LIVE WIRE DETECTOR

by Dave Goodman

The Maplin Live-Wire Detector is a fascinating and novel device which will detect the presence of mains electricity whether there's a current flowing or not. It's better than neon screwdrivers or multimeters because you do not have to make contact with the wire – it signals the presence of mains up to two inches (5cm) away and better than metal detectors, because it only indicates if the wire is live; also it's considerably cheaper.

A Most Useful Instrument

It's the sort of device every household should own and anyone can use it because you don't have to actually touch dangerous points with any part of the Live-Wire Detector. Even if the wires are not connected to anything at one end, Live-Wire will tell you if they're live. You could use it to find buried wires in dry plaster or plastic conduit or under floor or ceiling boards, though keep in mind that its sensitivity is only about two inches, so don't put a four inch nail where there was a negative reading! However, if you get a positive reading of a wire in a wall and there's nothing else electrical on that wall, then you can hammer the nail home with confidence anywhere else. The message then is: beware of negative readings.

Other uses of Live-Wire include detecting breaks in cables or appliance leads. If you have a suspect mains lead, plug it into the mains; run Live-Wire along the cable and at the point where the live wire is broken, Live-Wire will cease to sound and flash. If a fuse blows, Live Wire will indicate mains present up to all the fuses and mains present on the wires leaving every fuse except the dead one. If you're wallpapering and need to remove a switch plate, first check that you get a positive reading with the mains on, then switch off or remove the fuse from the circuit you think is the right one. With Live-Wire in the same position as before, it will no longer sound if you've found the right circuit. There are probably hundreds of other uses and one or two we've thought of include detecting ringing on telephone lines, detecting the EHT in TV sets (though Live-Wire will probably need to be desensitised).

Live-Wire will also detect static electricity but in this case, it must be moved into or through the static field and only while it is moving will the instrument sound.

Circuit Description

An AC electro-magnetic field is detected at IC1 pin 1. The 4069 inverter is connected in a linear by placing a feed-

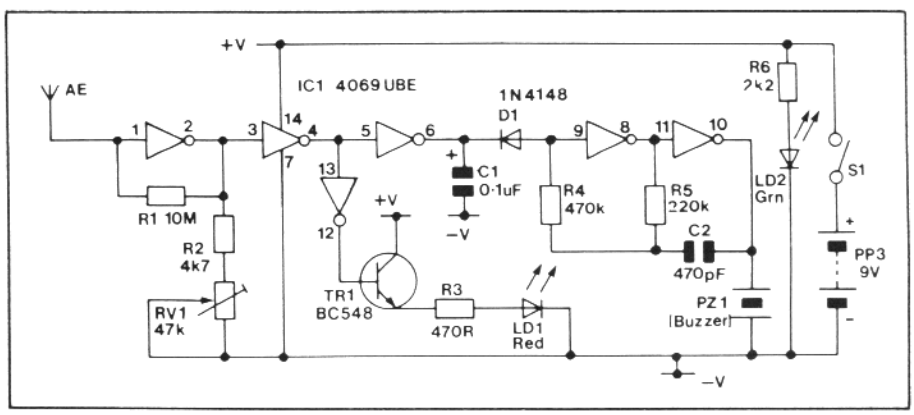
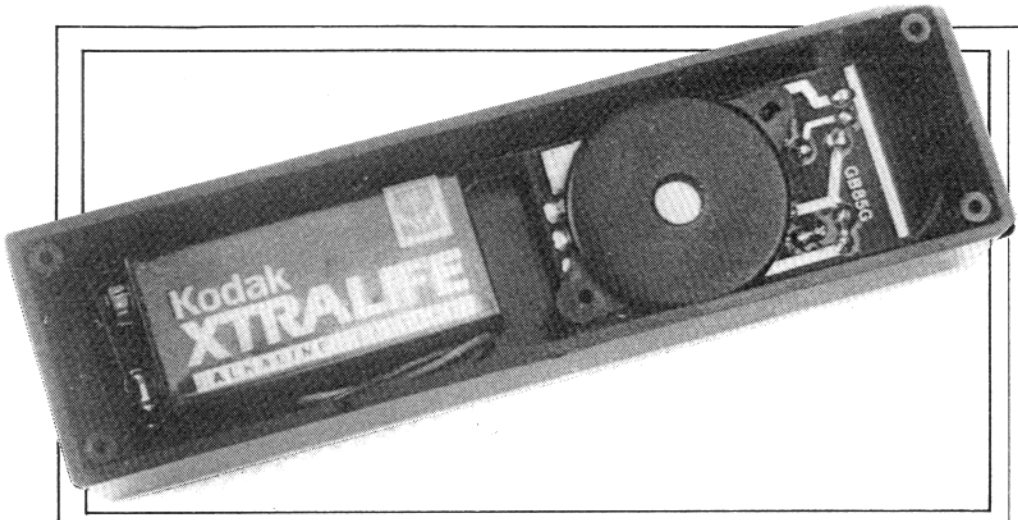


Figure 1. Circuit diagram of the Live-Wire Detector.



Inside view of the Live-Wire Detector prior to fitting the back panel.

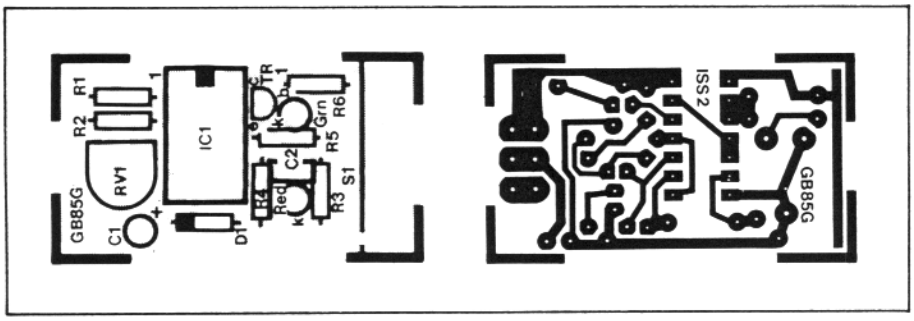


Figure 2. PCB legend and track.

back resistor between pins 1 and 2. The value chosen for R1 keeps the characteristics high CMOS input impedance so that changes in the surrounding electro-magnetic field produce a minute voltage change on the aerial track which are massively amplified in this stage.

RV1 sets the point at which the output from IC1 pin 4 will trigger the next two stages. This is necessary since the quiescent voltage at pin 2 will be different from one chip to another. Being a digital chip, this usually makes no difference but in linear mode, it is significant and RV1 has to be present to ensure that every Live-Wire can meet the specification. RV1, therefore, is adjusted to keep pin 4 high when not triggered.

Turning S1 on, lights LED2 which indicates that the circuit is active. If no electro-magnetic field is detected, then pin 4 will be high and the rest of the circuit is inactive. When an electro-magnetic field is detected, pin 4 goes low and pin 12 then goes high causing the emitter-follower TR1 to conduct, operating LED1.

At the same time, IC1 pin 6 goes high. D1 will now be reverse-biased which removes the continuous low 'hold-off' condition from pin 9 and allows the oscillator to run. The oscillator comprises the final stages of the 4069 and resistors R4,R5 and C2. The approximate frequency is 3·5kHz. The output of the oscillator drives the high impedance piezo-ceramic buzzer directly.

The circuit runs from a 9V PP3 battery. The current drain is approximately 10mA when the circuit is switched on and 17mA when it is detecting electricity.

An AC electro-magnetic field is one which is collapsing and re-establishing itself in phase with the frequency in the wire, e.g. for UK mains, it is 50Hz, This has the effect of turning D1 on and off, which stops and starts the oscillator, giving a characteristic buzzing sound. If the circuit was moved in a static electro-magnetic field, it will produce a pure high frequency tone.

As the circuit moves into a field, LED1 may operate before the buzzer starts to sound. It will gradually increase in brightness and during this time, at some point, the buzzer will sound before or just as the LED reaches full brightness.

Construction

With reference to Figure 2 and the Parts List, fit the components, with the exception of the slide switch, as follows: start by fitting each of the resistors into the positions shown. Next, insert the diode in position D1 ensuring that the device is correctly orientated. It is important that each of these components lies flat to the PCB as shown in the photographs.

Fit the two capacitors in their respective positions, noting that C2 is a polarised device which needs to be installed the correct way round. Carefully solder all these components in place and clip off the excess lead ends. Now insert IC1 and TR1 (so that their orientation matches up with that shown in the corresponding board legends), and fit preset RV1 in the position indicated. Carefully solder all the leads of these three components and cut off the excess leads of the lead-lengths.

The red LED (LD1) is inserted into the position marked on the pcb as 'Red' in Figure 2. Likewise, the green LED (LD2) is placed in the 'Grn' position. Correct positioning of these items is also critical, and the cathode (marked as 'k' in Figure 2) is the shorter lead of the LED. Adjust the two LEDs until the base of each coloured package is 6mm above the top surface of the board. Holding the LEDs absolutely vertical in that position, solder the four leads and clip off the excess lead-lengths.

Cut the two wires from the battery connector (black = −Ve; red = +Ve) so that they are 50mm (2in.) long, tin them, and referring to Figure 3, insert each in the appropriate hole and solder in place. Cut the wires from the buzzer so that about 25mm (1in.) of each remains, tin them, insert in the two remaining holes on the PCB and solder them in position. Note that buzzer polarity is uncritical. With a small screwdriver or trim tool, adjust RV1 until its wiper points to C1 as arrow in Figure 2, and finally check that all components have been inserted and soldered correctly.

Final Assembly and Testing

Referring to Figure 4, place the switch in the box so that its lever protrudes through the rectangular cut-out in the case. Ensuring that the two LEDs protrude through the appropriate round holes, insert the M2 bolts through the two holes on either side of the switch cut-out, pass them through the mounting holes of the switch and terminate with M2 nuts. When the bolts have been sufficiently tightened, position the PCB on the switch

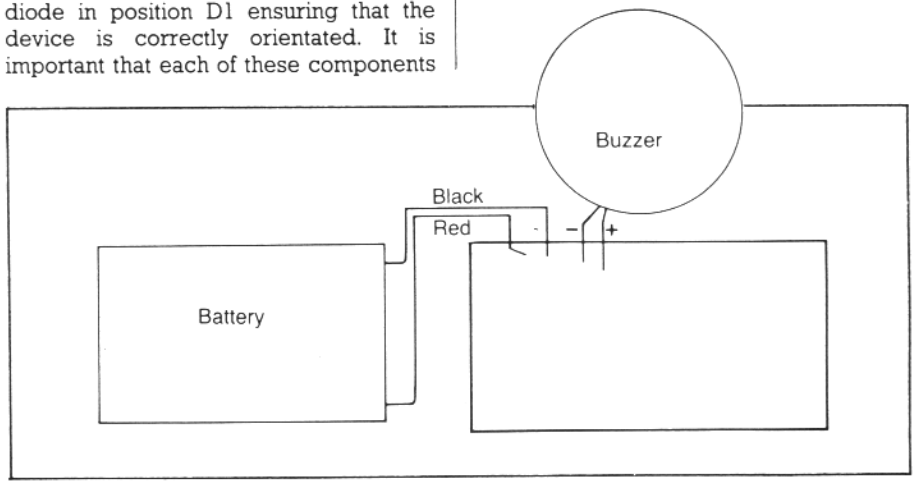


Figure 3. Live-Wire Detector wiring diagram.

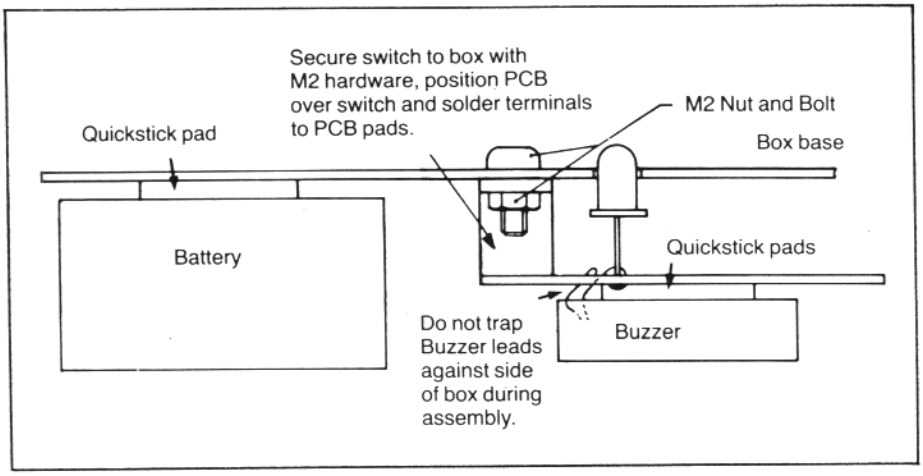


Figure 4. Overall assembly of the Live-Wire Detector.

terminals exposed within the case and solder in place. It must be checked that the board is mounted flush against the switch prior to soldering, otherwise undue strain could be placed on the PCB tracks. Please bear in mind that the switch effectively holds the PCB in place. Now solder the switch terminals to the PCB.

Stick the buzzer centrally onto the soldered side of the PCB using a quick-stick adhesive pad, as shown in Figure 5, so that the mounting ears of the buzzer point to the corners of the PCB and the buzzer lead-out wires are nearest the edge of the board. Ensure that the adhesive pad is fixed to the base of the buzzer, and not the top (which has a large central hole on it, from which the sound is emitted). Please note that the diameter of the buzzer may vary slightly. If it is found that it is too large to fit into the box, carefully remove some of the plastic casing of the buzzer with a sharp knife.

Install a new PP3 battery, preferably of the alkaline type, ensuring that it is fitted to the battery clip the right way round, even a momentary incorrect connection could cause damage. Depending on the position of the on/off switch the Live-Wire Detector may already be switched on, indicated by the green LED

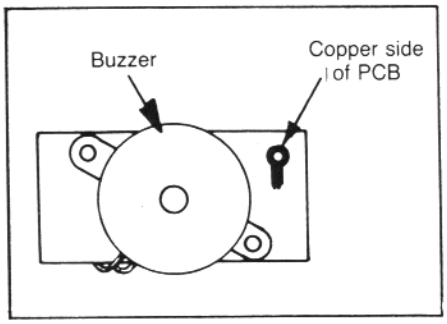


Figure 5. Buzzer mounting.

glowing, if this is the case, switch the unit off.

Plug an appliance into a mains socket and switch it on. Bring the assembly up to the cable, holding the battery end of the box. Switch the Live-Wire Detector on. The green LED should light and stay on. As you approach the appliance's cable, the red LED should light and the buzzer should sound.

RV1 must now be adjusted so that the unit starts to operate about 2 inches (5cm) from the cable. To increase the sensitivity, turn RV1 clockwise; vice versa to decrease the sensitivity. Do not try to make the unit too sensitive or you will find that it is occasionally triggered by your body, or for no apparent reason.

When RV1 is correctly adjusted, fix the battery into the box using the other sticky-pad, see Figure 4. Finally, screw the box lid on using the four screws provided.

Uses

This unit is extremely useful around the home, and because the user does not have to make actual contact with any part of a live circuit, it is perfectly safe to use. Even if the wires are not connected to anything at one end (i.e. no current is flowing), Live-Wire will reveal if they are live. Some of the many uses that we have identified include the following:

Finding wires concealed by plaster, plastic conduit, floor boards or ceiling panels. However, please bear in mind that the sensitivity of the unit is only about two inches, so do not hammer a four inch nail into a wall where there was a negative reading! However, if you get a positive reading and there is nothing else electrical on that wall, then you can confidently fix the nail anywhere else. Generally, negative readings should be treated with caution.

The detection of breaks in cables or appliance leads. If a mains lead is suspect, it is plugged into the mains and Live-Wire is run along its length. At the point where the live wire is broken, Live Wire will cease to sound and flash.

If a particular mains circuit needs to be isolated, for example, when a switch plate needs to be removed (e.g. for wallpapering a wall), first check that you get a positive reading with the Live-Wire Detector when the mains is switched on, then remove the lighting fuse and use Live-Wire Detector, *in the same position,* to verify that the correct fuse has been removed.

Detecting ringing on telephone lines.

Detecting the presence of EHT within a TV set (in this case, Live-Wire will probably need to be desensitised).

Live-Wire will also detect static electricity, but only when it is being moved into, or through, the static field.

LIVE-WIRE DETECTOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Specified)

R1	Econ Res 10M	1	(B10M)
R2	4k7	1	(M4K7)
R3	470Ω	1	(M470R)
R4	470k	1	(M470K)
R5	220k	1	(M220K)
R6	2k2	1	(M2K2)
RV1	Hor Encl Preset 47k	1	(UH05F)

CAPACITORS

C1	Tant 100nF 35V	1	(WW54J)
C2	Ceramic 470pF	1	(WX64U)

SEMICONDUCTORS

TR1	BC548	1	(QB73Q)
D1	1N4148	1	(QL80B)
IC1	4069UBE	1	(QX25C)
LD1	Mini LED Red	1	(WL32K)
LD2	Mini LED Green	1	(WL33L)

MISCELLANEOUS

S1	Sub-Min Slide	1	(FH35Q)
	PP3 Clip	1	(HF28F)
	Min Piezo Sounder	1	(FM59P)
	Poziscrew M2 6mm	1 Pkt	(BF41U)
	Steel Nut M2	1 Pkt	(JD63T)
	Live Wire Det Case	1	(FT39N)
	Quickstick Pad	1 Strip	(HB22Y)
	PCB	1	(GB85G)
	Instruction Leaflet	1	(XK07H)
	Constructors' Guide	1	(XH79L)

OPTIONAL

B1	Battery PP3	1	(FK62S)

The above items (excluding Optional) are available as a kit.
Order As LK63T (Live Wire Detector Kit)

MAPLIN

MAPLIN ELECTRONICS PLC
P.O. Box 777, Rayleigh, Essex, SS6 8LU,
United Kingdom
Telephone: +44 (0) 1702 554000
Fax: +44 (0) 1702 554001
Email: Sales@maplin.co.uk
World Wide Web: http://www.maplin.co.uk