

# proximity detector

There are many methods of detecting the presence of a person within a specified area, for example by using ultrasonic or microwave Doppler techniques, which are the methods frequently employed in intruder alarms. The approach adopted in this article is based on the fact that a person moving about in a room alters the geometry and strength of the electric field that invariably exists. The circuit detects changes in the electric field and produces an audible warning.

Natural and artificial electric fields exist practically everywhere. Their geometry and strength is influenced by the presence of objects, particularly conductors, that are in the field, but in a static situation, i.e. with no moving objects, field patterns will change only slowly, over a period of some hours. If a large conducting object such as a human body moves through an electric field then it will distort the field pattern. Due to the electric charges generated on clothing by friction these variations in the electric field can be very large. In a carpeted room, particularly if the carpets are of man-made fibre, the changes can be even more pronounced.

An electric field can be monitored by a sensor electrode connected to the input of a high impedance amplifier. The electrode will acquire a potential which is dependent on the field strength at the point where the electrode is mounted. Changes in field strength can also be detected very easily by using an analogue voltage comparator.

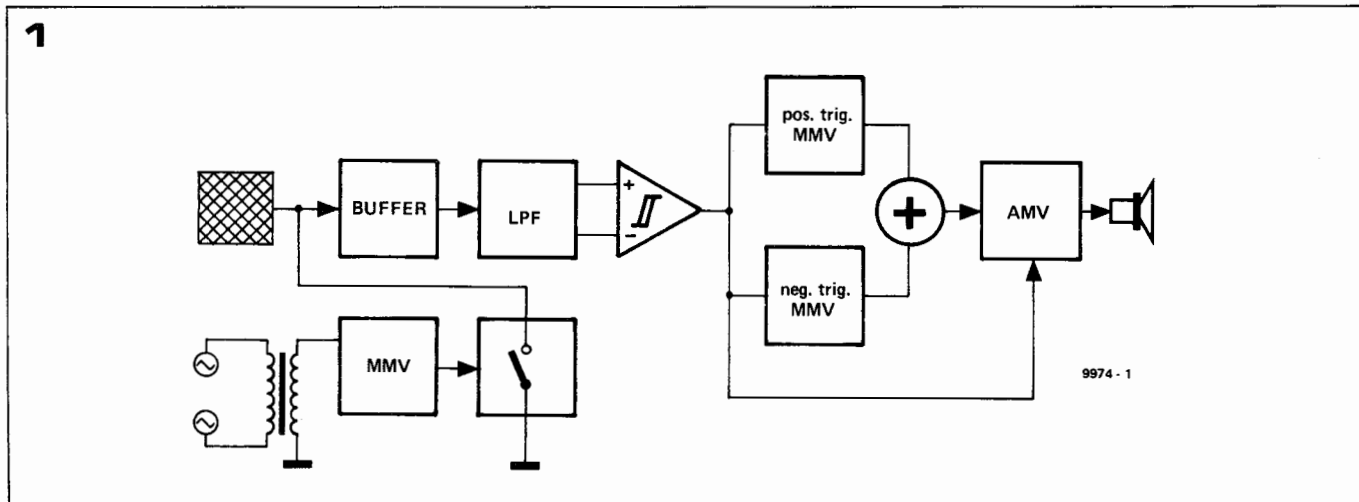
If the output of the sensor electrode amplifier is connected to one input of a comparator then the voltage at that input will consist of that due to the normal electric field with a changing voltage due to any variations in the field superimposed upon it. If the same signal is connected to the second input of the comparator via a lowpass filter with a very low cutoff frequency ( $\sim 0.2$  Hz) then the signal appearing at this input will consist only of the voltage due to the static component of the electric field. Whilst it can follow slow changes due to natural variations in the field over a period of time it will be unable to

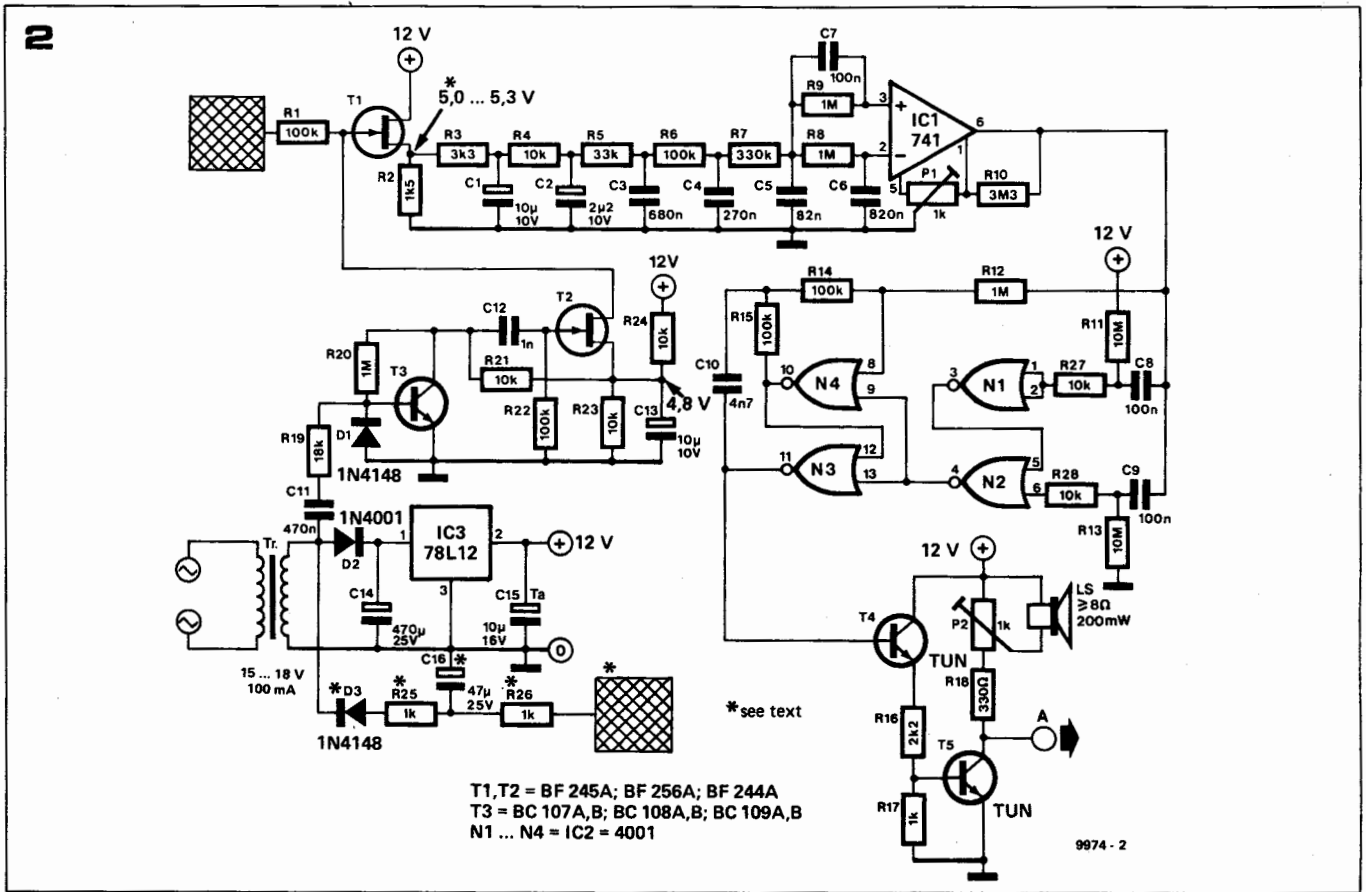
follow voltage changes due to objects moving in the field. The voltage on the second input of the comparator thus provides a reference against which to measure changes in the field. Normally the voltage on both inputs of the comparator will be the same, but if the field changes then the voltage on the first input of the comparator will vary and the comparator output will change state.

Two problems must be solved before a practical field variation proximity detector can be built. The first is caused by the 50 Hz AC field which is invariably present in any building where there is mains wiring, and which the sensor would see as a rapid change in field strength. This problem can be overcome by using a second lowpass filter to remove the 50 Hz component from the signal picked up by the sensor plate. The cutoff frequency of the filter (1.8 Hz) is chosen so that the 50 Hz component is completely suppressed, but is still sufficiently high to pass the somewhat slower changes in voltage caused by movements in the field.

The second problem is that, since the amplifier connected to the sensor plate has a high input impedance (which it must have to detect electric fields) the voltage on the sensor plate cannot discharge. The sensor plate will therefore simply charge up to the highest voltage that it sees and any drop in voltage will not register. This problem is solved by periodically discharging the sensor plate through an (electronic) switch. To avoid possible spurious signals caused by beating between the 50 Hz AC voltage and the signal that controls the dis-

Figure 1. Block diagram of the proximity detector.





charge switch, it is essential that the plate should be discharged in synchronism with the mains frequency. This is achieved simply by having a 50 Hz mains signal control the switch.

**Block diagram**

Figure 1 shows a block diagram of the proximity switch. The sensor plate is connected to the input of a high impedance buffer amplifier. This is followed by a lowpass filter, which consists of two sections. The first is the 50 Hz filter; the output of this section connects to the first input of the comparator, i.e. the 'signal' input. A second filter section with a much lower cutoff frequency precedes the second input to the comparator, the 'reference' input. The signal arriving at the signal input of the comparator will thus consist of the total voltage picked up by the sensor plate, i.e. the static reference plus any variations caused by objects moving in the field, whilst only the (practically) unchanging reference voltage will get through the second filter section to the reference input of the comparator.

At the output of the comparator are connected two monostable multivibrators, one of which is positive-triggered and the other negative-triggered, so that either positive- or negative-going transitions of the comparator output can be detected. The outputs of the two monostables are used to control an astable multivibrator, which drives a loudspeaker to give an audible warning. By using the output of the comparator to vary the frequency of

the astable a two-tone signal is provided, the frequency depending upon whether the comparator output is high or low.

**Complete circuit**

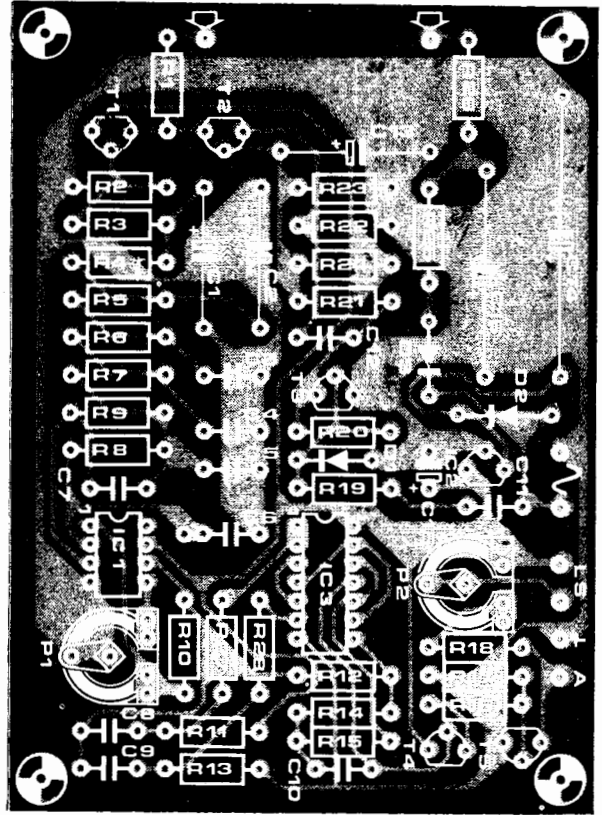
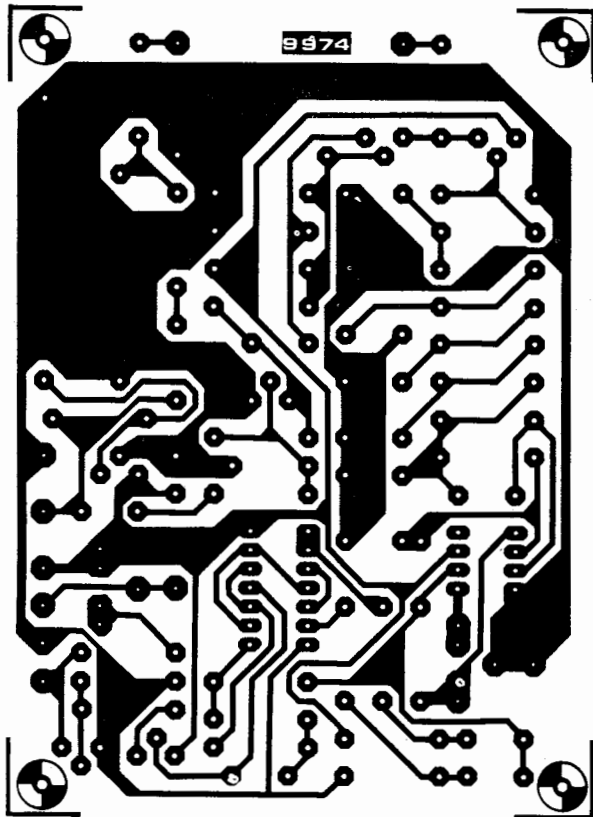
The complete circuit of the proximity detector is given in figure 2. The sensor plate is connected to the gate of T1, which is a FET connected as a source follower. This stage has an extremely high input impedance and a low output impedance. The gain is slightly less than unity. Resistors R3 to R7 and their associated capacitors form the lowpass filter which removes 50 Hz signals. The output of this filter is connected to the non-inverting input of the comparator, a 741 op-amp via R9 and C7. A lowpass filter section with a very long time constant (R8·C6, approximately 800 ms) removes all but very slow variations from the voltage applied to the inverting input of IC1.

To obtain clean switching of the comparator output a small degree of hysteresis is introduced by applying positive feedback to one of the offset inputs via R10. Negative-going transitions or the comparator output cause the input of N1 to be pulled low via C8. The output of N1 therefore goes high and the output of N2 goes low. Positive-going transitions of the comparator output take the input of N2 high via C9, so that in this case also the output of N2 goes low. The length of time for which the output of N2 remains low depends on the time constant C8·R11 (or C9·R13). N3 and N4 are connected as an astable multivibrator, which drives a small audio amplifier consisting of T4 and T5. When

Figure 2. Complete circuit of the proximity detector.

Figure 3. Printed circuit board and component layout for the proximity detector (EPS 9974).

3

**Parts list.****Resistors:**

R1, R6, R14, R15, R22 = 100 k  
 R2 = 1k5  
 R3 = 3k3  
 R4, R21, R23, R24, R27, R28 = 10 k  
 R5 = 33 k  
 R7 = 330 k  
 R8, R9, R12, R20 = 1 M  
 R10 = 3M3  
 R11, R13 = 10 M  
 R16 = 2k2  
 R17, R25, R26 = 1 k  
 R18 = 330  $\Omega$   
 R19 = 18 k  
 P1, P2 = 1 k preset

**Capacitors:**

C1, C13 = 10  $\mu$ /10 V  
 C2 = 2 $\mu$ 2/10 V  
 C3 = 680 n  
 C4 = 270 n  
 C5 = 82 n  
 C6 = 820 n  
 C8, C9 = 100 n  
 C10 = 4n7  
 C11 = 470 n  
 C12 = 1 n  
 C14 = 470  $\mu$ /25 V  
 C15 = 10  $\mu$ /16 V tantalum  
 C16 = 47  $\mu$ /25 V

**Semiconductors:**

T1, T2 = BF 244A, BF 245A,  
 BF 256A  
 T3 = BC 107A/B, BC 108B/C,  
 BC 109B/C  
 T4, T5 = TUN  
 D1 = 1N4148, 1N914  
 D2, D3 = 1N4001  
 IC1 = 741  
 IC2 = N1 ... N4 = 4001  
 IC3 = 78L12

**Miscellaneous:**

15 V or 18 V/100 mA mains transformer

the output of N2 is low the multivibrator will oscillate. An input to the multivibrator from the comparator, via R12, alters the multivibrator frequency depending on whether the comparator output is high or low. The sensor plate is discharged every 20 ms by FET T2. Transistor T3 turns off at each negative-going zero-crossing of the mains waveform, at which point T2 conducts briefly and discharges the sensor electrode.

**Power supply**

Power for the circuit is obtained from a mains transformer with a 15 V or 18 V secondary rated at 100 mA or greater. The output voltage of the transformer is half-wave rectified by D2 and smoothed by C14 before being fed to a 12 V IC regulator. The mains transformer also provides the 50 Hz signal to switch T3 and T2.

For optimum sensitivity the 0 V rail of the circuit must be connected to an earth point such as mains earth or a metal water pipe. If no such earth is available then an 'artificial earth' must be used consisting of a second electrode connected to a negative supply voltage as shown in figure 2. However, if a true earth is used then R25, R26, C16 and D3 can be omitted.

**Construction and use**

A printed circuit board and component layout for the proximity detector are given in figure 3. All the components, with the exception of the loudspeaker and mains transformer, are mounted on this board. The electrode(s) may be

made from copper laminate board approximately 15 cm square. If two electrodes are used, they should be mounted about 1 metre apart. The sensor plate must be well-insulated from surrounding objects. Probably the best method is to mount it on the outside of the box in which the circuit is housed using nylon spacers. The unit should function immediately when switched on, and the only adjustments required are to vary P1 for the best sensitivity and to set the volume of the audible warning using P2.

Although intended mainly as demonstration of the principle, the circuit can also be used for practical applications such as intruder alarms, provided its limitations are known. The proximity detector is much less prone to false alarms than ultrasonic or microwave Doppler alarms, which can be triggered by flapping curtains or rattling doors and windows. However, the circuit may be falsely triggered by changes in field strength caused by switching on and off of electrical equipment. This is not such a problem if the unit is intended to protect unoccupied premises, provided care is taken not to mount it in the vicinity of equipment that switches on and off automatically, such as a refrigerator or freezer.

To trigger an external alarm or other circuit the signal from point (A) may be used. This is normally high, but when the audible warning sounds point (A) goes alternately high and low at the same frequency. M

