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Constructional Project

GARAGE LINK by TERRY de VAUX_BALBIRNIE

Have you left the garage door open all night again? You need this versatile, license exempt, coded radio link.

Have you ever gone to get the car out of the garage and found that you left the door open all night? With luck, the car is still there and everything inside the garage untouched. You breath a sigh of relief and vow to be more careful in future.

OPEN DOOR

But what if the car had been stolen? How would you square that with the insurance company when you declared that the car is left overnight "in a secure garage"? What about the expensive power tools, bicycles, and gardening equipment you keep there?

These would be easily removed by any opportunist prowler. You could hardly show the "forcible entry" needed to make a claim on your household policy when all he had to do was walk in and take what he wanted!

WIRELESS LINK

This *Garage Link* circuit helps to prevent the garage door (or either door in the case of a double garage having twin doors) being left open all night. It works by establishing a radio link between the garage transmitter and some point inside the house. The indoor receiver then provides an audible warning in the form of a short bleep every 45 seconds.

The likely operating range is difficult to predict. In the open air,

the prototype operated reliably at a distance of over 20 meters (66ft). However, the range will be much less when used in buildings. The presence of metallic objects and even ordinary building materials will reduce the signal.

The prototype units were set up under "fair" conditions. The garage was built with single brick walls and the house with double walls made of brick and breeze block. The easily-obtainable range was approximately 8 to 10 meters (26ft to 33ft). Obviously working to as short a range as practicable will give the most reliable results.

ON SITE

With the likely operating distance in mind and before beginning construction work, it

is essential to check that there are suitable positions for the two units. The garage Transmitter does not need to be particularly close to the door as long as a piece of twin wire can be connected to it from a "remote" trigger switch there. It is better, in fact, if it is kept away from the door if this is made of metal.

Both units should be sited clear of large metallic objects. There should be a mains socket near the house-based Receiver because it is operated using a plug-in power supply unit.

The garage section is battery-operated, using a pack of four "AA" size cells inside the case. This avoids the need for a mains supply in the garage with possible safety implications. The batteries should last for one year approximately.

Of course, applications for this circuit are not confined to monitoring garage doors and many readers will have their

Self-contained Transmitter.

own ideas about how to use it. Because the Transmitter is self-contained, it could be used to monitor other doors, gates, windows, etc. In some situations, it would be necessary to use a waterproof enclosure but this is left up to the constructor.

LIGHT WORK

Since people often wish to leave the garage door open during the day, operation is held off until the light falls to a certain preset level. Another point is that the door might have been left open in the evening on purpose – perhaps because a member of the family is expected home soon.

This is one reason why the warning is given intermittently. It may then be ignored if required. The other reason is that it saves battery power.

Designing a circuit which would sound a warning if the garage door was left open would be easy if there was a clear path for a length of wire to

be laid between a switch at the door and a unit inside the house. Unfortunately, this is not usually the case.

Even where it would be theoretically possible to run such a wire, it is unlikely that there would be a neat and simple way of doing it. It would also involve drilling holes through walls or window frames. This is why it was decided to use a different approach and base this system on a radio link.

FOLLOW THE BAND

The use of the radio frequency (RF) spectrum is carefully controlled with specific bands being allocated for various purposes. In the UK, the body that oversees this is the Department of Trade and Industry (DTI). Some frequency bands are reserved for radio

and TV broadcasting, some for military, some for radio amateurs, some for the public services and so on.

Some small bands of frequencies are left on a license-exempt basis and may be used by anyone. However, strict regulations exist for their use. In particular, the power radiated must be extremely small so that no appreciable signal may be detected more than a short distance from the transmitter.

One such frequency is 418MHz and this is used for certain local pagers, car security devices, "wireless" house alarms

Fig.1. Block schematic of a simple radio link.

Fig.2. Transmitter code.

Fig.3. Circuit diagram for the Transmitter section of the Garage Link. Note that the normally closed contacts of microswitch S7 are used and that closing the garage door opens them. The "TE" designation at IC3 pin 14 means Transmit Enable (the bar over it means this signal's active state is

and so on. However, due to so-called TETRA services operating at around this frequency and more so in the future, the DTI have licensed 433MHz for the same purpose.

This frequency is already in widespread use in mainland Europe. Note that these are actually narrow bands (that is, ranges) of frequencies but for the sake of simplicity they are stated as spot values – 418MHz and 433MHz.

NO GUARANTEES

Although 433MHz equipment is probably less likely to suffer from interference problems especially in the coming years, there is always some risk of this occurring whichever frequency is used. Correct operation therefore cannot be guaranteed under all circumstances.

The prototype unit operates at 418MHz because the necessary modules were readily available at the time. However, there is no reason why similar 433MHz modules could not be used.

Another choice is whether to use AM (amplitude modulation) or FM (frequency modulation). Frequency modulation is more immune from interference, would provide a greater range and, for critical applications, would probably be better. However, here the less sophisticated AM system was used and it performed perfectly well.
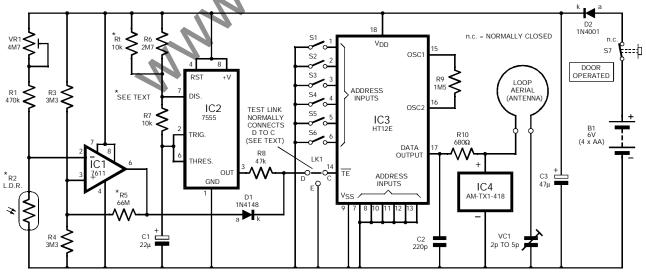
For those who are interested, modulation is the way in which radio waves carry

data. With AM it is the signal strength (amplitude of the waves) emitted by the transmitter which is varied with the frequency remaining constant. In the simplest case, this is performed by switching it on and off. With FM it is the frequency of the waves which is shifted slightly

while keeping a constant amplitude.

COMMERCIAL MODULES

To allow the use of home-made transmitters would lead the way to potentially botched equipment causing interference

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COMPONENTS

TRANSMITTER

Resistors
R1 470k
R2 sub-miniature light dependent resistor (LDR) -- dark resistance approximately 5 megohm (see text)
R3, R4 3M3 (2 off)
R5 66M (2 x 33M connected in series -- see text)
R6 2M7
R7 10k
R8 47k
R9 1M5 (or 1M and 470k in series -- see text)
R10 680 ohms
Rt 10k (test -- see text)
All 0.25W 5% carbon film, except R2

Potentiometer
VR1 4M7 miniature preset, horizontal

Capacitors
C1 22u radial electrolytic, 10V
C2 220p polystyrene
C3 47u radial electrolytic, 10V
VC1 miniature preset trimmer 2pF to 5pF

Semiconductors
D1 1N4148 signal diode
D2 1N4001 1A 50V rectifier diode
IC1 ICL7611 micropower opamp
IC2 ICM7555IPA CMOS timer
IC3 HT12E encoder
IC4 AM-TX1-418 transmitter module (see text)

Miscellaneous
S1 to S6 DIP switches (one strip of six)
S7 lever-arm microswitch
B1 6V battery pack (4 x AA)

PCB available from the *EPE Online Store* (code 7000261 -- transmitter) at **www.epemag.com**; plastic case size 118mm x 98mm x 45mm; 8-pin DIL IC socket (2 off); 18-pin DIL IC socket; battery connector (PP3 type); bracket for microswitch -- see text; connecting wire, solder, etc.

RECEIVER

Resistors
R1 100k
R2 10k
Both 0.25W 5% carbon film

Capacitors
C1, C2 470n miniature metallized polyester -- 2.5mm pin spacing (2 off)
C3, C4 220n miniature metallized polyester -- 2.5mm pin spacing (2 off)
C5 100u radial electrolytic, 25V

Semiconductors
D1 1N4001 1A 50V rectifier diode
TR1 ZTX300 *npn* general-purpose transistor
IC1 AM-HRR3-418 receiver module
IC2 HT12F decoder
IC3 78L05 5V 100mA voltage regulator

Miscellaneous
S1 to S6 DIP switches (one strip of six)
WD1 piezo buzzer -- DC operation 3V to 24V at 10mA
FS1 250mA miniature PCB mounting fuse (see text)

Printed circuit board available from the *EPE Online Store* (code 7000262 -- receiver) at **www.epemag.com**; plastic case size 102mm x 76mm x 38mm; 9V 300mA (unregulated) mains adapter plus socket to suit; 18-pin DIL IC socket; SIL socket for receiver module, see text; connecting wire, solder, etc.

See also the SHOP TALK Page!

Approx. Cost Guidance Only	*Transmitter (Excl. batts)*	**$27**	*Receiver (Excl. mains adapter)*	**$37**

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with vital services. The actual transmitter (but not the circuit controlling it) must therefore be commercially-built to the prescribed specification. It is then said to be "DTI MPT1340 approved, W.T. license exempt".

Appropriate commercial modular transmitters are available quite cheaply. The simplest variety has only two wires, which are used for the power supply and aerial (antenna), and this is the type used in this project.
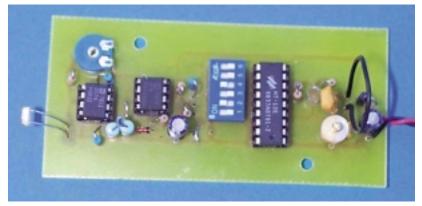
The receiver section is based on a matching receiver module. No traditional "radio" skills are therefore needed during construction and setting-up.

BASIC LINK

A simple radio link between two positions using a transmitter and receiver tuned to the same frequency is shown in Fig.1. Switching on ("keying") the transmitter would send out radio waves from its aerial. The signal would be picked up by an aerial at the receiver and, after suitable processing, the LED (light-emitting diode) connected to its output would operate. By switching the transmitter on and off, the LED would flash in sympathy.

However, this type of system would be vulnerable to false triggering. Every time the receiver picked up a signal from any other source of radio waves operating at or about the same frequency, the LED would come on.

To avoid this, the transmitter is keyed according to a certain pre-arranged digital

code. Only if this code is matched at the receiver end will an output be given. The receiver may well pick up signals which carry no code at all or carry the wrong code (from similar equipment) but, in either case, it will have no effect.

CODED LINK

To illustrate this, suppose the code consists of the six-bit word: 1 0 1 1 0 1. In this case a "1" would be given by switching the transmitter on for a certain time and a "0" by switching it off for the same time. The signal given by the transmitter is shown graphically in Fig.2. The receiver would then be pre-set to "see" this code and no other.

In the *Garage Link*, the code has twelve bits (although only six of them may be changed by the user). It is, therefore, very unlikely that any signal, apart from the intended one, would carry the correct code. If someone within range happened to be operating similar equipment and using the same code then all that would be necessary would be to change it.

Unfortunately, any strong signal at about the working frequency and not carrying the

code could swamp the receiver so that it would not "see" the weaker signal from the transmitter. During that time, no output would be given.

CIRCUIT DETAILS – TRANSMITTER

The complete circuit diagram of the Transmitter section of the *Garage Link* is shown in Fig.3. While the garage door is open, it allows the normally-closed (NC) contacts of microswitch S7 to close and establish a supply to the circuit from the 6V battery pack, B1. When the door is closed, the switch contacts open and no current flows. This method has the advantage that for much of the time, the battery is not being drained.

Diode D2 prevents damage to the circuit if the supply were to be connected in the wrong sense. If it was, the diode would not conduct and nothing would happen. For the moment, ignore IC1 and IC2. IC3 is an encoder,
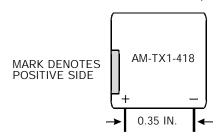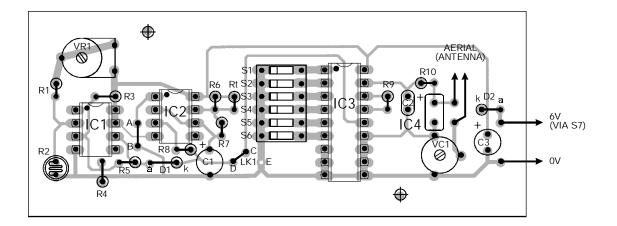
MARK DENOTES POSITIVE SIDE

AM-TX1-418

+   −

0.35 IN.

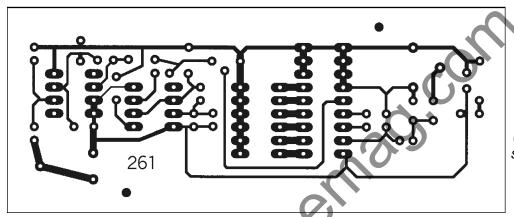*Fig.5. Transmitter module (IC4) pin polarity identification.*

Fig.4. Printed circuit board component layout and (approximately) full size underside copper foil master for the transmitter.

which keys the transmitter according to the pre-arranged code. IC4 is the transmitter module.

The twelve address inputs of IC3 are at pins 1 to 8 and pins 10 to 13. These may be set to logical 1 or 0 to provide the chosen code. Four of the addresses could also be used to carry separate data but this is not done here.

To establish the code some of the address pins are connected to the 0V line to provide logical 0 status. Any pin left unconnected automatically assumes logic 1.

CODESETTING

Setting up the code is carried out using a set of DIP (dual in-line package) switches (S1 to S6) on the PCB (printed circuit board). With a switch on,

a "0" is set and by switching it off, a "1". This gives a simple means of changing the code at any time if required.

It seemed unnecessary to allow user selection of all the addresses, so here only IC3 pin 1 to pin 6 may be set using the DIP switches. The other addresses (pins 7, 8 and 10 to 13) are tied to 0V together with pin 9 which is the 0V input, making them always logic "0".

When the TE (transmit enable) pin 14 is made low (imagine this is so for the moment), the data present on the address pins is given serially at the data output, pin 17. This is in the form of four-word groups and continues as long as pin 14 (TE) is kept low.

If it is low for less than the time taken for one word, it will still transmit a four-word group.

When the low state of pin 14 is removed, pin 17 finishes its current cycle then stops.

The rate at which data is transferred is determined by the frequency of an on-chip oscillator. This, in turn, is set by the value of resistor R9 connected between pin 15 and pin 16 (Osc1 and Osc2). The specified value sets a frequency of 2kHz approximately.

The data from IC3 pin 17 is used to power the transmitter module direct. When it is high, the transmitter (IC4) receives current and sends out a signal. When low, it is off. A short loop aerial (antenna) is used to radiate the waves and trimmer capacitor VC1 is used to tune it for maximum signal strength.
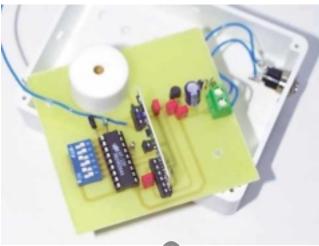
PULSETIME

It is not necessary for the

Transmitter to be providing data continuously – in fact, this would run down the batteries without good reason. IC3 pin 14 (transmit enable) only needs to be pulsed low for sufficient time to provide the bleeps at the Receiver.

To provide these pulses, IC3 pin 14 is connected via resistor R8 and test link LK1, to the output (pin 3) of the astable based on timer IC2. A continuous string of pulses is then produced.

The frequency and mark/space ratio (that is, how long each pulse is high compared with low) is determined by the values of resistors R6 and R7 in conjunction with capacitor C1. With the values specified, one cycle is produced every 42 seconds with each "low" taking 0·2s but this is subject to a fairly wide tolerance.

Test resistor *Rt* is connected in parallel with resistor R6 to begin with. This sets a much shorter time period (about half a second) so the buzzer bleeps rapidly. This will be useful for testing and setting-up purposes. At the end of setting up one of *Rt* end leads is cut to disconnect it from the circuit.

SEEING THE LIGHT

The light-sensing aspect of the circuit is based on operational amplifier (opamp) IC1. This inhibits the action of the encoder when the light level is high enough. The opamp is of a type which requires very little quiescent current (10uA approx.). It therefore has negligible effect on the life of the batteries.

The non-inverting input (pin 3) of IC1 receives a voltage equal to one-half that of the supply (nominally 3V) due to the potential divider action of resistors R3 and R4. The inverting input (pin 2) is connected to a further potential

AM-HRR3-418

38.1mm

2mm

13.7mm

1 2 3   7   10   15

1.27mm

P.C.B. HOLES ON 0.1 INCH PITCH

PIN NO.	FUNCTION
1	R.F. V_{CC}
2	R.F. GND
3	ANTENNA
4,5,6	NOT CONNECTED
7	R.F. GND
8,9	NOT CONNECTED
10	A.F. V_{CC}
11	A.F. GND
12	A.F. V_{CC}
13	*TEST POINT
14	DATA OUTPUT
15	A.F. V_{CC}

*NOT USED

Fig.7. Receiver module pin layout and function details.

Fig.6. Full circuit diagram for the Receiver section of the Garage Link. The designation "VT" at IC2 pin 17 means Valid Transmission.

Fig.8. Printed circuit board component layout and (approximately) full size copper foil track master for the Receiver.

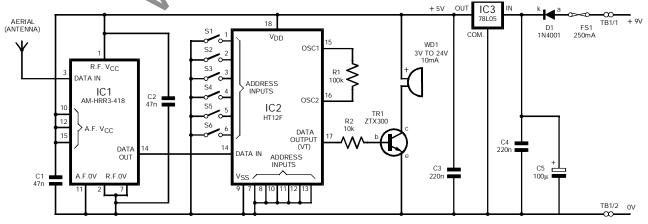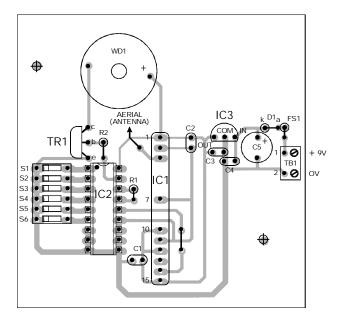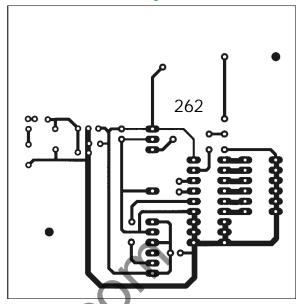divider. Its top arm consists of fixed resistor R1 connected in series with preset potentiometer VR1. The lower arm is light-dependent resistor (LDR) R2.

When the LDR is brightly illuminated, its resistance will be lower than the R1/VR1 combination and the voltage at pin 2 will be less than 3V – that is, less than that at pin 3. With the opamp non-inverting input voltage exceeding the inverting one, the output at pin 6 will be high.

This state is transferred through diode D1 to IC3 pin 14. Whatever the state of IC2 output, IC3 "transmit enable" pin will be made high so operation is inhibited.

FAILING LIGHT

As the light level falls, the resistance of the LDR increases and at some point will exceed that of the R1/VR1 combination. The voltage at the inverting input will then exceed 3V – that is, greater than that at the non-inverting one. The opamp will

switch off and pin 6 will go low. This state is blocked by diode D1 so it has no effect on the encoder (IC3) which is now controlled by the astable (IC2) alone.

The exact light level at which the transition occurs is determined by the adjustment of preset VR1. Resistor R5, which is connected between IC1 non-inverting input and the output, introduces a small amount of positive feedback and ensures a sharp switching action at the critical light level.

While actually transmitting data the circuit requires some 2mA, but between pulses the prototype used less than 95uA. Due to the short pulse length, the average current is very small. Remembering that when the garage door is closed there is no current drain at all, the overall current needed by the Transmitter is even less.

CONSTRUCTION – TRANSMITTER

Important Note: The design of the aerial is specified by UK regulations. There are two configurations possible but, of these, a *tuned loop* is used here. *The enclosed area must not exceed 700 square mm and it must be integral within the unit – it cannot be placed externally and driven through a feeder.* Radio amateurs please note: *this transmitter is not type approved for use with a quarter wave or helical antenna .*

All components for the Transmitter (apart from the battery pack) are mounted on a single-sided printed circuit board (PCB). The topside component layout and (approximately) full size underside copper foil track master are shown in Fig. 4. This board is available from the *EPE Online Store* (code 7000261) at **www.epemag.com**

Begin construction by drilling the two fixing holes and soldering the IC sockets, DIP switches S1 to S6, and the two link wires in position. One of these is soldered between

The lever-arm microswitch mounted on a small metal bracket.

points A and B. The other is the *test link* (LK1 – C-D-E). The wire should be soldered as shown between C and D for normal operation.

Next, the resistors, capacitors and diodes (taking care with the polarity of capacitors C1, C3 and the diodes) can be mounted and soldered in position. If a 1·5MΩ resistor is not available for R9, connect one 1MΩ and one 470kΩ in series.

In the prototype, resistor R5 (66MΩ) consisted of two 33MΩ units connected in series to make up the value. You could use a single resistor having a value of between 56MΩ and 100MΩ if this is available.

Cut the LDR (R2) leads to a length of about 15mm and solder it in place. Bend the leads through right angles so that the "window" points to the side (see photograph). Solder the positive (red) and negative (black) wires of the PP3-type battery connector to the "+6V" (via switch S7) and "0V" points respectively on the PCB.
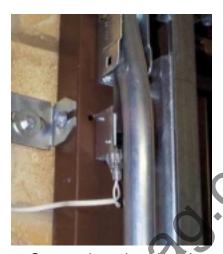
LOOP AERIAL

The prototype aerial was made using a piece of light-duty single-core insulated wire cut to a length of 80mm. The end 1mm or so was stripped and the wire bent into a loop. It was then soldered into the "aerial"

position on the PCB.

TRANSMITTER MODULE

Before unpacking the transmitter module, remove any

Garage door closed – microswitch arm compressed, power off!

static charge that might exist on the body by touching something which is "earthed" such as a metal water tap. This is because it is a static-sensitive device and such charge could damage it.

Cut its leads to a length of 15mm and solder it in place on the PCB, using minimum heat from the soldering iron. Take care over the polarity – the positive end is identified by a black mark on the body.

Taking the same anti-static precautions, unpack IC2 and IC3. Insert them in their sockets taking care over the orientation. By leaving IC1 position empty for the moment, the light-sensing aspect of the circuit will be disabled and this will simplify testing.

Adjust trimmer capacitor VC1 so that the plates are *not* meshed or only slightly so (look

closely at it while rotating the top screw). This gives the minimum capacitance of 2pF, which worked well in the prototype.

RECEIVER

Garage door open – microswitch arm released, power on!

The complete circuit diagram of the Receiver section of the *Garage Link* is shown in Fig.6. The receiver module IC1 requires a 4·5V to 5·5V supply.

The total current requirement of the circuit is 5mA approximately, which could not be maintained by a battery over a long period of operation. This is why a mains power adapter (sometimes referred to as a battery eliminator) is called for.

The power adapter supplies a nominal 9V to the input of voltage regulator IC3, via fuse FS1 and diode D1. The output of IC3 provides the 5V needed by the receiver module, and this is also used by the rest of the circuit. Fuse FS1 prevents possible damage in the event of a short-circuit.

Diode D1 prevents damage if the supply were to be

connected the wrong way round. This is a possibility where plug-in power supply adapters are used, because the output polarity is sometimes uncertain. If the supply was reversed, D1 would not conduct and nothing would happen.

The receiver module is in the form of a single-in-line package – that is, it has only one row of pins. Not all the pins are present and gaps are left where they would have been. The numbering takes into account those which are present as well as those which are not so, although there are 15 numbered "pins", only 10 of them actually exist. The pin layout and designations are shown in Fig.7.

There are separate pins for the positive supply feed to the RF (radio frequency) and the AF (audio frequency) sections. These are pin 1 and pins 10, 12 and 15 respectively. There are also separate ground (0V) connections for these (pins 2 and 7 for RF and pin 11 for AF).

The same power supply is used for both sections, but they are decoupled separately using capacitors C1 and C2. The aerial is connected to IC1 pin 3 (Data In). The amplified data appears at output pin 14.

DECODING

The decoder IC2 is, in many respects, similar to the encoder (IC3) in the Transmitter unit. The receiving code is set up in the same way using a set of DIP switches S1 to S6. The non-settable address pins 7, 8 and 10 to 13 are fixed with a logic state of 0, by tying them to the 0V line. Pin 9 is connected along with these because it is the 0V input. Data is applied to pin 14 (Data In) from the receiver

module output, pin 14.

Resistor R1 connected between pin 15 and pin 16 (Osc1 and Osc2) sets the decoder oscillator frequency. This needs to be approximately fifty times higher than that used in the transmitter section and the specified resistor sets it at 100kHz approximately.

When correct data arrives at IC2 pin 14, pin 17 (Valid Transmission) goes high. Current then flows, via the resistor R2, into the base (b) of transistor TR1 and the buzzer WD1 in the collector (c) circuit operates. Since data is received in short bursts as determined by the Transmitter output, the buzzer will sound with regular bleeps.

CONSTRUCTION – RECEIVER

All components for the Receiver (apart from the supply input socket) are also mounted on a single-sided printed circuit board (PCB). The topside component layout and full size underside copper foil track master are shown in Fig.8. This board is available from the *EPE Online Store* (code 7000262) at **www.epemag.com**

Begin construction by drilling the two fixing holes then solder the terminal block TB1, link wire, IC sockets, and DIP switches S1 to S6 in position. Use pieces of single in-line (SIL) socket for receiver module IC1 – *do not solder this IC directly onto the board.* You could make these by cutting up a dual-in-line socket.

Solder all resistors and capacitors in position taking care over the orientation of electrolytic capacitor C5. Add fuse FS1. In the prototype this

was the PCB-mounting type; this is convenient because it will probably never blow.

Follow with diode D1, transistor TR1, regulator IC3 and buzzer WD1, again, taking care over their orientation. Note that the flat face of the regulator is *downwards* and that of the transistor to the *right*. Some regulators have a different pin arrangement so check this point if necessary.

PRELIMINARY SET-UP

Attach a PP3-type battery connector to terminal block TB1, taking care over the polarity. A 9V battery will be used for testing but it will be replaced with the plug-in, mains adapter, power supply at the end.

Solder a piece of light-duty stranded wire 18cm long to the "aerial" point. This corresponds to one-quarter of a wavelength approximately. Note that, unlike the Transmitter aerial, this could be placed outside the case. You could even use a short telescopic aerial, if you wish.

Observing the anti-static precautions again, insert IC2 and the receiver module, IC1, into their sockets. IC1 will only fit one way – that is, with the components side facing IC2. *Take great care when inserting it.* If too much force is used, the pins will bend and possibly damage it. Note also that the pins are fairly long and will not push fully "home".

PRELIMINARY TESTS

Decide on a code for the two units. It does not matter what it is, but the DIP switches (S1 to S6) in each unit must be set in exactly the same way.

Connect a PP3 battery to the Receiver and pull out the aerial into a straight line. Place the two units approximately 2m (6ft approx.) apart. Insert the cells into the Transmitter battery holder and connect it up. Note that the maximum voltage to be used with the Transmitter is 6V – more than that will damage it.

With luck, the buzzer will begin sounding with rapid bleeps! Remember, resistor *Rt* is in the circuit and the time period has been reduced for testing.

If it fails to work, change the alignment of the transmitter aerial. Try moving the units closer together to see if that improves matters. Experiment with the adjustment of capacitor VC1. If it still doesn't work, check that the code switches in each unit are definitely set in the same way. A faulty soldered joint at a DIP switch in either unit could set the wrong code and prevent the system from working.

AT FAULT

If there is still a fault, it is more likely to be in the Transmitter, because this has two distinct sections. These are the encoder and transmitter on one hand and the light sensor (but this part has been temporarily disabled) and astable on the other. If there is a persistent fault, you could try isolating it to one of these sections.

First, remove the ICs observing the anti-static precautions mentioned earlier. Now, change the connection of the "test link" LK1 on the PCB so that C connects to E. This takes IC3 pin 14 to 0V and allows the Transmitter to send data continuously. If it now

works, check the earlier stages. If nothing happens, it is more likely that the fault lies in the Receiver. Assuming the two units are operating over a short range, try increasing it. Move them to the point where the buzzer operates intermittently or in a "chirping" way due to periods which lack proper data. Adjust VC1 using a *plastic* trimming tool (a metal screwdriver blade will affect operation) to tune the Transmitter aerial for the best signal. Increase the range to 10 meters and make further adjustments as necessary. Experiment with the orientation of the aerials.

LIGHT WORK

To check the light-sensing stage (IC1), first disconnect the Transmitter battery. Observing the anti-static precautions, insert IC1 taking care over the orientation. Adjust preset VR1 fully anti-clockwise (this means it does not have to be very dark to operate and simplifies testing).

Re-connect the battery and test the system. With sufficient light reaching the LDR (R2) sensitive surface, the buzzer should stop sounding. When the LDR is covered, it should begin again. If this does not work, try covering the LDR more carefully – perhaps sufficient light is still reaching it. Cover the LDR with black opaque PVC tape so that the transmitter works continuously again.

ON TRIAL

With the aid of an assistant, hold the two units in various trial positions to find the best ones. As with any very low-power radio equipment, there will be good and bad spots. Check with the car in the garage. The

orientation of the Transmitter loop is important. Set this and the Receiver aerial for best effect.

Do not use metal boxes to house the units – only plastic ones. Metal boxes would screen the circuits and prevent radio waves passing in or out!

FINAL ASSEMBLY – TRANSMITTER

Place the Transmitter PCB and battery holder on the bottom of the box in their correct positions. When deciding on the orientation of the PCB take account of the direction from which the LDR will receive light. Ideally, it should end up pointing towards the garage door so that when this is open, it will receive "outside" light. Alternatively, try to direct it towards a window.

Mark through the fixing holes, remove everything again and drill them through. Holding the PCB in place, a small distance above the base of the box, mark the LDR position. Measure the position of preset VR1 and mark the lid directly above it. Remove the PCB and drill these holes.

The one for the LDR should be about the same diameter as its window. The hole for VR1 should be large enough to allow it to be adjusted from the outside using a small screwdriver or trimming tool. Drill a hole near the right-hand side of the PCB for the wires leading through from the garage door switch.

Before attaching the PCB, drill two holes in the back of the box clear of all internal components. These will be used for attaching the unit to the wall later. Secure the PCB using
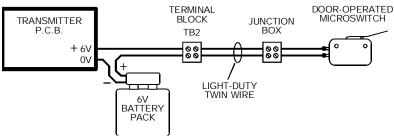
Fig.9. Interwiring between the Transmitter and remote door-operated microswitch.

plastic washers on the bolt shanks. The LDR leads should be bent so that the window lies a few millimeters behind the hole drilled for it. Secure the battery holder using adhesive fixing pads or a small bracket.

– RECEIVER

Disconnect the battery and remove the connector from the terminal block TB1. Place the Receiver PCB on the bottom of its box and mark through the fixing holes. Take it out and drill these through. Measure the position of the buzzer and drill a hole in the lid larger than that in the buzzer itself for the sound to pass through.

Check the type of connector fitted to the mains adapter power supply unit. Drill a hole in the side for a socket of the same type and attach it. Drill two holes in the back of the box (clear of the PCB) to attach it to the wall later. Secure the PCB using plastic washers on the bolt shanks.

Solder two pieces of connecting wire to the power socket. Take care that the correct tags are used. Check the polarity of the power supply unit output and connect the wires to terminal block TB1 observing the correct polarity.

If you are unsure about this, do not worry. If the receiver does not work at the end it will be simply a matter of reversing

these wires. If you are using a power supply unit with an adjustable output, you may find that the "6V" setting actually provides over 9V when used under the low-load conditions of this circuit.

Attach the Transmitter and Receiver units in their final positions.

SWITCHED ON

Decide on the switching arrangement for switch (S7) at the garage door. In the prototype, a lever-arm microswitch was used. This was attached to a small aluminum bracket (see photograph) which was, in turn, secured to the doorframe. The microswitch had a large paddle-style lever, which allowed for some tolerance in fitting, although any type could probably be used.

The switch should be operated by some part of the door mechanism, which moves relatively slowly when the door is operated. This will avoid heavy jarring as the door closes.

Hold the switch assembly in position and check that the lever will be pressed to the point where the switch clicks as the door reaches its closed position. Check carefully that this does not interfere with normal operation of the door.

Attach the switch and make any adjustments as necessary.

Make sure the switch lever still has some movement left when the door is closed so that it is not placed under any undue strain.

CONNECTING UP

Identify the switch contacts that "break" (open) when the door is closed (that is, the normally-closed contacts). There is usually a diagram of this on the side of the microswitch. Using spade receptacle connectors, attach a short piece of light-duty twin stranded wire to the appropriate tags. This should be sufficient to reach a small junction box (the burglar alarm type is ideal) attached near the doorframe.

Referring to Fig.9, complete the external wiring. Any light-duty twin stranded wire will be suitable. You will need to place a 2-way piece of screw terminal block TB2 inside the transmitter case.

Cut the red battery connector wire and connect its free ends to the terminal block. Connect the switch wires to the block, via the junction box, as shown. If two switches are used for two doors, connect them in parallel.

Connect the power supply unit to the Receiver and test the whole system. If it fails to work, reverse the polarity of the power supply wires.

The Receiver aerial wire could be either routed around the inside of the case (make sure the end is insulated so that it cannot make metallic contact with any internal components. Alternatively, it can be allowed to hang outside through a small hole.

LIGHTING-UP TIME

It is now time to remove the tape from the LDR in the Transmitter so that the light-sensing part operates. Wait until it is dark enough and, with the lid in place and the garage door open, adjust preset VR1 so that the system just responds at this point.

You will find that the light level at which the unit starts to operate (going dark) is not quite the same as that at which it stops operating (going light). This is due to the effect of feedback resistor R5 in the Transmitter. If the effect is too pronounced, increase its value or remove it.

You may find that the LDR "sees" the garage light when this is switched on. Of course, this would hold the buzzer *off*. This would probably be an advantage because if someone was working in the garage at night with the door open, the buzzer would not sound.

If you want it to operate under these circumstances, shield the LDR so that the garage light does not reach it. Bending its leads so that it lies further behind the hole and directing the unit more carefully at the source of "outside" light will also help.

Remove the Transmitter lid and cut through one of the leads of test resistor, *Rt*. Move the cut ends apart to prevent them from touching. The buzzer should now give a short bleep every 45 seconds approximately.

ON APPROVAL

Before putting the system into permanent service, it is important to display a mark on the transmitter stating that it conforms to DTI Specification MPT1340. This must state the wording "MPT1340 W.T. License Exempt". The size must not be less than 10mm x 15mm and the figure height must not be less than 2mm.