The Driveway Sentry

By JIM ROWE

Here's a low cost, easy to build and install sensor system for detecting moving vehicles like cars, trucks, tractors or other farm machinery. It can also be used to detect the opening and closing of metal gates and roller doors.

Unlike other sensing systems that use light, heat or ultrasonic sound waves to detect motion, the Driveway Sentry operates by sensing small changes in the Earth's magnetic field – the same magnetic field that is sensed by a compass.

Since cars, trucks and similar vehicles contain a significant amount of ferrous metal (iron, steel etc), they inevitably produce small temporary changes in the Earth's magnetic field when they move into or through an area.

That's how the Driveway Sentry detects them, using a special high-sensitivity shielded remote sensor unit.

Because it doesn't generate any sensing fields of its own, the Driveway Sensory produces no environmental pollution of any kind; it's quite 'clean'.

Also, because it only senses moving iron and steel objects like vehicles, it is much more selective than other kinds of sensor.

This makes it immune to false alarms from birds, dogs, cats, sheep, cattle and other animals, falling tree branches, rain and snow, people walking past and so on.

At the same time it can be used to detect the movement of vehicles which

MAIN FEATURES

Exit Delay: Allows the system to be switched to non-sensing 'sleep mode' for a period of about six minutes, to allow the owner's vehicle to exit from the property without activating the Driveway Sentry. At the end of the Exit Delay period, the system returns to its movement sensing mode.

Test Button: Allows the system to be manually triggered into 'movement detected' alarm mode, without having to drive a vehicle past the remote sensing unit. This makes system adjustment much easier and more convenient.

Piezo Buzzer: Produces a high-pitched sound to attract your attention when movement is detected. This sound can be disabled if you prefer the system to respond silently.

Relay Contacts: The Driveway Sentry control box includes a DPDT relay with two sets of changeover contacts. These are activated when the system detects movement, allowing the Sentry to be connected to security systems, telephone diallers, radio transmitters and so on. It can also be used to control mains lighting, electric gates or other equipment, via an external mains-rated relay.

Alarm Duration Control: Allows the duration of the system's 'movement detected' alarm mode to be adjusted between a minimum of two seconds and a maximum of about 25 seconds.

Probe Sensitivity Control: Allows the sensitivity of the Sentry's remote sensing unit to be adjusted over a wide range, so it can be set for reliable vehicle (or gate or door) movement detection without being too sensitive and susceptible to false alarms.

Low Power Consumption: Operates from 12V DC power, with a low current drain and power consumption – less than 70mA (0.84 watts), even in 'movement detected' alarm mode. This means that the system can be operated from a 12V battery and/or solar power in rural and other remote situations.

contain very little ferrous metal – like aluminium trailers, boats and caravans - simply by attaching a strong magnet to the underside of their frame. The magnet ensures that if they're moved past the Driveway Sentry's remote sensor unit, the Earth's magnetic field will be disturbed locally and the system will activate.

The Driveway Sentry can also be used to detect the opening or closing of a ferrous metal gate, or a roller door made from the same material, simply by placing the remote sensor unit in the appropriate position.

It can even be used to detect the opening and closing of non-ferrous (ie, timber or aluminium) gates or roller doors, again simply by attaching a magnet to them. In short, the Driveway Sentry has a multitude of motion-sensing uses around the home, farm or industrial facility.

By the way, the remote sensor unit doesn't have to be mounted directly under the driveway or gateway, so there's no need to cut a trench in your concrete drive. It's sufficiently sensitive to detect moving vehicles within a range of about 3-5 metres, so it will work quite well when buried in a shallow trench alongside the driveway or gateway.

The system operates from 12V DC and draws very little current: less than 30mA when 'armed' and waiting, and no more than 70mA when it senses movement and is 'alarmed'.

This means it's very economical and can easily be operated from a 12V battery and/or solar power, as an alternative to an AC plugpack supply.

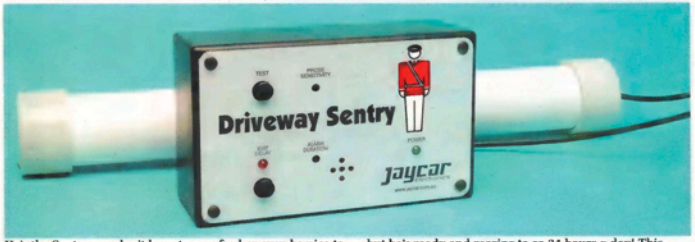
The Driveway Sentry has been developed by Jaycar Electronics, and as a result the kit will only be available from Jaycar.

Because the project's remote sensing unit uses a special construction and involves many thousands of turns of fine wire, this will be supplied pre-built and sealed in a waterproof housing with 30m of special shielded cable attached. This should be sufficient to connect the sensor back to the Driveway Sentry in most home or business situations.

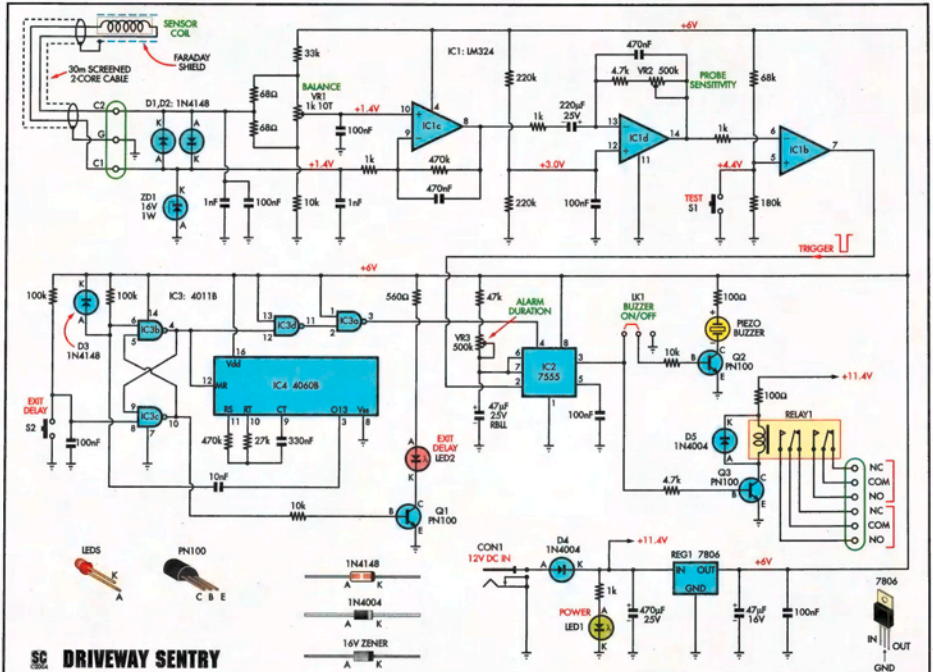
However if you need to monitor vehicle movement much further away from your house or office (say at a remote entrance gate or machinery shed), its alarm outputs can be connected back to your main security system via a VHF or UHF radio link.

How it works

The heart of the Driveway Sentry is its remote sensor, which as we said has many thousands of turns of fine wire wound on a long rod of 'soft' iron.



He's the Sentry you don't have to pay, feed or even be nice to . . . but he's ready and rearing to go 24 hours a day! This photo shows the control box and behind that, the sensor which is buried in the ground alongside your driveway.


SENSOR COIL
FARADAY SHIELD
30m SCREENED 2-CORE CABLE
C2
G
C1
D1,D2: 1N4148
ZD1 16V 1W
33k
68Ω
68Ω
BALANCE VR1 1k 10T
100nF
1nF
100nF
10k
1nF
+1.4V
IC1: LM324
IC1c
IC1d
IC1b
470k
470nF
220k
1k
220µF 2.5V
100nF
+3.0V
470nF
4.7k VR2 500k
PROBE SENSITIVITY
68k
1k
180k
+4.4V
TEST S1
TRIGGER
+6V
100k
100k
D3 1N4148
IC3: 4011B
IC3a
IC3b
IC3c
IC3d
560Ω
IC4 4060B
Vdd
RS RT CT Q13 Vss
470k
27k
330nF
10nF
EXIT DELAY
S2
100nF
EXIT DELAY LED2
Q1 PN100
10k
47k
ALARM DURATION
VR3 500k
IC2 7555
47µF 25V
100nF
LK1 BUZZER ON/OFF
100Ω
PIEZO BUZZER
10k
Q2 PN100
+11.4V
100Ω
RELAY1
D5 1N4004
Q3 PN100
4.7k
NC
COM
NO
NC
COM
NO
LEDS
PN100
1N4148
1N4004
16V ZENER
CON1 12V DC IN
D4 1N4004
REG1 7806
IN OUT GND
1k
POWER LED1
470µF 25V
47µF 16V
100nF
7806
IN OUT GND
DRIVEWAY SENTRY

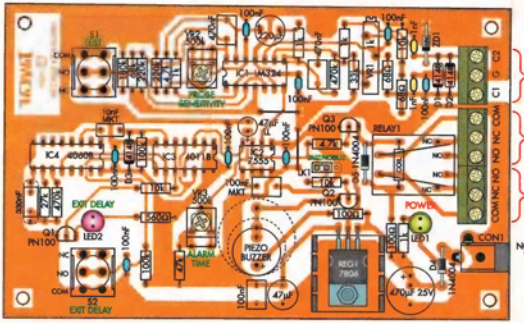


Fig. 1 (left): the complete circuit diagram, and Fig.2 (right): the PC board overlay. As you can see, various size piezo buzzers can be accommodated on this board. Note the comments about the relay in the text: neither its contacts nor the PC board tracks are rated to handle 240VAC – however, it can be used to switch an external 240VAC rated relay.

This makes the coil very sensitive to small changes in the Earth's magnetic field, of the type produced by a vehicle moving nearby. As a result of the magnetic field changes, the coil generates tiny low frequency AC voltages, and it's these that are fed back to the Control Box via twin shielded cable. They are then amplified and used to trigger the alarm circuit.

Because the sensor coil also tends to pick up a significant amount of electrical noise and mains hum, it must be fitted with a Faraday shield. This is a thin sheet of metal foil encasing the coil, providing it with an electrostatic shield (without also forming a shorted turn). The shield is connected back to the Control Box ground via the cable screening braid. The full circuit is shown in Fig.1.

Inside the box, the small voltages induced in the sensor coil are amplified by about 470 times in a DC amplifier stage using IC1c – one section of an LM324 quad op-amp.

Because of the high gain, this stage is provided with fine manual control over bias balancing, using 10-turn trimpot VR1. Diodes D1 and D2, along with zener diode ZD1 are used to protect IC1c from blocking or damage caused by induced voltage 'spikes'.

The output from IC1c is further amplified by IC1d, configured as an AC amplifier stage with gain adjustable between about 5 and 500 times using trimpot VR2.

This brings the peak amplitude of the amplified sensor coil signals up to a level where they are capable of being applied to IC1b, which compares them with a reference voltage of +4.4V from the voltage divider formed by the 68kΩ and 180kΩ resistors.

When the peak value of the amplified sensor signals exceeds the +4.4V reference level, the output of comparator IC1b switches low.

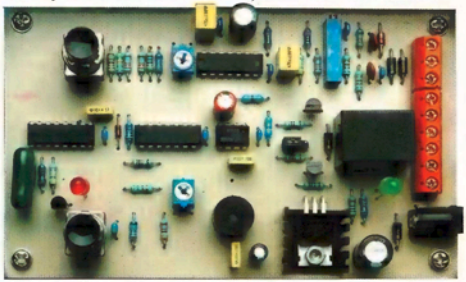
This negative-going pulse is used to trigger IC2, a 7555 timer IC configured as a one-shot. The output of IC2 (pin 3) then switches high, for a time period set by the RC time constant connected to pins 6 and 7. Trimpot VR3 allows you to adjust this alarm duration time between about two and 25 seconds.

When IC2 triggers on, it switches on transistor Q3 and operates the relay. The relay contacts can then be used to switch power to a siren, turn on security lights or trigger your main security system.

At the same time, the high level on pin 3 of IC2 can be used to turn on transistor Q2 which controls the small piezo buzzer mounted in the Driveway Sentry control box. If you don't want this internal buzzer to sound, it can be disabled by moving link LK1 over to the earthy side.

Note that pushbutton switch S1 can be used to temporarily ground the positive input of comparator IC1b. This forces the output of IC1b low, triggering IC2 in the same way as a signal peak from IC1d.

So S1 provides a handy Test function, allowing you to do things like adjust the alarm duration without



The completed PC board, as mounted in the jiffy box.

Parts List – Driveway Sentry

1 PC board, code DRIVSENT, 133 x 83mm
1 Jiffy box, UB1 size (158 x 95 x 53mm)
1 Magnetic Sensor potted coil assembly (Jaycar)
1 12V DPDT relay, 5A contact rating
1 piezo buzzer
2 DPDT pushbutton switches (S1,S2)
3 3-way terminal blocks, PC-mounting
1 2.5mm concentric power connector, PC-mounting
1 3-pin SIL header strip, with jumper shunt
1 19mm square U-shaped heatsink
4 M3 tapped spacers, 25mm long
4 M3 machine screws, 9mm long countersunk head
5 M3 machine screws, 9mm long round head
1 M3 hex nut and star lockwasher

Semiconductors

1 LM324 quad op amp (IC1)
1 7555 CMOS timer (IC2)
1 4011B quad NAND gate (IC3)
1 4060B binary counter (IC4)
1 7806 +6V regulator (REG1)
3 PN100 NPN transistors (Q1,Q2,Q3)
1 16V 1W zener diode (ZD1)
1 5mm green LED (LED1)
1 5mm red LED (LED2)
3 1N4148 silicon diodes (D1,D2,D3)
2 1N4004 1A silicon diodes (D4,D5)

Capacitors

1 470µF 25V RB electrolytic
1 220µF 25V RB electrolytic
1 47µF 16V RB electrolytic
1 47µF 25V RBLL electrolytic
2 470nF MKT polyester
1 330nF greencap or MKT
8 100nF multilayer monolithic ceramic
2 100nF MKT
1 10nF MKT
2 1nF disc ceramic

Resistors (0.25W 1%)

2 470kΩ	2 220kΩ	1 180kΩ	2 100kΩ	1 68kΩ
1 47kΩ	1 33kΩ	1 27kΩ	3 10kΩ	2 4.7kΩ
4 1kΩ	1 560Ω	2 100Ω	2 68Ω	

1 1kΩ trimpot, horizontal 10-turn (VR1)
2 500kΩ trimpots, horizontal (VR2,3)

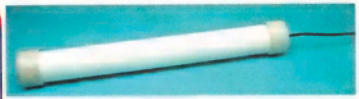
WHERE TO GET THE KIT:

This project was designed and developed for Jaycar Electronics, who own the copyright to the circuit, PC board and illustrations.

A kit of parts will be available exclusively from all Jaycar Electronics stores shortly after this issue goes on sale.

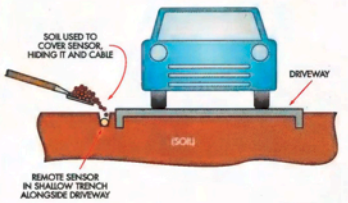
The kit (KC5402) has all components listed above, including the unique sensor coil and retails for $179.00 including GST.

Contact your nearest Jaycar Electronics store or visit www.jaycar.com.au



The remote sensor, potted inside its PVC pipe protective cover. Don't try to remove it – the chances are very high that you will damage or destroy it!

The drawing below shows how the sensor can be located in a trench alongside the driveway – you don't have to cut a hole in the concrete to use the Driveway Sentry.



having to drive a vehicle near the remote sensor unit.

All of the remaining circuitry around IC3 and IC4 is used to provide the Driveway Sentry's 'exit delay' function. This operates quite simply by holding the reset pin (pin 4) of IC2 low for a fixed period of about six minutes, after power is first applied to the Driveway Sentry or after pushbutton S2 is pressed at any later time. With its reset pin held low, IC2 is prevented from triggering during that time, allowing you to drive out in your own vehicle before the Sentry is re-armed.

The exit delay circuit consists of a simple R-S flipflop using IC3b and IC3c, two of the gates in a 4011B quad NAND gate. When power is first applied or when S2 is pressed, the flipflop is switched into its reset state (pin 4 low), by the temporary low on pin 8. This low is applied to the reset pin (12) of IC4, a 4060B oscillator/14-stage binary divider IC. IC4 is thus allowed to begin oscillating and counting.

This proceeds for around six minutes, after which IC4's pin 3 (output O13) finally drops to the low logic level. This negative-going edge is coupled via the 10nF capacitor back to pin 6 of IC3b, which switches the flipflop back into its set state. In this state pin 4 goes high, holding IC4 in its reset state and stopping its oscillator and counter.

At the same time, gates IC3d and IC3a (used as inverters) apply a logic high to the reset pin of IC2, allowing it to be triggered again. So the Driveway Sentry is re-armed.

Notice that during the exit delay time, there is a logic high on pin 10 of IC3c, the lower flipflop gate. This is used to turn on transistor Q1, which allows current to flow through LED2. This LED is therefore only illuminated during the exit delay period.

The power supply section of the Driveway Sentry is straightforward. Diode D4 provides reverse polarity protection on the 12V DC input, while regulator REG1 provides

a stable +6V supply for all of the electronics apart from the relay. LED1 gives indication that the Driveway Sentry has +12V power and is operating.

Construction

Apart from the remote sensor unit, all of the Driveway Sentry's components and circuitry are mounted on a small PC board measuring 133 x 83mm and coded DRIVSENT. It is mounted in a standard UB1 jiffy box measuring 158 x 95 x 55mm, which forms the control box. The remote sensor unit connects to it via the 30m shielded cable.

Since the remote sensor unit will be supplied fully built up, you will only have to wire up the control box - ie, fit the components to the PC board. This should be quite straightforward if you use the PC board overlay diagram (Fig.2) and the internal photo as a guide.

Begin assembly by fitting the two wire links to the board. These are near IC2 in the centre and they are both 0.4" long (so you can use '0Ω' dummy resistors if you prefer). Also fit the three-way SIL header strip for LK1 at this time – it goes between IC2 and the relay location. Then fit the three 3-way terminal blocks, which go on the right-hand end of the board. The 2.5mm DC input socket can be fitted as well, down in the lower right-hand corner.

Now fit the resistors. Follow these with the smaller unpolarised capacitors, then the larger unpolarised and polarised capacitors. Make sure you fit the latter with the correct orientation, as shown in the overlay diagram. Note that there are two different 47µF electrolytics: one a low leakage (RBLL) type, usually in a case with an orange coloured sleeve, and the other a standard RB type in a black sleeved case. The low leakage unit goes near IC2 in the centre of the board, while the standard electro goes just to the left of REG1.

Next mount the three trimpots, the relay and the piezo buzzer. Note that the PC board provides multiple holes for the buzzer, to cope with different buzzer pin spacings.

The two pushbutton switches can be fitted after this, but you may need to slightly enlarge the PC board holes for these with a jeweller's file, to allow their lugs to pass through the board sufficiently for soldering.

Begin fitting the semiconductors by adding the various diodes, making sure you fit them in the correct locations and with the correct polarity. Then fit the three transistors, watching their orientation also.

The completed PC board mounted in a UB1 Jiffy Box. Note the hole and slot cut in the ends of the box – the hole (right) is for the plugpack mains adaptor, while the slot allows the wiring from the sensor unit and the wiring to external alarm/ controlled devices to enter the box.

Follow these with REG1, which is mounted horizontally with a 19mm U-shaped heatsink. Its three leads are bent downwards 6mm from the device body and soldered underneath.

The regulator body is held firmly down in contact with the heatsink using a 9mm long M3 machine screw with a star lockwasher and M3 nut.

The four DIL ICs are fitted next, making sure you fit each one the correct way around as shown in the overlay diagram.

As three of the ICs are CMOS, take the usual precautions to minimise the risk of electrostatic damage. Use an earthed soldering iron, and ideally earth yourself before picking up these devices. Also solder their supply pins to the PC board pads first, before soldering the other pins.

The final components to fit are the two LEDs, which are both 5mm types. The green LED fits in the LED1 position just below the relay, while the red LED fits in the LED2 position just above pushbutton S2.

Both mount vertically with the lower surface of their body 20mm above the board, so they will protrude through matching holes in the box front panel when it's assembled. They are also both orientated with their 'flat' side downwards, and their longer anode lead towards the top of the board.

Your Driveway Sentry board assembly should now be complete, and ready for testing.

Testing and setup

For the initial testing, there's no need to connect the remote sensor unit to the PC board assembly. Just connect a 330Ω resistor temporarily between terminals C1 and C2 at upper right on the board, as a passive 'stand in'.

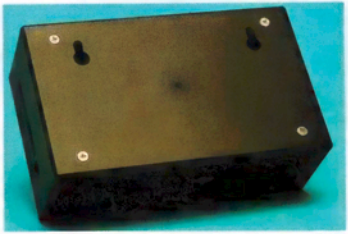
Then connect a plugpack or another source of 12V DC to CON1, the board's DC input connector at lower right.

If all is well, both LEDs should immediately light – LED1 because power is present and LED2 because the exit delay timing circuit has already begun counting. LED2 should remain on for about six minutes after power-up, just as it should do after you press button S2.

Next, connect a DMM to pin 8 of IC1, and measure the voltage. It should be between +2.5V and +3.0V. If it isn't inside this range, adjust trimpot VR1 until it is.

Now set trimpot VR3 to about mid-range and check that link LK1 is in the 'buzzer on' position. Also wait until LED2 is off, showing that the exit delay circuit has timed out. Then press Test button S1, which should make the relay operate and the buzzer sound.

If the buzzer operating time is not to your liking – ie, it's too short or too long – this can be changed quite easily by adjusting trimpot VR3. The adjust-



A couple of keyhole slots cut in the rear of the Jiffy Box makes it easy to mount the box on a wall. Naturally, these need to be cut before the PC board is installed in the box.

ment range is from about two seconds up to about 25 seconds.

The only other adjustment to be made to the Driveway Sentry is to vary the sensitivity of the sensor probe. This is done in much the same way as for the alarm duration, but by adjusting trimpot VR2. The adjustment must be done later though, when the system has been installed and the remote sensor unit connected. For the present, simply set VR2 to its midrange position.

Final assembly

The final step in building the Driveway Sentry is to fit the PC board assembly inside the main part of the box. It mounts via four 25mm long M3 tapped spacers, using four 9mm long M3 countersink head screws to fasten the spacers in the box, and four 9mm long M3 round head screws to attach the PC board.

When the board is mounted inside the box the pushbuttons will protrude through matching holes in the front panel, as will the two LEDs. The Probe Sensitivity (VR2) and Alarm Duration (VR3) trimpots can also be adjusted using a small screwdriver through their labelled adjustment holes.

A 10mm diameter hole in the right-hand end of the box allows the 12V DC cable to enter, while an adjacent rectangular slot allows entry of the various sensor unit and relay contact cables.

As you can see from the diagram of Fig.3, the rear of the box has two elongated holes to allow the completed control unit to be mounted on a wall using two 8G x 25mm self-tapping screws or similar. The screws should be fitted to the wall exactly 100mm apart, in horizontal alignment and screwed in with their heads only 2.5mm away from the wall.

Mount the control box in a position where it's unobtrusive, yet easy to access so you can press the Exit Delay button before leaving.

Locating the sensor

The remote sensor unit is housed in a sealed plastic tube 50mm in diameter and 370mm long. It's designed to be placed in a shallow trench alongside your driveway, so that it's out of sight while still being near any vehicles moving on the driveway. If there's a steel-framed gate at the driveway entrance, you can mount the remote sensing unit under the area where the gate is swung open, so it will detect the gate being moved as well as a moving vehicle.

Note that the remote sensing unit doesn't have to be mounted directly under the driveway, because it's quite sensitive. So there's no need to cut a trench in your concrete drive – just bury the sensor a small distance down in a lawn or garden bed alongside the drive.

The sensor is connected back to the control unit via its attached 30m long screened cable. The two inner wires of the cable connect to terminals C1 and C2, while the earthing screen connects to the centre 'G' terminal.

There's no need to dig a deep trench for the probe. It only needs to be about 100mm below the surface, where it should be hidden and protected from damage. The cable can be run back to the nearest building in a narrow trench of about the same depth.

Sensitivity adjustment

Once the sensor unit has been fitted in position and connected back to the control unit, you're ready to make the final adjustment: probe sensitivity. As explained earlier this can't be done using the Test button; it can only be done using a vehicle moving along the driveway, or someone opening or closing the gate or roller door for you.

Trimpot VR2 is turned clockwise to make the probe more sensitive, or anticlockwise to make it less sensitive. The best setting is where the probe reliably detects the smallest moving vehicle likely to enter or leave via the driveway, without being more sensitive than this.

If you simply adjust VR2 for maximum sensitivity (ie, fully clockwise), the Driveway Sentry may then be prone to giving 'false alarms' due to passing radio transmitters or mobile phones, or during electrical storms.

Putting it to use

When the Driveway Sentry is 'armed' and detects movement, it immediately produces an alarm sound from the buzzer and operates the relay. The relay contacts can be connected to another security system, so that when the relay operates this can initiate further action like triggering a loud siren, dialling a security firm, dialling your own mobile phone or whatever action you choose.

Please note that the relay contacts in the Driveway Sentry control box are NOT rated for switching 240V AC mains power.

So if you want to have the Sentry turn on high power floodlights or other mains-operated equipment when it detects vehicle or gate movement, you'll need to do this via a second external relay with mains-rated contacts (or a mains-rated solid state relay).

The Driveway Sentry's relay contacts can activate the external relay, to control the mains-powered lighting or equipment. Jaycar can supply a mains-rated solid state relay which would be quite suitable for this: the SY-4080, which can switch up to 3A at 240V (ie, 720W).

The main external connection options for the Driveway Sentry are illustrated in the diagram of Fig.3. As you can see it's very easy to hook the Sentry up to a larger security system, using a length of two-wire cable. One wire connects to either COM terminal on the control box, and the other wire to either the NO (normally open) or NC (normally closed) terminal in the

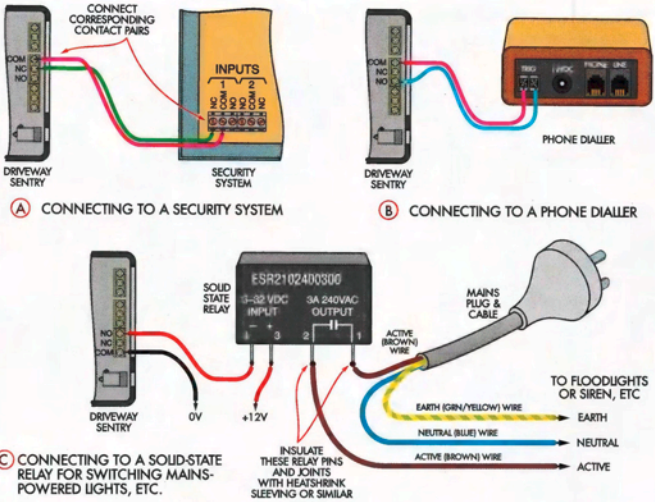


Fig. 3: connecting the Driveway Sentry to various external devices.

same group – depending on the security system input you connect it to at the other end.

If the security system input expects NO contacts, connect to the NO terminal; if it expects NC contacts, connect to the NC terminal.

Connecting the Sentry up to a phone dialler is just as easy. Again you simply use a two-wire cable, connecting it to a COM terminal and either of the matching NO or NC terminals depending on the type of contact action needed to trigger the dialler.

When you want to connect the Driveway Sentry so it can switch on external floodlights or a high-power siren powered by the mains, this can be done by connecting one of the Sentry's relay contact sets so that it can operate an SY-4080 solid state relay, or some other relay rated to switch 240V power.

As you can see, the positive input (control) terminal of the solid state relay is connected to the +12V supply, while its negative input is connected to the NO terminal of the Sentry contacts.

The COM terminal of the same set of contacts is then connected to 0V, so the solid state relay will be operated (turned on) when the Driveway Sentry detects a moving vehicle or gate.

The solid state relay's output connections are then used to switch 240V power to your siren or floodlights, etc. **SC**

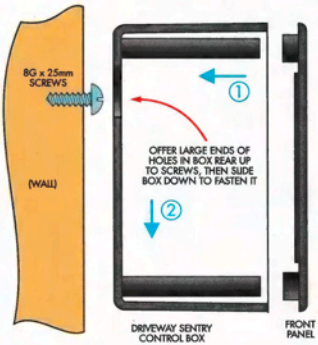


Fig.4: mounting the Driveway Sentry on a wall.