Mega328 LCR-T4 Tester - Power On condition, no device under test.

Mega328 Transistor Tester

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Tester Description:

The Mega328 Transistor Tester, model LCR-T4, comes as a fully assembled board, but without the wood block shown in the picture. The wood block just makes the unit more stable by giving it some weight. It is often sold with an acrylic case, or the case may be purchased separately.

The Tester will automatically detect NPN, PNP, and Field Effect Transistors (FET), diodes (including dual diode, zener diode and light emitting diode), triodes, thyristors, triacs, and SCRs, with automatic identification of the transistor pinout. It also tests resistors (including adjustable potentiometers), capacitors, and inductors.

Size:	2-7/8" long x 2-3/8" wide x 1-1/8" tall circuit board 4-3/8" long x 2-3/4" wide x 3/4" tall wood block
Type:	Transistor Tester
Inductor:	0.01mH - 20H
Capacitor:	25pF - 100,000uF
Capacitor ESR:	Of capacitors >0.1uF
Resistance:	0.1 ohm resolution, maximum 50M ohms

Features:

- Uses the Microchip Atmega328 surface mounted technology (SMT) chip.
- Uses a 128x64 liquid crystal display (LCD) with a green backlight.
- Automatically checks the component’s pins and displays them on the LCD.
- Automatic detection of NPN and PNP transistors, N-channel and P-channel MOSFETs, diodes, Zener diodes <4.5 Vdc, dual diodes and LEDs), triodes, thyristors, triacs, resistors, inductors, capacitors (including ESR).
- Measures adjustable potentiometers, if wiper not positioned at one end.
- Measures capacitor ESR of capacitors >0.1uF, with resolution of 0.01 ohms.
- Measures the rate of decline (Vloss) of Capacitors >5000pF (Q value).
- Can identify zener diodes whose reverse breakdown voltage is <4.5 Vdc.
- Measures bipolar transistor current amplification factor and base-emitter threshold voltage.
- Measures the reverse capacitance of a single diode.
- Measures the collector or emitter junction reverse capacitance of bipolar transistors.
- Measures the gate threshold voltage and gate capacitance of a MOSFET.
- In the transistor, the MOSFET protection diode's amplification factor and base can be sensed to determine the forward bias voltage of the emitter transistor.
- Uses a 9V battery; draws about 40mA current for green backlight; only draws 20nA when OFF.
- Automatic shutdown.

Operation:

Operation is simple, and there are no calibrations to be made.

The Transistor Tester has three Test Points (TP1, TP2, TP3) within the test socket and three pads for surface mount components. The Test Points in the test socket are arranged in the pattern displayed on the circuit board silk screen just above and possibly below the test socket. There are several different models of this board, and the test socket configuration varies with each model.

When testing two or three lead components, the leads must be placed between different test points, that is, place a component in the test socket such that each pin of the component is in a separate test point.

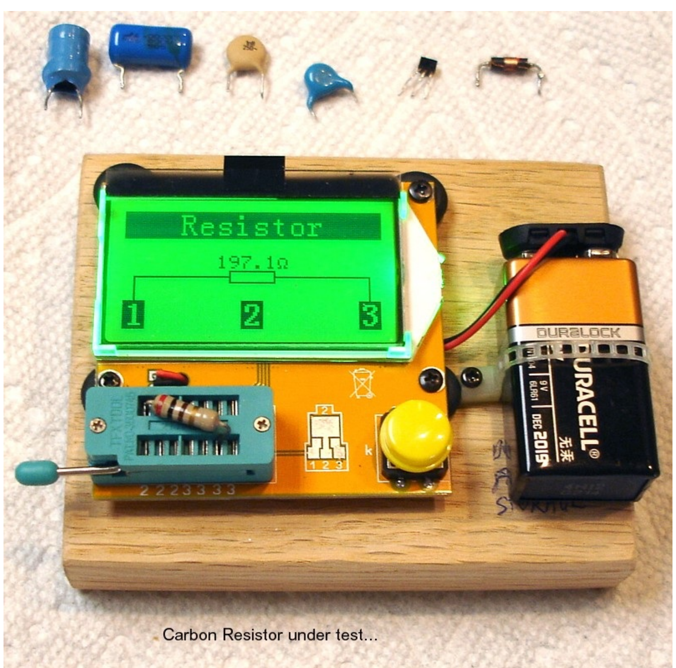
Push the button to turn the Tester ON. The Tester will sense the component and attempt to identify it. If it is successful, the Tester will display the component name, diagram and measured values for 30 seconds, as described later in this paper, then shut OFF. If unsuccessful, the tester will display a large question mark '?' and: "No, unknown or damaged part." for 30 seconds before shutting OFF.

You may change components while the results of the present test are being shown and press the button again to restart the test without waiting for the Tester to turn off.

Testing Procedures:

The Tester shows the model number and battery voltage with every start. There is no minimum voltage, the display just becomes dim and testing may become erratic. See the picture above for the start screen.

Note: Two resistors may be placed in series by using three test points and may be tested at the same time. This is great for finding and testing for a matched pair of resistors. However, this will not work with other two-lead components. For whatever reason, only one component is generally found or, such as testing an inductor and resistor at the same time, the Tester may report both as resistors. I believe this is because the Tester is programmed to recognize two resistances, such as a variable potentiometer, but not other combinations of discrete components.



Carbon Resistor under test...

Resistors:

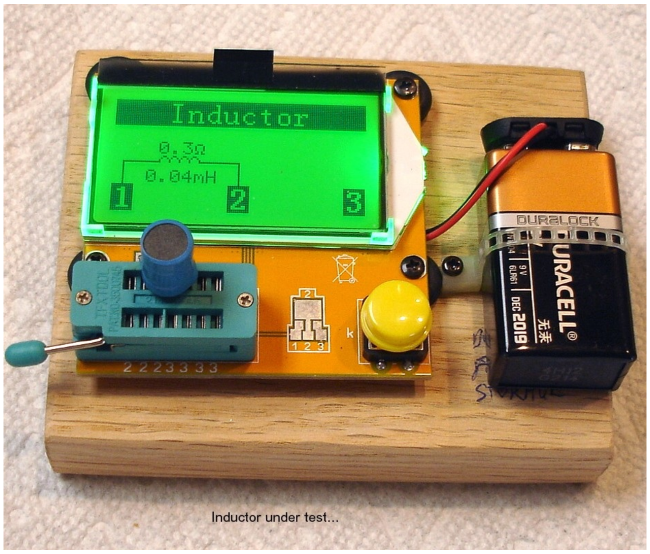
Insert a resistor between any two test points.

Note: If you try to measure small resistor values, you should keep the resistance of plug connectors and cables in mind. The quality and condition of plug connectors are important, also the resistance of cables used for measurement. So keep any cable leads short.

A diagram of the resistor between the two test points chosen and the resistance (0.1 ohm resolution, maximum 50M ohms) value will be shown.

Inductors:

To check coils, the normal measurement of the inductance is based on the measurement of the time constant of the current growth. The detection limit is about 0.01mH, if the resistance of the coil is below 24 ohms. For bigger resistance values, the resolution is only 0.1mH. If the resistance is above 2.1kohms, this technique can never be used to detect coils.



To test, insert an inductor between any two test points.

A diagram of the inductor between the two test points chosen, the resistance value and the inductance value (0.01mh - 20H) will be shown:

Note: Measurement resolution is only 10µH, so it is not possible to measure very small inductors.

Capacitors:

WARNING: Always be sure to discharge capacitors BEFORE connecting them to the Tester! The Tester may be damaged before you have switched the Tester ON. Likewise, use extreme caution when you try to test components mounted in a circuit. The equipment must be disconnected from power AND be sure NO residual voltage remains in the equipment.

What is Capacitor ESR?

Practical capacitors and inductors as used in electronic circuits are not ideal components with only capacitance or inductance. However, they can be treated, to a very good degree of approximation, as being ideal capacitors and inductors in series with a resistance. This resistance is defined as the Equivalent Series Resistance (ESR).

If not otherwise specified, the ESR is always an AC resistance [vague] measured at specified frequencies, 100 kHz for switched-mode power supply components, 120 Hz for linear power supply components, and at the self-resonant frequency for general application components. Audio components may report "Q factor", incorporating ESR among other things, at 1000 Hz.

In a non-electrolytic capacitor and electrolytic capacitors with solid electrolyte, the metallic resistance of the leads and electrodes and losses in the dielectric cause the ESR. Typically quoted values of ESR for ceramic capacitors are between 0.01 and 0.1 ohms. ESR of non-electrolytic capacitors tends to be fairly stable over time; for most purposes real non-electrolytic capacitors can be treated as ideal components.

Aluminum and tantalum electrolytic capacitors with non solid electrolyte have much higher ESR values, up to several ohms; electrolytic capacitors of higher capacitance have lower ESR. ESR decreases with frequency up to the capacitor's self-resonant frequency.

A very serious problem, particularly with aluminum electrolytic capacitors, is that ESR increases over time with use. ESR can increase enough to cause circuit malfunction and even component damage, although measured capacitance may remain within tolerance. While this happens with normal aging, high temperatures and large ripple current exacerbate the problem. In a circuit with significant ripple current, an increase in ESR will increase heat accumulation, thus accelerating aging.

Electrolytic capacitors rated for high-temperature operation and of higher quality than basic consumer-grade parts are less susceptible to becoming prematurely unusable due to ESR increase. A cheap electrolytic capacitor may be rated for a life of less than 1000 hours at 85°C (a year is 8760 hours). Higher-grade parts are typically rated at a few thousand hours at max-rated temperature, as can be seen from manufacturers' data sheets. If ESR is critical, specification of a part with higher temperature rating, "low ESR" or larger capacitance than is otherwise required may be advantageous. There is no standard for "low ESR" capacitor rating.

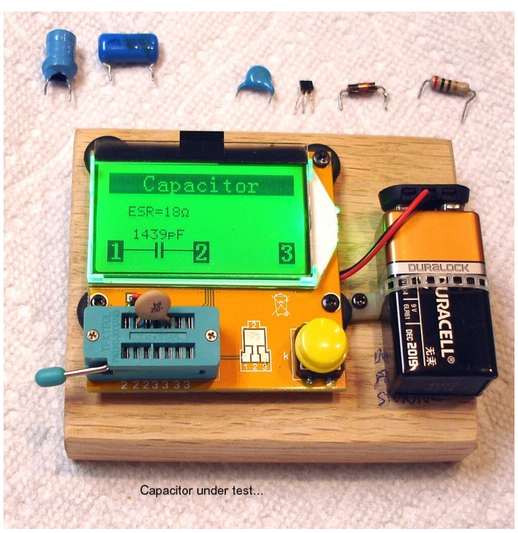
Polymer capacitors usually have lower ESR than wet-electrolytic capacitors of the same value, and stable under varying temperature. Therefore, polymer capacitors can handle higher ripple current. From about 2007 it became common for better-quality computer motherboards to use only polymer capacitors where wet electrolytic capacitors had been used previously.

The ESR of capacitors larger than about 1 µF is easily measured in-circuit with an ESR meter.

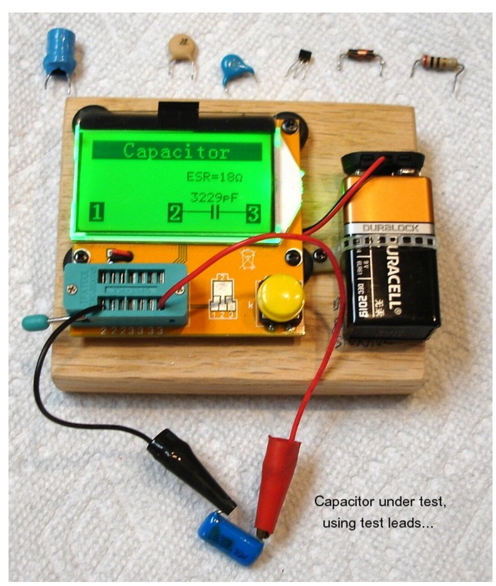
Typical values of ESR for various types of capacitors:

Type:	**22 µF**	**100 µF**	**470 µF**	**Freq. used**
Standard aluminum	7–30 Ω	2–7 Ω	0.13–1.5 Ω	120 Hz
Low-ESR aluminum	1–5 Ω	0.3–1.6 Ω		100 KHz
Solid aluminum	0.2–0.5 Ω			500 Hz
Sanyo OS-CON	0.04–0.07 Ω	0.03–0.06 Ω		100 KHz
Standard solid tantalum	1.1–2.5 Ω	0.9–1.5 Ω		100 KHz
Low-ESR tantalum	0.2–1 Ω	0.08–0.4 Ω		100 KHz
Wet-foil tantalum	2.5–3.5 Ω	1.8–3.9 Ω		not stated
Stacked-foil film	< 0.015 Ω			100 KHz
Ceramic	< 0.015 Ω			100 KHz

Warning: Always discharge ALL capacitors before placing them in the Tester. Any residual voltage could damage parts of the Tester!



Capacitor under test...



Capacitor under test, using test leads...

Note: As with small resistor values, you should keep the resistance of plug connectors and cables in mind when measuring the ESR value of capacitors. With a poor connection cable an ESR value of 0.02 can grow to 0.61 ohms.

For measuring capacitance, the Tester's capacitance values are computed from the time constant created by the serial connection of built-in resistors and capacitor during charging.

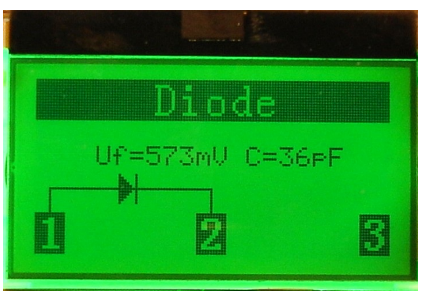
To test, insert a capacitor between any two test points.

A diagram of the capacitor between the two test points chosen, the capacitance (25pF - 100,000uF) value is shown. For electrolytic capacitors, Vloss value and an associated ESR resistance value may be shown.

Notes:

- Can only measure capacitance from 25pF-100mF, with 1pF resolution.
- This Tester often gives the capacitance value in nF, where 100nF = .1uF.
- For capacitors >.1uF, the Tester will also give the Equivalent Series Resistance (ESR). The ESR has a highest resolution of 0.01Ω.
- Capacitors >5000pF will also show the rate of decline (Vloss) after the charging voltage of the capacitor value to reflect the quality factor (Q value).
- If testing a <25pF capacitor, the test must include a 30pF capacitor. Test a 30pF capacitor, then test again after the other capacitor is connected in parallel. Subtract the measured value of the 30pF capacitor with the results obtained.

Diodes:

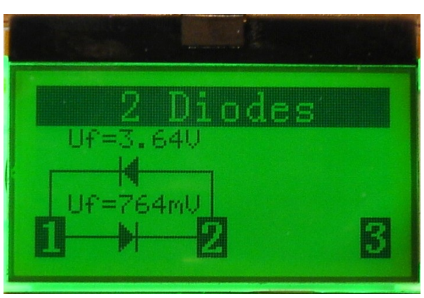


Insert a diode between any two test points. Polarity will not matter.

A diagram of the diode between the two test points chosen, the Uf value in mV and capacitance value in pF will be shown.

We will discuss Uf in a second. But, first I wanted to show the difference if the diode under test is a small Zener Diode. Look at the next picture...

Zener Diodes:



The testing procedure remains the same as a normal diode, which shows a Uf (forward voltage) of about 600-800mV. A zener diode can be detected **if** the reverse breakdown voltage is lower than about 4.5Vdc. It will appear as a double diode, with one direction showing the forward Uf of about 700mV, and the second in the opposite direction with a Uf equal to the **zener voltage** of the diode, in this case, 3.64Vdc.

Note: While two normal diodes may be measured in series, do **not** measure an ordinary diode and a zener diode simultaneously.

What is Uf?

This tester uses a value label foreign to me, but checking the web seems to show that Uf is actually Vf or the forward voltage drop of a diode from the anode to the cathode. This is used in relation to normal diodes, light emitting diodes or the diodes inside a transistor. Essentially it is the "on voltage", or the forward potential below which a diode will not conduct. A typical value for "normal" diodes is 0.7 volts; germanium and Schottky diodes will be lower.

Light Emitting Diodes:

Again, the testing procedure is the same as for a diode. Insert the LED between any two test points. Polarity will not matter.

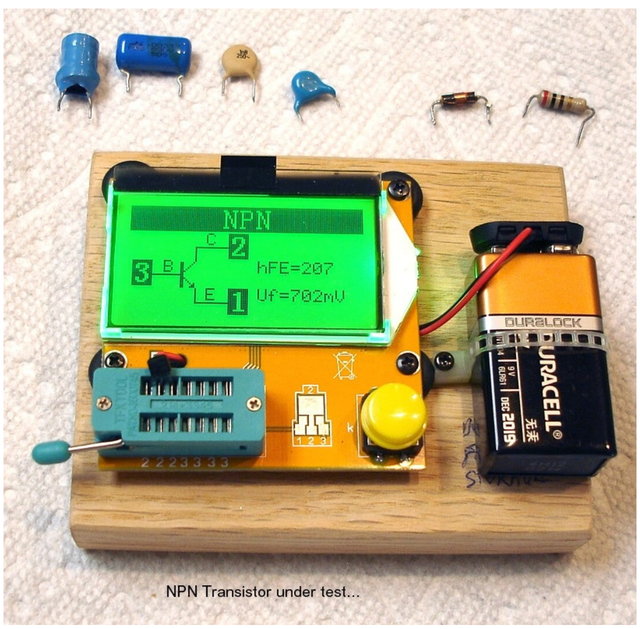
The Tester will cause the LED to flash a few times, then display the name Diode and the diagram of the diode between the two test points chosen, from which you may determine the LED anode and cathode, if necessary. The Uf (forward voltage) value in the range of 1-2Vdc and capacitance value in the range of 1-30pF will be shown.

If testing an infrared LED or others operating beyond the range of visible light, no flashing will be seen, but the diode symbol and normal values will be displayed.

If testing a bi-color LED, the LED should flash each color as the voltage is applied in each direction. The Tester will display the name 2 Diodes and will show the diagram of both diodes and the measured forward voltages, Uf, in both directions.

Transistors:

For normal measurement of the three pins of a PNP or NPN transistor, the pins can be connected in any order to the measurement inputs of the Transistor Tester.



NPN Transistor under test...

After pushing the start button, the Tester shows the type (NPN or PNP), a diagram of the transistor being tested with the pins identified and what test points they are attached to.

Finally, the current amplification factor ß or hFE and the forward voltage drop, Uf, by which the amplification factor is measured, are also shown.

Note: Later, similar, but more powerful transistor tester models with higher density screens are able to detect any integrated protecting diode of the collector - emitter path and are also able to show the collector current Ic, if the common emitter circuit is used for the hFE determination, or the emitter current Ie, if the common collector circuit is used for measuring the amplification factor.

What is hFE?

The hFE (which is also referred to as ß) of a transistor is the current gain or amplification factor of a transistor. It is the factor by which the base current is amplified to produce the amplified current of the transistor. The unamplified current is the base current, which then undergoes amplification by a factor of hFE to produce an amplified current which flows through the collector and emitter terminals.

A transistor works by feeding a current into the base of the transistor. The base current is then amplified by hFE to yield its amplified current. So if 1mA is fed into the base of a transistor and it has a hFE of 100, the collector current will be 100mA.

Every transistor has its own unique hFE. The hFE is normally seen to be a constant value, normally around 10 to 500, but it may change slightly with temperature and with changes in collector-to-emitter voltage.

Check the transistor's datasheet for the hFE value in its specifications.

Note that hFE may refer to DC or AC current gain. Many datasheets may just specify one value, such as the DC gain. The datasheets will normally specify whether the hFE value is for DC or AC current gain.

Also, note that as the hFE value is highly variable, many datasheets will specify a minimum and maximum hFE for the transistor. It is very hard for transistors to be produced with a precise hFE value during the manufacturing process. Therefore, manufacturers generally specify a range that hFE may be within.

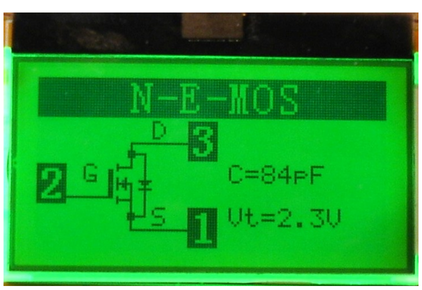
Because hFE is so widely variable and unpredictable in nature, good transistor circuit design is important to give stable, predictable amplification for transistor circuits to account for this unpredictability.

What is Uf?

As with the diode testing, Uf is actually Vf, and in this case is the forward voltage drop between the base and the emitter. For silicon transistors this is usually just below 700mV, while for some of the germanium transistors, Uf goes somewhere between 100mV and 200mV.

Let’s check out two other special transistors that I took pictures of...

What is the N-E-MOS?

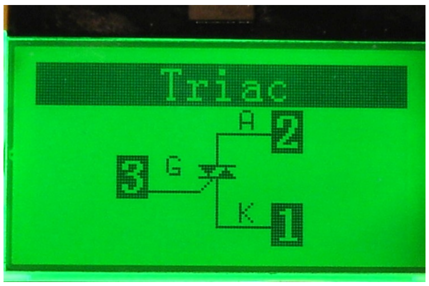


Well according to Wikipedia, the metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET), also known as the metal–oxide–silicon transistor (MOS transistor, or MOS), is a type of field-effect transistor that is fabricated by the controlled oxidation of a semiconductor, typically silicon. It has an insulated gate, whose voltage determines the conductivity of the device. This ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. The MOSFET is the basic building block of modern electronics.

A key advantage of a MOSFET is that it requires almost no input current to control the load current, when compared with bipolar transistors (bipolar junction transistors, or BJTs). In an enhancement mode (the E in the label) MOSFET, voltage applied to the gate terminal increases the conductivity of the device. In depletion mode transistors, voltage applied at the gate reduces the conductivity. MOSFETs are easily miniaturized, consume much less power, cheaper to make, and allow higher density, than bipolar transistors. Since MOSFETs can be made with either p-type or n-type semiconductors (PMOS or NMOS logic, respectively), complementary pairs of MOS transistors can be used to make switching circuits with very low power consumption, in the form of CMOS (complementary MOS) logic.

In addition to the diagram of the MOSFET, the Tester provides the capacitance and Vt, which is the threshold voltage at which current begins to flow.

What is the Triac, Thyrister and SCR?



TRIAC, from TRIode for Alternating Current, is a generic trademark for a three terminal electronic component that conducts current in either direction when triggered. Its formal name is bidirectional triode thyristor or bilateral triode thyristor. A thyristor is analogous to a relay in that a small voltage induced current can control a much larger voltage and current.

TRIACs are a subset of thyristors and are related to Silicon Controlled Rectifiers (SCRs). TRIACs differ from SCRs in that they allow current flow in both directions, whereas an SCR can only conduct current in a single direction.

The Triac's pins in the picture are A - anode, G - gate, and K - Cathode. Some minimum voltage at the gate causes the device to conduct current bidirectionally between the anode and cathode. This tester does not provide this minimum voltage.

Most TRIACs can be triggered by applying either a positive or negative voltage to the gate (an SCR requires a positive voltage). Once triggered, SCRs and TRIACs continue to conduct, even if the gate current ceases, until the main current drops below a certain level called the holding current.

Problem Semiconductors:

You should keep in mind by interpreting the measurement results, that the circuit of the Transistor Tester is designed for small signal semiconductors. In normal measurement condition the measurement current can only reach about 6mA. Power semiconductors often make trouble because of residual current with the identification and the measurement of junction capacity value.

The Tester often can not deliver enough ignition current or holding current for power Thyristors or Triacs. So a Thyristor can be detected as an NPN transistor or diode. Also it is possible, that a Thyristor or Triac is detected as unknown.

Another problem is the identification of semiconductors with integrated resistors. So the base - emitter diode of a BU508D transistor can not be detected by reason of the parallel connected internal resistor. Therefore, the transistor function cannot be tested either.

Power Darlington transistors also have a problem with detection because of internal base - emitter resistors, which make it difficult to identify the component with the undersized measurement current.

Disclaimer: As no manual could be found for this series of testers, the above information is from the Tester's listed specifications with operational description from later, similar models and personal experimentation. Please report any errors to the author by email at: z100lifeline@swvagts.com. Thank you.