PROJECT

PROJECT RATING 2

Discriminating CONTINUITY TESTER

XV25C
Issue 3

by Ian Hickman

This project owes its advanced performance to the use of the latest LinCMOS™ technology. The completed unit checks components of all sorts both passive and active, and is safe to use on all normal semiconductor devices.

When servicing a piece of electronic gear, electrical equipment such as a vacuum cleaner, or even the car, a continuity tester is most essential. Until a few years ago, I used to use the low ohms range on a multimeter, and many readers probably do the same. However, an audible indicator is often more convenient, for instance in car maintenance when delving into the innards of the works under the bonnet, since the tester can be perched wherever convenient, rather than having to be within view. Continuity testers of this sort have been available for longer than I can remember, but some of them are in fact less useful than one might think. For instance, in the case of an electrical machine, one usually wants assurance that a connection is really sound, i.e. has a resistance of much less than an ohm: the same goes for car work, and even for electronics, where a poor signal earth connection on a hi-fi amplifier can be responsible for hum problems.

Some continuity testers will indicate a connection as good, even if it has a resistance of several or many ohms. This is misleading at best, and in many circumstances worse than useless; a good continuity tester should indicate clearly whether a connection is well under 1Ω or not. The project described below does just this, and also provides useful information at the other extreme – indicating leakage in the range 1 to 10MΩ. In fact, used as described later in the article, it can check out a multiway screened cable, say, or a rack backplane, in less than half the time needed to test it using separate leakage and continuity testers. It achieves this by an ingenious arrangement of several overlapping bridge circuits. The Wheatstone Bridge is one of the earliest and still a fundamental example of the arrangements used in electrical measurements.

This project owes its advanced performance to the use of the latest LinCMOS™ technology (LinCMOS™ Texas Instruments), the TLC27L4CN quad op amp featuring exceedingly low bias current. This enables it to work from a source impedance of 1MΩ without incurring offset errors. In addition to testing for continuity and leakage, the completed unit checks components of all sorts both passive and active, and is safe to use on all normal semiconductor devices. It is protected against accidental connection to voltage sources up to and including 240V AC mains, and is unlikely to be inadvertently left switched on thanks to its 'watchdog' function. This, together with minimal current consumption, ensures exceptionally long battery life.

FEATURES

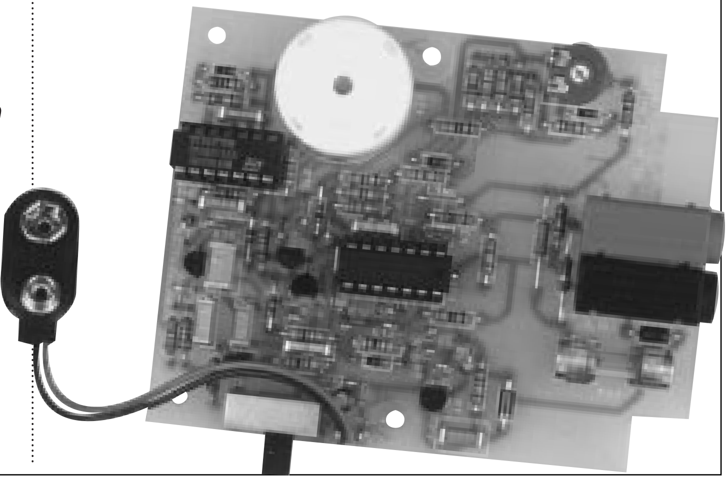
- Uses latest LinCMOS™ Technology
- Uses Wheatstone Bridge principle
- Internal fuse protection
- 9V portable operation
- Watchdog function
- Minimal current consumption

APPLICATIONS

- Continuity testing
- Leakage testing
- Checks both passive and active components

Important Safety Note

This project is a general-purpose test instrument for checking continuity and leakage. It is not designed to test earth continuity, earth loop impedance or insulation on 230V AC mains installations systems or equipment for compliance with British IEE Wiring Regulations, nor on installations systems or equipment for this or any other mains voltage for compliance with any other specifications or regulations. The internal F100mA F fuse protects against permanent damage due to accidental connection to DC or AC sources up to 240V. Instrument operates to specification after fuse replacement.

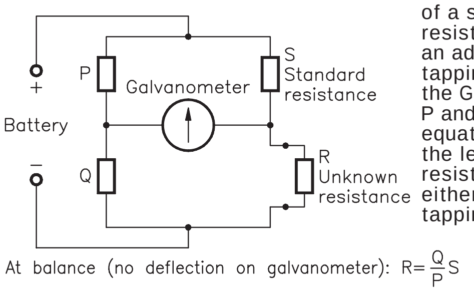


The Wheatstone Bridge

This instrument was invented by Sir Charles Wheatstone, who was born in Gloucester, in 1802, and died in Paris in 1875. Whilst still a minor, he set himself up in London as a maker of musical instruments, and in 1823 attracted scientific attention with a paper in the 'Annals of Philosophy' entitled New Experiments on Sound, followed by many other papers. As a professor at King's College London, in 1836 he exhibited experiments demonstrating the velocity of an electric current, leading to a joint patent with W. F. Cooke for an electric telegraph. Elected an FRS in 1836 and knighted in 1868, he is remembered first and foremost for the 'bridge circuit' named after him. The Wheatstone Bridge enables an unknown resistance to be measured by comparison with a known standard resistance, even though they may be of different values. The scheme depends upon the remarkable uniformity of drawn wire, not only the mechanical properties such as diameter, hardness etc. being constant along its length, but also its resistance.

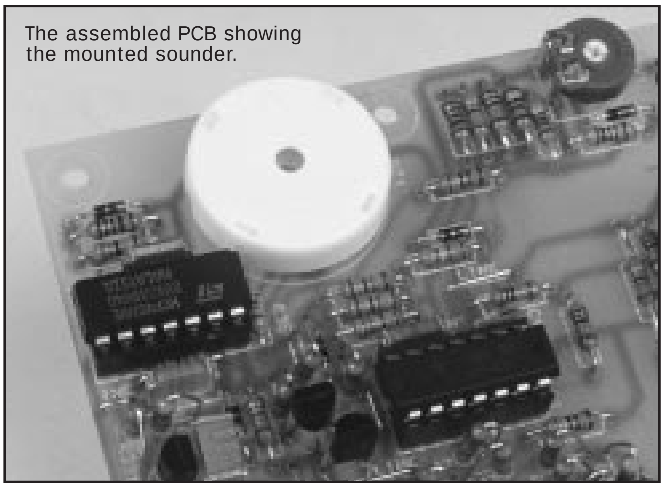
The basic Wheatstone arrangement is shown in Figure 1, where P and Q are the lengths of wire either side of the tapping point leading off to the galvanometer. Due to the uniform resistance per unit length of the wire, when the ratio P/Q = S/R there is no potential difference between the terminals of the galvanometer, and hence no deflection – the bridge is said to be 'at balance'. Knowing the lengths P and Q (their actual resistance does not need to be known) and the value of the standard resistance S, the value of the unknown resistance R is determined. To achieve the high degree of accuracy of which the arrangement is capable, thanks to the great uniformity of the wire, a considerable length of it is needed, so that the distances P and Q can be measured with very high resolution.

It as later realised that if the battery were replaced by an audio frequency generator and the galvanometer by a sensitive earpiece, the arrangement would work equally well. Furthermore, it was now possible to measure inductors or 'condensers', by using a known inductor or capacitor respectively at S. With this arrangement, the exact frequency of the audio generator did not need to be known. Later versions of the bridge enabled other arrangements to be used, e.g., an inductor could be measured using a capacitor as the standard, though in this case a good, pure sine source was necessary, as was a knowledge of its frequency. Indeed, one version (the Wien Bridge) was designed to measure not the value of a component, but rather the frequency of the AC source.



P and Q may consist of a single length of resistance wire with an adjustable tapping point for the Galvanometer. P and Q in the equation are then the lengths of resistance wire either side of the tapping.

Figure 1. Circuit diagram of Wheatstone Bridge.



The assembled PCB showing the mounted sounder.

Circuit Description

In addition to Figure 2, the block diagram Figure 3 shows the full circuit diagram of the Discriminating continuity and leakage tester, at first sight it seems rather complex. However, depending upon the resistance across the test probes, only the relevant part of the circuit operates, so the workings can be explained section by section.

Leakage Measurements

The operation of the leakage detection circuitry, uses a bridge which consists of P, S, Q and R. Where P is 1M (R1), S is 1M (R11), Q is 1·018M which comprises of 1M (R13) plus 18k (R14), and R' (1·33MΩ) which consists of R (330k R4 and 1M R5) in parallel with the resistance across the test terminals. When the test leads are open circuit, the non-inverting (NI) input of IC1B is positive with respect to (WRT) its inverting input and therefore its output is at +9V so that TR1 is off, and the oscillator formed by IC2A and IC2B cannot run (being inhibited via diode D3). Furthermore, via R8 the inverting (I) input of IC1A is positive WRT its NI input, so its output is at 0V, connecting R12 in parallel with Q (R13 plus R14) and depressing the voltage at the NI input slightly.

If the resistance across the test leads falls to about 3MΩ, the voltages at the I and NI inputs of IC1A become equal, and its output voltage begins to rise. Positive feedback via R12 causes it to flip up momentarily to +9V, which charges up C2 via R15 and D5. This causes IC1A output to fall back to 0V, where it remains until C2 discharges sufficiently via R8 for the action to repeat. The result is a series of clicks from the piezo sounder BZ1 which is driven by IC2C and IC2D, the former being enabled on pin 8 since the output from IC1D is at +9V. As the resistance across the test leads falls below 3MΩ, the clicks merge first into a burp – then into a tone which rises higher, reaching a maximum with a resistance of about 50kΩ across the test leads.

The Power-up Bridge

For resistances below about 50kΩ, the leakage bridge runs out of discrimination, simply producing its maximum frequency tone. To measure resistances down in the ohms range, the bridge must be powered up to a much higher current. This permits a measurable (albeit still very small) voltage drop across the unknown resistor. The power-up bridge works as follows: where now P is 2MΩ consisting of 1MΩ (R11) and 1MΩ (R13), Q is 18kΩ (R14), S is 1MΩ (R1) and R is the resistance across the test leads (in parallel with R4 and R5). When R falls to about 9kΩ, the power-up bridge is in balance and the inputs of IC1B are at the same voltage. Its output starts to fall, turning on TR1, which powers up the bridge by supplying about 10mA to the external circuit via R2, F1 and R3. However, this raises the voltage at the NI input of IC1B, which therefore turns TR1 off again, the proportion of the time for which TR1 is on increasing as the resistance across the tests leads falls below 9kΩ. Meanwhile, IC1A is still running, producing the high leakage tone, so the 80mV at IC1B's I input is modulated by the switching action of IC1A via R12 and R13.

When the resistance across the test leads has fallen to a little under 8Ω, the voltage at IC1B's NI input is lower than 80mV, even with TR1 hard on permanently. The power-up bridge now consists of P, Q, S (R2 820Ω) and the external circuit, and it is out of balance such that TR1 is on permanently, since IC1B's output is stuck low. This removes the clamp via D3 from the oscillator IC2A, IC2B, which therefore commences to run.

Continuity Measurements

For values of resistance across the test leads of about 8Ω down to 3Ω, the high leakage tone continues to sound as before. At this point the continuity bridge comes into play, where P is 330kΩ (R4), Q is 1MΩ (R5), S is 1Ω (R3) and R is the resistance under test. IC1C is arranged to amplify the degree of bridge unbalance, since the bridge output is so small: when

SPECIFICATION

Supply voltage:	Internal 9V battery type PP3
Supply current:	530µA quiescent, 13mA operating
Typical battery life	
On but not sounding:	800+ hours
Sounding leakage tone – intermittent use:	150+ hours
Sounding continuity tone – intermittent use:	25+ hours

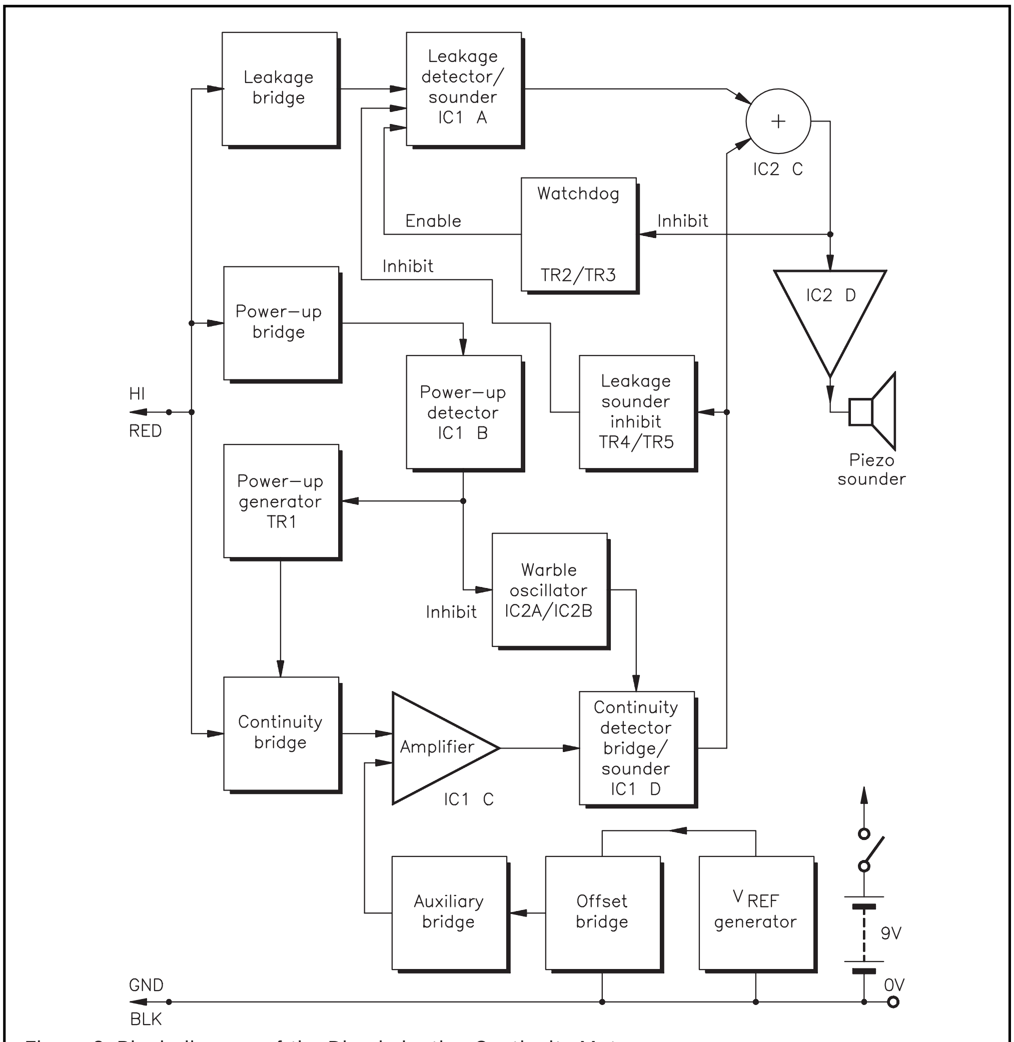


Figure 2. Block diagram of the Discriminating Continuity Meter.

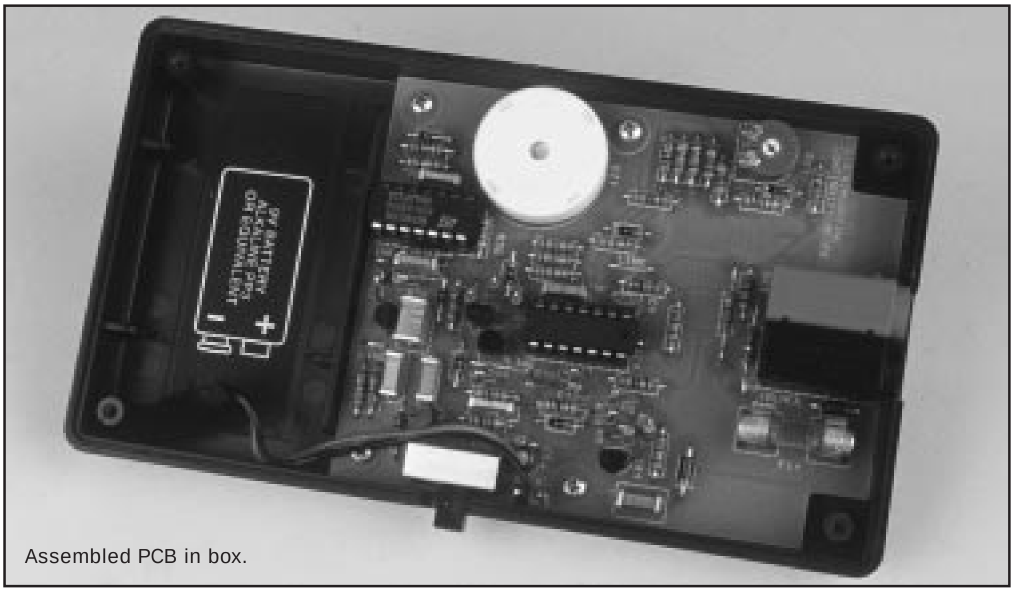
R = 3Ω the bridge is in balance with the voltage at point Y (the junction between R4 and R5), equal to that at point X (the junction between R3 and R6), whilst when R = 0Ω, point Y is a mere 7·5mV positive WRT X. On the other hand, the corresponding voltage change at IC1C's NI input is 22·5mV, so that the common mode input is much larger than the wanted change in bridge output voltage.

At 3Ω, the continuity bridge approaches balance, so the output of IC1C starts to rise from zero, towards +9V. The gain of IC1C is set at about × 820, the ratio of the effective negative feedback resistor at IC1C's I input to R6 – due to the 'tee' attenuator network, R19/20/21 are equivalent to a single 820MΩ resistor. The output of IC1C is applied to the lower end of one arm of a bridge comprising R24, R32, R34 and R37. When the output of IC1C rises sufficiently, the voltages at the inputs of IC1D approach equality, and it commences to oscillate in exactly the same way as described earlier for IC1A. As soon as IC1D starts to oscillate, its first negative going edge turns on TR4 which in turn charges up C8 and turns on TR5. Via R27, this pulls the I input of IC1A well below its NI input, inhibiting the leakage tone and leaving input A of gate IC2C enabled.

The 3Ω threshold for R at which IC1D commences to oscillate is set up by injecting an offset from RV1 into the NI input of IC1C via R18. To avoid the offset injection interacting with the large common mode input into IC1C, the offset is injected via an auxiliary bridge, where the ratio of R18 to the resistance seen looking into point Y is equal to the ratio of R19 to R6. The offset injected via the auxiliary bridge is obtained from the bias bridge R22, R23, R31 and RV1, the voltage applied to which is stabilised by D7. Thus all told, the instrument incorporates no less than 'six' bridge circuits!

The Warble Tone Oscillator

With the continuity bridge fully powered up, IC1B output is at 0V, so D3 is reversed biased, allowing the warble tone oscillator IC2A, IC2B to run. This it does at about 4Hz, with an asymmetrical mark/space ratio, since on one half-cycle, C3 is charged via R17, whilst on the



Assembled PCB in box.

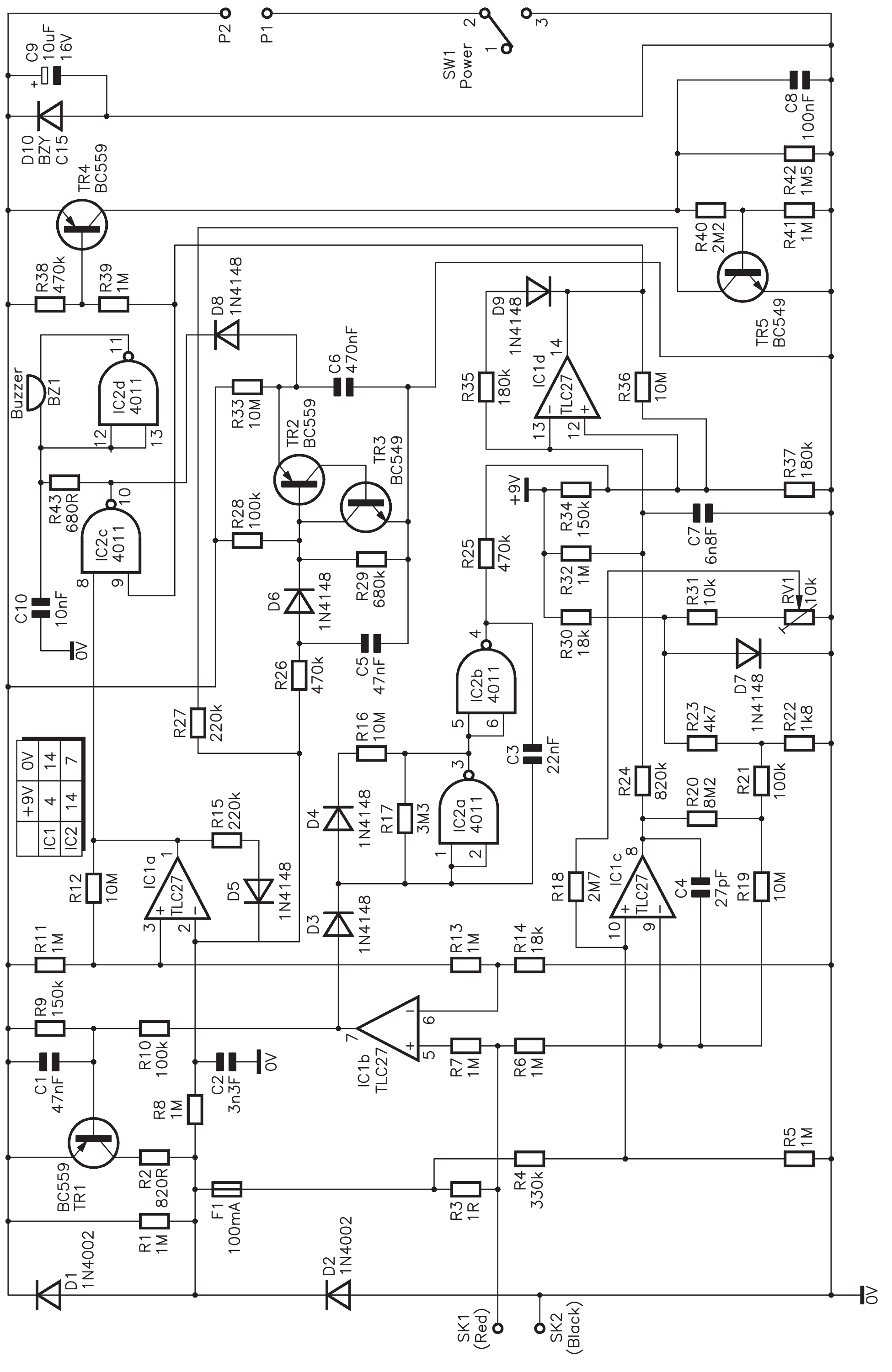


Figure 3. Circuit diagram of the Discriminating Continuity Meter.

other it is discharged via R17 and R16 in parallel. When the resistance under test (RUT) equals 3Ω, IC1D can only oscillate when the output of IC2B is low, pulling down the threshold at IC1D's NI input via R25. Thus the piezo sounder BZ1 emits bursts of a very low frequency tone with short gaps in between. As the value of the RUT falls, the pitch of the interrupted tone rises, C8 keeping TR5 bottomed and hence the leakage tone oscillator IC1A muted during the gaps. When the RUT falls to about 1·5Ω, by which time the pitch of the interrupted tone (the 'dashes') has risen to a middling value, the output voltage of IC1C has reached a point where IC1D can oscillate (at a low-frequency) even when the output of the warble tone oscillator at IC2B is high. Thus there are now middling pitched dashes interspersed with low pitched dots. As the RUT falls below one ohm, the pitch of both dashes and dots rises, the former being the higher, as indicated in Figure 4. As with the leakage tone, so with the continuity tones: as the RUT falls so their pitch tends to level off at some maximum value. The circuit is so arranged that this happens to the dashes tone first, so that about RUT = 150mΩ (milli ohms) the dots tone catches up, whilst when the RUT equals zero, the dots tone is actually higher than the dashes tone. Thus with practice, the sound the instrument makes will indicate to the user the approximate resistance between the test leads anywhere in the range 0 to 3Ω.

The Watchdog

One problem with battery instruments is that all too often it is found, when they are required for use, that they are inoperative, due to an exhausted battery. Usually, the reason is that they have been inadvertently left switched on. Incorporating a pilot light is hardly a sensible move, due to the current it would draw, but this instrument solves the problem by making use of the piezo sounder to draw attention to itself. If the continuity and leakage tester is left switched on but not in use, it will emit a characteristic chirp tone every twelve seconds or thereabouts. C6 charges up via R33 until the voltage at TR2's emitter exceeds that at its base, whereupon TR2 and TR3 act as a programmable unijunction transistor, momentarily conducting heavily and discharging C6 again. Via D6, C5 is also discharged, effectively grounding the right-hand end of R26. This activates the leakage tone oscillator IC1C, whose pitch falls as C5 charges up again through R26, resulting in a characteristic down-chirp, and alerting the user that the instrument is still switched on. Whenever the instrument is actually in use, indicating either continuity or leakage, C6 is repeatedly discharged via D8, disabling the watchdog chirp both during use and for 12 seconds afterwards.

Protection

The continuity and leakage tester is designed for use on 'dead' circuits, i.e. on circuits which are not powered up. Nevertheless, the instrument is protected against connection to live voltage sources, even AC mains, by virtue of its design. If the voltage at the test leads substantially exceeds +15V, then the fault current through D1 and D10 will blow the F100mA fast acting fuse F1. Similarly, the fuse will be blown by a negative voltage causing fault current via D2. This still leaves the NI input of IC1B and both inputs of IC1C connected

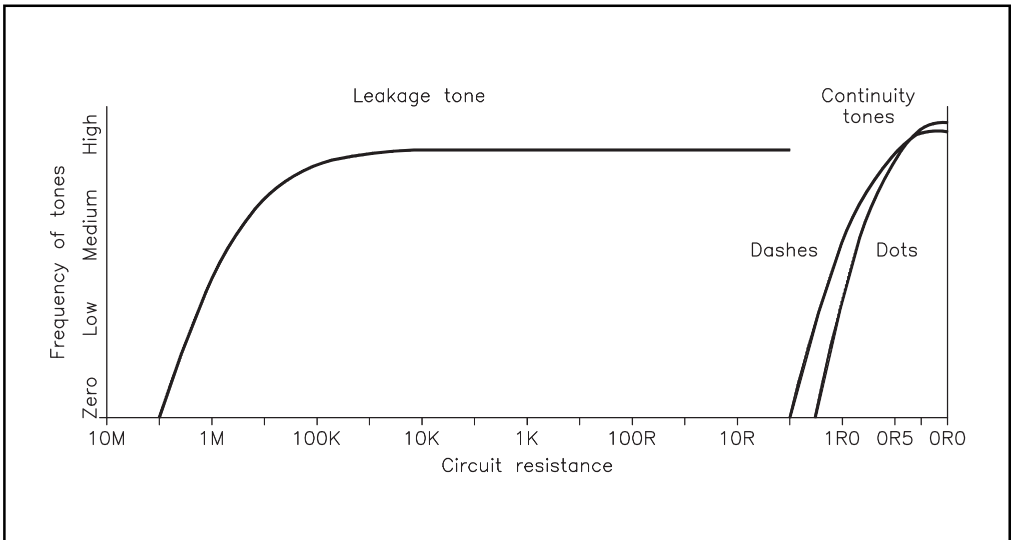


Figure 4. Graph showing frequency of tone versus resistance value.

to the input, but the series resistors R4, R6 and R7 are so high that the current is limited to a value that can be handled by the device's internal protection circuitry. Thus the instrument will sustain no permanent damage from connection to a live source, though replacement of F1 will be necessary to restore normal operation. Note that when replacing the fuse F1, it is *essential* to use an exact replacement rated for 230V AC mains operation. If a fuse designed for use on low voltage circuits is used, then if the unit is accidentally connected to the mains, the fuse may fail to clear the fault; it will open, but can sustain an arc, resulting in a fault current which must then be cleared by a fuse within the mains circuit itself. This can result in permanent damage to many of the components within the instrument.

Construction

The PCB has a printed legend that will assist you when positioning each item, see Figure 5. As all components are mounted on the PCB, construction is straightforward. However, it is essential to make sure that all components are inserted in their correct locations and that polarised components such as the various diodes and C9 are fitted the right way round; mistakes can be costly to rectify. Use resistor or diode offcuts for links on the board. The order of fitting the components is not critical, but it is most convenient to mount the smaller components first, and then the IC sockets, do not fit the ICs themselves until assembly of the PCB is complete. The board should be given a final check-over with an eyeglass, looking for solder splashes between tracks, dry joints or other possible problems. When you are sure all is well, fit the ICs into their sockets.

Box Drilling

To complete the project; the drilling details of the case are given in Figure 6.

The front panel label (KP78K), which is included in the kit, is shown in Figure 7.

The exploded assembly details are shown in Figure 8, when complete, offer the unit up to the case.

The piece of self-adhesive foam strip, supplied in the kit, should be cut to an appropriate length and stuck onto the inside of the battery compartment lid to hold the PP3 battery firmly in place.

Testing and Setting Up

There are two sockets red and black, and for most purposes these will be adequate for the two test leads, but an optional ground lead (BZ223A) as shown in Figure 9 can be connected if required.

Potentiometer VR1 should be set initially at mid travel. Fit a new 9V PP3 battery, switch on, and wait. The unit should emit a chirp every 12 seconds or so. Now connect a 3·3Ω resistor across the leads and adjust RV1 so that the high leakage tone is replaced by low dashes, then back RV1 off so that the dashes are just replaced by the high leakage tone. No other adjustments should be necessary, although it will be useful to find out just how high a resistance just causes the leakage tone to sound. This can be determined roughly with the aid of various standard resistor values in the range 1 to 10MΩ. Despite the use of 1% resistors throughout the circuit, some unit to unit variation can be expected, but a low pitched leakage tone should appear at somewhere between 2 and 8MΩ.

The test current is 10mA when the resistance of the circuit under test is 8Ω or less. When the resistance of the circuit under test is over 9kΩ, the test source looks like +4V behind 570kΩ. When the resistance of the circuit under test is between 8Ω and 9kΩ, the average test current is such as to drop 80mV across the circuit under test. Maximum power dissipated in circuit under test is less than 1mW when the resistance of the circuit under test is less than 8Ω and less than 10µW when the resistance of the circuit under test is greater than 9kΩ. With a 100kΩ resistor a high clear tone is emitted, and when the leads are shorted together a characteristic warble tone is emitted.

Using the Continuity and Leakage Tester

NOTE: HCT, MCT, LCT means high, medium or low continuity tone. HLT, MLT, LLT means high, medium or low leakage tone.

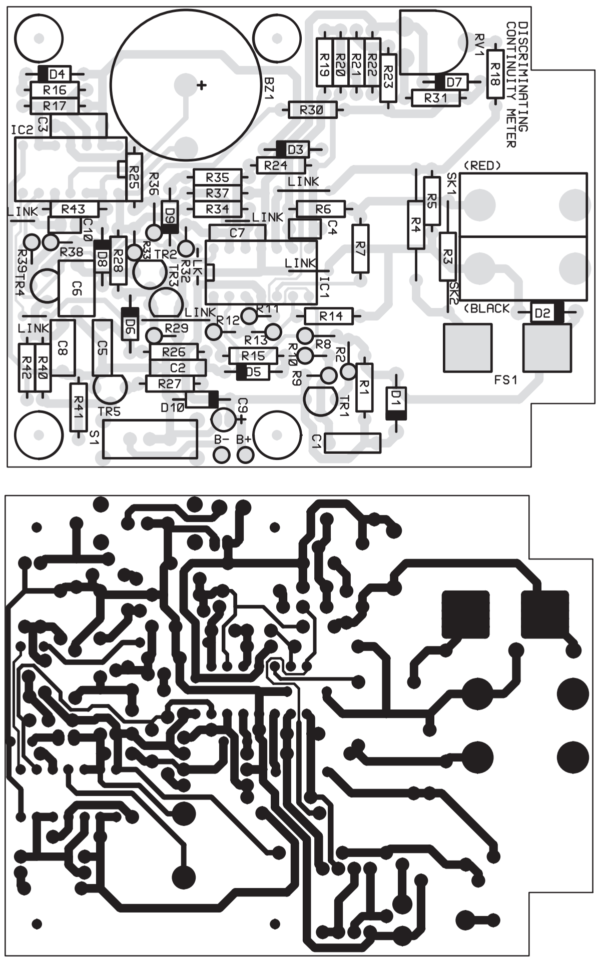


Figure 5. PCB legend and track.

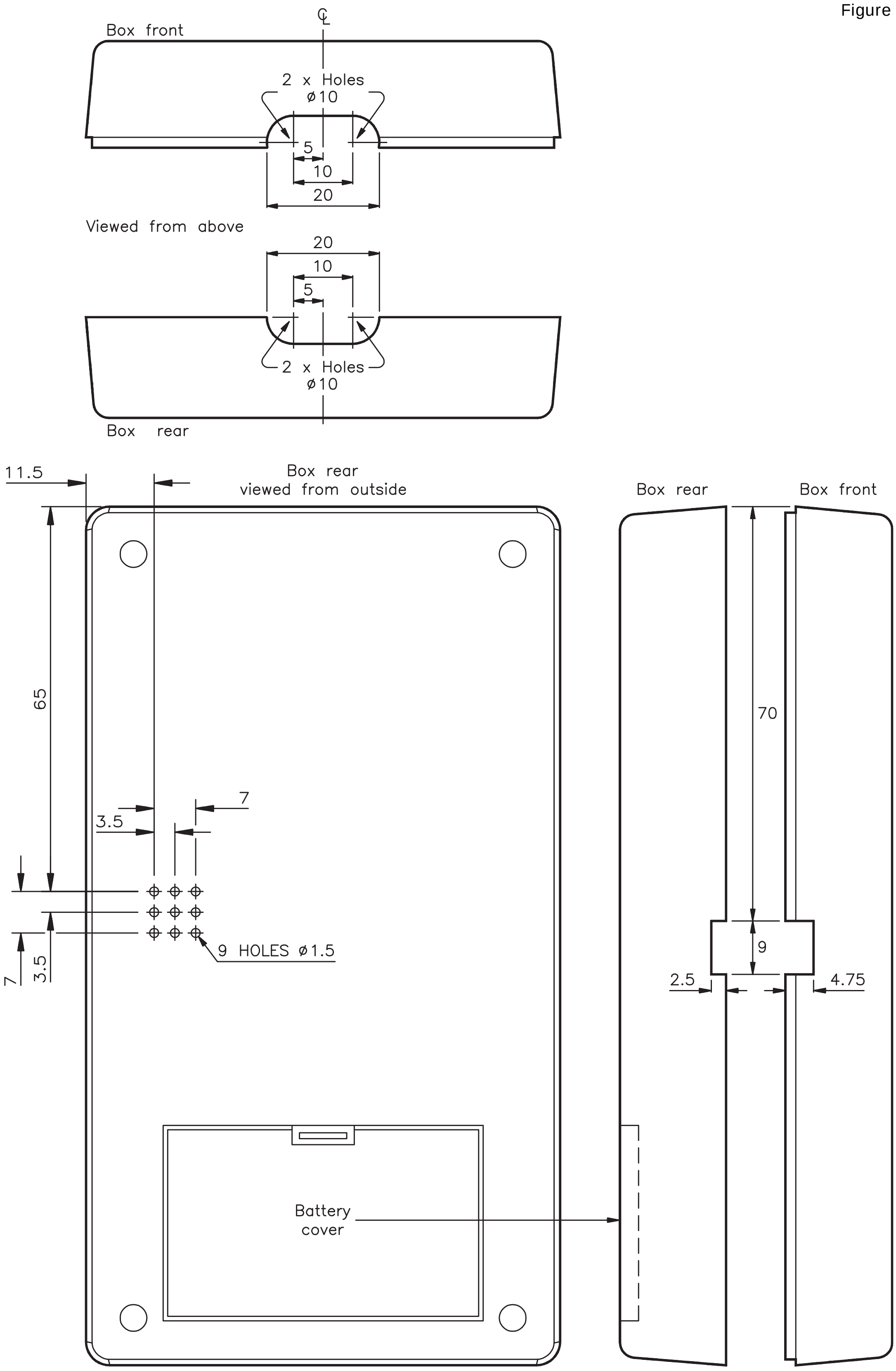


Figure 6. Box drilling.

Continuity Indication

Warble tone of alternate dots and dashes. Pitch indicates resistance in range 0 to 3Ω approximately.

Leakage Indication

Steady tone. Pitch indicates resistance in range 3Ω to 3MΩ approximately.

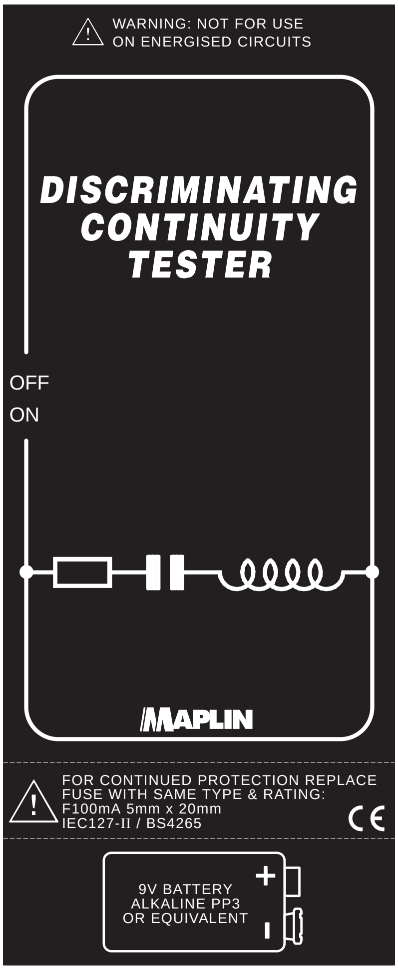
On Indication

Momentary chirp tone once every 12 seconds approximately. Inhibited during continuity or leakage tones and for 12 second afterwards.

Simple Continuity and Leakage Tests

Using the test leads, a good connection will produce HCT, similar to the sound with the two leads touching: the dots are

Figure 7. Front, rear and battery compartment labels.



higher in pitch than the dashes. If the dots and dashes are of the same pitch, the resistance is in the range 100 to 250mΩ (milli ohms). At higher resistances, the dot pitch is lower or even zero. As the resistance approaches 3Ω, the dash pitch falls to zero and is replaced above 3Ω by the steady HLT. At higher resistances still, this falls, reaching zero at approximately 3MΩ, see Figure 4.

Simultaneous Continuity and Ground Leakage Checks

When testing a multiway cable with overall screen, a backplane in a rack or shelf etc., connect the optional lead to the screen or shelf metalwork. Check continuity of each connection in turn, taking care to connect the red test lead to one end of a run before connecting the black test lead to the other end. Any leakage or short to ground will then be indicated by the leakage or continuity tone respectively. Then complete the test by connecting the black test lead to the other end of the run to check its continuity. Thus continuity checking also accomplishes ground fault checking simultaneously, with no extra time or effort.

Component Testing

Nearly all components can be checked qualitatively as 'good' or 'bad'. In the case of resistors, the approximate value can often be estimated by reference to Figure 4.

Capacitors. On connecting the test leads across a capacitor, the following effect is produced:-

1nF – click. 10nF – brief chirp. 100nF – pronounced downward chirp. 1µF – chirp lasting about 1·2 seconds. 10µF – leakage tone gradually falling. For tantalum and modern aluminium electrolytics, the tone will fall to zero. Older aluminium electrolytics may 'stick' at LLT.

Discrete semiconductors of all types, diodes, bipolar transistors, FETs, SCRs, Darlingtons, LEDs, Triacs etc, can all be checked. Forward junctions e.g., red test lead to base of an NPN transistor and black to emitter, will result in HLT; black lead to collector likewise. Reversed biased junctions including silicon diodes and most LEDs will result in silence. For germanium diodes, expect silence, LLT or even MLT, according to type and rating. Note that many Darlingtons have a built-in base-emitter resistor, so expect HLT for this junction both ways round. Also expect HLT between collector and emitter one way round due to the Darlington's built-in inverse collector-emitter diode.

Other components. The tester can also be used to check bulbs, loudspeakers, relay coils and contacts, chokes, inductors and transformers (including winding to winding, screen and frame/clamp leakage).

Production Testing

For simplified continuity testing on the production line, warble tone = pass, anything else = fail.

Maintenance

Protect the instrument from damp, do not drop or immerse in liquids. Use only a good quality battery and remove it when exhausted, or as indicated by faint tones.

The internal fuse may blow if the test leads are connected to an AC voltage source, or to a DC voltage source negative WRT ground (GND), or to a positive source in excess of about +15V WRT ground (GND). Before attempting to replace the fuse, disconnect the instrument from any external circuit. Access for fuse replacement is by removing the top half of the case, which is secured by four screws accessible from the rear of the instrument. Use only F100mA 20mm quick acting fuses to BS4265 or IEC127 standards, e.g., (EB39N).

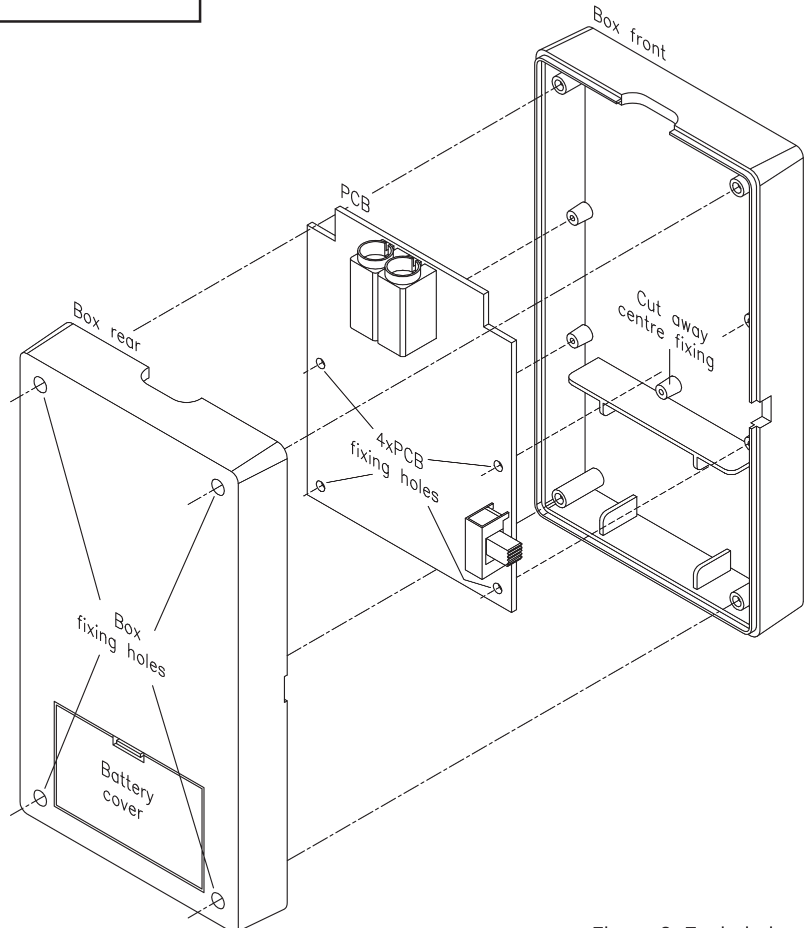


Figure 8. Exploded assembly.

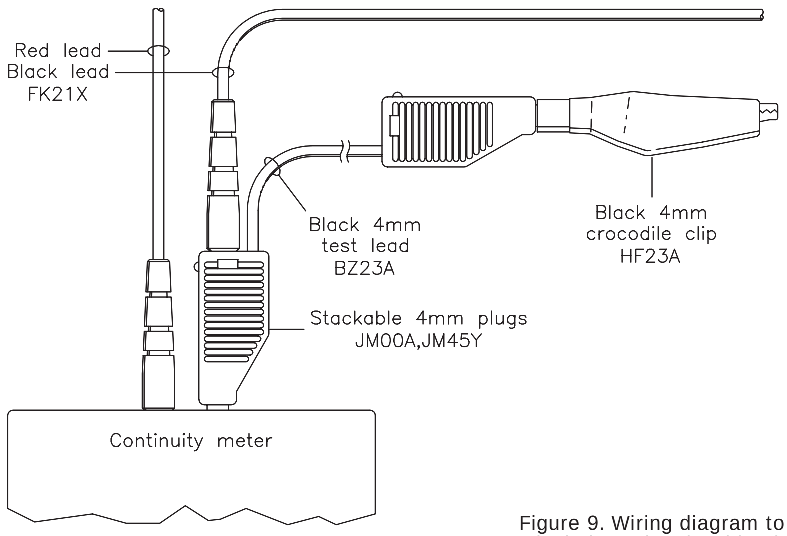


Figure 9. Wiring diagram to include optional 3rd lead.

PROJECT PARTS LIST

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

R1,5,6,7,8,11 13,32,39,41	1M	10	(M1M)
R2	820Ω	1	(M820R)
R3	1Ω	1	(M1R)
R4	330k	1	(M330K)
R9,34	150k	2	(M150K)
R10,21,28	100k	3	(M100K)
R12,16,19,33,36	10M	5	(M10M)
R14,30	18k	2	(M18K)
R15,27	220k	2	(M220K)
R17	3M3	1	(3M3)
R18	2M7	1	(M2M7)
R20	8M2	1	(M8M2)
R22	1k8	1	(M1K8)
R23	4k7	1	(M4k7)
R24	820k	1	(M820K)
R25,26,38	470k	3	(M470K)
R29	680k	1	(M680K)
R31	10k	1	(M10K)
R35,37	180k	2	(M180K)
R40	2M2	1	(M2M2)
R42	1M5	1	(M1M5)
R43	680R	1	(M680R)
RV1	10k Horizontal Enclosed Preset	1	(UH03D)
Test Resistor	3·3Ω	1	(M3R3)

CAPACITORS

C1,5	47nF Polylayer	2	(WW37S)
C2	3n3F Polylayer	1	(WW25C)
C3	22nF Polylayer	1	(WW33L)
C4	27pf Ceramic	1	(WX49D)
C6	470nF Polylayer	1	(WW49D)
C7	6n8F Polylayer	1	(WW27E)
C8	100nF Polylayer	1	(WW41U)
C9	10µF 16V Electrolytic	1	(YY34M)
C10	10nF 16V Polylayer	1	(WW29G)

SEMICONDUCTORS

D1,2	1N4002	2	(QL74R)
D3-9	1N4148	7	(QL80B)
D10	BZY C15	1	(QH18U)
TR1,2,4	BC559	3	(QQ18U)
TR3,5	BC549	2	(QQ15R)
IC1	TLC27L4CN	1	(AR57M)
IC2	HCF4011BEY	1	(QX05F)

MISCELLANEOUS

S1	R/A SPDT Slide Switch	1	(FV01B)
BZ1	PCB Piezo Sounder	1	(JH24B)
SK1	PCB Socket Red (4mm)	1	(JP22Y)
SK2	PCB Socket Black (4mm)	1	(JP20W)
	14-pin DIL Socket	2	(BL18U)
	Single-ended PCB Pin (1mm)	2 pins	(FL24B) ★
	20mm Fuse Clip Type 1	1	(WH49D)
	100mA Fast Acting Fuse	1	(EB39N) ★
	Plain HH2 Box	1	(ZB16S)
	Test Leads	1	(FK21X)
	PP3 Battery Clip	1	(HF28F)
	Front Panel Label	1	(KP78K)
	PCB	1	(GJ07H)
	Instruction Leaflet	1	(XV25C)
	Constructors' Guide	1	(XH79L)
	Sponge Block	1	(FS04E)
	Stick on Feet	1	(FE32K)

OPTIONAL (Not in Kit)

	Patch Cord Black (100cm)	1	(BZ23A)
	Crocodile Clip Black (4mm)	1	(HF23A)
	9V PP3 Alkaline Battery	1	(ZB52G)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT78K (Discriminating Continuity and Leakage Tester)

Please Note: Items in the Parts list marked with a ★ are supplied in 'package' quantities (e.g., packet, strip, reel, etc.), see current Maplin catalogue for full ordering information.

The following new items (which are included in the kit) are also available separately.

Discriminating Continuity and Leakage Tester PCB
Order As GJ07H

Discriminating Continuity and Leakage Tester
Front Panel Label ***Order As KP78K***

F100mA 20mm Quick Acting Fuse (BS4265 IEC127)
Packet of 10 ***Order As EB39N***

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