

Assembly Manual

Sigchecker: Signature Analyser

K-7226



ACN 000 445 956

KIT

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This simple instrument can compare circuits point by point. If you have a faulty board and a good board for comparison, you can easily find the bad components and repair the board. There is no need to understand circuits, nor even to have any diagrams. If you are a circuit trouble shooter, you'll like this one.

I have lived a long time designing, mending and re-designing electronic circuitry, and I have developed a vision of heaven where everything has a correctly updated schematic and a complete operating description in good basic English engraved on the inside of its cover.

While I hope to go to that heaven one day, I am still cursed with living in a world where more and more electronic devices come without any information at all, or have operating and service pamphlet translated from Japanese, Chinese or German by some first year Arts and Language student.

Along with other people, my 'non electronic' friends buy such gadgets and then I get asked to 'please look at it, it doesn't work'. If I say that I have very little chance of reviving it without a circuit diagram, I come close to losing a friend.

To avoid such difficulties, I have learnt to behave like a medico rather than an engineer. After all, medics do not find circuit diagrams or data sheets tucked into their patients' pockets, nor can they write to the manufacturer for a service manual. And yet they often manage to do the right thing and reap rich rewards of money, status and friendship.

The reason for their success is that they do not insist on understanding all the intricacies of the hardware and software. Instead, they take a good working model, and compare it node by node with the sick one.

When they find the node with the greatest discrepancy, they replace all the components around the bad node with new or good second-hand spares, remake all the connections as best they

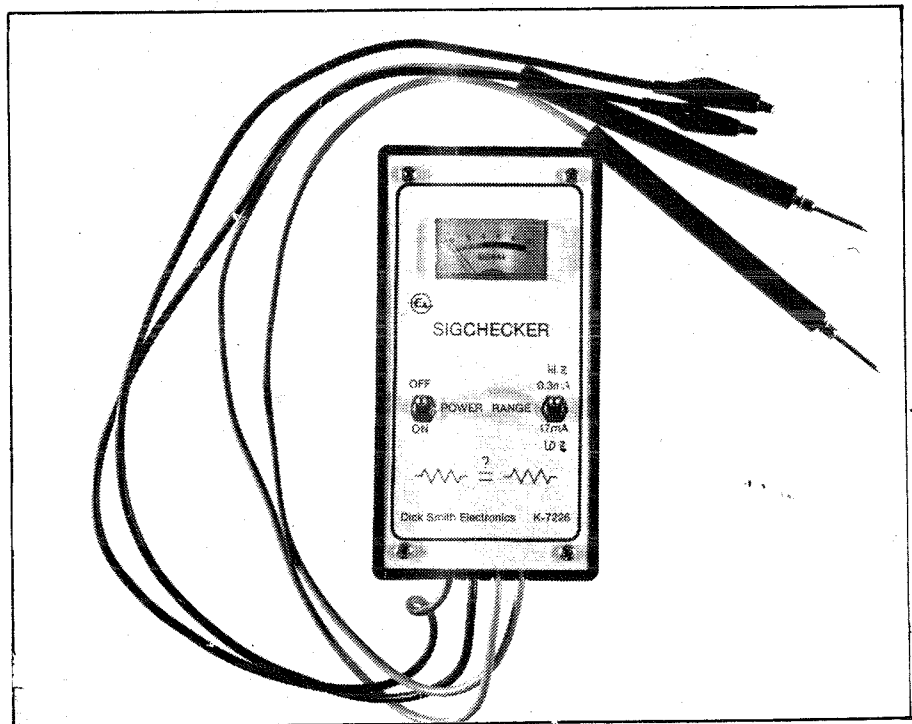
can and keep repeating the process until either the patient is cured, or runs out of money, or they find that the model is past its use-by date and spares are no longer available!

In electronics the same approach can also bring good results, but there is an ideological hurdle.

As properly trained engineers, we cannot accept the rather loose understanding of what we are doing and we have therefore invented a scientific sounding name for what down-to-earth people would call the 'idiot approach'. It is called *signature analysis*.

'Real' signature analysers are complex pieces of analog and digital electronics, often connected to a bed-of-nails setup, sitting at the end of a production line and costing five digit dollars. They do an excellent job in quality control. They can stimulate whole blocks of circuitry with complex waveforms, then analyse the responses and come up with detailed reports identifying present and even future trouble spots and recommending remedial actions.

Then there are the poor man's signature testers. About 10 years ago I came across the first of them, the Huntron Tracker.



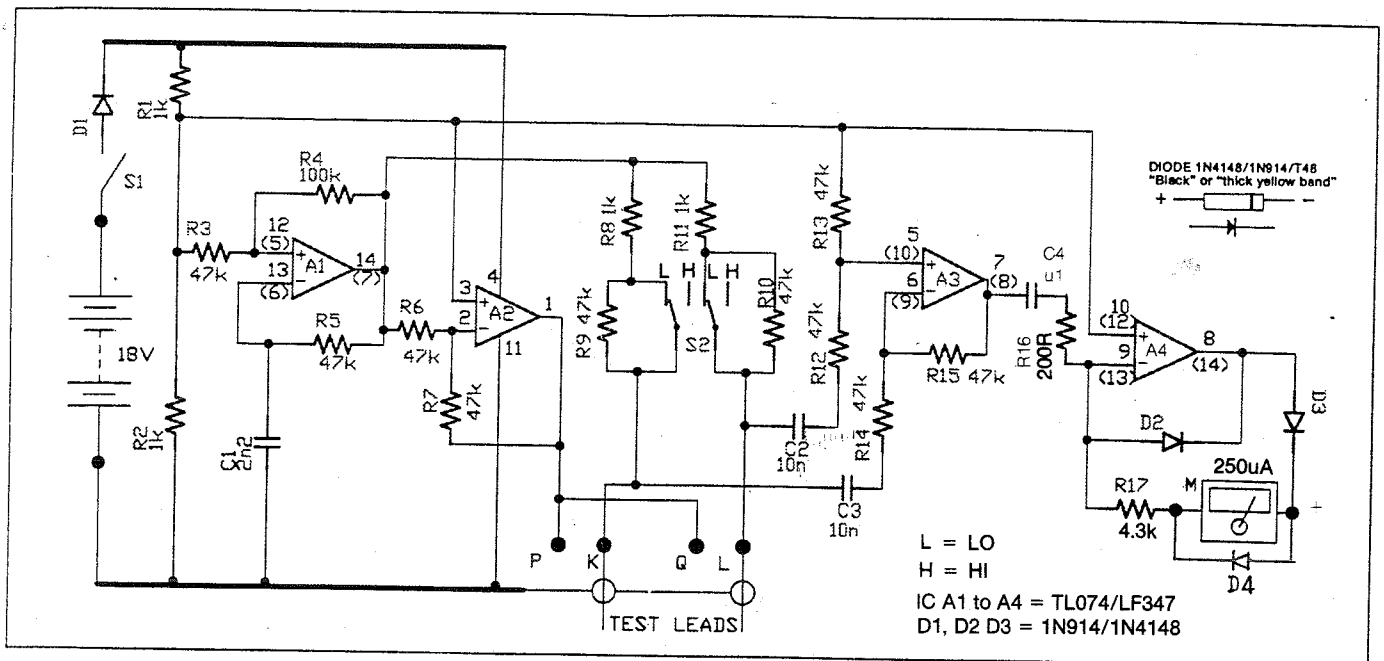


Fig. 1. Here's the complete schematic for the Sigchecker. It's based on a single quad op-amp chip, as you can see.

The instrument had three test wires. One was a 'common', the others had two identical low power sources of AC behind them. The instrument had a CRT which displayed an X/Y plot of voltage against current at one or the other of the AC sources. The display alternated between the two sources.

I bought one of these instruments for my (then) employer and we found it very useful. If you had a faulty board and another good board of the same kind, you could place the two (unpowered) boards side by side, strap the earth lines together, connect the strap to the 'common' lead of the Huntron and press the two AC source probes simultaneously to corresponding points on the two boards under test.

This amounted to signature analysis for one node at a time. If there was a resistor between the source and common, the corresponding CRT picture would be a sloping straight line with a slope proportional to the value of the resistance. A diode would produce a right-angled knee, a zener would produce a 'Z' shaped pattern. A capacitor would produce a circle which was flattened if the capacitor was leaking.

If the two circuits under test were identical, the display pattern would alternate between two very similar shapes. If there was a significant difference, e.g. a good capacitor in side A and an open circuit or a resistor in side B, the display would alternate between an ellipse and a sloping line, two obviously different patterns. We soon learnt that most good pins on transistors and ICs look simply like combinations of zeners and resistors and can be easily distinguished from 'blown' pins which look like open circuits, short circuits or leaky diodes.

Using the tester, one could track down a 'bad' component on a big board in a tiny fraction of the time it would take to find the circuit diagram, interpret it and under-

stand the working of the board. Furthermore, the troubleshooting could be delegated to those not normally inclined to bother about details of current flow in a tangle of components, while those who normally thrive on unravelling such detail could be assigned to writing project specs, work schedules, budgets and grant applications.

Most good and most bad things in life come to an end, and recently I have had to retire from the job which made the Huntron accessible to me. I have had to acquire my own test equipment.

Nowadays many oscilloscopes, particularly those designed for the service technician have a test facility similar to our old Huntron. Unfortunately, I had not the foresight to buy one of those. Instead, I bought an aging top-of-the-line HP model. I have since missed the unashamed simplicity of the curve tracing faultfinder.

I started developing a curve-tracing attachment for the HP, which I thought might make a good hobby project for anyone with a CRO. Then I had the idea of comparing square wave responses. There is no need to display pictures on a CRT to compare waveforms; you can do it with a meter.

This tester is small enough to ride in a service bag beside a multimeter, and can find most components that are more than 5% out of spec.

Square wave testing

As any seasoned CRO driver knows, square waves are handy test signals. They can be generated simply and accurately and they are rich in harmonics — i.e., they contain high and low frequencies together. They can therefore simultaneously test capacitive and inductive circuits, as well as resistances and semiconductors.

The voltage waveform at any point in a

circuit depends on two factors: the driving source and the components connected to that point. If the waveforms are not as expected, then the circuit you have is not the circuit you think you have.

Fig.2 shows eight examples of the kind of waveshapes one should expect from the application of a squarewave generator to frequently seen component configurations. Readers who recognise these familiar shapes might want to skip the next paragraph.

In Fig.2 the generator waveforms at point A are the same for all cases. In each case the generator has a source resistance drawn horizontally. The components (loads) under test are drawn vertically. In case I, the (vertically drawn) resistive load simply attenuates the original squarewave, resulting in a reduced squarewave at B.

In case II, the diode clamps point B at about +0.6V above ground during the positive half-cycle. During the negative half-cycle no current flows in the diode and the voltages at A and B are the same. If the load were a zener diode, the voltage at B would be clamped at the zener voltage during the negative half-cycle.

In case III the load is capacitive and the voltage at B cannot rise and fall instantly as the drive at A changes polarity. B rises and falls exponentially along the familiar $1 - e^{-t/RC}$ curve. The bigger the product of R and C, the longer the rise time. If the capacitor were very large, the voltage at B might not finish rising by the end of each half cycle, and the waveform at B would look like a string of bendy triangles. On the other hand, if R or C were small, the rise time at B would be almost as fast as at A.

Case IV shows what happens if the capacitor is leaking. The overall amplitude is reduced. Case V shows the waveform for a capacitor that has a poor connection inside, or has a resis-

tor in series with it. The waveform is almost the same as that in III, except for a very steep initial rise followed by the exponential portion.

The effect of an inductive load is shown in Case VI. The instant sharp spike at B for every change at A is a sure sign that there is an inductor in the load. If there is also a capacitance, as shown in cases VII and VIII, the spikes are blunted, and oscillations occur during the recovery period after the initial slope.

The wiggly waveform in the recovery period is usually called 'ringing' (as in bells) or damped oscillation. The ringing frequency is the resonant frequency of the LC circuit and the decay time of the ring depends on the Q of the circuit. Detailed discussion of ringing waveforms is beyond the scope of this article.

The obvious but often-forgotten general rule in interpreting square wave responses is that in the period immediately after a transition at A, the behaviour of the voltage at B is determined by the reactive components in the load (capacitors and inductors). On the other hand, the level to which B finally settles, i.e. the voltage just before the next transition, is determined by resistive loads.

For small inductors and capacitors the settling period might be very short compared with the cycle time of the square wave. In such a case the test will fail to detect the small components. For large capacitors the settling time may be longer than the cycle time. In such cases the test may fail to detect leakage in a capacitor.

How Sigchecker works

As illustrated in Fig.2, each component configuration has its unique response pattern when stimulated by a square wave generator. This pattern can be called a 'signature'. Signatures of identical components will be identical. Therefore, if the signature of a good component is compared with that of a faulty one, there will be a difference during part or all of each cycle of the source waveform. The SIGCHECKER simply integrates the magnitude of that difference and shows it on a meter.

In practice, there is always a small difference between any two circuits, even if both are OK. Therefore, the meter sensitivity must be set so that only real discrepancies like 10% or more give sizeable deflections.

A further difficulty in choosing the sensitivity arises from the range of impedances that a trouble shooter can encounter. Impedances between 100 ohms and one megohm are commonly encountered, and at least two values of source impedance are needed for the squarewave tester to be useful over such a large range of impedances.

Circuit description

The SIGCHECKER circuit is shown in Fig.1. It is based on a single quad JFET

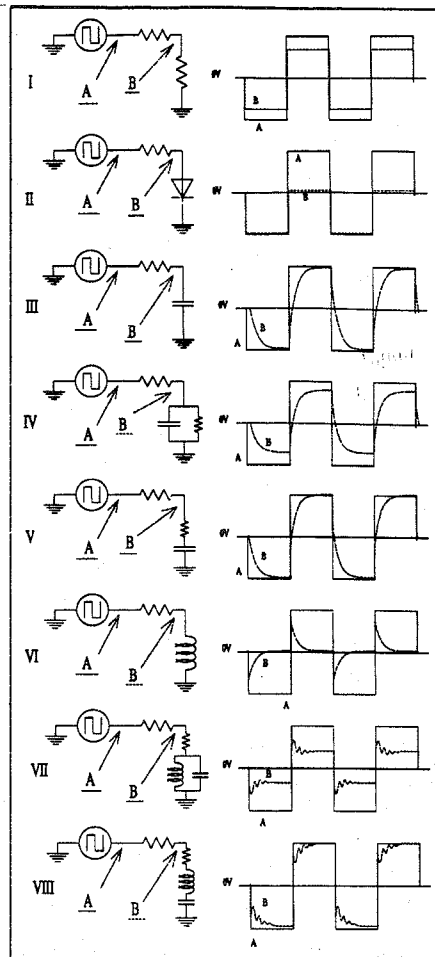


Fig.2: What happens when various common circuit components are fed with a square wave.

opamp LF347 (A1-A4). A TL074 works just as well.

The circuit will work powered by just one 9V battery and if you live in 'digital LS country' and do not venture into industrial electronics or radio, one of the 216 (or PP3) 9-volters is sufficient. I prefer to have two 9V batteries in series because this enables me to test 'high voltage' components — e.g., 12V and 15V regulators, crow-bar zeners and such like.

BUT BE WARNED: With an 18V supply and on its 'LOW' range, the SIGCHECKER can drive up to 17mA through the component under test which can damage some components!

In this description the circuit voltages are quoted for an 18V supply. If the supply is different, all other circuit voltages will be correspondingly different. When powered with 18V, the whole circuit uses 18mA with the test leads open and up to 35mA with the test leads shorted.

The batteries are shown at the left of Fig.1. S1 is the ON/OFF switch, while diode D1 prevents damage if the battery connection is accidentally reversed. R1 and R2 derive a mid-supply bias line of 9V.

For simplicity of board layout, the matrix board and the PC version do not have the FET input quad amp A connected in the same way. Where the con-

nections are different, the pin numbers in the matrix version are shown in brackets.

A1, the first section of A is the basic square wave oscillator whose frequency is set at about 7kHz by R5 and C1. The voltage across C1 ramps up and down between 6V and 12V as determined by the hysteresis produced by positive feedback resistors R3 and R4.

The square wave from A1 is the test waveform, applied via the source resistors R8 and R11 and through the test leads K and L to the circuits under test. The range switch S2 changes the source resistance of the test waveform. S2 is shown as a DPDT switch because this is the most commonly available.

Only one side is used, making it a DPST type. With the switch in the LO position, the contacts are closed and the source resistance in each lead is 1k. In the HI position, the contacts are open and the 47k resistors R9, R10 are added in series with R8, R9 respectively. The test leads K and L must be screened in order to keep their capacitances to ground constant during testing.

A2 is a unity gain inverter whose output is applied to the circuits under test via the 'common' leads P and Q. With one circuit under test connected between P and K, and the other between Q and L, both circuits are tested with a positive polarity during one half cycle of the square wave and with a negative polarity during the other half cycle. This ensures that diodes are properly checked in both directions.

The signature waveforms appearing at the terminals K and L are compared in the differential input op-amp A3. The need for adjusting input offset is eliminated by AC coupling of the signal with C2 and C3 and restoring the DC operating point to mid-supply with R13. The coupling and DC restoration circuits are such that the output of A3 is at 9V when there is no difference between K and L, and deviates from the 9V level whenever there is a difference.

These deviations are AC coupled via C4 to A4, which forms a 'precision AC to DC converter' with the diodes D2 and D3. The resulting rectified output deflects the 50uA meter. Resistors R16 and R17 set the gain of the converter and thus control the sensitivity of the indication. The meter reading is always positive regardless of the polarity of the deviation at the output of A3.

For a long time I have been trying to design an instrument in which all the resistors are of the same value. The SIGCHECKER is probably the closest yet: it uses 10 x 47k, 4 x 1k and three others. Has anyone done better?

Unfortunately, there are some less elegant aspects of the design. The two test leads K and L must be screened and the screens must be connected to battery negative. If these leads are not screened, the stray capacitance between the sensing wire and nearby objects (e.g. one's hands) can vary and give quite false indication

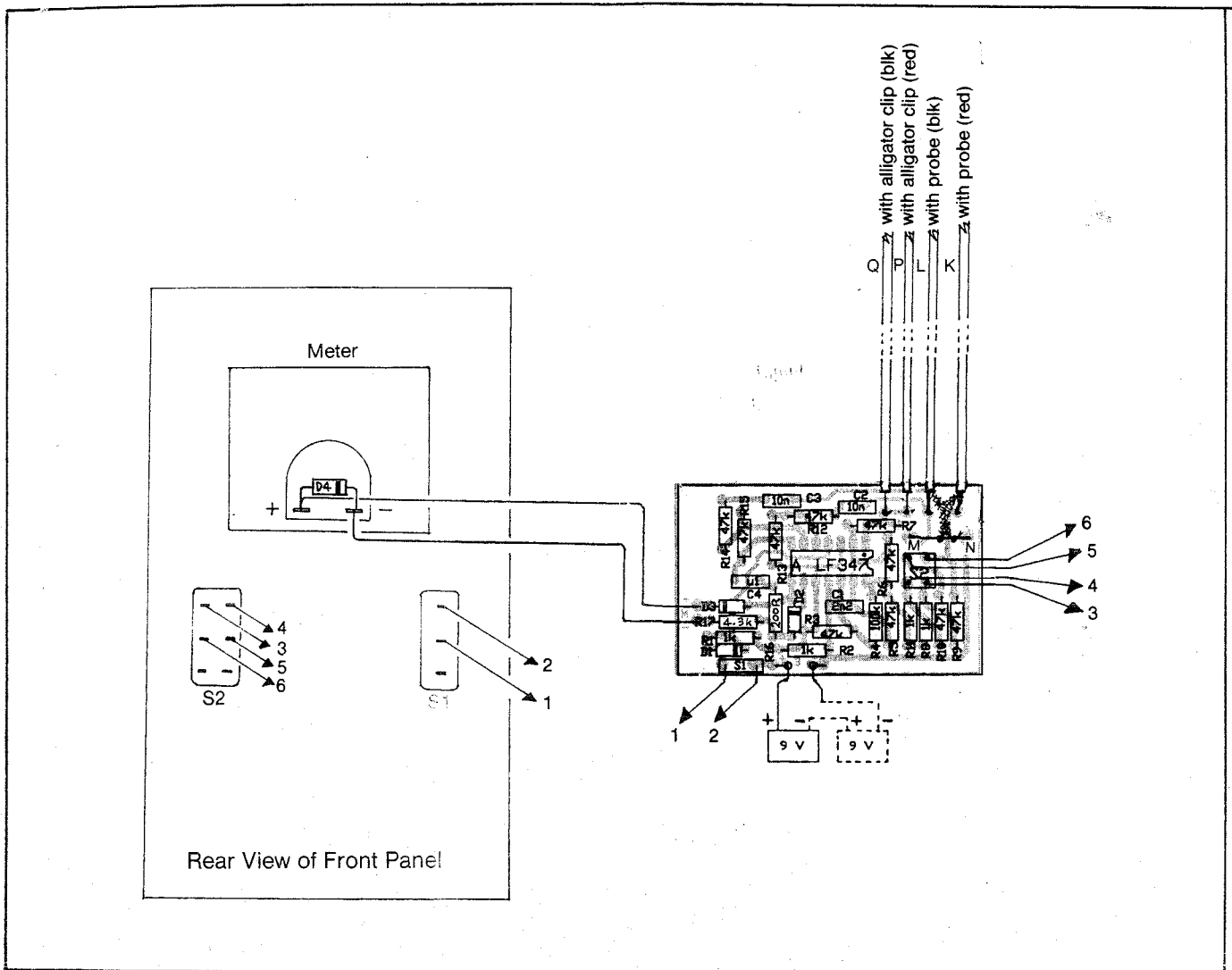


Fig.3. An overlay/wiring diagram for the Sigchecker, showing where everything goes both on and off the board. Note that the wiring connections for the test leads are made from the copper side of the board.

PARTS LIST

Resistors (All 1/4 watt)

- 10 47k 1% m/film (yel-vio-blk-red)
- 1 4.3k 1% m/film (yel-org-blk-brn)
- 4 1k 1% m/film (brn-blk-blk-brn)
- 1 200R 1% m/film (red-blk-blk-blk)
- 1 15k 1/5% (brn-grn-org) - for testing only
- 1 100k 5% (brn-blk-yel)
- 2 8.2k 5% (gry-red-red) - for testing only

Capacitors

- 1 0.1uF/100n/104k MKT polyester
- 2 0.01uF/10n/103k MKT polyester
- 1 0.0022uF/2n2/222k MKT polyester

Semiconductors

- 1 LF347/TL074 quad op amp
- 4 1N914/1N4148 silicon diodes

Miscellaneous

- 1 zippy box 41 x 68 x 130mm
- 1 pre-punched silk screened front panel
- 1 PCB, coded ZA1332
- 1 signal meter 250uA
- 1 min. toggle switch DPST
- 1 min. toggle switch SPST
- 2 battery snaps; 2 alligator clips (red & black); test lead set; length of shielded cable; hookup wire and solder.

on the meter. The two leads should be roughly of the same length and made from the same type of cable. The lower the cable capacitance, the better the checker will be at finding small capacitors that have gone open. The two 'common' leads P and Q need not be screened.

A further requirement is that the gains of the two channels in the checker be identical. The eight resistors R8 through R15 must be either within 1% of the nominal value, or they must be in matched pairs, each pair being matched within 1%. If the pairs are not closely matched, the checker might indicate a discrepancy between test objects when there is none, or vice-versa. The pairs to be matched are: R8 with R11, R9 with R10, R12 with R14, R13 with R15. 1% metal film resistors are supplied with this kit so you can forget all about matching them.

I have found that two ranges of source impedance for the excitation signal are adequate. I live on the humid Central Queensland coast where even 'insulators' might not exceed 10M, so any sensible resistor stays below two megohms.

Resistors lower than 100 ohms normally do not break down, and if they do, the burnt remains are quite obvious to the naked eye.

So the SIGCHECKER is intended for comparing circuits in the range between 100 ohms and one megohm. If you need a bigger range, you will have to fit another pair of source resistors to the circuit and a three-way range switch.

The source resistors are 47k (R9 and R10) for the high impedance range, and 1k (R8 and R11) for the low one. Most 'electronic' circuits can be tested on the high range with both poles of the range switch S1 open. Automotive, power and light circuits need the low range.

Construction

The SIGCHECKER circuit is built on a PC board coded ZA1332. The board fits in the slots of a DSE zippy box size UB3 (see photo).

The moving coil meter used in the SIGCHECKER is calibrated 0-250uA. This is meaningless when comparing unknown components. The purists among us should take the cover off the meter and paint the scale green from zero to '4' and the red above '4' may help later when you are explaining to lay friends what the SIGCHECKER is for.

The meter and switches are mounted on the front panel. This is supplied pre-drilled and silk screened making con-

struction easier. The meter is glued to the front panel.

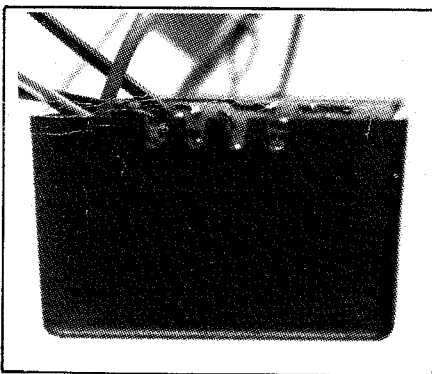
Assembling the components on the printed circuit board needs no explanation, follow Fig.3 carefully.

The test leads should be long enough to reach the job but no longer, we suggest about 500mm long. The longer the leads, the greater their capacitance and the poorer the SIGCHECKER's ability to detect faults in small capacitors. We have supplied a set of test leads with banana plugs at one end and the test probes at the other, to be used for one set of connections and a length of shielded cable for the other set of connections.

Before we begin to wire up the test lead we will need to remove the test probes and banana plugs from the leads supplied.

Cut the red and black wires, plus also the shielded cable to 500mm lengths. Solder these leads to the PCB, with the black lead going to point 'Q' and the red lead to point 'P' as shown in Fig.3. Then solder the lengths of shielded cable to the points marked K and L, with the shield screen wires solder to the points marked M and N. Note all these connections are made to the track (copper) side of the PCB.

The lead finally leaves the box through four notches filed in the edge of the board (see photo).



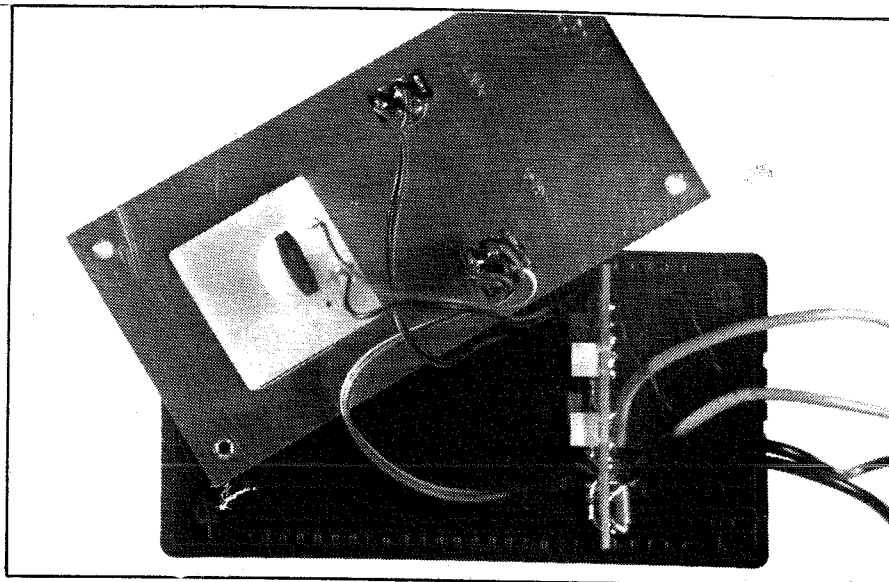
The notches in the box should be of a tight fit on the four leads.

The two 'common' leads P and Q should have small alligator clips fitted to their business end. The two screened leads K and L should be fitted out with the test probes. The shield screens from these leads are not part of the measuring circuit and should be trimmed off and left unconnected at the probe ends.

Mount the PCB into the case as shown in the photo. If the PCB interferes with the front panel you will be required to file the edge's until this is no longer a problem. Also before mounting the battery, place a piece of cardboard between PCB track (copper) side and battery. This will prevent any shorts from the battery case. If using two batteries the second battery is placed on the top side of the PCB. To prevent the second battery from moving place some foam packaging inside.

Firing it up

When all wires and components are in



A shot inside the prototype, showing where everything goes. The meter is held inside the front panel by some glue.

place and soldered up, you are ready to apply power. If you have a regulated power supply you should set its current limit to about 50mA, its voltage to 18, connect the SIGCHECKER and switch on. If you do not have a power supply, connect the battery (9 or 18 volts), switch on and keep fingers crossed.

You are unlikely to see smoke leaking out of the wires, but you may still be in trouble. Hopefully the meter will show a small deflection (between 0 and 2). If it does, try connecting a 8.2k (range switch in Hi position) resistor to one pair of test leads (P and K). The meter should move rapidly to full scale.

Then connect another 8.2k resistor to the other pair of test leads (Q and L). The meter should return to a small reading. Now shunt one of the resistors with a 15 k resistor. The meter should again speed to full scale. If all these checks work out OK, you have a good SIGCHECKER and can go troubleshooting Commodore 64's, Playmasters, Epsos and the like.

However, a large proportion of well proven circuits that I and other people build don't work when we first power them up. If this happens, remember the rule about the circuit you think you have and the circuit you do have. Then look again at Fig.1 and read the circuit description.

If you do not understand it, you need help from a Guru. If you understand it, then check volts at strategic points. If the voltage is not as expected, examine the components and connections around the sick point.

The first strategic test is to measure the voltage between pins 4 and 11 of the IC. It should be about the same as at the supply (across the battery). Then check that pin 3 is at half the supply voltage. If you have a CRO, check for square waves on the test leads. The waveforms on the 'common' leads should be in the opposite phase to those on the screened leads.

If you do not have a CRO you can use a multimeter. On DC volts ranges, the meter should read about half battery volts between battery negative and the 'common' leads and somewhat less between battery negative and the screened leads.

The same multimeter should read zero when connected between any two leads. Then check that pins 7 and 8 of the IC are at the same potential as pin 3.

Hopefully, all this checking of voltages will have located the trouble.

The small print

The SIGCHECKER is a good simple faultfinding aid, but it has some limitations. Firstly, it can only check the points in the circuit that are accessible to the probes. It cannot detect faulty locations in a ROM or RAM, or a bad register in a CPU chip. Fortunately, such internal faults are less common than the usual 'stuck pin' somewhere on the bus.

Secondly, it is not 'idiotproof'. If connected to equipment that is powered up, damage may result. When connecting the SIGCHECKER to any patients, always make sure that the patients are unpowered, i.e. disconnected from power supplies, and batteries.

Thirdly, some commonsense is needed when using the SIGCHECKER. The LO range is for testing large electros, transformers and low resistances.

It can pump 17mA through the circuit under test and some delicate semiconductors can be damaged by such high test currents. It is a good idea to keep the range switch always on the HI range, except when you know that a low impedance test is needed, e.g. when comparing microfarad capacitors and/or resistors below 1k (look for the multiplier band).

In much the same way as the CRO-based curve tracing testers, the SIGCHECKER cannot find all types of faults

on all types of circuits, but it is good for at least 80% of TV, stereo, computer and printer troubles. Its simplicity and low price make it a good tool for the busy troubleshooter.

Putting it to use

The SIGCHECKER is for comparing a faulty piece of equipment with a good one, point by point until the faulty node is located. At the faulty node the difference between signatures will be greatest. However, other nodes may also be mismatched and sometimes the decision whether a node is faulty or not is not a clear-cut one.

To look for faults, make sure that the two boards (or other circuits) to be compared are disconnected from power and batteries. Place them side by side, component side up and connect the 'common' test leads of the SIGCHECKER to what might be the 'ground' of the boards under

test. Usually this is a wide track with some big electrolytics on it.

Place the range switch at HI and turn the checker ON. The meter (scaled from 0 to 10) should read between zero and two. Select a starting point (e.g., a leg on an important looking chip or a high value resistor) on the 'good' board and press one of the probes to it. Note that the meter reads full scale as soon as contact is made. If it does not, you may have a faulty lead or a faulty 'common' connection somewhere.

Check and rectify. Then press the second probe to the corresponding point on the 'bad' board and note that the meter returns to a low reading. If it does not, you may have found the faulty component already, or there is a bad contact between the SIGCHECKER and the boards. Check and rectify.

A rule-of-thumb calibration is that full scale reading means a significant mis-

match, which is worth investigating (are all the test leads making contact?). A reading between '4' and full scale means that there is a mismatch, e.g. 5% difference in resistors or a 100pF capacitor missing in a 8.2k load.

A reading below '4' means either that there is a good match or that the circuit under test is 'out of range' of SIGCHECKER's source resistance. Points that have resistors of 1k and less connected to them should be checked on the LO range. All other points should be checked on the HI range.

That's about it. I trust you'll find your SIGCHECKER as useful as I've found the prototype.

Notes & Errata

STORE LOCATIONS:

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