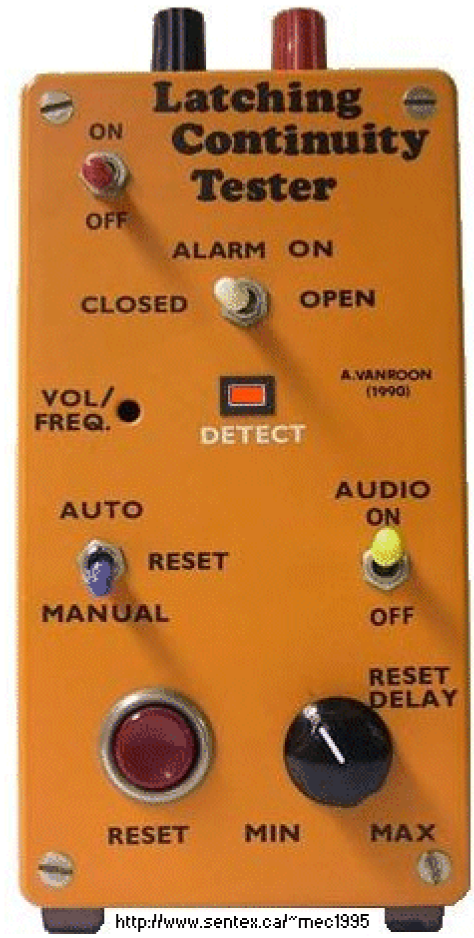
# Latching Continuity Tester

by Tony van Roon

***"This Latching Continuity Tester can help you locate those difficult-to-find intermittent short and opens that other testers always seem to miss. It has been part of my workbench for many years and performs superb. I have solved many intermittent problem with this highly flexible unit."***




A continuity tester is a must on every service bench for testing cables, pc-boards, switches, motors, plugs, jacks, relays, and many other kinds of components. But there are times when a simple continuity test (or your multi-meter) doesn't tell the whole story. For example, vibration-induced problems in automobile wiring can be extremely difficult to detect because a short or open is not maintained long enough for a non-latching tester to respond. And an analog meter is too slow to react.

This latching continuity tester detects intermittent (and steady state) opens and shorts. The tester will detect and latch on an intermittent condition with a duration of less than a millisecond. In addition, it provides both visual and (defeatable) audio indicators, uses only one inexpensive and easy-to-find IC, and can be built very cheap if you have a well-stocked junk box. For those who like 'kit' building, it is available.

## Circuit Elements:

The heart of the circuit is a 4093 quad two-input NAND Schmitt trigger, one gate of which is shown in Fig. 1-a. The gate functions as shown in Fig. 1-b. Nothing happens until the ***enable*** input goes high. When that happens, the output responds to the input as follows.

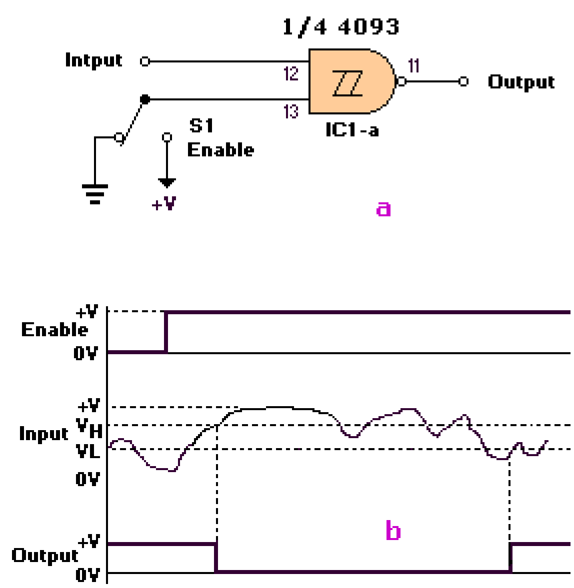



**Fig. 1 -- A Schmitt Trigger (a) is insensitive to input signals between $V_H$ and $V_L$ (b). The output changes state only when the enable input is high.**

As long as the input voltage stays between $V_H$ and $V_L$, the output stays high. But when the input goes above $V_H$, the output goes low. The output will not go high again until the input goes below $V_L$. That characteristic is what gives the Schmitt trigger its ability to "square-up" a slowly changing input signal. The Schmitt trigger is ideally suited for our application because it is not dependent on edge triggering, and because both slow and fast signals trigger it when either threshold is exceeded.

We use two gates of the 4093 as a combination detector and latch. The gates are cross connected to form an SR (***S***et-***R***eset) flip-flop. When pin 12 goes low, pin 11 will go high. That high may be used to enable an LED or other indicator. Switch S1 is used to select whether the tester will provide output when it detects an open or a short. In the ***OPEN*** position, pin 12 is held low, so the output of the gate is normally high. When the test leads are connected across a short, pin 12 is pulled high, so the output drops low. The circuit works in the converse manner when S1 is in the ***CLOSED*** position.

As shown in Fig. 2-a, we use another Schmitt trigger to build a gated astable oscillator. A gated astable oscillator produces output as long as the ***GATE*** input is high. Fig. 2-b shows the waveforms that are present at various points in the circuit. When the pin-8 input goes high, pin 10 goes low, and C1 starts

discharging through R1.
When $V_C$ falls below $V_L$, the output of the gate goes high, so C1 starts charging through R1. When $V_C$ exceeds $V_H$, the output again drops low. Oscillation continues in that way as long as the gate input remains high. The frequency of oscillation is given by a fairly complex equation that can be simplified, for purposes of approximation, as F = 1 / R1C1.

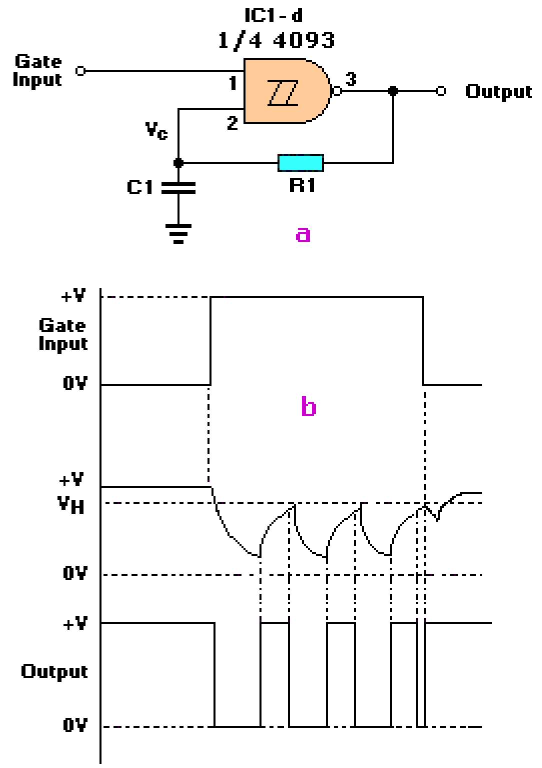
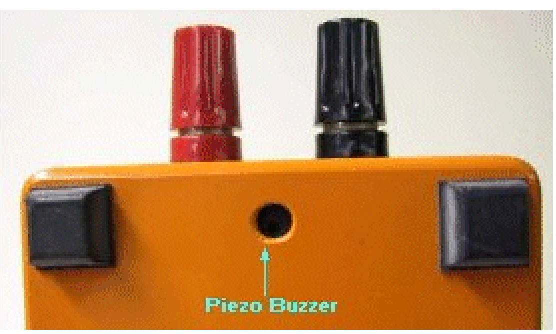



Fig. 2 -- An Astable Oscillator (a) may be built from a single gate, a resistor and a capacitor. The circuit oscillates at a frequency of about 1/R 1C1 whenever the gate input is high (b).

## Putting it all together:

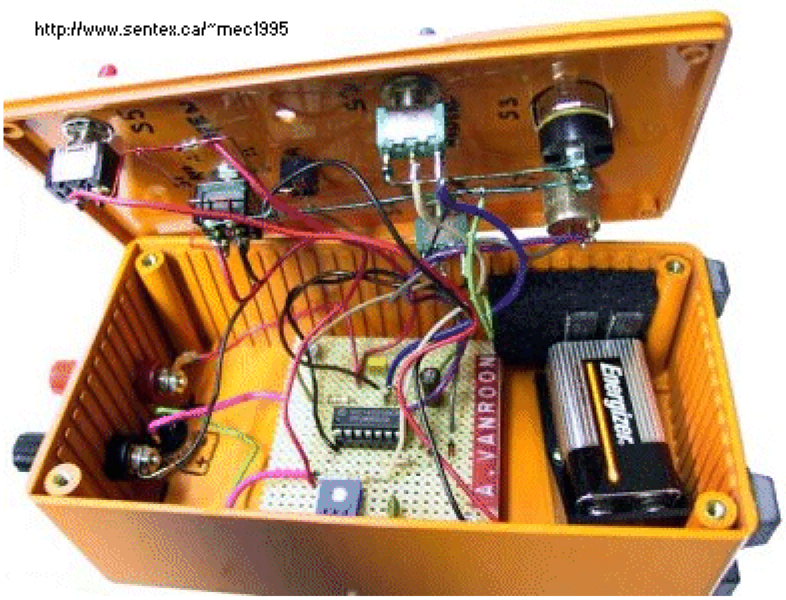
The complete circuit is shown in Fig. 3. In that circuit, IC1-a and IC1-b function as the flip-flop/detector. The output of IC1-a is routed through S4, ***AUDIO***. When that switch is closed, IC1-d is enabled and an audio tone will be output by BZ1. The frequency of that tone can vary from 1000Hz to well above the audio range (100KHz), according to the setting of R4. In addition, R4 varies frequency and volume simultaneously, so you can set it for the combination that pleases you best. Originally we used a PM (Permanent Magnet) speaker. When the detector has not been tripped, the full power-supply voltage is across the buzzer, but no current is drawn. The reason is that the piezo element is like a capacitor and does not conduct DC current. When the circuit is oscillating, the buzzer consumes a current of only about 0.5 milli-amp. The output of the flip-flop/detector circuit also drives IC1-c. If S2 is in the ***AUTO*** position, the output of IC1-c will automatically reset the flip-flop after a period of two to six seconds, depending on the position of R7. If S2 is in the ***MANUAL*** position, the LED will remain lit (and the buzzer will continue buzzing, if S4 is on) until manual ***RESET*** switch S3 is pressed




## Construction:

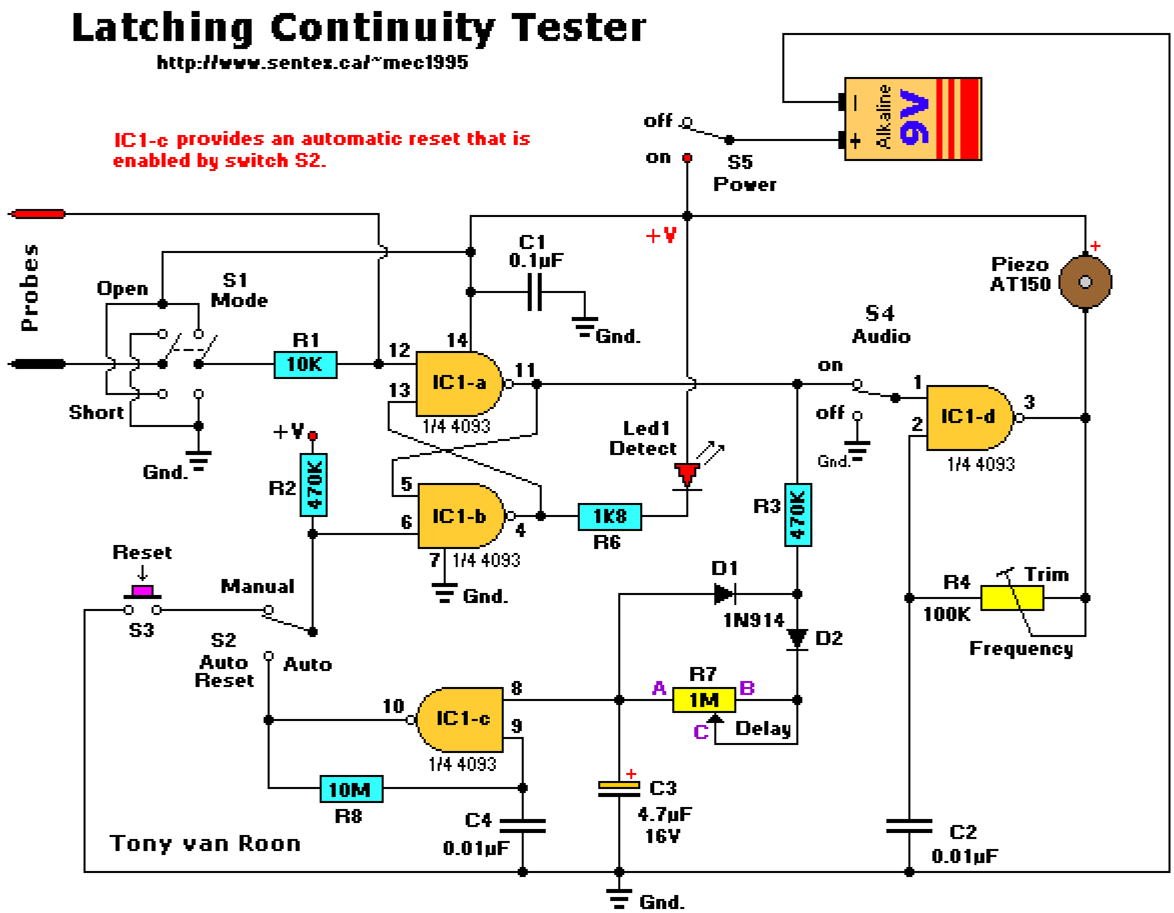
Picture at the left shows the tester from the back. The hole is for the piezo buzzer. The circuit may be built on a piece of perfboard or Vero-board, or on a PCB. The PCB is designed to take board-mounted switches, which makes a neat package and eliminates a rat's nest. (see prototype picture below).
Referring to Fig. 4, mount and solder the components in this order: diodes, fixed resistors, IC-sockets, capacitors, variable resistors, and then the pcb mounted switches. The regular ones will work too it just means more wire. Mount the buzzer and the LED last as described below. Trimmer potentiometer R7 is manufactured by Piher (903 Feehanville Drive, Mount Prospect, IL 60056); it has a shaft that extends through the panel. If the Piher pot is unavailable, an alternate is available from Digi-Key (701 Brooks Ave, South, P.O. Box 677, Thief River Falls, MN 56701). The disadvantage of the alternate is that it has no shaft, so it must be adjusted using a miniature screwdriver.

The circuit board can be mounted in several ways. Stand-offs, rubber feet, or simply two layers of double-sided foam tape works great! The LED and the buzzer should be inserted in the appropriate holes in the pcb now. Then install the top cover, and adjust the height of the LED so that it protrudes through the top cover. Then solder its leads. Mount the buzzer over the little hole either the front panel or the back using silicone rubber adhesive (RTV or double sided foam-tape-with-a-hole-in-the-middle).




We mounted a pair of banana jacks on the top of our prototype's case, but you could solder the wires directly to the appropriate points on the circuit board, tie strain reliefs on the wires, and then solder alligator clips to the ends of the wires. However, a set of good leads are really not all that expensive and it does give the tester more flexible usage as you have the opportunity to use a variety of different leads to suit your purpose.
The nine-volt (alkaline) battery is secured to the side of the case with a clip or use a holder. Your completed Printed Circuit Board should appear as shown in Fig. 5., or if you have a previous version of the pcb (8 and earlier) then see the layout at the bottom of this page.

**Usage Hints:**
Set S1 for ***short*** or ***open*** depending on the condition to be tested. Then connect the test leads across the circuit to be tested. If an intermittent condition is detected, the LED will illuminate, and the buzzer will sound (if S4 is on). If you don't remove the test leads (assuming if S2 is set for ***AUTO Reset***, the LED will flash (very fast)and audio will warble at a rate determined by the reset circuit. On a 'zero' ohm short the led will flicker, indicating a direct connection or short.
It is very important that the test leads make a positive connection with the circuit to be tested. In fact, clips should be used instead of test leads. There are good test leads available for about $15 which are hardened stainless-steel and have sharpened points which were my personal choice. This detector is so sensitive that, when it is initially connected across a long length of parallel wires or traces, it may latch due to capacitance between the wires. As a matter of fact, it happens with my model all the time. Just press the reset switch S3 (if in manual mode) when that occurs.




## [Parts List](#)

R1 = 10K
R2,R3 = 470K
R4 = 100K Trim-pot (Bourns 3386)
R5 = Not used (prototype)
R6 = 1.8K (1800 ohm)
*R7 = 1M Potmeter (Lin)
R8 = 10M
C1 = 0.1uF, ceramic
C2,C4 = 0.01uF ceramic
C3 = 4.7uF/16V, Elec.

IC1 = 4093B Quad Nand Schmitt Trigger
D1,D2 = 1N914, signal diodes
LED1 = Red, 5mm, High Brightness
BZ1 = Piezo Buzzer (PT-1550W) or AT-150
S1 = DPDT, miniature toggle
S2,S4,S5 = SPDT, miniature toggle
S3 = SPST, momentary push, normally open
Additionally: IC socket, case (4.75"x2.5"x1.5"), 9V battery clip, banana jacks, knob for R7, enclosure (Hammond 1591-D)

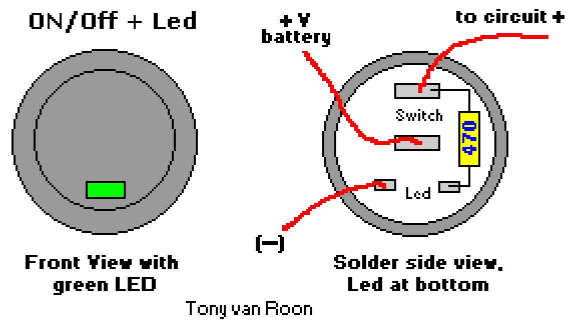
For the diagram and parts for the AT-121 piezo buzzer, check this circuit: [AT-121 Driver Circuit parts]

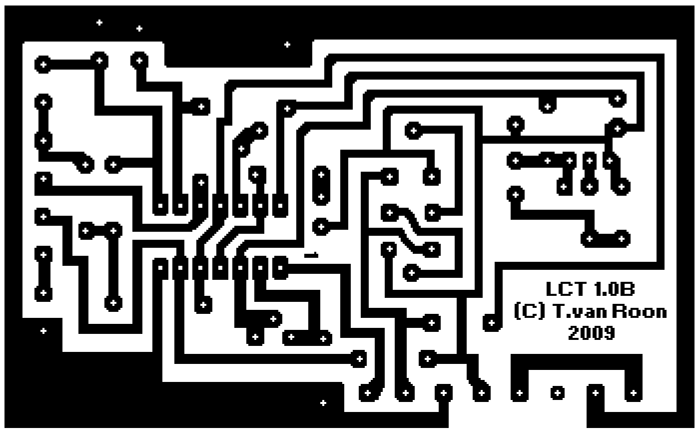
A complete KIT for this tester is available. [Click Here]

**Note: You can use any type, regular switch, and they are fine (and cheaper) just more soldering and more wires. On the other hand, you can customize the look like I did with the rocker switch/led, and the rectangular indicator Led.**

## Optional:

I used a rocker type on-off switch with led indicator (in my second unit), for a more professional look. The drawing below shows how to hook it up just in case you're starting out in electronics.


ON/Off + Led
+V battery
to circuit +
Switch
470
Led
(–)
Front View with green LED
Solder side view, Led at bottom
Tony van Roon


LCT 1.0B
(C) T.van Roon
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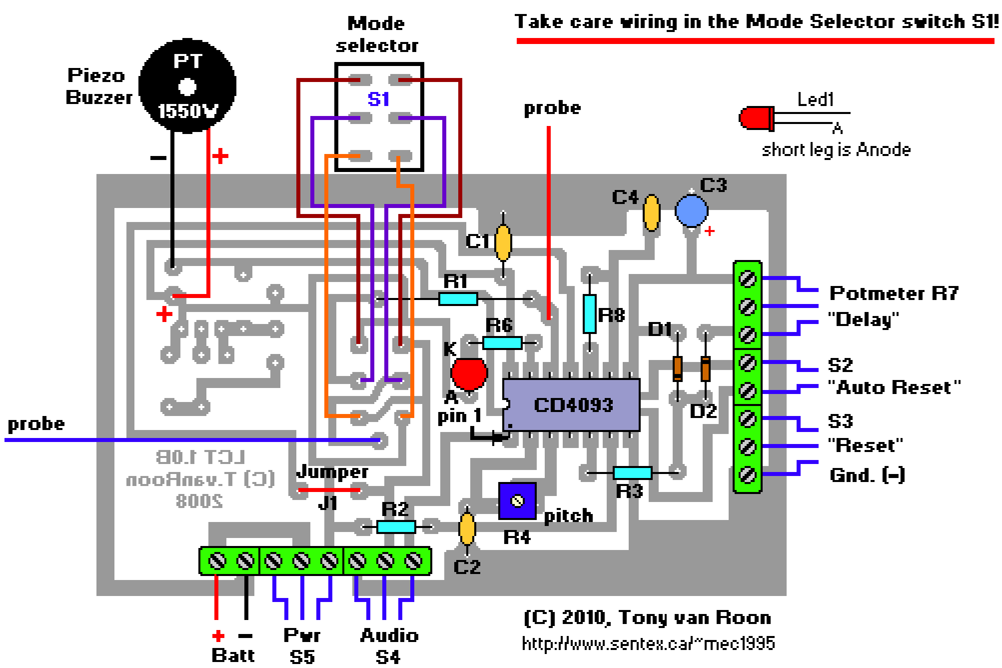
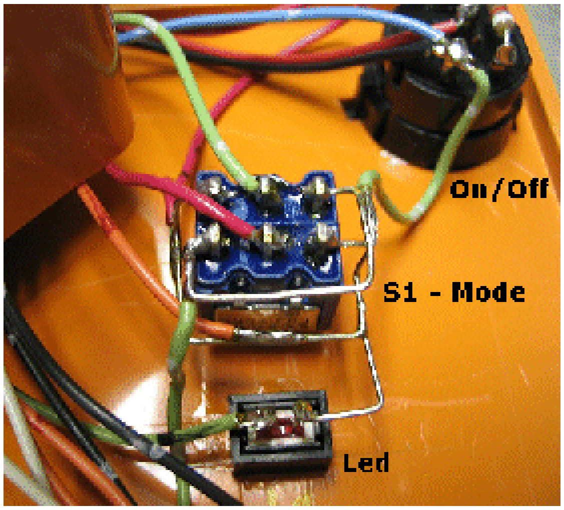
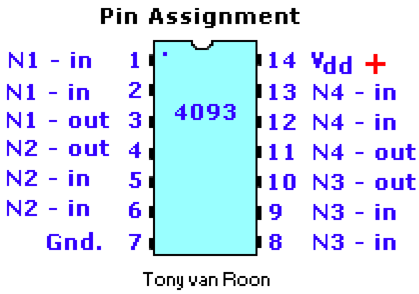

Mode selector
Take care wiring in the Mode Selector switch S1!
Piezo Buzzer
PT
1550V
S1
probe
Led1
A
short leg is Anode
C4
C3
C1
R1
R8
R6
D1
K
A
pin 1
CD4093
D2
Potmeter R7
"Delay"
S2
"Auto Reset"
S3
"Reset"
Gnd. (–)
probe
Jumper
J1
R2
pitch
R3
R4
C2
+ –
Batt
Pwr
S5
Audio
S4
(C) 2010, Tony van Roon
http://www.sentex.ca/~mec1995




Above photo (left) is obsolete 7-20-2010 but shows how the mode switch S1 was wired up. Almost all problems send to me via email contained: ***"my tester doesn't work"*** and are related to faulty wiring of this switch. Pay some good attention to it!

All parts can be easily obtained via Digikey, Mouser, Newark, Radio Shack, or available here in the form of a building KIT. I'm fine-tuning this project at this time. There are a couple of extra holes on the pcb meant for the driver circuit. Ignore them if you ordered the kit with pcb version 9.0. When you're done soldering everything up check your wiring before connecting the battery. Especially with the switches (5) it is very easy to make a wiring error. Good luck and have fun building this most versatile project.