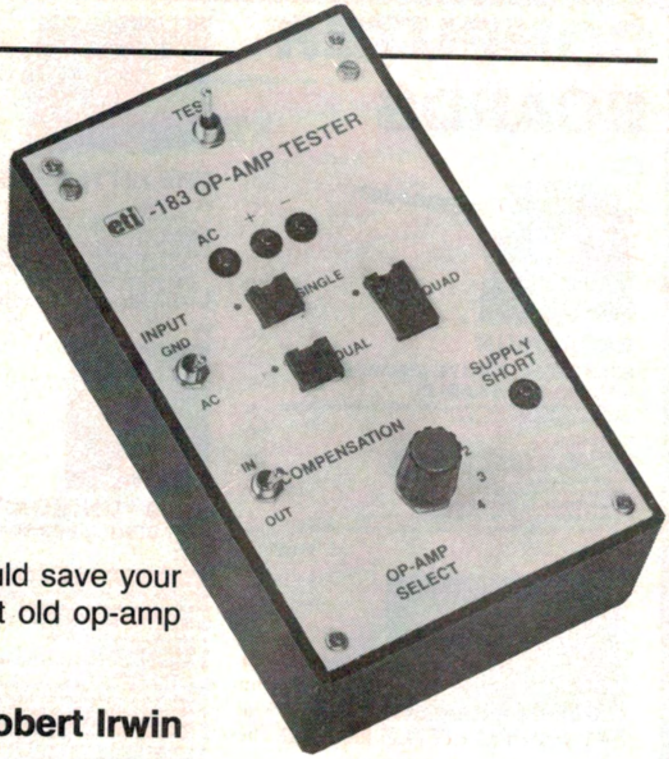
OP-AMP TESTER



The ETI-183 is a simple op-amp tester which could save your future projects hours in agonizing over using that old op-amp that's been lying in the drawer for the last year.

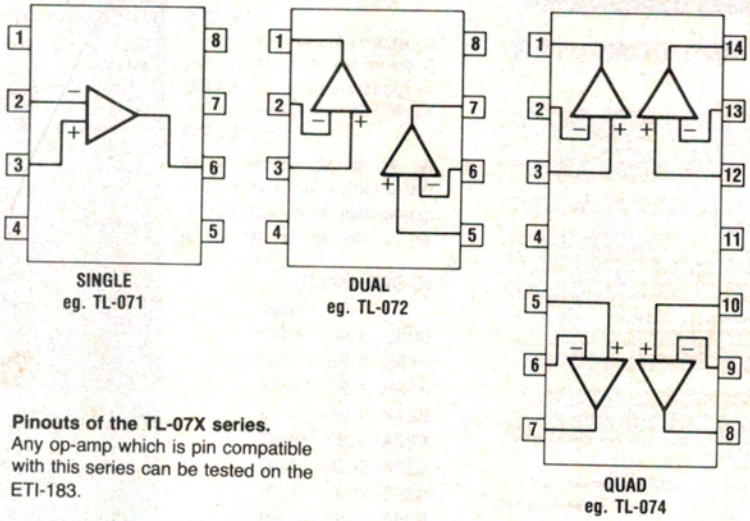
Robert Irwin

TEN YEARS AGO it was a must for anyone working in electronics to be equipped with some kind of device, (simple or hideously complex), that could test a transistor and determine its questionable state of health. The transistor tester is still a favourite workhorse but with the increase in the use of the op-amp as a basic building block it became essential for the analogue artisan to have a quick and easy means of checking ICs. This project is designed to be a simple stand-alone unit which will tell you, in terms of a few LEDs, whether your op-amp belongs in your next project or on the scrapheap with the vegetable peelings.

Design Details

The tester was designed to accommodate single, dual and quad packages with equivalent pinouts to those of the TL08x series. This includes most of the popular general purpose op-amps such as the μA741, LM301 and LF347. Three tests are provided on the tester. Firstly, an excessive power supply current indication tells you that there is a short circuit on the op-amp power supply pins. The other two tests find out whether the op-amp is, in fact, amplifying properly. For both of these tests the op-amp is configured as a non-inverting, dc amplifier with a gain of 20. A dc test can be performed which grounds the input of the op-amp and indicates any excessive dc offset on the output. If the output sits at one of the rails in this situation then it is probably deceased. To make sure the op-amp is in fact amplifying, a square wave is connected to the input. The output is monitored by a window comparator which turns on two LEDs to indicate that the signal is being amplified up to the correct level on both the positive and negative sides.

When dual or quad packages are being tested, each op-amp in the package is tested individually. The appropriate op-amp is selected by a four position rotary switch and the ac and dc tests are then applied to this op-amp only. For op-amps that require compensation, such as the LM301, a 10 pF capacitor can be switched in across pins 1 and 8. This is only necessary for single op-amp packages as all the dual and quad packages that can be used with this tester are internally compensated.



Pinouts of the TL-07X series.
Any op-amp which is pin compatible with this series can be tested on the ETI-183.

Construction

Construction should begin by carefully checking the pc board for broken or shorted tracks. If the pc board checks out OK then start soldering. The eight wire links should be located and soldered in first. These are made up of pieces of tinned copper wire cut to the appropriate length. Resistors and trimpot can go in next. Note that the resistors in the feedback circuit of the test op-amps are of 1% tolerance. Solder in the capacitors making sure that you get the polarity correct on the two electrolytics. The bipolar electrolytic has no polarity and can be put in either way round. The next step is to solder in the ICs, zeners and transistor. It is vitally important to get these components the right way round. If you wish you can use sockets with the ICs.

Now comes the hard bit! The prototype was mounted on the front panel of a jiffy box so the trick comes in getting all the LEDs, test sockets and switches the correct height. The four position rotary switch can be mounted and soldered in flush with the board. If you do not have a pc board mount type switch you will have to trim the pins on the back with a pair of side cutters so that they will fit through the holes.

Next mount the three wirewrap IC sockets that are to be used for the test ICs. The pins on these should all be the same length so mount the sockets to stand up off the pc board about 14 mm making sure that they are all the same height and level. They can be 'tacked' in by soldering just two pins on each socket rather than soldering all pins at this stage. This will make any height adjustments a lot easier.

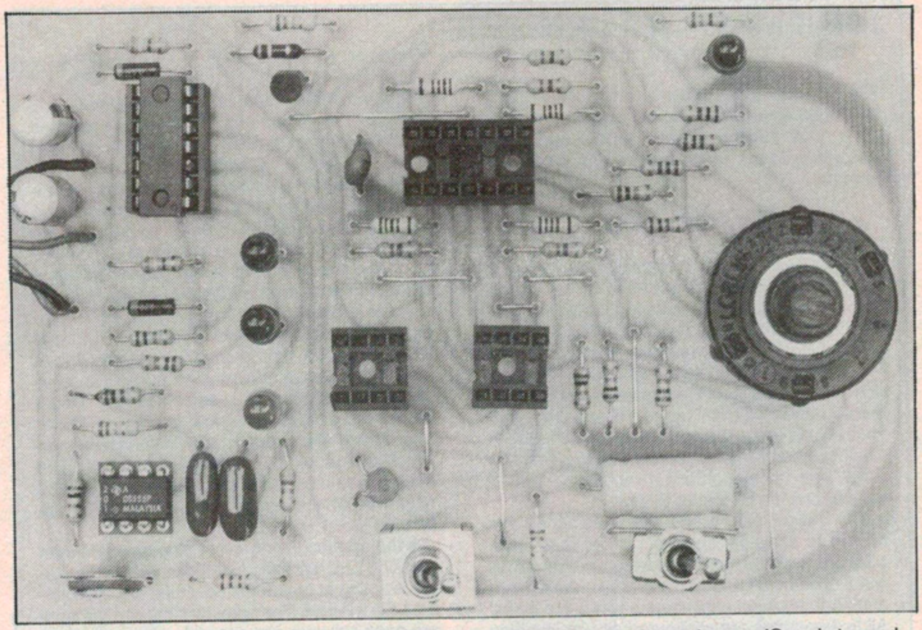
The INPUT and COMPENSATION toggle switches can be mounted in one of two ways. Small lengths of hookup wire (about 20 mm) can be attached to the lugs of the switches and then soldered into place on the pc board or the lengths of tinned copper wire (such as the type used for wire links) can be soldered on to the switch lugs to form 'legs' for the switch to stand on. If you use the latter method then do not, at this stage, solder the switches to the pc board but merely poke the wire legs through the holes on the board and leave them. The height can be adjusted when you mount the board and the switches soldered in then. The four LEDs should also be just pushed into the holes on the pc board and left, then soldered in later.

Finally, the battery terminals and power switch should be wired up with hookup wire according to the wiring diagram and overlay. Take careful note of the polarities of the terminals and leads. There has been provision made on the pc board for a BNC socket to allow a CRO to monitor the output from the DUT (Device Under Test). If you want this the socket should be wired in with hookup wire at this stage. This completes the pc board for now and you can turn your attention to the box.

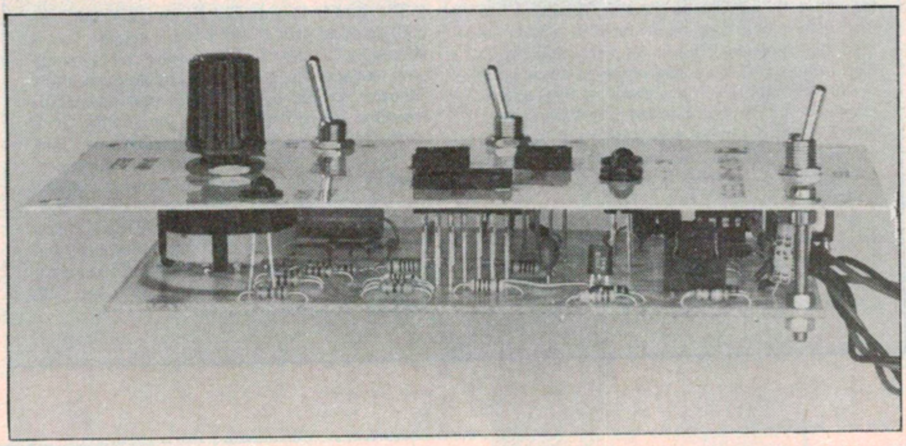
The prototype was housed in a 150 x 90 x 50 mm jiffy box. The pc board mounts on the aluminium lid. The front panel can be marked using the front panel artwork as a template. Mark the positions of all the holes to be drilled and the corner points of the three holes for the IC sockets. The holes for the LEDs and toggles can be drilled using a 6.5 mm drill and the hole for the rotary switch can be drilled using a 9.5 mm one.

Unless you have a suitable square punch set, the easiest way of cutting out the holes for the IC sockets is to drill a hole in the centre of each socket position and file it out to size with a small square file. Be careful not to file too big a hole. If you are including a BNC socket for a CRO output then a suitable hole should be drilled in the side of the box.

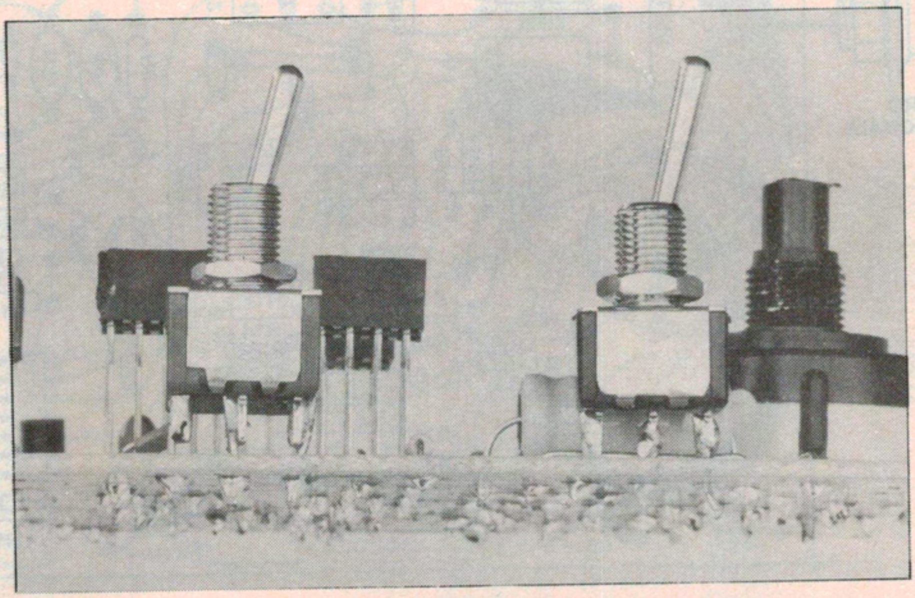
Once you have cut all the holes, do a trial fit to make sure everything lines up OK. Once everything fits, the Scotchcal front panel can be stuck on. If you have a blue on white plastic Scotchcal label it would be advisable to spray the aluminium front panel with white paint before applying the Scotchcal. When it is dry the Scotchcal can be carefully applied. Line it up accurately the first time because once it has stuck you'll have a hard time getting it off again. Trim out the holes in the Scotchcal with a sharp knife or scalpel but be careful not to tear it.



Top view of the pc board showing the position of components. Note the three wirewrap IC sockets used for the test op-amps.



How it all fits together. The board is mounted on the front panel by way of the rotary switch and two mounting bolts. The height of the LEDs should be adjusted after mounting of the board.



Mounting of the two toggle switches. Note the wire legs soldered to the switch lugs to enable them to be pc board-mounted.

HOW IT WORKS — ETI-183

The circuitry for the tester is fairly simple. IC1 is an LM555 timer which, in this case, is configured as a free running astable multivibrator. The frequency of the multivibrator is given by the formula:

$$f = 1.49/(R1+R2)C3.$$

With the values given this gives a frequency of approximately 1 kHz. The output of the LM555 forms the ac signal that is used to drive the DUT (Device Under Test). A green LED, LED1, is used to indicate an output from the LM555 with R7 limiting the current to about 4 mA. The output from the LM555 is divided down by the resistive divider network formed by R6, R8 and RV1. RV1 controls the level of signal being fed to the DUT. The input can be switched from ac to ground by SW2 and the appropriate op-amp input is selected by the B pole of SW3.

The device test sockets are wired up so that the single package, op-amp 1 of the dual package, and op-amp 1 of the quad package are all wired up in parallel. Op-amp 2 of the dual and op-amp 2 of the quad package are wired in parallel. All test op-amps are configured as non-inverting stages. The feedback network is the same for all op-amps and comprises a 100k feedback resistor with a 4k7 resistor to ground. Op-amp 1 has the addition of a 100p capacitor (C6) across the feedback resistor. This is for extra stability at high frequencies for some single op-amps such as the NE5534 which are prone to oscillations. Capacitor C7 can be switched in between pins 1 and 8 of the op-amp 1 test position to take into account op-amps such as the LM301 which need compensation between these pins for stable operation.

A 100R resistor is included on the output of each op-amp to provide some load isolation and enhance stability, and a 47k resistor is connected from each input to ground to provide a dc path to ground when the op-amp is not selected.

The appropriate output is selected by the C pole of SW3. The output from the op-amp is selected by the other pole of SW2 to be either dc coupled or ac coupled via C5 and R9.

The output is fed to the input of a window comparator formed by IC2a and IC2b. The positive input of IC2a is biased to 3.3 V by ZD1 and the negative input of IC2b is biased to −3.3 V by ZD2. The two spare inputs are connected to the output of the op-amp. When the voltage from the op-amp is between +3.3 and −3.3 V both comparator outputs are high therefore LED2 and LED3 are off. If the op-amp output goes above +3.3 V the output of IC2a swings low and turns on LED2. If the output goes below −3.3 V then the output of IC2b goes low turning on LED3. Therefore, if the output is a symmetrical squarewave, as it should be, each LED will be turned on and off in turn as the output swings positive and negative with the overall effect of both LEDs appearing lit.

If the op-amp is only amplifying one side then only one LED will light. In the dc mode, if the output is sitting at one of the rails then the appropriate LED will light. The outputs of the comparators are open collector and can sink a few milliamps. The current is limited by R12 and R13 to about 1.5 mA.

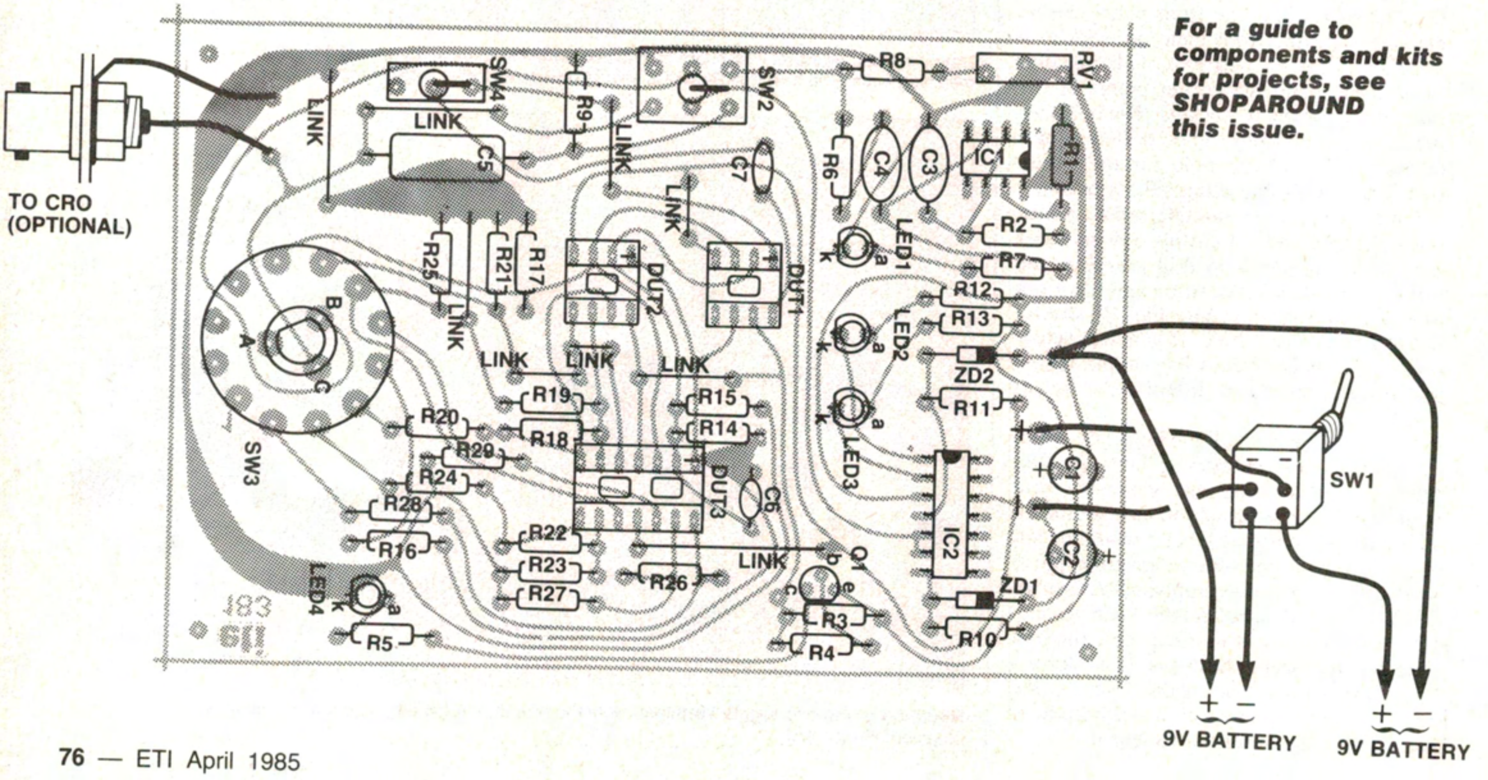
The power is supplied by two 9 V batteries connected to give a split 9-0-9 V supply. This is filtered by C1 and C2. The positive rail to the op-amp test sockets is monitored by an overcurrent indicator formed by Q1, LED4 and associated resistors. R3 is in series with the supply. Q1 is connected across this resistor in such a way that, as the current being drawn from the supply increases, the voltage across R3 increases. When this voltage reaches 0.6 V the transistor, Q1, starts to turn on which turns on LED4 indicating that excessive current is being drawn from the supply. This occurs at about 10 mA. To increase the current that can be drawn before the LED turns on simply decrease R3.

PARTS LIST — ETI-183

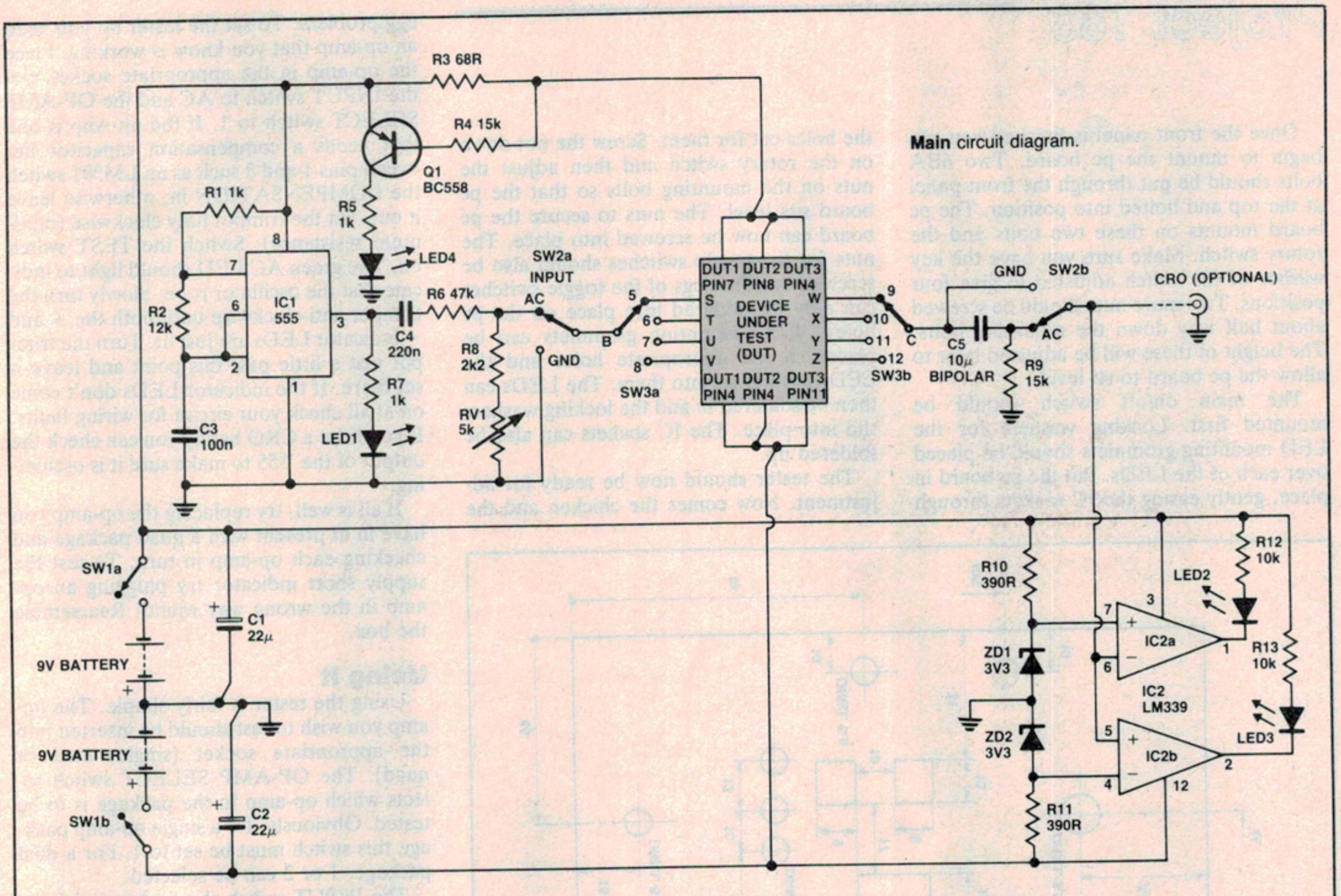
Resistors	all ¼ W 5% unless noted
R1, 5, 7	12k
R2	33k
R3	68R
R4,9	15k
R6	47k
R8	2k2
R10, 11	390R
R12, 13	10k
R14, 18, 22, 26	100k 1%
R15, 19, 23, 27	4k7 1%
R16, 20, 24, 28	100R
R17, 21, 25, 29	47k
RV1	5k trim.
Capacitors	
C1, 2	22µ 25 V RB electro.
C3	100n greencap
C4	220n greencap
C5	10µ 25 V bipolar electro. axial mount
C6	100p ceramic
C7	10p ceramic
Semiconductors	
IC1	LM555
IC2	LM339
ZD1, 2	3V3 400 mW zener
LED1	green 5 mm LED
LED2, 3, 4	red 5 mm LED
Q1	BC558 or similar
Miscellaneous	
SW1	DPST momentary action toggle
SW2	DPDT toggle
SW3	3 pole, four position rotary switch
SW4	SPDT toggle

ETI-183 pc board; 2 x 216 battery terminals; 2 x 8 pin wirewrap IC sockets; 14 pin wirewrap IC socket; 150 x 90 x 50 mm jiffy box; 2 x 6BA 25 mm bolts; 6 x 6BA nuts; 30 cm length tinned copper wire; 4 x LED mounting grommets and washers; hookup wire.

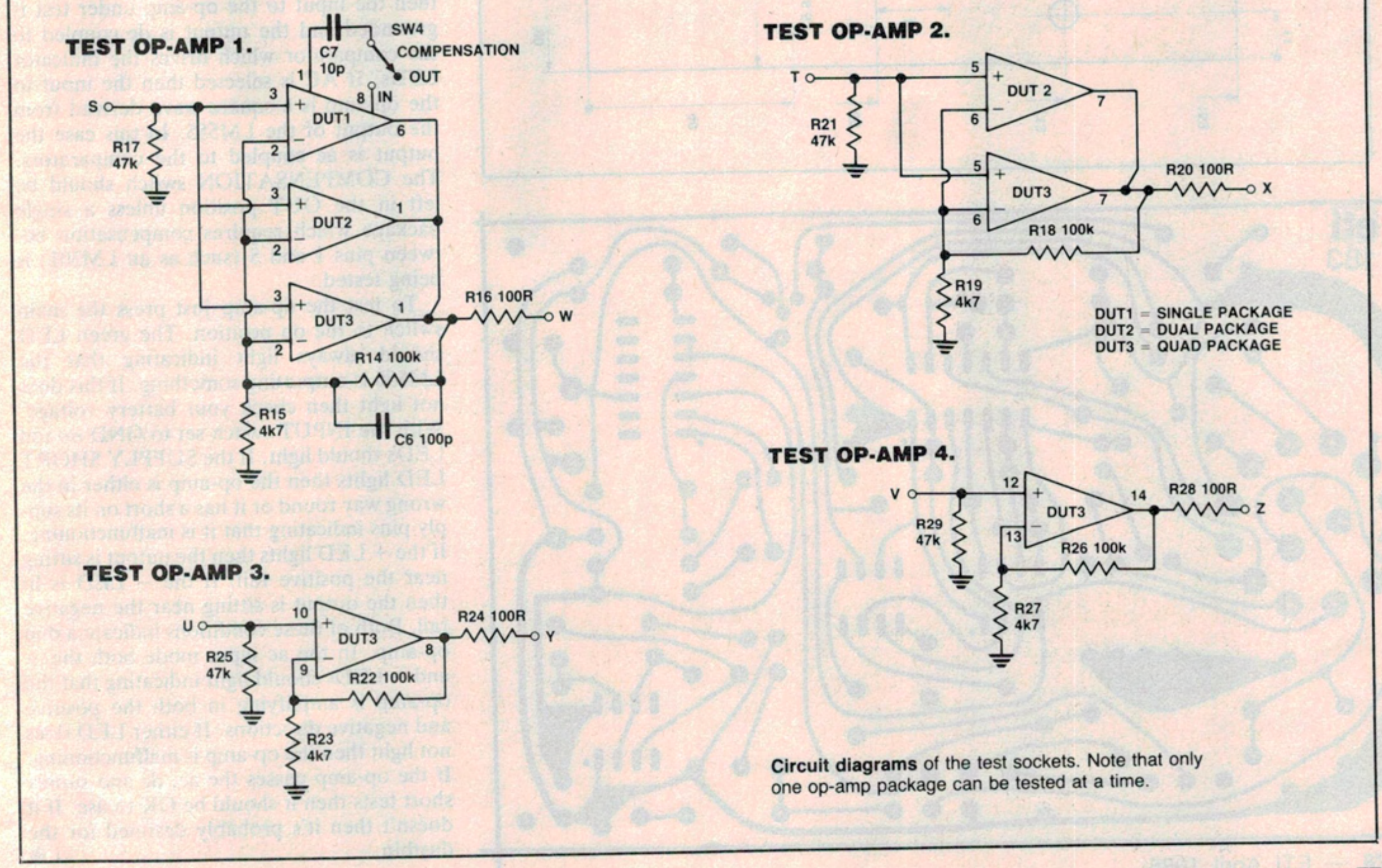
Estimated price: $25



For a guide to components and kits for projects, see SHOPAROUND this issue.



Main circuit diagram.



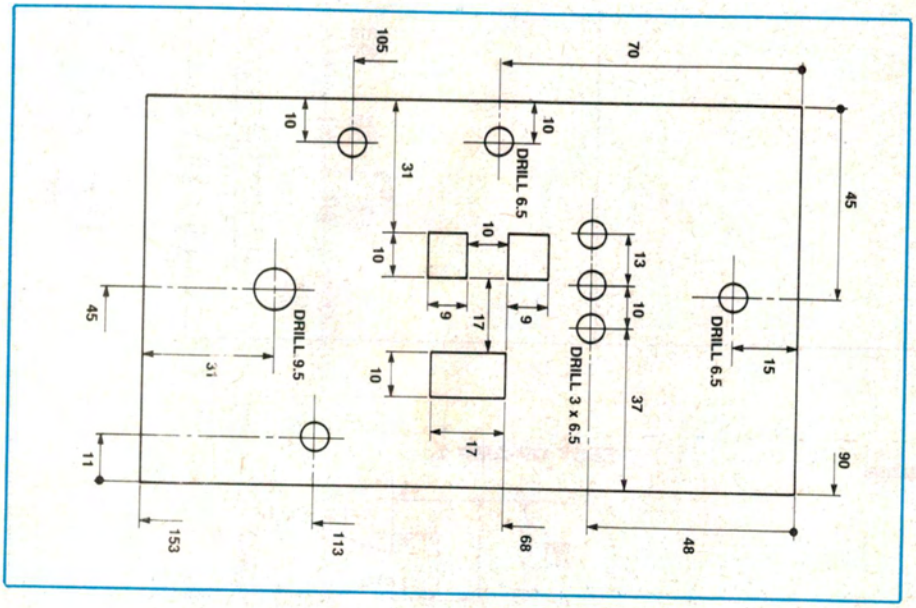
Circuit diagrams of the test sockets. Note that only one op-amp package can be tested at a time.

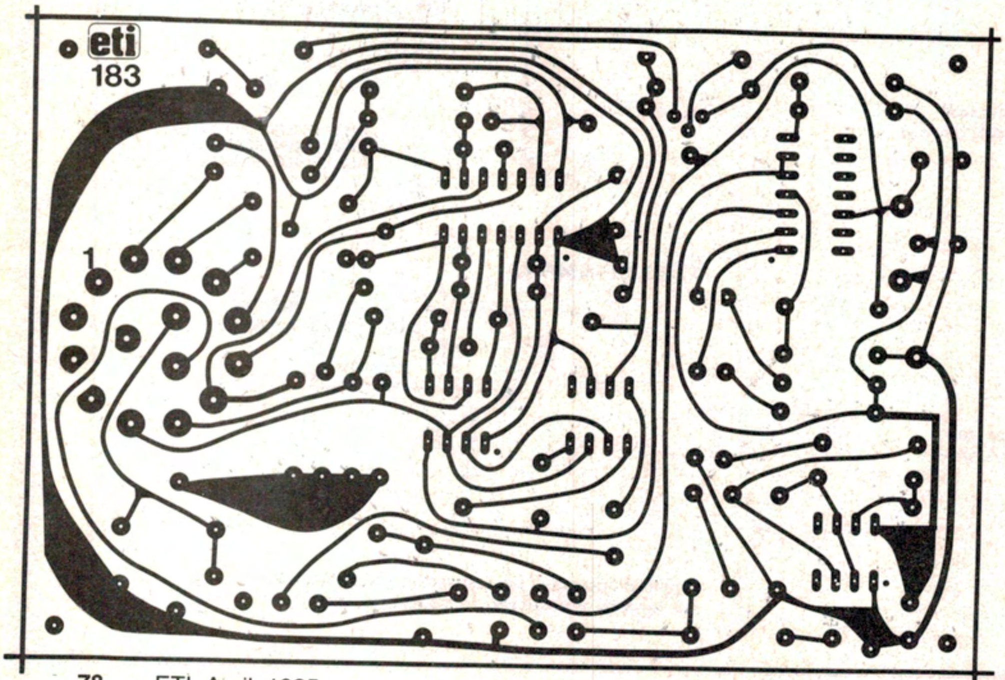
Once the front panel is finished you can begin to mount the pc board. Two 6BA bolts should be put through the front panel at the top and bolted into position. The pc board mounts on these two bolts and the rotary switch. Make sure you have the key washer of the switch adjusted to give four positions. Two more nuts should be screwed about half way down the mounting bolts. The height of these will be adjusted later to allow the pc board to sit level.

The main on/off switch should be mounted first. Locking washers for the LED mounting grommets should be placed over each of the LEDs. Put the pc board in place, gently easing the IC sockets through the holes cut for them. Screw the nut down on the rotary switch and then adjust the nuts on the mounting bolts so that the pc board sits level. The nuts to secure the pc board can now be screwed into place. The nuts for the toggle switches should also be screwed on. The legs of the toggle switches can now be soldered into place on the pc board. LED mounting grommets can be placed in the appropriate holes and the LEDs pushed up into them. The LEDs can then be soldered in and the locking washers slid into place. The IC sockets can also be soldered up.

The tester should now be ready for adjustment. Now comes the chicken and the egg problem. To set the tester up you need an op-amp that you know is working. Place the op-amp in the appropriate socket. Set the INPUT switch to AC and the OP-AMP SELECT switch to 1. If the op-amp is one that needs a compensation capacitor between pins 1 and 8 such as an LM301 switch the COMPENSATION in, otherwise leave it out. Set the trimpot fully clockwise (minimum resistance). Switch the TEST switch on. The green AC LED should light to indicate that the oscillator is on. Slowly turn the trimpot anti-clockwise until both the + and – indicator LEDs are just lit. Turn the trimpot just a little past this point and leave it set there. If the indicator LEDs don't come on at all check your circuit for wiring faults. If you have a CRO handy you can check the output of the '555 to make sure it is oscillating.

If all is well, try replacing the op-amp you have in at present with a quad package and checking each op-amp in turn. To test the supply short indicator try plugging an op-amp in the wrong way round! Reassemble the box.





Using it

Using the tester is fairly simple. The op-amp you wish to test should be inserted into the appropriate socket (single, dual or quad). The OP-AMP SELECT switch selects which op-amp in the package is to be tested. Obviously, for a single op-amp package this switch must be set to 1. For a dual package, 1 or 2 can be selected.

The INPUT switch should be set for the test you wish to perform. If GND is selected then the input to the op-amp under test is grounded and the output is dc coupled to the comparator which drives the indicator LEDs. If AC is selected then the input to the op-amp is a square wave derived from the output of the LM555. In this case the output is ac coupled to the comparators. The COMPENSATION switch should be left in the OUT position unless a single package which requires compensation between pins 1 and 8 (such as an LM301) is being tested.

To test the op-amp just press the main switch to the on position. The green LED should always light indicating that the LM555 is outputting something. If this does not light then check your battery voltage. With the INPUT switch set to GND *no* red LEDs should light. If the SUPPLY SHORT LED lights then the op-amp is either in the wrong way round or it has a short on its supply pins indicating that it is malfunctioning. If the + LED lights then the output is sitting near the positive rail. If the – LED is lit then the output is sitting near the negative rail. Both of these conditions indicate a dud op-amp. In the ac input mode both the + and – LEDs should light indicating that the op-amp is amplifying in both the positive and negative directions. If either LED does not light then the op-amp is malfunctioning. If the op-amp passes the ac, dc and supply short tests then it should be OK to use. If it doesn't then it's probably destined for the dustbin. ●