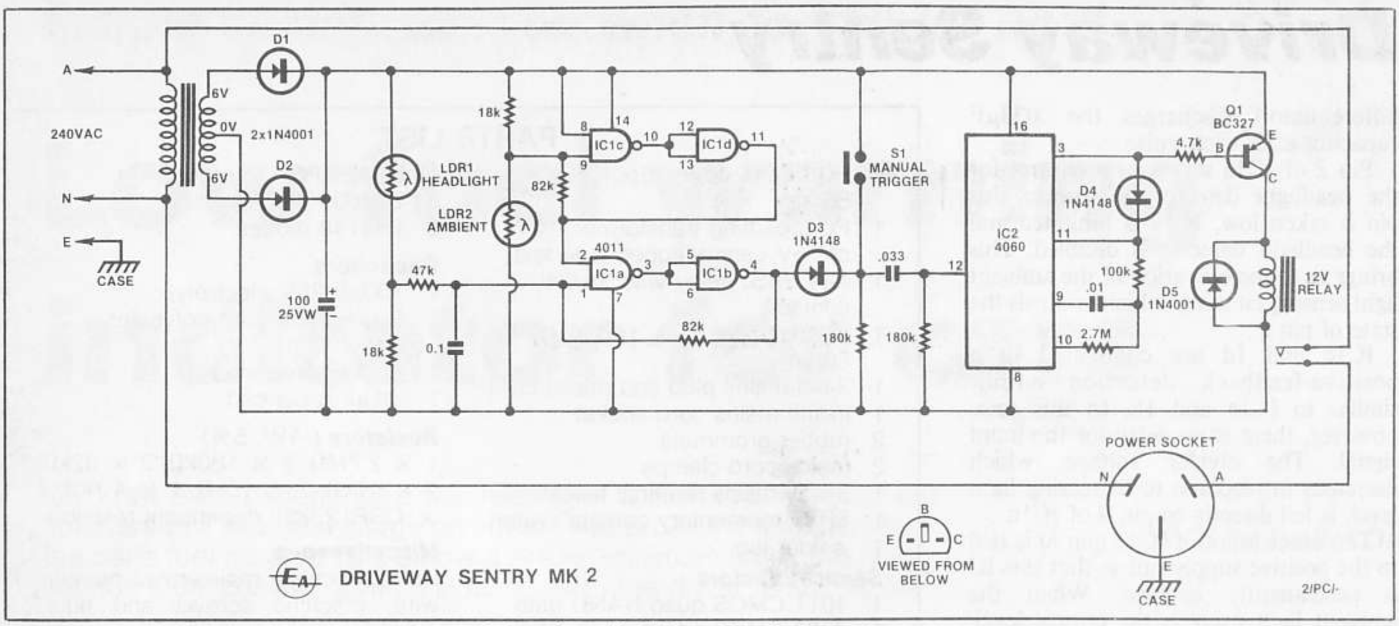
A number of intermediate outputs (Q4 to Q13) are also available on the 4060 but these are not used in this circuit. Instead, the 4060 is configured so that it stops counting after the Q14 output (pin 3) goes high.

Pin 3 of the 4060 drives a PNP transistor which, in turn, controls the relay. This means that the lamp is on while ever Q14 is low; ie, from the start of counting until the positive transition of Q14.

Included in the input circuitry of the 4060 are several inverter stages with outputs available at pins 9 and 10. This is a particularly useful feature as it enables the input section to be configured as a 2-gate oscillator to provide clock pulses



The Driveway Sentry Mk.2 uses the same case, transformer, relay and sensors as the original version, Note mounting arrangement for the LDRs.



IC1 and the two LDRs provide detection and control triggering while IC2 provides the timing function.

for the counter circuitry.

The 0.1μF capacitor and 2.7MΩ resistor on pins 9 and 10 are the timing components for the clock. These set the clock frequency to about 32Hz which means that pin 3 of IC2 (4060) goes high for just over four minutes.

Note the diode (D4) connected between pin 3 and the clock input (pin 11). When pin 3 of IC2 goes high, this diode pulls pin 11 high and stops the clock. This step is necessary otherwise IC2 would continue to count, with pin 3 alternately going high and low at four minute intervals.

The only way another timing cycle can be initiated is to reset IC2 by momentarily pulling the reset pin (pin 12) high. This is the function of the detection and triggering ciruitry based on IC1.

Detection and triggering

Light detection is performed by the two LDRs which are connected in series with 18kΩ resistors across the supply rails. The voltage at the midpoint of each divider (ie, at the resistor-LDR junction) thus varies in proportion to the amount of light falling on the LDR. When LDR1 senses the headlights, the voltage at the junction goes high.

Conversely, when LDR2 senses a high ambient light level, the voltage at the junction is pulled low.

During daylight, the ambient light detection circuitry inhibits the headlight detection function. Let's assume, however, that LDR2 is in darkness and that pin 2 of IC1a is high.

IC1a functions as the detector for the headlight sensor. Note, however, that the voltage divider output is not applied directly to IC1a. Instead, it first passes through a delay circuit consisting of a 47kΩ resistor and a 0.1μF capacitor. This circuit provides sufficient delay to prevent the circuit from triggering on lightning flashes.

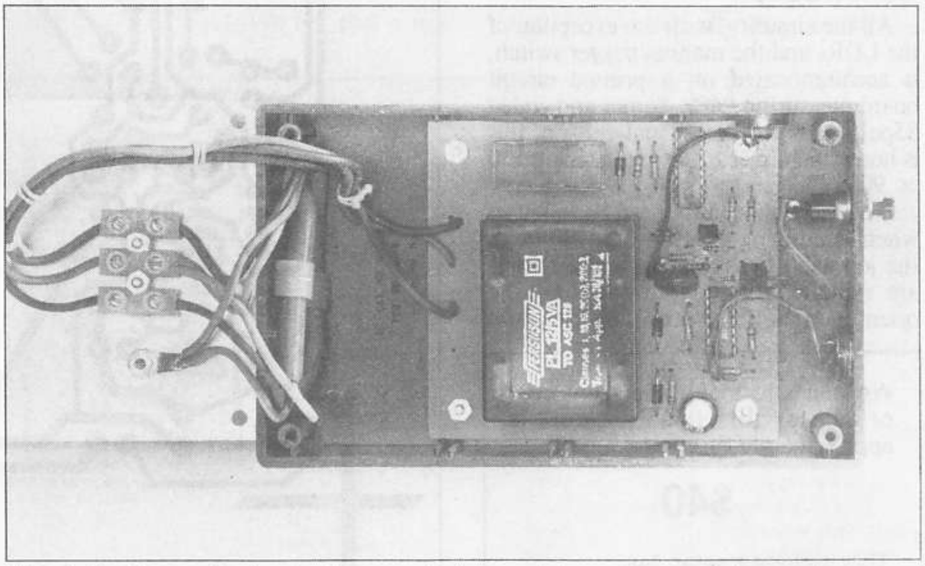
Ideally, the detectors monitoring the voltage dividers would consist of devices using Schmitt trigger inputs. This form of detection is necessary to prevent erratic operation when marginal triggering or inhibit conditions exist. Unfortunately, Schmitt input NAND gates have become rather scarce lately so the Driveway Sentry uses ordinary NAND gates set up to operate as Schmitt triggers.

To make ordinary NANDs operate as Schmitts, they need to be provided with positive feedback. Since NANDs are inverting gates, positive feedback cannot be arranged simply by connecting the output back to the input. Instead, another inversion of the NAND output must be carried out and this signal fed back to the input.

IC1b performs this second inversion for the headlight sensing circuit. Its output (pin 4) is connected back to the input (pin 1) via an 82kΩ resistor to provide about 200mV of hysteresis.

Operation of the detector circuit is quite simple. When LDR1 detects the car's headlights, pin 1 of IC1a goes high, pin 3 goes low and pin 4 of IC1b goes high. This high is applied via D3 to a differentiator network (.033μF and 180kΩ) which delivers a positive-going pulse to pin 12 (reset) of IC2.

Diode D3 serves to isolate IC1b from the manual trigger switch (S1). When operated, S1 connects the differentiator input to the positive supply rail to simulate detection. The second 180kΩ resistor (connected to the input of the



View inside the completed unit. The manual trigger switch may be mounted remotely at some convenient location, or deleted if not required.

Driveway Sentry

differentiator) discharges the .033μF capacitor after each pulse.

Pin 2 of IC1a serves as a control for the headlight detector. Whenever this pin is taken low, IC1a is inhibited and the headlight detector is disabled. This brings us to the operation of the ambient light-sensing circuitry which controls the state of pin 2.

IC1c and 1d are configured in a positive-feedback detection circuit similar to IC1a and 1b. In this case, however, there is no delay for the input signal. The divider voltage, which decreases in response to increasing light level, is fed directly to pin 9 of IC1c.

The other input of IC1c (pin 8) is tied to the positive supply rail so that this IC is permanently enabled. When the ambient light exceeds the critical level, the output of IC1d (pin 11) switches high and the headlight detector circuit is disabled.

All this means in practice is that the circuit is automatically disabled during daylight hours. Note, however, that the manual trigger function operates at all times.

Power for the circuit is supplied from a centre-tapped transformer with either a 12V or 15V secondary. This transformer drives a full-wave rectifier circuit (D1 and D2) while a 100μF capacitor provides the necessary filtering. The resultant DC supply will be either about 10V for a 12V transformer or about 12V for a 15V transformer.

The transformer, by the way, is a PC-mounting type. Any one of the following types may be used: Ferguson PL12/5VA, Ferguson PL15/5VA, Arlec AL7VA/12 or Arlec AL7VA/15.

Construction

All the circuitry, with the exception of the LDRs and the manual trigger switch, is accommodated on a printed circuit board measuring 94 × 86mm and coded 85pc1. As with the original version, this is housed in a plastic case measuring 150 × 90 × 50.

No special procedure need be followed when assembling the PC board although the job will be easier if the smaller parts are mounted first. Note carefully the orientation of the semiconductors and the electrolytic capacitor. The transformer and relay can be salvaged from the old PC board if you are upgrading from the earlier version.

Once the PC board has been completed, attention can be turned to the final assembly. The mains cords enter through grommetted holes at one end of the case and are anchored using cord clamps. The other end of the case carries the manual trigger switch and the ambient sensing LDR.

As previously mentioned, the manual trigger switch can be mounted remotely if desired (or it can be deleted altogether). The PC board is mounted at the end of the case adjacent to LDR2 and S1 using machine screws and nuts.

The headlight sensing LDR is mounted on one side of the case so that it faces in a different direction to the ambient sensing LDR. We fixed the

PARTS LIST

- 1 PC board, code 85pc1, 94 × 86mm
- 1 PC-mounting transformer, 12V or 15V centre-tapped (see text)
- 1 12V SPST relay with 5A/240V contacts
- 1 plastic utility case, 150 × 90 × 50mm
- 1 3-pin mains plug and mains cord
- 1 in-line mains cord socket
- 2 rubber grommets
- 2 mains cord clamps
- 1 3-way mains terminal block
- 1 SPST momentary contact switch
- 1 solder lug

Semiconductors

- 1 4011 CMOS quad NAND gate
- 1 4060 CMOS 14-stage counter
- 1 BC327 PNP transistor
- 3 1N4001 diodes
- 2 1N4148 diodes

Capacitors

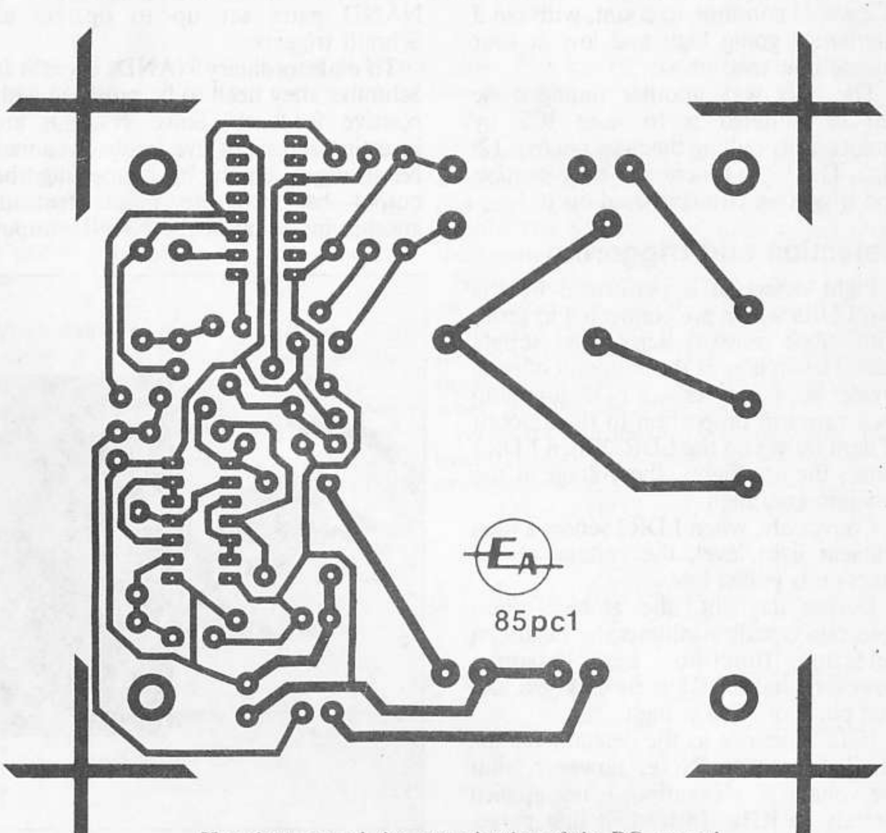
- 1 100μF 25V electrolytic
- 1 0.1μF metallised polyester (greencap)
- 1 .033μF greencap
- 1 .01μF greencap

Resistors (¼W, 5%)

1 × 2.7MΩ, 2 × 180kΩ, 2 × 82kΩ, 1 × 47kΩ, 2 × 18kΩ, 1 × 4.7kΩ, 2 × ORP12 light dependent resistors

Miscellaneous

Rainbow cable, mains-rated hookup wire, machine screws and nuts, solder.

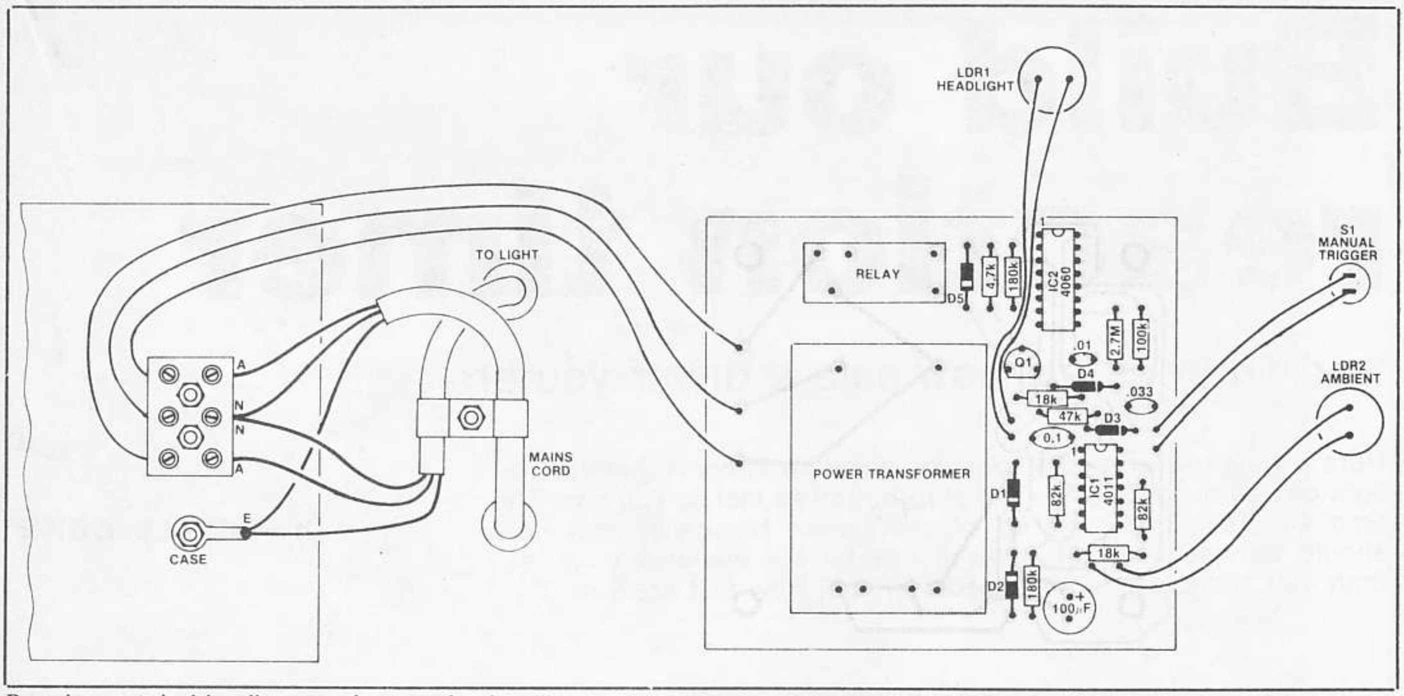


Here is an actual size reproduction of the PC artwork.

We estimate that the current cost of parts for this project is approximately

$40

This includes sales tax.



Parts layout and wiring diagram: take care when installing the semiconductors and the electrolytic capacitor.

LDRs in position using epoxy adhesive.

The lengths of the mains cords will depend on your chosen location for the Sentry. It must be protected from the weather but, at the same time, be located so that LDR1 will fall within the car's headlight beam. If these two requirements prove incompatible, it may be necessary to mount LDR1 remotely from the rest of the circuit.

The 3-way terminal block is secured to the metal lid and should be positioned so that it sits about half way between the transformer and the end of the case. This will prevent the possibility of pinching the wires when the lid is fitted. The earth lead (green/yellow) is soldered to an earth lug adjacent to the terminal block.

Make sure that you use mains-rated cable for the connections between the terminal block and the PC board. Connections to the two LDRs and to the trigger switch can be run using rainbow cable.

The output cord is terminated with an in-line mains socket for connection to the external light fitting. Take care to ensure that the socket is correctly wired. Fig.1 shows the correct wiring terminations for the mains plug and socket.

Testing

To test the Driveway Sentry, connect a lamp to the power socket and temporarily cover the two LDRs with black masking tape. The Sentry can now be checked for correct operation by briefly uncovering the headlight sensing LDR. If the ambient light level is not high enough to trigger the circuit, try shining a torch directly on the LDR.

Note that the circuit will not cancel, even after the expiry of its timing cycle, if the headlight sensing LDR is not covered again after triggering has occured.

If the circuit functions normally thus far, uncover the ambient sensing LDR and check that it inhibits circuit operation in high ambient light levels. The manual trigger switch should initiate a timing cycle whenever it is pressed.

During the test procedure, it may be more convenient to use a much shorter period than the normal four minutes. This can be arranged by reducing the value of the timing resistor. Connecting a 10kΩ resistor in parallel with the 2.7MΩ resistor, for example, will reduce the period to a few seconds.

Installation of the Driveway Sentry should be relatively straightfoward, although some experimentation may be necessary to find a position where it is triggered by your car's headlights but not by passing traffic or by street lamps. In extreme cases, it may be necessary to recess the ambient LDR or to provide some form of shielding for it. Any mains wiring, other than that described here, should be carried out by a licensed electrician.

Build our reaction timer

And find out just how safe a driver you are

Here is a simple and easy to make Reaction Timer. When the red light comes on, you go for the stop button as fast as you can. The time you take is registered on the meter. Normally, your time should be less than 250 milliseconds for the pushbutton or less than 400 milliseconds for a pedal switch. How fast are you?

by GERALD COHN

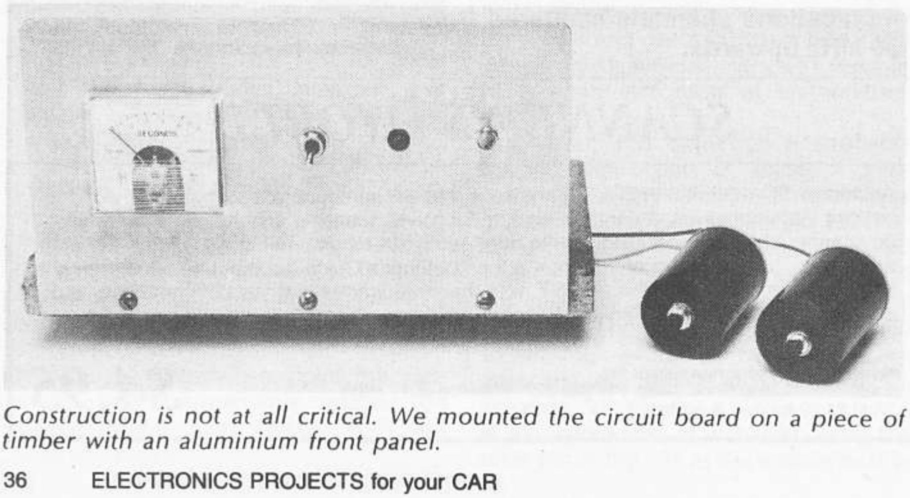
When you are driving, your reaction time in an emergency can make the difference between rapid evasive action and possible fatalities. It is well known that reaction time is affected by the driver's physical condition and his psychological outlook at the time. In some cases, the driver does not register the emergency at all and drives straight into a disaster.

Some people stoutly maintain that alcohol does not adversely affect their reaction time and may even improve it. Limited tests that the author has witnessed would indeed seem to indicate that a limited amount of alcohol does not affect physical reaction time to any extent. What is affected is judgement. But that is another story.

Eventually, reaction time testing may become part of the general driver licensing procedure. Even licence renewals may be conditional upon passing a reaction test and sight test. Who knows? In the meantime, we have produced a unit to measure reaction times up to one second. If your reaction time is longer than that you are disaster material anyway!

The unit presented here will enable a number of interesting reaction tests to be made. To perform the tests, two people are required. One acts as a starter and presses a button to light up an indicator on the tester. The other person is the one being tested, and must hit their button to turn off the light. The reaction time can then be read from the meter. The starter then has a reset button to zero the meter before the test is repeated.

An approach to measuring a small time interval of less than one second can take two general directions. First, logic circuitry can be used and the result displayed in digital form. All that would be required is a 100Hz square wave oscillator driving a couple of decade counters plus the associated decoders and drivers for the digital display. The test would be merely starting and stopping the clock. The readout would be in the form of two digits which would be multiplied by ten to give the result in milliseconds. For example, a readout of 34 would represent 340 milliseconds.



Construction is not at all critical. We mounted the circuit board on a piece of timber with an aluminium front panel.

An alternative and simpler approach is to use an analog circuit. This produces a steadily rising voltage which is stored and held at the end of a given time interval which represents the reaction time.

But how do you produce a steadily rising DC voltage, ie, a voltage increasing at a constant rate for a maximum interval of one second? All that is required is to charge a capacitor at a constant current. The resulting voltage across the capacitor will rise at a constant rate.

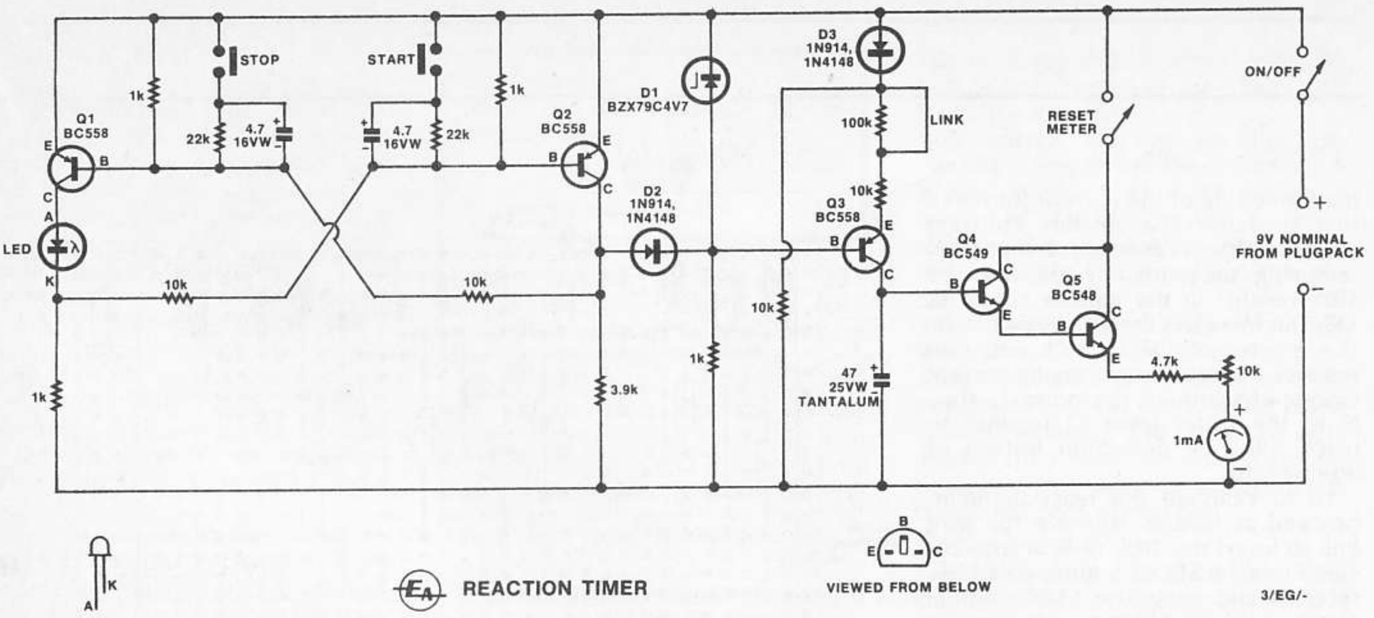
This can be shown by derivation from the fundamental relationship:

$Q = CV$

Where V represents voltage, Q represents charge in coulombs and C represents capacitance in Farads.

If we rewrite the above equation as $V = Q/C$ and then divide both sides by time in seconds, we get : rate of voltage change in volts per second is equal to the number of coulombs per second divided by the capacitance. But 1 ampere is equal to 1 coulomb per second, ie, current is the rate of charge flow. So dividing the capacitor charging current by the capacitance gives us the rate of voltage change. So the way to get a constant rate of voltage increase is to charge the capacitor with a constant current.

We can set the rate of voltage increase by selecting the value of constant current and the size of the capacitor. The capacitor must have very low leakage relative to the value of the charging current. The capacitor that we chose was a 47uF tantalum electrolytic. Aluminium electrolytics must not be used as their leakage is too high for this application. If we select a rate of voltage increase of 7 volts per second, the constant charging current required is 0.33mA.



The circuit diagram of the timer. The flipflop (Q1, Q2) controls constant current source Q3, which provides the charging current for the 47uF capacitor.

Refer now to the circuit diagram (Fig 2). The constant charging current to the capacitor is provided by Q3 and its associated components. The basic circuit of a constant current source using one transistor is shown in Fig 1. A reference voltage provided by a zener diode is applied to the base of the transistor and the emitter resistor is selected to set the collector current. The voltage across the emitter resistor becomes the reference voltage minus the base-emitter voltage of the transistor.

In the basic circuit we have shown a zener diode which provides a reference voltage of 4.7V. This would result in a voltage across the emitter resistor of 4.0V (allowing for a base-emitter voltage of 0.7V). Any tendency for the collector current to increase would increase the emitter voltage by the same amount, which would bias the transistor off which would drop the current back to where it should be, and so on. The reverse process applies if the collector current tends to reduce.

Later on in the article we will explain the component differences between Fig. 1 and the current source Q3 in the complete diagram.

Having described how to obtain a voltage which increases linearly with time using a constant current source to charge a capacitor, we can now discuss how to start and stop the current source. We do this with an RS flipflop consisting of Q1 and Q2.

The flipflop has uneven collector loads. Q1 has a 1k resistor in series with a light emitting diode while Q2 has a 3.9k load. This means that when power is first applied to the circuit, Q2 always turns on while Q1 is held off. Q2 effectively shorts out the voltage reference zener diode D1 via D2 which turns off the current source Q3. Just to make sure that Q3 is turned hard off, diode D3 is connected in series with the emitter. The diode voltage is held constant by bias current from the 10k resistor to the 0V line.

So the situation at switch on is that Q2 is on which holds Q3 off, and so the voltage across the 47uF capacitor remains at zero. To start charging the capacitor, the START button is pressed which momentarily removes the base voltage of Q2. This turns Q2 off and Q3 on allowing the capacitor to charge.

At the same time as Q2 goes off, Q1 comes on and illuminates the light-emitting diode. The person being tested must then hurriedly press the STOP button which reverts the flipflop to its original condition and turns Q3 off. The voltage which then appears across the capacitor represents the elapsed time. All that remains is to measure this voltage while making sure that the capacitor's charge is not bled away so fast as to make the meter pointer drop rapidly. In other words, we have to measure the capacitor voltage but make sure that the current drawn off by the measuring circuit is as low as possible.

Our method of monitoring the capacitor voltage is to use a Darlington transistor pair to drive a 1mA meter via appropriate resistors. With the high beta of the composite transistor the input current from the capacitor is very low — less than 1 microamp.

The Darlington transistor pair, Q4 and Q5 actually constitute a simple "sample and hold" circuit.

Several features of the circuit remain to be explained. First, the RESET button. This resets the meter to zero after a test so that it can be repeated. Notice that the capacitor is not discharged directly by shorting out. Rather, we remove the positive supply voltage from the Darlington, so that the capacitor discharges via the two base-emitter junctions and the meter circuit.

This effectively reduces the capacitor voltage to slightly less than the forward-bias base voltage of the Darlington pair, ie, slightly less than 1.2V. So instead of rising from zero at the start of a test, the capacitor voltage rises from approximately 1.2V. This means that as soon as the capacitor voltage begins to rise during a test, the meter pointer rises accordingly.

A simple, easy-to-reproduce calibration procedure presented a major problem in development of the project. No matter how ingenious or complex a circuit such as this might be, it is useless if it cannot be accurately calibrated by the would-be constructor who has a minimum of test instruments at his disposal. We believe we have solved this in a neat fashion.

The calibration is performed by alter-

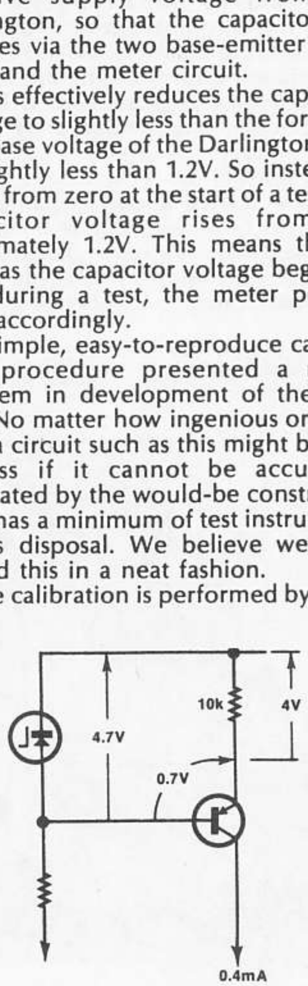


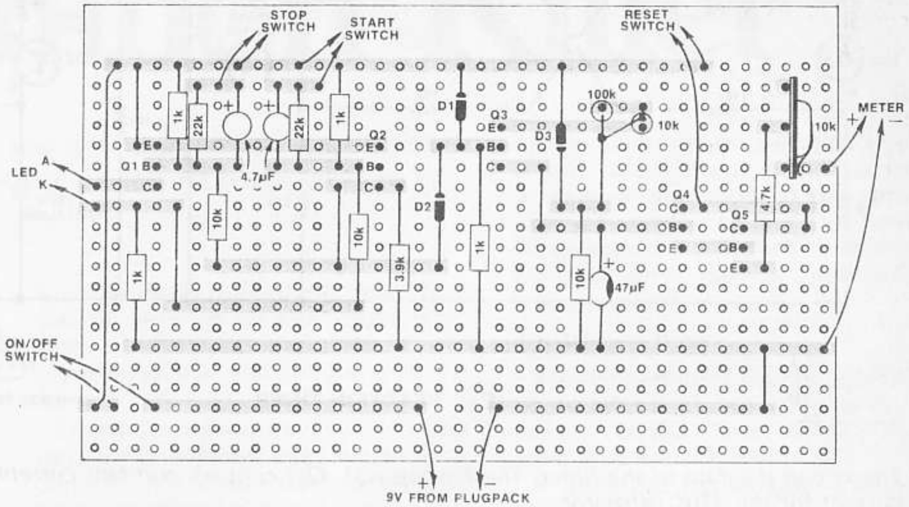
Fig 1. Basic constant current source.

ing the setting of the current source so that it delivers a smaller constant current. This is done by temporarily removing the wire link shorting the 100k resistor in the emitter circuit of Q3. This increases the total resistance in the emitter of Q3 to 110k and thus reduces the capacitor charging current to one-eleventh of the normal value. Now, the meter takes 11 seconds to reach full-scale deflection instead of one second.

So to calibrate the reaction timer, proceed as follows. Remove the wire link to insert the 100k resistor into circuit. Press the START button, wait a few seconds and press the STOP button. Now press the RESET button to zero the meter. Now press the START button, wait exactly 11 seconds and press the STOP button. Now set the 10k preset potentiometer so that the meter reads full scale. This will have to be repeated a few times because the meter reading drops slowly.

Having set the 10k preset potentiometer so that the meter takes exactly 11 seconds to rise from zero to full scale, the wire link can be replaced to short out the 100k resistor and the unit is ready to perform testing. Ideally, the 10k and 100k resistors should be 1pc units, but in practice 5pc units will be close enough.

We specify an LED in the circuit because it has almost instantaneous response time, ie, light is emitted as soon as voltage is applied. The use of an incandescent lamp in this role would inevitably cause errors because of the thermal lag of the filament.



The overlay diagram showing the cuts in the copper tracks and the placement of the components. Note the orientation of the transistors, diodes and capacitors.

Notice that the 10k resistor in the base voltage divider of Q2 is fed from the junction of the LED and the 1k resistor, and not from the collector of Q1. This is to avoid the small current flowing in the 10k resistor from partially lighting the LED.

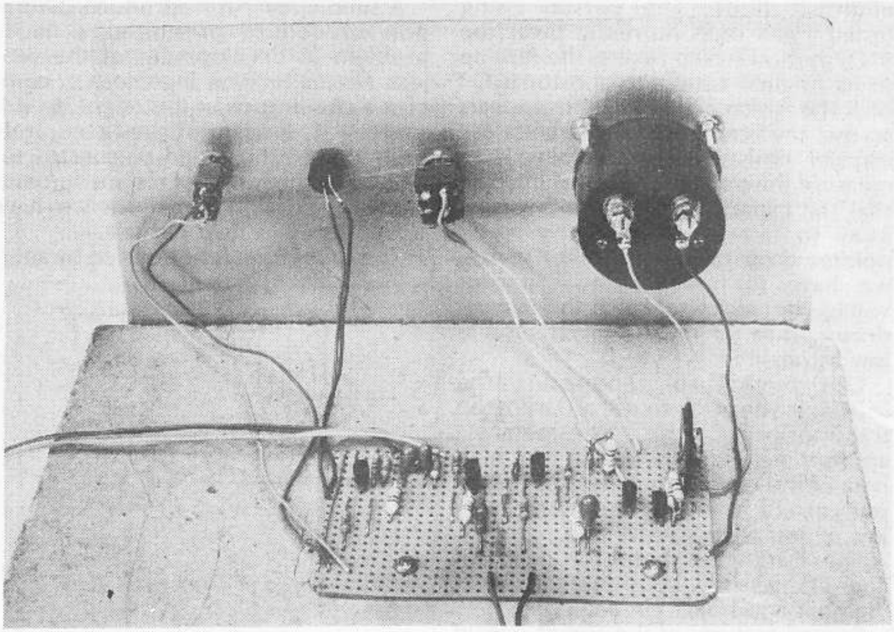
Construction of the reaction timer is not critical as far as layout is concerned. It can be built cheaply onto a piece of timber or "dressed" up to look the part of a piece of test equipment. Our approach to the construction is shown in the photographs, but this is only a suggestion.

All the circuit components are mounted on a small section of Veroboard, 60 x 95mm. We used Veroboard with 2.5mm conductor spacing which is the most readily available type.

Take care to observe the orientation of the transistors and the polarities of the diodes and the elecrolytic capacitors. These are shown in the wiring diagram.

The two resistors, 10k and 100k, associated with the constant current source, Q3, are wired "end on" and a loop of hookup wire is soldered to their ends to short out the 100k resistor. The details are shown in the wiring diagram. The idea is just to "tack" the wire with your soldering iron so that it is easily removable for the calibration procedure.

The LED, toggle switches and meter are mounted onto a piece of aluminium sheet fastened at right angles to a piece of timber. The Veroboard is also mounted on the piece of timber. The START and STOP



A rear view of the completed timer showing the wiring etc. The link across the 100k resistor can be seen just to the left of the pot.

We estimate that the current cost of parts for this project is approximately

$20

This includes sales tax but does not include the cost of the DC plugpack.

buttons were mounted in plastic film containers (pill cases would also be suitable) for easy use.

We used a 1mA meter movement and changed the units that are read from the meter to seconds instead of mA. This was done by erasing the letters "mA" and then replacing them with "SECONDS" using rub on lettering.

The STOP switch could be mounted in a floor jig with both a brake and an accelerator pedal to simulate the braking procedure, ie lifting the foot from the accelerator pedal and onto the brake pedal to halt the car. Here the STOP switch will require protection from mechanical abuse.

The unit is powered from readily available plugpack type power supplies, delivering a nominal 9V at 300mA. The voltage will normally be more than 9V at the current drawn by the circuit, and will probably be between 10 and 11 volts. Actually the circuit will function with supply voltages between 9 and 18 volts.

Well, there you have it, a device that will tell you whether or not you stand to qualify for the "Traffic Menace Of The Year Award". Go to it then. How fast is your reaction time?

1 1mA meter movement
2 miniature SPDT toggle switches
2 miniature N/O contact pushbuttons
1 9 volt plugpack/battery eliminator (not included in price estimate)
1 piece Veroboard 60 x 95mm

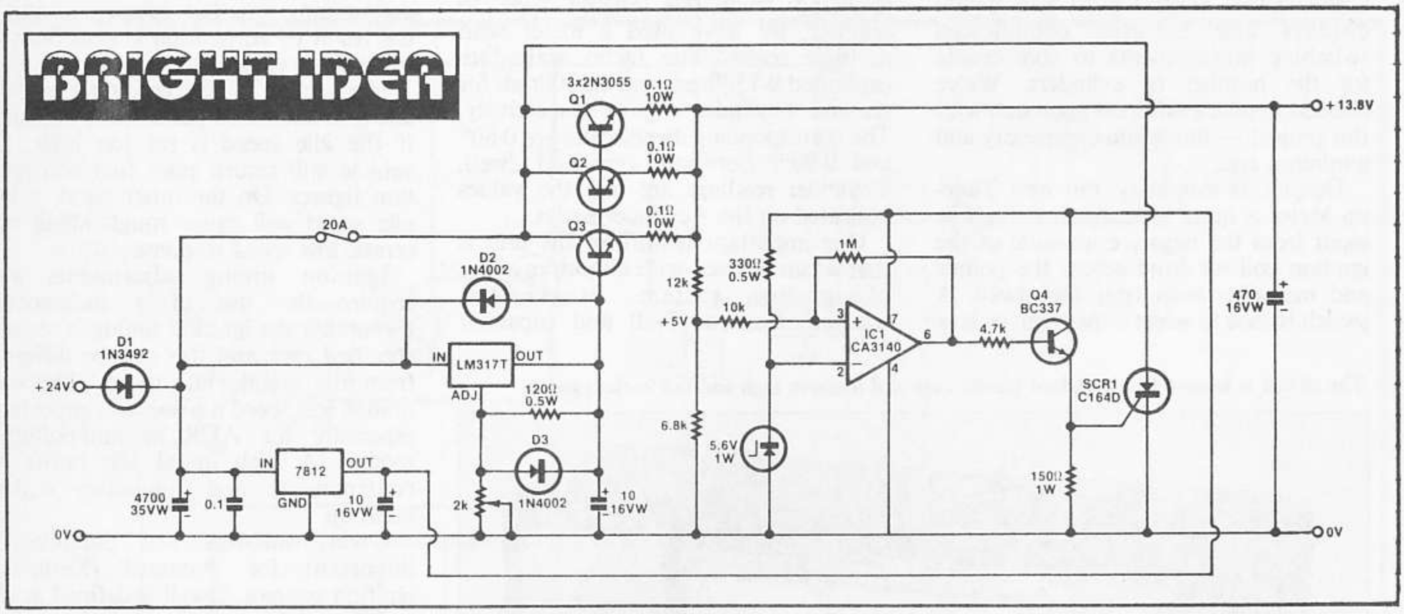
SEMICONDUCTORS
3 BC558 PNP transistors
1 BC549 NPN transistor
1 BC548 NPN transistor
2 1N914 or 1N4148 diodes
1 BZX79C4V7 zener diode
1 red LED

RESISTORS (¼ or ½W, 5% tolerance)
4 x 1k, 1 x 3.9k, 1 x 4.7k, 4 x 10k, 2 x 22k, 1 x 100k
1 x 10k trimpot

CAPACITORS
2 x 4.7uF/16VW electrolytic
1 x 47uF/25VW tantalum

MISCELLANEOUS
Timber, aluminium sheet, solder, hookup wire, screws etc.

Note: Components with higher ratings may generally be used providing they are physically compatible.



24 to 12 volt converter

This circuit should prove popular with truck and bus owners. The converter can power 12V equipment from a 24V battery at currents up to 20A. There is overvoltage protection which works by blowing the fuse if the regulated voltage reaches 15.5V

An LM317 three terminal regulator is used to control the paralleled transistors, Q1, Q2 and Q3. These provide the high current demanded by the load, while the regulator supplies base current to each transistor. The 0.1Ω 10W resistors in the emitter of each transistor ensure that the transistors source an equal share of the load current.

The regulator voltage is set by the 2kΩ trim potentiometer at the adjust terminal. Diodes D2 and D3 protect the regulator, while D1 protects the entire circuit from reverse polarity.

The overvoltage protection circuitry consists of IC1, transistor Q4 and the SCR. IC1 is connected as a Schmitt trigger to switch transistor Q4 when the regulated voltage level exceeds a certain level.

Pin 3 of IC1 is normally at 5V due to the voltage divider consisting of the 6.8kΩ and 12kΩ resistors. The inverting input, pin 2, is fixed at 5.6V by the zener diode. Should the regulated output voltage exceed 15.5V, the voltage at pin 3 becomes greater than 5.6V and the op amp output at pin 6 goes high, turning on Q4. This switches SCR 1 which shorts the supply via the fuse. The fuse therefore blows and removes power to the transistors.

A 7812 regulator supplies the positive 12V for the op amp and transistor Q4.

P. Howarth
Gunnedah, NSW.

For Saturday afternoon mechanics:

Tacho-dwell meter for tune-ups

Here's the most basic tune-up meter we've described for a long time. It's easy to build and calibrate and can be used with four, six or eight cylinder engines. Best of all, it should only cost about $20 all up.

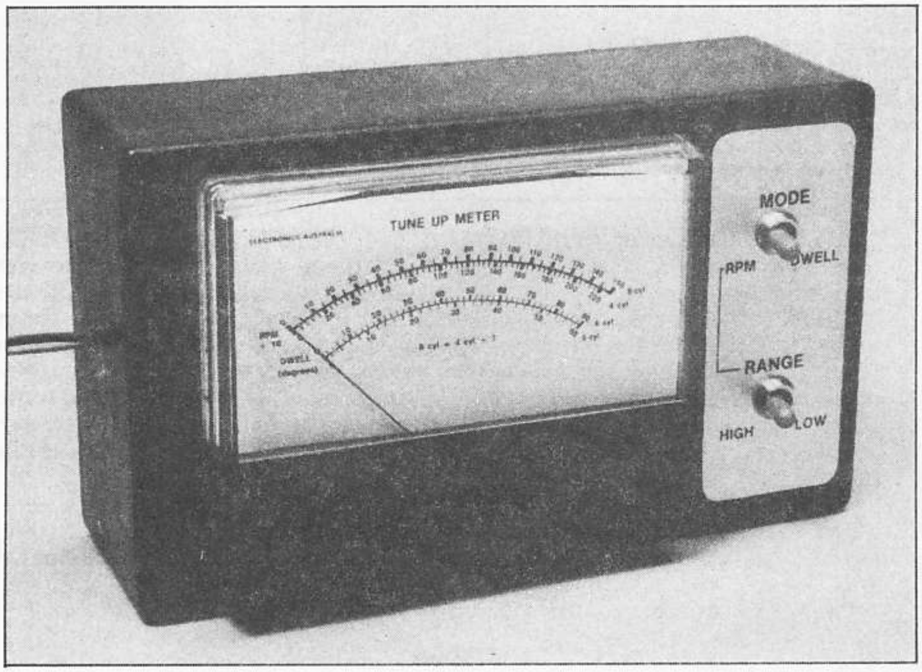
by COLIN DAWSON

In recent years, our tune-up meter projects have become increasingly sophisticated. Several even had digital displays and featured complicated switching arrangements to compensate for the number of cylinders. We've decided to take a different approach with this project — minimum complexity and minimum cost.

Despite its simplicity, our new Tune-up Meter is quite versatile. It derives its input from the negative terminal of the ignition coil (or from across the points) and measures both rpm and dwell. A switch is used to select either high (x 2) or low (x 1) rpm ranges.

Rather than switch ranges when changing from one engine type to another, we have used a meter with multiple scales. The tacho scales are calibrated 0-1500rpm and 0-2200rpm for six and 4-cylinder engines respectively. The corresponding dwell scales are 0-60° and 0-90°. For both rpm and dwell, 8-cylinder readings are half the values indicated on the 4-cylinder scales.

One important feature of the unit is that it can be used with almost any type of ignition system. Breakerless, transistor-assisted (TAI) and capacitor discharge (CDI) ignition systems are all compatible.



The circuit is housed in a standard plastic case and features high and low tacho ranges.

The unit will prove particularly useful for tuning cars with standard ignition systems. Many cars still fall into this category and, with tune-ups costing around $40 a throw, there is a good case for doing it yourself.

Even modern cars equipped with "set and forget" type breakerless ignition are not immune to ignition system vagaries. While the repair may sometimes be beyond the scope of a weekend mechanic, it is often still worthwhile determining whether rough running is the result of an ignition system fault or some other cause.

Irrespective of the ignition type, the idle rpm should be periodically adjusted. If the idle speed is set too high, the vehicle will return poor fuel consumption figures. On the other hand, a low idle speed will cause rough idling and erratic low speed response.

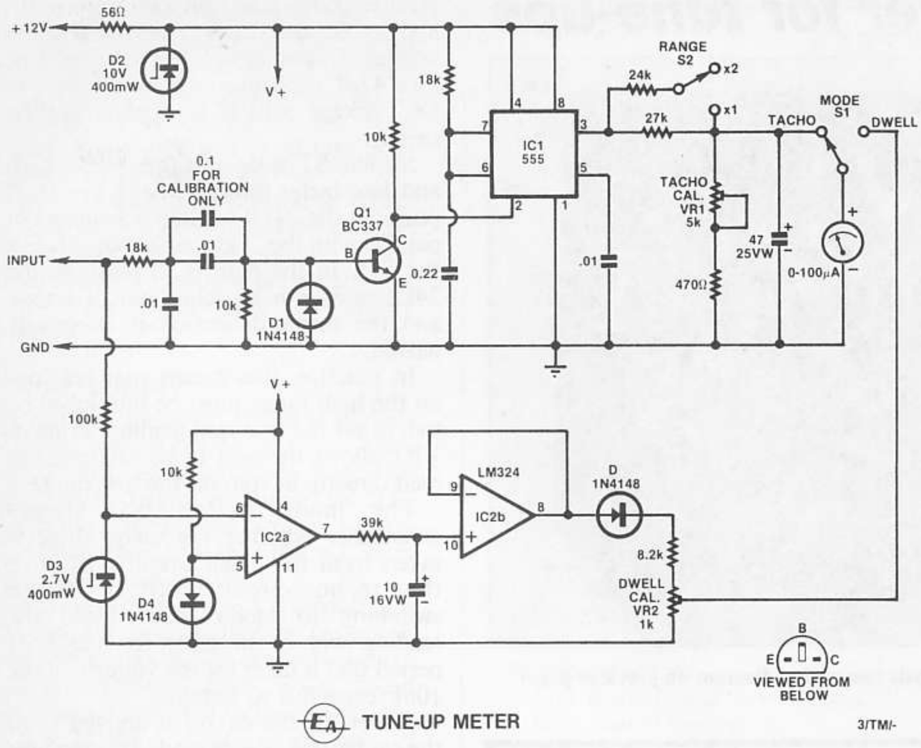
Ignition timing adjustments also require the use of a tachometer. Generally, the ignition timing is set at a specified rpm and this can be different from the engine idle speed. The cold (initial) idle speed is also quite important, especially for ADR27a anti-pollution models. A high initial idle burns off contaminants and minimises carbon build up.

Dwell settings are particularly important for standard (Kettering) ignition systems. Dwell is defined as the number of degrees of camshaft rotation for which the points are closed. Correct adjustment ensures minimum points wear and an acceptable spark strength.

The dwell angle is not quite so critical where TAI or CDI are fitted, but the setting should still be made within specifications. Note, however, that the unit will not read dwell on many cars fitted with breakerless ignition. This is of academic significance only as the dwell angle is not adjustable in these cases.

How it works

The circuit bears more than a passing resemblance to the Digital Engine Analyser published in EA, July 1983.



Q1 and IC1 form the tacho circuit while IC2 forms the dwell circuit. The input is derived from the negative terminal of the coil

We have substituted a 100μA moving coil meter in place of the digital display and also simplified the switching. In most other respects, the circuit is unchanged.

The input pulses can be processed in two ways, depending on whether the circuit is switched to tacho or dwell mode. Dwell is the simpler of the two — let's look at this first.

The dwell circuitry is centred around IC2, an LM324 quad op amp package. This IC is unusual in that its inputs can be pulled all the way down to the negative supply rail. This makes the LM324 particularly suitable for use with a single supply.

The waveform appearing at the negative terminal of the ignition coil is at the supply potential (plus inductive spikes) when the points are open and ground when the points are closed. Although higher voltages can easily be clipped, the op amp input must be capable of monitoring the ground potential.

In fact, the input is clipped by zener diode D3 and its associated 100kΩ resistor. This limits the input pulses to a maximum of 2.7V. While this may seem rather severe, the explanation is that it prevents the circuit from being triggered by ringing in the ignition system. For about two milliseconds after the points open, there is a considerable amount of ringing superimposed on the positive supply voltage. This effect is eliminated by the clipping circuit.

The clipped input pulses are subsequently fed to the inverting input of IC2a which functions as a comparator. A reference voltage of 0.7V is provided by D4 and this is applied to the non-inverting input (pin 5). IC2a thus compares the clipped input signal and the reference voltage. Whenever the input voltage is lower than the reference voltage, IC2a's output is high, and vice versa.

The output of IC2a (pin 7) is therefore a square wave with the same frequency as the points operation.

This square wave signal is fed into an integrator consisting of a 39kΩ resistor and a 10μF capacitor. The voltage appearing across this capacitor is DC and its level is determined by the input duty cycle. Since the duty cycle depends on the dwell angle, it follows that the voltage on the 10μF capacitor is proportional to the dwell angle.

IC2b is configured as a voltage follower. It monitors the integrator voltage and reproduces this voltage exactly at its output (pin 10). This output is a low impedance and can be used to drive the meter.

Notice that a diode (D5) is included in the output circuit. This does not function as a rectifier — the signal is already DC. Rather, the forward voltage (approximately 0.7V) is used to compensate for the residual output voltage of IC2b. The LM324, in common with most other op amps, can not swing its output to the supply rails, and the diode is needed to prevent a permanent meter offset.

The 8.2kΩ resistor and 1kΩ trimpot connected between D5 and ground provide a means of calibrating the dwell reading.

Tacho circuit

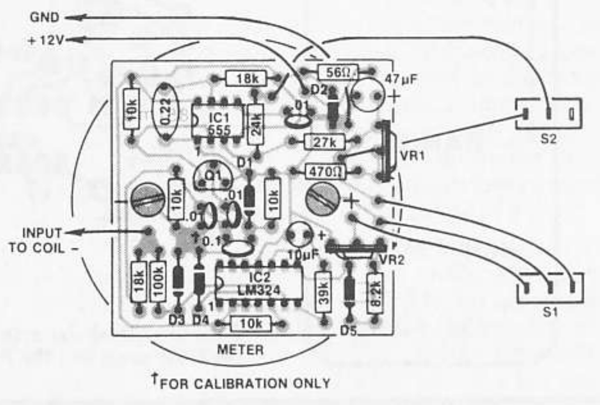
In the tacho mode, the input signal is applied to a voltage divider consisting of 18kΩ and 10kΩ resistors and filtered by a .01μF capacitor. From there, the signal is applied to a differentiating network (.01μF) which produces positive and negative output spikes coinciding with the rising and falling edges of the input waveform. Diode D1 clips the negative-going spikes to prevent damage to the base-emitter junction of transistor Q1.

Transistor Q1 is normally held off by its 10kΩ base-emitter resistor and is briefly turned on each time a positive pulse is applied to its base. Q1 thus functions as a detector. It produces a brief negative-going pulse at its collector each time the points open (or the coil-switching transistor turns off). These pulses are used to trigger IC1, a 555 timer.

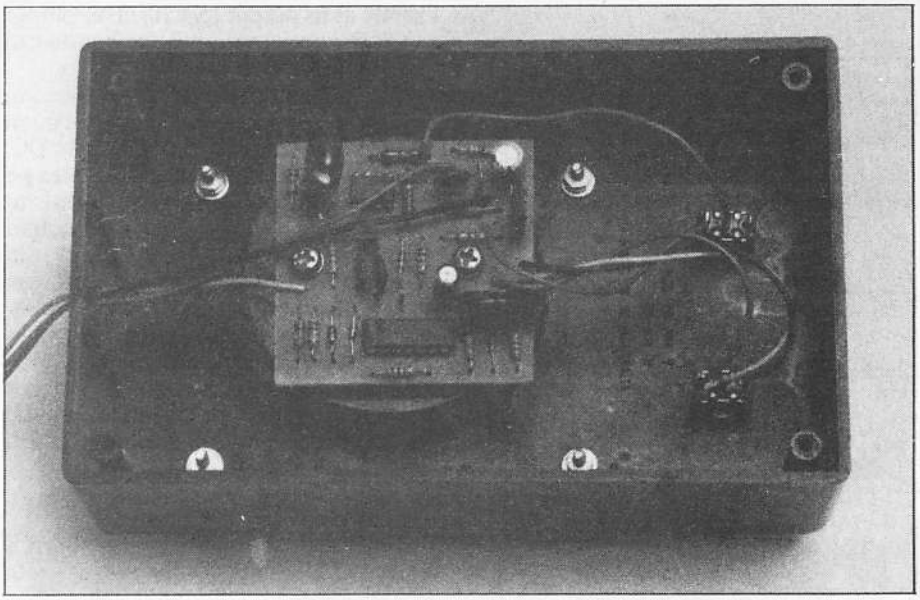
IC1 is configured as a monostable. It produces a brief positive pulse on its pin 3 output whenever a negative-going trigger pulse is applied to pin 2 (ie, each time the points open). The actual monostable period is 1.1 times the RC time constant set by the 18kΩ resistor and 0.22μF timing capacitor, or about 4.4ms.

IC1's output thus consists of a train of

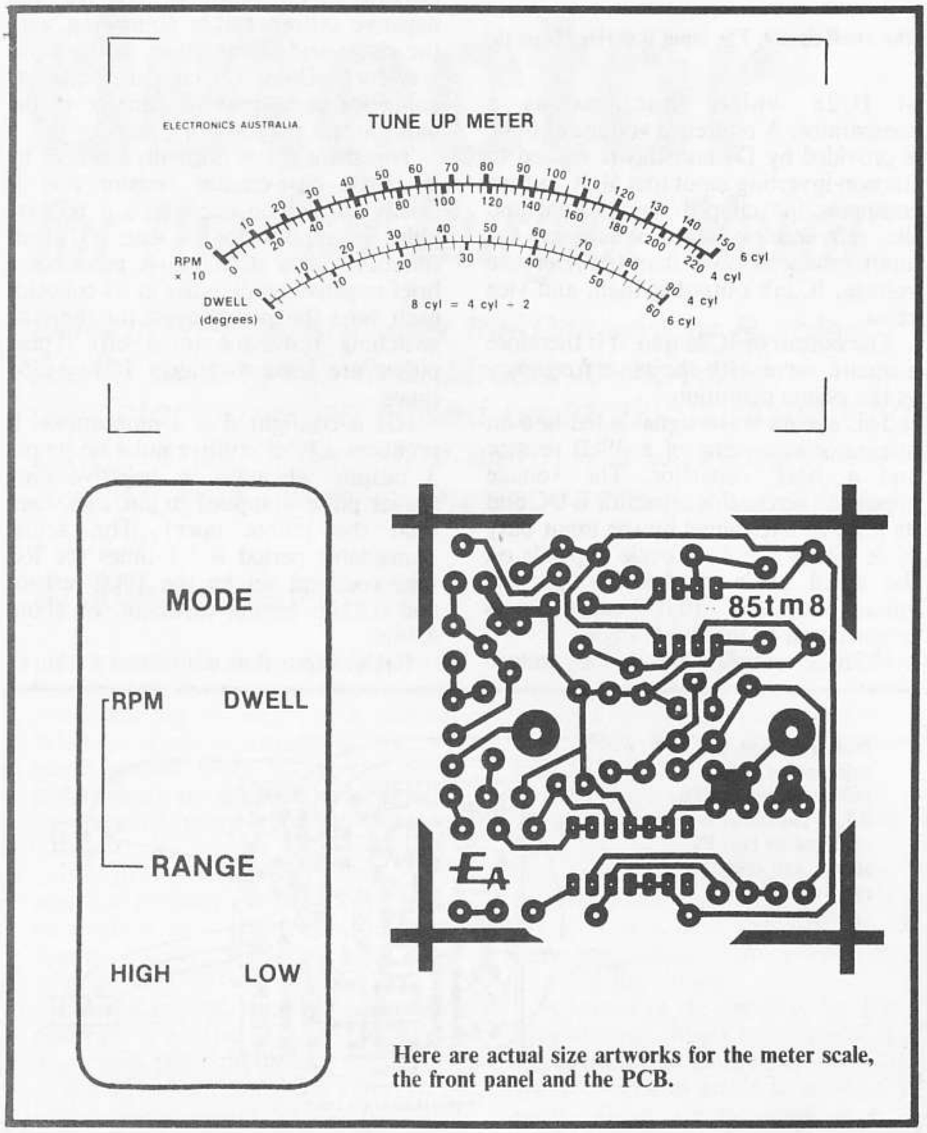
Note carefully the orientation of all polarised parts. The 0.1μF capacitor is soldered to two PC stakes and must be removed after calibration.



Tacho-dwell meter for tune-ups



The PCB is mounted directly on the meter terminals (see wiring diagram on previous page).



Here are actual size artworks for the meter scale, the front panel and the PCB.

positive-going pulses of constant width and amplitude. These pulses are fed to a voltage divider network and integrated by a 47μF capacitor to produce a steady DC voltage which is applied to the meter.

Switch S2 selects between the high and low tacho ranges. In the low (x 1) position, the 24kΩ resistor is switched in parallel with the 27kΩ resistor on pin 3 of the 555. In the high (x 2) position, the 24kΩ resistor is switched out of circuit and the meter deflection is effectively halved.

In practice, this means that readings on the high range must be multiplied by two to get the true rpm reading. Trimpot VR1 allows the unit to be calibrated to read directly in rpm on the low range.

The mode switch (S1) simply determines whether the meter drive is taken from the dwell circuitry (IC2) or the tacho circuitry (IC1). When switching to tacho from dwell, the reading will be in error for the brief period that it takes for the voltage on the 10μF capacitor to stabilise.

Power for the circuit is derived from the car battery. Zener diode D2 regulates the supply rail to +10V DC to make the circuit insensitive to variations in battery voltage. D2 also protects the circuit against reverse battery connection.

Finally, the circuit shows a 0.1μF calibration capacitor in parallel with the .01μF capacitor on the base of Q1. This larger capacitor is necessary because the waveform generated by the calibration circuit (Fig.1) has a much slower risetime than that generated by the ignition system.

Construction

The Tune-up Meter is housed in a plastic utility box measuring 150 x 90 x 50mm. This is fitted with an aluminium lid which, on the prototype, forms the back panel. We expect that kit retailers will supply Scotchcal artworks for the meter scale and the front panel.

The first job is to cut the main mounting hole for the meter. If you don't have a hole saw, this can be done by drilling a series of holes inside the circumference of the cutout area and then filing to a smooth shape.

Note that the cutout is offset to the left of centre on the front panel. Once the cutout has been made, mark out and drill the four screw mounting holes for the meter.

The Scotchcal label can now be affixed to the front panel and mounting holes drilled for the two switches. A hole must also be drilled in one end of the box to allow access for the power and input leads.

Most of the components are accommodated on a small printed circuit board (PCB) coded 85tm8 and measuring

PARTS LIST

1 0-100μA meter, 100 x 80mm panel size
1 plastic utility box, 150 x 90 x 50mm
1 PCB, code 85tm8, 54 x 55mm
2 SPDT toggle switches
1 Scotchcal front panel, 34 x 81mm
1 Scotchcal meter scale, 95 x 52mm
3 2-metre lengths of automotive cable (red, black and blue)
3 alligator clips to suit
2 PC stakes

Semiconductors
1 555 timer IC
1 LM324 quad op amp
1 BC337 NPN transistor
1 10V 400mW zener diode
1 2.7V 400mW zener diode
3 1N4148 diodes

Capacitors
1 47μF 25V electrolytic
1 10μF 25V electrolytic
1 0.22μF metallised polyester (greencap)
1 0.1μF greencap (see text)
3 .01μF ceramic

Resistors (0.25W, 5% unless stated)
1 x 100kΩ, 1 x 39kΩ, 1 x 27kΩ, 1 x 24kΩ, 1 x 18kΩ 0.5W, 1 x 18kΩ, 4 x 10kΩ, 1 x 8.2kΩ, 1 x 470Ω, 1 x 56Ω, 1 x 5kΩ 10mm vertical trimpot, 1 1kΩ 10mm vertical trimpot

Calibration circuit
1 1kΩ 0.25W resistor
1 4.7V 1W zener diode
1 9-18V mains transformer

55 x 54mm. This board is mounted directly on the meter terminals.

No special procedure need be followed when assembling the board but note carefully the orientation of the ICs, transistor, diodes and electrolytic capacitors. Two PC stakes are used to terminate the leads to the 0.1μF calibration capacitor. The 18kΩ input resistor should be a 0.5W type to provide a 250V rating.

The rest of the wiring details can be gleaned from the wiring diagram. Three clip leads are required for the coil and battery connections. These should be run using automotive hookup wire and should be colour coded to avoid confusion (eg, red for positive, black for negative, blue for input).

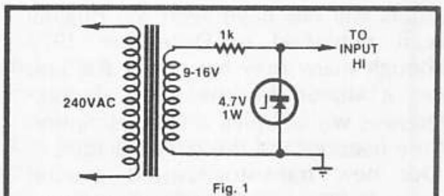


Fig. 1
This simple calibration circuit uses the mains as a frequency reference.

Construction can now be completed by re-calibrating the meter scale. First, undo the two large retaining screws and unclip the front cover. This done, remove the meter scale by undoing the two small retaining screws, then fit the new scale and re-assemble the meter.

Calibration

Despite the number of scales on the meter, the calibration procedure is straightforward.

The tachometer circuit is calibrated by using the mains as a frequency reference. Fig. 1 shows the calibration circuit. This uses a 4.7V zener diode to clip the 9-18V secondary output of a mains transformer to provide a suitable 50Hz input waveform. Most readers will have a suitable transformer on hand.

Note: 50Hz corresponds to 3000 sparks per second which is equivalent to 1000rpm for a 6-cylinder car, 1500rpm for a 4-cylinder car and 750rpm for an 8-cylinder car.

The Tune-up Meter can be powered from a bench power supply or from the car's battery during the calibration procedure.

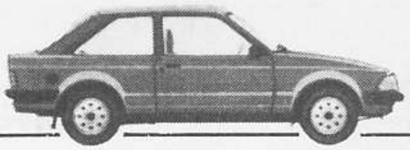
Connect the calibration circuit to the Tune-up Meter (don't forget the ground connection), select the low (x 1) tacho range, and solder the 0.1μF calibration capacitor to the PC stakes. Trimpot VR1 should now be adjusted so that the meter reads 1000rpm on the 6-cylinder scale.

Now switch to the high range and check that the reading is halved. If all is well, remove the 0.1μF calibration capacitor.

The dwell calibration is even easier. All you have to do is adjust VR2 for a full-scale reading (60° on the 6-cylinder scale) with the input lead open circuit.

Finally, accurate engine tuning requires the use of a timing light. These can be purchased for around $30 and are well worth the investment.

Now with longer spark duration



Transistor-assisted Ignition System

We present a revised version of the transistor-assisted ignition originally featured in Electronics Australia's December 1979 issue. Read how it compares with the new "high energy" ignition systems installed on the latest model cars.

by LEO SIMPSON

In the years since December 1979, when Electronics Australia published their Transistor-Assisted Ignition system, it would appear that thousands of these units have been installed and, by and large, they have performed well. In line with the modest claims made for the system at the time of publication, the major improvement has been increased service intervals for the breaker points and slight gains in fuel economy (up to 5%). Users of four-cylinder cars have also reported improved engine smoothness.

In the intervening three years since the circuit was published, a considerable number of cars have been made available with breakerless ignition systems fitted as "original equipment", although surprisingly this is by no means universal. A significant number of these breakerless systems are referred to by the car manufacturers as "high energy" systems. How do these compare with our circuit and can our circuit be improved to take note of these recent developments?

Before answering these questions, let us start from the beginning. Many of our readers will not have seen the original circuit published in December 1979 although many may have built the unit from a kit. So for the sake of completeness we will give a full description of the features and the circuit details.

Our new transistor-assisted ignition system offers significant advantages over the conventional Kettering system. For a start, as with other electronic systems, it relieves the points of the heavy burden of coil current switching while still passing enough current through them to keep them clean.

This means that once the system is initially set up it will not be necessary to readjust the system until wear of the rubbing block becomes significant. In practice, this means that every 15,000 kilometres or so, the points should be regapped and the timing readjusted. So, in essence, the car will stay in peak tune for much longer periods than would otherwise be the case and long term economy will be improved.

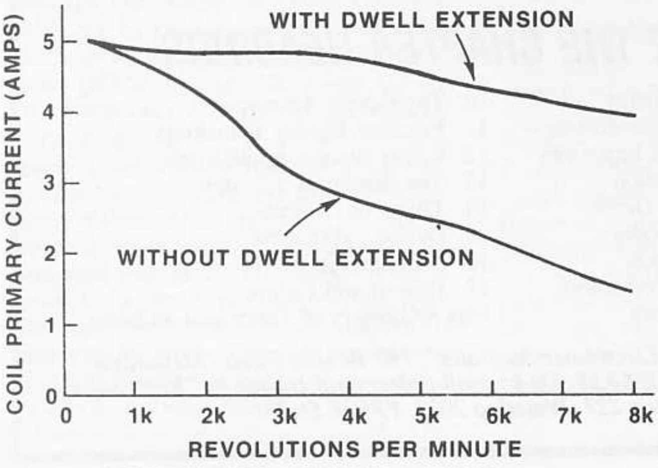


Fig. 1 (left) shows how the dwell extension feature maintains coil current and, therefore spark energy up to very high engine speeds (in this case, for a 6-cylinder motor).

Starting performance of the transistor assisted ignition system can be expected to be on a par with a freshly tuned Kettering system. However, in the conventional Kettering system starting performance normally deteriorates as the points become worn, so as time goes on, the transistor system is superior.

At low engine speeds, the spark energy of the transistor system will be comparable with a freshly tuned Kettering system with new points fitted. This is because the voltage drop across the main switching transistor is less than 300 millivolts when turned on. This is comparable to the voltage drop across a typical set of points when they are reasonably new. As points become worn, the voltage drop may increase to one volt or more at maximum coil current.

As engine speed rises, the spark energy of the conventional Kettering system is reduced due to the relatively slow build-up of current in the coil primary. Our transistor-assisted system maintains spark energy at a high level even up to very high engine speeds by using "dwell extension".

Dwell extension

The term "dwell" refers to the time the points are closed and is measured in terms of degrees of distributor camshaft rotation. Our circuit provides for dwell extension by switching on the coil 0.9 milliseconds after the points open. This means that we have artificially determined the spark duration at 0.9 milliseconds.

The photographs of the oscilloscope waveforms show the performance of the system. The first photograph shows the coil waveform without dwell extension.

At the instant of points opening the coil voltage rises very quickly until the spark discharge occurs, at which the voltage falls to a relatively low level while the coil secondary resonates with its distributed capacitance at about 10 to 15kHz. When the spark is extinguished, the remaining coil energy is dissipated by resonance in the primary circuit at a much lower frequency.

In a normal ignition system then, the spark lasts for less than one millisecond. Our circuit takes advantage of this fact by fixing the spark duration at 0.9 milliseconds. In the second oscilloscope photograph, the effect of dwell extension can be seen. Note that the main coil transistor is turned on before the primary resonance occurs. This has the effect of increasing the amplitude of the main coil primary voltage (the spike).

By the way, these photographs were taken at the very high spark rate of 300 sparks per second. These are unrealistic figures for normal motoring, corresponding to 4500rpm in a V8, 6000rpm in a 6-cylinder and 9000rpm in a 4-cylinder motor.

At lower spark rates the comparison with normal Kettering ignition is not nearly so favourable but the transistor assisted ignition does give a significant increase in available spark energy from idle speed and up. Whereas the normal system begins to taper off the spark energy from idle speed upwards, the transistor system with dwell extension does a much better job of maintaining spark energy up to spark rates far beyond the capability of normal engines. Fig. 1 illustrates this.

This great improvement in spark energy comes about in two ways. Consider the fact that a normal coil and ballast resistor system takes about 15 milliseconds for the current to rise to saturation (and thus provide maximum spark energy). Since in a 6-cylinder motor the points provide an approximate 50% duty cycle, this means that if sparks are required less than 30 milliseconds apart, the coil current will not reach saturation level. And a 30 millisecond period coincides with a spark rate of only 33 sparks/second or only 667rpm for a 6-cylinder motor.

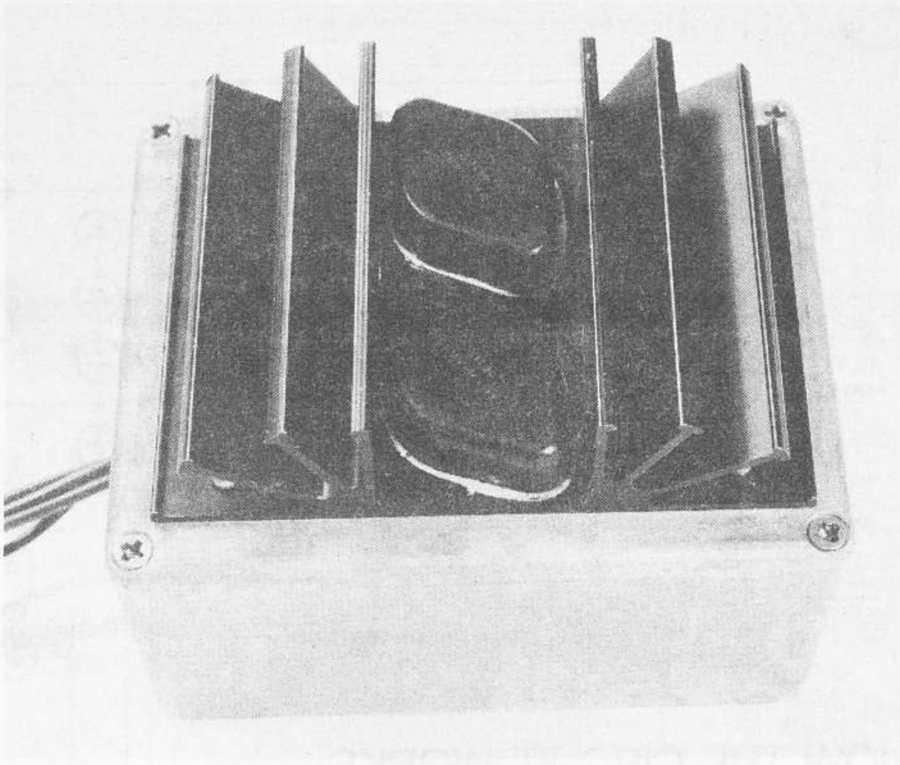
Coil not fully discharged

The main reason for the improvement is not so much the extra time for the coil current to build up but the fact that the coil transistor is turned on before the spark extinguishes naturally and primary coil resonance occurs. The fact is that when the coil transistor is turned on again the coil energy has not been fully dissipated. In fact, after the spark extinguishes there is considerable energy remaining in the coil which is usually dissipated in useless primary resonance.

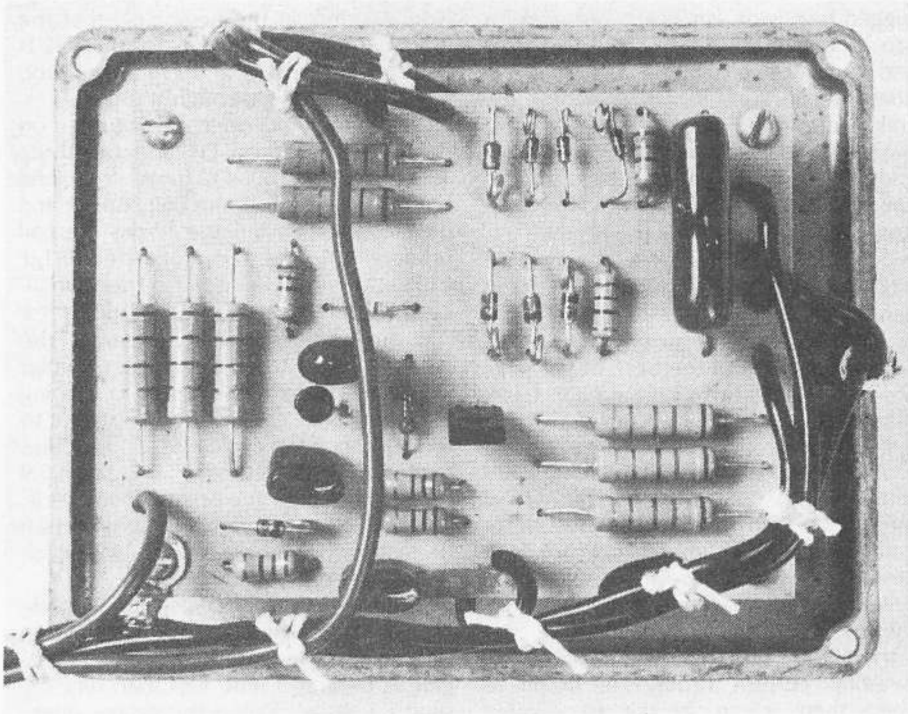
Other features of this transistor assisted circuit are comprehensive protection of both the ignition system components and the electronic circuitry itself, and the ability to drive a standard tachometer without any modifications. Note, however, that impulse tachometers should be connected across the switching transistor (Q4) instead of across the points.

Is there a catch to all this? Are there no disadvantages of this new transistor ignition system compared with conventional or CDI systems? Well there are a few side-effects of the new system but you could hardly class them as major drawbacks.

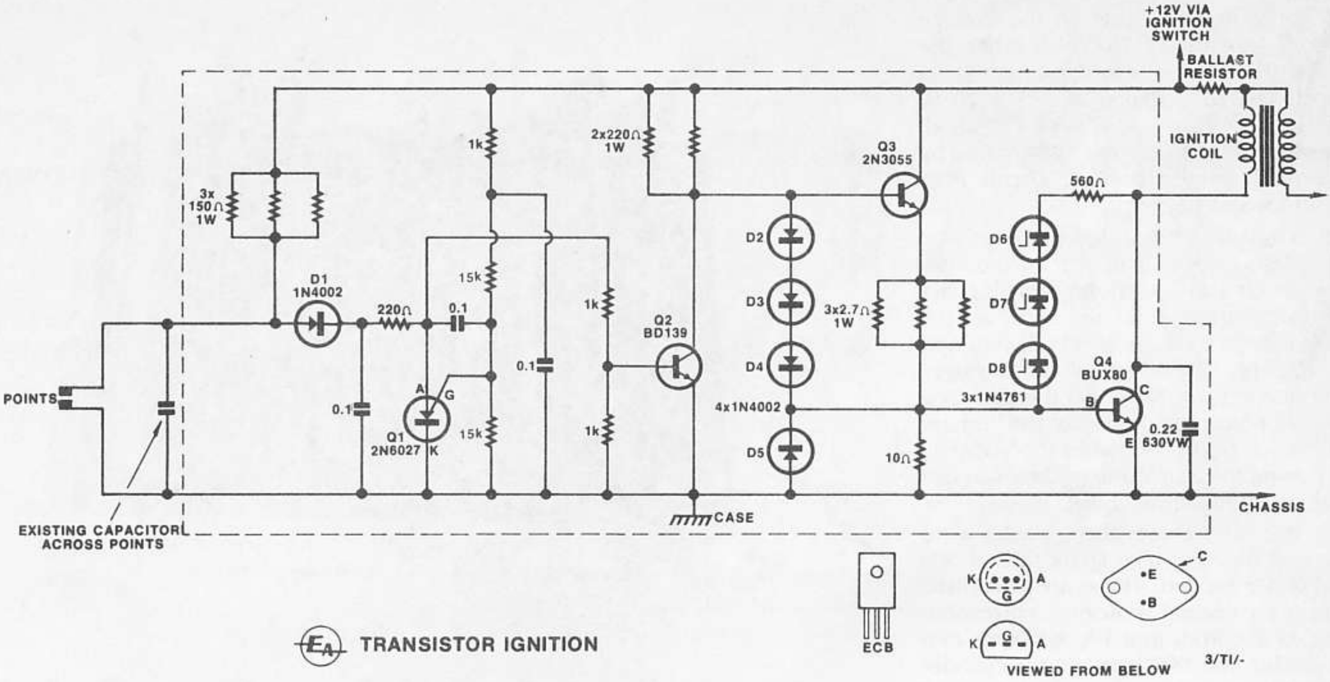
For example, because of the dwell extension feature, the coil is maintained in saturation for a much higher proportion



The transistor-assisted ignition is built into a rugged metal diecast case. The large heatsink helps dissipate the heat generated by constant current source Q3.



This view shows the assembled PC board. Note that all the diodes are "shock-mounted" by installing them with a loop at one end (see text).



TRANSISTOR IGNITION

HOW THE CIRCUIT WORKS

The heart of the circuit is Q4 which is a rugged transistor especially intended for use in converters, switching regulators and automotive ignition systems. Q4 does the arduous job of switching the coil current. It is protected against excessive voltages by a 0.22μF capacitor and by a string of three 75V zener diodes and a 560Ω limiting resistor between base and collector. Q4 is switched on and off by Q3 which, together with a diode string D2, D3 and D4 and three paralleled 2.7Ω emitter resistors, is set up as a constant current source to deliver 1.3 amps to the base of Q4. This ensures that Q4 turns on hard and has a saturation voltage of around 300 millivolts or less.

Q3 is biased on by two paralleled 220Ω resistors and controlled by Q2. Q2 is turned on and off by the distributor points, via D1. Ignore Q1 for the moment, as it does not control the primary switching function but provides the dwell extension feature.

Three 150Ω resistors in parallel provide "wetting" current through the points to keep them clean in the fume-laden atmosphere inside the distributor cap. Now assume, at the beginning, that the points are closed. This means that Q2 is held off and so Q3 and Q4 are on and current is passing through the coil.

When the points open, Q2 is turned on by base current via D1 and the three 150Ω resistors. Thus Q2 turns off Q3 and Q4 which interrupts the coil current and develops a high voltage across the coil primary. D1 and the associated 0.1μF capacitor form a points "debounce" circuit to prevent erratic triggering.

In the normal course of events, the points will eventually close again, so that D1 ceases to be forward-biased, turning Q2 off and Q3, Q4 on again to recommence the cycle. But Q1 modifies that cycle by turning Q2 off 0.9 milliseconds after the points open. Q1 is, in fact, a programmable unijunction transistor (or anode gate SCR) which works in the following way.

When the points are closed, the anode of the PUT (programmable unijunction transistor) is held close to zero while its gate is held at a little less than half the supply voltage. When the points open, the anode will be lifted up to almost the full battery voltage while the gate, by virtue of the 0.1μF capacitor tied between gate and anode, will be forced up to about 1.5 times the battery voltage.

This 0.1μF capacitor then discharges via the voltage divider made up of two 15kΩ resistors and a 1kΩ resistor. When the capacitor is discharged to the point where the gate voltage is 0.6 volts less than the anode voltage, the PUT triggers on and removes the forward bias from Q2. Q1 stays in the latched condition until the points close again.

So the PUT enables transistors Q3 and Q4 to turn on much sooner than they otherwise could if controlled directly by the points.

The only remaining components requiring comment are the diode D5 and the parallel 10Ω resistor. The resistor effectively ties the base of Q4 to its emitter and thus improves its ability to withstand high voltage. D5 protects the base-emitter junction against reverse biasing.

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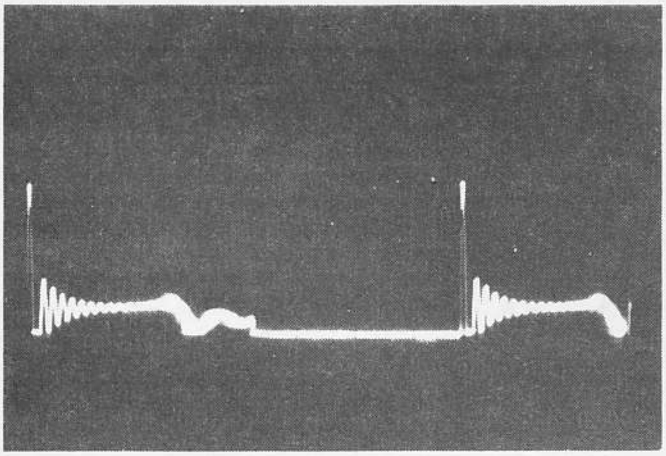
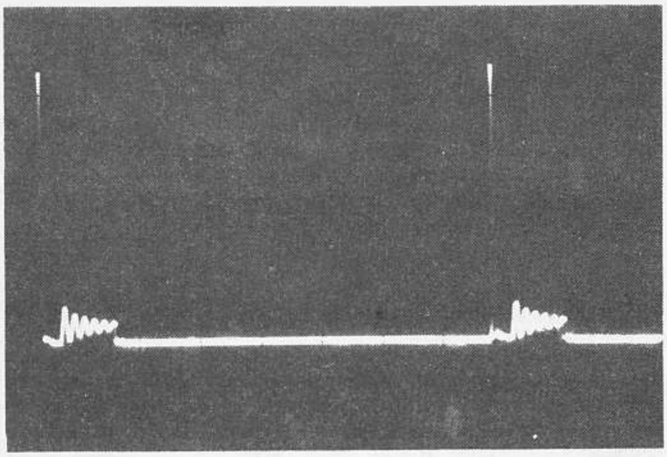
of its operating time. So the average current passing through the coil is about 80% higher. Or, to put in another way, the coil current is increased from about 2.5 to 4.5 amps.

In addition, the transistor drive circuitry draws about 1.5 amps so the total current drain of the transistor-assisted system is around six amps versus 2.5 amps for the conventional system.

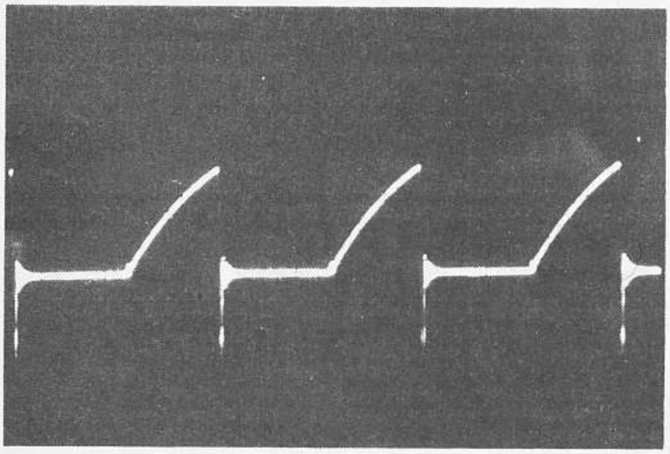
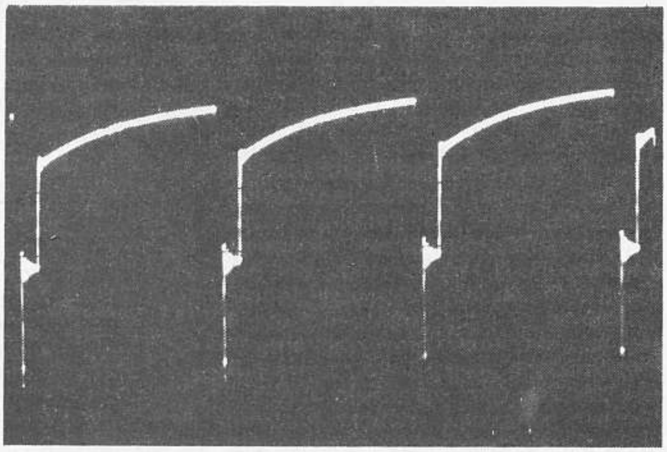
The extra current drain is unlikely to pose much of a problem for the car electrical system but the extra coil current does mean that the coil runs hotter. This has not proved to be a problem for the oil-filled coils on modern cars. Even so, the coil should ideally be placed so that it receives cooling air from the fan.

High Energy Systems

Well, that about sums up the main features of our transistor assisted ignition system. How does it compare with the so-called "high energy" systems now being installed on many new cars such as the Commodore, Falcon and Rover? The most important feature of these systems is not a "hotter" spark or a higher voltage

These two photos show the coil primary voltage from the circuit without (left) and with dwell extension (CRO settings: 50V/div and 0.5ms/div). Note: photos at right are for the older system with 0.6ms spark duration.

These two photos show the coil current without (left) and with dwell extension (CRO settings: 2A/div and 2ms/div).

output from the coil but, rather, a long spark duration, as much as two milliseconds in the case of the Commodore. This is most important in achieving reliable combustion of the generally lean mixtures used in recent model cars. The "high energy" means that the system also has the ability to refire a spark plug if it has been extinguished by turbulence of the mixture.

How do these new electronic systems achieve such a long spark duration? In any ignition system (apart from capacitor discharge types) the spark duration is determined firstly by the amount of energy stored in the coil and secondly by the resistance path presented by the spark plug.

The new high energy systems do not resort to dwell extension (as far as we know) to achieve this greater energy storage in the coil. No, they generally dispense with the ballast resistor in series with the coil and take advantage of the power transistor, which is usually a Darlington, to switch much heavier currents into the coil. Naturally, these systems are breakerless and, with no dwell extension circuitry involved, there is no risk of a coil burnout in the event of the ignition being left on while the motor is stationary. There is also the advantage of a comparatively simple circuit which should be very reliable, as seems to be the case.

Let us state, from the outset, that unless you are willing to modify the coil or ballast resistor in your system from "standard" it is not possible to gain these really long spark durations from the EA circuit. And in any case, we would strongly advise against doing so. Operating a normally ballasted coil without a ballast resistor will burn it out in a short time, probably within less than half an hour.

Even so, readers who are familiar with the original circuit published in December 1979 will realise that we have increased the spark duration from 0.6 to 0.9 milliseconds. There is no benefit in even greater extension of the spark time because the system with standard coil does not store enough energy.

> We estimate that the current cost of parts for this project is approximately
>
> **$35**
>
> This includes sales tax.

The only result of an attempt to extend the spark beyond 0.9 millisecond (by altering circuit components) will be that the spark will extinguish of its own accord at about one millisecond and the remaining energy stored in the coil will be dissipated in useless primary resonance. As outlined above, the major advantage of the dwell extension feature would then be lost.

Don't open up the plug gaps

Before we leave this topic, there is one final aspect which should be noted. In the past, when fitting electronic ignition, car enthusiasts have often increased the spark plug gaps by as much as 50% to take advantage of the higher spark voltage which is usually available and thereby gain a longer spark "path".

(In our previous article we recommended that distributor points and spark plugs be left at normal settings to allow a quick changeover to normal ignition, should this be necessary in the case of a failure.)

But note that we said above that spark

duration is determined also by the resistance path presented by the spark plug. If the resistance is increased the actual spark duration will be shorter, for a given coil energy storage. So, opening the plug gaps will give a longer spark "path" but it will also give a shorter spark duration. On balance then, there is no advantage to be gained by increasing the spark plug gaps.

Circuit changes

Apart from the change to the spark duration, we have made two other changes to the circuit in the light of three years experience with the system. The first is to change the paralleled base bias resistors for Q3 from 120Ω to 220Ω and the second is to change the mounting arrangement for the various diodes.

The reason for the latter changes is that we know of a number of these systems that have failed because one of the three diodes, D2, D3 or D4, which provide the voltage reference for the current source, Q3, has failed and gone "open-circuit". This causes Q3 to conduct very heavily and burn out its three 2.7Ω emitter resistors. This usually chars the printed board so badly that it also has to be replaced.

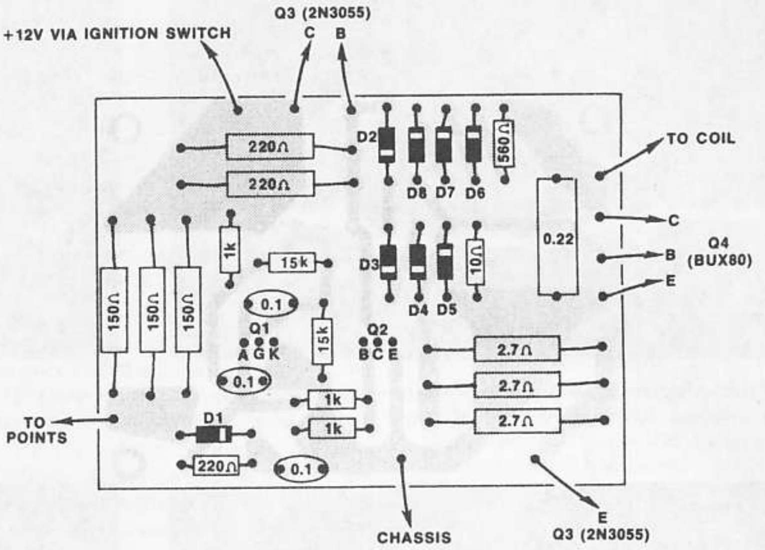
By changing the base bias resistors for Q3, it is not likely to conduct so heavily. More importantly, by mounting each diode with a "stress relief" loop at one end, it is less likely to fail.

Elsewhere in this article we give details of an optoelectronic distributor head which can be used with our transistor ignition system. We have mixed feelings about this option. On the one hand, the opto system eliminates the distributor points entirely and should give smoother idling. On the other hand, it precludes the possibility of a quick change back to standard ignition in case of a failure.

While the odds of such a failure occurring are probably fairly long, it does bear thinking about. We have devised a system which gives changeover in a few minutes and which could easily be done by even a "non-electronics inclined" mechanic in the event of a failure while your spouse or relative is driving the car. By contrast, a failure in an all electronic system would probably be a "tow away job".

Construction

The entire transistor ignition circuit is housed in a diecast aluminium box. We used an Eddystone box measuring 93×56×119mm but any diecast box which can comfortably accommodate the PC board and power transistor heatsink will be suitable. A diecast box is preferred to a folded sheet metal box in that it is more rugged and can be made splashproof easily.



The 150Ω, 220Ω and 2.7Ω resistors are all 1W units; the 0.22μF capacitor across the BUX80 (Q4) should be rated at 630VDC or 250VAC.

WHAT ABOUT CDI?

Incidentally, we debunked CDI systems in our December 1979 article because of a number of problems, chiefly circuit reliability, tendency to cross-fire and lack of compatibility with automotive tachometers. We no longer recommend any CDI design, including our own version described in July, 1975.

We stand by what we said then: that CDI is not suitable for four-stroke auto engines, particularly those that comply with pollution regulations. Not only will the cross-firing tendency of capacitor discharge ignition cause rough running but it is highly likely that it will cause damage to piston crowns. Nor is it likely to have any benefit for fuel economy as the very short spark duration is likely to result in less reliable fuel ignition.

It is significant that not one automobile manufacturer has incorporated CDI as standard equipment.

CDI does have a place in two-stroke engines where its ability to fire fouled plugs is an advantage and cross-firing is not a problem.

All the components with the exception of the two power transistors are mounted on a small PC board measuring 91×68mm and coded 79ti11.

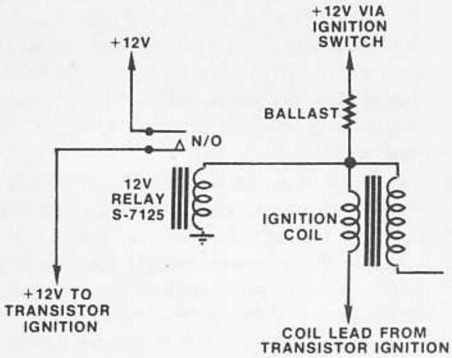
The two power transistors are mounted on the lid of the diecast box together with a single-sided heatsink which is readily available from most kitset suppliers.

If the heatsink does not come pre-drilled you should first drill it using a TO-3 mica washer as a template. After drilling, remove any burrs by using a large diameter drill. Next, position the heatsink on the lid of the diecast box in such a way that it does not interfere with the lid-securing screws and then punch suitable drill centres in the lid and drill and deburr the holes in the previous manner.

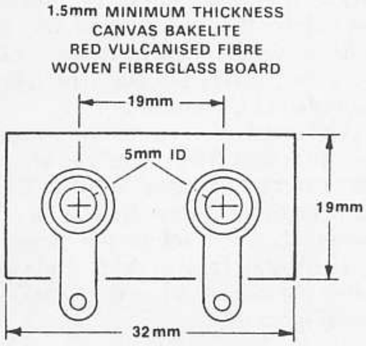
With the heatsink free of any metal shavings or other grit, a thin layer of thermal conducting compound or silicone grease can be applied in the area underneath the transistors and on the mica washer. Some heatsink compounds may contain beryllium, a highly toxic substance, so apply the compound carefully with a cotton bud and avoid skin contact with it. Mount the transistors with the mica insulating washers and plastic bushes in position and then check that the case of both transistors is insulated from the heatsink and lid using a multimeter or other continuity checker.

We used plastic TO-3 transistor covers on both transistors. These are essential both to eliminate the possibility of short circuits and also to isolate the rather high voltages which are present on the case of Q4.

Q4 may either be a BUX80 as originally specified or a Motorola 2N6547. At pre-



This circuit is suggested as a method of connection in cars with the ballast resistor in the wiring harness.



EYELET/SOLDER LUG ASSEMBLY

Use one of these lug assemblies to make the connections to the ignition system.

sent we know of no other transistors which are suitable equivalents so any other transistors which are substituted for Q4 should be regarded as bogus (unless the kitset supplier includes in the kit a note of authorisation from "Electronics Australia").

Now the components can be soldered onto the PC board. The only problems which might be encountered here are with the orientation of the diodes, the PUT and BD140 transistor, so pay special attention to the wiring diagram.

Note that the diodes should all be installed with a loop at one end, as shown in the photograph. The loop may be at either end although we have made it at the cathode end in each case.

Note that parallel combinations of resistors have been used in three instances. This is done because one watt resistors are cheaper and generally more readily available than equivalent five watt wirewound resistors and their temperature rise is not as great. Even so, one watt resistors can still become quite warm so mount them slightly off the board.

We suggest that you delete two of the three parallel 150Ω 1W resistors if you intend fitting the optional optoelectronic trigger circuit. This will reduce dissipation in the MJE340 trigger transistor, as well as lowering its "saturation" voltage.

Wires to the transistors and to the various external connections are heavy gauge 4mm auto cable. This won't fit easily into a standard PC hole so we suggest that you could either redrill the holes to an appropriate size or use PC stakes. If PC stakes are used make sure they fit tightly into the PC hole so they can't fall out when a wire is soldered onto them.

Mounting holes for the PC board should now be drilled. The PC board is mounted on the lid using brass or plated standoffs, screws, nuts and shake-proof washers. The holes will pass through both the lid and the heatsink, so ensure that the mounting screws don't interfere with the fins on the heatsink first. Before installing the PCB, wire up the leads to the power transistors. Use one-metre lengths of wire to provide the chassis, points, coil and battery connections to the PCB.

When the unit is actually installed these lengths may be increased or decreased and suitable lugs or connectors attached. The chassis cable is also connected to a lug on one of the standoffs so that the circuit is connected to the car chassis via the case as well.

Clamp the cables before they exit the box using a cable clamp; if necessary, build up the cable thickness with insulation tape to give a tight fit. The cable should exit via a grommetted hole on a side of the box which will actually face downwards when installed. This will help keep water out of the unit.

The only remaining task is to install the completed unit into the car. For reliable performance of the unit choose a well-ventilated spot – ideally well away from possible splashing by mud or water. Near the front grille or on the wheel housing would be suitable positions.

Install the case by the use of a suitable bracket or drill several holes in the bottom of the case and secure it to the vehicle by means of 12mm×No. 10 self-tapping screws. With the unit mounted, the various connections to the car electrical system can be made.

For this purpose, we recommend the use of an eyelet/solder lug assembly. This sits on what is normally the points connection of the coil but which now is connected to the collector of Q4. The remaining connection point of the solder lug assembly connects the points wire from the distributor back to the "To points" lead in the transistor ignition.

The other connection to the coil remains as standard because it is the same whether transistor or conventional ignition is being used. In this way it is simply a matter of swapping leads to the eyelet assembly on one side of the coil, if a changeover is necessary. We do not recommend any other system of changeover which may involve switches or plugs.

Most kitset suppliers already supply this eyelet as standard.

Apart from the connections to the ignition coil and points it is also necessary to

Parts List

1 PC board, code 79ti11, 91mm×68mm
1 diecast aluminium box, 118×93×56mm, Eddystone 6908P or similar.
1 dual TO-3 heatsink (see text)
3 metres red 4mm auto cable
1 metre black 4mm auto cable
4 25mm brass standoffs
2 sets of TO-3 mounting hardware, ie, mica washers, insulating bushes, screws and nuts.
2 TO-3 transistor insulating caps
1 eyelet/lug assembly

SEMICONDUCTORS
1 BUX80, 2N6547 transistor
1 2N3055 transistor
1 BD139 transistor
1 2N6027 PUT
5 1N4002 diodes
3 1N4761 75V zener diodes

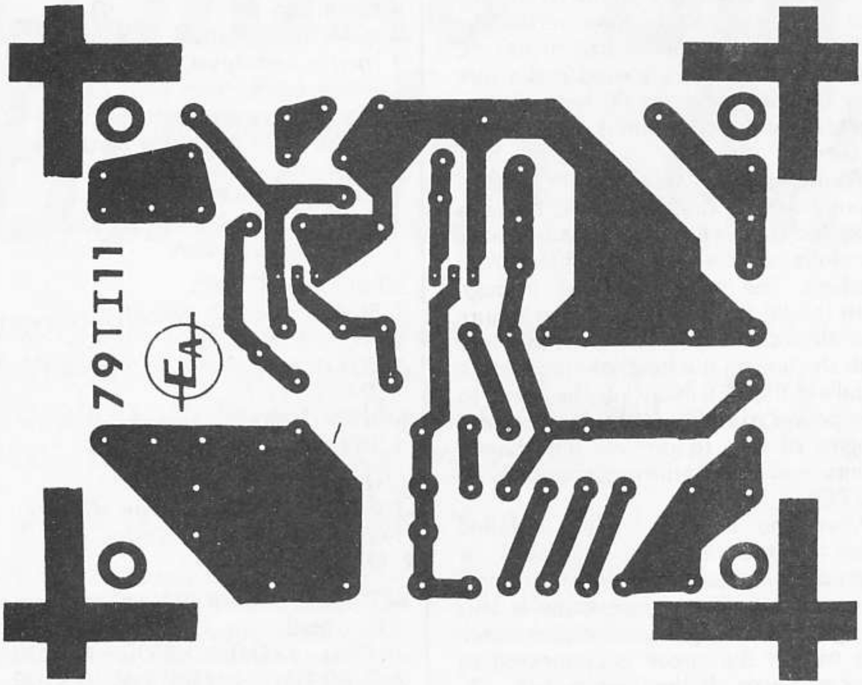
CAPACITORS
1 0.22μF 630VW or 250VAC
3 0.1μF metallised polyester (greencap)

RESISTORS (¼W or ½W unless specified)
2×15kΩ, 3×1kΩ, 1×560Ω, 1×220Ω, 2×220Ω/1W, 3×150Ω/1W, 1×10Ω, 3×2.7Ω/1W.

ADDITIONAL PARTS FOR OPTO-ELECTRONIC TRIGGER OPTION
1 printed circuit board set, code 81ti6, 74×58mm
1 5401 quad two-input NAND gate (do not substitute)
2 MJE340 NPN transistors
1 TIL81 phototransistor
1 TIL31 infrared LED
1 5.6V 400mW zener diode
4 1kΩ resistors (¼ or ½ watt)
1 680Ω resistor (¼ or ½ watt)
1 470Ω resistor (¼ or ½ watt)
1 39Ω resistor (½ watt)
2 brass pillars
Machine screws and nuts, cable clip, two-core cable etc.

NOTE: Resistor wattage ratings and capacitor voltage ratings are those used for our prototype. Components with higher ratings may generally be used provided they are physically compatible.

Transistor-assisted Ignition



Actual size artwork for the PCB.

connect the +12 volt lead to the battery via the ignition switch. Some circuit designs actually obtain power via the ballast resistor, which means that the circuit would probably be easier to install but it also has the disadvantage of reducing coil current and so reducing spark energy.

If your car has a separate ballast resistor then it is a simple matter to connect to the ignition switch side of the resistor. Some cars, though, use a ballast wire, which complicates the situation because it is then necessary to guide the +12 volt lead from the transistor ignition through an appropriate hole in the firewall to the actual ignition switch itself. Alternatively, if you do not wish to drill through the firewall then you can use the circuit shown elsewhere in this article. It consists simply of a relay connected to the coil side of the ballast resistor which switches the +12 volt from the battery directly. The relay can be installed inside the box.

With installation complete, the system can be tested. The points gap should be set exactly as specified by the car manufacturer. Note that if a "dwell meter" is used to set the points gap, then it is probably best to do this adjustment when the vehicle is running with conventional ignition.

FEEDBACK

TAI ballast resistor may run too hot:

TRANSISTOR-ASSISTED IGNITION: A few years ago we decided to overcome some problems with a Valiant 215 car by fitting a transistor-assisted ignition system as described in EA, in December 1979. It was the circuit featuring extended dwell so that the coil current flowed for a much greater proportion of the time and the coil had a much greater duty cycle, if we may borrow a term from transformer jargon.

During investigation of poor high power performance, or more correctly, lack of power during times when the compression pressures in the cylinders of the engine were high, we measured the current drawn by the coil. It was realised that the average current through the coil was lower than the specification of the car manufacturer.

It was further realised that the average current through the coil should be very nearly the same as the current specified with the engine stopped and points closed. Then we found something else. The higher current with longer dwell resulted in greater heating of the normal dropping resistor in series with the coil (specified in the Valiant as 0.5 to 0.6 ohms) and the coil current actually fell. Since the coil also runs hotter, its resistance could also be expected to be higher.

Fitting parallel resistors (actually a complicated system of coil resistors from the local car wreckers) enabled us to adjust the coil to a running current of about 4 amps. We moved the coil from the engine block to a position on the mudguard wall.

The improvement in performance is outstanding. As an example, the top speed is now 103mph, as indicated by the speedo (pre-metric) and a tachometer which is believed to be reliable. Since the car had done about 130,000 kilometres and is fairly worn, this seems adequate to us (more than adequate . . . Ed.).

Provided we wipe the accumulation of oil from the points occasionally (the distributor may be worn), or whenever running becomes slightly rough, the performance of the ignition system is now what it should be. (A. B., North Mackay, Qld.)

• As you are now aware, we updated this circuit (see article above). Your comments about the ballast resistor are pertinent, especially to those using open-wire construction. These would become much hotter at higher currents and thus their resistance would increase. Even so, we would not have expected the marked effect you report and we wonder if the original ballast resistance was not suffering from the effects of many years of exposure and resultant oxidation.

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