



## GM328 Transistor Tester Operations Manual

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*Z-100 LifeLine*  
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### Tester Description:

The GM328 Transistor Tester is sold as a kit and requires some experience in soldering skills as three of the parts are small surface mounted devices. A soldering iron with a needle point tip would be very helpful here. I have seen some kits sold with the three surface mount parts already installed. The kit is often sold with an acrylic case, or the case may be purchased separately. Please see the separate document on GM328 Transistor Tester Assembly for assembly assistance. This manual will concentrate on Operational Procedures.

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. The Tester detects power transistors with FET protection diodes built in. It also tests resistors (including adjustable potentiometers), capacitors, and inductors.

This Tester can also generate a single square wave with 20 set frequencies from 1Hz to 2.0MHz, can measure frequencies from 1Hz to 2.9MHz with resolution to 0.001mHz, and can use an AC/DC power adapter (6.8-12Vdc, 30mA current).

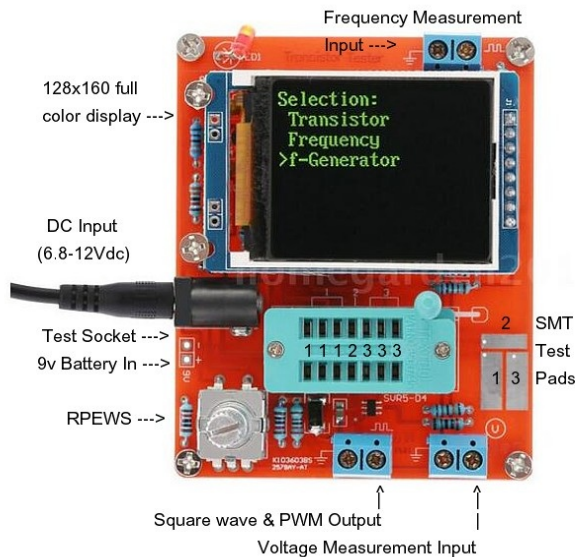
The Tester has amazing specifications in a small package:

Size:	3-1/8" long x 2-1/2" wide x 1-1/8" tall circuit board
Type:	Transistor Tester
Display:	128x160 pixel color display with backlight; 8x20 characters; 16-bit, 65k color
IC PROM:	Atmel Atmega328P 28-pin PROM DIP IC chip
Power:	9v battery or AC/DC power adapter (6.8-12Vdc, 30mA current)
Control:	Rotary Pulse Encoder With Switch (RPEWS); auto shutdown
Inductor:	Measures inductors, 0.01mH - 20H
Capacitor:	Measures capacitors, 25pF - 100,000uF
Capacitor ESR:	Displays ESR of capacitors >0.1uF
Resistance:	Measures resistors to 0.1 ohm resolution, maximum 50M ohms
Freq Counter:	1Hz to 2.9MHz (Megahertz), with resolution to 0.001mHz; Samples and reports the frequency every few seconds
Freq Generator:	Simple, single square wave at 20 set frequencies; From 1000mHz(1Hz) to maximum of 2000KHz(2.0MegaHertz).
PWM Generator:	Variable (1-99%) duty cycle pulse signal (10-bit PWM) at fixed 7812.5Hz frequency.

## Features:

- 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.
- Measures frequencies from 1Hz to 2.9MHz (Megahertz).
- Square wave generator for 20 set frequencies between 1Hz to 2MHz.
- PWM square wave generator with variable (1-99%) duty cycle pulse signal (10-bit PWM) at fixed 7812.5Hz frequency.

## Physical Layout of the Assembled Tester:



## Power:

The Transistor Tester requires power from 6.8V - 12Vdc. This can be from a 9V battery or an AC/DC power adapter. When the power is ON, the current is about 30mA at 9Vdc; after shutdown, it still draws about 20nA current.

The Tester will automatically switch OFF after a component test and no further action is performed by the user.

## Liquid Crystal Display (LCD):

The Tester uses an 1.77" (measured diagonally), 128x160 pixel Liquid Crystal Display (LCD). It is a general LCD Red-Green-Blue (RGB), 65k color display module with an embedded controller, similar to the popular ST7735S, and has a backlight. It interfaces to the Tester via an 8-pin connector.

Similar displays are used with the Arduino, Raspberry Pi, and STM32. However, this LCD module is NOT compatible with those generally for sale on Ebay! While the capabilities and specifications are identical, the 8-pin connector pinout is **NOT** the same.

## Liquid Crystal Display Specifications:

Size:	1.77" diagonal across the viewing area.
Display Type:	Thin-Film-Transistor (TFT) Liquid Crystal Display (LCD)
Display Format:	Graphic 128(RGB) x 160 dot matrix
Input Data:	4-wire SPI Serial Interface

Drive IC: ST7735S or similar  
 Backlight System: 2-LED White Color, 3.3Vdc maximum  
 Brightness: 80 nits (low compared to others)  
 Colors: 56k, 16-bit colors  
 Pixel Size: 0.219mm tall x 0.219mm wide  
 Character Size: 8 Rows by 20 Columns  
 LCD Active Area: 28mm (1.1") tall x 35mm (1.38") wide  
 Ports Required: Minimum of 4 IO ports  
 Operating Temp: -20 to +70 degrees Centigrade  
 Operating Voltage: +3 to +5.0Vdc  
 Pin Descriptions: (Best guess based on Vdc measurements)  
     Pin 1 Backlight control pin (3.3Vdc, for full bright)  
     Pin 2 RES, LCM Reset pin, when low, resets Ctrlr Chip  
     Pin 3 SDA, Serial Data Input  
     Pin 4 SCL, Serial Clock Pin  
     Pin 5 CS, Chip Select  
     Pin 6 DC, Data/Command Control  
     Pin 7 Vcc, +5.0Vdc  
     Pin 8 Ground

### Control:

The Transistor Tester is controlled by a "Rotary Pulse Encoder With Switch" (RPEWS), which supports four operations:

- Power on
- Short-press
- Press and hold (long-press)
- Left and right rotation

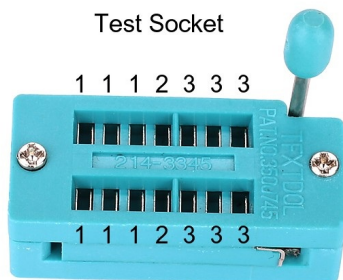
The Tester is turned ON with a short-press of the RPEWS. If a component to be tested is placed in the test socket, the Tester will sense the component and attempt to identify it. If it is successful, the results will be displayed on the screen, as described later in this paper. If unsuccessful, the user will be informed of such action before shutting OFF.

Following the component check, and before automatically shutting OFF, the unit will wait 15 seconds for user action. A long-press OR rotation of the RPEWS left or right will enter the Function Menu. In the Function Menu, a ">" in the left column indicates the present menu item selected. To select another function, rotate the RPEWS left or right and do a short-press on the function selected.

To exit a Function, press and hold (long-press) the RPEWS knob until you are returned to the Function Menu.

### Operation:

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 the test socket. The left six (3+3) belong to TP1, the middle two (1+1) belong to TP2, and the right six (3+3) belong to TP3.

To the right of the test socket are three test pads that can be used to test surface mount components.

**Note:** The numbers of the test pads on the silk screened board, if labeled at all, may NOT be numbered correctly. Please check them with an ohmmeter to match the pins of the Test Socket. Mine had to be labeled as shown in the above picture.

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.

**Note:** If TP1 and TP3 are selected, the Tester will enter a "series test mode", where repeat tests are done automatically. You may change components at any point in this series. Exit the series with a long-press of the RPEWS. The test may be started again with a short-press of the RPEWS.

### Self-test & Calibration:

**Note:** This Tester requires calibration before use.

The Self-test & Calibration can be started by either:

- Shorting all test points and turning the device ON
- Selecting it from the Function Menu

**Note:** To short the Test Points together, simply construct a small test component of three short lengths of wire, twisted and soldered together.

Upon sensing the shorted test pins, the Tester will prompt with *Selftest mode..?* and a RPEWS short-press (within 2 seconds) will direct the tester into self-test mode. The color of the Tester's LCD will change to white on a black background. If not short-pressed within 2 seconds, the Tester will resume normal measurement.

The Tester will sense the shorted probes and report:

```
Selftest mode..  
R0=.32 .35 .30Ω (Yours may be different)
```

When the test procedure prompts *Isolate Probes!* ... remove the shorted test component from the test socket. The Tester will sense the disconnection of the Test Points and report the values of *Ri\_Hi* and *Ri\_Lo*, such as:

```
Ri_Hi=22.4Ω  
Ri_Lo=20.3Ω
```

Then it reports *C0* on a new page, such as:

```
C0 41 42 47pF,  
OK
```

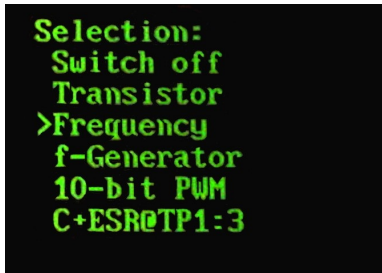
The calibration procedure begins next, if the unit has not been calibrated, by prompting:

```
1-||-3 > 100nf  
0nF ...
```

Insert any capacity capacitor from 100nF to 20μF between TP1 and TP3. With this capacitor, the offset voltage of the analog comparator will be compensated for better measurement of capacity values.

**Note:** Do not insert the capacitor until it is asked for.

The test procedure ends when it reports: *Version 1.12k* and *Test End*.



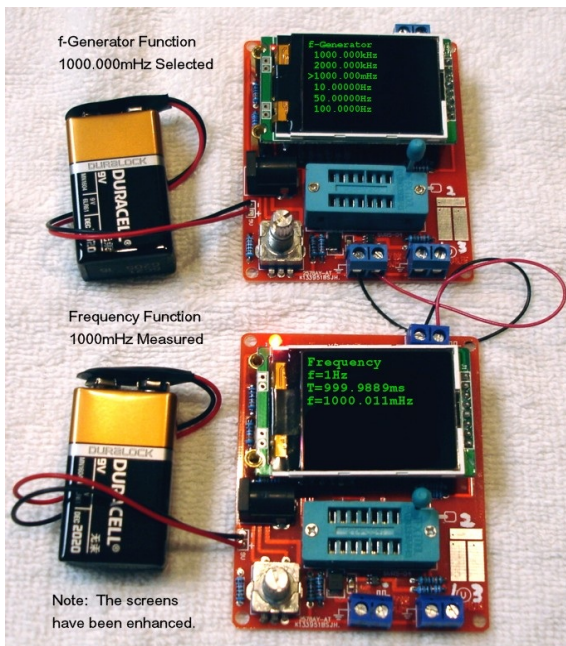
At the end of a test (before auto-off), a long-press or rotation of the RPEWS will enter the Function Menu. In the Function Menu:

- RPEWS rotation changes the selection
- RPEWS short-press selects Function action
- RPEWS long-press will exit the Function Menu

Let's look at each function now...

## Function Menu Descriptions:

- **Switch off** - The Tester will shut down immediately.
- **Transistor** - Transistor test; it is also the default Function at switch ON. Please see the section, Testing Components, next for a detailed description.
- **Frequency** - Measurement of frequency. For frequencies below 25kHz the normal measurement is followed by a measurement of time period. This additional measure only follows after a normal frequency measurement.



The picture on the left shows two GM328 Testers; the top Tester is generating a frequency of 1000mHz (millihertz or 1Hz) for the bottom Tester to measure. Note the input and output terminals, as these are unmarked on the circuit boards.

The top Tester, in f-Generator Function (described next), has a wide selection of 20 frequencies from which to choose. The choice is made by rotating the RPEWS left to move the '>' up, or right to move down. A short-press of the RPEWS selects the frequency.

The bottom Tester is in the Frequency Function. Frequencies from 1Hz to 2999KHz can be read.

- **F-Generator** - This Function can output a square wave, with 20 set non-adjustable frequencies to choose. (See Frequency above.)
- **10-bit PWM** - The function "10-bit PWM" (Pulse Width Modulation) generates a fixed frequency (7812.5Hz) with selectable pulse width at the pin TP2.



The pulse width begins at 50%, as shown, but can be adjusted by rotation of the RPEWS; left to decrease the percent value, right to increase the percent value.

Additionally, a short-press (< 0.5 sec) of the RPEWS will increase the pulse width by 1%. A long-press of the RPEWS will increase the pulse width by 10%.

If 99% is overstepped, 100% is subtracted from the result.

The function can be exited with a very long key press (> 1.3 sec).

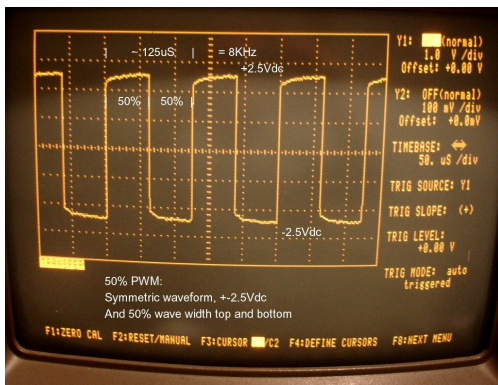


## What is Pulse Width Modulation?

Once again from Wikipedia, **Pulse width modulation (PWM)**, or **pulse-duration modulation (PDM)**, is a method of reducing the average power delivered by an electrical signal, by effectively chopping it up into discrete parts. The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load ON and OFF at a fast rate. The longer the switch is ON compared to the OFF periods, the higher the total power supplied to the load. Along with Maximum Power Point Tracking (MPPT), it is one of the primary methods of reducing the output of solar panels to that which can be utilized by a battery. PWM is particularly suited for running inertial loads such as motors, which are not as easily affected by this discrete switching, because they have inertia which causes them to react slowly to changes. The PWM switching frequency has to be high enough not to affect the load, which is to say that the resultant waveform perceived by the load must be as smooth as possible.

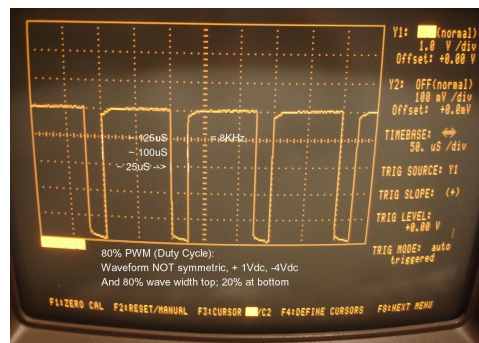
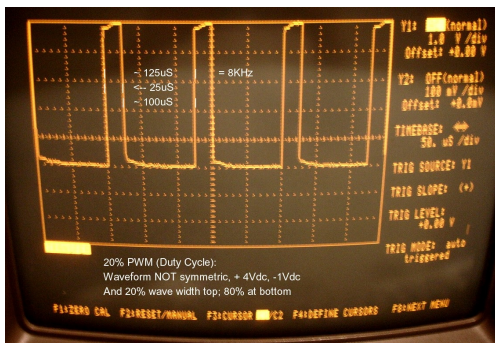
The rate (or frequency) at which the power supply must switch can vary greatly depending on load and application. For example, switching has to be done several times a minute in an electric stove; 120Hz in a lamp dimmer; between a few kilohertz (kHz) and tens of kHz for a motor drive; and well into the tens or hundreds of kHz in audio amplifiers and computer power supplies.

The main advantage of PWM is that power loss in the switching devices is very low. When a switch is OFF, there is practically no current, and when it is ON and power is being transferred to the load, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM also works well with digital controls, which, because of their ON/OFF nature, can easily set the needed duty cycle. PWM has also been used in certain communication systems where its duty cycle has been used to convey information over a communications channel. PWM is also used often with computer fans.



The term duty cycle describes the proportion of 'ON' time to the regular interval or 'period' of time; a low duty cycle corresponds to low power, because the power is OFF for most of the time. Duty cycle is expressed in percent, 100% being fully ON. When a digital signal is ON half of the time and OFF the other half of the time, the digital signal has a duty cycle of 50% and resembles a "square" wave (See the pictures at left and below).

When a digital signal spends more time in the ON state than the OFF state, it has a duty cycle of >50%. When a digital signal spends more time in the OFF state than the ON state, it has a duty cycle of <50%.



- **C+ESR@TP1:3** - The function "C+ESR@TP1:3" selects a stand-alone capacity measurement with ESR (Equivalent Series Resistance) measurement at the test pins TP1 and TP3. Capacities from 2 $\mu$ F up to 50mF or 50,000 $\mu$ F can be measured, while the 1-||-3 test can measure 25pF - 100,000 $\mu$ F.

**Note:** Because the measurement voltage is only about 300mV, in many cases the capacitor can be measured "in circuit" without previous disassembling. The series of measurements can be finished with a long-press of RPEWS.

- **Selftest** - The menu function "Selftest" is a full self test with calibration. With that call, all the test functions T1 to T7 and also the calibration with external capacitor is done every time, as follows:

The test begins with a flashing *Short Probes!* prompt. If you do not short the probes within about 2 minutes, the test continues by reporting Ri\_Hi and Ri\_Lo and continues from there (see below).

When you short the probes, the test procedure reports the zero resistance (R0) of the pin combinations 1:3, 2:3 and 1:2, such as:

R0=.32 .35 .30 $\Omega$

Next, the Tester prompts *Isolate Probes!* The Tester will sense the disconnection of the Test Points and reports the resistance of the port outputs to the 5V side (Ri\_Hi) and to the 0V side (Ri\_Lo), such as:

Ri\_Hi=22.4 $\Omega$   
Ri\_Lo=20.3 $\Omega$

and reports the zero capacity values (C0) with all pin combinations (1:3, 2:3, 1:2 and 3:1, 3:2, 2:1) on a new page, though mine only showed one set of values (See Show Data for both sets), such as:

C0 41 42 47pF  
OK

The calibration procedure begins next with the prompt:

1-||-3 >100nf  
0nF

Insert any capacity capacitor from 100nF to 20 $\mu$ F between TP1 and TP3. With this capacitor, the offset voltage of the analog comparator will be compensated for better measurement of capacity values.

Lastly, the correction values for the comparator (REF\_C) and for the reference voltage (REF\_R) are also shown, such as:

REF\_C=10  
REF\_R=-14.

The tests end when it reports: *Version 1.12k* and *Test End*.

- **Voltage** - Voltage measurement. Because a 9:1 (180K:20K) voltage divider is connected, the maximum external voltage can be 50Vdc. The measurement can also be exited by continuous rotation of the RPEWS.
- **Show data** - The function, "Show Data" shows the version number of the software and the data of the calibration. These are the zero resistance (R0) of the pin combinations 1:3, 2:3 and 1:2. In addition, the resistance of the port outputs to the 5V side (RiHi) and to the 0V side (RiLo) are shown. The zero capacity values (C0) are also shown with all pin combinations (1:3, 2:3, 1:2 and 3:1, 3:2, 2:1). Lastly, the correction values for the comparator (REF C) and for the reference voltage (REF R) are also shown. Every page is shown for 15 seconds, but you can select the next page by a key press or a **right** turn of the rotary encoder. With a **left** turn of the rotary encoder, you can repeat the output of the last page or return to the previous page.

The display screens of Show Data from one of my Testers was:

```
Version 1.12k
R0=.32 .35 .30Ω
Ri_Hi = 22.4Ω
Ri_Lo = 20.3Ω
C0 41 42 47pF
    44 46 45pF
REF_C = 10
REF_R = -14
```

Then it began showing pairs of diagrams:

```
BJT-NPN      BJT-PNP
N-JFET       P-JFET
N-E-IGBT     P-E-IGBT
N-D-IGBT     P-D-IGBT
N-E-MOS      P-E-MOS
N-D-MOS      P-D-MOS
```

Then it showed the diagrams for the following four components:

```
Resistor
Coil
Capacitor
Diodes (left & right)
```

Finally, it finished with a display of the entire Character Set, and returned to the Function Menu.

- **FrontColor** - This function can change the color of the font, the 16-bit color is encoded in RGB(565) format; that means red maximum = 31, green maximum = 63, blue maximum = 31 respectively. In the function, a short-press can index the base color to change, turn **left** to decrease its value and turn **right** increase its value. A long-press will save the result and exit the function.  
Please keep in mind the FrontColor and the BackColor can **not** be the same - the LCD would show nothing. If this happens, however, you need to do a Selftest. Enter the Selftest by turning the Tester ON with shorted probes. Selftest will change the back color to black and front color to white automatically. When the Selftest is finished, long-press back to the Function Menu to modify the color again. If you do not change the color, and turn the Tester off, the color will return to the original set color when the Tester is turned ON again!
- **BackColor** - This function is the same as FrontColor, except it changes the background color.
- **1-||-3** - This function can measure the series capacitance between TP1 and TP3. This function can measure capacitance from 25pF - 100,000uF. However, it can measure much smaller capacitors, by testing with a 30pF capacitor. First, 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.  
A long-press will exit the function.
- **1-(resistor & inductor symbols)-3** - This function can measure the series resistance and inductance between TP1 and TP3. A long-press will exit the function.
- **DS18B20** - The DS18B20 is a Digital Thermometer with 1 wire communicating protocol. It looks like a transistor due to its TO-92 component package, so it can fit into the Tester. When entering this function, Row 2 of the LCD will show a string "1=GND 2=DQ 3=VDD". This means to connect TP1 of the Tester to GND of the DS18B20, and so on. The Tester can **not** sense the pin configuration of the DS18B20 because it is an integrated circuit. Therefore, you must install the DS18B20 according to the string given.





The Tester reads the temperature using 12-bit resolution. It first starts a "Convert T"[44h] command, and then reads a series of 9 bytes of the "SCRATCHPAD" and the "64-BIT LASERED ROM". Fetch the first two bytes within the "SCRATCHPAD" and convert these to the readable temperature shown at row 3 of the LCD.

Scratchpad	BYTE
TEMPERATURE LSB	0
TEMPERATURE MSB	1
TH/USER BYTE 1	2
TL/USER BYTE 2	3
CONFIG	4
RESERVED	5
RESERVED	6
RESERVED	7
CRC	8

For example, the following is read from the DS18B20:  
Scratchpad: 1E 02 4B 46 7F FF 0C 10 5F

It means:

Scratchpad	BYTE	Byte Read
TEMPERATURE LSB	0	1E
TEMPERATURE MSB	1	02
TH/USER BYTE 1	2	4B
TL/USER BYTE 2	3	46
CONFIG	4	7F
RESERVED	5	FF
RESERVED	6	0C
RESERVED	7	10
CRC	8	5F

The 64-BIT ROM is structured as:

[ 8-bit CRC Code ] [ 48-bit Serial Number ] [ 8-bit Family Code (28h) ]  
MSB                    LSB    MSB                    LSB    MSB                    LSB

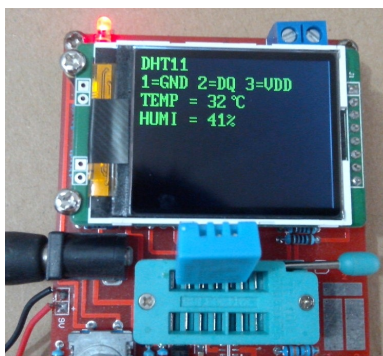
For example, the 64-bit ROM has: 28 FF 34 5D 36 16 04 BE

Which means:

[ 8-BIT FAMILY CODE ] = 28  
[ 48-BIT SERIAL NUMBER } = 0416365D34FF  
[ 8-BIT CRC CODE ] = BE

The temperature at row 3 of the LCD is shown in the decimal system. For others, the number is hexadecimal. The Tester measures temperatures from -55°C to +125°C. To exit this function, press and hold the RPEWS > 3 sec.

- **DHT11** - The DHT11 is a sensor with temperature and humidity measurements. The degree of accuracy is +-5% Relative Humidity (RH) and +-2 degrees C.

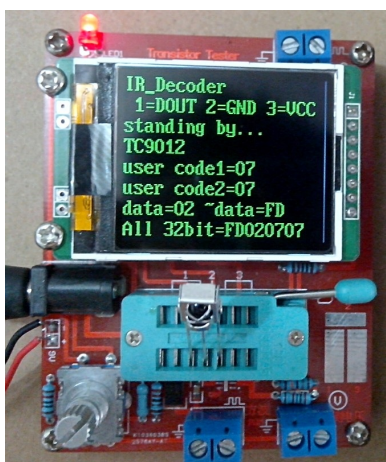


The Tester measures temperatures from 0 to 50 degrees Centigrade and measures relative humidity from 20-90% RH.

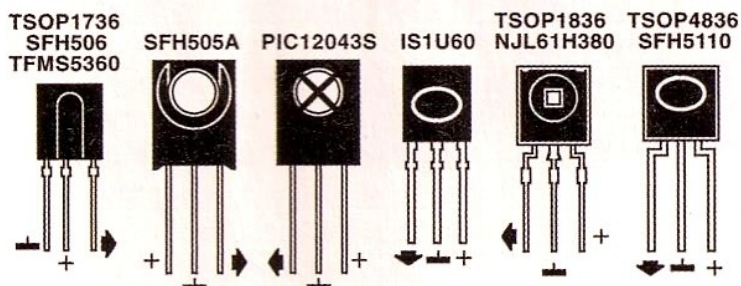
When entering this function, Row 2 of the LCD will show a string "1=GND 2=DQ 3=VDD". This means to connect TP1 of the Tester to the GND of the DHT11, the "N/A" pin of the DHT11 can be floating or connected to GND. TP2 of the tester is connected to DATA of the DHT11, and TP3 of the Tester is connected to Vcc of the DHT11. The Tester can **not** sense the pin configuration of the DHT11. Therefore, you must install the DHT11 according to the string.

When a reading occurs, the temperature is shown at row 3 and humidity is shown at row 4. To exit this function, press and hold the RPEWS > 3 sec.

- **IR\_decoder** - The function of decoder is achieved by a IR receiver module.



When entering the IR\_Decoder Function, Row 2 of the LCD shows a string "1=DOUT 2=GND 3=VCC". This means to connect TP1 of the tester to the GND of the IR receiver module, and so on. Here are the pinouts for some popular IR Receiver Modules:



The IR\_Decoder Function supports two infrared remote control protocols

1. uPD6121
2. TC9012

The two protocols are the same except the lead code; Protocol 1 is 9ms+4.5ms but Protocol 2 is 4.5ms+4.5ms. A successful decode is listed at rows 4 - 8 of the LCD, where row 4 displays the IR protocol (TC9012 or uPD6121), row 5 and row 6 display "User code1" and "User code2", and row 7 displays the data and the Bitwise NOT of the data (~data). Row 8 displays the four bytes together. The hexadecimal system is used to display ALL of the numbers.

The uPD6121 and uPD6122 are infrared remote control transmission ICs using the NEC transmission format that are ideally suited for TVs, VCRs, audio equipment, air conditioners, etc. By combining external diodes & resistors, a maximum of 65,536 custom codes can be specified. These ICs come in small packages, thus facilitating the design of light and compact remote control transmitters. The NEC transmission format consists of leader codes, custom codes (16 bits), and data codes (16 bits). It can be used for various systems through decoding by a microcontroller.

- **IR\_Encoder** - This function is a simulation of an IR Remote Controller. It can drive an IR LED connection at the tester's PWM output interface associated with the user input. Since the Tester can only provide about 6mA current, the Control distance is less than a regular IR Remote Controller.

In the first column of the LCD is shown a ">". This symbol can move up or down by rotation of the RPEWS to select a certain item. Row 2 of the LCD is to select a protocol, like the IR\_Decoder above. There are two protocols to select from, "TC9012" and "uPD6121" and can be changed by rotating the RPEWS knob when the ">" appears at row 2. Row 3 and row 4 change the "user code 1" and "user code 2" value by rotating the RPEWS knob; **left** rotate will decrease and **right** rotate will increase the value. Press and hold the RPEWS knob for >1S and <3S (>3S will exit this function) will add the value by 0x10 to reach the expected value faster. Row 5 changes the "data", and the Bitwise NOT of the "data" (~data) auto calculated by the Tester. Row 6, the "emit:" is used to start a transmit. Move ">" to this line and rotating the RPEWS knob, will start the transmit. An "->" will appear soon until the transmit is complete.

This function is "strongly" correlated with the IR\_decoder. Without the decoder, the value of the user code and data is unknown, unless you already know them from other methods.

The infrared remote control protocol of "TC9012" is frequently used on televisions in China.

- **C(uF)- correction** - This function sets the correction value for big capacitor measurement. Positive values will reduce the measurement results.

## Testing Components:

### General Notes:

- Normally, the Tester begins in Transistor Test mode, automatically checking if a component is found at the Test Socket or test pads. The Tester also shows the battery voltage with every start.
- If the voltage falls below a limit, a warning is shown behind the battery voltage. If you use a rechargeable 9V battery, you should replace the battery as soon as possible or you should recharge.
- The measured supply voltage will be shown in display Row 2 for 1 second with "VCC=x.xxV".
- When checking two-lead passives, such as resistors, capacitors, and inductors, these can all be measured in the default test mode between TP1 and TP3, but can be tested between any two test points.
- If TP1 and TP3 are selected to check these passives, the test will enter 'series test' mode, where the test is repeated every few seconds. You can replace the component with another component at any time. The test may be exited with a long-press of the RPEWS, and restarted with a short-press of the RPEWS.
- If a component is polarized (for example, electrolytic capacitors), favor TP1 for the negative lead/cathode.
- Capacitors should be discharged before measuring. Otherwise the Tester can be damaged before the start button is pressed.
- If you try to measure components within an assembled circuit, the equipment should always be disconnected from its power source. Furthermore you should be sure that no residual voltages reside in the equipment. All electronic equipment has capacitors that store power inside!
- If you try to measure little resistor values, you should keep the resistance of plug connectors and cables in mind. The quality and condition of plug connectors and the resistance of cables used for measurement are important.
- The same is true for the ESR measurement of capacitors. With a poor connection cable, an ESR value of 0.02 ohms can grow to 0.61 ohms.
- While interpreting transistor measurement results, keep in mind that the circuit of the Tester is designed for small signal semiconductors. In normal measurement conditions, the measurement current can only reach about 6mA. Power semiconductors often cause identification difficulty and inaccurate measurement because of residual current value.
- You should not expect very good measurement accuracy from this simple Tester, especially in ESR and inductance measurements.

Push the RPEWS button to turn the Tester ON. The Tester will sense any component installed and attempt to identify it. If it is successful, the Tester will display the component name, diagram and measured values for about 25 seconds, then shut OFF. If unsuccessful, the tester will display a large question mark '?' and: "No, unknown or damaged part." for 10 seconds before shutting OFF.

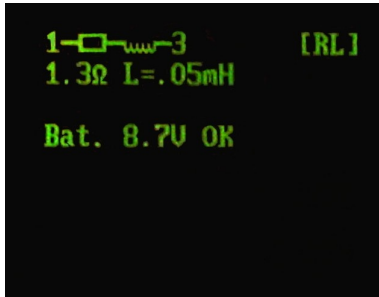
You may change components while the results of the present test are being shown and press the button again to restart the test without waiting for the Tester to turn off.

The Tester shows the model number and battery voltage with every start. If the voltage falls below a limit, a warning is shown behind the battery voltage. If you use a rechargeable 9V battery, replace the battery as soon as possible or recharge.

**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.

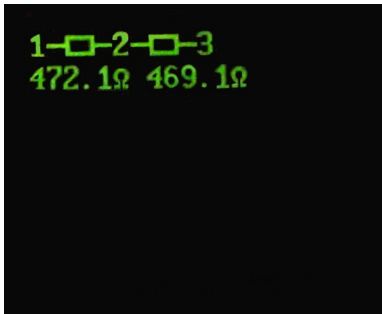
**Resistors:**

To test, 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 also important. So keep any cable leads short and connectors in good condition.

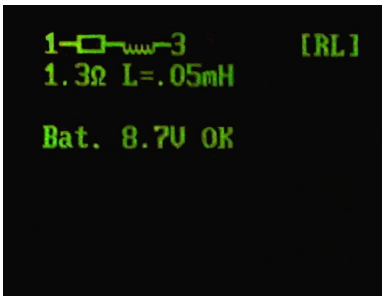
A diagram of the resistor between the two test points chosen, the resistance (to 0.1 ohm resolution; maximum 50M ohms), and any associated inductance values will be shown. The last line shows the Battery voltage.



You can also measure two resistors, end to end in series, or variable potentiometers. For the potentiometer, attach test leads to the three leads in 1, 2, 3 order and the display should be similar to that shown here.

**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 2.1k ohms, this technique can never be used to detect coils.



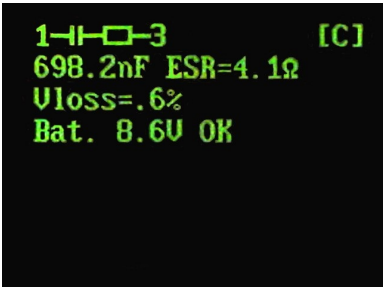
To test, insert an inductor between any two test points.

A diagram of a resistor and 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. 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.



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 and resistor between the two test points chosen, the capacitance (25pF - 100,000uF) value and, if the capacitor is larger than 90nF, the associated ESR value will be shown.

**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.

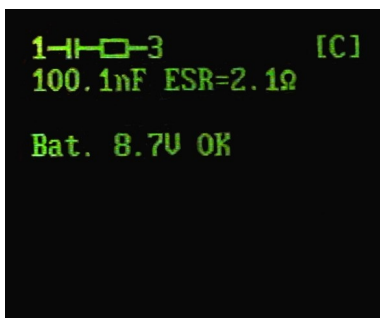
For Capacitors >5000pF, the Tester will also show the rate of decline (Vloss) after the charging voltage of the capacitor value to reflect the quality factor or (Q value) and an associated ESR resistance value.

### 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  $\mu\text{F}$  is easily measured in-circuit with an ESR meter.

**Typical values of ESR for various types of capacitors:**

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

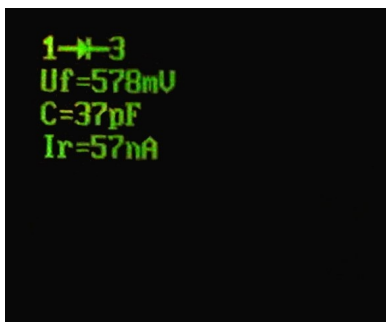
**Warning:** Always discharge ALL capacitors before placing them in the Tester. Any residual voltage could damage parts of the Tester!

**Notes:**

- Can only measure capacitance from 25pF-100mF, with 1pF resolution.
- This Tester often gives the capacitance value in nF, where 100nF = .1 $\mu\text{F}$ .
- For capacitors >90nF, the Tester will also give the Equivalent Series Resistance (ESR). The ESR has a highest resolution of 0.01 $\Omega$ .
- 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:**

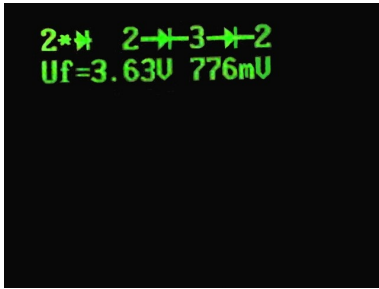
Insert a diode between any two test points. Polarity will not matter.



A diagram of the diode between the two test points, the  $U_f$  value in mV, the capacitance value in pF and the Reverse Current in nA will be shown.

We will discuss  $U_f$  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  $U_f$  (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  $U_f$  of about 700mV, and the second in the opposite direction with a  $U_f$  equal to the **zener voltage** of the diode, in this case, 3.63Vdc.

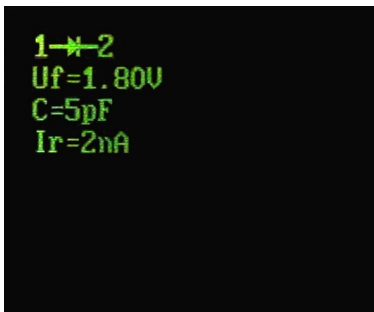
**Note:** While two normal diodes may be measured in series, do **not** measure an ordinary diode and a zener diode simultaneously.

### What is $U_f$ ?

This tester uses a value label foreign to me, but checking the web seems to show that  $U_f$  is used in some languages, but it is actually  $V_f$  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.

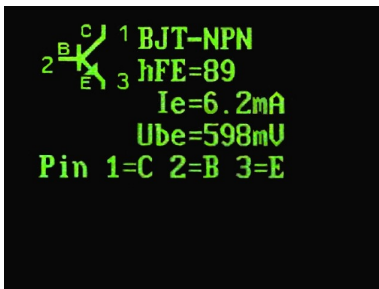


The Tester will cause the LED to flash a few times, then display the diagram of the diode between the two test points chosen, from which you may determine the LED anode and cathode, if necessary. The  $U_f$  (forward voltage) value in the range of 1-2Vdc, the capacitance value in the range of 1-30pF and the Reverse Current in nA 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 show the diagram of both diodes and the measured forward voltages,  $U_f$ , 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.

After pushing the start button, the Tester shows the diagram of the transistor being tested with the pins identified and what test points they are attached to.

The current amplification factor  $hFE$  or  $\beta$ , emitter current  $I_e$ , forward voltage drop  $U_{be}$ , and the pinout are also shown.

### What is hFE?

The hFE (which is also referred to as  $\beta$ ) 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. 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.

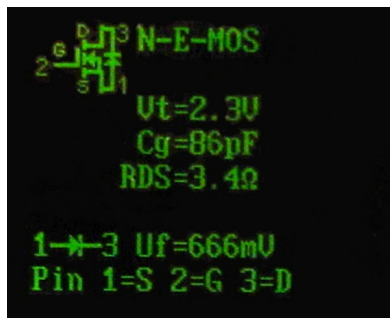
### What is Ube?

As with the diode testing, Ube is actually Vbe, 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, Ube goes somewhere between 100mV and 200mV.

Let's check out some 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 (a D in the label), voltage applied at the gate reduces the conductivity. MOSFETs are easily miniaturized, consume much less power, are 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.

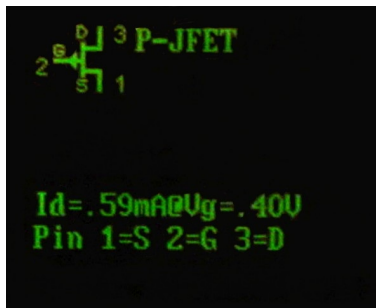
In addition to the diagram of the MOSFET, the Tester provides  $V_t$ , which is the threshold voltage at which current begins to flow,  $C_g$ , the capacitance at the gate and  $R_{DS}$ , the resistance between the drain and the source. A diagram of any diode and its  $V_f$  ( $V_f$ ), the forward voltage, may also be shown. Finally, the pinout is shown.

### What is the JFET?

Again from the internet, the junction gate field-effect transistor (JFET or JUGFET) is one of the simplest types of field-effect transistor. JFETs are three-terminal semiconductor devices that can be used as electronic-controlled switches, amplifiers, or voltage-controlled resistors.

Unlike bipolar transistors, JFETs are exclusively voltage-controlled in that they do not need a biasing current. Electric charge flows through a semiconducting channel between source and drain terminals. By applying a reverse bias voltage to a gate terminal, the channel is "pinched", so that the electric current is impeded or switched off completely.

A JFET is usually ON when there is no voltage between its gate and source terminals. If a potential difference of the proper polarity is applied between its gate and source terminals, the JFET will be more resistive to current flow, which means less current would flow in the channel between the source and drain terminals. JFETs are sometimes referred to as depletion-mode devices as they rely on the principle of a depletion region which is devoid of majority charge carriers and the depletion region has to be closed to enable current to flow.



JFETs can have an N-type or P-type channel. In the N-type, if the voltage applied to the gate is less than that applied to the source, the current will be reduced (similarly in the P-type, if the voltage applied to the gate is greater than that applied to the source). A JFET has a large input impedance (sometimes on the order of 1010 ohms), which means that it has a negligible effect on external components or circuits connected to its gate.

In addition to the diagram of the JFET, the Tester provides  $I_d$ , which is the current flow from the drain in mA at  $V_g$ , the voltage applied at the gate when current begins to flow. Finally, the pinout is shown.

### What is the Triac, Thyristor 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 A1 and A2, and G is the gate. Some minimum voltage at the gate causes the device to conduct current bidirectionally between A1 and A2. In addition to the diagram, the  $V_f$ , or  $V_f$ , forward voltage is shown.

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 and Recognition:** As no detailed manual could be found for this series of tester, the above information is from the Tester's listed specifications, operational descriptions found on the internet, Wikipedia's description of electronic parts and theory, and personal experimentation.

Please report any errors to the author by email at: [z100lifeline@swvagts.com](mailto:z100lifeline@swvagts.com).  
Thank you.



