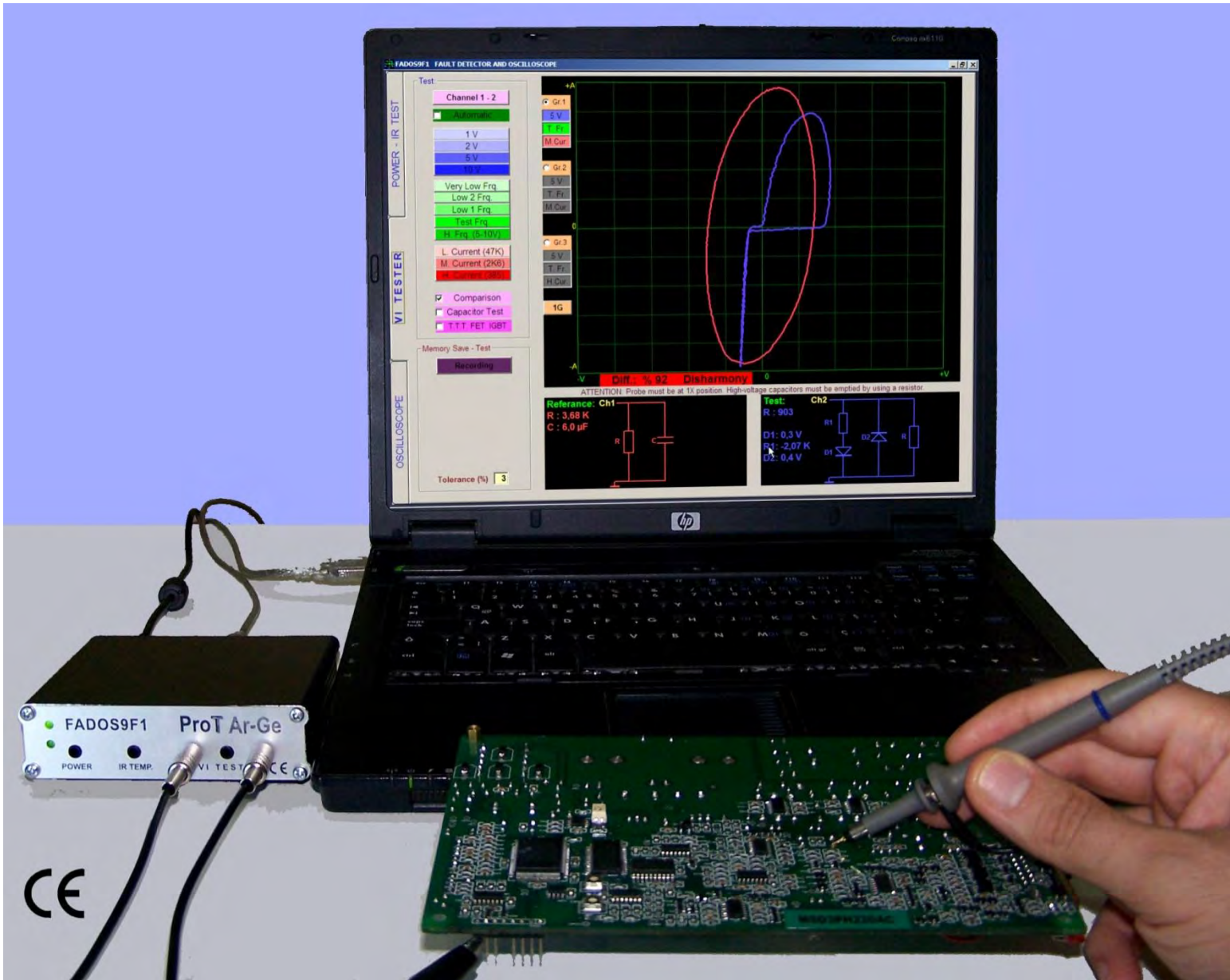


FADOS9F1

FAULT DETECTOR & OSCILLOSCOPE
9 FEATURES IN 1 DEVICE
USER MANUAL



PRODUCT DESCRIPTION - FADOS9F1 FAULT DETECTOR & OSCILLOSCOPE

The FADOS9F1 Fault Detector & Oscilloscope Device from the company **Prot Ar-Ge Endüstriyel Proje Tasarım Teknolojik Ar-Ge Ltd. Şti.** is designed to diagnose the failures in all types of electronic circuit boards. The FADOS9F1 PC is a based **VI Test Voltage-Current Analysis** device.

Signature Analysis is a power-off test method that is used to troubleshoot circuit boards. FADOS9F1 works by applying a current-limited sine wave through a serial resistor point of touched on circuit and Voltage - Current (Signature) graph is displayed on the computer screen. In addition to these features, the computer software analyzes the Voltage – Current graph and displays the equivalent circuit diagram and the values of the electronic components at the point of contact, which are provided to help the user to diagnose the failure with ease.

Using the **Dual Channel VI Test** feature, the intact and defective (or suspect) electronic circuit boards can be compared by probing the same points respectively, thus any failures beyond tolerances are diagnosed easily. All the VI graphs are compared by the software with accuracy of 2.5 mV and by analyzing 720 points. Therefore, the FADOS9F1 is very accurate.

Memory Recording feature; by means of this feature, the characteristics of the intact electronic circuit board (VI graph, equivalent circuit diagram and electronic components values) **are written on the computer's hard disk and taking these points as reference, you can compare** the defective (or assumed to be defective) electronic circuit boards accurately, easily and rapidly. At the same time, the data can be written on the photograph of the board. Thus, the recorded point can be seen on the photograph while making a comparison from the memory.

The software **produces different sounds** while comparing the matching and non-matching points during the test. Thus, the comparison can be made rapidly by focusing on the sounds without looking at the display constantly. The user can compare the electronic circuit boards from 3 different settings at the same time. (Selected Current-Voltage-Frequency steps)

In addition to the above features, the VI FADOS9F1 Test Device can be used as a **Dual-Channel Oscilloscope, Square Wave Generator** and **Analog Voltage Output**. When the Square Wave Signal Output is used, a signal is applied to the electronic circuit board and the other channels display the output signals on the oscilloscope screen.

Two more unique features have also been added to the FADOS9F1 in addition to the model FADOS7F1. The first one of these features is the **"Programmable DC Power Supply"**; by means of the adjustable power output between 0-16V and 20-1500mA, the DC Voltage/Current

graph of the electronic card supplies can be obtained. The second one is the **"IR Remote Temperature Measurement Probe"**, which is used for identifying the overheating components as a result of drawing excessive current. Using those two features together, diagnosing time for some failures can be shortened by as much as 5-10 times. Those features may be used as a new technique for trouble shooting.

The technicians, engineers and the people that repair electronic circuit boards as a hobby consider the VI graphs as an effective and efficient method for diagnosing the failures in the printed circuit boards. This method of comparing the VI signature provides information for the user to identify the defective area and components easily. After gaining some experience of the VI graphs, you will find the FADOS9F1 to be an indispensable troubleshooting tool for diagnosing the electronic circuit boards. It is quite simple to use and the failures can be identified just by looking at the graphs without making any comparisons.

When you test the electronic cards by using the FADOS9F1, do not energize the board and discharge the high voltage capacitors on the board in advance. The FADOS9F1 device does not cause any damages to the electronic circuit boards.

Usage Areas

ECU Automotive electronic circuit boards, servo-step motor drivers, circuit boards of medical devices, military electronic circuit boards, computer and monitor circuit boards, television-audio-radio circuit boards, circuit boards of textile machines, mobile phone electronic circuit boards etc. (all type electronic circuit boards.)

Electronic Component Test: Resistors, Capacitors, Inductors, Diodes (general purpose Diodes, Zener and High Voltage Diodes etc.), Transistors (NPN, PNP, JFET, MOSFET vs.), SCR, Triac, Optocouplers, Integrated Circuits (Digital, Analog) vs. (can test all electronic components).

Unique Features

Generating the **DC Voltage-Current Graph** of the electronic circuit board's power supply with Programmable DC Power Supply, **IR (infrared) Sensor (Temperature Test)**, **Equivalent Circuit Diagram** and **Measuring Values** of all components features are **unique** in the World and which cannot be found in any other similar products.

By means of the adjustable power output of the "Programmable DC Power Supply" between 0-16V and 20-1500mA. It gives energy to circuit boards and creating Power DC Voltage-Current Graph.

The "IR Remote Temperature Measurement Probe"; this sensor is used for identifying

overheating components as a result of drawing too much current.

Equivalent Circuit Diagram and Measuring Values of all components features; as an example; if resistor connected parallel to capacitor, it shows circuit diagram and value of them at the same time.

SECURITY

- 1-** FADOS9F1 is produced by using lead-free solder and designed in accordance **CE** regulations; users must use the following usage rules.
- 2-** Chassis must be isolated and grounded. Connect the chassis ground connection point of the probe is the same as your computer, careful to avoid the potential difference.
- 3-** Feature of oscilloscope, if probe key is set to **1X**, it measures ± 5 Voltage, probe key is set to **10X**, it measures ± 50 Voltage. Do not use above these limits of voltage.
- 4-** It tests electronic circuit boards without giving to energy. Before test, electronic circuit board and the devices must be made high-voltage capacitor discharges.
- 5-** The users of this equipment must have knowledge and experience to repair of electronic circuit boards. Thus, during using FADOS9F1, do not make this mistakes such as touch chassis to high-voltage, non-isolated ground, test high-voltage capacitor discharges. Without enough knowledge and experience in this subject, keep away high voltages such as mains voltage which can damage the system and themselves.
- 6-** Giving high-voltage from probes, series resistors which contained in the device damaged and makes the circuit an open circuit. In this case, the computer port which is connected device via USB port damaged but observed in other parts of the computer is not damaged.

FADOS9F1 PERFORMANS AND MEASUREMENT TOLERANCE

- 1-** FADOS9F1 is designed multi-function as Voltage- Current (VI) Signature Analysis Tester and Oscilloscope. The main of the feature device is VI Tester; in addition to this feature, computer software by analyzing voltage-current graph to displays equivalent circuit diagram and values of electronic components in specific tolerances. The equivalent circuit diagram and values are for informational purposes. As the device is not suitable for direct measurement. **And Computer software creates "Power Voltage-Current Graph"** and measures temperature of components in specific tolerances.
- 2-** Equivalent circuit diagram is drawing by software using mathematical functions and formulas; but rarely has the possibility of making mistake. This probability is more increased with applied externally electromagnetic fields of generated interference. The EMC Testing; 3V/M and the range of 80MHz-1GHz is approximately capacitor %1, resistor %3, diodes %1. Some fast diodes make oscillation in some frequencies, so that **can be perceived as 'active point' by the device.** VI Graph the rate of change: <1%.
- 3-** Components Value Measurement Tolerance:
 - Resistor: %2
 - Capacitor: %3
 - Diode Transmit Voltage: 0,1V
 - If Resistor and Capacitor are connected Parallel: Resistor:%4, Capacitor: %5
 - If Resistor and Diodes are connected Serial: %4
 - If Diode and Resistor are connected Parallel: %3
 - If 2 Diodes and a Resistor are connected Parallel: %10

Note 1: These tolerances valid, if resistor curve makes angle between 10 and 80 degree to horizontal axis. If resistor curve close to horizontal line, select **"Low Current Stage"** and; if resistor curve close to vertical line, select **"Middle or High Current Stage"** for reducing mistake rate.

Note 2: These tolerance valid, if capacitor ellipse of width/length ratio is greater than 1/4. This **ratio is less than 1/4 and ellipse's width** - length is thin and long. In such a case; change current step or/and frequency step for selecting step appropriate to components.

Oscilloscope voltage measurement tolerance: %0,5.

Product and Package Contents

- 1 FADOS9F1 Product
- 1 Software CD and User manual (Pdf)
- 1 IR Temperature Probe
- 2 Oscilloscope Probe
- 1 Com Probe (Crocodile)
- 1 USB Cable
- 1 DC Cable
- 1 Power Adaptor
- 1 FADOS9F1 Handbag

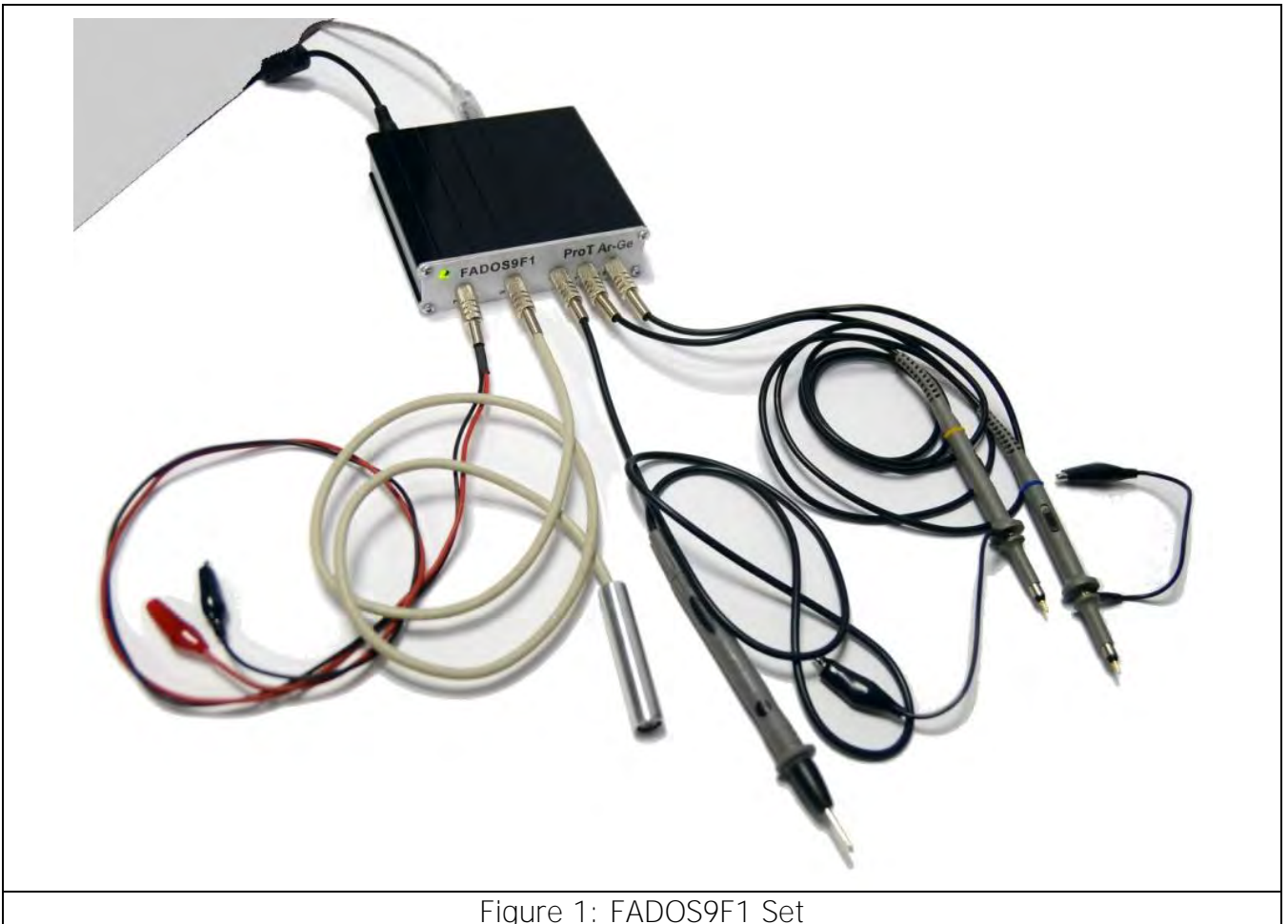


Figure 1: FADOS9F1 Set

FADOS9F1 TECHNICAL SPECIFICATIONS

A- FAULT DETECTION SPECIFICATIONS:	
Test Voltage	: $\pm 1V, \pm 2V, \pm 6V, \pm 12V, \pm 24V$
Test Resistance	: Low $47K\Omega$, Medium1 $3,5K\Omega$, Medium2 700Ω , High 250Ω
Test Frequency	: Very Low Frequency : 2 Hz Low2 Frequency : 4 Hz Low1 Frequency : 12 Hz Test Frequency : 32.5 Hz High Frequency : 355.4 Hz
Number of Channels	: 2 (Channel1 and Channel2)
Scan Mode	: Manual and Automatic. Automatic selection steps Voltage, Current and Frequency.
Other characteristics	: 1: Equivalent circuit diagram. 2: Resistor, capacitor, diode measurement. 3: Data recording and comparison from memory. 4: Display of graphs in different settings simultaneously.
B- POWER – IR TEMPERATURE FEATURES:	
DC Power Supply	: Power output adjustable between 0-16V 20-1500mA.
IR (Infrared) Sensor	: Measures 0 to 120 degrees according to the room temperature.
C- PC OSCILLOSCOPE FEATURES:	
Sampling Rate	: 400 K/S
Input Voltage	: Probe 1X: $\pm 5 V$ Probe 10X: $\pm 50 V$
Channel/ADC	: 2 Channel / 12 Bit
Accuracy	: 2,5 mV
Display Speed	: 0.02 mS/div...100 mS/div
Momentary Memory	: 64 Kbyte
D- DIGITAL AND ANALOG OUTPUT:	
Output	: Channel2
Output Voltage	: -12V...+12V (adjustable)
Frequency (Digital)	: From 0.2KHz to 25KHz
Connections	: The probes may be connected to all the connectors. The probe with the yellow band is always Channel1 and the probe with the blue band is always Channel2. The crocodile probe is always Com.
Dimensions	: 122mm L x 113mm W x 29mm H
Weight	: 1100 gram including all accessories.

Table 1: FADOS9F1 Technical Features

CONTENTS

	Page
PRODUCT DESCRIPTION - FADOS9F1 FAULT DETECTOR & OSCILLOSCOPE	2
USAGE AREAS.....	3
ELECTRONIC COMPONENT TEST.....	3
UNIQUE FEATURES.....	3
SECURITY	4
FADOS9F1 PERFORMANS AND MEASURUMENT TOLERANCE	5
PRODUCT AND PACKAGE CONTENTS	6
FADOS9F1 TECHNICAL SPECIFICATIONS	7
FADOS9F1 FAULT DETECTOR & OSCILLOSCOPE	10
INSTALLING THE FADOS9F1 SOFTWARE	12
LOADING DRIVER	14
CONNECTING THE TEST PROBES	15
GENERAL USAGE INFORMATION	17
POWER (SUPPLY) - IR TEMPERATURE TEST.....	19
POWER (SUPPLY) TEST - DC VOLTAGE CURRENT GRAPH.....	21
SAVING THE POWER (SUPPLY) DC VI GRAPH AND DEFINING THE RECORDING WINDOW.....	22
COMPARISON OF THE POWER (SUPPLY) DC VI GRAPH WITH THE DEFECTIVE (FAULTY) ELECTRONIC CIRCUIT BOARDS DC VI GRAPHS.....	23
IR TEMPERATURE TEST	26
RECORDING THE COMPONENT TEMPERATURES.....	26
DEFECTIVE ELECTRONIC CIRCUIT TEMPERATURE CHECK.....	29
MICRO VOLTAGE	32
VI TEST - FAULT DETECTION SCREEN FEATURES.....	33
OPEN CIRCUIT - SHORT CIRCUIT	37
VOLTAGE SELECTION.....	38
THE CHARACTERISTIC VI GRAPHS OF THE MAIN ELECTRONIC COMPONENTS.....	39
PASSIVE COMPONENTS R, L, C (RESISTOR, INDUCTOR, CAPACITOR) VI GRAPHS.....	40
RESISTOR VI GRAPH.....	40
CAPACITOR VI GRAPH	43
CAPACITOR (QUALITY - FAILURE CHECK) CAPACITY TEST - RC CIRCUITS VI GRAPHS	45
CAPACITY TEST.....	45
RC CIRCUITS VI GRAPH	46
INDUCTOR VI GRAPH	47
SEMI CONDUCTORS.....	48
DIODE VI GRAPH	48
ZENER DIODE VI GRAPH	51

TRANSISTOR - TRIAC - THYRISTOR - FET - IGBT - OPTO-COUPLER VI GRAPH	52
TRANSISTOR VI GRAPH.....	52
MOSFET - FET VI GRAPH	63
IGBT VI GRAPH	69
THYRISTOR (SCR) VI GRAPH	72
TRIAC VI GRAPH.....	74
OPTO-COUPLER VI GRAPH.....	76
INTEGRATED CIRCUITS (ICs - SMD INTEGRATED CIRCUIT TESTS).....	81
REGULATOR INTEGRATED CIRCUITS.....	86
RECORDING THE ELECTRONIC CIRCUIT COMPONENTS TO THE MEMORY AND COMPARING FROM THE MEMORY	89
RECORDING THE ELECTRONIC COMPONENTS TO THE MEMORY	90
COMPARING THE ELECTRONIC COMPONENTS FROM MEMORY	92
IMAGE SAVE.....	95
COMPARATIVE TEST OF THE MATERIALS IN THE ELECTRONIC CIRCUITS.....	96
3G - DISPLAY OF THE GRAPHS FOR 3 DIFFERENT SETTINGS.....	102
OSCILLOSCOPE - PROGRAM CHARACTERISTICS.....	105
DAC - SQUARE WAVE GENERATOR.....	108
ISSUES TO KEEP IN MIND - RECOMMENDATIONS.....	110
ERROR CODES	111
CONDITIONS OF WARRANTY.....	112

FADOS9F1 FAULT DETECTOR & OSCILLOSCOPE

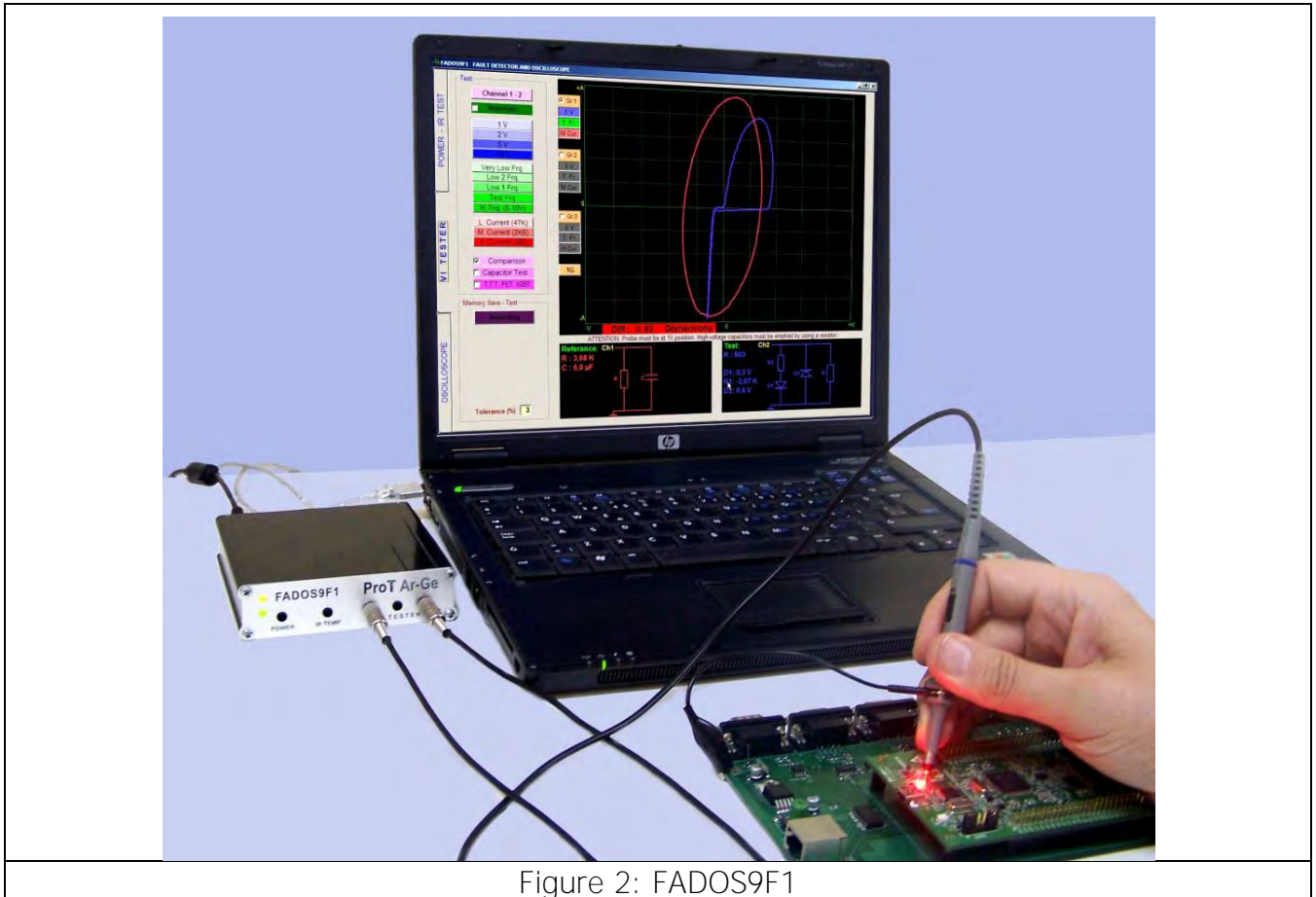


Figure 2: FADOS9F1

FADOS9F1 includes 9 important functions:

1. Double – Channel Fault Detection (Analog Signature Analysis - VI Graph)

Comparing good and faulty or suspect circuit boards without giving power to boards.

2. Programmable Integrated DC Power Supply

For giving energy to circuit boards and creating Power DC Voltage-Current Graph.

3. Non Touched IR Temperature Sensor

For detecting more heated components and draw out heat map of circuit board.

4. Equivalent Circuit Diagram

Composing R, C, or Diode Circuit Diagram according to the point touched.

5. Measuring Value of Resistors, Capacitors, and Diodes

Feature of measuring the value of touched point.

6. Fault Detection by Comparison from Memory

By recording data of good circuit boards to memory, comparing faulty or suspects boards from memory.

7. Double – Channel Digital Oscilloscope

As occasion may require, device can be used as oscilloscope.

8. Square Wave Signal Output

Ch.1 is used as oscilloscope and Ch.2 is used as signal generator.

9. Analogue Voltage Output

Ch.1 is used as oscilloscope and Ch.2 gives analog voltage output.

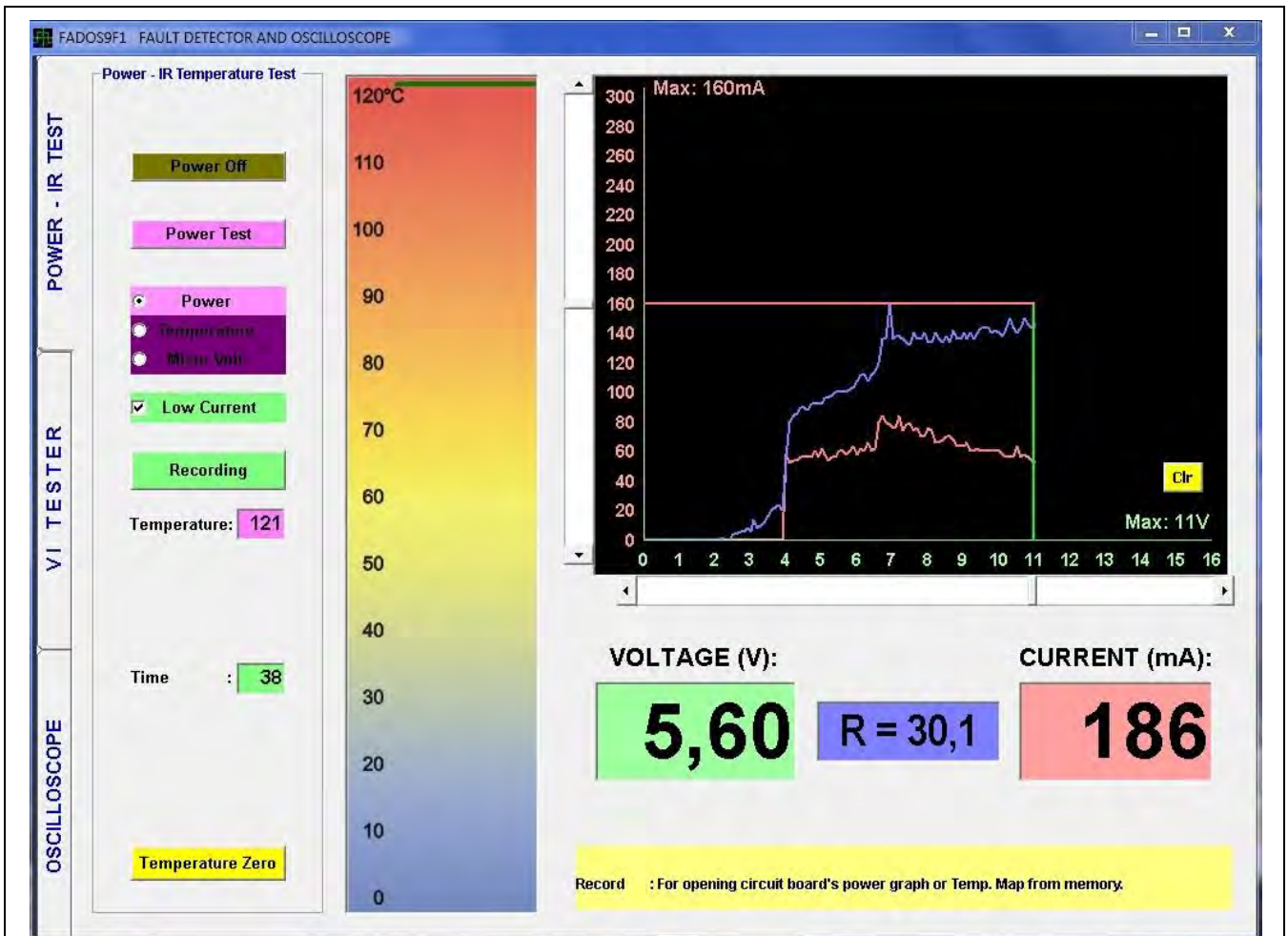


Figure 3: Energy (Power) – IR (Temperature) Test Screen

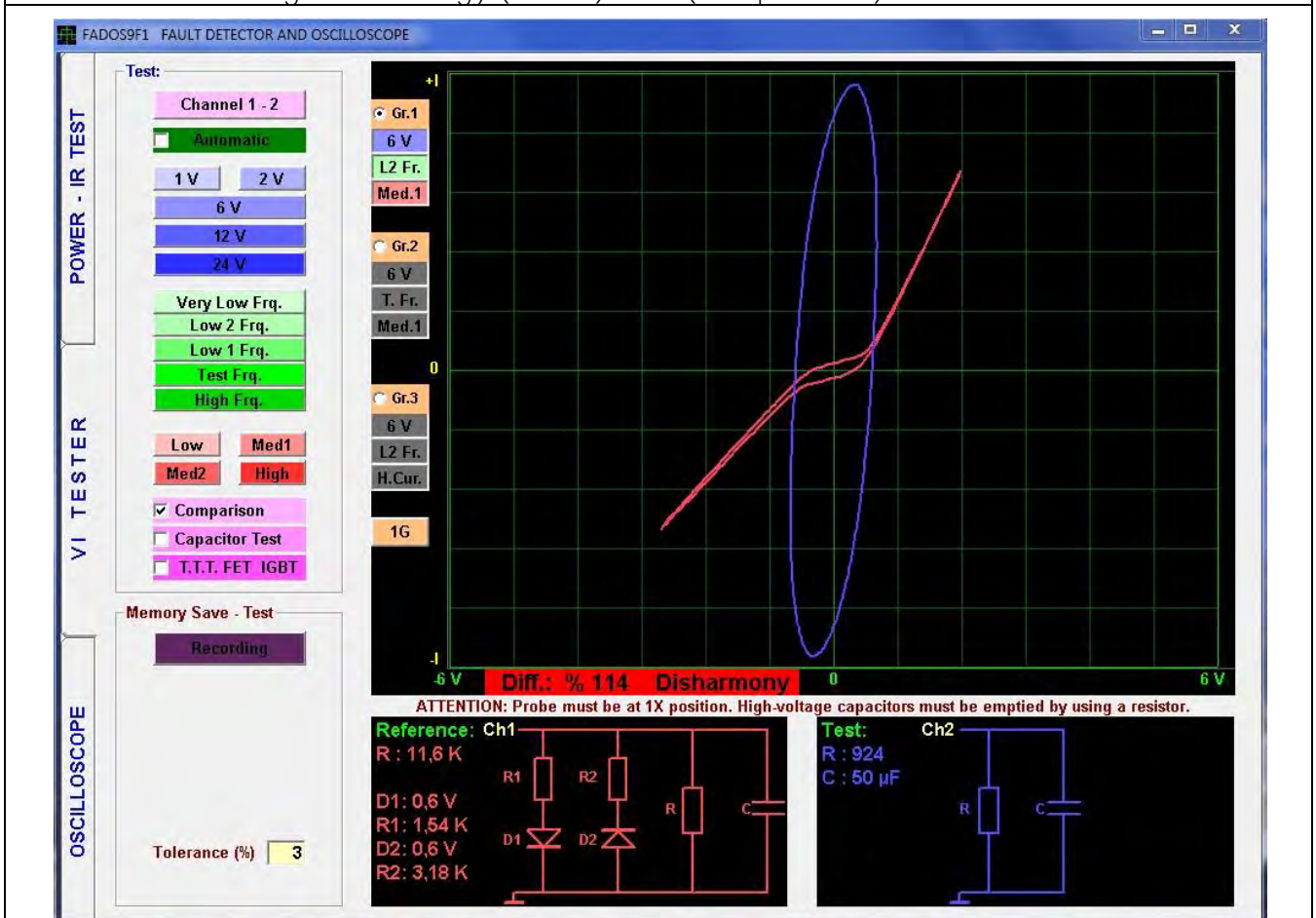


Figure 4: Fault Detector – VI Tester Screen



Installing the FADOS9F1 Software



- 1- Insert the FADOS9F1 software CD to the CD drive of the computer. The files in the CD are shown in Figure 6.
- 2- Attach the power adaptor of the FADOS9F1 and connect to the PC by means of a USB port. Download the driver provided with the CD. The Driver Installation is described in Page 14 in detail.
- 3- Click on FADOS9F1 SETUP.exe to install the program.

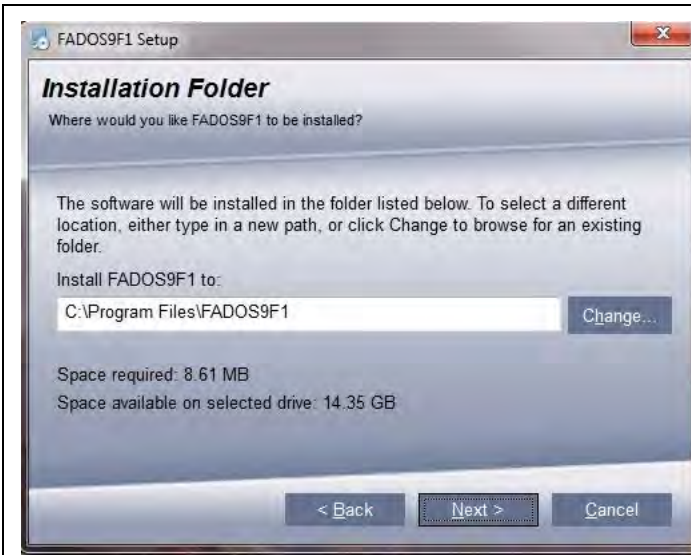


Figure 7: FADOS9F1 Setup (Step 1)

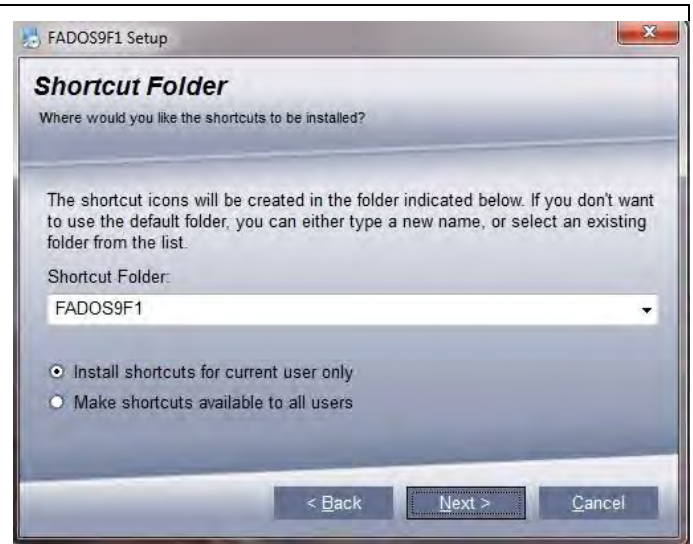


Figure 8: FADOS9F1 Setup (Step 2)



Figure 8: FADOS9F1 Setup (Step 3)

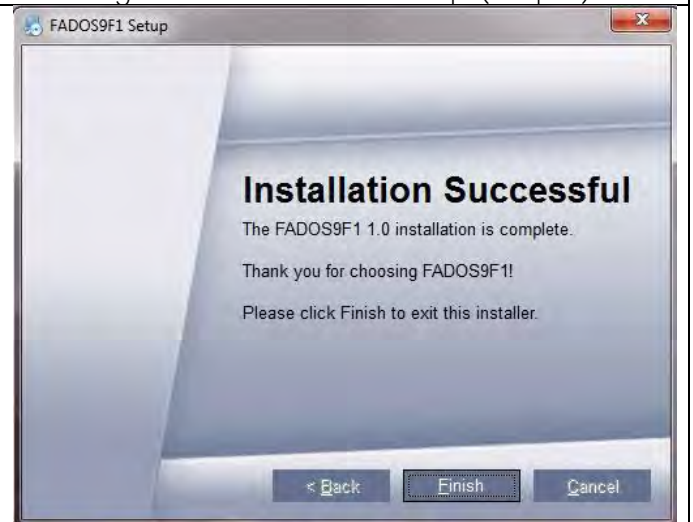


Figure 9: FADOS9F1 Setup (Step 4)

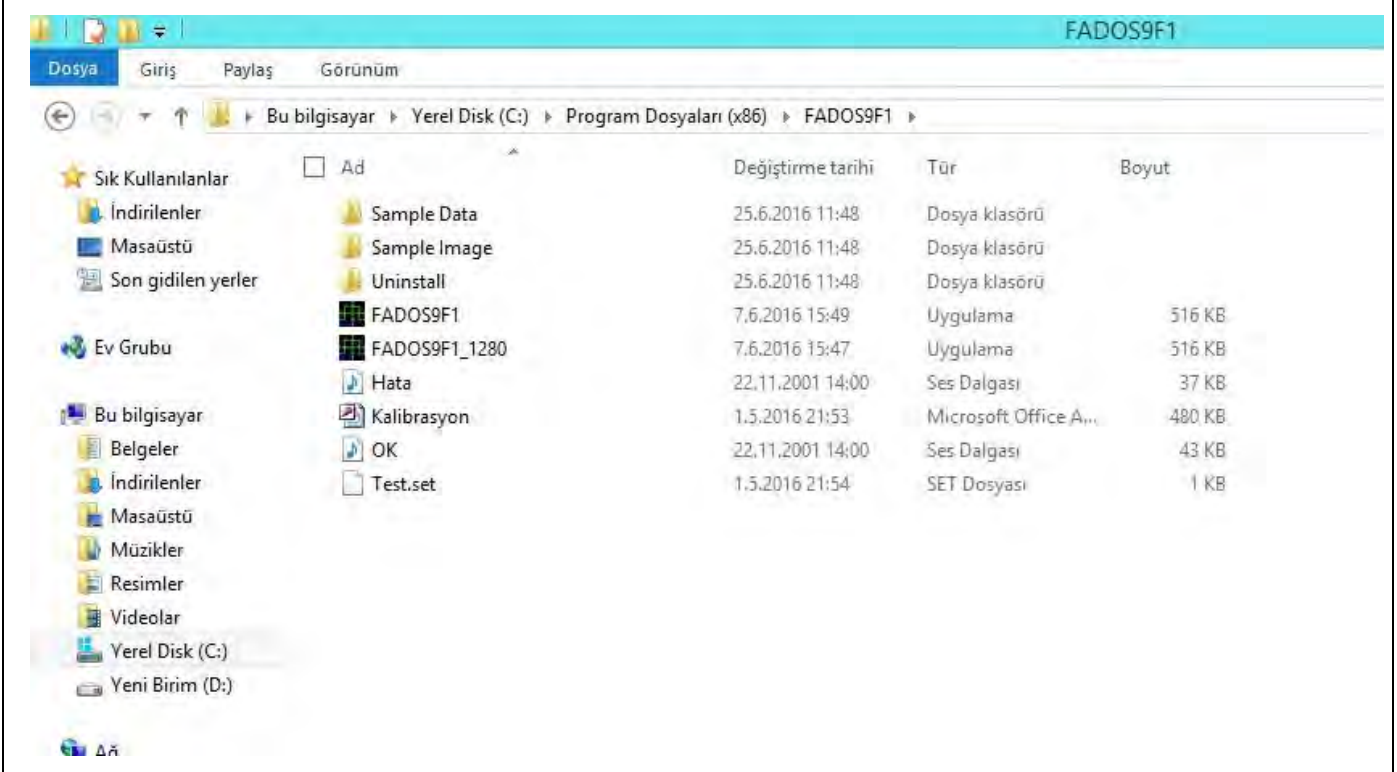


Figure 10: FADOS9F1 Setup

4- After installing the program run FADOS9F1.exe file shown in Figure 10. The FADOS9F1.exe is found in the Program Files(X86)/FADOS9F1 folder.

FADOS9F1_1280 exe is for the monitors with a resolution of 1024x1280.

Loading Driver

1- Connect the FADOS9F1 to the computer using a USB cable. Windows XP will display the message "New Hardware Found", whereupon you can load the driver directly. Insert the CD in to the CD driver and load the program directly.

2- For Windows Vista, Windows 7, Windows 8 or Windows 10, opens the Device Manager.

- Right click on the "My Computer" symbol on the desk top and click on device manager from the manage tab.

Or,

- Click on start
- Click on control panel
- Click on the system icon, and then click on the hardware icon.
- Click on the device manager from hardware.

3- Find the "FADOS9F1 Fault Detector" message in the device manager or find the "USB Serial Converter" Universal Serial Bus manager and right click on it then select "Update Driver".

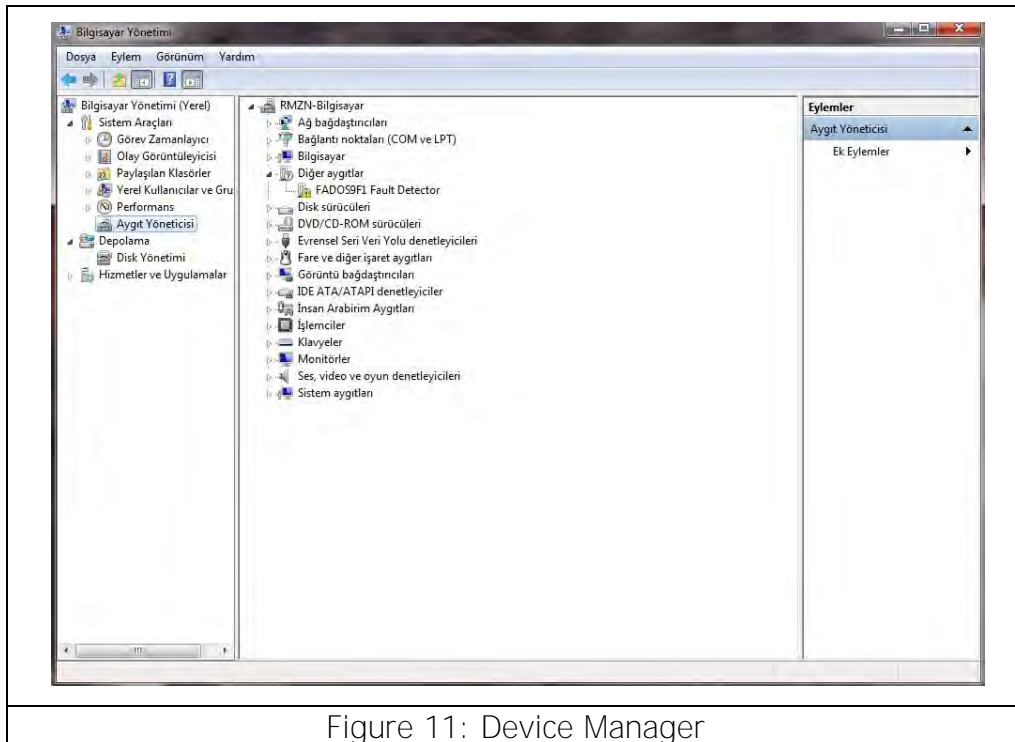


Figure 11: Device Manager

4- Select "Find the Best Driver" and find the FADOS Driver or FADOS Driver W8 in the CD using the browse option.

5- Click on "OK" to load the driver.

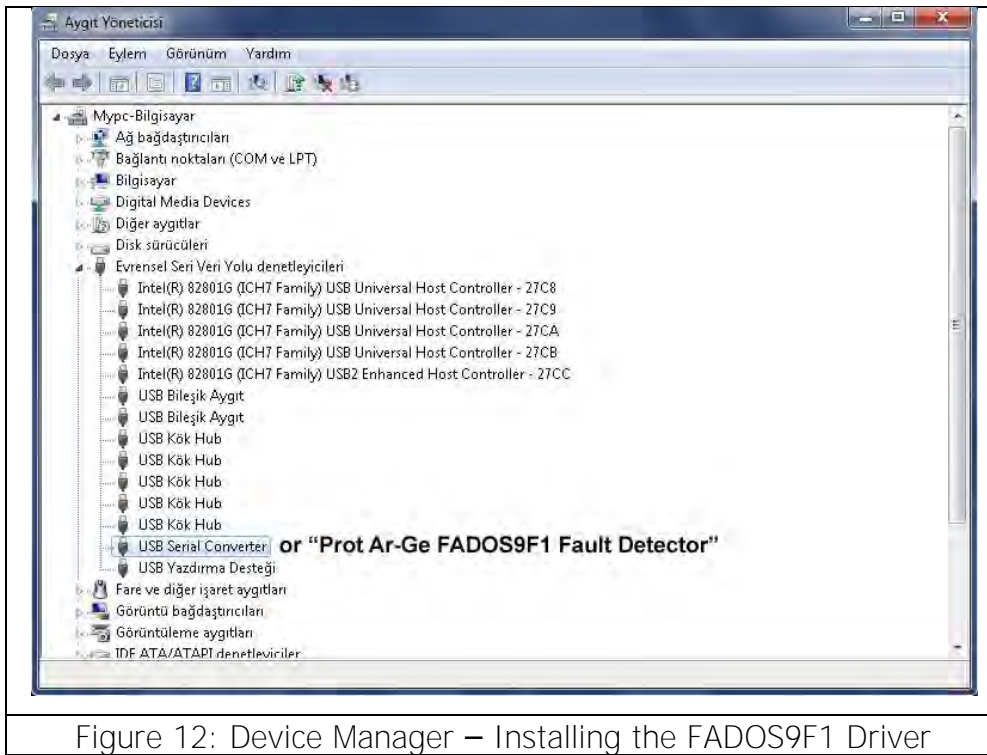


Figure 12: Device Manager – Installing the FADOS9F1 Driver

Note: The **FADOS Driver W8** driver is for the **Windows 8** and **Windows 10** versions. Each product has different calibration settings, so that please do not lost the FADOS9F1 program CD.

CONNECTING THE TEST PROBES

Connect the DC Power Cable (Red-Black Cable) to the Power Connector. IR Sensor Probe is connected to the IR TEMP. Connector. The Oscilloscope Probes and Com Probe (Crocodile) can be attached to all the connectors labeled VI TESTER. The probe with the Red Band is always Channel1, and the probe with the Blue Band is always Channel2. The Crocodile Probe is always "COM". The USB Cable is used for commutations between the computer and FADOS9F1. The Power Adaptor is connected to a mains plug (18 – 20 VDC).

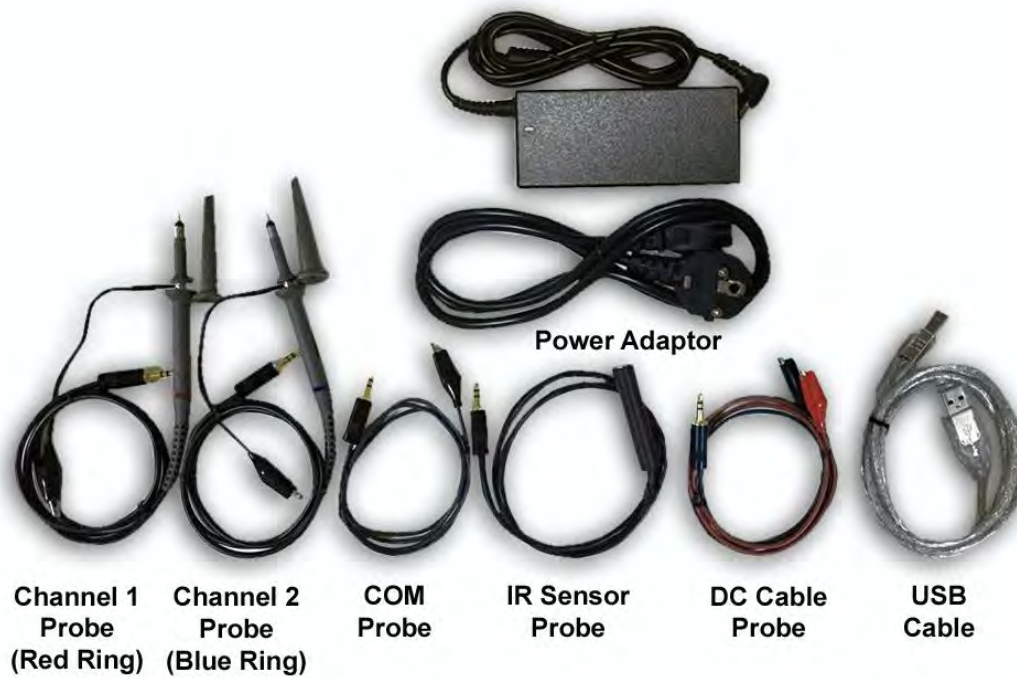


Figure 13: FADOS9F1 Accessory



Figure 14: FADOS9F1 Front View



Figure 15: FADOS9F1 Rear View



Figure 16: Probe in X1 Position

While testing the electronic components in the Fault Detector Test Screen (VI Tester), the Probe should be in the X1 position. No data can be obtained due to the high internal resistance of the X10 stage.

GENERAL USAGE INFORMATION

1. When run software, Power – The IR Temperature Test Screen opens and an input is entered to the VI Tester Screen or Oscilloscope – Analog Output Screen with the VI Tester Button.

While testing the electronic circuit boards, we recommend the user to use the Power – IR Temperature Test feature for testing.

- **Firstly, create good circuit board's "Power Voltage/Current Graph". Then save this graph to memory.**
 - The faulty or suspect electronic circuit **board's "Power Voltage/Current Graph" is compared with the good electronic circuit board's graph.**
 - If the faulty or suspect board draws too much current, it means that one or more components on the board are heating up. Use the IR sensor for trouble shooting the heating components.
 - If defective board draws less current than the intact board; it means an open circuit in **the board. In that case, open the "Oscilloscope Screen" to diagnose the broken circuit,** which the power cannot reach.
 - If the graphic of the faulty (defective) board is the same as the good board, the faulty **component can be diagnosed by opening the "VI Tester Screen".**
2. **Open circuit's graph is in the middle and horizontal position at Test-Fault Detect screen.** Current – Voltage Graph (VI) makes angle according to the value of resistance, capacitor is like circle and ellipse, short circuit is vertical position.

3. In the Medium current mode, in the areas with high resistor values, if the VI graph is closer to the horizontal axis, you can see the resistors with high values more clearly by switching to low current. If the VI graph is too close to the vertical axis, this means that the resistor value is low and you can read the values more clearly by switching to the high current mode.
4. Please test the capacitors in the test frequency mode generally. Use low current when the capacitor value is low and high current if the value is large. If the capacitor value resembles a thin line in high current at the vertical axis, you can see the value more clearly by reducing the frequency from the frequency mode.
5. The pins of a good integrated circuit are generally in form of a dual reverse diode (other than the supply and ground). Although the attached resistors and/or capacitors might affect the graph, the two reverse diodes should be observed. In the output of some integrated circuit only one diode may also be seen. But an image in form of a resistor would most probably mean a defective integrated chip.
6. The capacity test shows the quality of the electrolytic capacitor in particular. The more horizontal this curve is, the higher the quality of the capacitor is. The angle of the deteriorating capacitor makes an angle with the horizontal. If the angle is large, it means a defective capacitor. Because the circuit draws a current while in the board, this test can be deceptive, hence consider this while testing. In case of doubt, remove the capacitor from the circuit and then measure; in this measurement, the test devices may show all of them as intact. The best capacitor quality measurements can be done by **looking at the "Capacity-Resistor Curve" with this product. While making this measurement, adjust the frequency and current to become longer on the vertical axis of the graph, but without forming a multiple and thin graph.**
7. In case of a misshapen capacitor graph due to the effects of the diodes in the circuit, the value of the capacitor can be measured again after eliminating the effects of the diodes.
8. The important issue in trouble shooting is the shape of the graphs and their interpretation. Try to find the defects by comparing when starting. You should be able to distinguish the graphs of the good and defective materials in a short time. The Equivalent circuit diagram and values will aid you in the process. If you concentrate on the values in the equivalent circuit, diagnosing may take longer. Use the values of the components as necessary, but do not well on the values alone like the measurement logic of the test equipment. The evaluation logic of this product is based on the interpretation of the graphs, i.e. interpreting the graphs produced by the computer and generating the equivalent circuit diagram and showing the associated values.

POWER (SUPPLY) - IR TEMPERATURE TEST

When you run the Program, the Power (Energy) - IR Temperature Test Screen is opened. Energize the electronic circuit board in the Power (Energy) - IR Temperature Test section to generate a DC VI Graph. Thus the amount of current drawn by the board can be seen. Moreover, the temperature of the electronic components may also be measured using the IR (Infrared) Sensor. All the control keys to be used for the Power (Supply) IR Test are located on the left hand side of the panel.

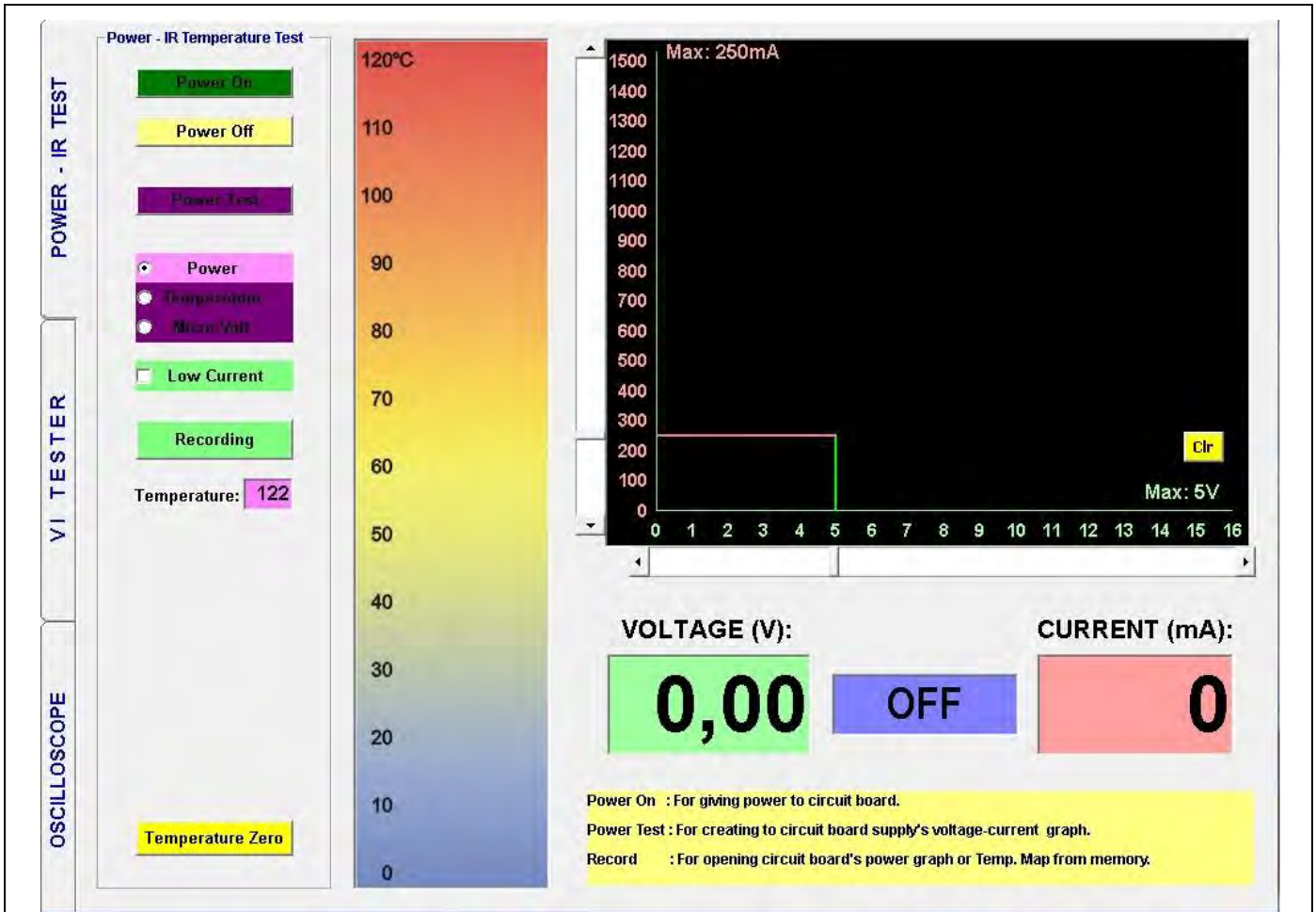
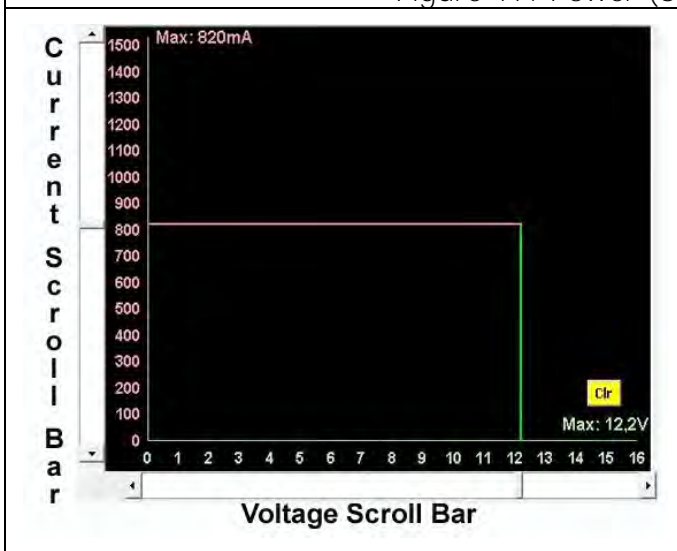


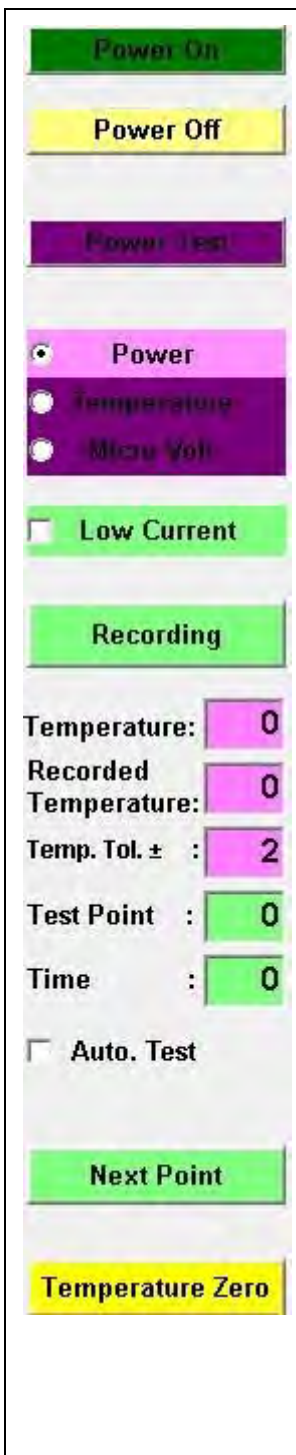
Figure 17: Power (Supply) - IR Test Screen




Current Bar: The current output is adjusted by sliding the bar upwards.

Voltage Bar: The voltage output is adjusted by sliding the bar left or right.

Clr : Deletes the DC Current – Voltage Graph.

 <p>Power On</p> <p>Power Off</p> <p>Power Test</p> <p><input checked="" type="radio"/> Power</p> <p><input type="radio"/> Temperature</p> <p><input type="radio"/> Micro Volt</p> <p><input type="checkbox"/> Low Current</p> <p>Recording</p> <p>Temperature: 0</p> <p>Recorded Temperature: 0</p> <p>Temp. Tol. ± : 2</p> <p>Test Point : 0</p> <p>Time : 0</p> <p><input type="checkbox"/> Auto. Test</p> <p>Next Point</p> <p>Temperature Zero</p>	<p>Power On : The FADOS9F1 gives an "Output" through the DC Power cables. If the electronic circuit board draws more than the current adjusted, the program limits the current to prevent the board from drawing excessive current.</p> <p>Power Off : Cuts off the Voltage.</p> <p>Power Test : Used for generating the "Current/Voltage Graph" of the electronic circuit board's power supply.</p> <p>Power : Selected for the DC Power Test and measurement.</p> <p>Temperature : Selected for the IR – Temperature Test and measurements.</p> <p>Micro Volt : Selected for the Microvolt measurements.</p> <p>Low Current : Selected for accurate measurements between 0-300 milli amperes.</p> <p>Recording : Opens the Records Window.</p> <p>Temperature : Shows the temperature values of the electronic components tested with the IR sensor.</p> <p>Recorded Temperature : Shows the temperature values of the electronic components stored in the memory.</p> <p>Temp. Tol. ± : Shows the ± Temperature Tolerance value. The user can change the tolerance.</p> <p>Test Point : Shows the serial number of the electronic component stored in the memory.</p> <p>Time : Counts down from 90 seconds.</p> <p>Auto Test : If the electronic component is within the tolerance value of the data stored, the next data are opened automatically.</p> <p>Next Point : Opens the next data stored.</p> <p>Temperature Zero : Used for compensating the IR sensor for the room temperature.</p>
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<p>VOLTAGE (V):</p> <p>10,70</p>	<p>CURRENT (mA):</p> <p>R = 198,1</p> <p>54</p>	<p>Voltage : Shows the Maximum Voltage.</p> <p>R : Shows the Circuit Resistance.</p> <p>Current (mA): Shows the current drawn by the Circuit.</p>
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 <p>20</p> <p>10</p> <p>0</p>	<p>Bold Green Line : Shows the temperature values of the electronic components.</p> <p>Thin Green Line : Show the ± Temperature Tolerance, i.e. If the temperature of the component is 8 °C, and the Tolerance value is 2, the green lines run between 6 °C and 10 °C.</p>
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Power (Supply) Test - DC Voltage Current Graph

1. The Power Cable is connected to the electronic circuit supply. Red Cable (+), Black cable (-). (Figure 18)
2. The maximum Voltage and Current values, which the circuit operates on, are adjusted from the scroll bars. (Figure 19)
3. The "Power Test" Button is clicked to energize the electronic circuit board. The "DC Voltage - Current Graph" is generated from "0 Volt to maximum Voltage in 100 mV steps. (Figure 20)
4. The "DC Voltage - Current Graph" is stored (recorded) by clicking on the "Recording" Button. (Figure 21)
5. The "Clr" Button is clicked to delete the "DC Voltage - Current Graph" from the screen. (Figure 22)

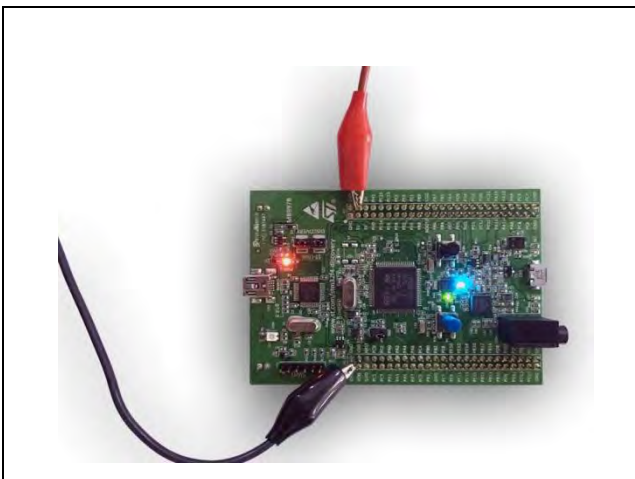


Figure 18: Connecting the Power Cables to the Circuit (Step 1)

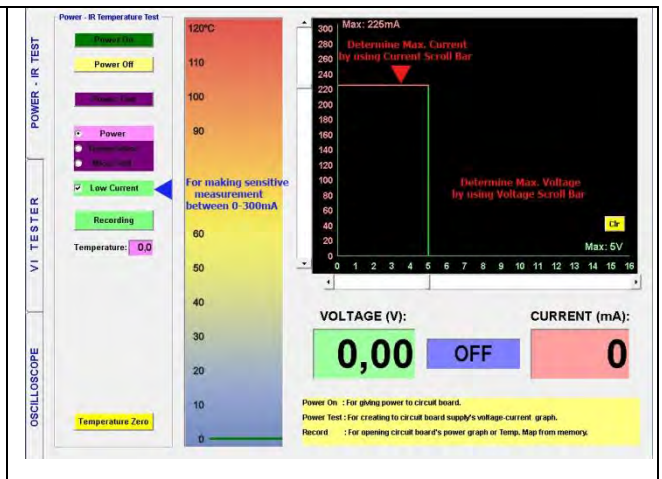


Figure 19: Adjusting the Voltage and Current (Step 2)

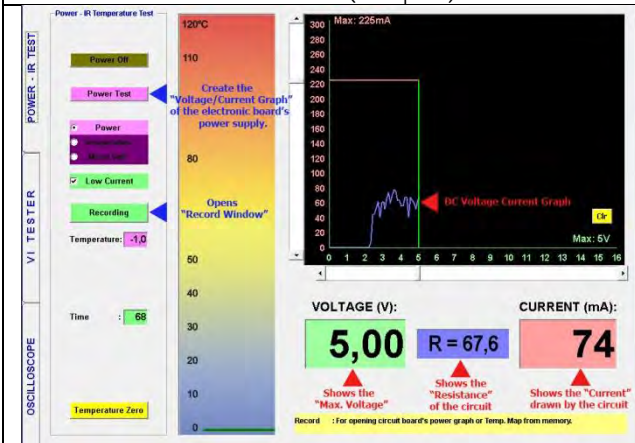


Figure 20: Generating the DC VI Graph (Step 3)

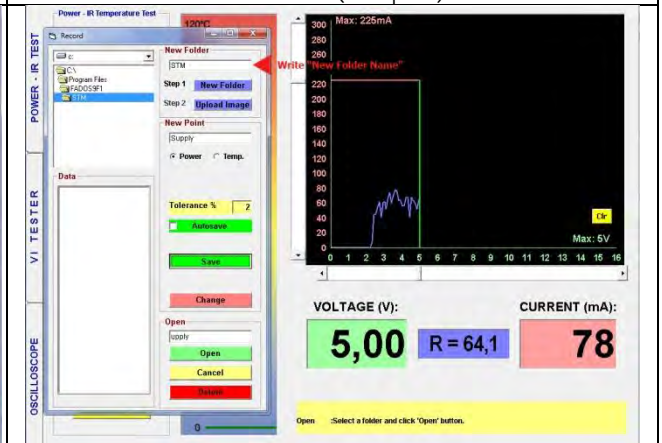
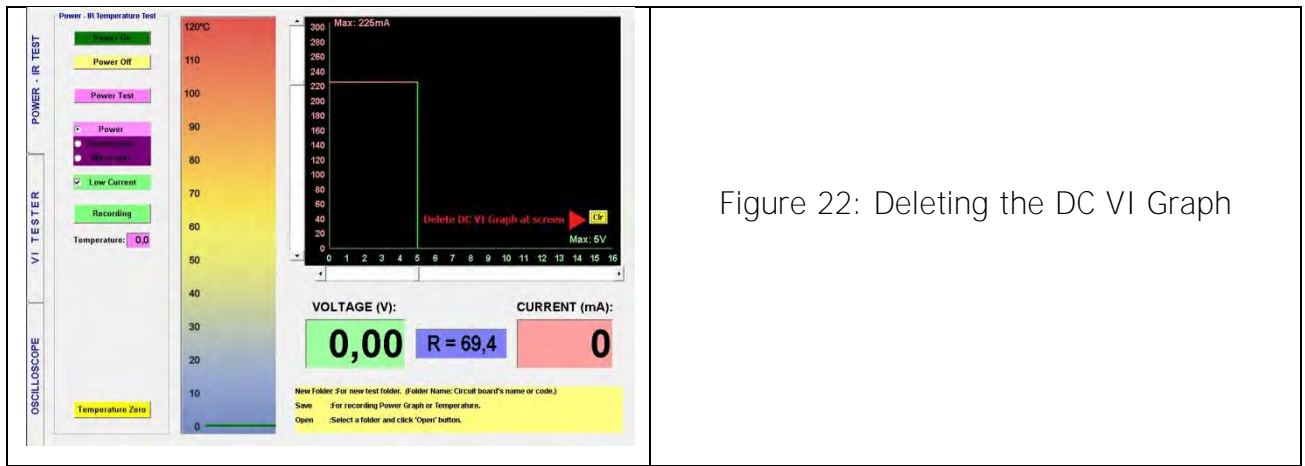


Figure 21: Recording the DC VI Graph (Step 4)



Saving the Power (Supply) DC VI Graph and Defining the Recording Window

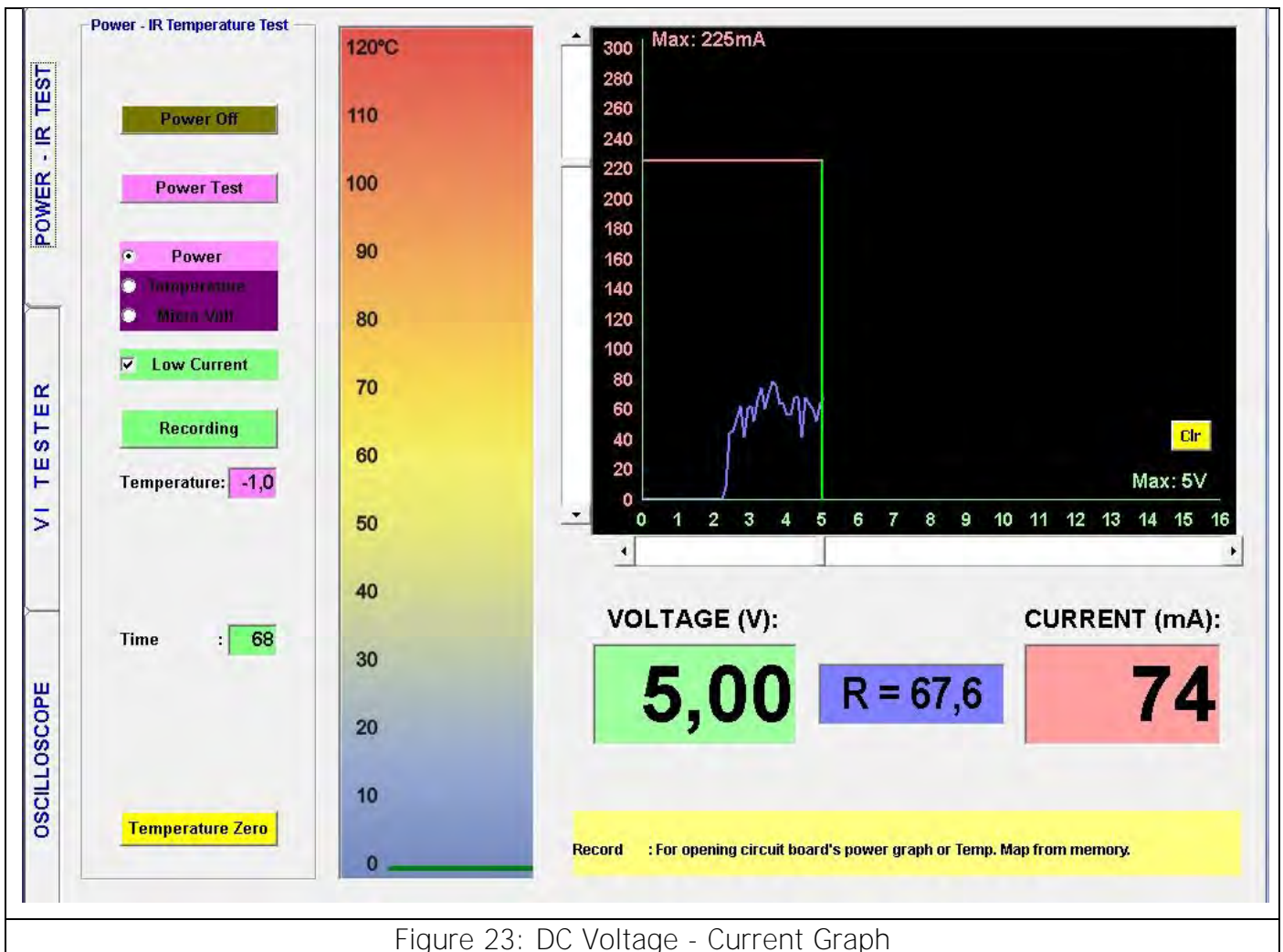




Figure 24: Recording Window

New Folder : Opens a folder in the computer's hard disk with the entered name to the New Folder line.

Upload Image: The software opens a screen for the circuit photo saved in the computer.

New Point : The name of the data to be saved in written.

Power : If the DC Voltage/Current Graph is to be saved, "Power" is selected.

Temp. : If the temperature value of the component is to be saved, Temp. is selected.

Tolerance % : Defines the tolerance range for the data to be saved.

Save : Saves the values for the (New point) to folder (New Folder) under name given.

Change : In order to change data for a test point saved before, the test point is selected from "Data" and the saved data are changed by clicking on the "Change" button.

Open : Opens the selected saved test data in "Data".

Delete : Deletes the data for the test point selected from "Data" from the computer.

Cancel : Closes the recording window.

Data : Shows the recorded data.

Comparison of the Power (Supply) DC VI Graph with the Defective (Faulty) Electronic Circuit Boards DC VI Graphs

Opening the Recorded Data : Click on the "Recording" button to open the "Record Window". Find the file created with a new name. Select the "Pwr_Dat." data from "Data". Open the recorded data by clicking on the "Open Button" (Figure 25 - 26).

- The Power Cable is connected to the power supply of the electronic circuit Red Cable (+), Black cable (-). (Figure 27)
- The "Power Test" button is clicked to generate the DC VI Graph of the defective or suspect board and is compared with the recorded data. (Figure 28)

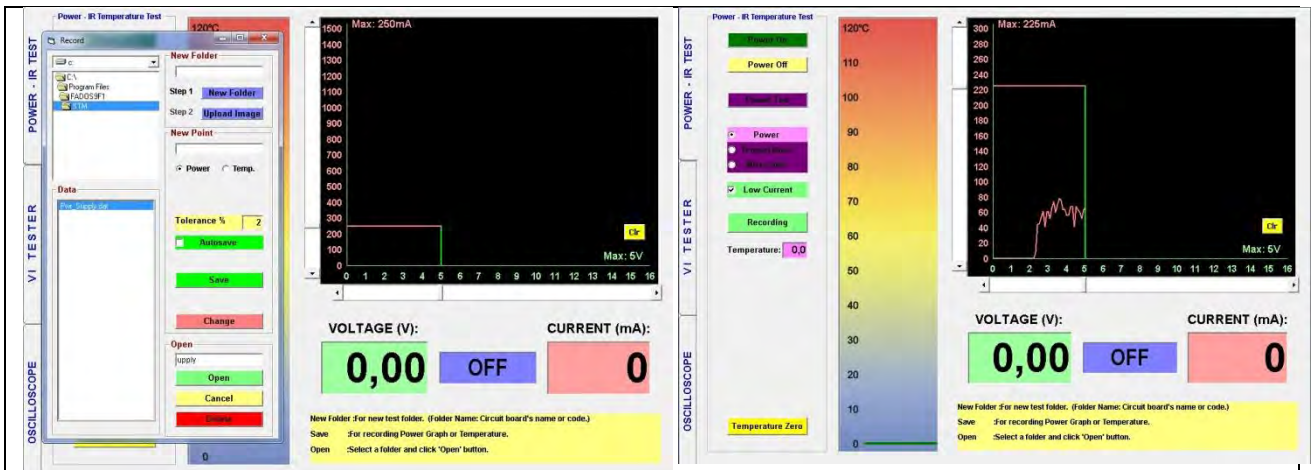


Figure 25: Opening the Recorded Data (Step 1)

Figure 26: (Step 2)

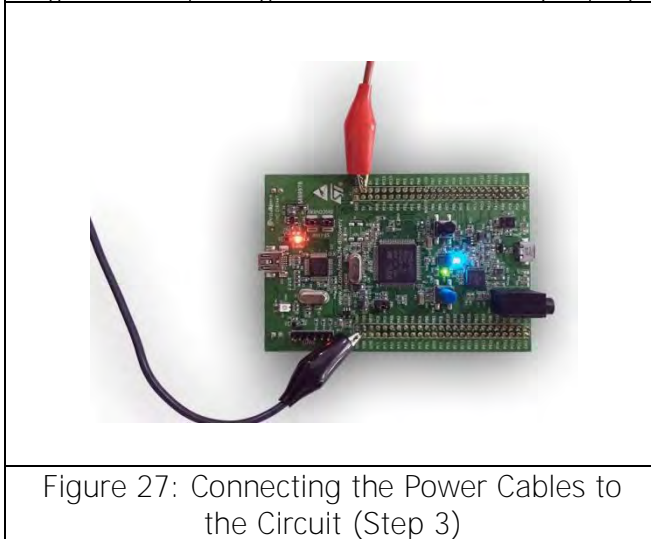


Figure 27: Connecting the Power Cables to the Circuit (Step 3)

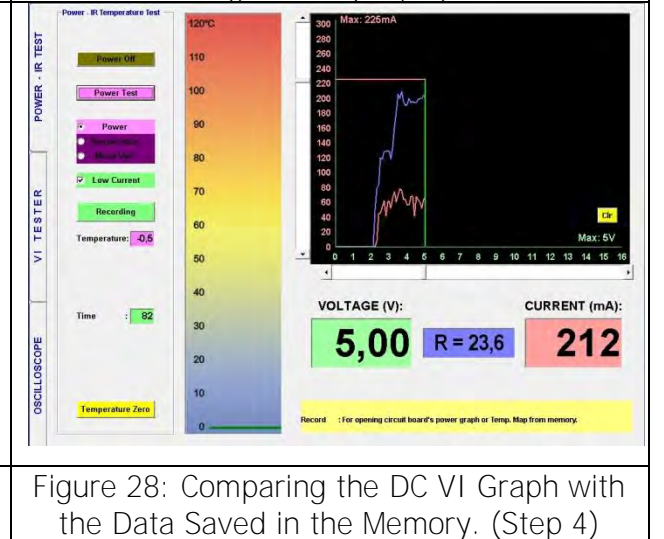


Figure 28: Comparing the DC VI Graph with the Data Saved in the Memory. (Step 4)

Note: The data recalled from the memory is shown in Red on the screen. The data for the electronic circuit board under test is shown in Blue.

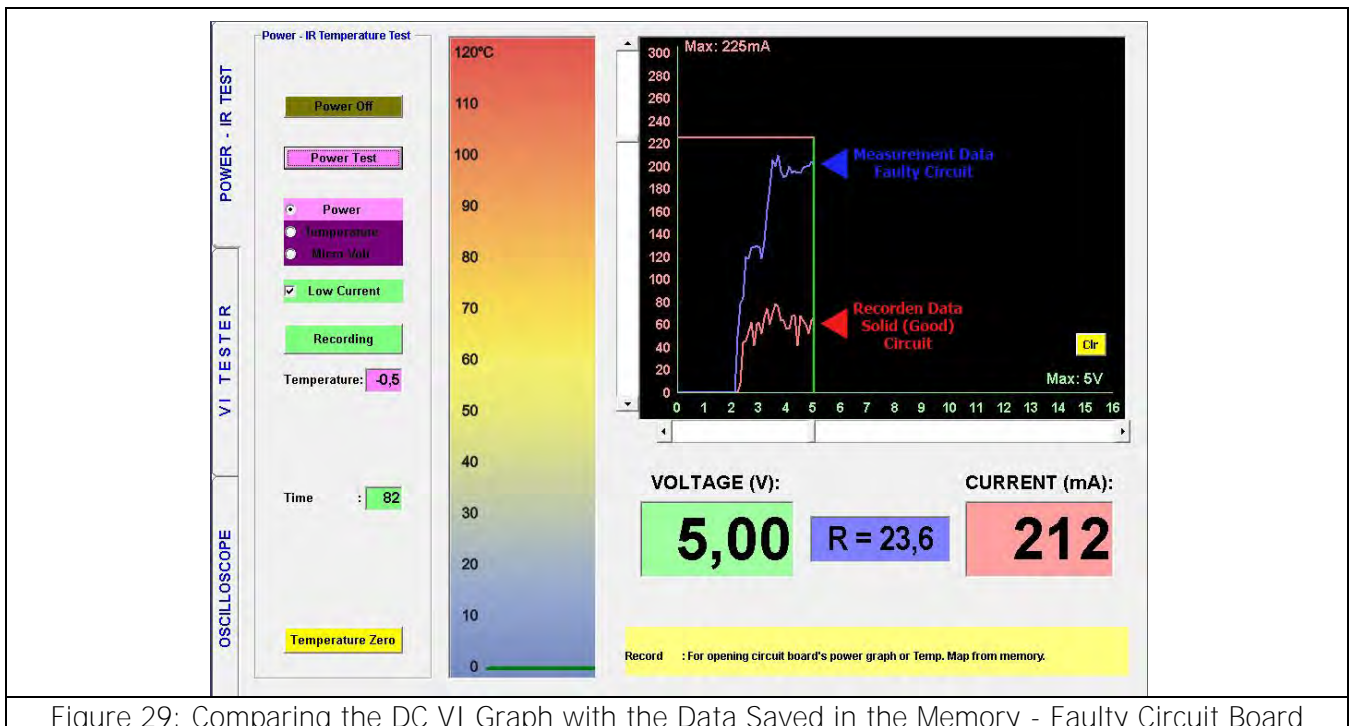


Figure 29: Comparing the DC VI Graph with the Data Saved in the Memory - Faulty Circuit Board

Power - IR Test Screen 2 graphs are displayed. If the defective electronic circuit board draws more current than the intact (working) electronic circuit board (as shown in Figure 29), this means that one or more components on the board are drawing current. The component that draws current heats up. The IR Sensor is used for diagnosing the heating components.

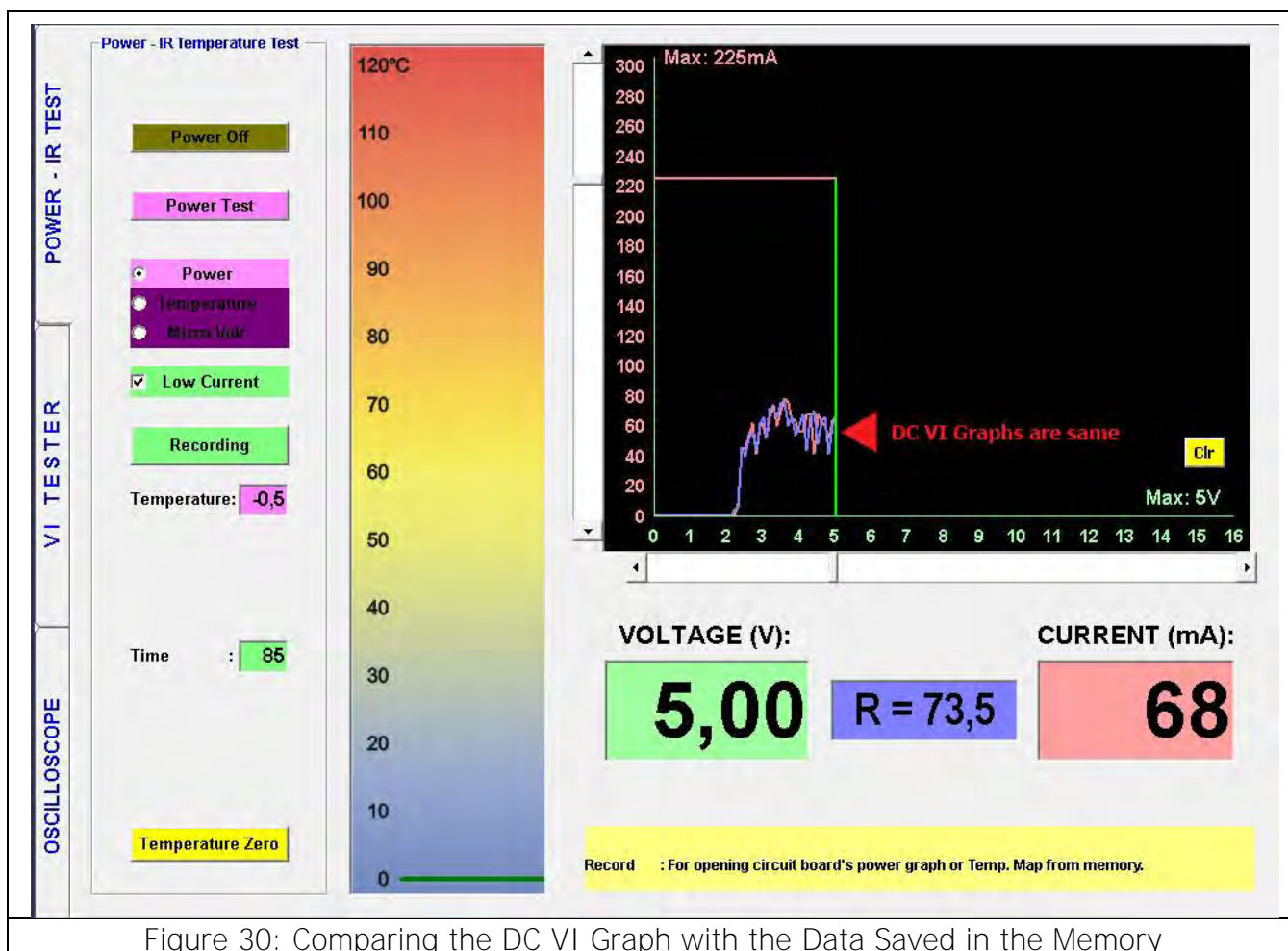


Figure 30: Comparing the DC VI Graph with the Data Saved in the Memory

If the graph of the defective or suspect board is same as the intact board (as seen in Figure 30), the "VI TESTER" screen is opened and the Analog Signal Analysis method is used to diagnose the defective components.

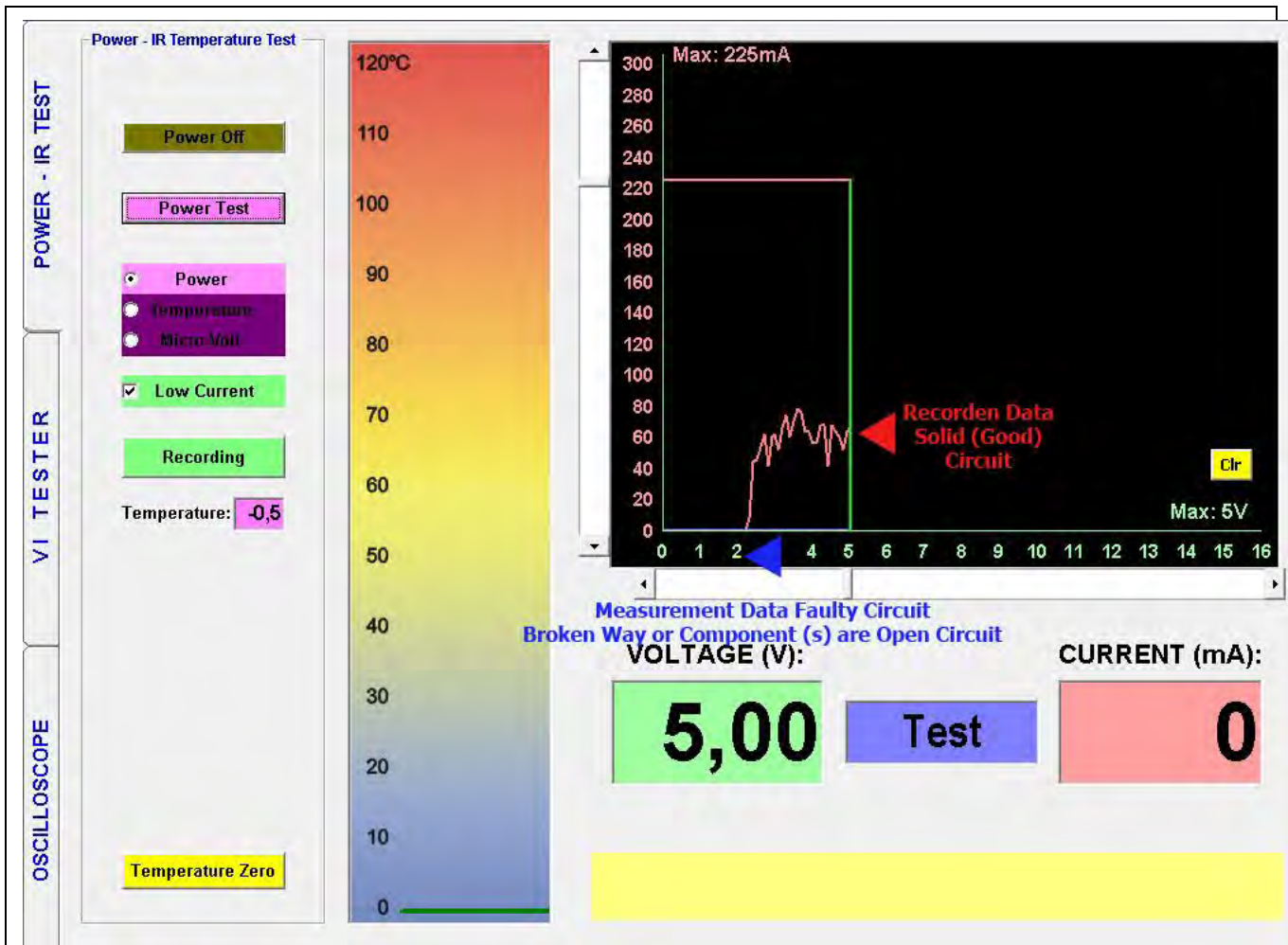


Figure 31: Comparing the DC VI Graph with the Data Saved in the Memory - Defective Circuit Board

If the defective board draws less current than the intact board (as shown in Figure 31); it means an open circuit in the defective electronic circuit board. **In such a case, the "Oscilloscope Screen" is opened to diagnose the broken circuit that cannot receive power.**

IR TEMPERATURE TEST

Recording the Component Temperatures

One of the unique features of the FADOS9F1 is the ability to measure the temperature of the electronic components with the Infrared (IR) Sensor and record the measurement temperature data to the memory. The recorded data is compared with the defective electronic circuit board data later on to diagnose the current drawing component (defective) easily and rapidly.

1. The maximum operating Voltage and Current of the circuit is adjusted using the scroll bars. (Figure 32)
2. The Power Cable is connected to the electronic circuit power supply. Red Cable (+), Black Cable (-). (Figure 33)

3. The "Power Test" Button is clicked to energize the electronic circuit board. The "DC Voltage - Current Graph" is generated from "0 Volt to max. Volt in 100 mV steps."

Note: In the IR Temperature Test, the electronic circuit board may also be energized by clicking the "Power On" Button. (Figure 33)
4. When the Voltage limitation is reached, if the Electronic circuit board is drawing current, the "Timer" starts counting down from 90 seconds to 0. (Figure 34)
5. The temperature selection is clicked and the "Recording" Button is pushed to open the Recording Window. The name of the folder to be recorded in the New Folder is entered. (if already entered for the DC Voltage - Current Graph, the folder to be saved in is selected) The photo of the electronic circuit board is selected from Image Upload. The photo is uploaded to the software by clicking "open" button and is displayed on the screen (Figure 35 - Figure 36 - Figure 37)
6. The component to be recorded is marked on the photo (thus selected); and if desired, the component name or code of the new point is written. (Figure 38)
7. The IR sensor is position on a point on the desk (a few mm above) and the "Temp Zero" button is pushed (Figure 39)
8. The IR sensor is brought over the component to be measured when the timer resets. (Figure 40)

Note: Do not touch the IR sensor to the component. Measure the temperature of the components from a few mm above.
9. When the Timer resets, the "Save" button is clicked to save the data (Figure 41)

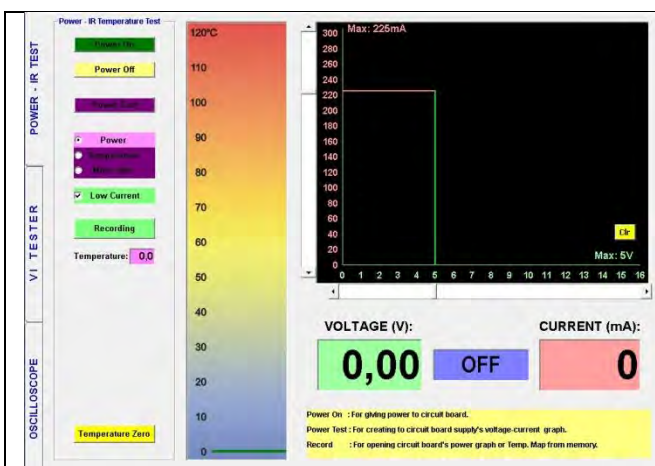


Figure 32: Adjusting the Voltage and Current (Step 1)

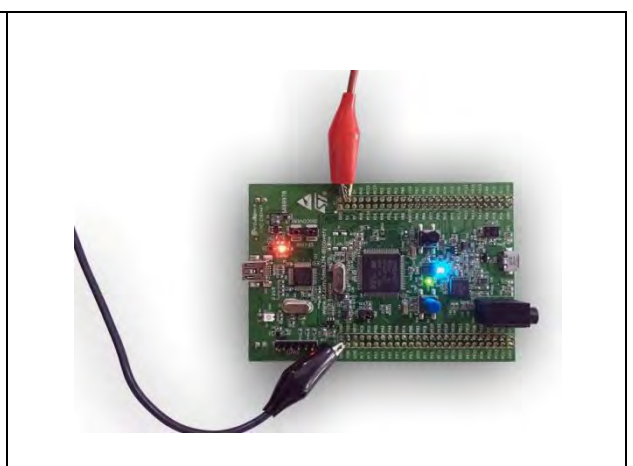


Figure 33: Connecting the Power Cables to the Circuit - Energizing (Step 2)

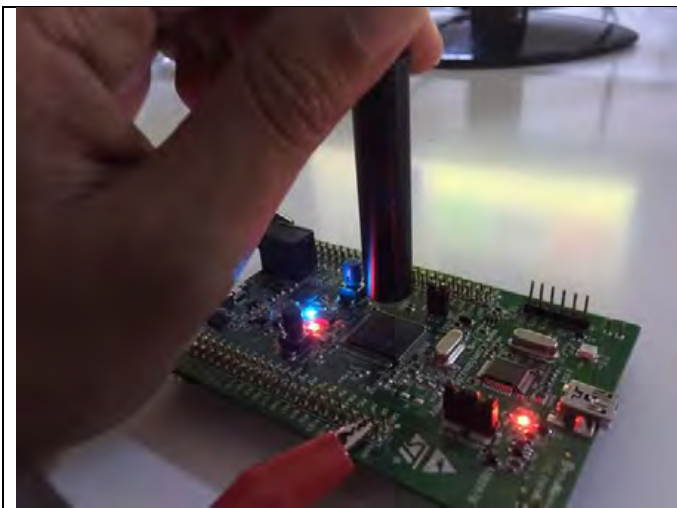


Figure 40: IR Sensor Component Temperature Measurement (Step 9)

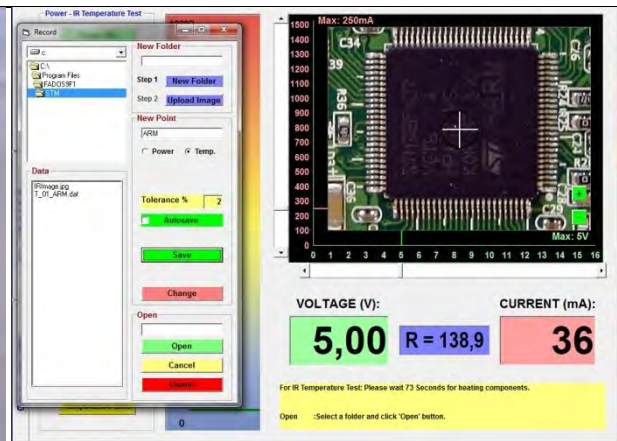


Figure 41: Recording the Temperature Data of the Component measured (Step 10)

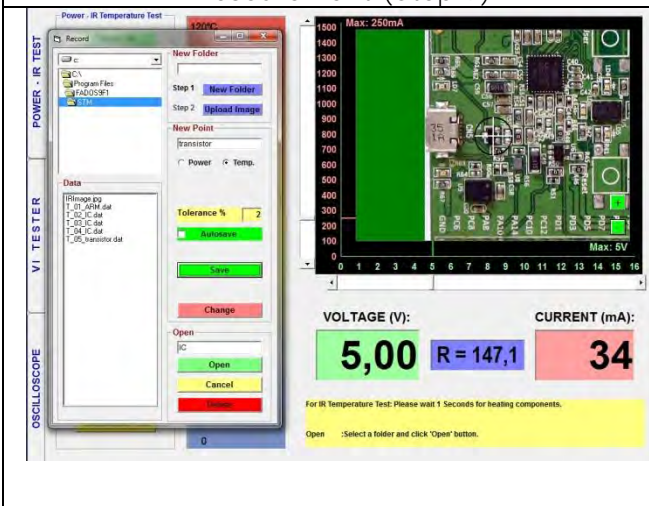


Figure 42: Recording the Electronic Material's Temperature Data

Defective Electronic Circuit Temperature Check

1. The maximum operating Voltage and Current of the circuit is adjusted using the scroll bars. (Figure 43)
2. The Power Cable is connected to the Electronic Circuit Power Supply. Red Cable (+), Black Cable (-). (Figure 44)
3. The "Power Test" Button is clicked to energize the electronic circuit board. The "DC Voltage-Current Graph" is generated from "0 Volt to max. Volt in 100 mV steps.
Note: in the IR Temperature Test, the electronic circuit board may also be energized by clicking the "Power On" Button. (Figure 45)
4. When the Voltage limitation is reached, if the Electronic circuit board is drawing current, the "Timer" starts counting down from "90" seconds to "0". (Figure 45)
5. The temperature selection is clicked and the "Recording" Button is pushed to open the recording window. The folder created with the New name is found. The "T_01.Dat" data is selected from "Data". The recorded data is opened by clicking on the "Open Button"

The component, whose temperature was recorded, is seen in the photo. The data for the component recorded are displayed on the left side screen. (Figure 46)

6. The IR sensor is position on a point on the desk (**a few mm above**) and the "Temp Zero" button is pushed. (Figure 47)

7. The IR sensor is brought over the component to be measured when the timer resets. (Figure 48)

Note: Do not touch the IR sensor to the component. Measure the temperature of the components from a few mm above.

8. The temperature of the first component is measured. If the value measured is within the recorded tolerance range of the recorded data, a sound indicating conformity is emitted, and **the "Next Point" is clicked to open the second recorded data. If the value measured is not within the recorded tolerance range of the recorded data, a sound indicating non-conformity is emitted and the current drawing component is thus diagnosed. If "Auto Test" is selected and the value measured is within the recorded tolerance range of the recorded data, the next recorded data is opened after a few seconds later automatically.** (Figure 49)

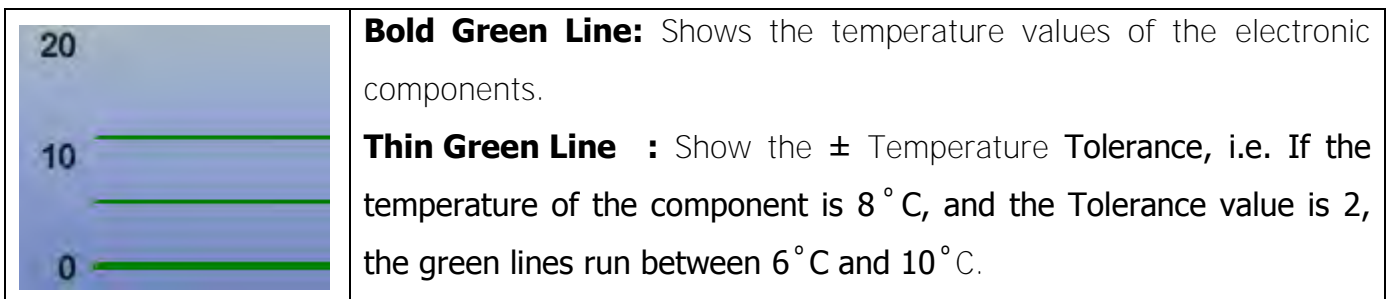


Figure 43: Adjusting the Voltage and Current (Step 1)

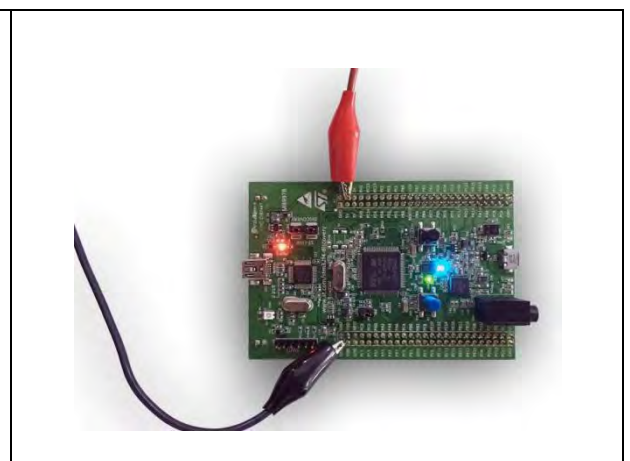


Figure 44: Connecting the Power Cables to the Circuit - Energizing (Step 2)

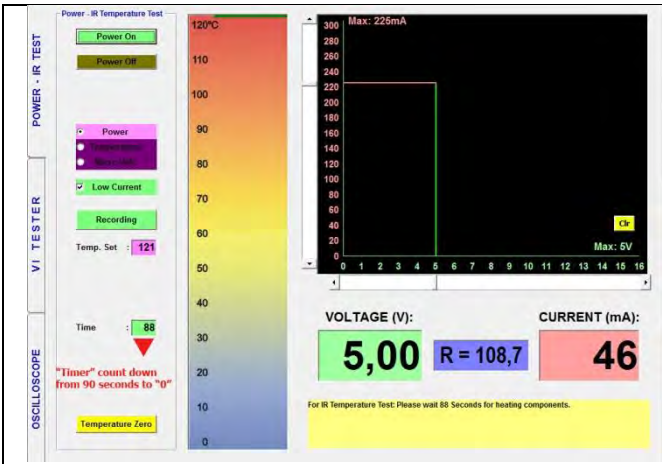


Figure 45: Timer 90 Seconds (Step 3)

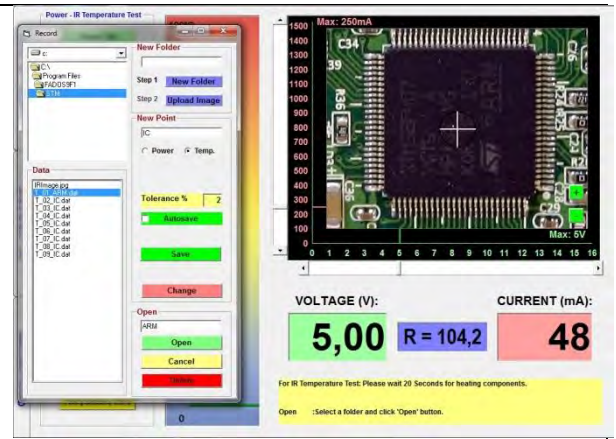


Figure 46: Opening the Recording Window (Step 4)

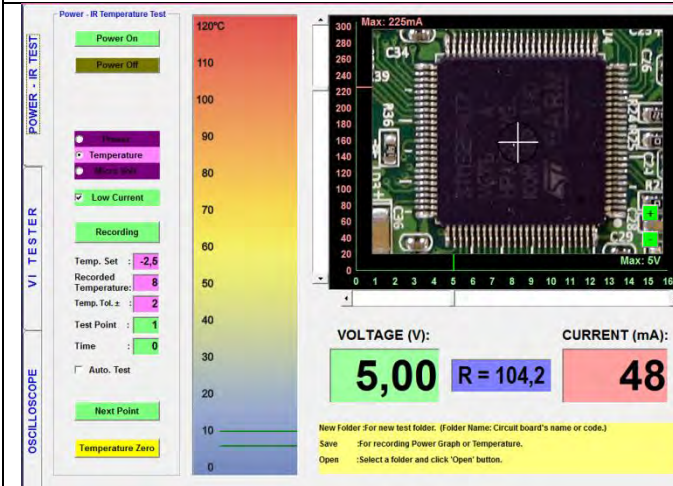


Figure 47: Opening the Recorded Data (Step 5)

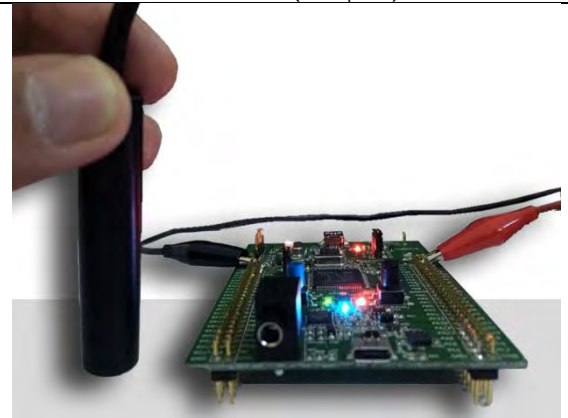


Figure 48: Resetting the IR Sensor Temperature according to the Measurement Point (Step 6)



Figure 49: IR Sensor Component Temperature Measurement (Step 7)

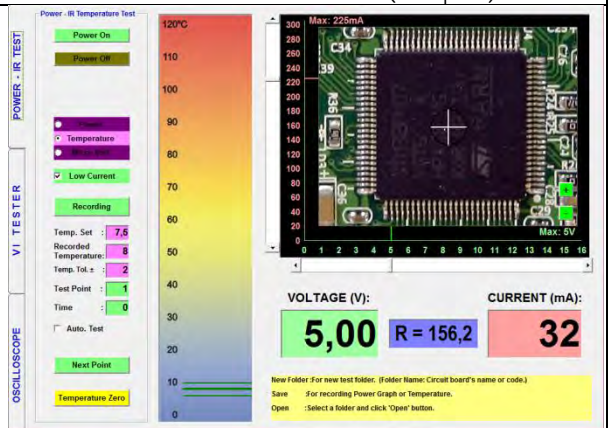
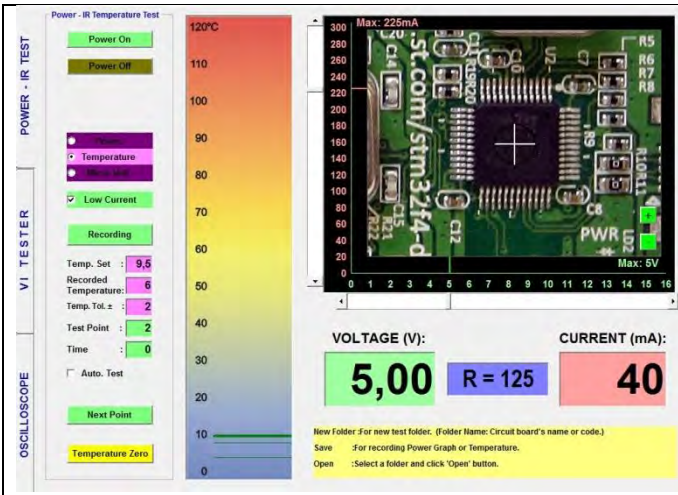


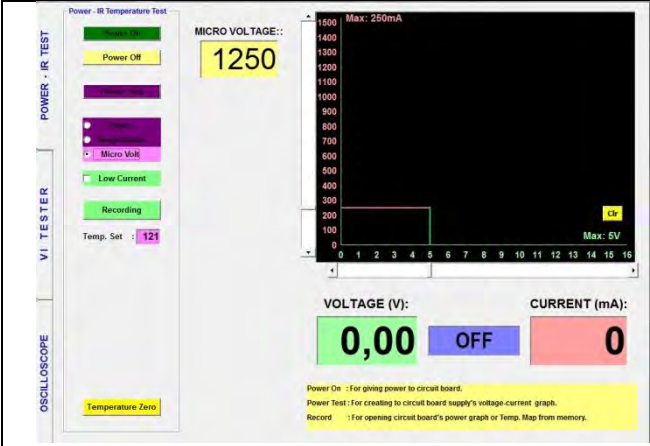
Figure 50: Comparing the Temperature Measured with the Data Saved in the Memory (Step 8)



If the value measured is within the recorded tolerance range of the recorded data, a sound indicating conformity is emitted, and the "next point" is clicked to open the second recorded data. If the value measured is not within the recorded tolerance range of the recorded data, a sound indicating non-conformity is emitted and the current drawing component is thus diagnosed.

Figure 51: Comparing the Temperature Measured with the data Saved in the Memory (Step 8)

Micro - Voltage



Micro - Volt: The FADOS9F1 may also be used for micro - volt measurements. Select the Micro-Volt option to open the Micro Voltage screen. Connect one of the probes of the Oscilloscope to the IR connector and conduct the microvolt measurement. You can measure the values below Maximum 2,5 μV.

Figure 52: Micro Volt

VI TEST - FAULT DETECTION SCREEN FEATURES

The VI Tester button is clicked in the FADOS9F1 program to open the VI Tester screen.

The FADOS9F1 operates by injecting a current-limited sinusoidal wave touched on the electronic circuit board through a series resistor and shows the Voltage – Current graph on the computer screen. The Voltage/Current rate is called "**V/I**", but is also called as the **Analog Signal Analysis** (Analog Signature Analyze – ASA) or **Impedance Test** by some sources as well. The Current–Voltage Analysis (Analog Signal Analysis) is a test conducted without applying power to the electronic circuit board and is used for eliminating the failures in the electronic circuit boards.

In addition to the above features, the computer software analyzes the Voltage-Current graph and shows the equivalent circuit diagram of the point contacted and the values of the associated components and those features are aimed at informing the user as an aid in trouble shooting the failures easily. With the FADOS9F1, the defective component is identified from the VI graph and the equivalent circuit diagram is intended for information only, since finding the defect just by looking at the equivalent circuit diagram may not be possible.

Note: While comparing two electronic circuit boards, there may be small differences in the circuit damages, even if the graphs may be identical. This does not indicate a defect in the board compared, since the main purpose is observing a difference between the VI graphs, hence the electronic circuit board under test may be considered as good.

While conducting a V/I graph screen test, connect the Probe crocodile or COM (Crocodile) probe to the electronic circuit board's chassis. **And touch the other probe to point to be tested with the device.** The device applies a signal to the point touched through the probe and the software runs a scan from negative voltage to positive voltage.

For example, if a 6V test voltage is selected, the FADOS9F1 applies a sinusoidal signal from -6V to +6V. The VI graph of the Electronic component is displayed on the screen. Each electronic material has its own unique characteristic curve (VI graph).

All the keys to be used for trouble shooting are placed on the left hand side of the panel.

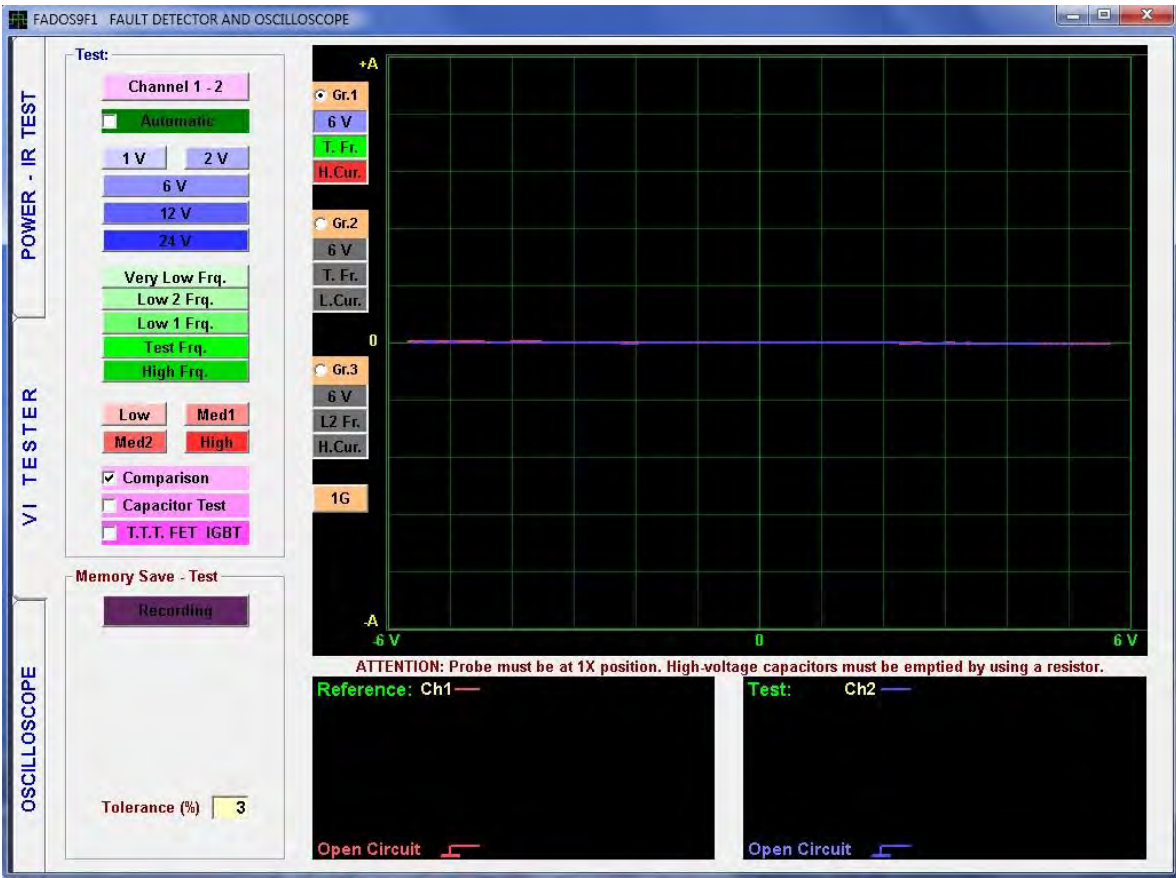


Figure 53: Fault Detector - VI Tester Screen

Channel 1 - 2

Automatic

1 V 2 V

6 V

12 V

24 V

Very Low Frq.

Low 2 Frq.

Low 1 Frq.

Test Frq.

High Frq.

Low Med1

Med2 High

Comparison

Capacitor Test

T.T.T. FET IGBT

Recording

Memory Save - Test

Recording

Test Point: 1

Point: R1

<--- --->

Tolerance (%) 3

Channel 1 - 2 : Used for selecting the Channels. The Channel button can display only the Channel1, Chanel2 or both channels simultaneously on the screen. Using Channel 1 and 2 at the same time is recommended.

Automatic : When this feature is selected, software determines the most suitable of the Voltage, Frequency and Current stages according to the characteristics of the point touched automatically. Click on automatic again to disable the automatic mode.

Voltage Stage(s) : The voltage to be applied to the board is selected by manually setting the $\pm 1\text{ V}$, $\pm 2\text{ V}$, $\pm 6\text{ V}$, $\pm 12\text{ V}$, $\pm 24\text{ V}$ stages from the voltage stage selector. Only one voltage may be selected at a time for a given test.

Frequency Stage(s) : The Frequency to be applied to the board is selected by manually setting the Very Low Frequency, Low 2 Frequency, Low 1 Frequency, Test Frequency, High Frequency stages from the Frequency stage selector. Only one Frequency may be selected at a time for a given test.

Current Stage(s) : The current to be applied to the board is selected by manually setting the Low Current, Medium1 Current, Medium2 Current, High Current stages from the Current stage selector. Only one Current may be selected at a time for a given test.

Comparison : We can compare various points on the intact and defective boards when this feature is selected.

Capacitor Test : We can measure the internal resistance of the capacitor and determine its quality when this feature is selected.

T.T.T. FET IGBT : When selected, this function determines the type of the T.T.T. FET IGBT etc. semi-conductors.

Recording : Opens the Recording window. The recording window menu is used for Recording or retrieving the recorded data.

Test Point : Shows the serial number of the point under test.

Point : Shows the name or code of the point under test.

← : Opens the previous test point.

→ : Opens the next test point.

Tolerance % : Defines the tolerance range for the test point. It can be changed by the user.

Graphs for 3 different settings as Gr.1: Gr.1, Gr.1 and Gr.3 (voltage – frequency – current) can be selected, which allows switching rapidly.

1G, 2G, 3G : 1, 2 or 3 graphs of different settings can be displayed on the screen simultaneously.

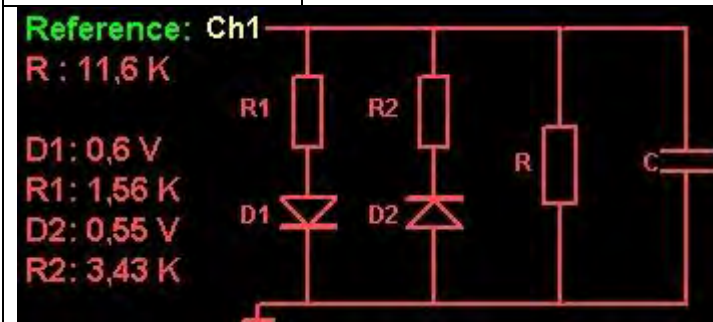
Gr.1

6 V

T. Fr.

H.Cur.

1G



Reference: When the data are recorded in the memory, the data in Channel1 (reference) are also recorded in the memory. Shows the equivalent circuit diagram and values of the electronic material under test.

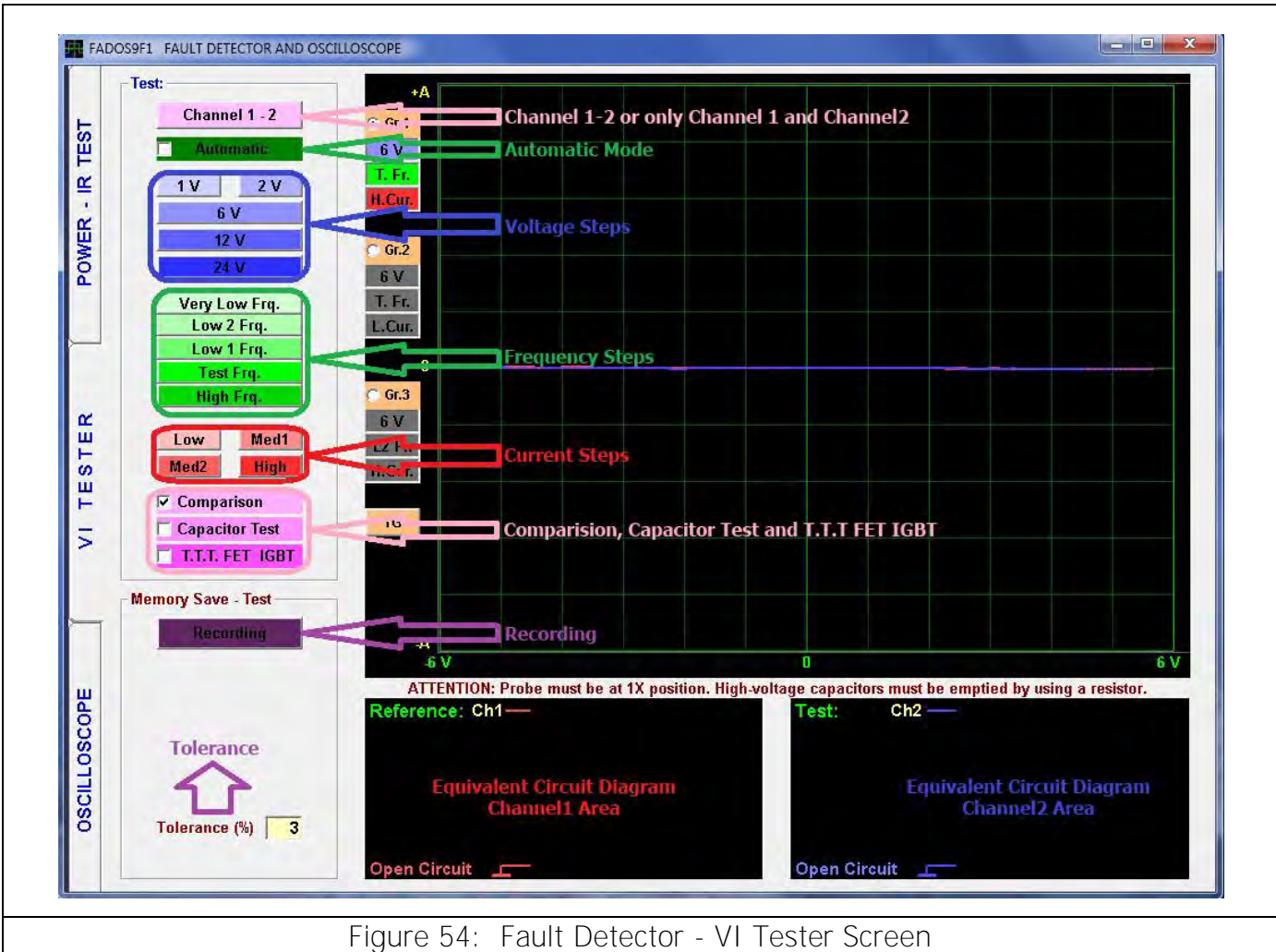


Figure 54: Fault Detector - VI Tester Screen

OPEN CIRCUIT - SHORT CIRCUIT

Open circuit is like a broken road between the component under test and the chassis, which causes zero current flow and maximum voltage drop between the test terminals.

The zero current and maximum voltage is represented with a straight line running from the left side of the screen to the right side (Figure 55 Channel2 Open Circuit).

The VI Tester screen is divided into small squares of same size. (as shown in Figure 55). The squares on the horizontal axis provide information about the test voltage selected. For example, if a 6 volt test voltage is selected, each square represents 1 volt. This is explained in detail in page 38.

Short circuit (Figure 55 Channel1 Short Circuit) causes maximum current flow and zero voltage drops between the test terminals.

Vertical Axis provides information on how much current the electronic material draws. While comparing; the defective component may conduct the same voltage as the intact component, may draw more or less current. We can see that easily by looking at the vertical axis.

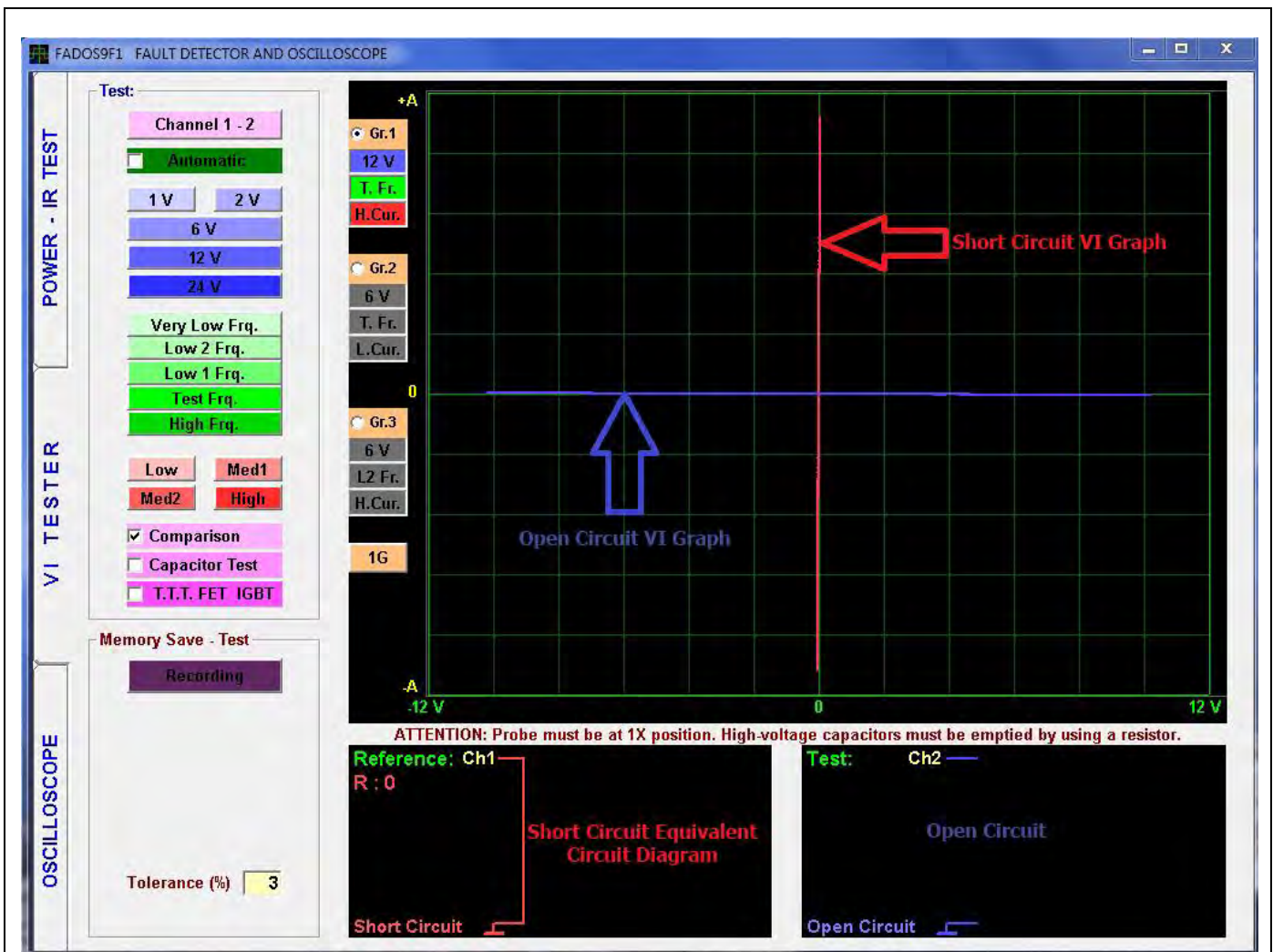


Figure 55: Short Circuit Graph (Channel1) - Open Circuit Graph (Channel2)



Figure 56: Short Circuit (Channel1) - Open Circuit (Channel2)

If we connect the Channel1 probe to the crocodile (Com), a short circuit is created between Channel1 and crocodile.

Moreover, we can discern which probe is probe is Channel1 and Channel2 by making a short circuit.

Voltage Selection

The FADOS9F1 test voltage stages are $\pm 1V$, $\pm 2V$, $\pm 6V$, $\pm 12V$ and $\pm 24V$. The FADOS9F1 tries to apply a current-limited sinusoidal test voltage in the above test voltage values to the point selected on the electronic circuit board through a series resistor.

VI Test screen is also divided in to squares of the same size. The squares on the horizontal axis provide information on the voltage ranges.



Figure 57: If the Test Voltage 1V, Each Square Represents 0,5V.



Figure 58: If the Test Voltage 2V, Each Square Represents 0,5V.

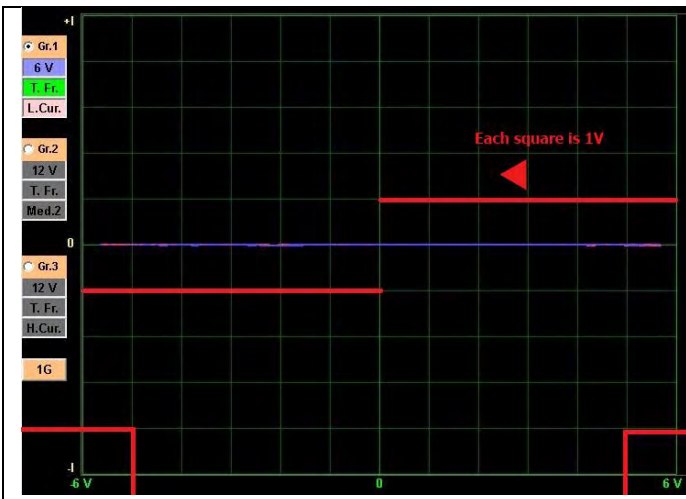


Figure 59: If the Test Voltage 6V, Each Square Represents 1V.



Figure 60: If the Test Voltage 12V, Each Square Represents 2V.

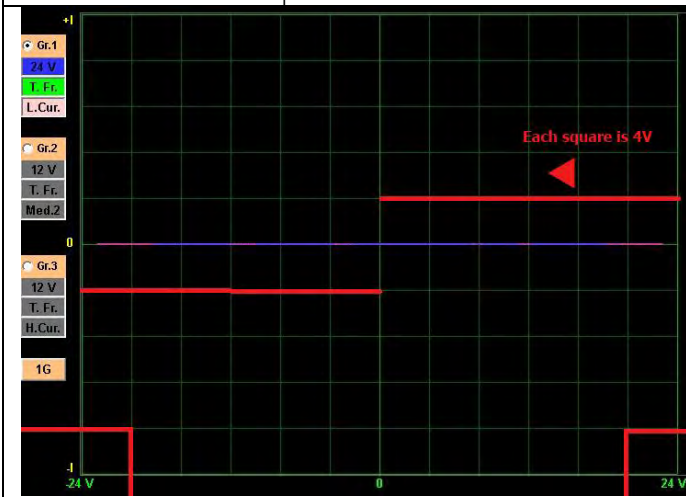


Figure 61: If the Test Voltage 24V, Each Square Represents 4V.

Test Voltage	Square Voltage
±1V	0,5V
±2V	0,5V
±6V	1V
±12V	2V
±24V	4V

The Characteristic VI Graphs of The Main Electronic Components

All the VI graphs are created by connecting one or more main electronic components to each other in parallel or in series. The main electronic components are the **Resistor** (Figure 62), **Capacitance** (Figure 63), **Inductance** (Figure 64) and **Diode** (Figure 65). The Electronic components respond differently to the test signal of the VI Test device.

The VI graph obtained by connecting the Electronic components in parallel or series is composed of the VI graphs of the electronic components connected on the electronic circuit board. For example, a VI graph composed of a resistor and capacitor is a combination of the VI graphs of the resistor and capacitor.

The **Resistor** VI graph is always a straight line between 0 and 90 degrees to the X axis. The **Capacitor** graph is an ellipse or a circle. The **Inductor** graph is elliptical or circular; due to the resistance of the wires in the inductor, the effect of the resistors is also observed in the graph.

The semi conductor **Diode** graph appears as one or more straight lines with a 90 degree angle in between.

All the electronic components can be tested by starting from those basic information.

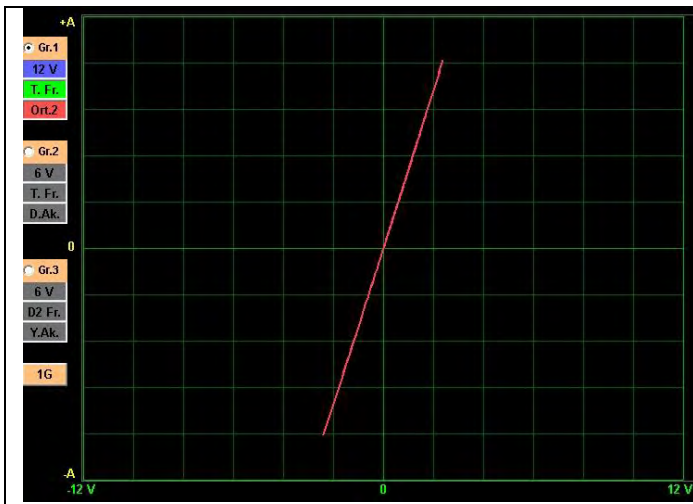


Figure 62: Resistor VI Curve

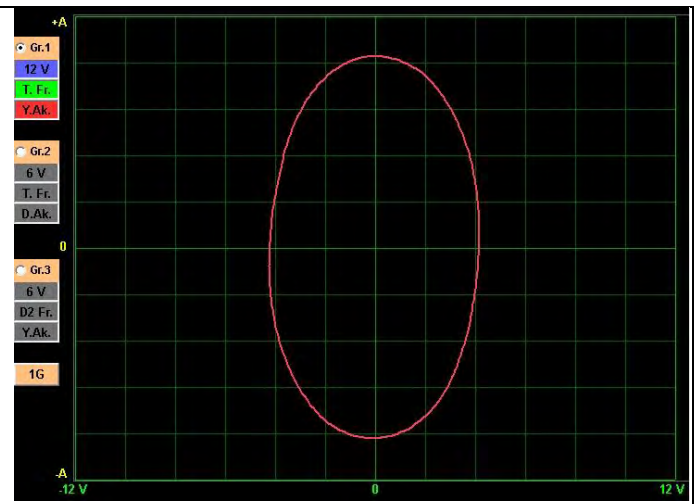


Figure 63: Capacitor VI Curve

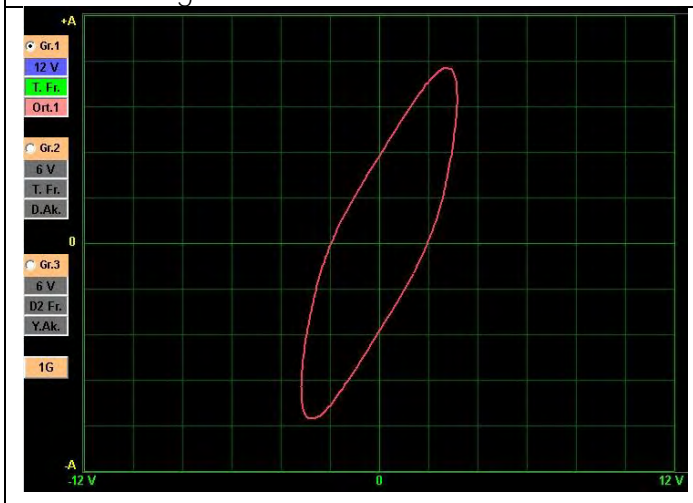


Figure 64: Inductor VI Curve



Figure 65: Diode VI Curve

R, L, C PASSIVE COMPONENT (RESISTOR, INDUCTOR, CAPACITOR) VI GRAPHS

Resistor VI Graph

According to the OHM's Law, the Resistance is Voltage/Current. In the Analog Signal Analysis test, the resistor graphs are represented as a visualization of the OHM's Law. Figure 66 shows the typical signal, equivalent circuit and values for a resistor. The amount of voltage applied to the resistor is shown along horizontal axis and the current induced is shown along the vertical axis. **Because the Voltage/Current is linear according to the Ohm's Law, the Resistor graph is represented by a straight line.** The Resistor graph makes a "0 - 90" degree angle from the horizontal. Resistor graph curve varies according to the current stages of the FADOS9F1 device or in connection with the value of resistor.

As the Resistor value increases, the angle of the Voltage/Current curve with the horizontal is reduced (approaches to "0" degree).

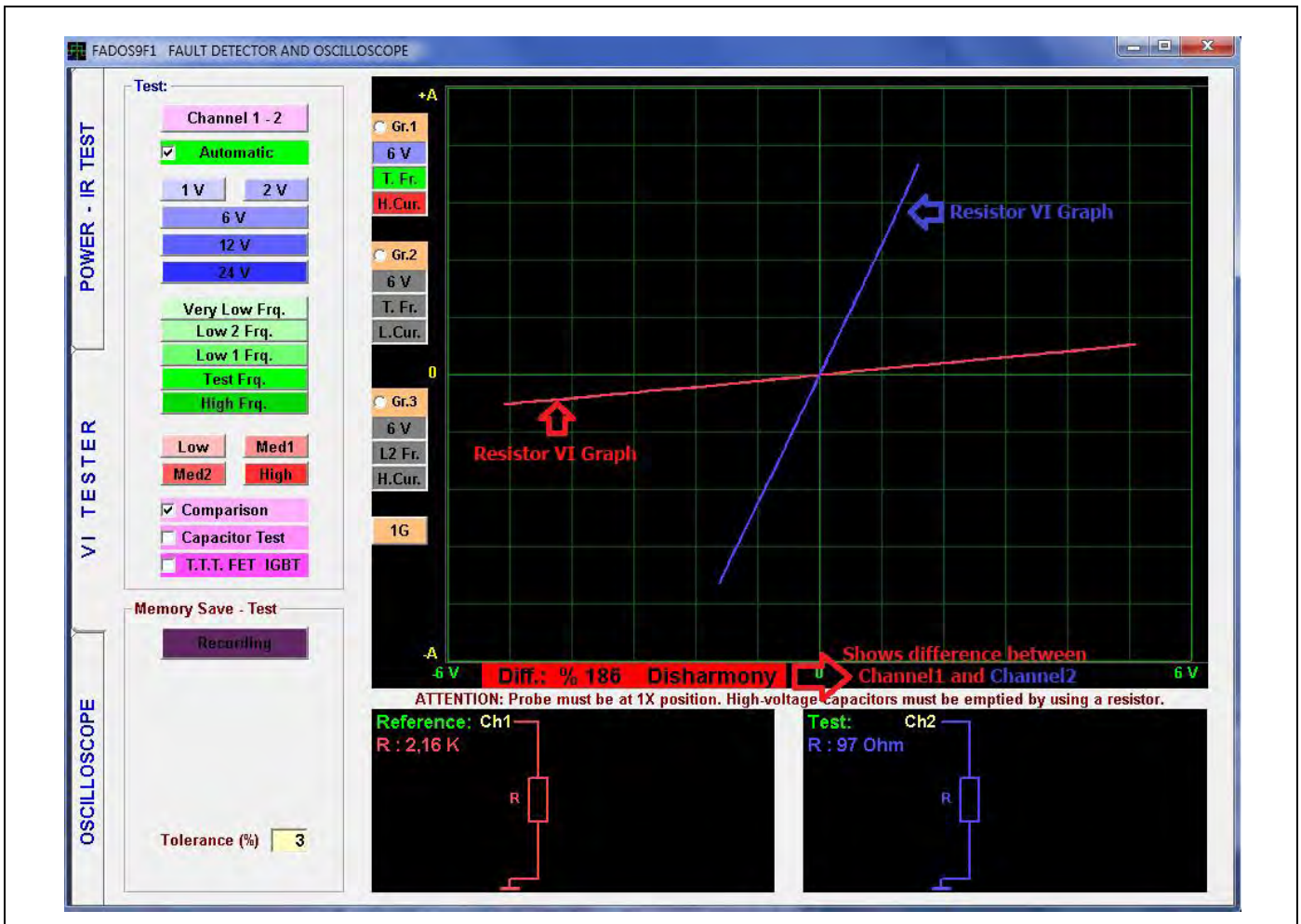


Figure 66: Resistor VI Graph, Equivalent Circuit Diagram and Value Measurement (Channel1 Red - Channel2 Blue)

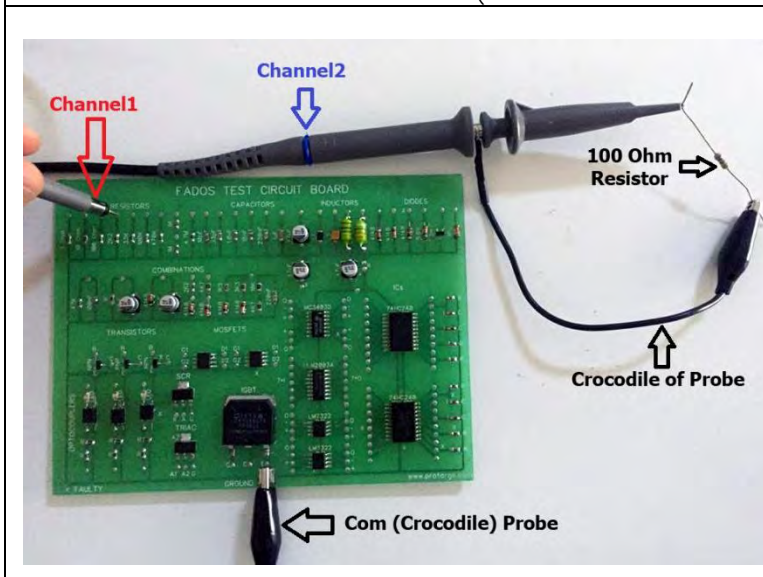


Figure 67: Measuring a 2,2 KΩ resistor in the Electronic circuit, and Measuring a 100 Ω Resistor

While measuring a resistor outside the circuit; connect to the crocodile to one foot (side) of the resistor and touch the probe to the other foot (side).

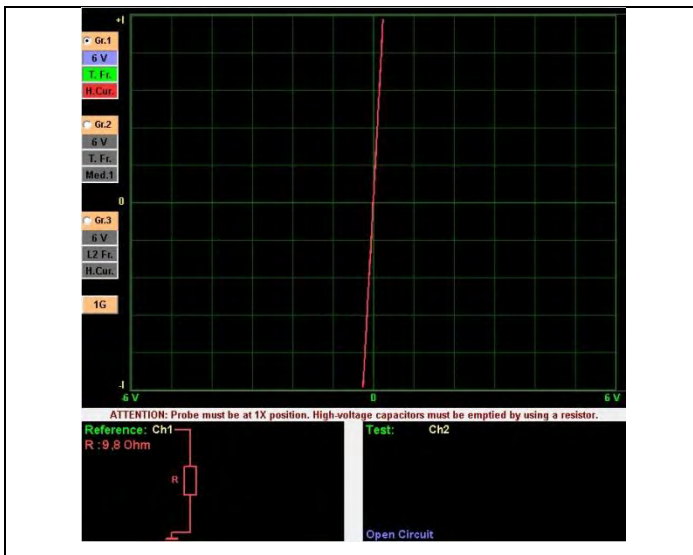


Figure 68: 10 Ω Resistor VI Graph

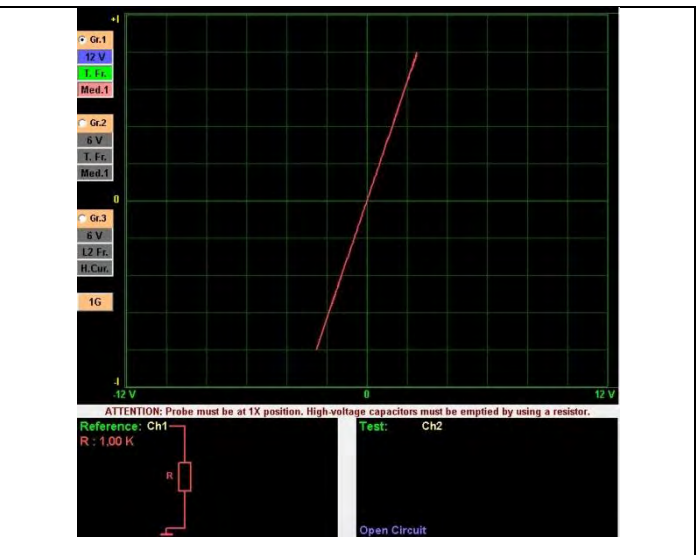


Figure 69: 1 KΩ Resistor VI Graph

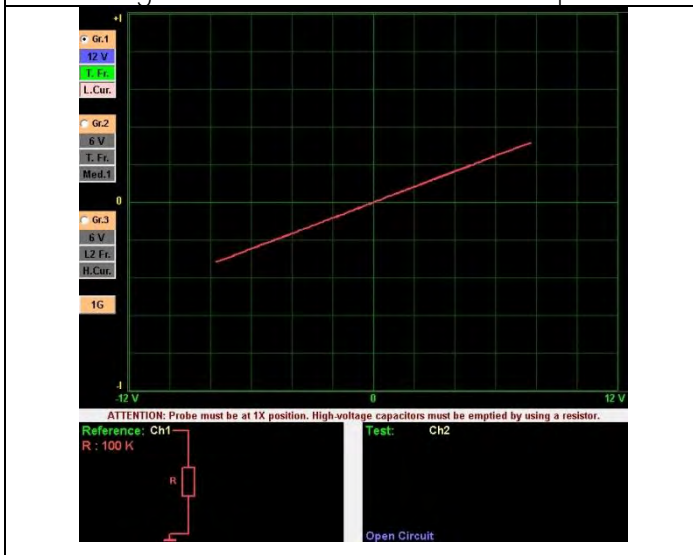


Figure 70: 100 KΩ Resistor VI Graph

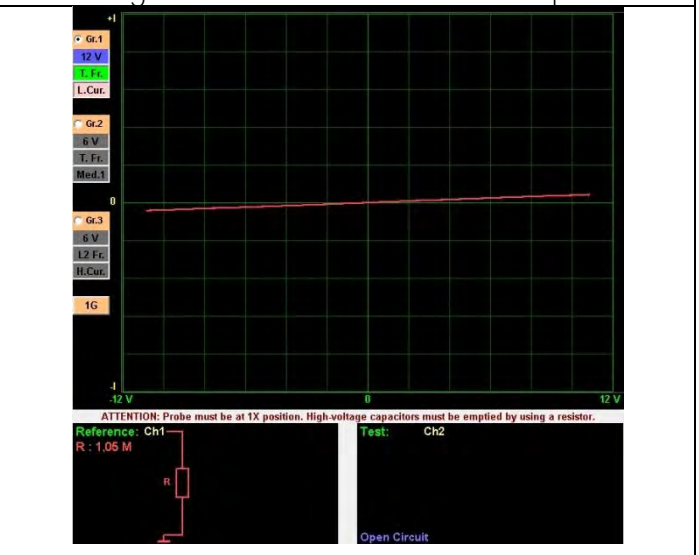


Figure 71: 1 MΩ Resistor VI Graph

The Low value resistors graphs that is close to the vertical axis. Therefore, while testing the low value resistors use the High Current Stage. The High value resistors graphs that is close to the horizontal axis. Therefore while testing the high value resistors use the Low Current Stage. Since the Resistor is not a reactive component, the voltage and frequency stages not change the resistor VI graphs.

Capacitor VI Graph

The Capacitor is an energy storing reactive component. Therefore, the VI graph is not a straight line like the resistor graphs. When the voltage is zero in a capacitor, the current is maximum and when the current is zero, the voltage is maximum. A phase difference occurs in the voltage and current flows through a reactive device. In that case, the capacitive components are like a circular or elliptical graph.

The width of the ellipse changes depending on the value of capacitor and the test stages of the FADOS9F1. Because the capacitor analog signal graph is a function of the capacitive reactance frequency, it changes when the test frequency is changed.

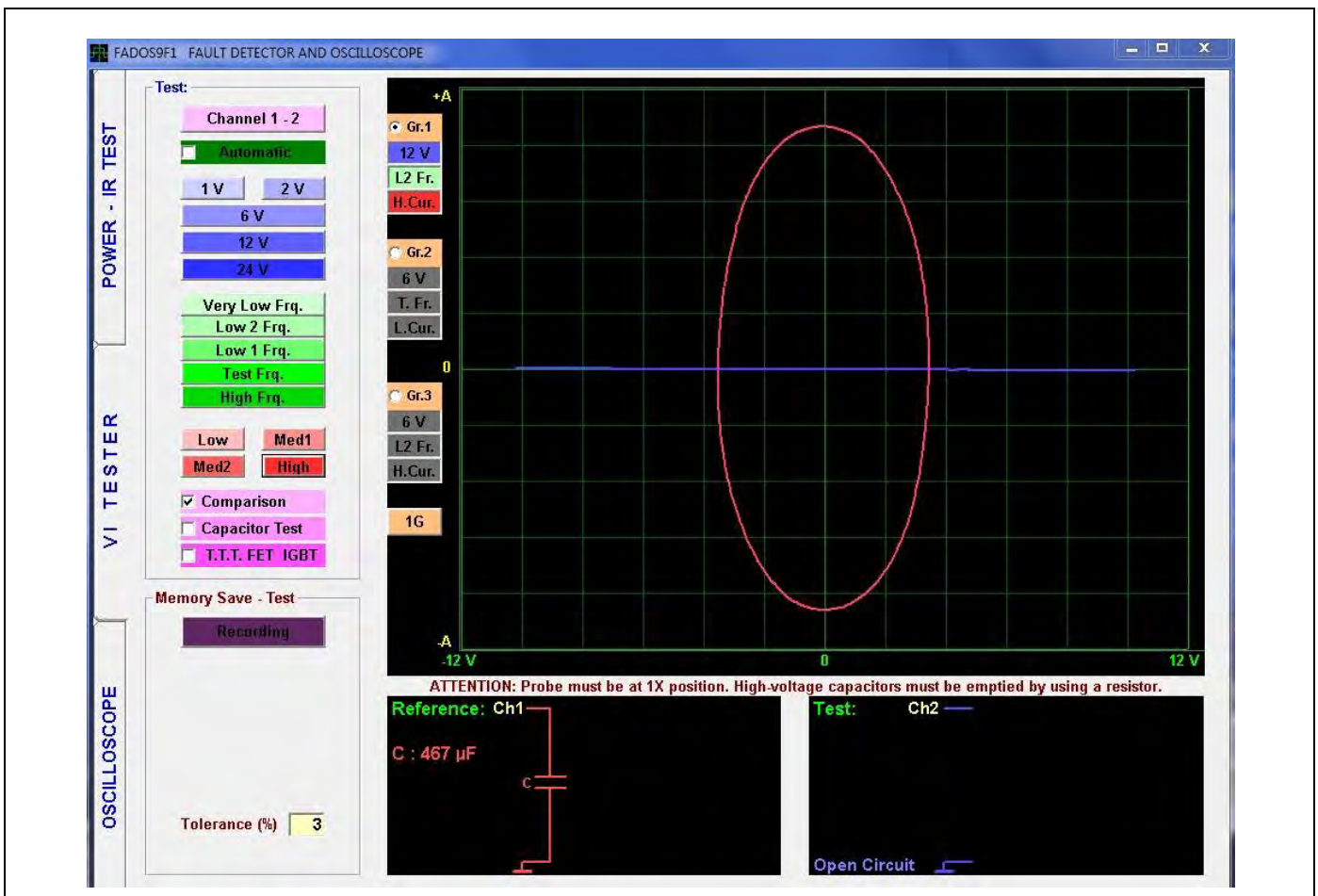


Figure 72: Capacitor VI Graph, Equivalent Circuit Diagram and Value Measurement (Channel1 Red - Channel2 Blue)

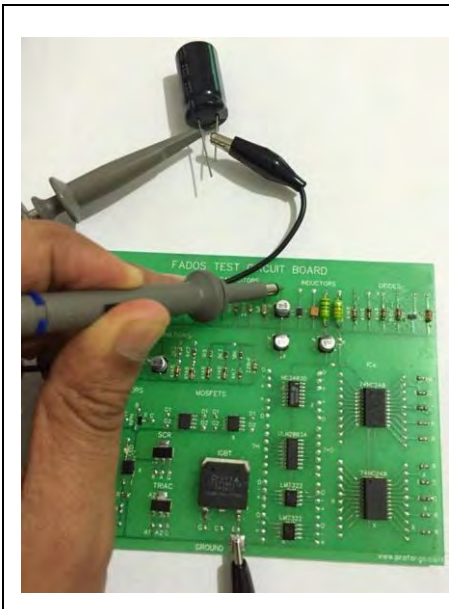


Figure 73: Measurement of a capacitor inside and outside of the circuit

While measuring the capacitors outside the circuit, connect the probe crocodile to one foot and the touch the probe to the other foot.

The Figures 74, 75, 76 and 77 show the Current/Voltage (VI) graphs, equivalent circuit diagrams and values for the capacitors.



Figure 74: 1.8 nF Capacitor VI Graph

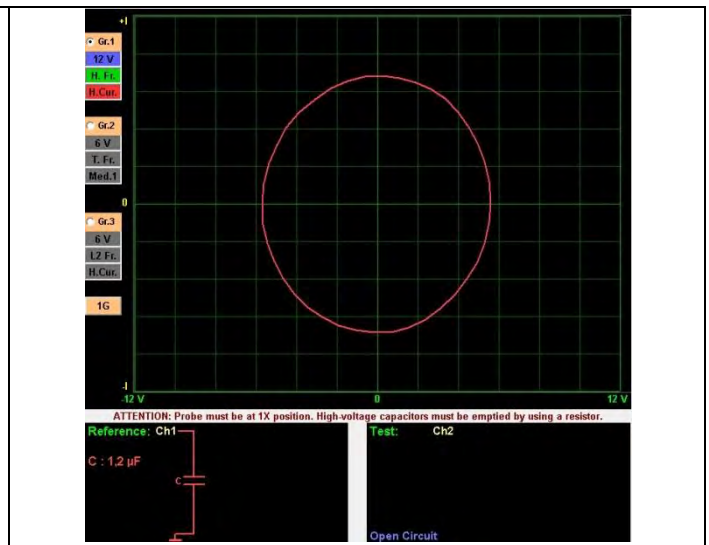


Figure 75: 1 μF Capacitor VI Graph

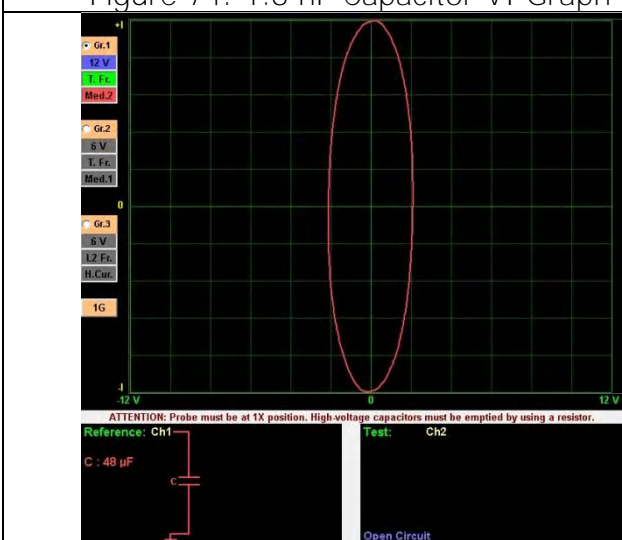


Figure 76: 47 μF Capacitor VI Graph

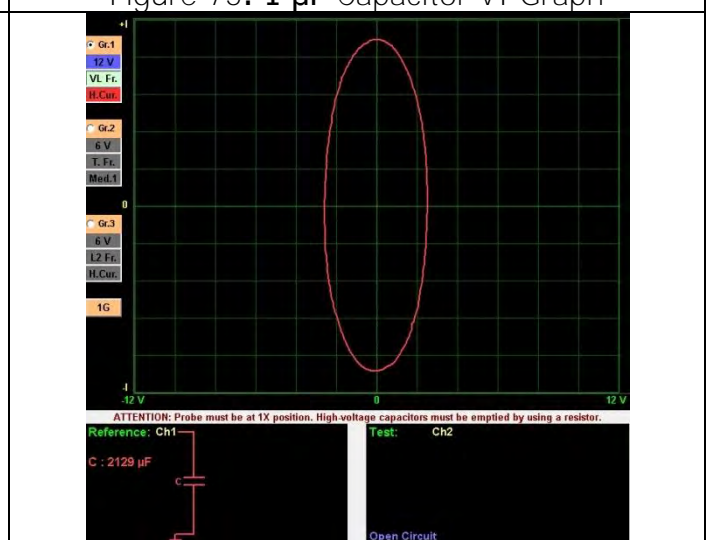


Figure 77: 2200 Capacitor VI Graph

The Capacitors should be tested after discharging. Test the Low value capacitors at the Low Current Stage and High Frequency. The VI graph of the Medium value capacitors is an ellipse close to a circle. The VI graph of the High value capacitors is close to the vertical axis. Test the high value capacitors at high current. If the Capacitor value of the capacitor is very high, decrease the frequency.

Note 1: Since the frequency stage drops while testing the High capacity capacitors, the graph appears on the screen with a 1 second delay. If a delay occurs in the graph during an in-circuit test, it shows the presence of a high capacity capacitor in the circuit tested.

Note 2: High Frequency stage uses at only 6 Voltage stage.

CAPACITOR (QUALITY - FAILURE CHECK) CAPACITY TEST - RC CIRCUITS VI GRAPHS

Capacity Test

The Capacitor failures caused by leaking in the capacitor in general and as a result, the capacitor acts as if a resistor is connected in parallel. The quality of the leaky capacitors is decreased.

The leaky capacitors can be identified easily thanks to the capacity test characteristics of the FADOS9F1.

For conducting a capacitor quality and failure test, the active type of the probe is connected to the anode (+) or cathode (-) pole and the chassis probe is connected to the cathode (-) or **anode (+) pole of the capacitor, then the "Capacitor Test"** is clicked from the test characteristics menu and a nearly linear graph appears on the screen. The closer the graph is to the X axis, the higher is the quality of the capacitor. But, if the graph approaches the horizontal too much, it means that the quality of the capacitor is reduced or leaking or defective. The components leaks are very common especially in the electrolytic capacitors. Disconnecting one foot of the capacitor from a circuit effectively means having removed the capacitor, and the capacitor test can be applied easily.

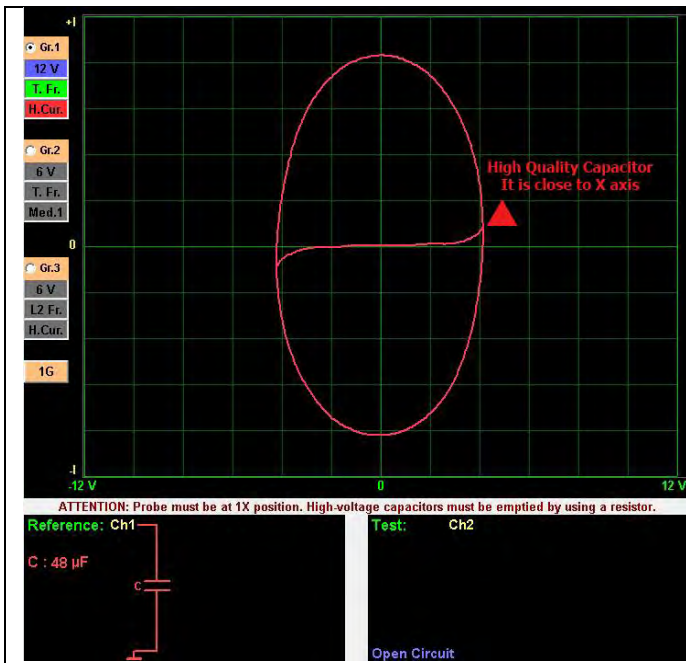


Figure 78: High Quality Capacitor

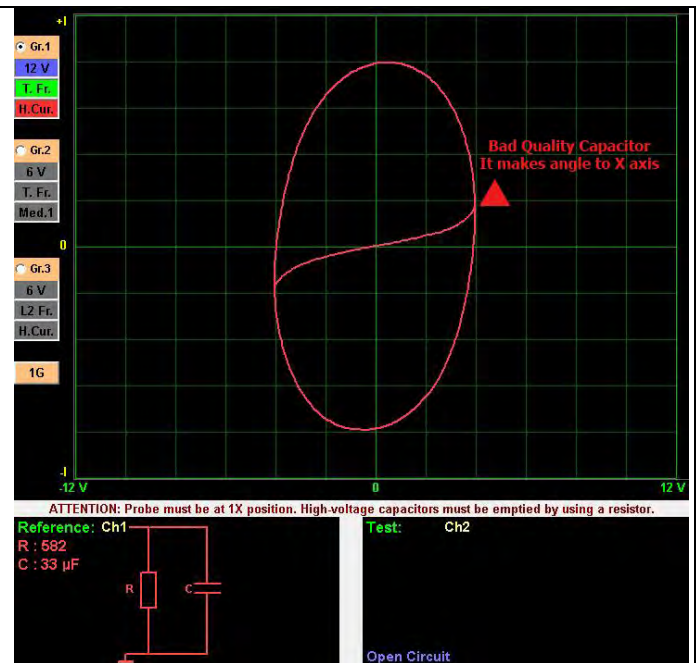


Figure 79: Low Quality Capacitor

RC Circuits VI Graph

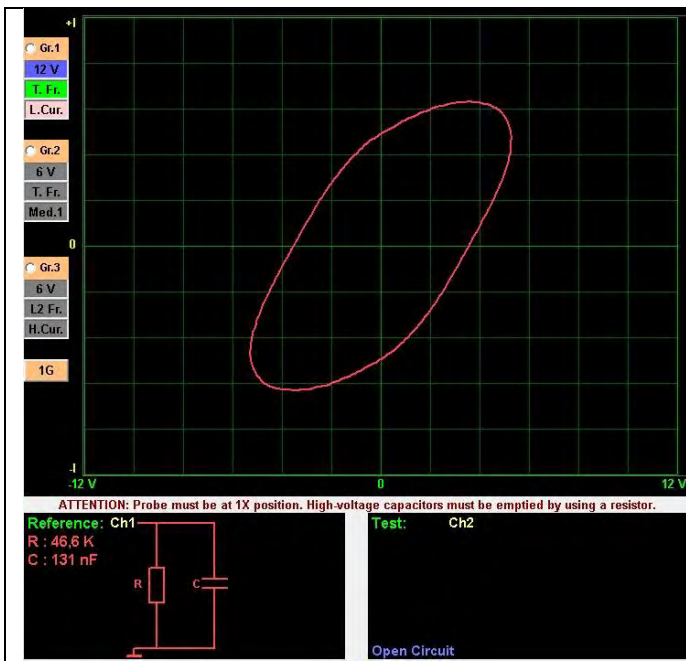


Figure 80: Capacitor - Resistor Parallel Connected

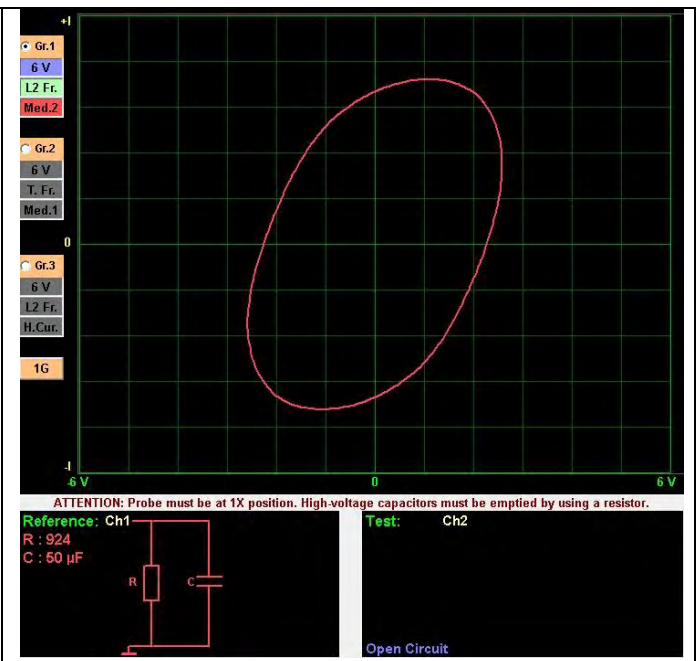


Figure 81: Capacitor - Resistor Parallel Connected

VI graph of the circuits comprised of Resistors and capacitors are composed of the VI graphs of the resistors and capacitors and the graphs of the RC circuits make an angle to the axes.

Inductor VI Graph

The VI graph of the inductors is elliptical or circular like the capacitors. The width of the ellipse depends of the value of the component and the test stage of the device. Theoretically, the graph of a pure inductor is in form of an ellipse, but the ellipse may be distorted with the effect of the resistance of the inductor wires. The current stages cause changes in the shape of the ellipse, the changing the voltage stages has little effect on the ellipse.

The easiest way to troubleshoot the inductors is comparing the VI graphs of the suspect and intact inductors.

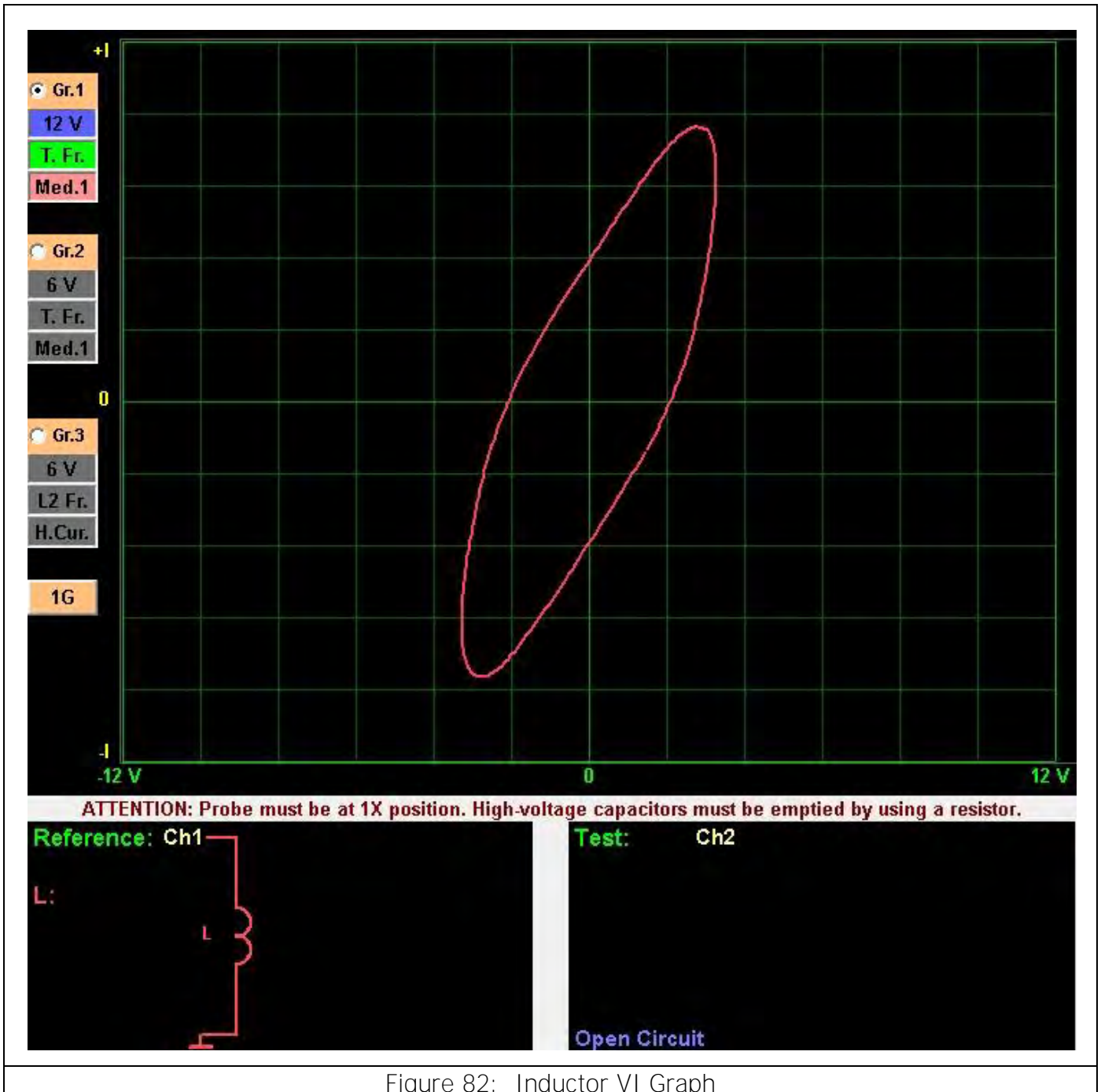
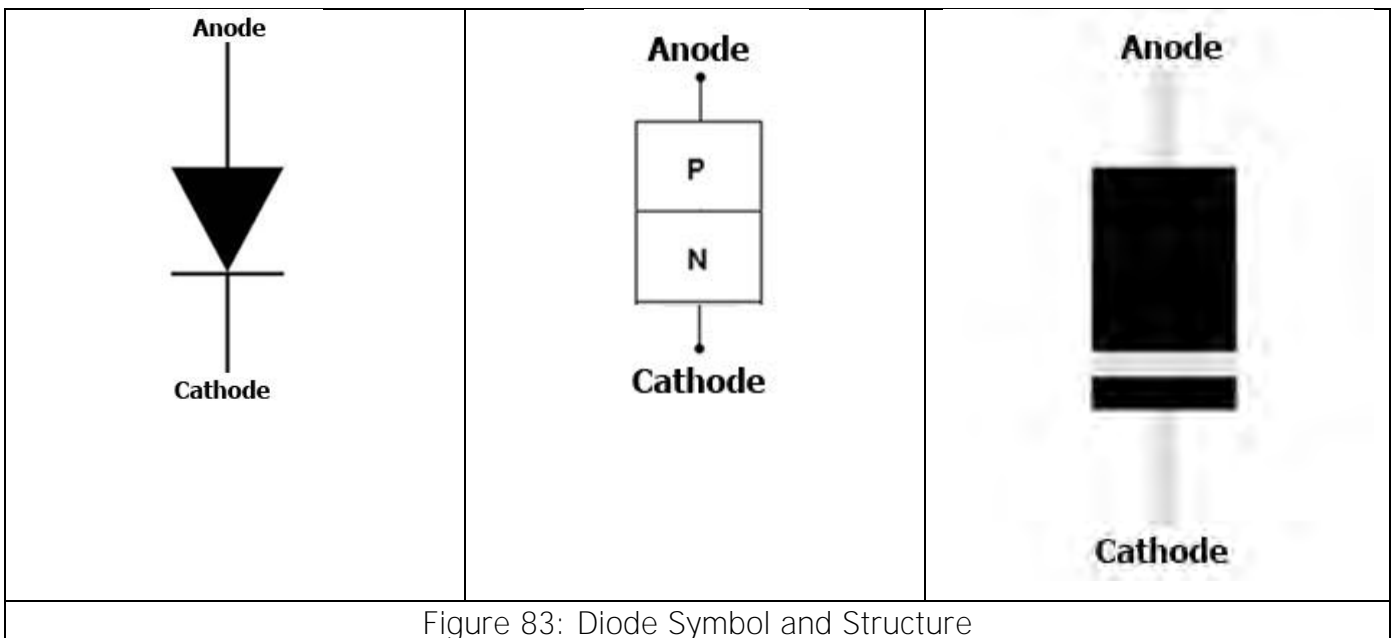


Figure 82: Inductor VI Graph

SEMI CONDUCTORS

Diode VI Graph

The Diodes are the building stones of the semi conductor electronic circuit components. All transistors, logical gates, integrated circuits are manufactured by combining the diodes. The diode is manufactured by joining the N and P type materials. The P pole of diode is called the "Anode" and the N pole is called "Cathode". In general, the diode is an electronic circuit component, which conducts the current in one direction only and blocks the flow in the opposite direction.



The diode starts conducting after the voltage applied exceeds a certain value. The reason for that is the voltage barrier that is formed at the surface of the junction of the materials used for making the diode. This voltage value is called the "threshold" voltage.

The Threshold voltage for the Germanium diodes is around 0,2 V - 0,3 V, and around 0.6 V - 0.7 V for the silicone diodes. The Threshold voltage may vary slightly according to the operating temperature of the diode.

If the voltage applied to the Diode is less than the threshold voltage, the diode does not conduct and the graph resembles an open circuit and will start conducting and allow current flow only when the applied voltage exceeds the threshold value. The point of current conduction is called the "junction", where a horizontally and vertically straight graph is generated.

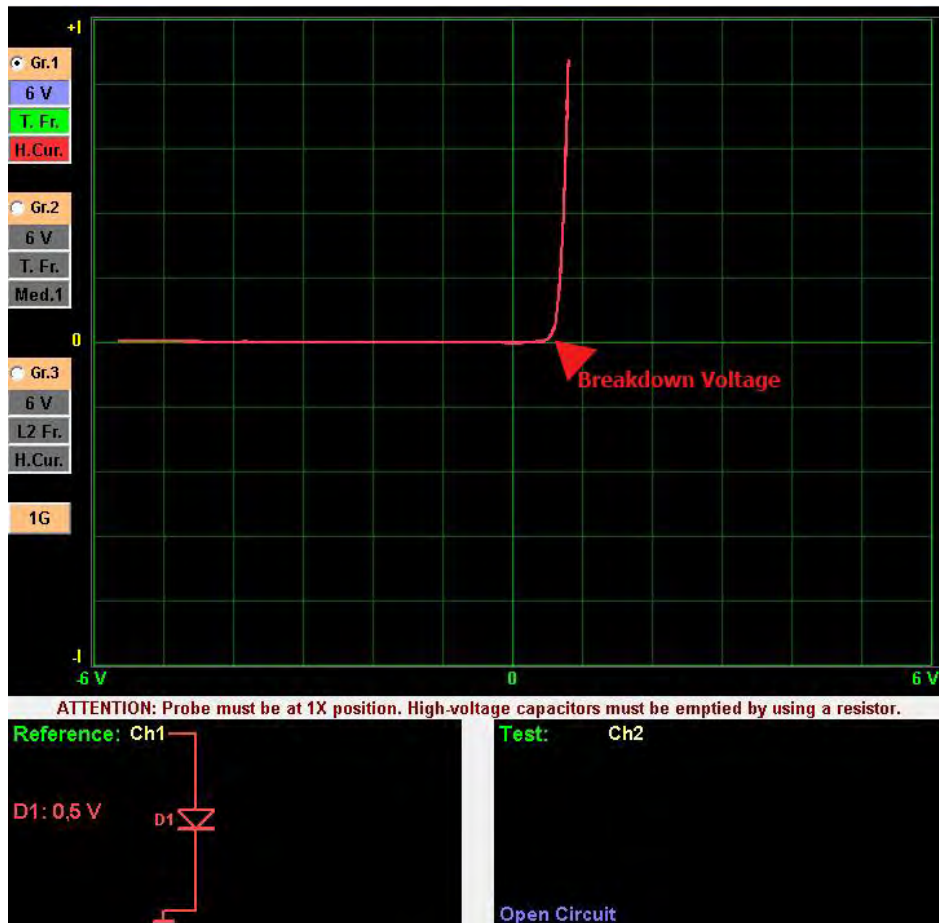


Figure 84: Diode VI Graph, Equivalent Circuit Diagram, Conduction Voltage Value

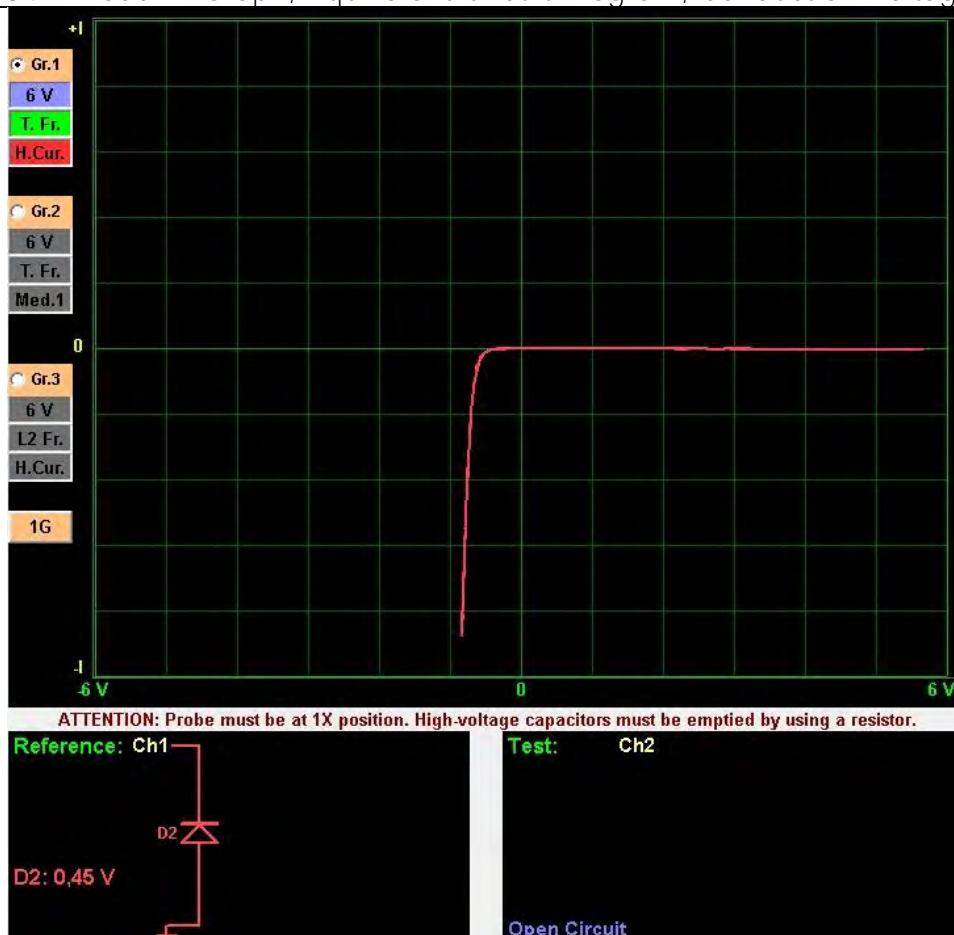


Figure 85: Diode Direction; Reverse Anode - Cathode

When the Semi conductor components fail, they generally act like resistors, but may also resemble open circuits. When the Diodes lose its semi conductor properties, the junction starts leaking current. (Figure 86 - Figure 87)

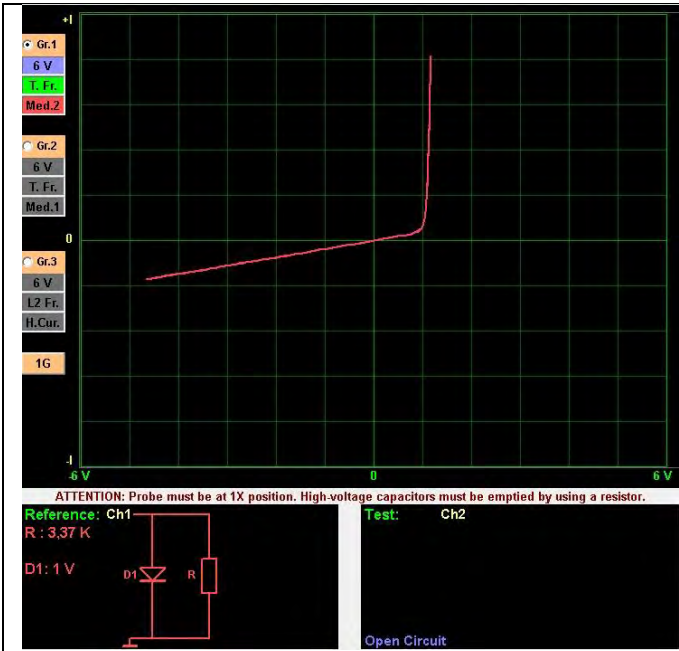


Figure 86: Defective Diode Graph

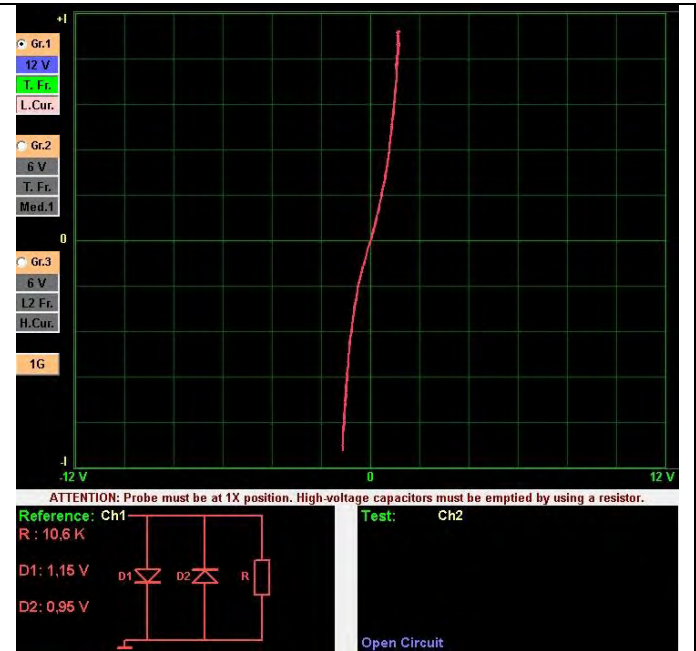


Figure 87: Defective Diode Graph

The new circuit graph generated by connecting the Electronic components in parallel or in series is a combination of the graphs of the components used in that circuit.

When a series resistor is connected to the diode, the diode makes an angle with horizontal starting from the junction point. (Figure 88 and Figure 89)

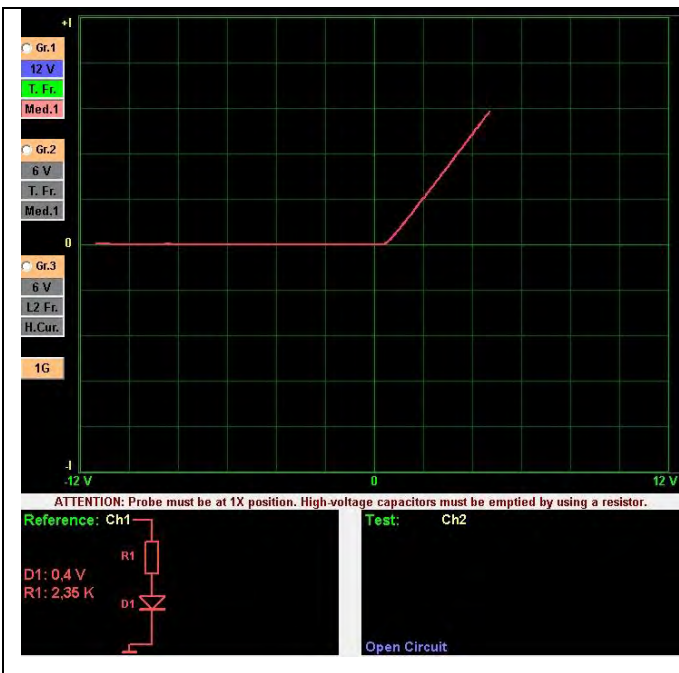


Figure 88: Diode - Resistor Series Connected

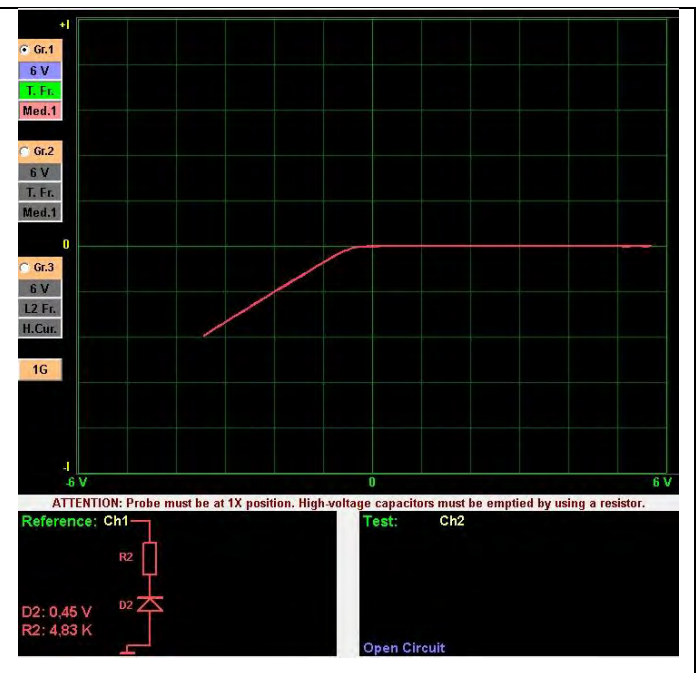


Figure 89: Reverse Diode - Resistor Series Connected

For example, a parallel resistor is connected to the diode as seen in Figure 90 and capacitor is connected in parallel as shown in Figure 91. We can observe the effects of a resistor or capacitor or resistor connected to the diode in parallel on the vertical axis as shown in the graphs. When a series resistor is connected to the diode, the diode makes an angle with horizontal starting from the junction point. This graph is quite common for the electronic circuits. We can change the voltage stages of the FADOS9F1 to stop the diode from conducting and concentrate on the VI graphs of the other components.

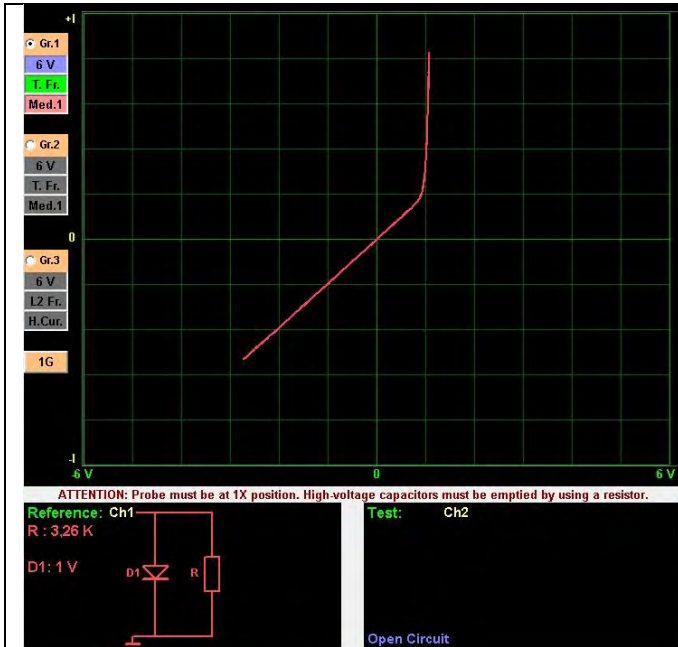


Figure 90: Diode - Resistor Parallel Connected

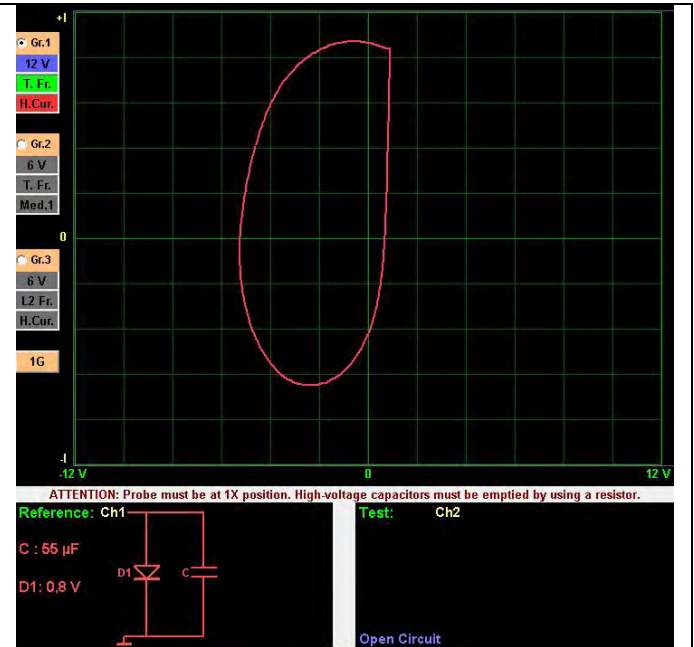


Figure 91: Diode - Capacitor Parallel Connected

Zener Diode VI Graph

The Zener diode is special type of diode in general, which has a silicone structure comprised of P and N type semi-conductor materials. The main purpose of the diode is keeping the voltage applied to its poles stable. In that, they do not conduct until the voltage exceeds a certain value. This voltage is called the "Zener Breakdown" voltage.

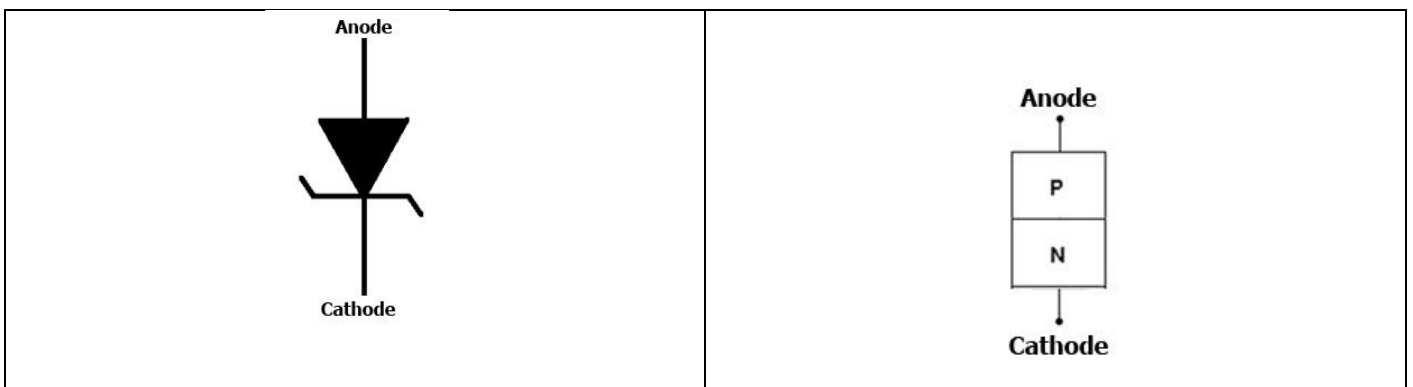


Figure 92: Zener Diode Symbol and Structure

When connected to the circuit with the correct polarity, it operates like a normal diode, but in case of reverse polarity, it operates on the zener diode principle and provides electrical protection to the component it is connected. Therefore, the zener diodes are often connected in reverse polarity to for protection purposes.

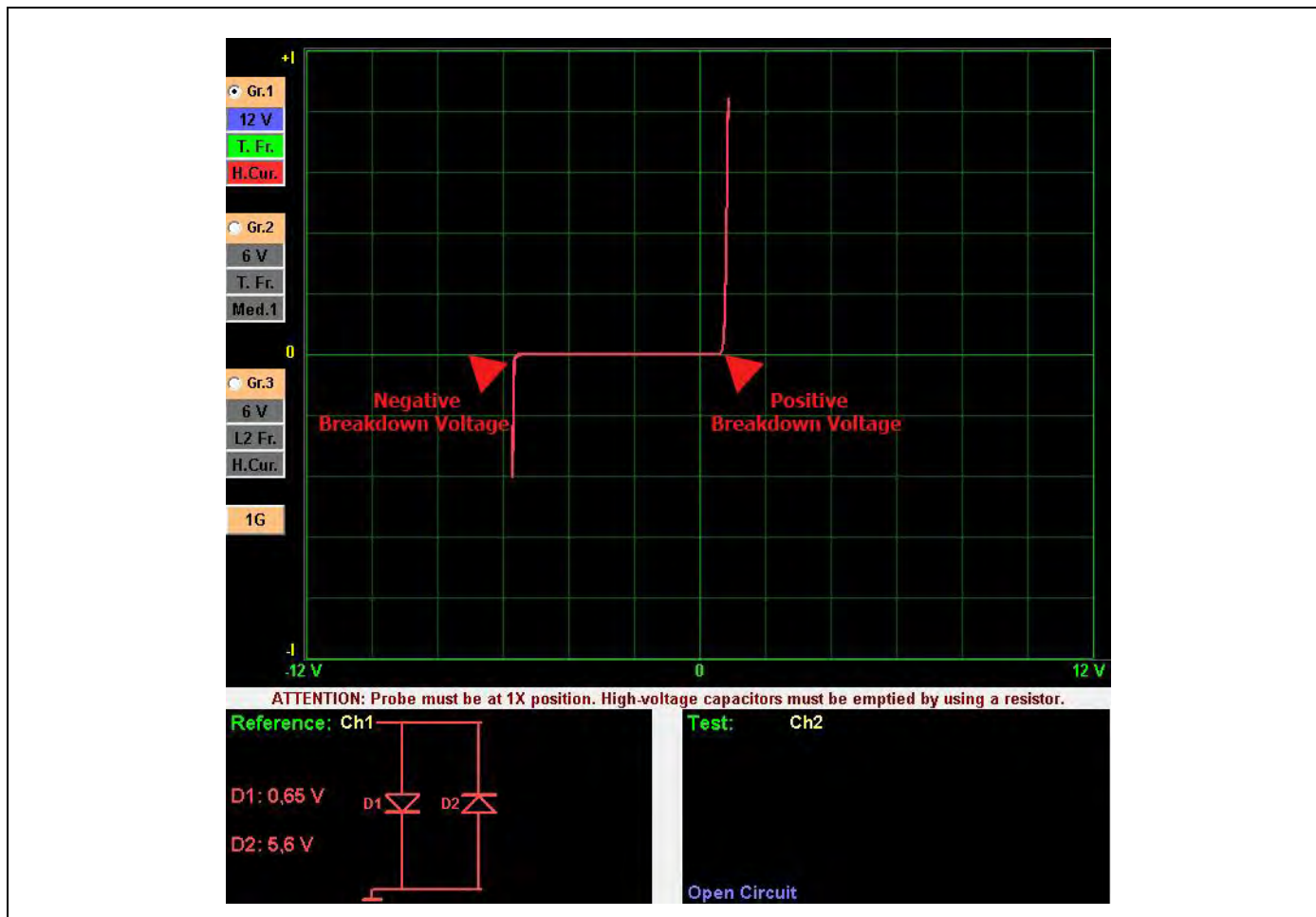


Figure 93: Zener Diode VI Graph, Equivalent Circuit Diagram and Conduction Voltage Values

There two breakdown points in the zener graph in the positive and negative directions. The zener graph is frequently observed while testing the integrated circuits (ICs).

TRANSISTOR – TRIAC – THYRISTOR – FET – IGBT – OPTO-COUPLER VI GRAPH

Transistor VI Graph

The Transistors are composed of three semiconductor elements arranged in NPN or PNP configuration. In the NPN type transistor structure, a P type semi conductor base material is placed between two N type semi conductor materials in a thin layer. The structure of the PNP type transistor is similar to the NPN type. In the PNP type transistor structure, an N type semi conductor base material in placed between two P type semi conductor materials. The only difference is, a N type semi conductor base material in placed between two P type semi conductor materials in a thin layer.

The poles of the transistors composed of three circuit elements are called the Emitter (E), Base (B) and Collector (C).

In the equivalent circuit of a Transistor, the Collector – Base connection is like a diode graph and the Base - Emitter graph is like a zener diode. We can check if the transistor is conducting by using the FADOS9F1.

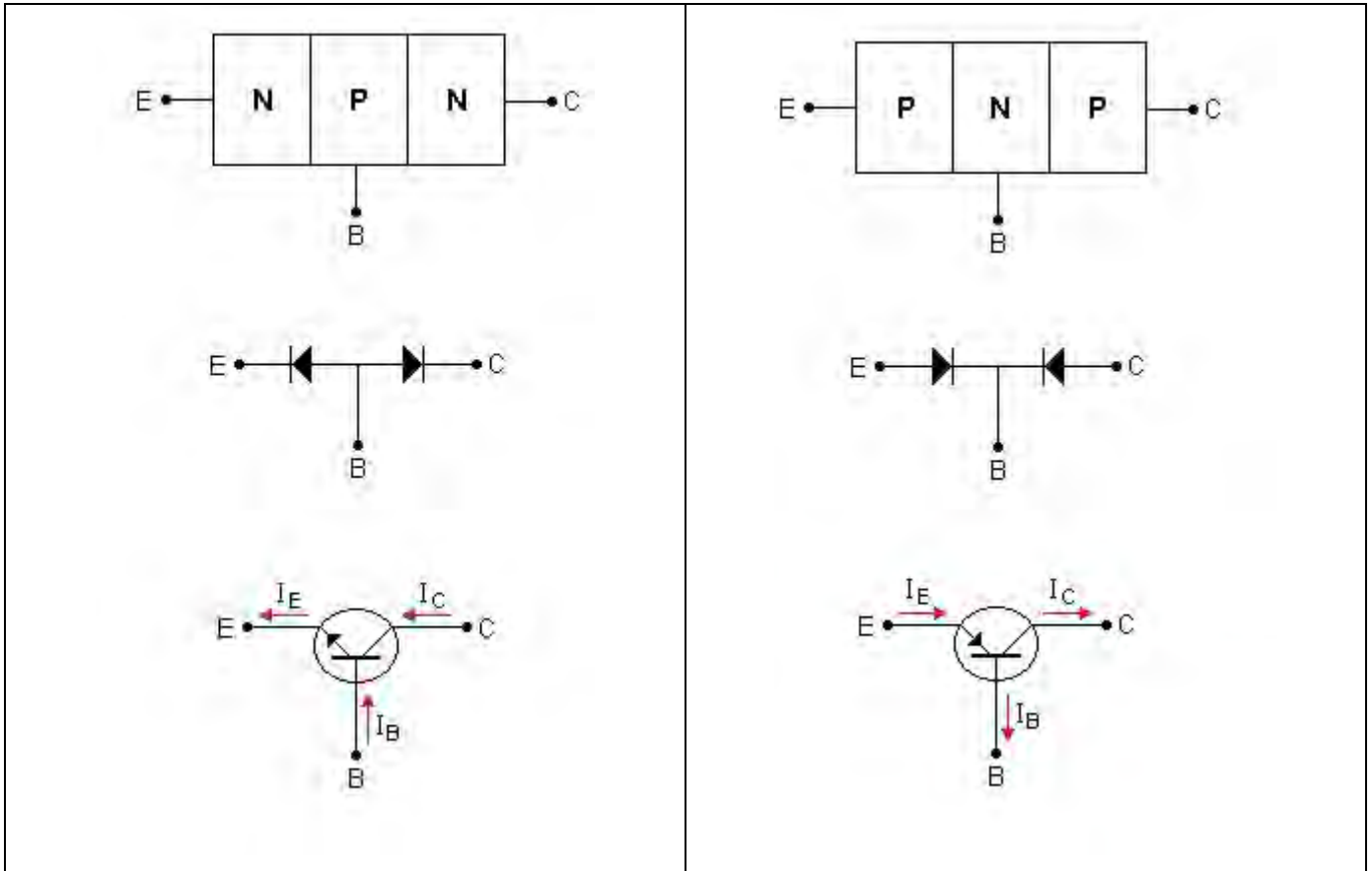


Figure 94: NPN Transistor Symbol and Structure Figure 95: PNP Transistor Symbol and Structure

If the **T.T.T FET IGTB** option is clicked in the FADOS9F1 test characteristics menu, the software analyzes the transistor type as N or P. To do that, the Emitter is connected to the chassis. One of the probes is connected to the Base to trigger the transistor and the other to the Collector to detect the conduction. When the Base pole is triggered, the resistance value between the Collector and Emitter drops and allows current flow. The amount of current flowing through the Collector and Emitter depends on the current applied to the base.

For example, the Emitter is connected to the chassis. The Channel2 (or Channel1) probe is touched to the Collector and the other probe is touched to the Base of the transistor, whereupon the current will start flowing through the collector and a change will be observed in the Collector VI graph of the transistor that was just triggered. If the **T.T.T FET IGTB** option is selected (clicked), the type of the transistor is analyzed. Figure 104 illustrates the VI graph of an NPN type transistor and Figure 123 illustrates the VI graph of a PNP type transistor. Absence of leakage at the cut-off region (fully horizontal) corroborates the intact status of the device.

NPN Type Transistor VI Graph Samples

BC850C (SMD) NPN Transistor

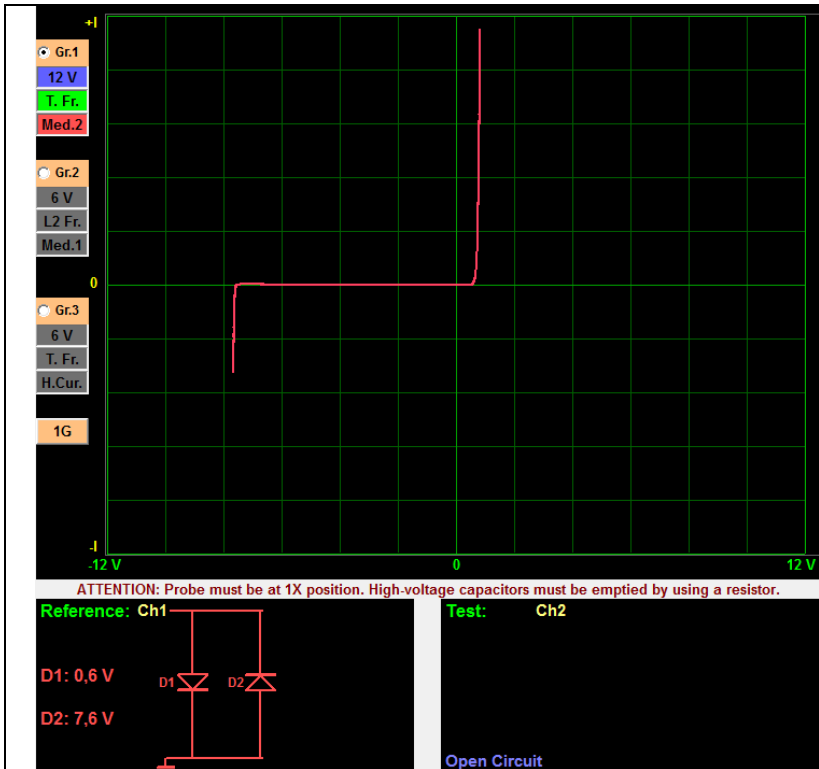


Figure 96: Base (+) Emitter (-) VI Graph

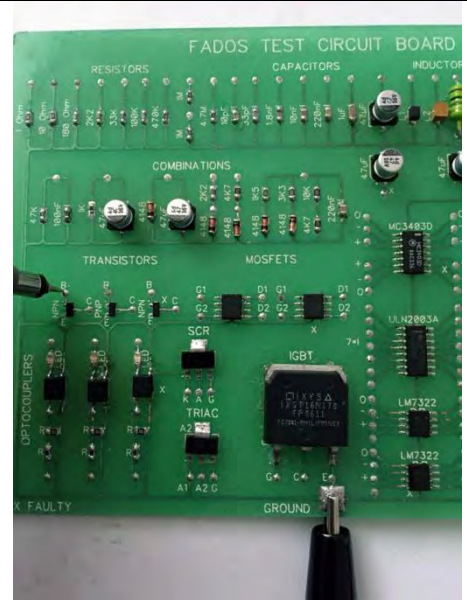


Figure 97: Channel1 Probe Used for Base - Emitter Measurement

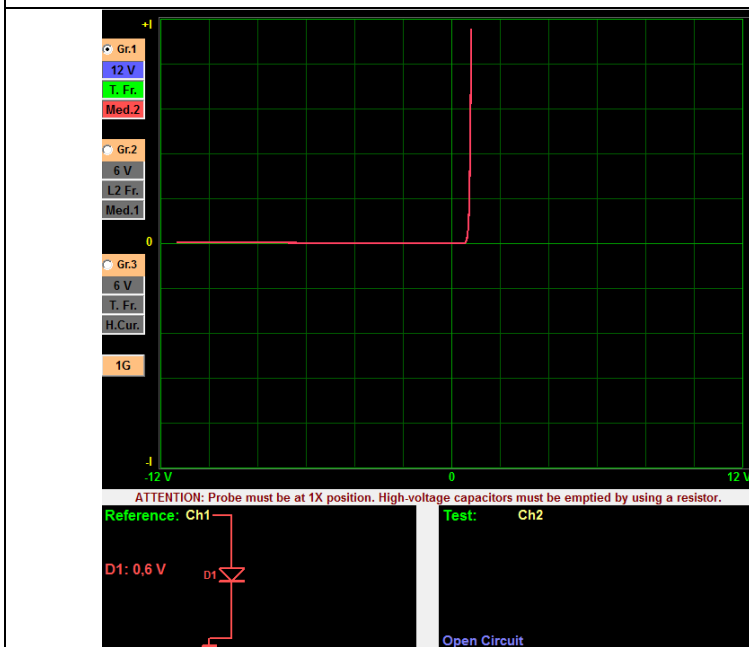


Figure 98: Base (+) Collector (-) VI Graph

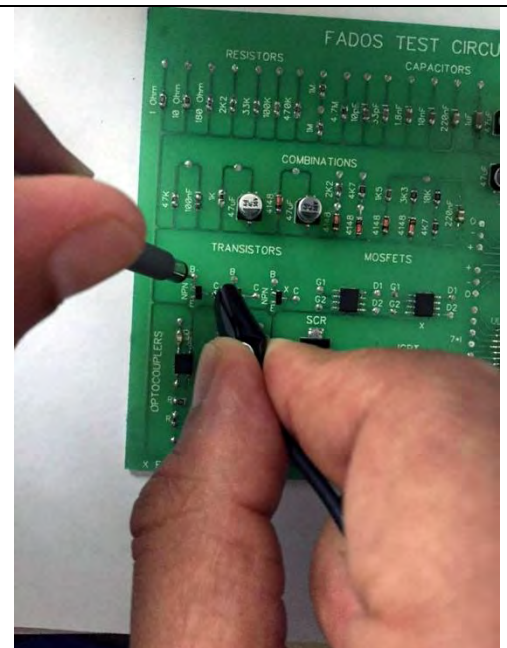


Figure 99: Channel1 Probe Used for Base - Collector Measurement

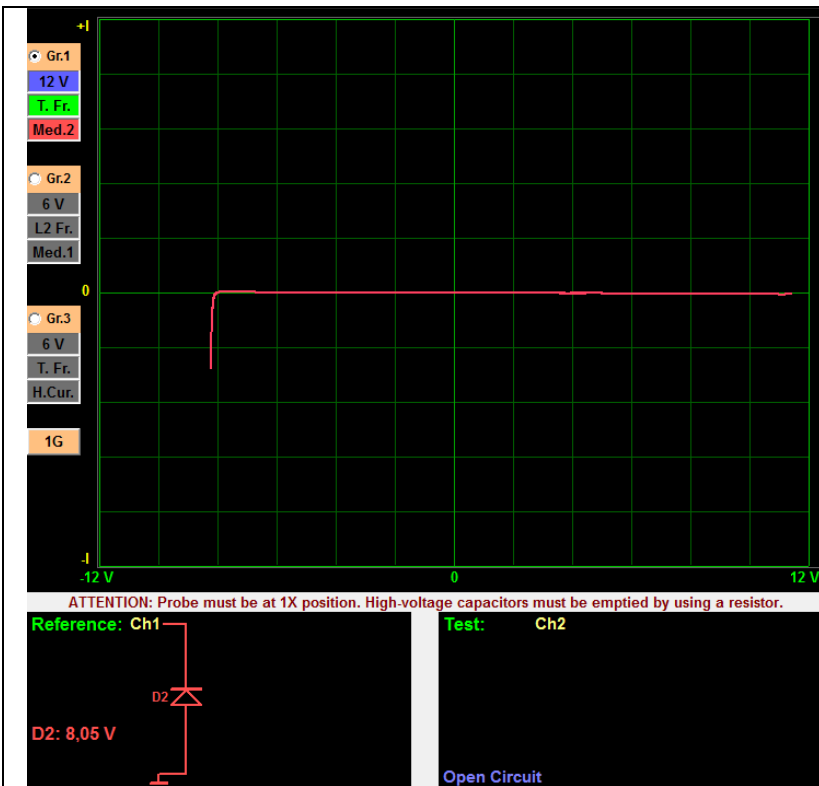


Figure 100: Collector (+) Emitter (-) VI Graph

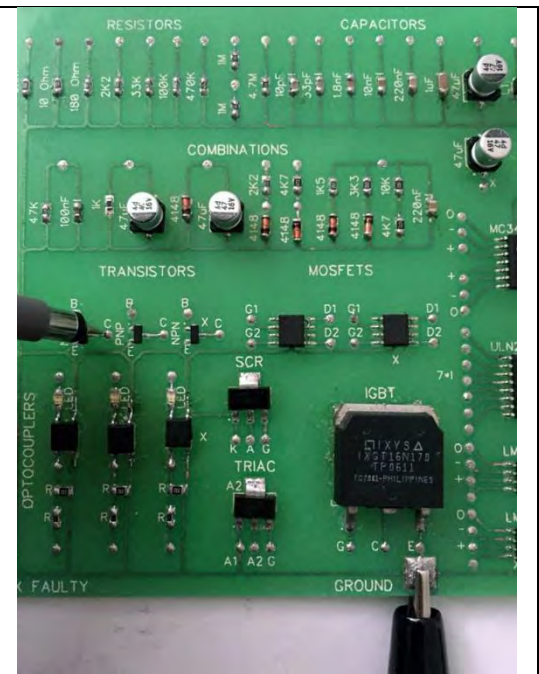


Figure 101: Channel1 Probe Used for Collector - Emitter Measurement

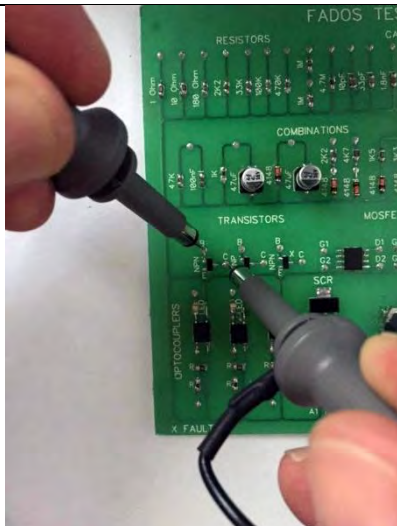


Figure 102: Channel1 (+), Channel2 (+), COM (-) Transistor Test

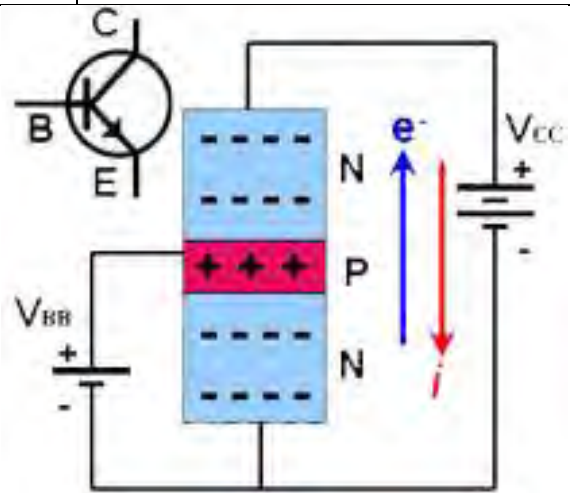


Figure 103: Transistor Conduction

In the NPN type transistors, while the positive side of the V_{bb} source charges the base positively, the negative side of the V_{cc} side pushes the electrons at the emitter upwards as seen in Figure 103. The compressed electrons are pulled by the base. That is, the electrons at the emitted conduction band overcome the E-B voltage barrier and enter the base region, but since the base region is very narrow, 98% of the electrons coming from the emitter side pass to the collector side while approximately 2% remains in the base region. The plus side of the V_{cc} source pulls the electrons to the collector region, which makes the electron flow continuous and as long as the base current is applied, the electron flow from the emitter to the collectors goes on. In the NPN type transistors the electrons move upward while the holes move downwards,

hence the plus signal applied at the base is said to cause an electron flow from the collector to the emitter. The emitter current is equal to the sum of the base and collector currents. We can test a transistor with the FADOS9F1 as shown in Figure 103. As shown in Figure 102, one of the channels may be connected to the Vcc supply and the other to the Vbb supply. The COM Probe is connected to the chassis. When you touch the Channel1 to the Collector, you will either see a graph as shown in Figure 100 or an open circuit. When the base is triggered (touched) with Channel2, the current flow between the collector and emitter will be shown on the graph (Figure 104).

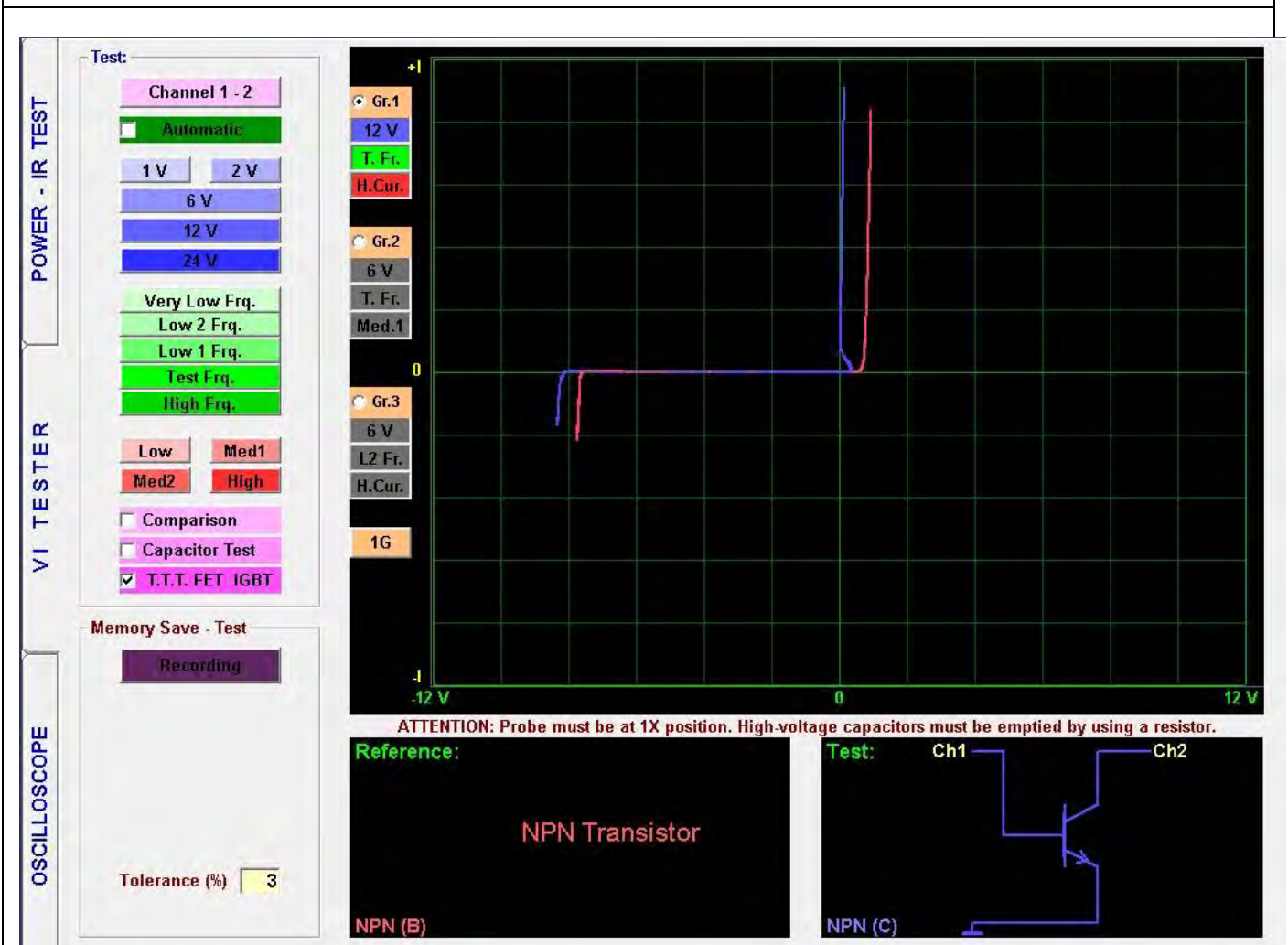


Figure 104: NPN Transistor VI Graph, Equivalent Circuit Diagram (Channel1 Base, Channel2 Collector)

C546B NPN Transistor



Figure 105: Channel1 Probe used for Base - Emitter Measurement

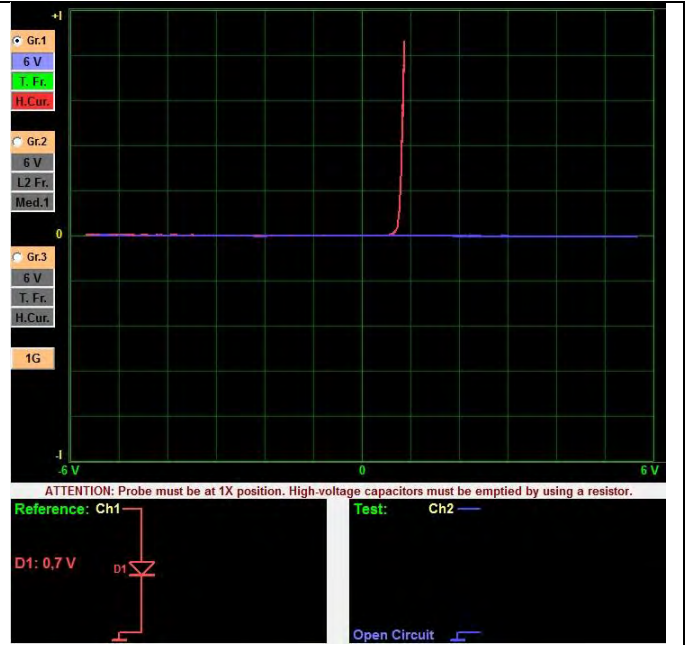


Figure 106: Base (+) Emitter (-) VI Graph

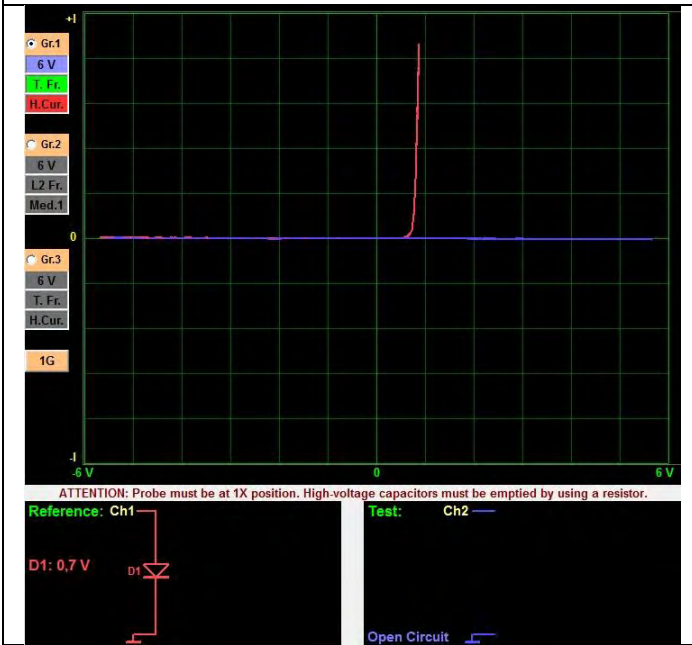


Figure 107: Base (+) Collector (-) VI Graph

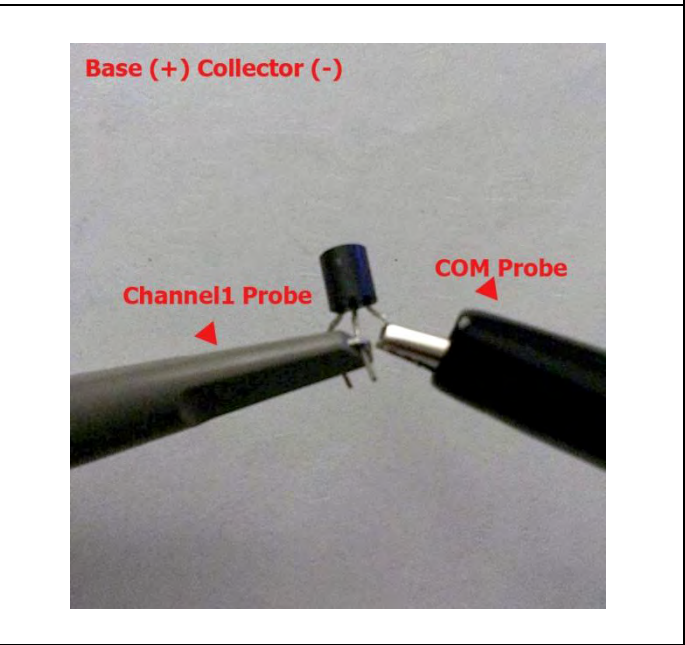


Figure 108: Channel1 Probe Used for Base - Collector Measurement

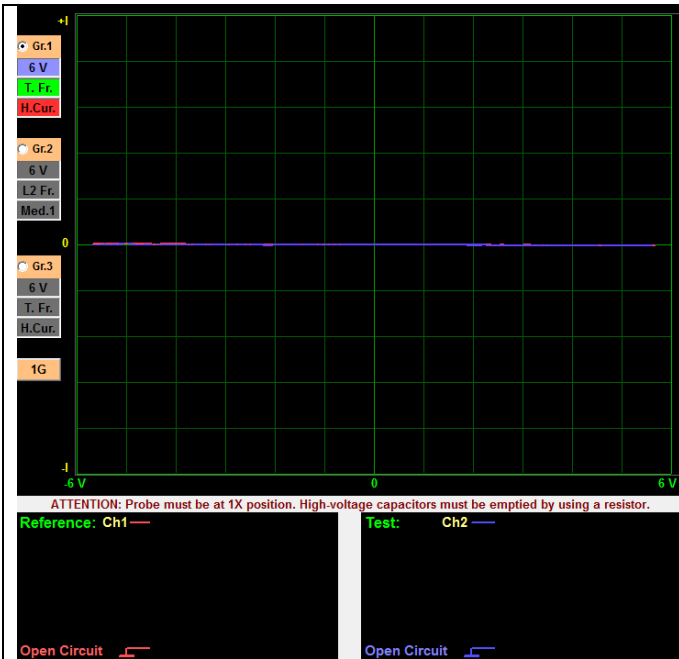


Figure 109: Collector (+) Emitter (-) VI Graph

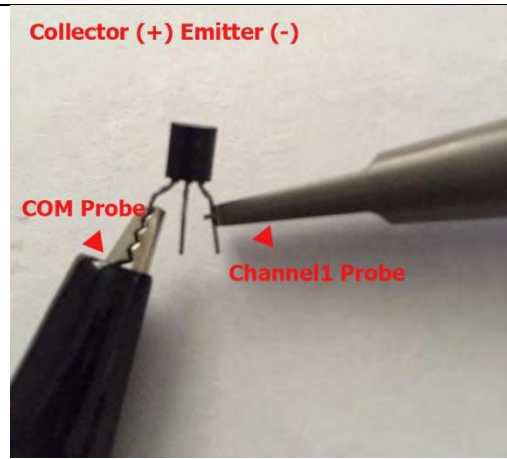


Figure 110: Channel1 Probe Used for Collector - Emitter Measurement

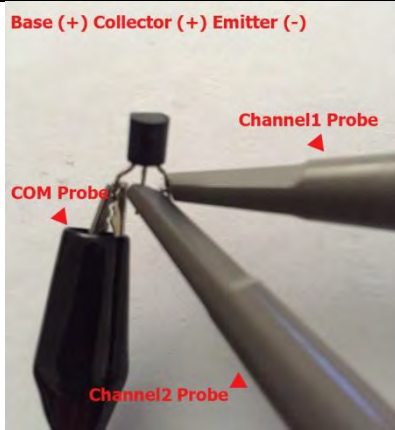


Figure 111: Channel1 (+), Channel2 (+), COM (-) Transistor Test

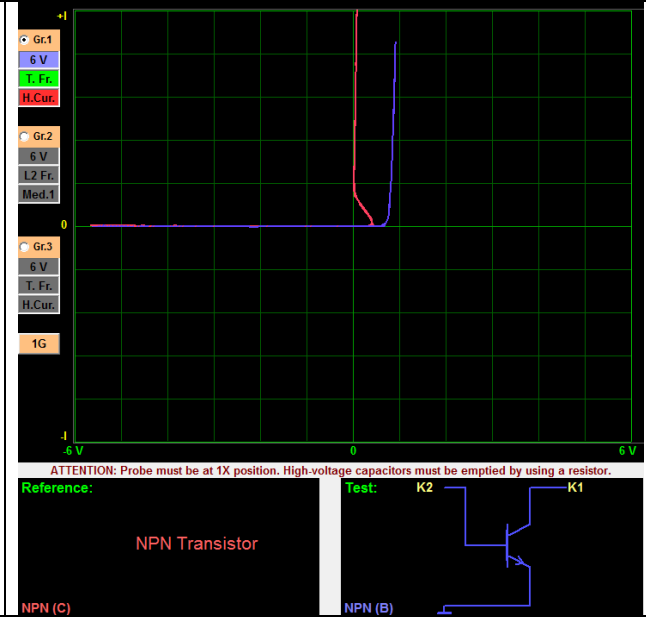


Figure 112: NPN Transistor VI Graph, Equivalent Circuit Diagram (Channel1 Collector, Channel2 Base)

2N3055 NPN Transistor

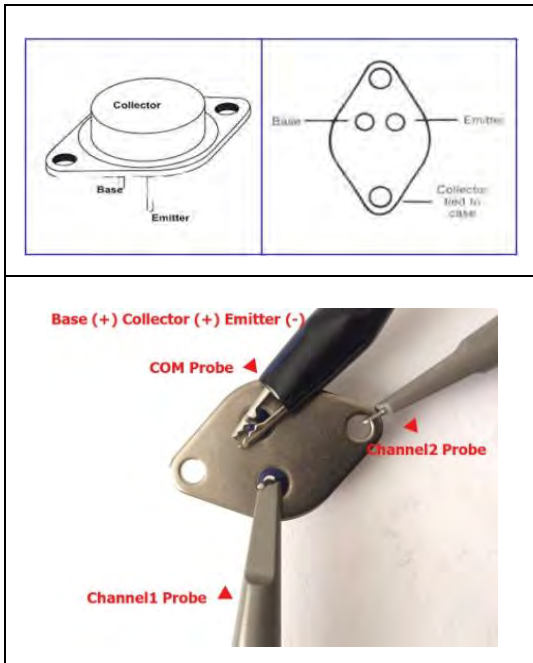


Figure 113: Channel1 (+), Channel2 (+), COM (-) Transistor Test

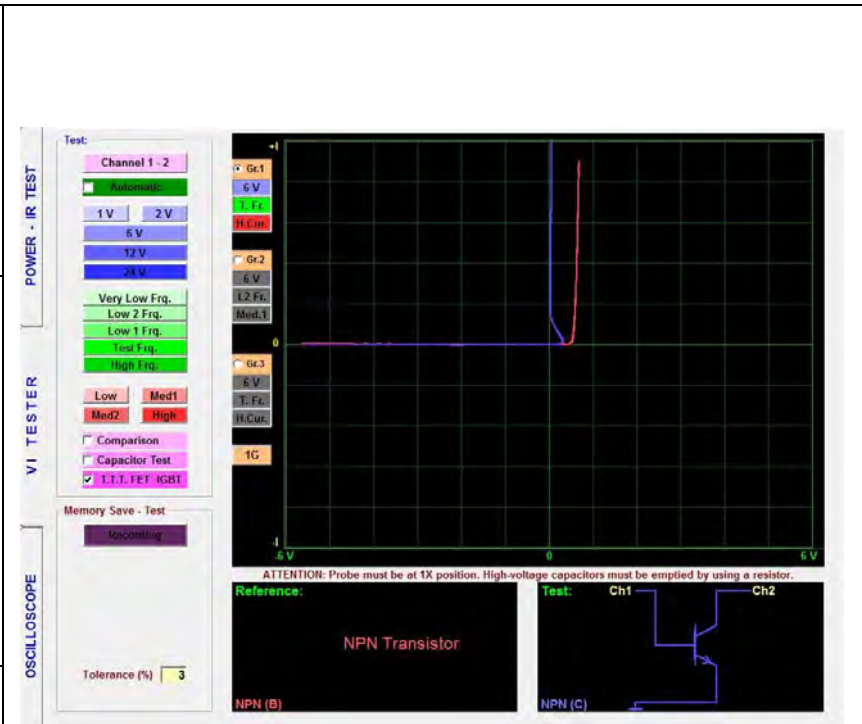


Figure 114: NPN Transistor VI Graph, Equivalent Circuit Diagram (Channel1 Base, Channel2 Collector)

PNP Type Transistor VI Graph Samples

BC857C PNP Transistor

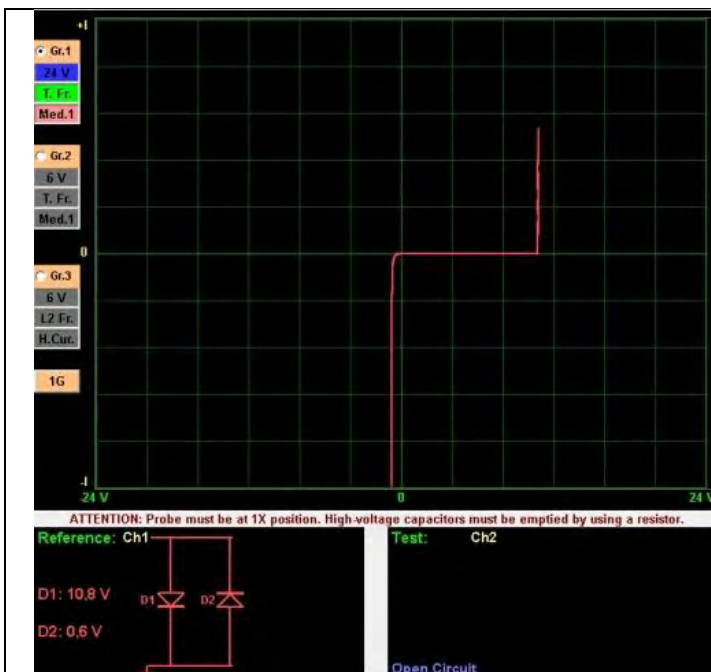


Figure 115: Base (+) Emitter (-) VI Graph

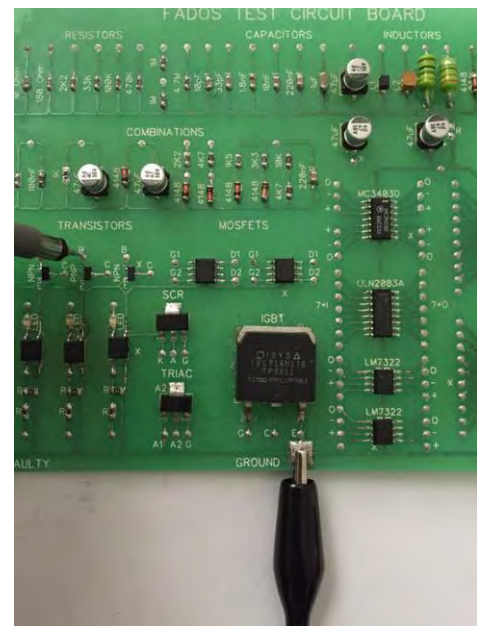


Figure 116: Channel1 Probe Used for Base - Emitter Measurement

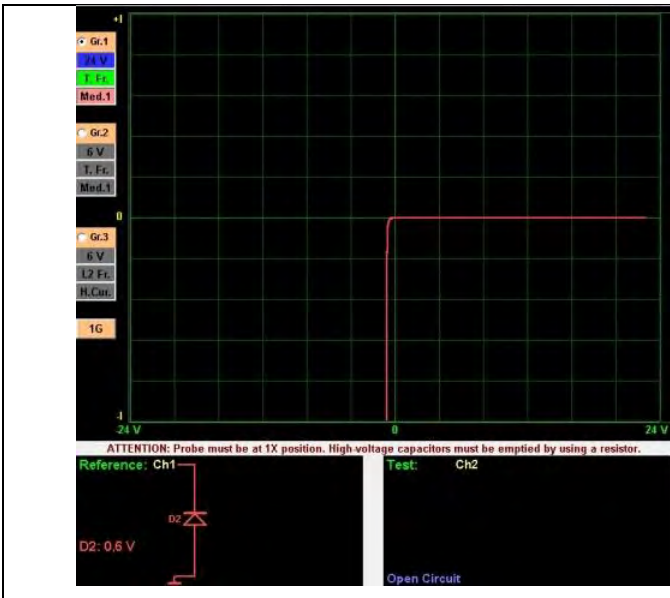


Figure 117: Base (+) Collector (-) VI Graph

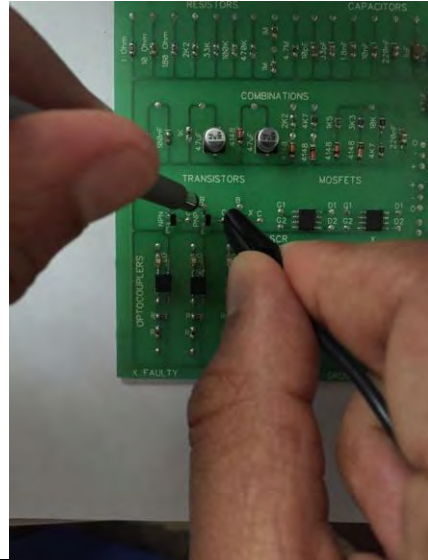


Figure 118: Channel1 Probe Used for Base - Collector Measurement

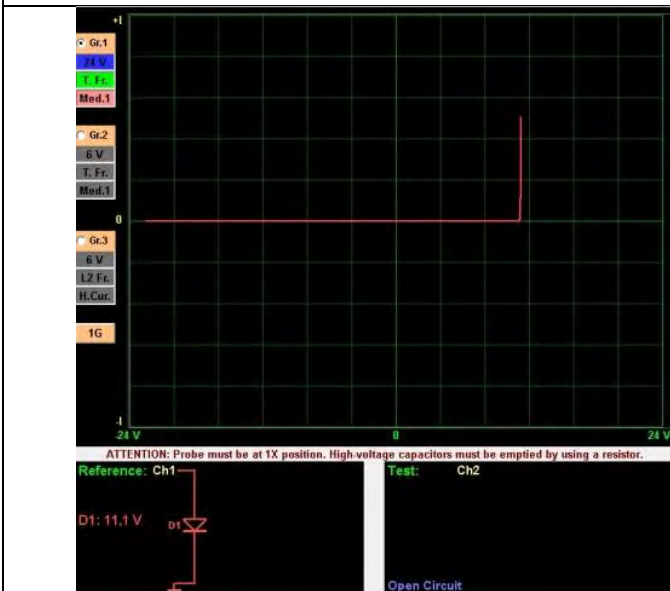


Figure 119: Collector (+) Emitter (-) VI Graph

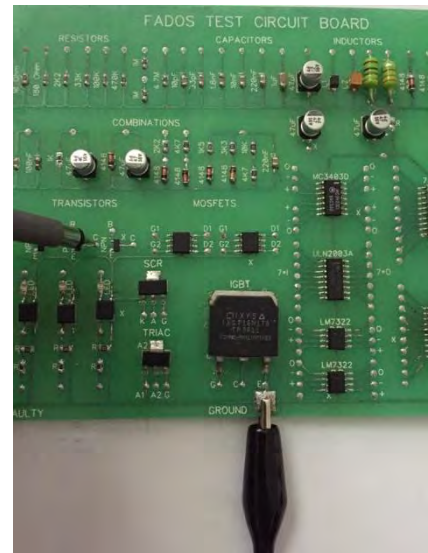


Figure 120: Channel1 Probe Used for Collector - Emitter Measurement

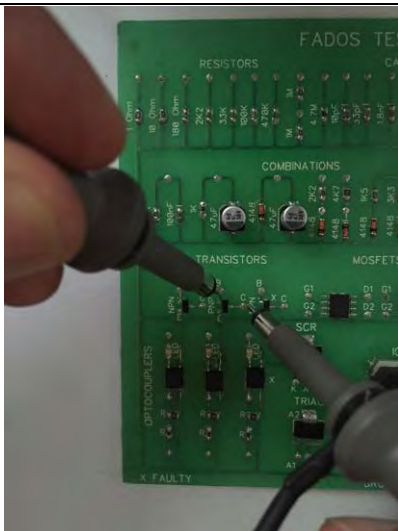


Figure 121: Channel1 (+), Channel2 (+), COM (-) Transistor Test

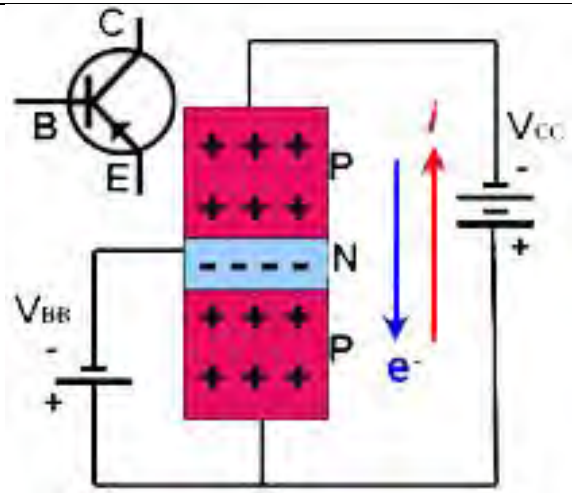


Figure 122: Transistor Conduction

In the PNP type transistors, while the minus side of the Vbb source pulls the base side towards negative, the plus side of the Vcc source pushes the plus charged holes at the emitter region upwards as shown in Figure 122. The plus charges thus compressed are pulled towards the base and migrate to the collector region from here. Since the minus side of the Vcc source attracts the holes in the collector region, the hole movement gains continuity. As long as the VBB current is present, this movement from the emitter towards the collector also continues. In the PNP type transistors, the electrons move downwards and holes move upwards and therefore, the minus signal applied to base is said to cause a current flow from the emitter to the collector.

We can test a transistor with the FADOS9F1 as shown in Figure 122. One of the channels may be connected to the Vcc supply and the other to the Vbb supply (Figure 121). The COM Probe is connected to the chassis. When you touch the Channel1 to the Collector, you will either see a graph as shown in Figure 119 or an open circuit. When the base is triggered (touched) with Channel2, the current flow between the collector and emitter will be shown on the graph (Figure 123).

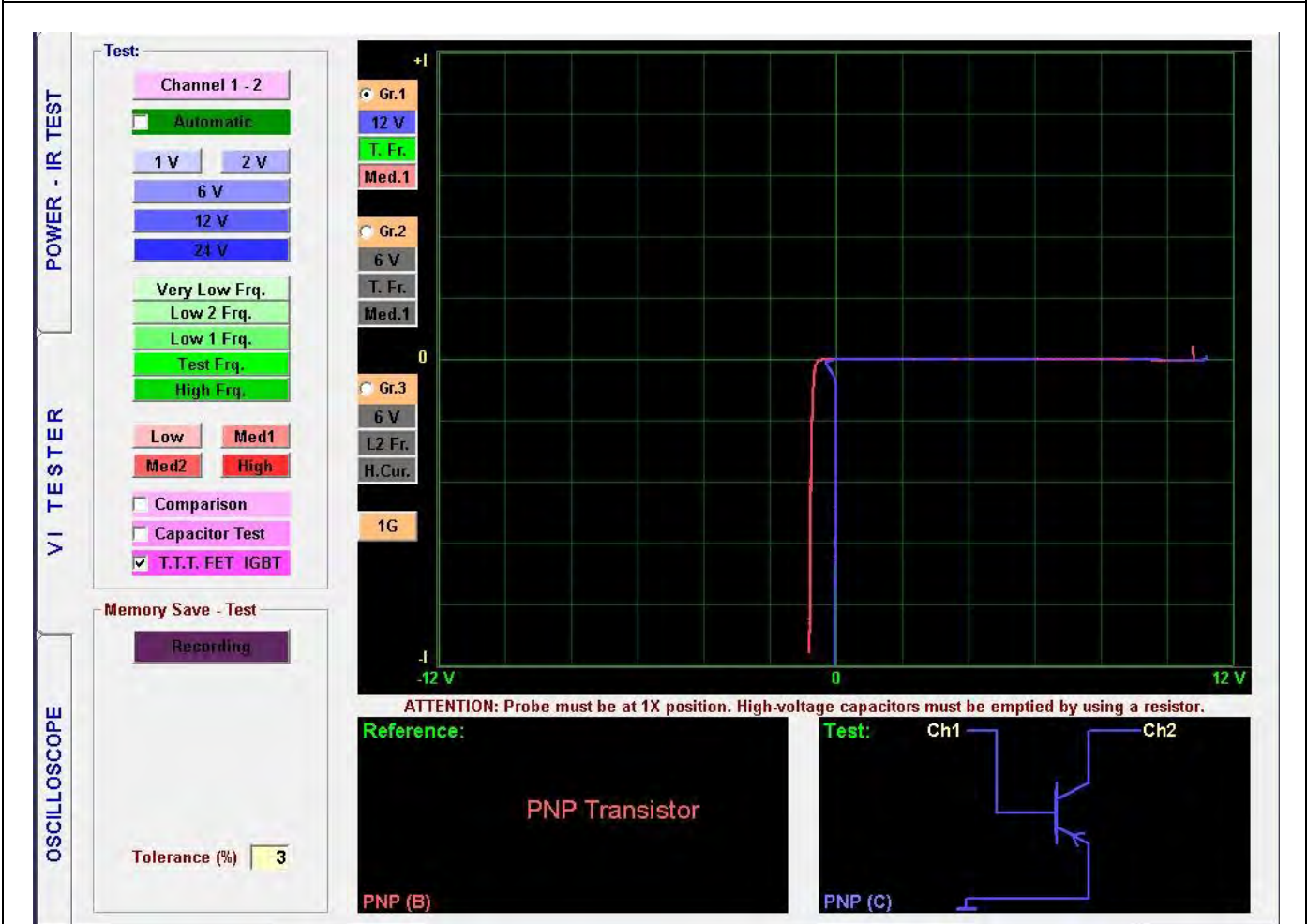


Figure 123: PNP Transistor VI Graph, Equivalent Circuit Diagram (Channel1 Base, Channel2 Collector)

TIP42C PNP Transistor

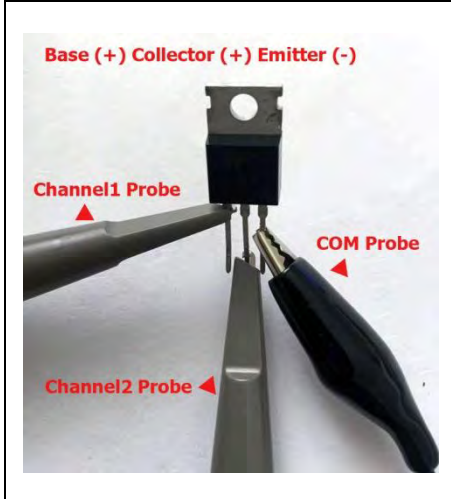
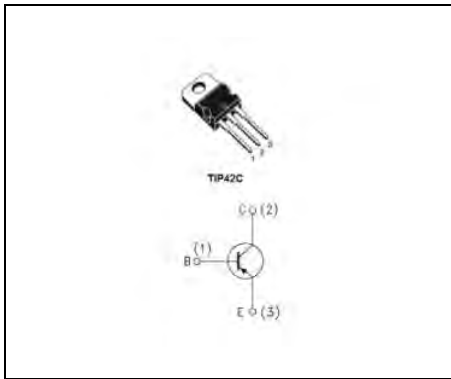


Figure 124: Channel1 (+), Channel2 (+), COM (-) Transistor Test

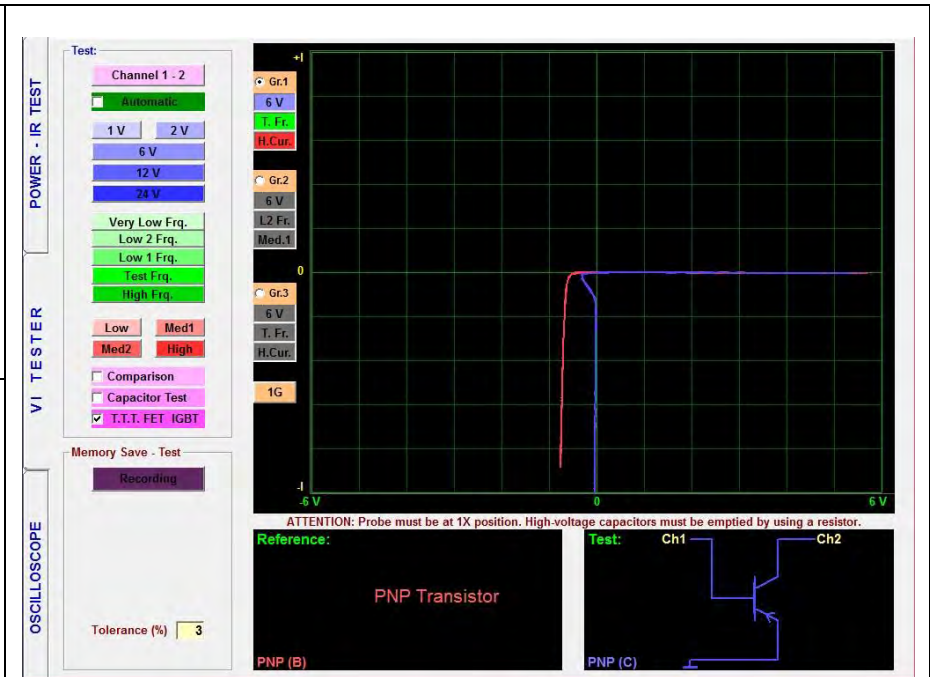


Figure 125: PNP Transistor VI Graph, Equivalent Circuit Diagram (Channel1 Base, Channel2 Collector)

C556B PNP Transistor

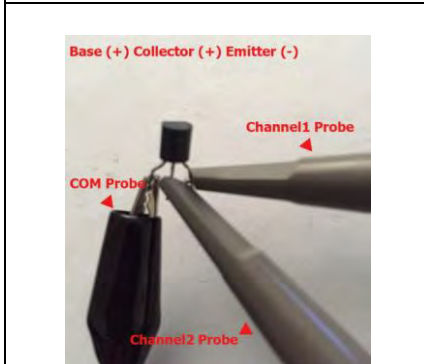
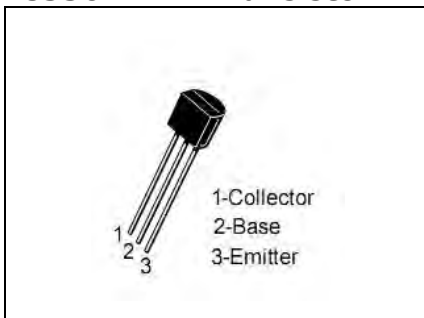


Figure 126: Channel1 (+), Channel2 (+), COM (-) Transistor Test

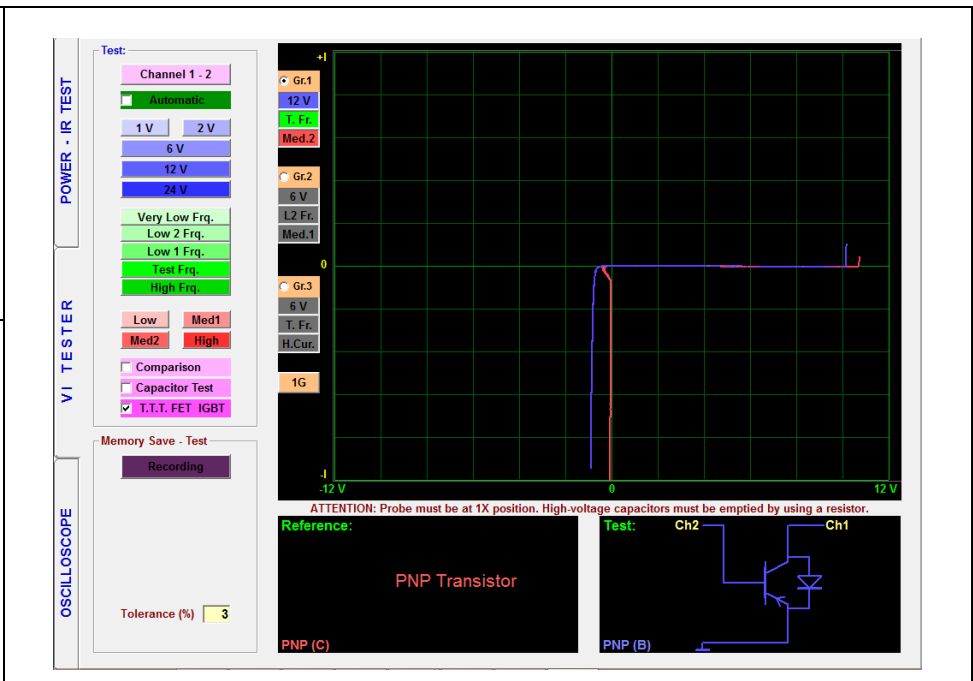


Figure 127: PNP Transistor VI Graph, Equivalent Circuit Diagram (Channel1 Collector, Channel2 Base)

MOSFET – FET VI Graph

The Mosfet is field effect transistor, which is used in the analog and digital circuits frequently. The Mosfets are also three-pin devices like the transistors. Those pins are the G (gate, normal transistor's base pin), S (source) and D (drain, normal transistor's collector).

N Channel JFET Transistor: The N channel JFET transistor is a combination of two P type and one N material.

P Channel JFET Transistor: The operating principle of the P channel JFET transistors is the same as the N channel JFETs. The only difference is the direction of polarization and the reverse location of the P and N materials.

The FETs consist of a channel that contains a semi conductor material and a region (Gate) made of a semi conductor materials with opposite characteristics. The Gate diode shapes the diode with its connections at both ends of the channel (source and drain) and those diodes can be tested. Both probes can be used for testing the 3 pin active devices. One of the probes shows the triggering signal and the other shows the conduction state. If conduction starts, when the T.T.T FET IGTB feature is clicked in the test characteristics menu, the type of the FET – MOSFET as N type or P type FET is analyzed.

IRF3205 Power Mosfet (N)

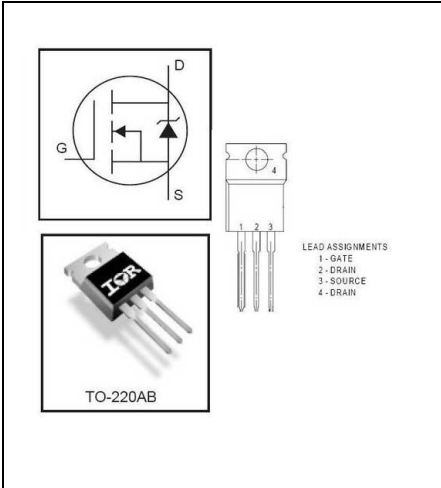


Figure 128: Channel1 Probe Used for Gate - Source Measurement

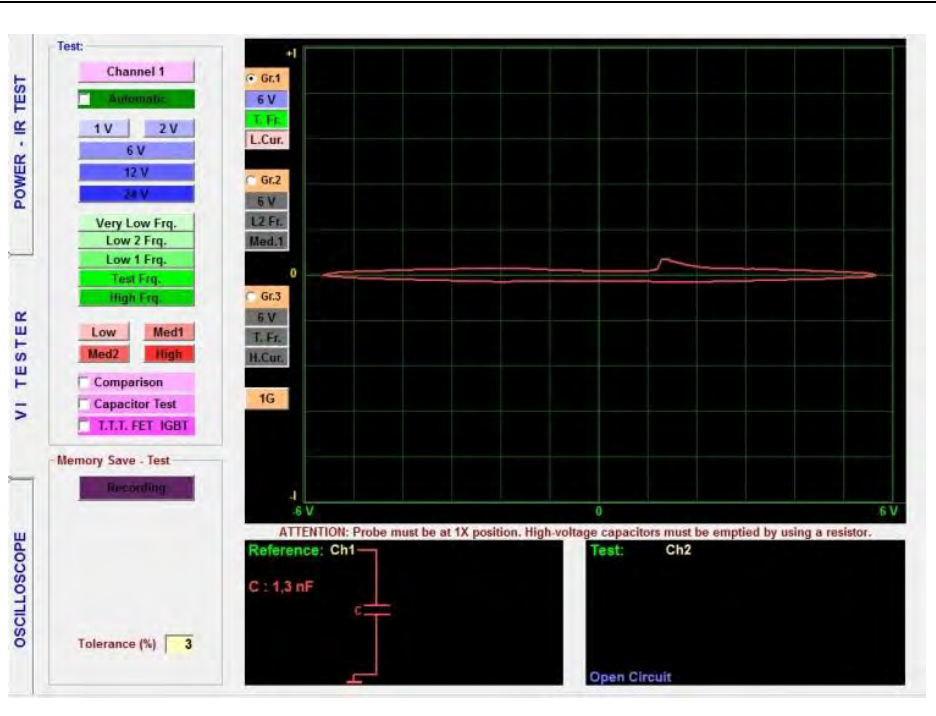


Figure 129: Gate (+) Source (-) VI Graph

In the Mosfets, the input impedance is high, and the internal capacitance between the electrodes is very low. Therefore, a capacitor effect is observed between the Gate and Emitter. When the gate pin is touched with the probe, the capacitor starts charging and when we remove the probe, the capacitor starts discharging. Depending on the charge and discharge state, that is the fullness condition, of the capacitor the following graphs may be observed during the Drain - Source test.

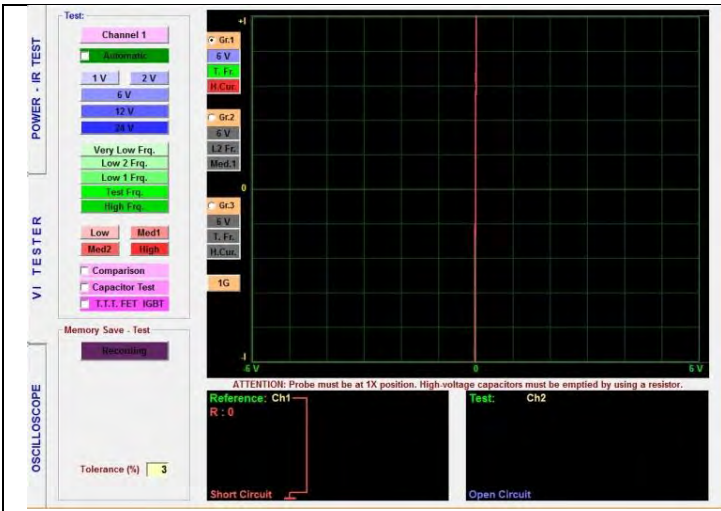


Figure 130: Drain (+) Source (-) VI Graph

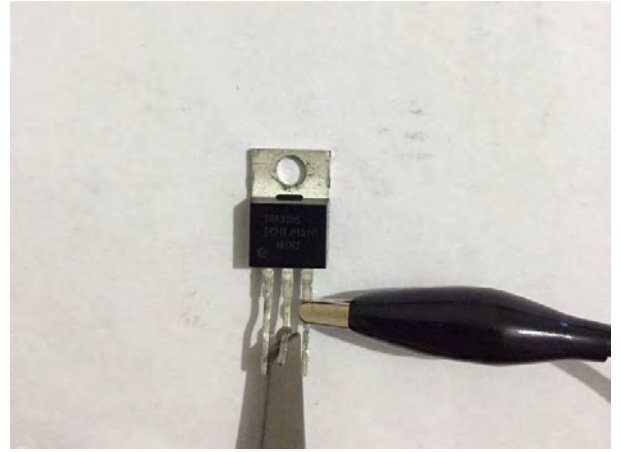


Figure 131: Channel1 Probe Used for Drain - Source Measurement

The VI graph between Drain (+) and Source (-) is shown in Figure 130 according to the fullness (charge) rate of the capacitor between the Gate and Emitter.

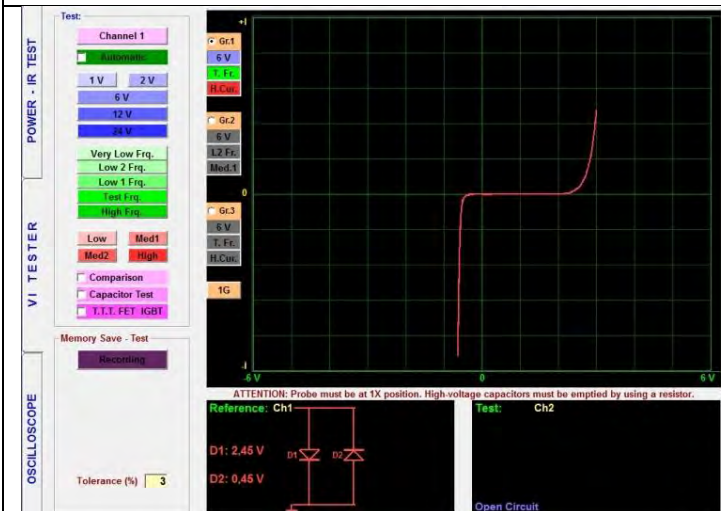


Figure 132: Drain (+) Source (-) VI Graph



Figure 133: Channel1 Probe Used for Drain - Source Measurement

The VI graph between Drain (+) and Source (-) is shown in Figure 132 according to the fullness (charge) rate of the capacitor between the Gate and Emitter.

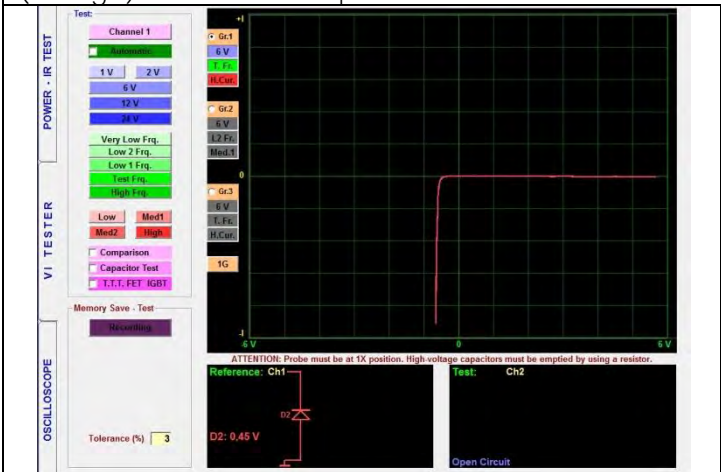


Figure 134: Drain (+) Source (-) VI Graph



Figure 135: Channel1 Probe Used for Drain - Source Measurement

The VI graph between Drain (+) and Source (-) is shown in Figure 134 according to the fullness (discharge) rate of the capacitor between the Gate and Emitter.



Figure 136: Channel1 (+), Channel2 (+), COM (-) Transistor Test

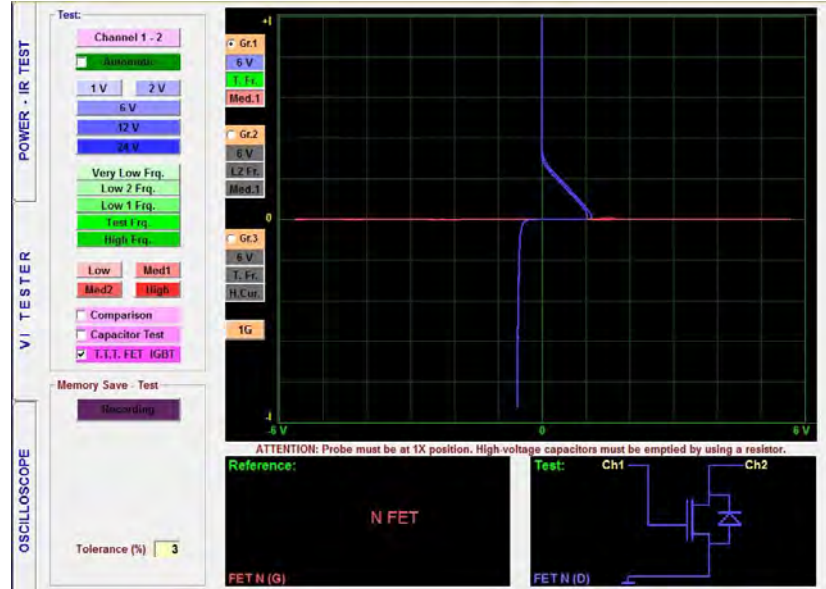


Figure 137: N FET VI Graph, Equivalent Circuit Diagram

P FET

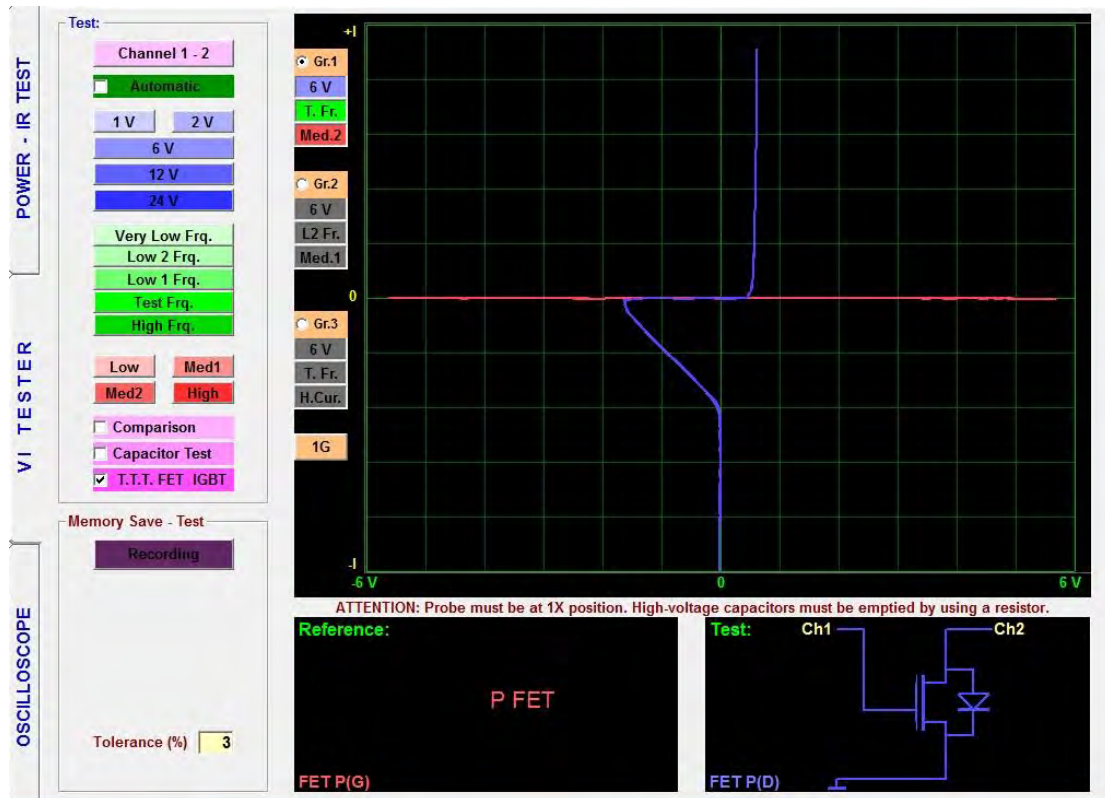


Figure 138: P FET VI Graph, Equivalent Circuit Diagram

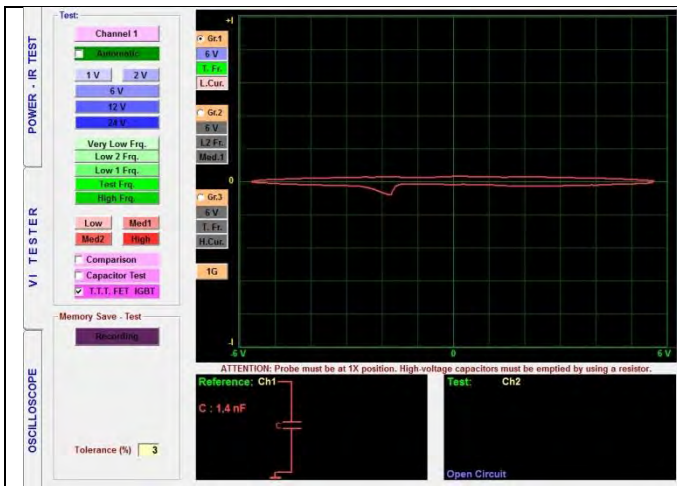


Figure 139: Gate (+) Source (-) VI Graph
 A capacitor effect is observed between the Gate and Emitter. When the gate pin is touched with the probe, the capacitor starts charging and when we remove the probe, the capacitor starts discharging. Depending on the charge and discharge state, that is the fullness condition, of the capacitor the following graphs may be observed during the Drain - Source test.

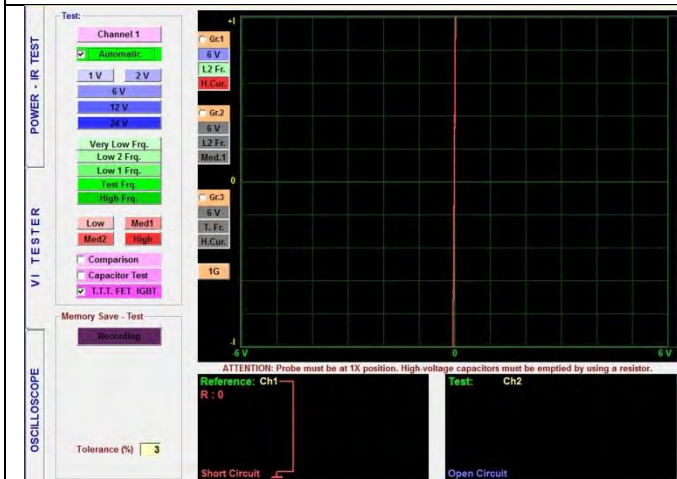


Figure 140: Drain (+) Source (-) VI Graph
 The VI graph between Drain (+) and Source (-) is shown according to the fullness (charge) rate of the capacitor between the Gate and Emitter (charging).

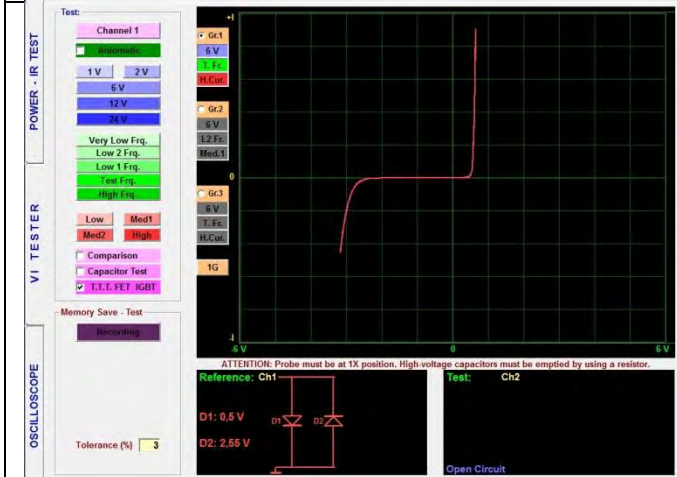


Figure 141: Drain (+) Source (-) VI Graph
 The VI graph between Drain (+) and Source (-) is shown according to the fullness (charge) rate of the capacitor between the Gate and Emitter.

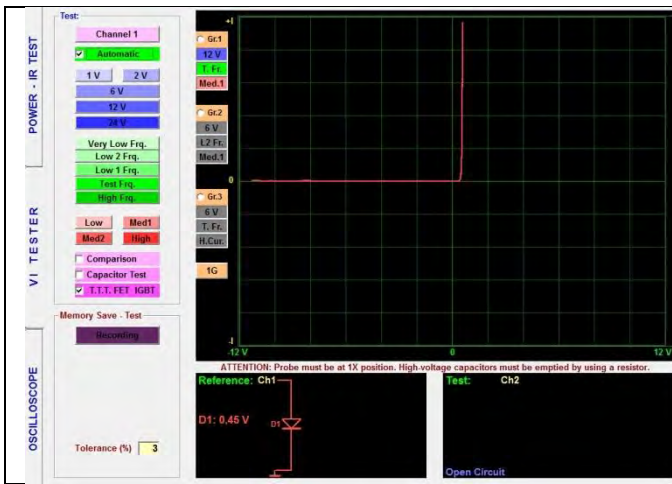


Figure 142: Drain (+) Source (-) VI Graph
The VI graph between Drain (+) and Source (-) is shown according to the fullness (charge) rate of the capacitor between the Gate and Emitter (discharging).

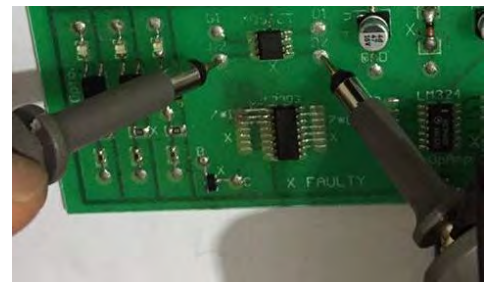
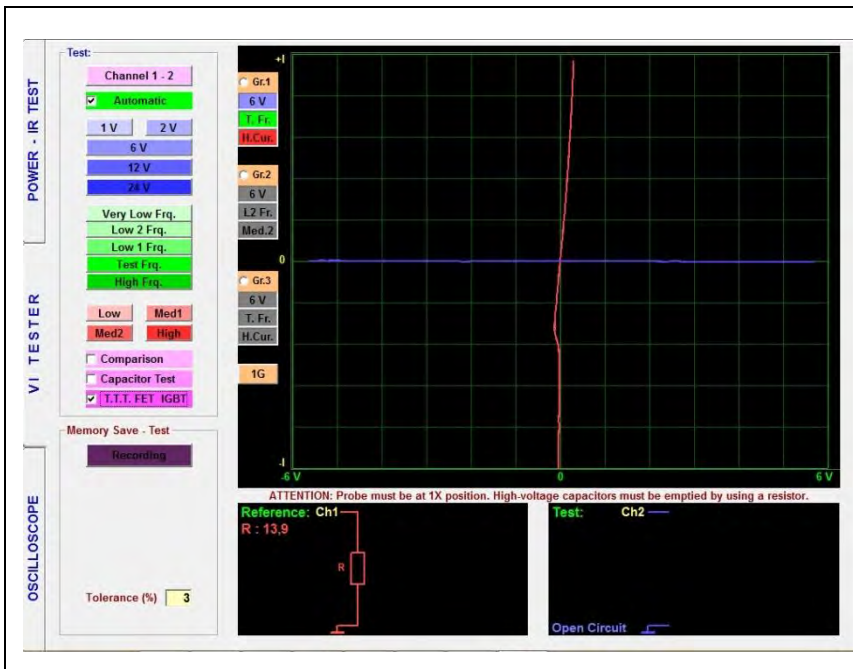


Figure 143: Sample of a Defective P Channel FET

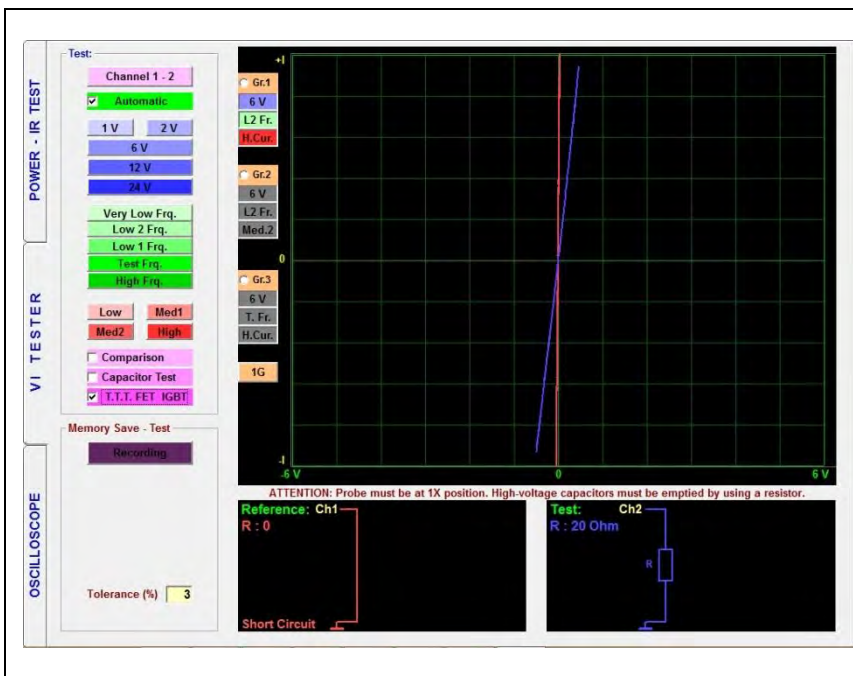
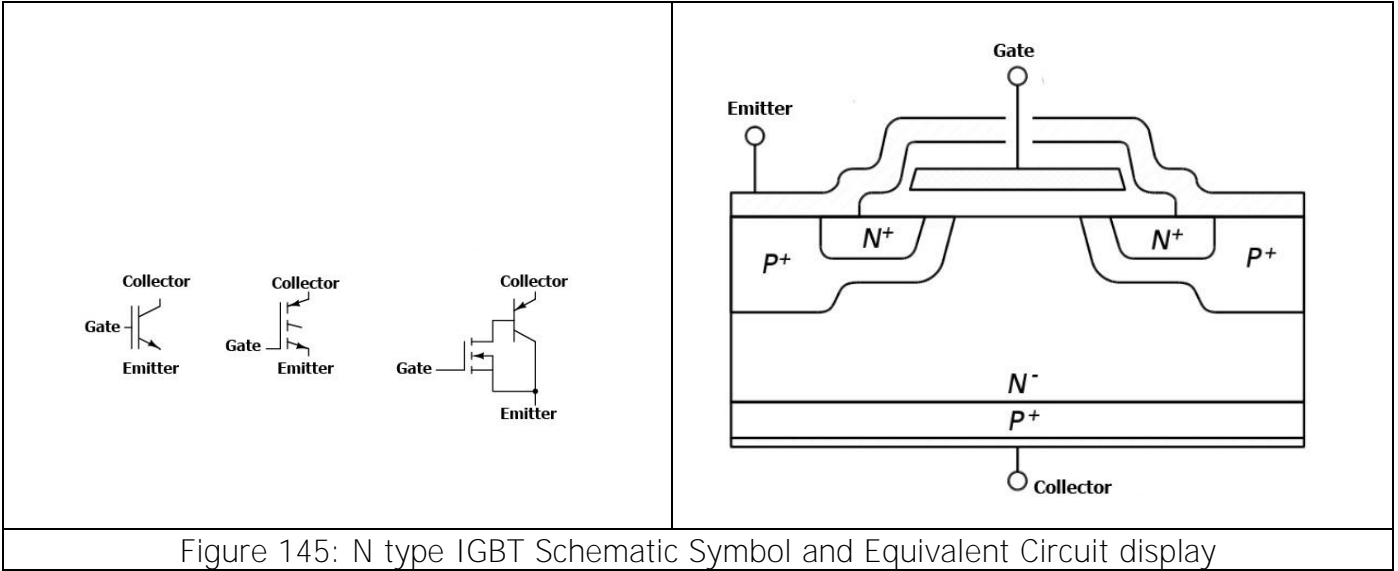


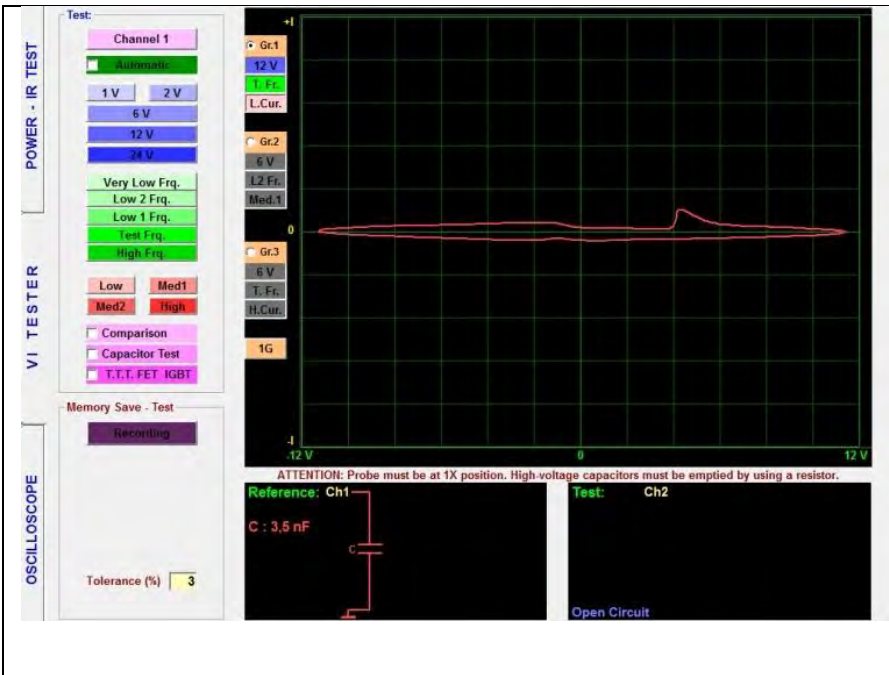
Figure 144: Sample of a Defective N Channel FET

IGBT VI Graph

Insulated Gate Bipolar Transistor (IGBT) is basically comprised of a 3-pin semi conductor device. It is made of 4 layers (P-N-P-N) and is controlled by a metal oxide semi conductor (MOS). It is called an insulated transistor as well. It is mostly used in the power circuits. Therefore, it is one of the first devices that comes to mind when we talk about power electronics. Its main function is switching and it executes the switching function very rapidly and effectively.



IXGH 16N170 IGBT



In the IGBTs, the input impedance is high, and the internal capacitance between the electrodes is very low. Therefore, a capacitor effect is observed between the Gate and Emitter. When the

gate pin is touched with the probe as shown in Figure 146, the capacitor starts charging and when we remove the probe, the capacitor starts discharging. Depending on the charge and discharge state, that is the fullness condition, of the capacitor, the following graphs may be observed during the Collector - Emitter test.

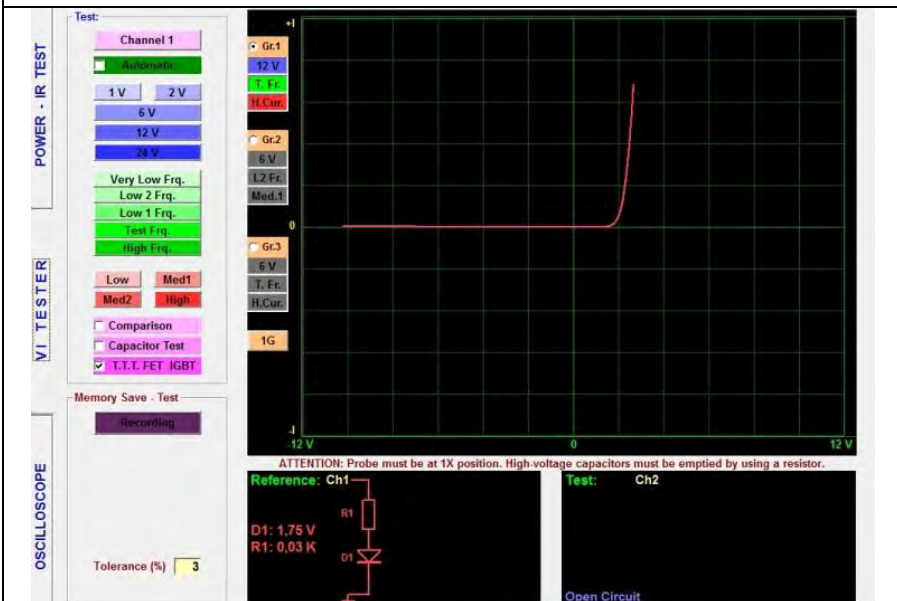


Figure 148: Collector (+) Emitter (-) VI Graph



Figure 149: Channel1 Probe Used for Collector - Emitter Measurement

The VI graph between Collector (+) and Emitter (-) is shown in Figure 148 according to the fullness (charge) rate of the capacitor between the Gate and Emitter (charging).

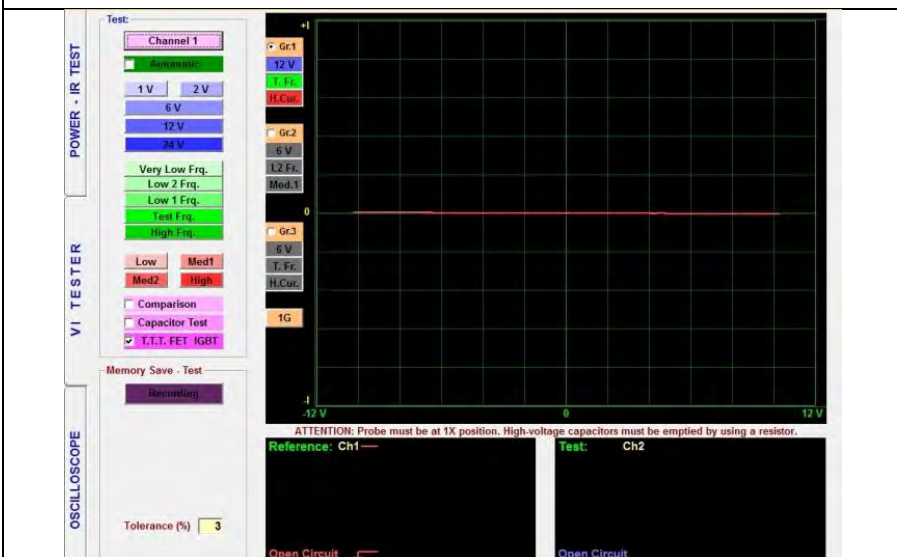


Figure 150: Collector (+) Emitter (-) VI Graph



Figure 151: Channel1 Probe Used for Collector - Emitter Measurement

The VI graph between Collector (+) and Emitter (-) is shown in Figure 150 according to the fullness (charge) rate of the capacitor between the Gate and Emitter (discharging).

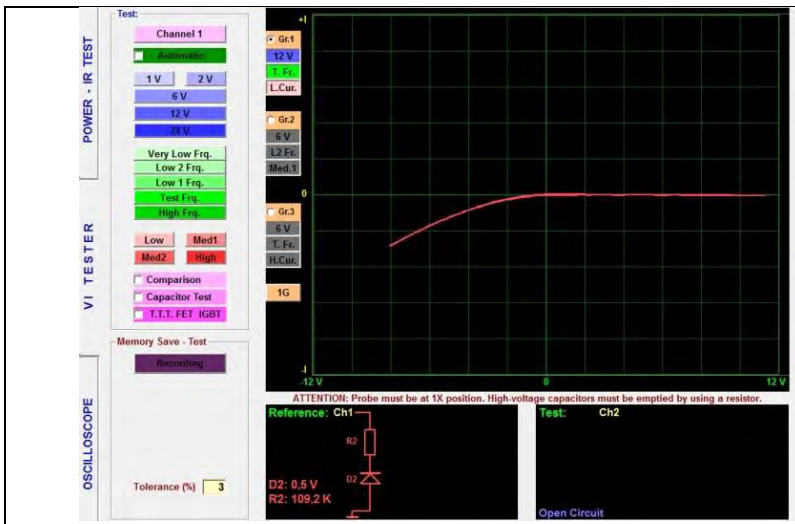


Figure 152: Collector (+) Emitter (-) VI Graph



Figure 153: Channel1 Probe Used for Collector - Emitter Measurement

The VI graph between Collector (+) and Emitter (-) is shown in Figure 152 according to the fullness (charge) rate of the capacitor between the Gate and Emitter (discharging).

Note: The appearance of the graphs may differ depending on the Voltage, current and frequency stages.

For example, in Figure 152, the voltage between the Collector (+) and Emitter (-) has been measured as 12V, measured at the test Frequency and Low current.

In Figure 150, the 12 V value in graph shown in Figure 152, it was measured at the test Frequency and High current.

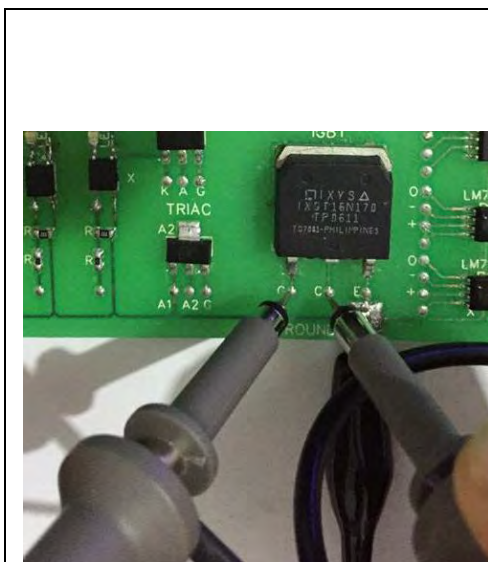


Figure 154: Channel1 (+), Channel2 (+), COM (-) IGBT Test

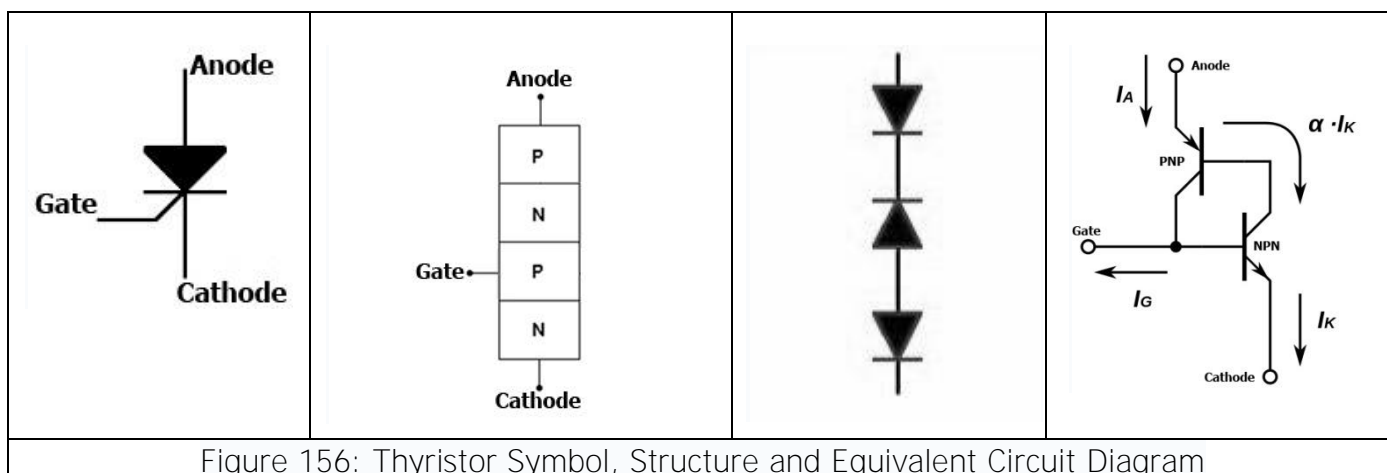


Figure 155: IGBT VI Graph, Equivalent Circuit Diagram

Note: In the Analog Signal Analysis, we have tried to illustrate the VI graphs of the same point (in the electronic material) at different voltage, frequency or current stages. The VI graphs may give different responses against different test stages. For example, an electronic material that does not conduct under high current may start conducting under low current etc. Those conditions are illustrated in Figure 150 and Figure 152.

Thyristor (SCR) VI Graph

The Thyristor structure is composed of four consecutive layers of P type and N type semi conductors. The two of the three pins of the thyristor are the anode at the P type semi conductor portion and a cathode at the N type semi conductor and the other is connected to the Gate extending from the P type section closer to the cathode.



BT168G Tristör

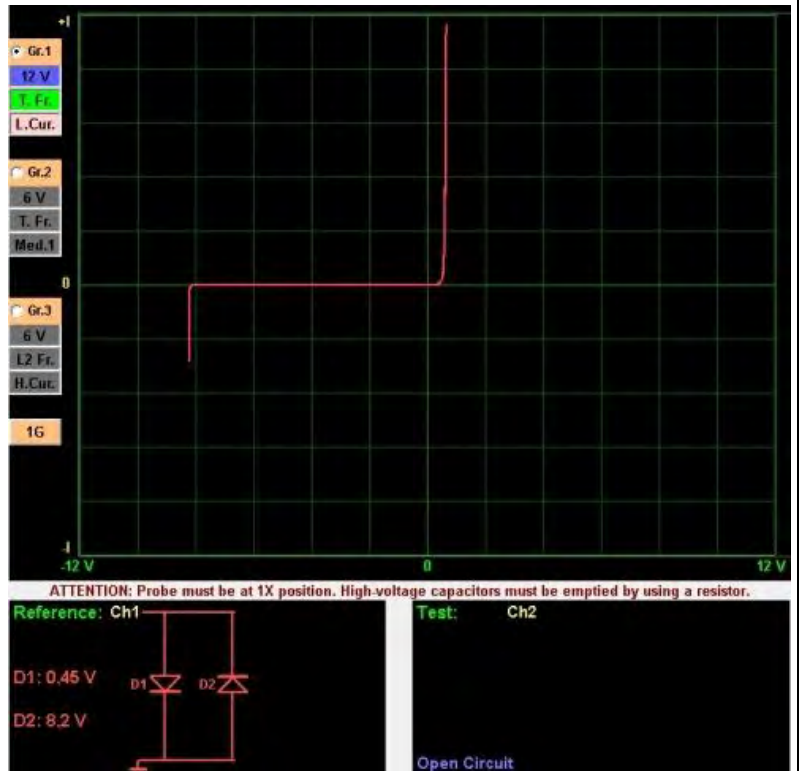


Figure 157: Channel1 Probe Used for Gate - Cathode Measurement

Figure 158: Gate (+) Cathode (-) VI Graph



Figure 159: Channel1 Probe Used for Gate - Anode Measurement

Figure 160: Gate (+) Anode (-) VI Graph



Figure 161: Channel1 Probe Used for Anode - Cathode Measurement



Figure 162: Anode (+) Cathode (-) VI Graph



Figure 163: Channel1 (+), Channel2 (+), COM (-) Thyristor Test

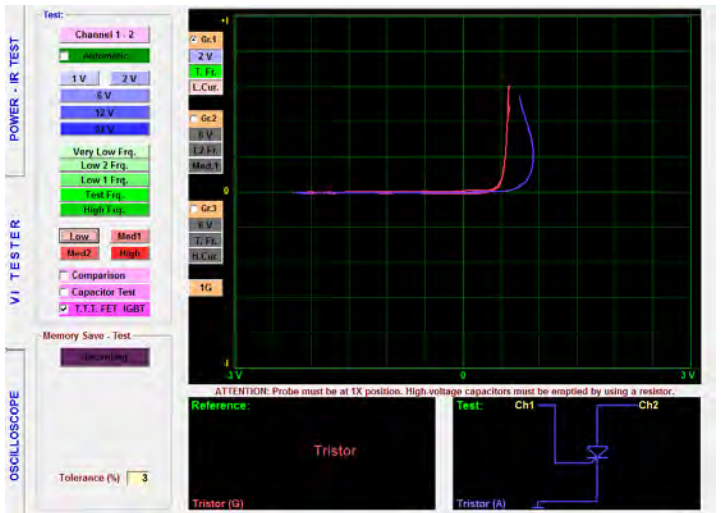


Figure 164: Thyristor VI Graph Equivalent Circuit Diagram

Triac VI Graph

The Triac is composed of two thyristors of N gate and P gate connected to each other in reverse and is a semi conductor device that conducts the alternating current in both directions. It has a more advanced construction than the thyristor. The triac is also a circuit component used in power electronics like the thyristor.

It has 3 pins as the A1 (Anode 1), A2 (Anode 2) and Gate. The triacs can operate on both DC and AC voltage.

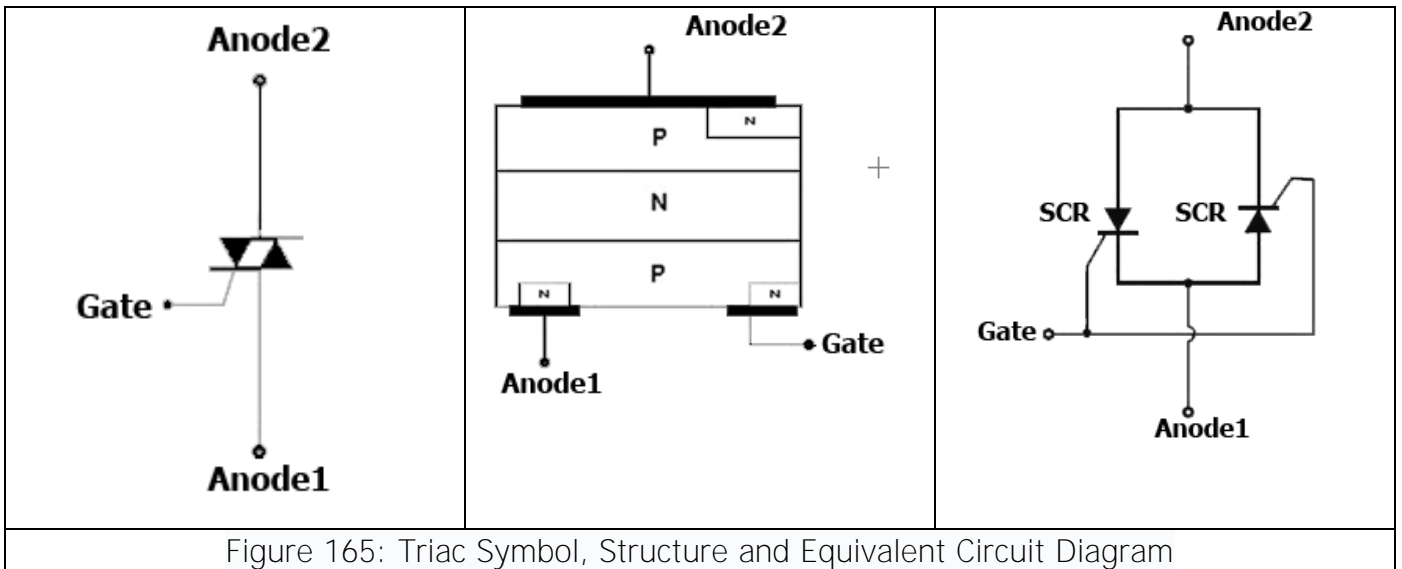


Figure 165: Triac Symbol, Structure and Equivalent Circuit Diagram



Figure 166: Channel1 Probe Used for Gate - Anode1 Measurement

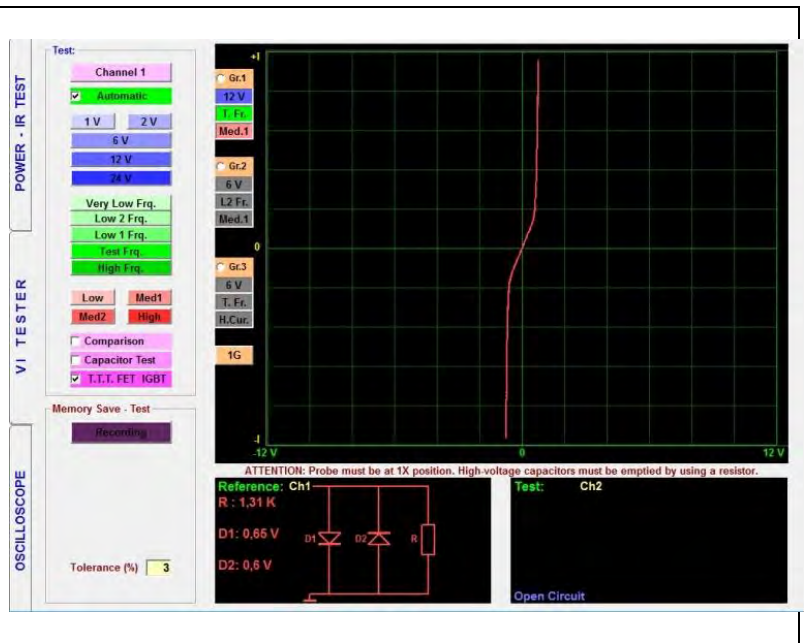


Figure 167: Gate (+) Anode1 (-) VI Graph

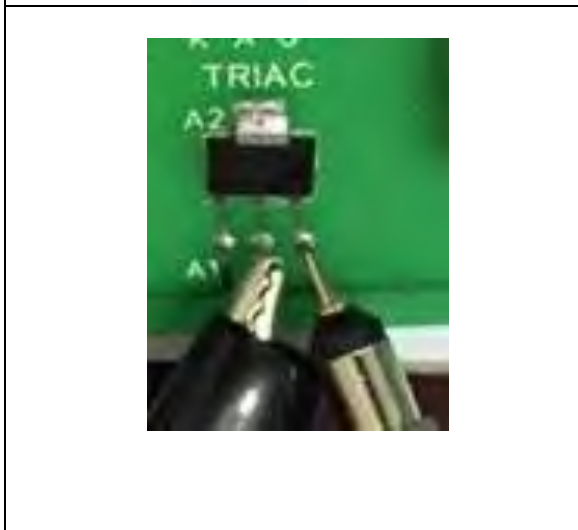


Figure 168: Channel1 Probe Used for Gate - Anode2 Measurement



Figure 169: Gate (+) Anode2 (-) VI Graph



Figure 170: Channel1 Probe Used for Anode2 - Anode1 Measurement

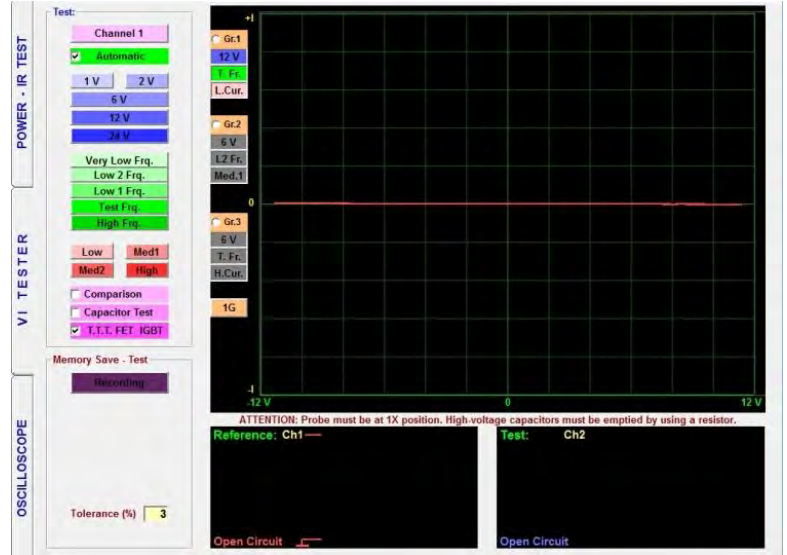


Figure 171: Anode2 (+) Anode1 (-) VI Graph



Figure 172: Channel1 (+), Channel2 (+), COM (-) Triac Test

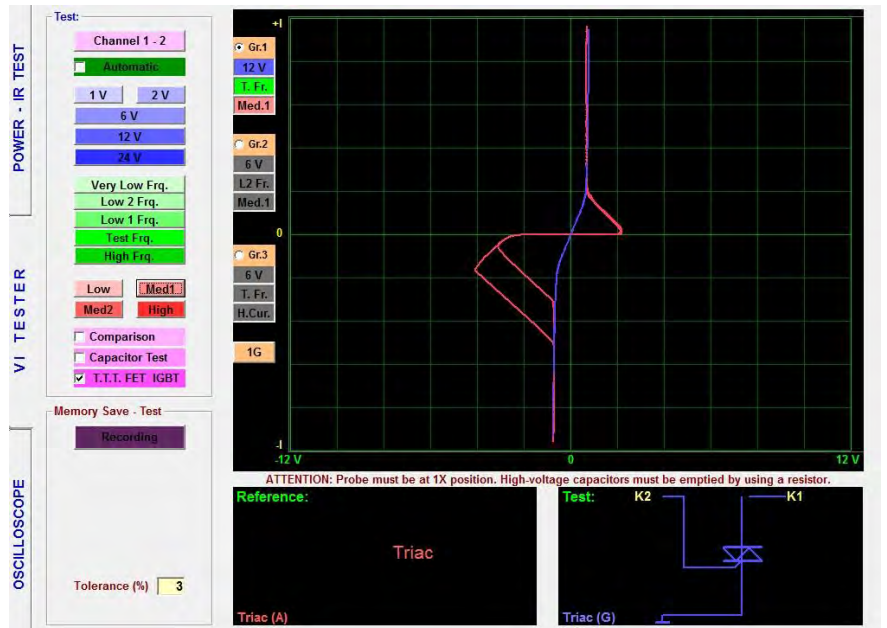


Figure 173: Triac VI Graph Equivalent Circuit Diagram

Opto-coupler VI Graph

The Opto-couplers are the circuit components that are composed of a light emitting and a photo-receiver element with optical connection between each other and are used for controlling high voltage and current by means of low voltages without any electrical connection to isolate two circuits electrically.

The function of the opto-coupler is separating two circuits physically from each other, that is isolating them electrically. As an example, in the circuits, where 12 V and 220 V are used, opto-couplers are used for keeping those two different voltages separately. Thus thanks to the opto-

couplers, different currents in the same circuit are isolated from each other to ensure a safe current flow and faultless operation of the circuit.

They may have different structures from Transistor, triac, mosfet, thyristor, ttl, logic and cmos to darlington, parallel connection etc. Some of them may have triggering pins in extra for using in special external applications. For example, the PC817 has 4 pins, of which two are for the LED and the other two forms the base pin for the collector and emitter of the transistor and there is no separate pin for the base. The 4N25 has 6 pins, one of which is for the base.

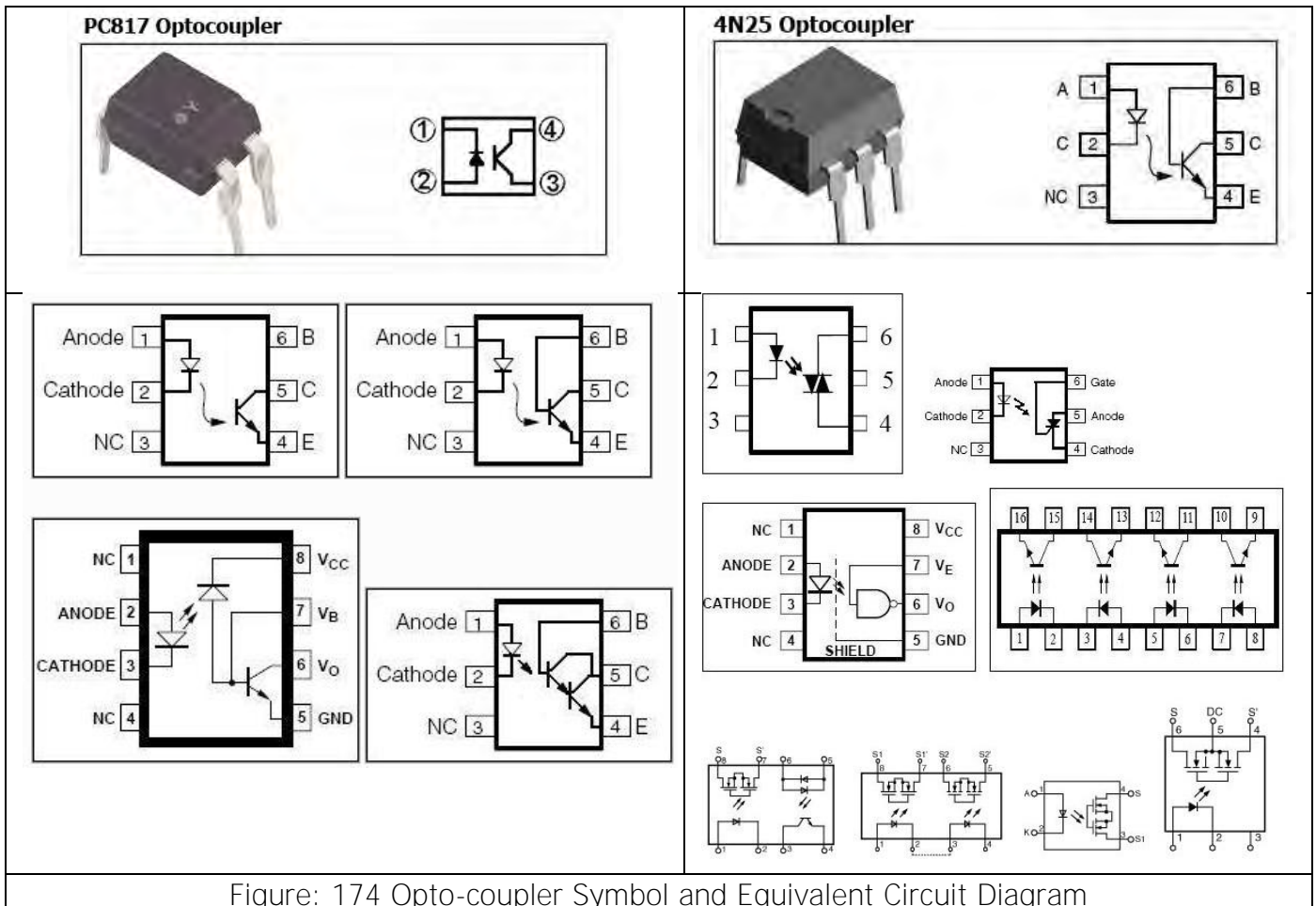


Figure: 174 Opto-coupler Symbol and Equivalent Circuit Diagram

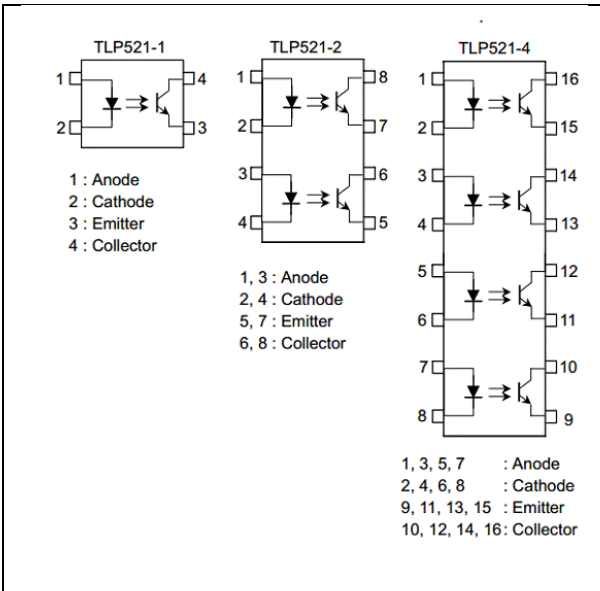


Figure 175: TLP521-X Opto-coupler Equivalent Circuit Diagram

Figure 176: TLP521-1, TLP521-2, TLP521-4 Opto-coupler

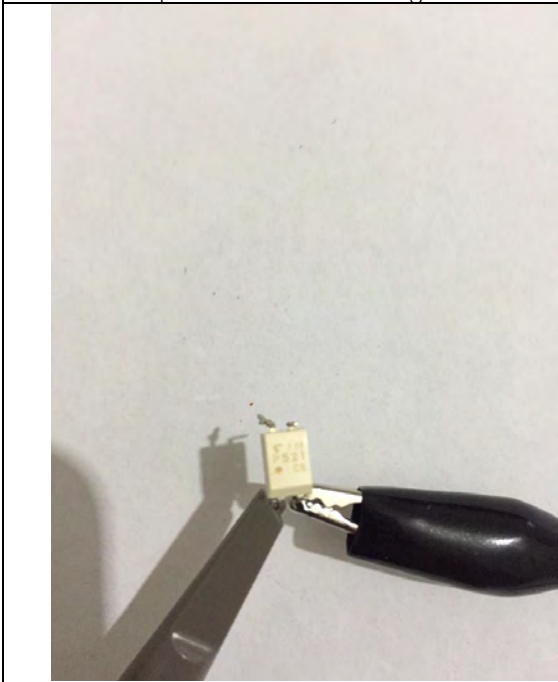


Figure 177: TLP521-1 Test Channel2 (Anode) - COM (Cathode)

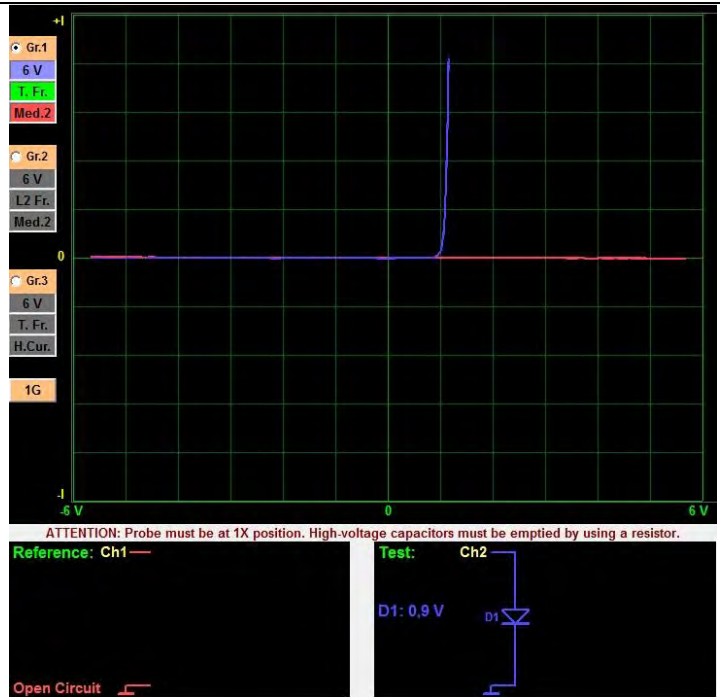


Figure 178: TLP521-1 Test Channel2 (Anode) - COM (Cathode) VI Graph

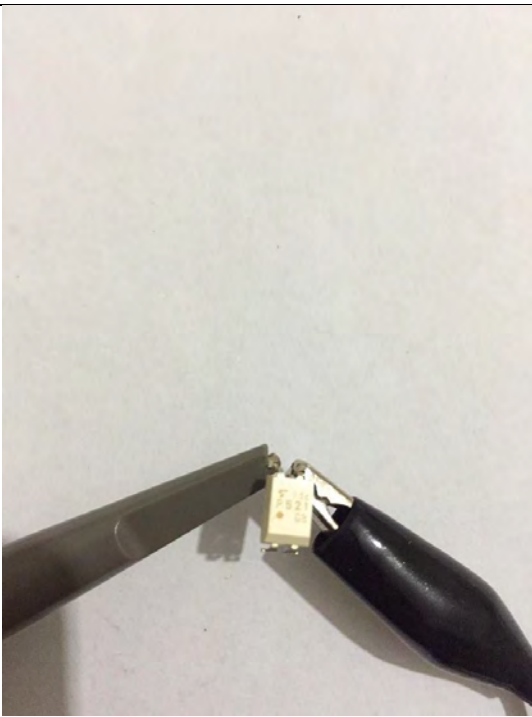


Figure 179: TLP521-1 Test Channel1 (Collector) - COM (Emitter)

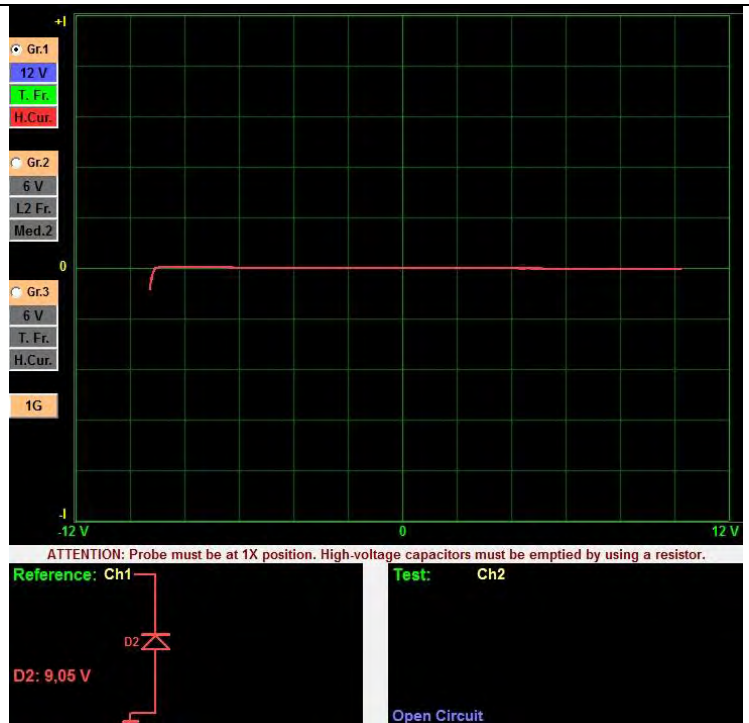


Figure 180: TLP521-1 Test Channel1 (Collector) - COM (Emitter) VI Graph



Figure 181: TLP521 - 1 Test Channel1 (Collector) - COM (Emitter), Channel2 (Anode) - COM (Cathode)

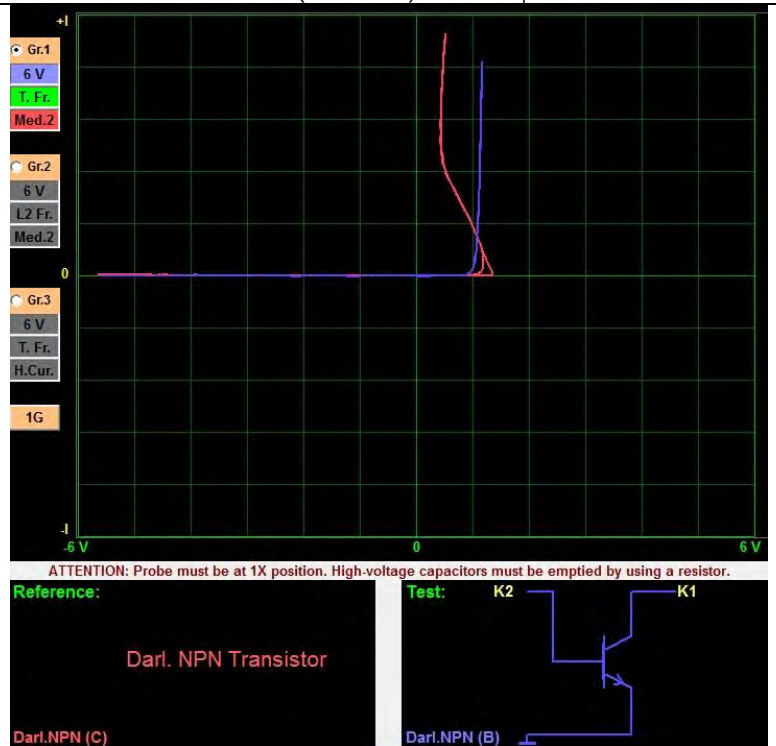


Figure 182: TLP521-1 Opto-coupler VI Graph

Note: TLP521-2 Optocoupler is comprised of 2 x TLP521-1 Opto-coupler and the TLP521-4 Optocoupler is comprised of 4 x TLP521-1 Opto-couplers. After examining the data sheet, the pins with the same names and same functions are compared to each other for testing.

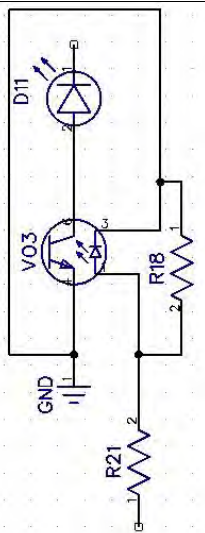
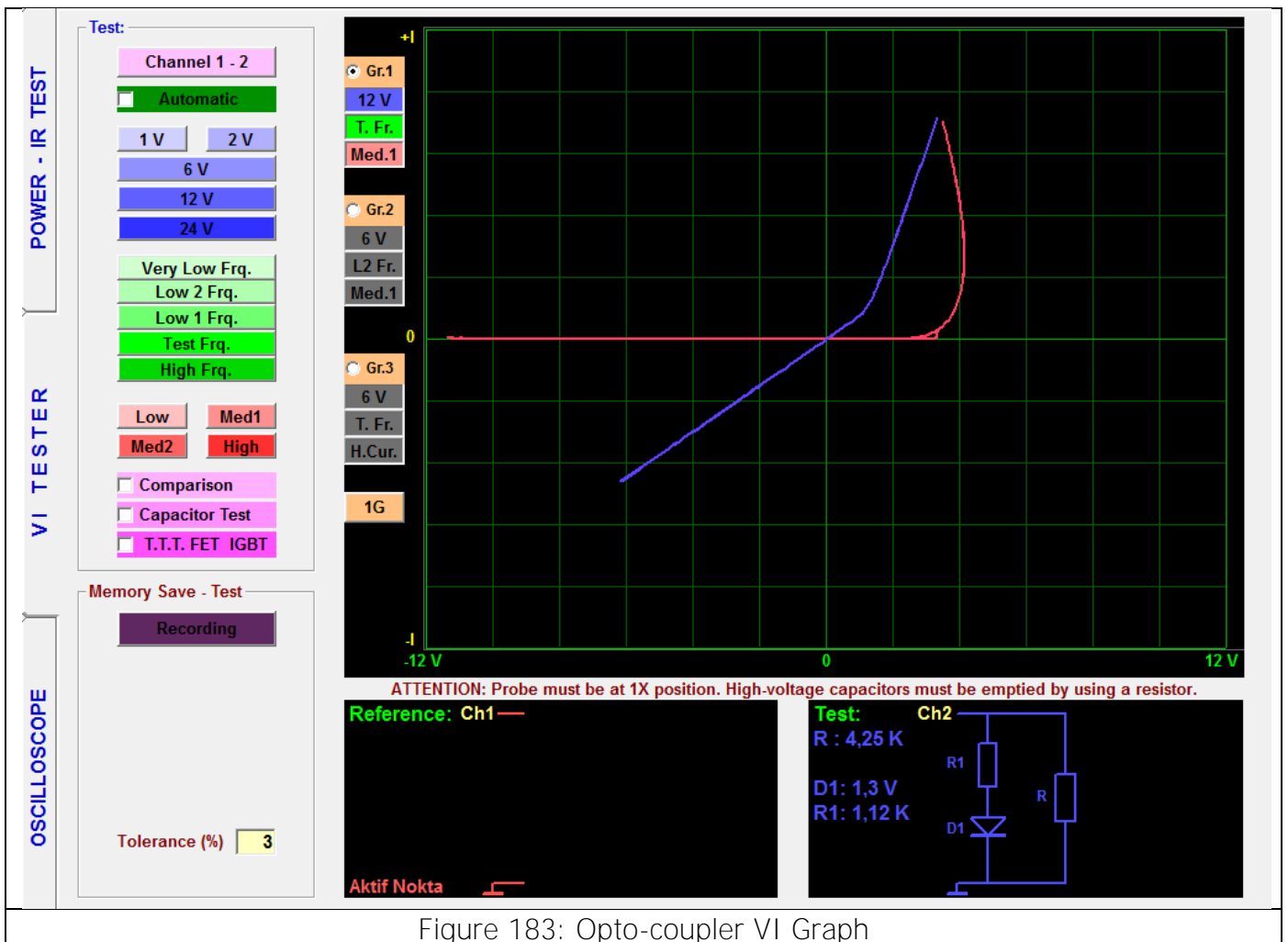


Figure 184: IS181GB Opto-coupler Circuit

Note: Figure 183 shows the VI graph of the IS181GB opto-coupler in the circuit given on the left side. A signal is applied to the V03 optocoupler in the circuit over the resistor R21 (Channel2); we can understand when the opto-coupler starts conducting from the diode D11 (LED). The can check if the LED is conducting by touching the Channel1 probe to the cathode pin of the diode D11 If the LED conducts, the opto-coupler is intact.

INTEGRATED CIRCUITS (ICs – SMD INTEGRATED CIRCUIT TESTS)

The Integrated circuits are composed of the semi conductor components and protective zener diodes and or diodes are connected to all the pins for protection. Therefore, when the integrated circuits are tested, their VI graphs resemble the zener diodes or normal diodes.

The VI graph of the Integrated circuit Vcc pin resembles the graph of a diode and a capacitor connected in parallel. The graph of a short circuit is displayed for the GND pin.

While testing the Integrated circuits in the circuit, because the integrated circuit pins are connected to the other components in the circuit, the graphs of the IC pins may look like the graphs for the components connected to the zener diode (or diode) in parallel or in series. While testing an integrated circuit (except the short circuit test), IC shorting the Vcc and GND pin of the Vcc together is recommended. Connect the Crocodile probe to the GND pin and touch the IC pins with the probe for testing. If the Integrated circuit pins do not display the graphs for the zener or diodes, the integrated circuit pin is damaged and so the integrated circuit (IC) is damaged.

The Digital integrated circuits contain more than one components of the same type. Although they may have more than one pins, they may yield several different VI graphs. The data sheets of the Digital integrated circuits are checked for testing the pins that give the same output or have the same inputs (the pins with the same functions and names) against each other.

For example, when we examine the data sheet for the 74LS02 IC;

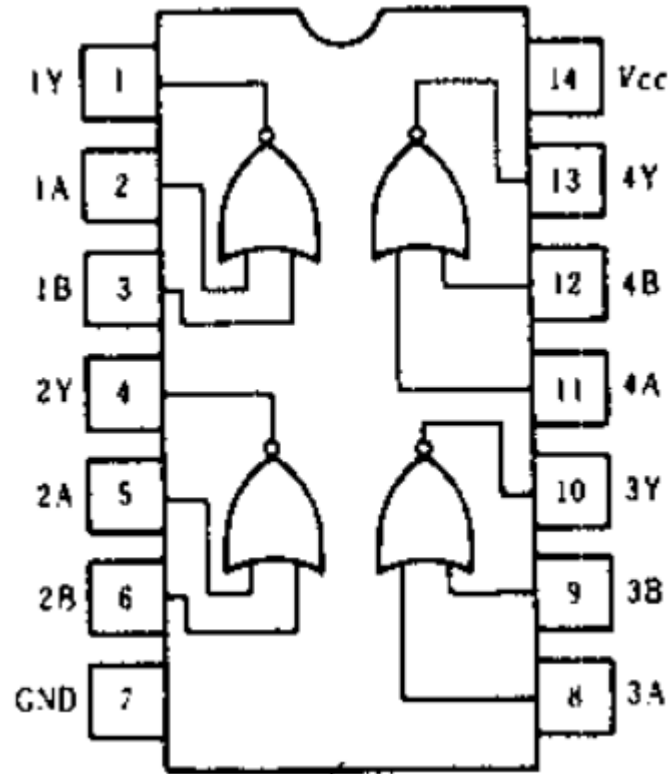


Figure 185: 74LS02 Pin Configuration

The 74LS02 integrated circuit is comprised of 4 NOR gates with 2 inputs positive. When we examine the Integrated circuit datasheets, there are four different connections as the input, output, Vcc (power) and ground. There are 4 NOR gates with 2 inputs (A and B pins) and an output (Y pin). The Pins 2,3,5,6,8,9,11,12 are the input pins and their VI graphs have to be identical. The Pin 1, 3, 10 and 13 are the output pins and their VI graphs have to be identical. The Pin 14 is Vcc and Pin 7 is the GND. We can find the defective pin easily by comparing the pins with the same graph against each other.

The VI graphs for the 74LS02 IC is shown below. When the integrated circuits are tested outside the circuit, connect the COM probe or crocodile of probe to the Ground pin. Also the Ground and Vcc pins can be short circuit and connect the crocodile. For the example below, the Vcc pin and GND pin were shorted together.

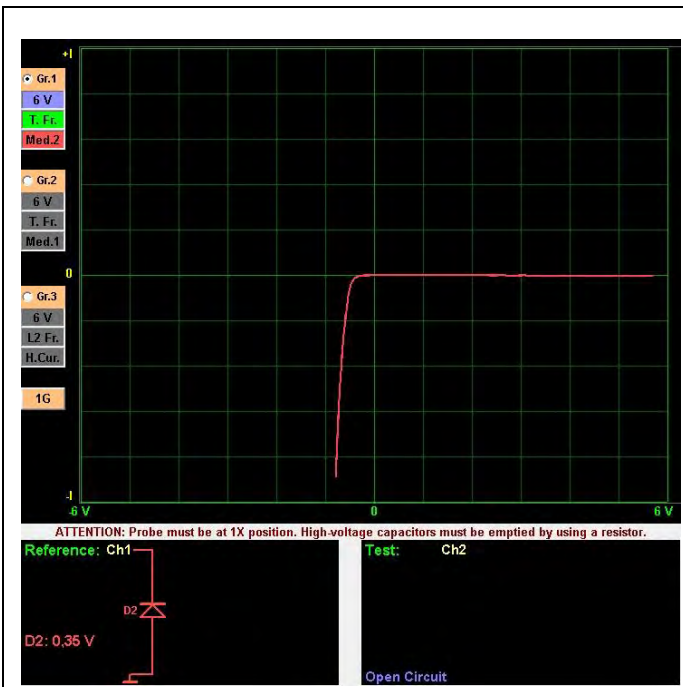


Figure 186: 74LS02 Input VI Graph

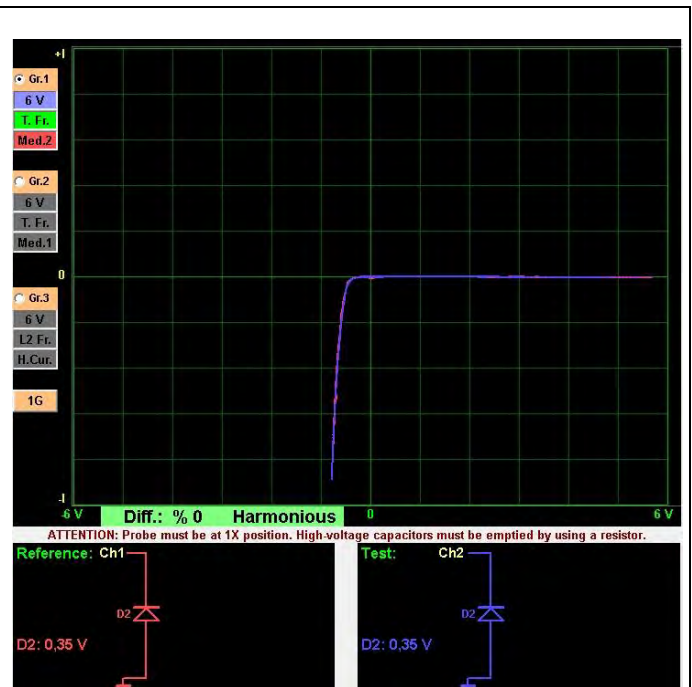


Figure 187: 74LS02 Input VI Graph Comparisons Against Each Other

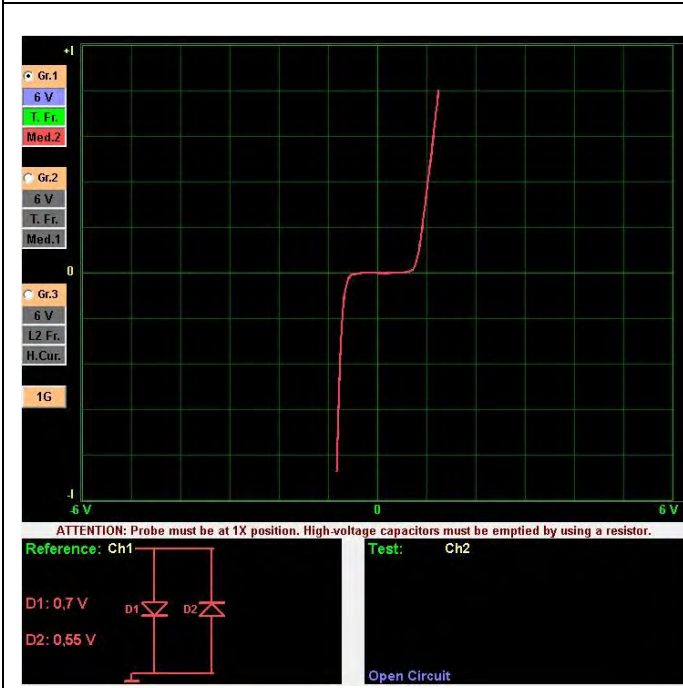


Figure 188: 74LS02 Output VI Graph

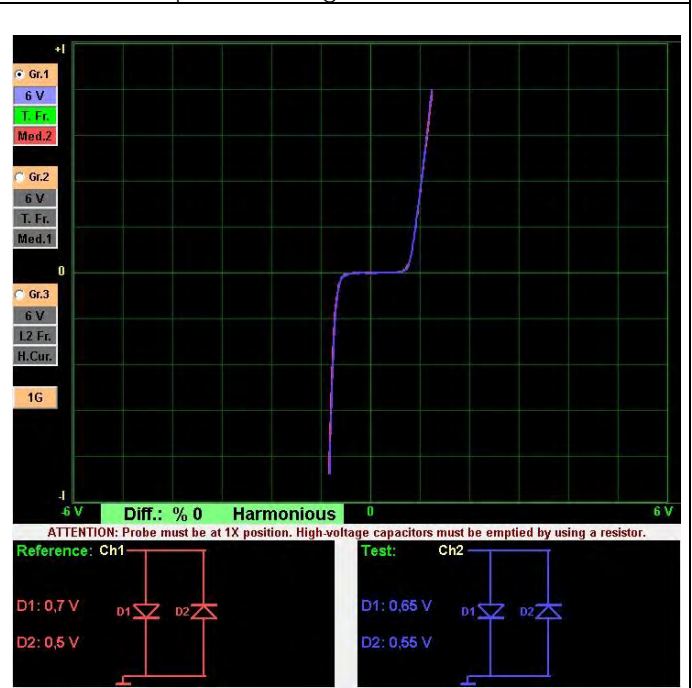


Figure 189: 74LS02 Output VI Graph Comparisons Against Each Other

The Analog integrated circuits are called the “op amps” in general. We may see a different VI graph for each pin. The reason for that is the particular architecture of the IC and the connection of the components used in the IC to each other. Like the Digital integrated circuit tests, the pins with the same names and functions in the analog integrated circuits should be the same VI graphs.

For example, when we examine the datasheet for the ULN2003 analog IC, it has 7 inputs (1,2,3,4,5,6,7 pins) and 7 outputs (10,11,12,13,14,15,16 pins). The Input and outputs should

have the same VI characteristic curves respectively. The pins with the same names and functions are tested by comparing them to each other.

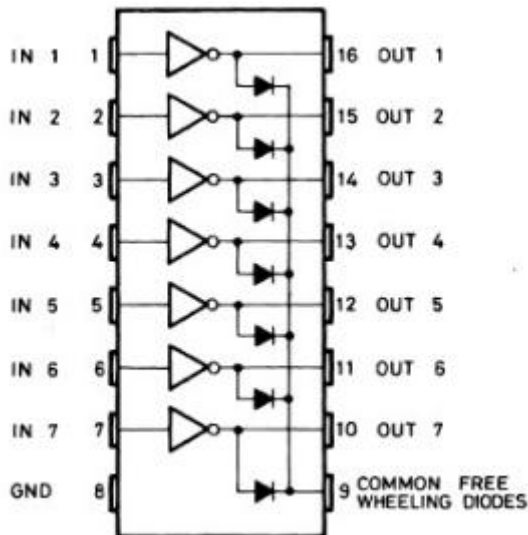


Figure 190: ULN2003 Pin Configuration

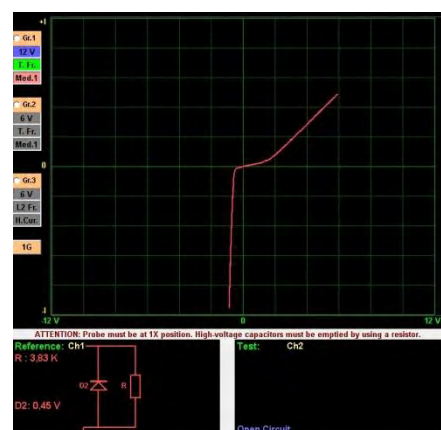


Figure 191: ULN2003 Input VI Graph

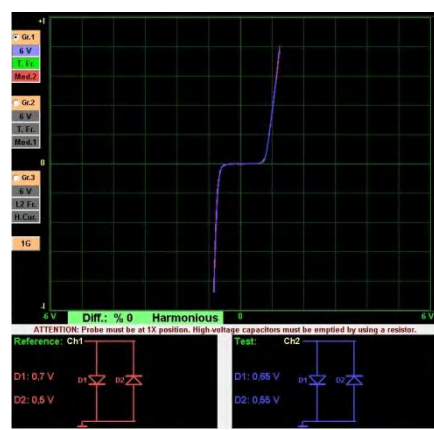


Figure 192: ULN2003 Input VI Graph Comparisons Against Each Other (Intact Pin)

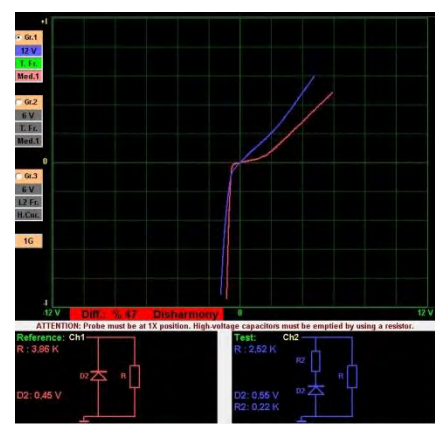


Figure 193: ULN2003 Input VI Graph Comparisons Against Each Other (Defective Pin)

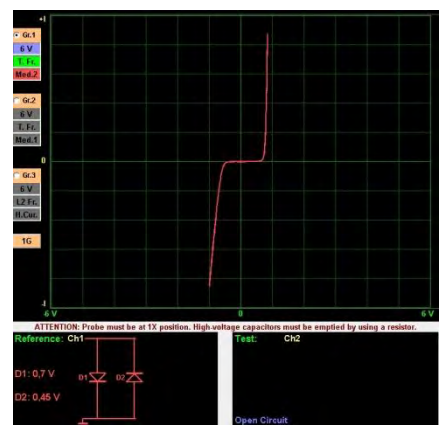


Figure 194: ULN2003 Output VI Graph

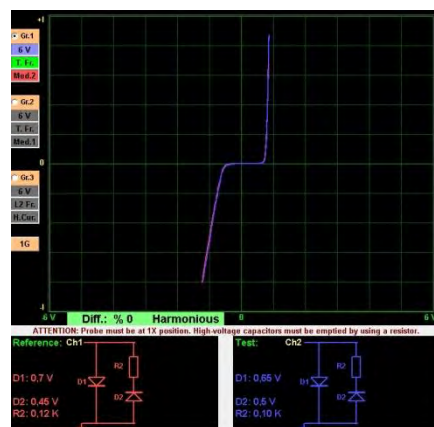


Figure 195: ULN2003 Output VI Graph Comparisons Against Each Other (Intact Pin)

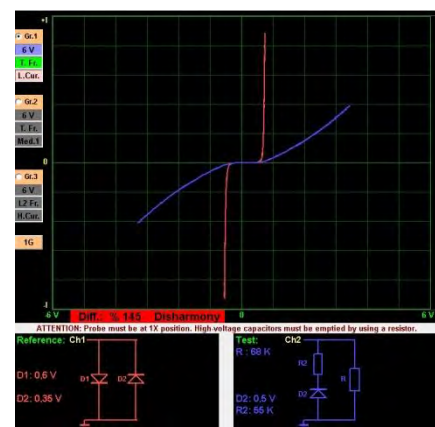


Figure 196: ULN2003 Output VI Graph Comparisons Against Each Other (Defective Pin)

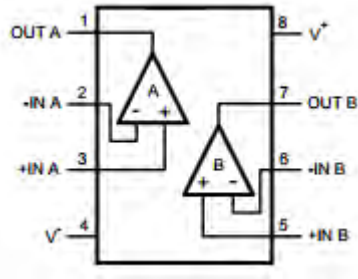


Figure 197: LM732 2MA Pin Configuration

The LM732 2Ma is an op-amp with 2 outputs. The Integrated circuit has 2 opamps inside. We can compare those op-amps against each other. That is, we can compare the Pin 2 and Pin 6 (non-inverting); Pin 3 and Pin 5 (inverting) and Pin 1 and Pin 7 (output) against each other respectively.

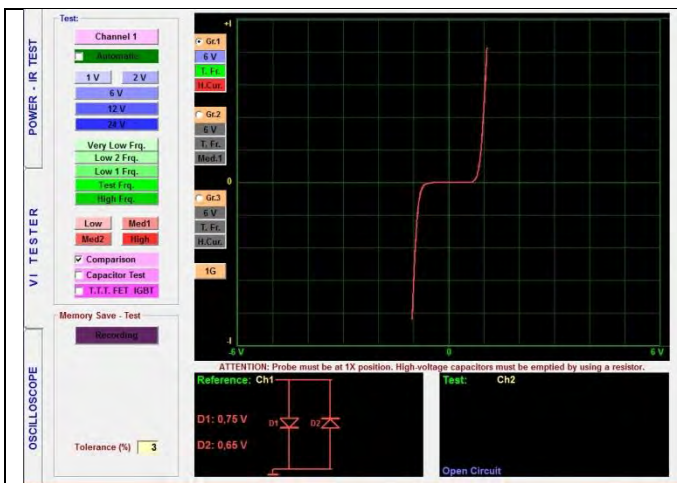


Figure 198: LM732 2MA In (+) VI Graph

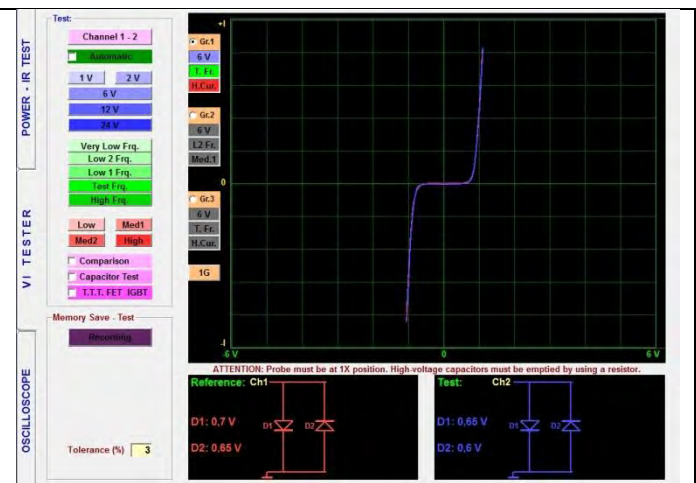


Figure 199: LM732 2MA In (+) VI Graph Comparisons Against Each Other (Intact Pin)

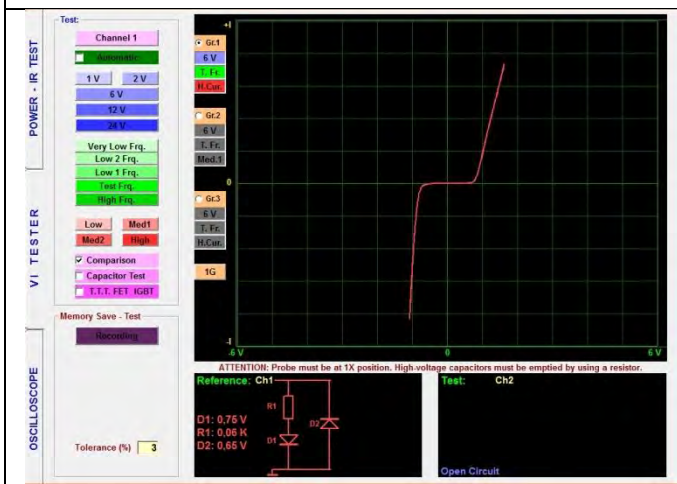


Figure 200: LM732 2MA In (-) VI Graph

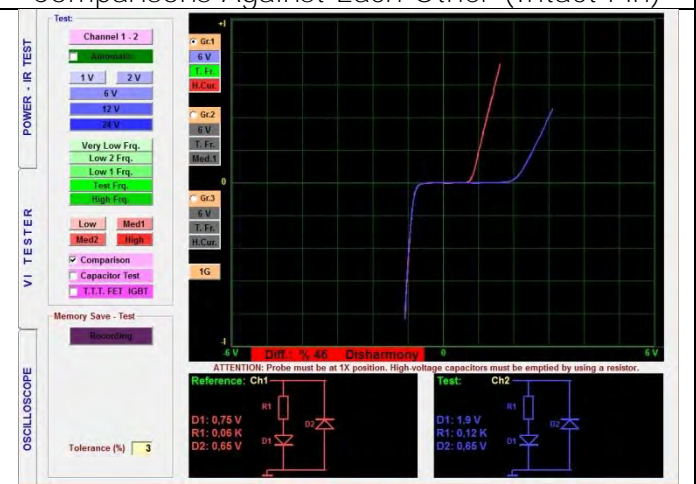


Figure 201: LM732 2MA In (-) VI Graph Comparisons Against Each Other (Defective Pin)

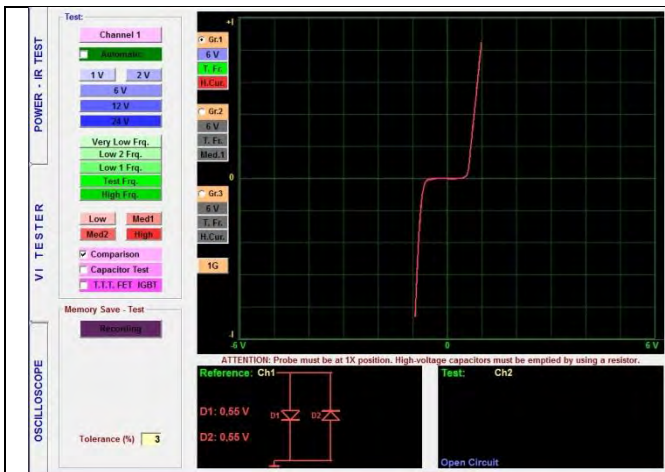


Figure 202: LM732 2MA Out VI Graph

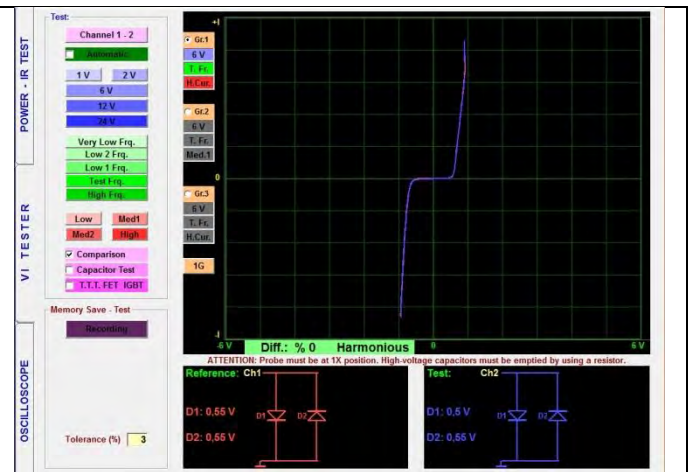


Figure 203: LM732 2MA Out VI Graph Comparisons Against Each Other (Intact Pin)

The best way of troubleshooting the op-amps is comparing the graph of an op-amp that is known to be intact with the graph of the defective or suspect op-amps.

Note: Some manufacturing differences may be present in the integrated circuits and therefore, the signals inside the circuits cannot be guaranteed since the production processes may differ, despite using similar production methods. To make the comparisons, use the ICs from the same manufacturers, because the integrated circuits from different manufacturers may yield different signal forms. Saving the signal forms in the computer may make the subsequent works easier.

Regulator Integrated Circuits

A Regulator circuit means a circuit that maintained the output voltage or current at a fixed value. They may also be called “Regulation circuits” or “Regulators”.

The 78XX integrated circuits are electronic components used in the regulator circuits that provide a positive (+) output. They can handle up to 1 Ampere of current. The purpose of the regulator is providing a fixed positive output regardless of the input voltages (within certain limits of course). The Output voltages are written in the XX part. The 78 part denotes a + voltage output. For example a 7805 integrated circuit will produce a fixed 5V output from a 6-12V volt input.

The 79XX integrated also provide an fixed voltage output like the 78XX integrated circuits, but their difference is that 79XX series integrated circuits yield a negative (-) output. For example the 7905 series integrated circuits provide a -5V fixed output voltage.

Those integrated circuits are 3 pin devices. The pins are IN (input), GND (chassis) and OUT (output) pins. The voltage applied to the Input pin is reduced to the XX value at the output. A voltage equal to at least to output voltage has to be applied to the input of the integrated circuits.

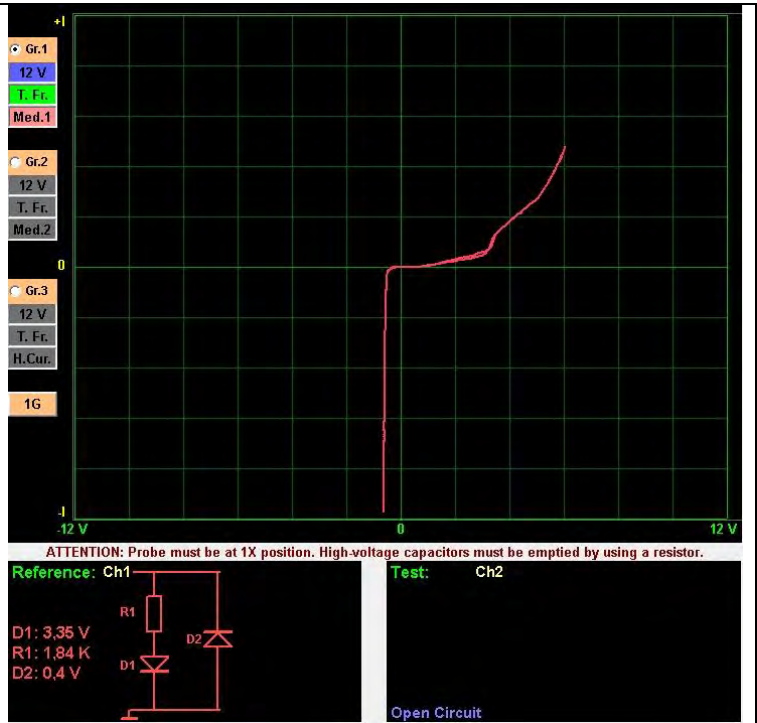
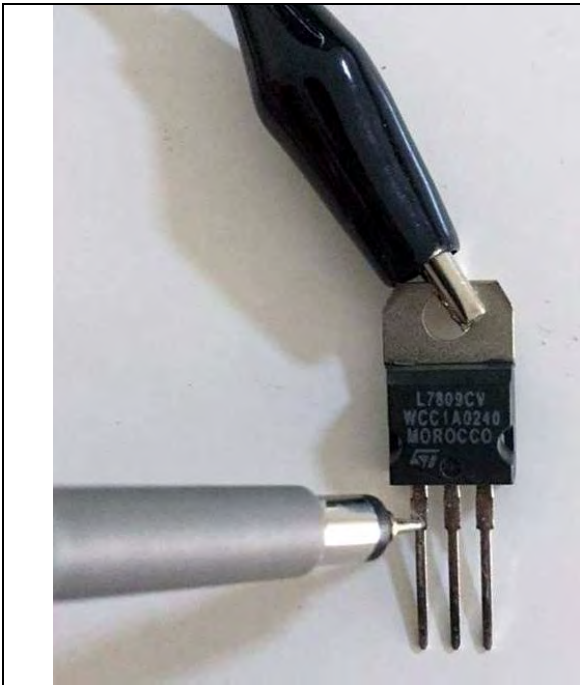
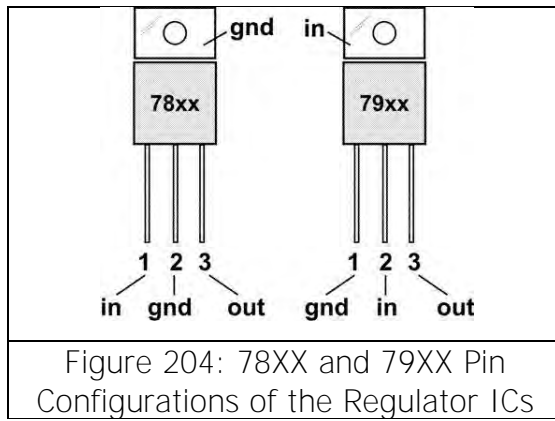


Figure 205: 7809 Input VI Graph Channel1 (Input) - COM (GND)

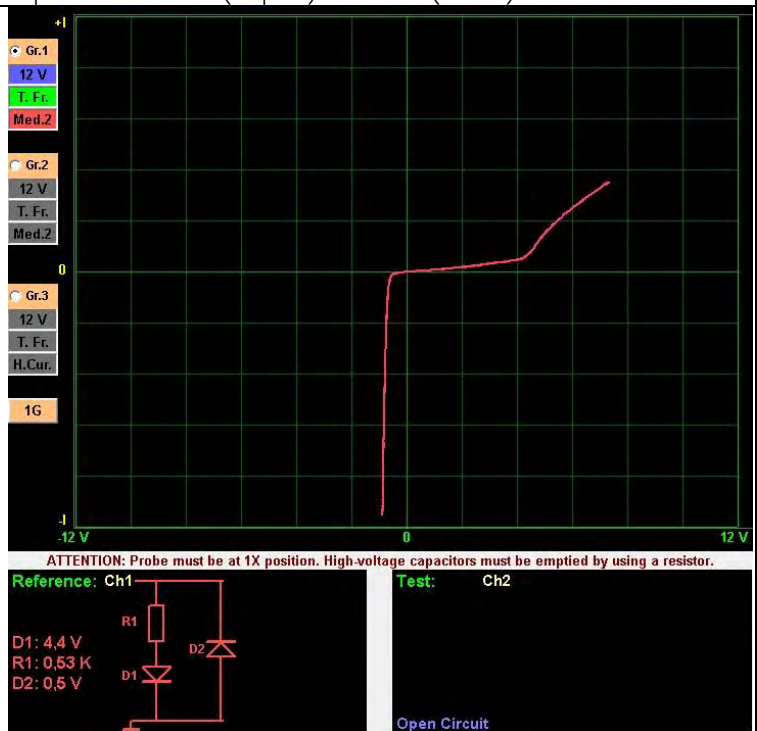
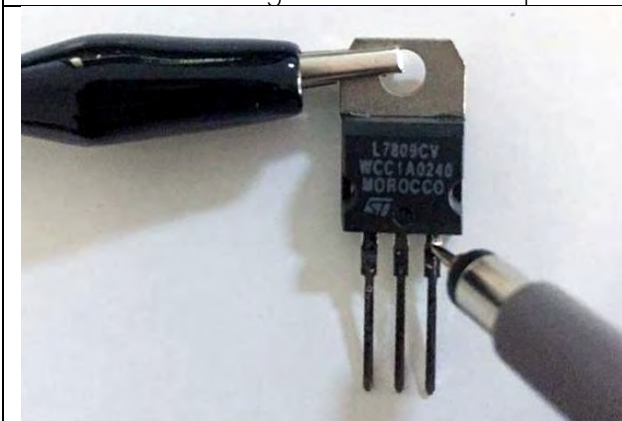


Figure 206 : 7809 Output VI Graph Channel1 (Output) - COM (GND)

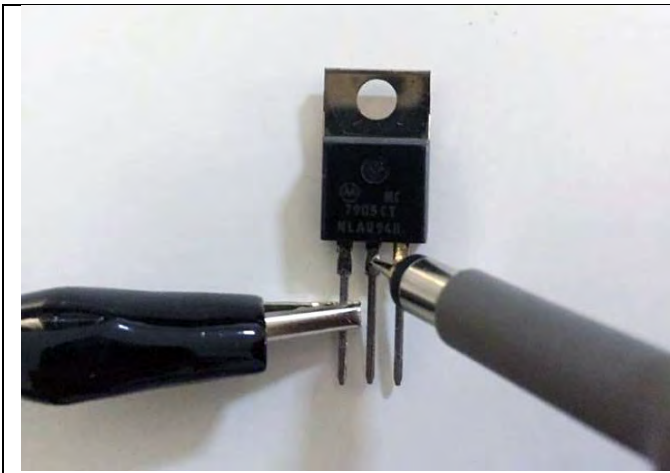


Figure 207 : 7909 Input VI Graph Channel1 (Input) - COM (GND)



ATTENTION: Probe must be at 1X position. High-voltage capacitors must be emptied by using a resistor.

Reference: Ch1	Test: Ch2
D1: 0,45 V	Open Circuit
D2: 0,6 V	
R2: 1,11 K	

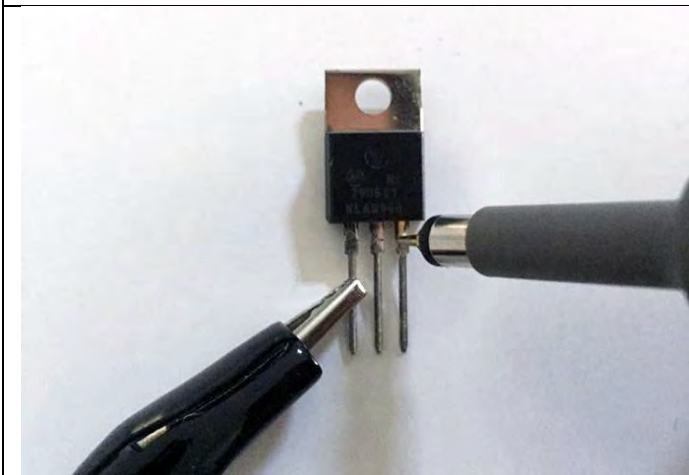


Figure 208 : 7909 Output VI Graph Channel1 (Output) - COM (GND)

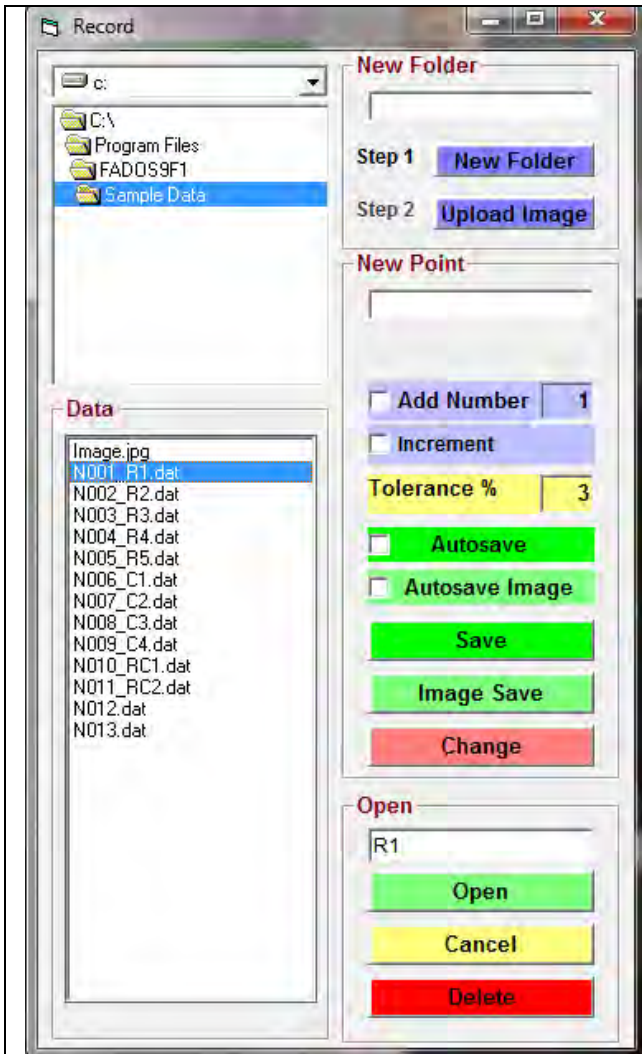


ATTENTION: Probe must be at 1X position. High-voltage capacitors must be emptied by using a resistor.

Reference: Ch1	Test: Ch2
R : 2,60 K	Open Circuit
D1: 0,65 V	
D2: 2,9 V	
R2: 0,84 K	

RECORDING THE ELECTRONIC CIRCUIT COMPONENTS TO THE MEMORY AND COMPARING FROM THE MEMORY

Another feature of the FADOS9F1 Fault Detector and PC Oscilloscope is the ability to record (save) the data of the materials in the electronic circuit to the computer. The recording capacity depends on the hard disk capacity of the computer.



New Folder: New Folder opens a new folder on the hard disk with the name written to that line.

Upload Image: The software screen displays the circuit's photo saved in the computer.

New Point: The name of the data to be saved is entered. If left blank, the software adds a, "N001, N002 etc." file number to the file automatically.

Add Number: Adds a number to the file to be saved.

Increment: Increases the number of the data to be saved.

Tolerance %: Specifies the tolerance range of the data to be saved.

AutoSave: Channel 1 is connected to the pin or leg of the electronic material to be saved. The Software saves the data after a few seconds automatically and emits a sound confirming that the data were saved.

AutoSave Image: If the Autosave feature is selected, clicking on the save key saves the VI screen as a photograph automatically.

Save: Saves the graph of the test point (New point) data to the file designated (New Folder) with the name assigned.

Image Save: Saves the VI graph of the test point (New point) data to the file designated (New Folder) as a photograph with the name assigned.

Change: To change data of a test point saved previously, the graph of the test point saved is selected from "Data" and Channel1 is touched to the new test point to be saved and data of the test point saved previously is changed.

Open: Opens the saved test data selected from "Data".

Delete: Deletes the saved test data selected from "Data" from the computer.

Cancel: Closes the recording window.

Data: Displays the data saved.

Figure 209: Recording Window

Recording the Electronic Components to the Memory

1. The Com Probe or Probe crocodile is connected to the chassis (GND) of the board (GND taken as reference).
2. The **"Recording"** Button is pressed to open the **"Recording Window"**. The name of the folder to be saved in the **"New Folder"** is entered to create a new folder.
3. If a photo is to be recorded and a photo of the board is available in the computer, click on the **"Image Upload"** and select the photo of the electronic circuit board desired from the window opened. The photo is loaded to the software by clicking on the **"Open"** button. The photo of the circuit is opened at the lower right corner of the VI test screen. **The Software changes the name of the photo as "image" automatically. For example; if the name of the photo is "Figure.jpg", the software changes the name to "image.jpg" automatically and saves to the folder as "image.jpg". It is displayed as "image.jpg" in the Recording Window Data.** The green colored buttons in the photo are for the **"+", "-"** zooming function. The electronic material to be recorded in the board is selected by sliding the curser on the photo to the right or left. Thanks to that feature, when you make a comparison from the memory, you can see the location of the point recorded on the board.
4. The name of the point (data) to be recorded is written to the **"New Point"**. Touch the Channel1 probe to the point to be recorded and consecutive recordings are made by pressing the record button. The data saved in the **"Data"** section are seen as **N001_X** vs. (the name or code of the data to be saved for the X New Point).
If no name is entered for the **"New Point"**, the software saves the data automatically in numerical order (N001, N002 etc.)
5. If **"Add Number"** is selected, the software adds a number to the data automatically and if the **"Increment"** is selected, increases the number added to the component by one after recording the component.
For example, to save the VI graph of an IC component named "X", the "X" is entered in to the "New Point" field. The "Add Number" and "Increment" are selected. The Channel1 is touched to the X component's pin in the electronic circuit and the VI graph appears on the screen. The "Save" is clicked to save the data for the component "X".
6. Maximum 999 data can be saved in a save folder.
7. **We can record the components' graphs faster by selecting the "Autosave" feature.** Channel1 is touched to the pin of the component to be recorded and after waiting for a

few seconds, a “recorded” sound is emitted, confirming the automatic saving of the VI graph of the point.

Note: The user has to touch the component under test firmly after selecting “Autosave”, since the graph of the component is saved only after a few seconds after the probe touches the component. If the user does not touch the component firmly, the software still continues to record, hence care should be exercised while using the “Autosave”.

8. The Components’ VI graphs may also be recorded using the print screen. To do that, after touching the Channel1 probe to the component’s pin, click on the “Image Save” button to save the VI graph as a screen photo.
9. If “Autosaveimage” selected and the “Save” button is clicked, the VI graphs are recorded automatically as a photo and as data as well. The “Autosave” and “Autoimage” features can be used in coordination.

Changing the saved data; the data to be changed is selected from “Data”. If a new name is to be assigned to the data, the code of the data is entered in to the new recording. Channel1 is touched to the point to be recorded and the “Change” button is clicked, thus changing the existing data.

To erase any saved data, the data to be deleted is selected from “Data” and the “Delete” button is clicked.

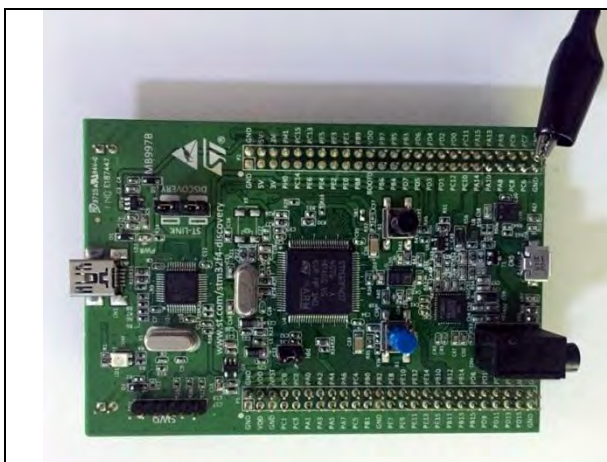


Figure 210: Connecting the Crocodile Probe Electronic Circuit Board Chassis (Step 1)

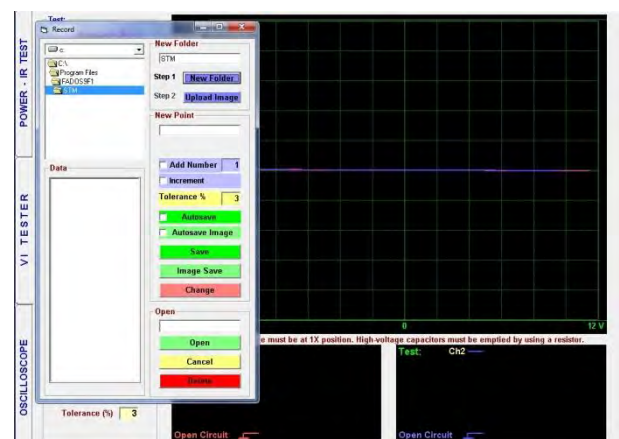


Figure 211: Clicking the Recording Button to Open the Record Window (Step 2)

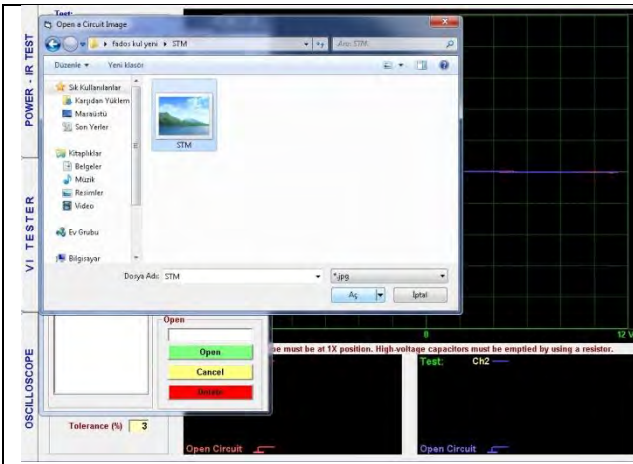


Figure 212: Loading the Photo of the Electronic Circuit to the FADOS9F1 Software (Step 3)

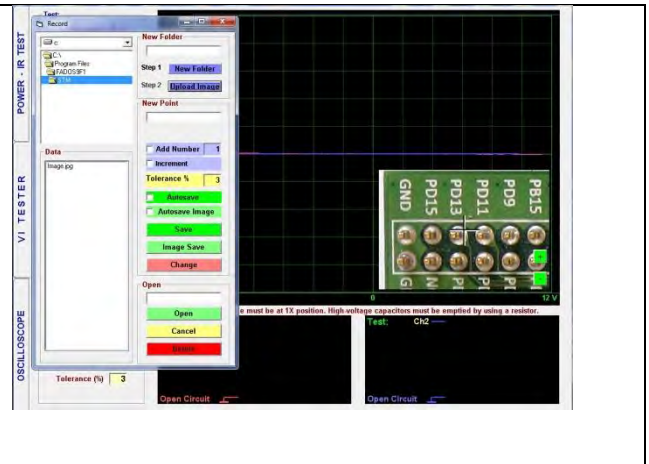


Figure 213: Loading the Photo of the Electronic Circuit to the Software (Step 4)



Figure 214: Touching the Channel1 Probe to the Component to be Recorded (Step 5)

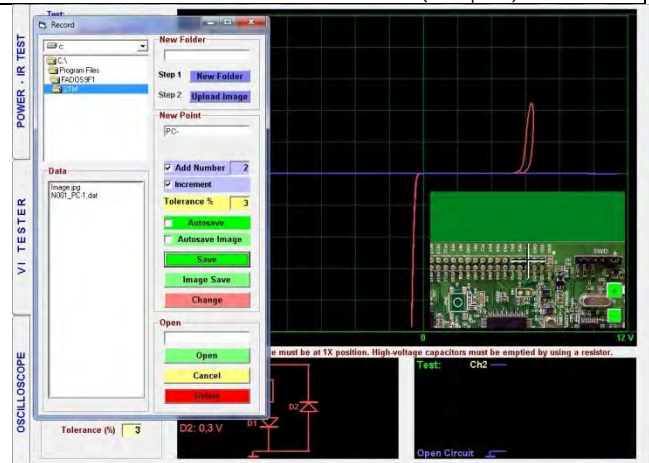


Figure 215: Saving the Electronic Circuit Component's VI Graph (Step 6)

Comparing the Electronic Components from Memory

Click on the Recording Test selection in the FADOS9F1 test characteristics menu to open the Recording Menu. Enter a circuit name or code to open a New Folder. The name of the point (data) to be saved is entered in to the "New Recording". Touch the Channel1 probe to the point to be recorded and consecutive recordings are made by pressing the record button. If no name is entered for the "New Point", the software saves the data automatically in numerical order (N001, N002 etc.). Maximum 999 data can be saved in a save folder. If "Add Number" is selected, the software adds a number to the data automatically and if the "Increment" is selected, increases the number added to the component by one after recording the component.

1. The "Recording" button is clicked to open the recording window. The folder save with the New name is found. The data saved in "Data" is selected and opened by clicking the "Open" Button. The graph and data of the data saved is displayed on Channel1. The

number of data is shown in the test area under the Memory Save Test menu and the pin to be tested is shown at the “Point” area.

2. If the recording is made with a photo, the photo of the electronic circuit board is shown in the lower right corner and the point to be tested can be seen in the photo.
3. The Com Probe or Probe crocodile is connected to the chassis (GND) of the board (GND taken as reference).
4. Channel2 probe is touched to the point to be tested. If the point value measured is within the recorded tolerance range of the recorded data, a sound indicating conformity is emitted, and then the “Next Point” is clicked to open the second recorded data. If the value measured is not within the recorded tolerance range of the recorded data, a sound indicating non-conformity is emitted and the next point is not selected after lifting the probe. The “Arrow Button” on the right in the Recording Test Menu is clicked to go to the “Next Data”.



Figure 216: Connecting the Crocodile Probe Electronic Circuit Board Chassis (Step 1)

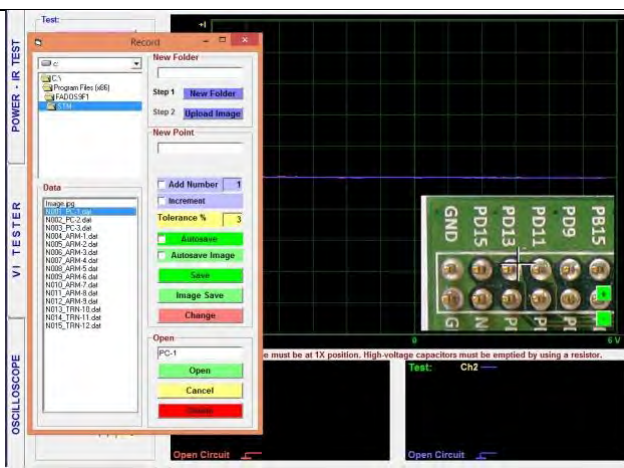


Figure 217: Clicking the Recording Button to open the Record Window (Step 2)

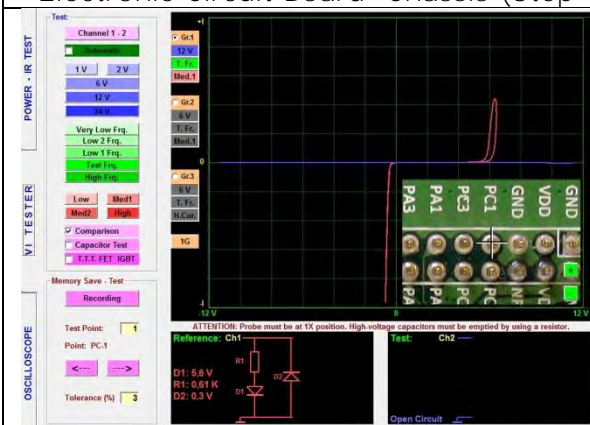


Figure 218: Opening the Recorded Data in the VI Screen (Step 3)



Figure 219: Touching the Channel2 Probe to the Component to be Tested (Step 4)

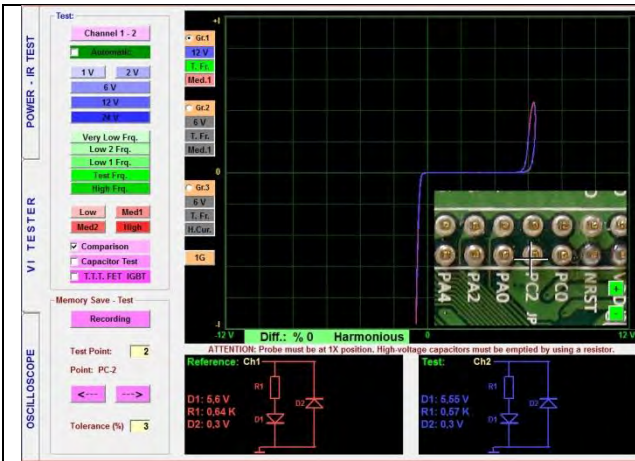


Figure 220: Memory Comparison of Intact Component (Step 5)

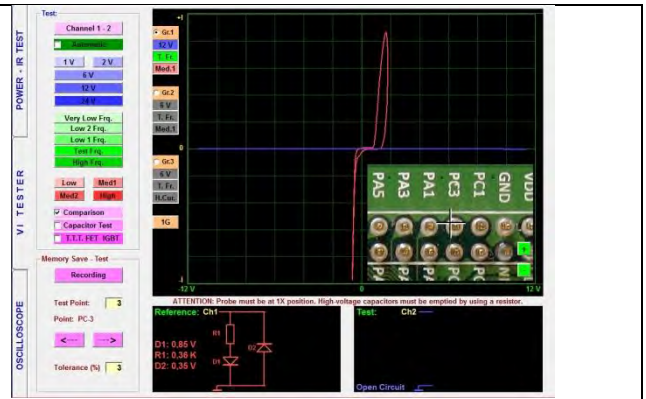


Figure 221: If the Data Measured is Recorded and Conformant; the Next Data is Opened Automatically

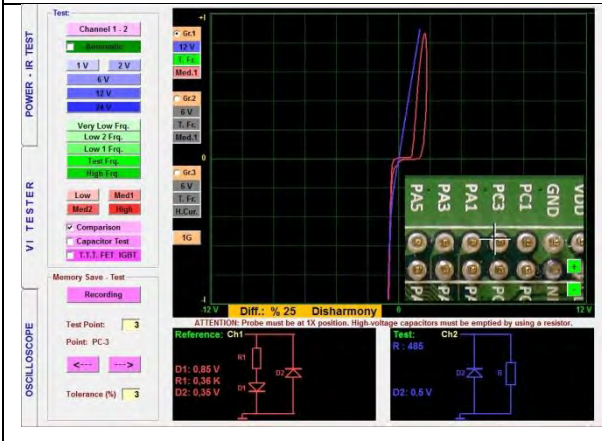


Figure 222: Memory Comparison (Defective Component)

The device emits different sounds for the compatible and un-compatible graphs. This feature allows making the tests rapidly without looking at the screen constantly.

Note: The test points in the Electronic circuits can be recorded with Channel1 only. We can open the test points recorded using the Recording menu as reference in Channel1 and make the comparison tests for the defective circuit points with Channel2.

Image Save

The screen shots of the VI graphs may also be recorded using the print screen. In **"Page 90"**, the **"Save"** button is clicked for recording the electronic component data to the memory for the **"Electronic Components Memory Recording"**. If we want to record the screen shots only, the **"Image Save"** button is clicked instead of the **"Save"** button.



Figure 223: Connecting the Com Probe Electronic Circuit Board Chassis (Step 1)

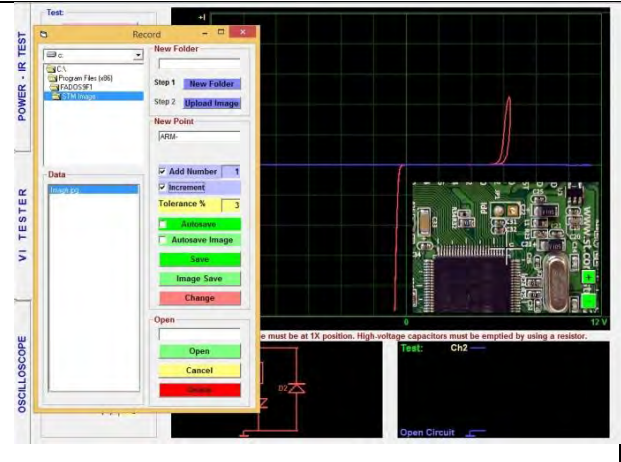


Figure 224: Touching the Channel1 Probe to the Component to be Recorded (Step 2)

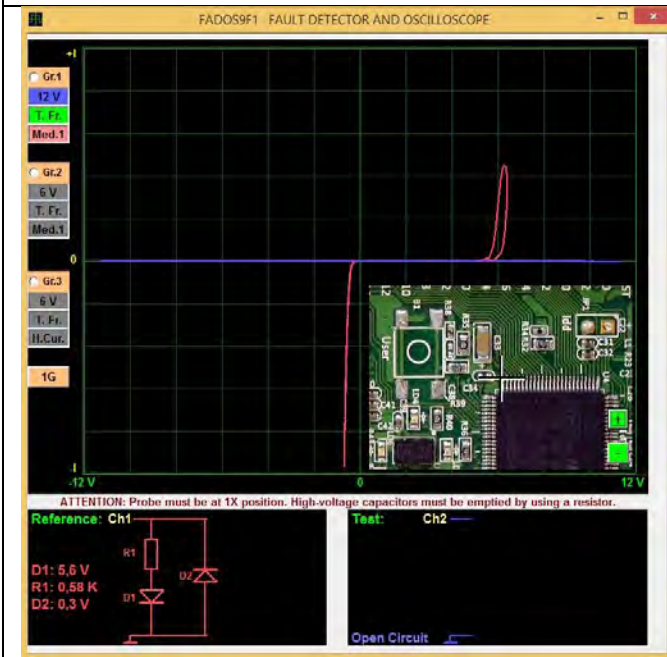


Figure 225: Clicking the ImageSave Button (Step 3)

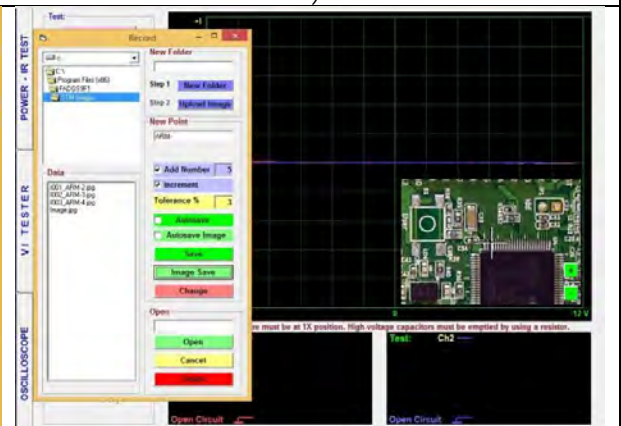


Figure 226: Recording the VI Graphs as Photos



Figure 227: Displaying the Recorded VI Photos in the Folder Created

Note: When the "Image Save" button is clicked, the data are recorded as "I001 .jpg". VI graphs are saved as "N001 .dat". In order not to confuse the recorded data, saving the VI graphs and Image Save data in different folders is recommended.

Note: The Windows operating systems can save the recorded data in the "Virtual Store" folder.

The "Virtual Store" folder can be found in;

C:\Users**(Computer Name)\AppData\Local\VirtualStore\Program Files (x86)\FADOS9F1\

COMPARATIVE TEST OF THE MATERIALS IN THE ELECTRONIC CIRCUITS

When an electronic material is tested in the circuit, it produces a mixed signal due to the parallel or series connections to the other materials in the circuit. If you have enough experience in Analog Signal Analysis, (of the VI graphs), the failure can be found by interpreting the graphs. The aim in Electronic circuit board repairs is diagnosing the failure without removing the components on the board.

Comparing the VI graphs of the intact and defective electronic circuit boards are determined with the FADOS9F1 allows diagnosing the defective materials in a short time. The comparison is made by touching the pins of the materials on both electronic circuit boards to find the difference between them.

While comparing two electronic circuit boards, the following points should be observed:

- 1)** The electronic circuit boards to be tested should not be energized. Since the capacitors are energy storing devices, they should be discharged (especially high voltage capacitors).
- 2)** The Electronic cards must be identical (version etc.)
- 3)** Connect the COM probe (or crocodile of probe) to the common chassis (GND) of the Electronic circuit board. The GND point can be found by following the GND (Vss) pin of the IC or the anode pin of the electrolytic capacitors. If a low capacitive graph is observed at the points tested, it means that the GND point is not right. Some electronic circuit boards may have more than one GND points. The reason for that is the presence of components operating on different voltage values in the board. In order to eliminate the capacitive noise, the supply and GND may be shorted. This will offer the advantage of comparing the VI curves both according to the GND and the Vcc pin.

4) While comparing, firstly the circuit board supply (the regulator integrate) is tested. If the supply of the circuit board is defective, the same failure will appear in all the other electronic components in the circuit.

The input and output connectors on the circuit board are compared and if any difference is found, the path from the connector can be traced to the defective component.

One particular feature of the FADOS9F1 is that the software emits different sounds for the matching and un-matching graphs. Thus, the comparison can be made rapidly by focusing on the sounds without looking at the display constantly.

5) In order to diagnose the defective component in the area showing the difference, the COM probe is connected to the deviant point. The components connected to that point are compared, whereby the defective material is identified without removing from the circuit. The suspect material may also be tested after removing from the circuit if desired.

6) After replacing the defective component identified, the comparison test is repeated on the circuit boards.

If an intact board is not available, the defective cards may be compared against each other to diagnose the defective material. Sometimes a particular fault may not be present in another board. Therefore, the most suspect components are checked first to diagnose the failure.

The VI graphs of the Electronic materials are different from each other. With adequate experience on the VI graphs, a defective component on a single defective board can also be diagnosed. If there may be symmetrical circuits on a board, they may be compared against each other. The integrated circuits in the circuit may be diagnosed by checking the datasheets and then testing the pins with the same functions (input – output pins) respectively. Because the IC pins have protective diodes, the diode or zener diode curves should be observed. If there may be any short circuits, open circuits or irregular resistor or diode – zener curves, the integrated circuit is defective. If necessary, the IC can be removed from the circuit and the pins tested after shorting the GND and Vcc pins.

The transistor, FET, IGBT, Thyristor etc. 3-pin devices may be tested by checking if they are conducting.

Recording the data to the memory after repairing the Defective circuit is recommended.

While making a comparison with the FADOS9F1 device, the chassis of the intact board is connected to Channel1 and suspect board to Channel2. Start comparing from the power supply

lines and progress towards the inputs and outputs and any other places suspected. The comparison can be made rapidly by focusing on the sounds without looking at the display constantly. First the supply circuit of the electronic circuit board (the regulator) is checked, if the regulator circuit is defective, the signals from all the components may show differences while comparing. The other components are tested after eliminating the regulator circuit failure.

Sometimes an un-matching sound may be heard due to the charging and discharging of some capacitors, but the graph curve will eventually become compatible once the capacitor is charged after waiting for a short while.

Because the tolerance range of the Capacitors is quite large, some small mismatches may be seen in the VI graphs while comparing, but when the graph is examined closely, the source of the mismatch will be identified as the capacitor tolerance. The Vcc and GND are shorted in order to prevent the capacitors in the Supply circuit from charging.

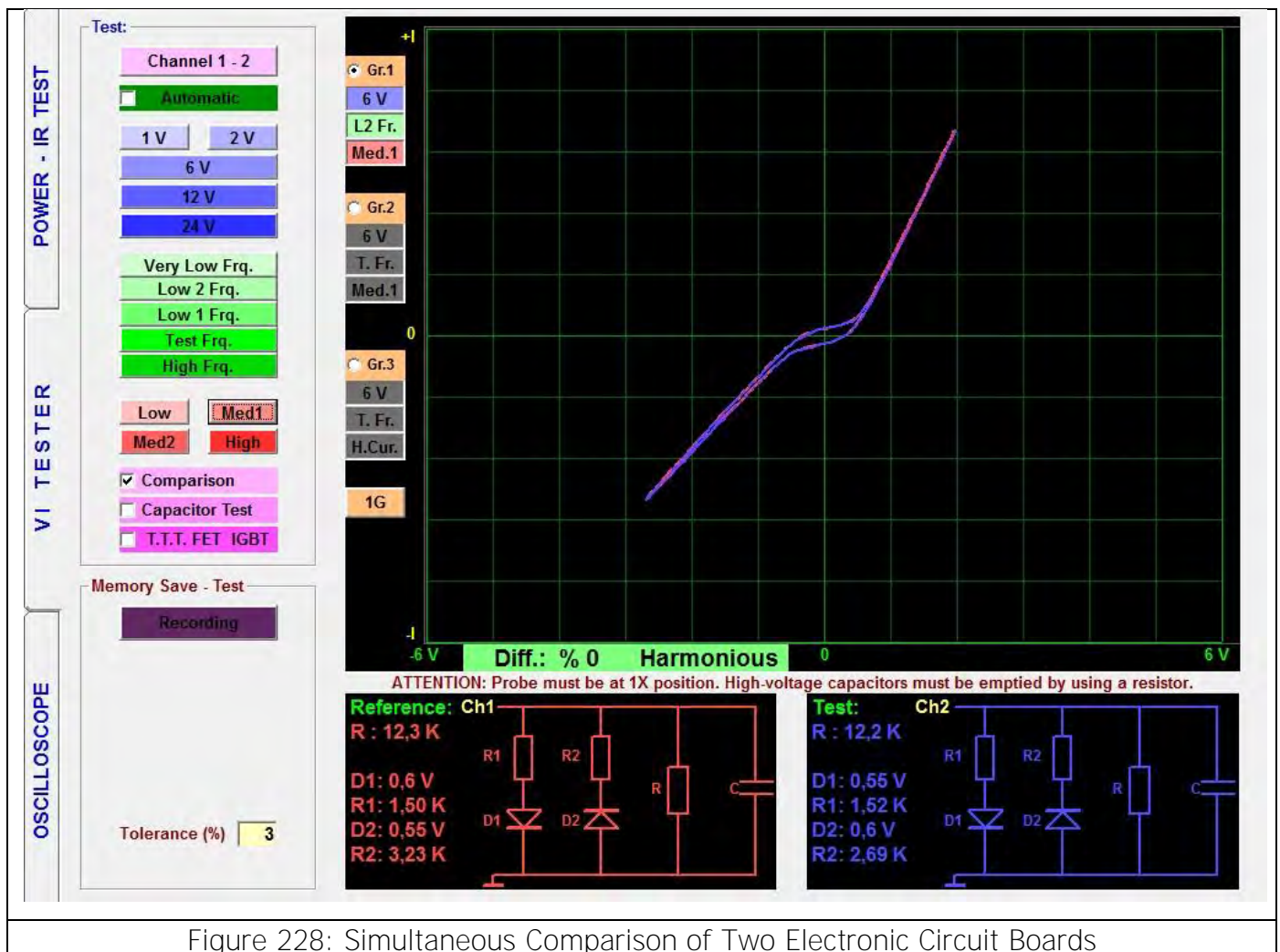


Figure 228: Simultaneous Comparison of Two Electronic Circuit Boards

A very accurate comparison can be made with this system and the values that remain within the given tolerances are considered as compatible. However, interpreting the small differences as defects or not depends on the experience of the user.

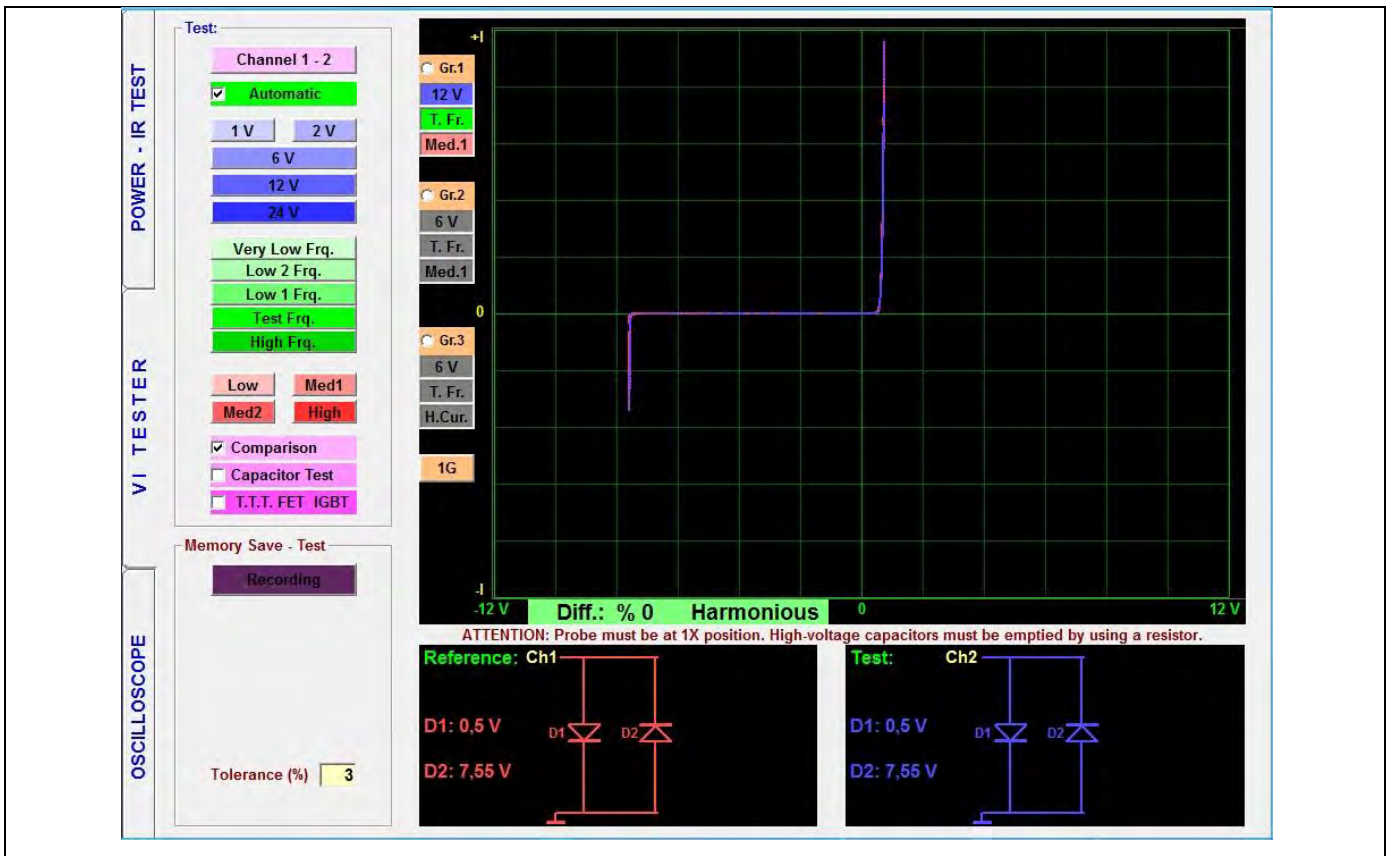


Figure 229: Comparing the Transistor Base Areas (Intact Component)

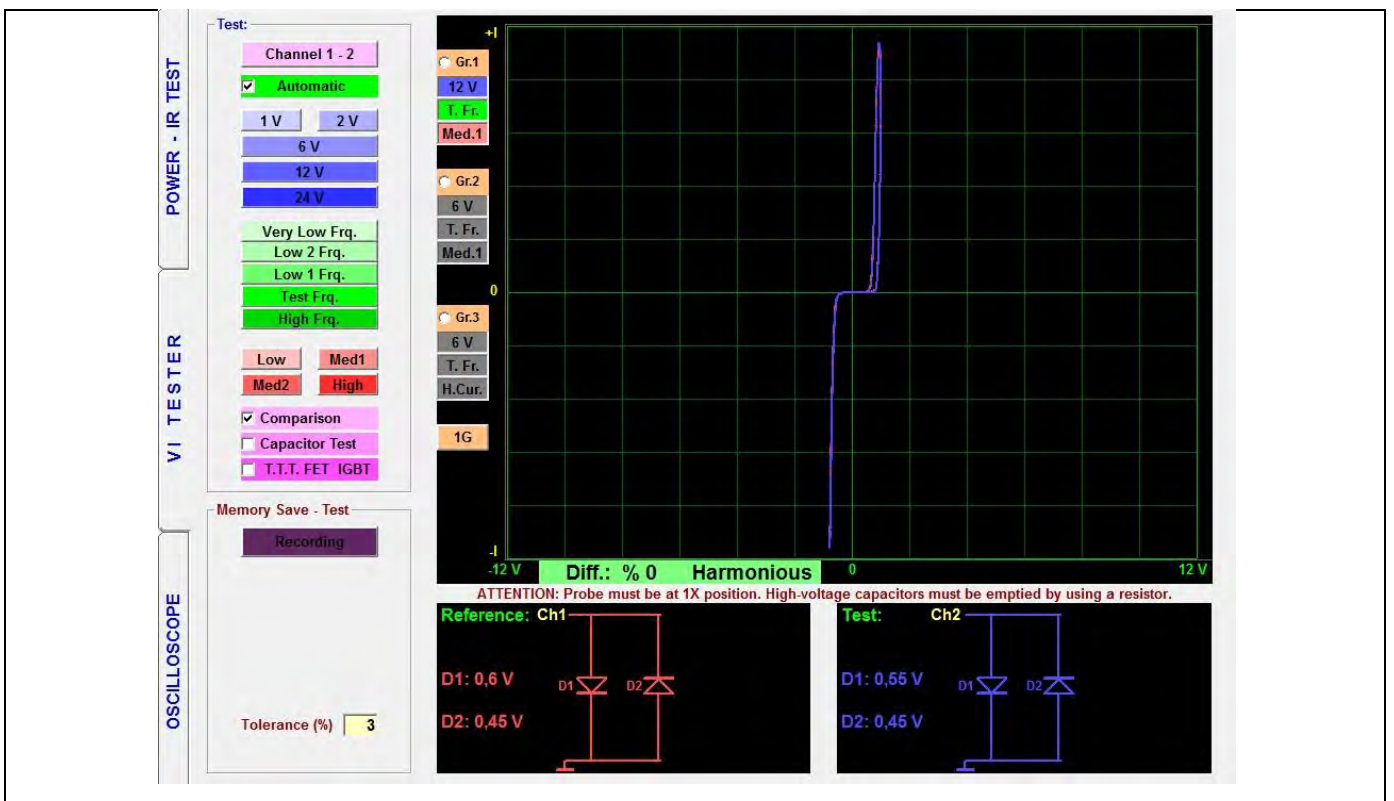


Figure 230: Comparative Test

The Integrated circuits generally contain dual reverse diodes. Capacitors or resistor may be connected to these diodes. If an Integrated circuit pin has a dual reverse diode, that pin of the integrated circuit may be considered as intact. In particular, if a perfect match is found, this point should be intact.

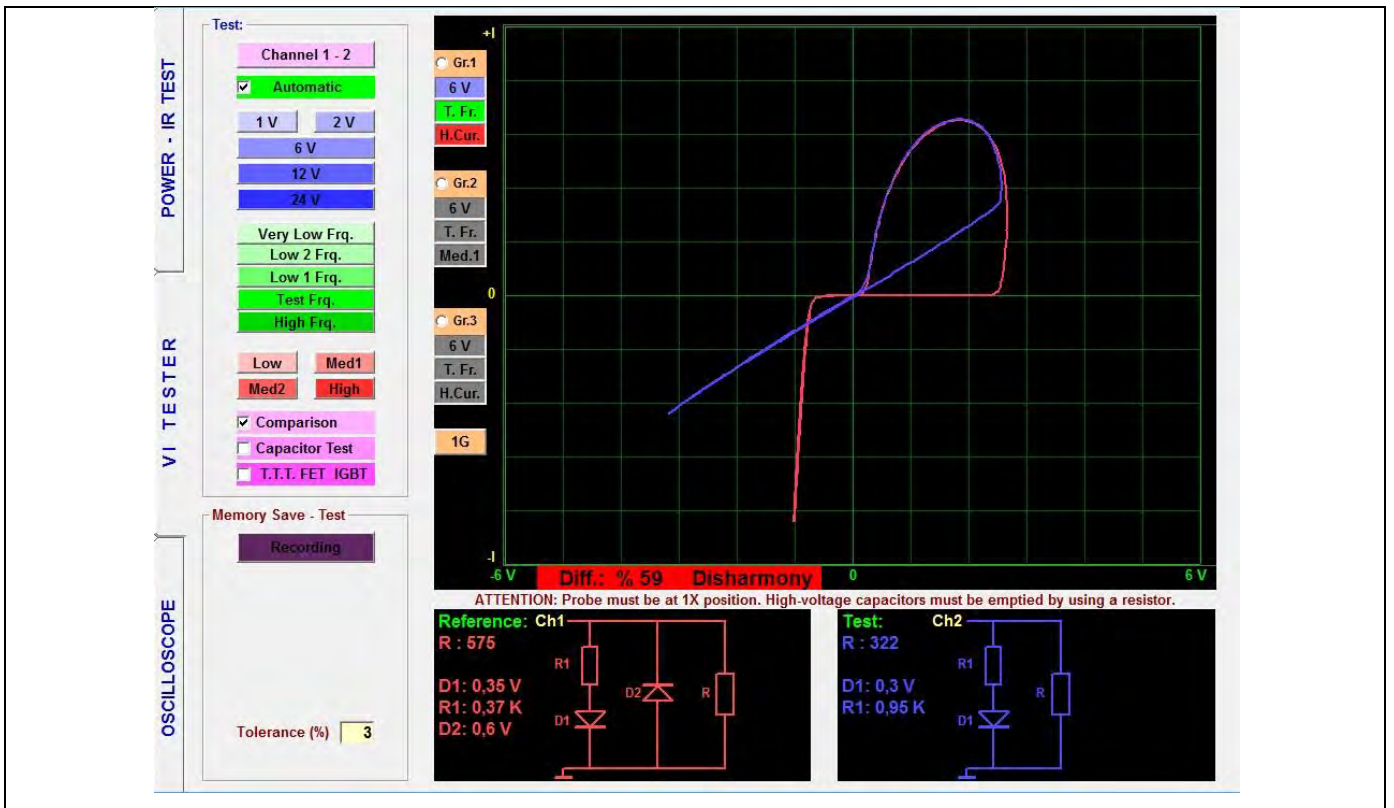


Figure 231: Comparative Test - Defective IC (Channel2)

The important difference to pay attention in Figure 231 is the presence of an open circuit in a limiter diode of the when tested with Channel2.

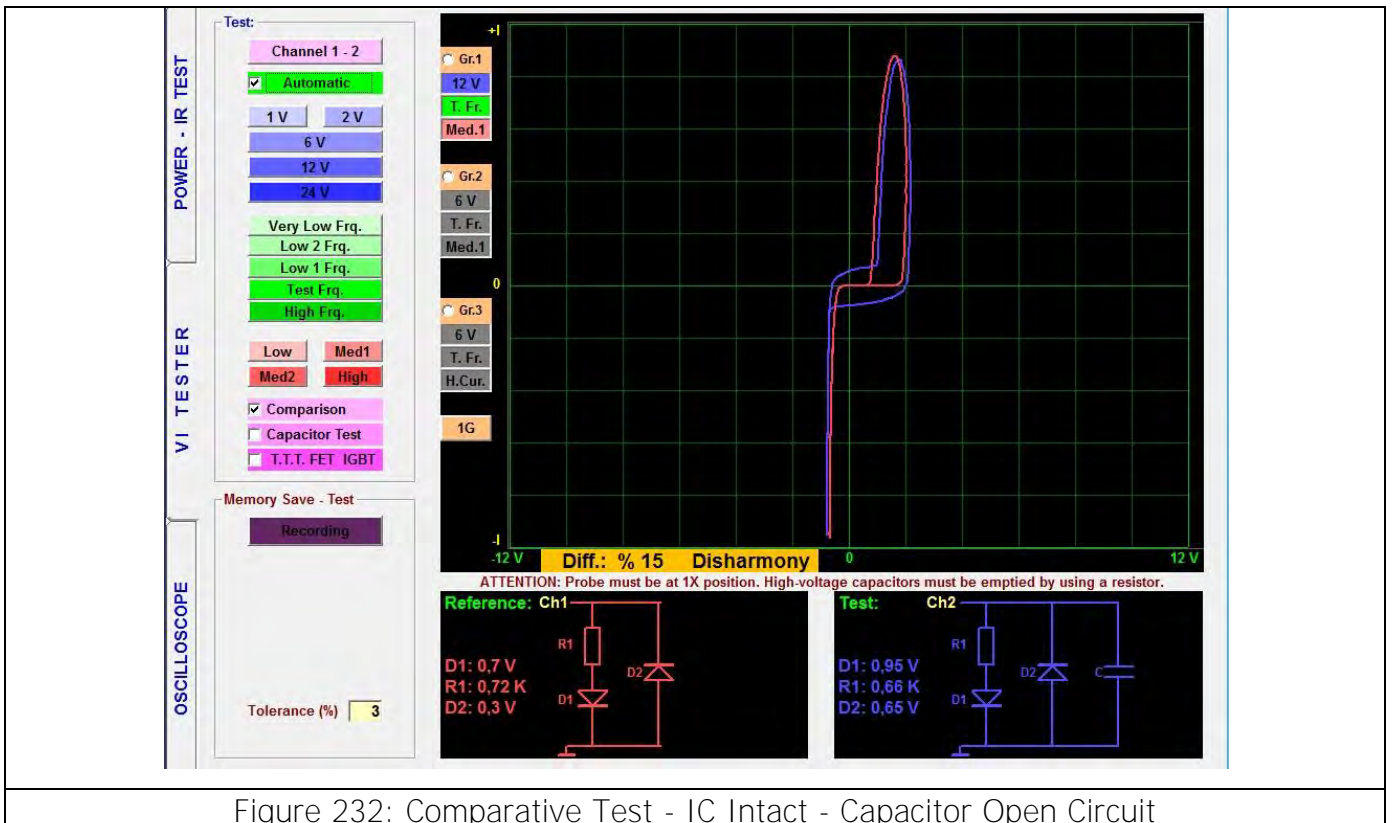


Figure 232: Comparative Test - IC Intact - Capacitor Open Circuit

The important difference to pay attention in Figure 232 is the presence of an open circuit in a capacitor of the when tested with Channel1. In this case, the Integrated circuit is intact but the capacitor is defective.

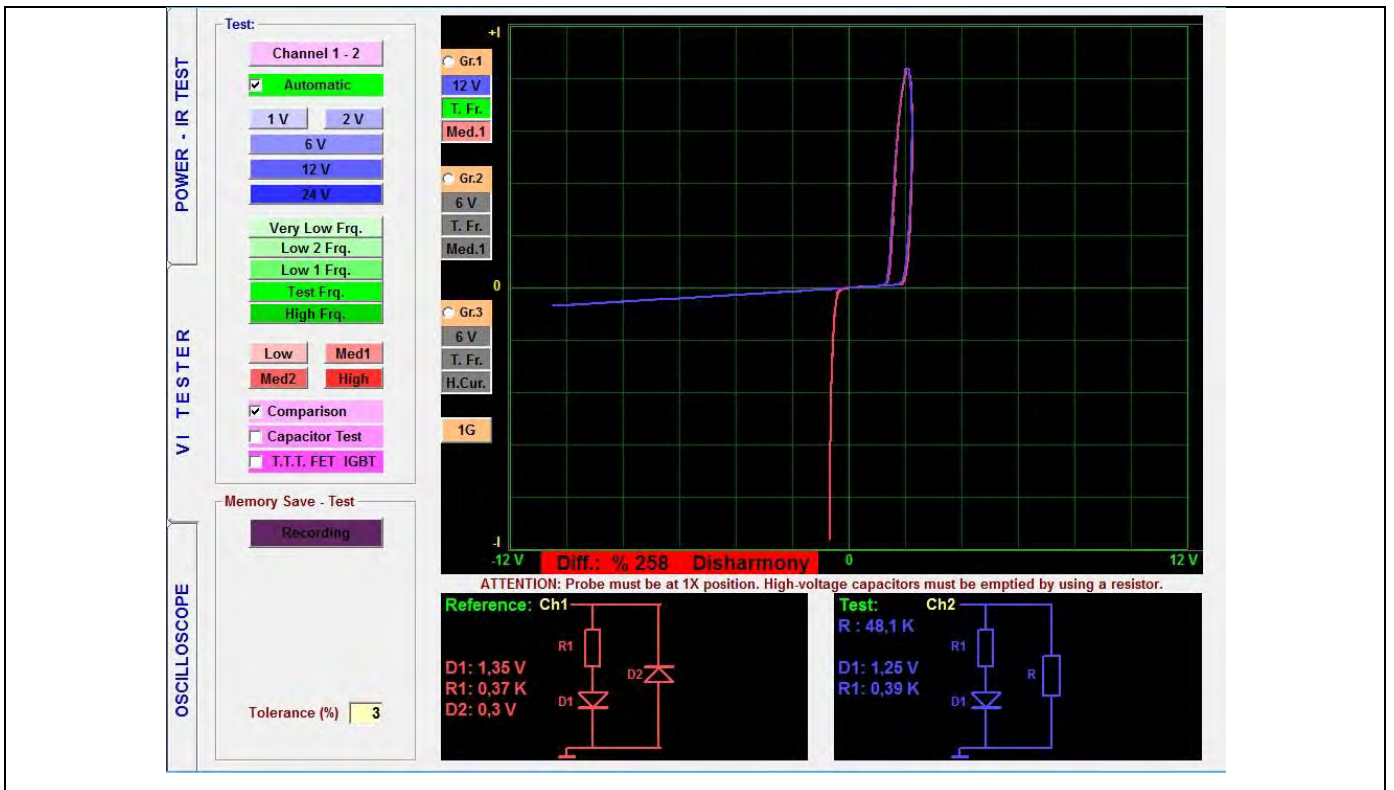


Figure 233: Comparative Test - Faulty IC (Channel2)

The important difference to pay attention in Figure 233 is the presence of a defective limiter diode in the IC acting as a when tested with Channel2.

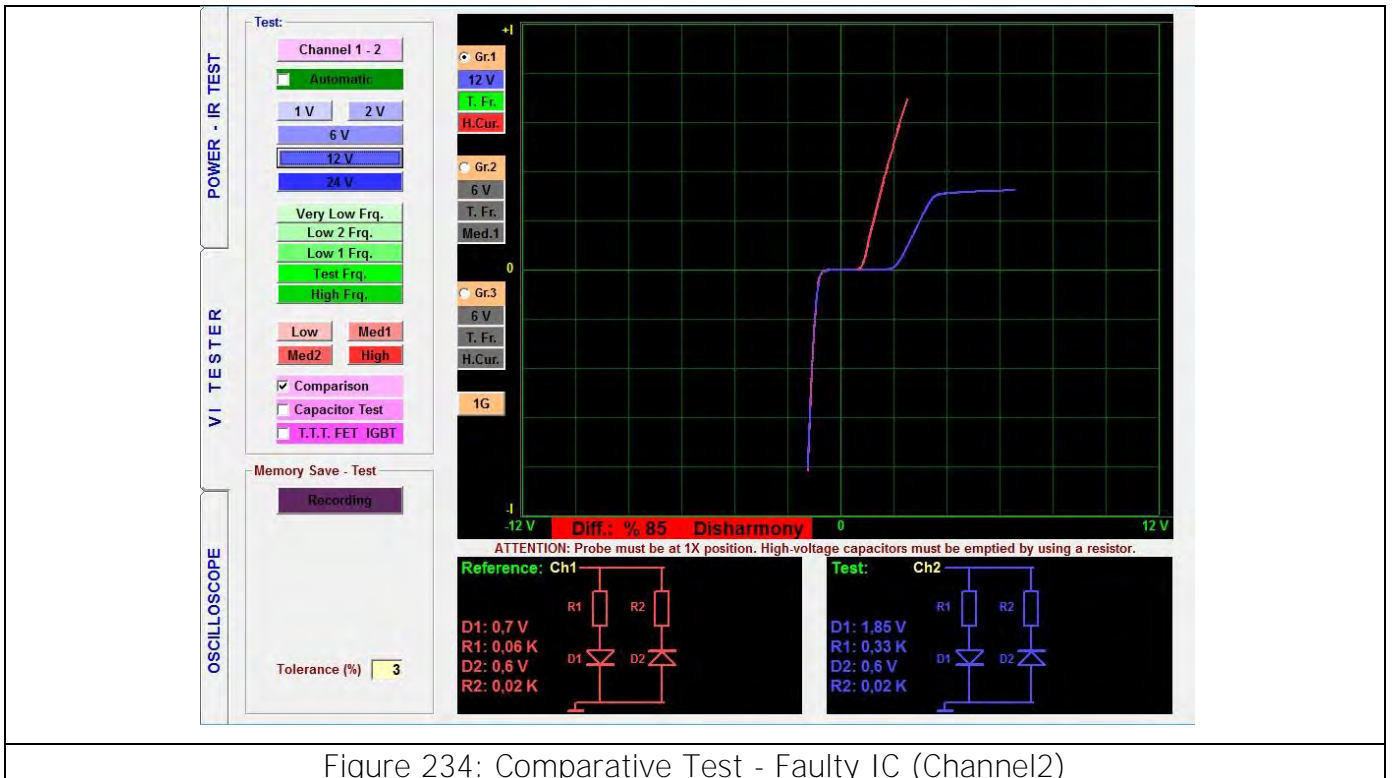


Figure 234: Comparative Test - Faulty IC (Channel2)

In the example given in Figure 234, a damaged zener diode due to a destroyed IC pin tested with Channel2 is illustrated.

3G – DISPLAY OF THE GRAPHS FOR 3 DIFFERENT SETTINGS

The FADOS9F1 can make comparisons on the electronic circuit boards at 3 different settings simultaneously.

By clicking the 1G button, the failure diagnostics screen 2G, that is Gr.1 and Gr.2 active graph, and in 3G the Gr.1, Gr.2 and Gr.3 can be displayed by selecting different voltage, frequency and current stages.

Using this method, the response of the electronic component against different voltage, frequency and current stages can be observed. E.g. while **some electronic material's graph may** appear intact under low current, it may prove to be defective under high current.

For example in Figure 235; click the 1G button once to select 2G, i.e. VI screen 2 graph setting. Click on Gr.1 to select the Voltage stage 6V and set the Frequency stage Test Frequency, Current stage to Low Current. Click on Gr.2 to select Voltage stage 6V and set the Frequency stage Test Frequency, Current stage to High Current. In that case, the Voltage and Frequency stages are same, but the current stage is different. As seen on the screen, 2 graphs will appear. If the comparison feature is selected, the 2 electronic circuit boards may be compared at two different settings.



Figure 235: 2G Graph Screen



Figure 236: 3G Graph Screen

For example in Figure 236; click the 1G button twice to select 3G, i.e. VI screen 3 graph setting. Click on Gr.1 to select the Voltage stage 12V and set the Frequency stage Test Frequency, Current stage to Low Current. Click on Gr.2 to select Voltage stage 12V and set the Frequency stage Test Frequency, Current stage to Medium Current. Click on Gr.3 to select Voltage stage 12V and set the Frequency stage Test Frequency, Current stage to High Current. In that case, the Voltage and Frequency stages are same, but the current stage is different. As seen on the screen, 3 graphs will appear. If the comparison feature is selected, the 2 electronic circuit boards may be compared at three different settings.

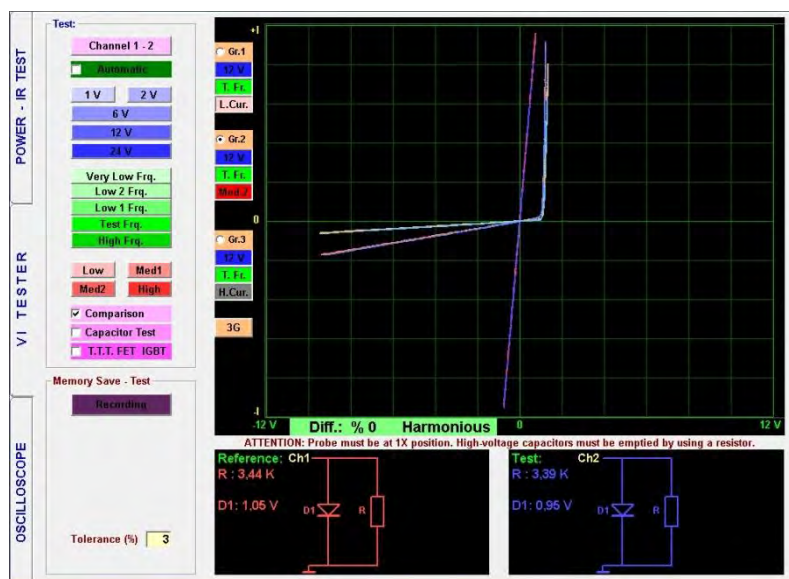


Figure 237: 3G Comparison

In Figure 237, comparison of the 3 graphs at 3 different settings and a perfect match at different settings is shown.

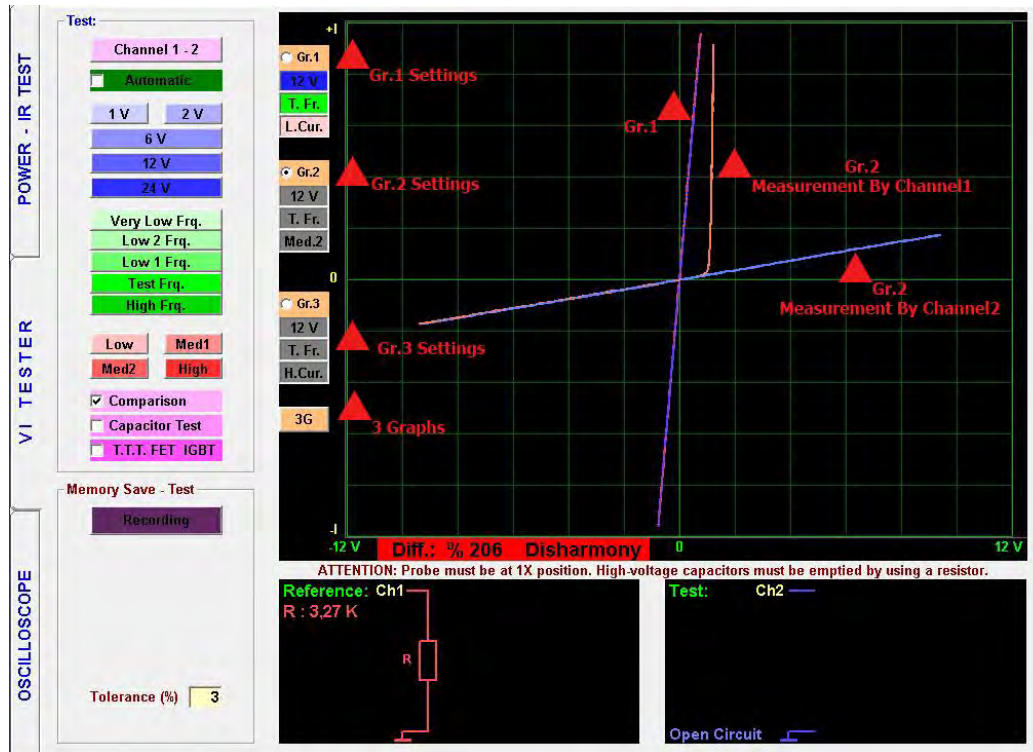


Figure 238: 3G Comparison

Figure 238 shows comparison of 3 graphs at 3 different settings. As seen in the example, the material, which shows a perfect match at low current, shows a mismatch at Medium2 current. Therefore, the electronic material tested is defective.

Note: High Frequency stage uses at only 6 Voltage stage and you should not use High Frequency at 3G features.

OSCILLOSCOPE – PROGRAM CHARACTERISTICS

As a device with the widest measurement capabilities used for measuring and evaluating the electrical signals, the oscilloscope allows determining the wave form, frequency and amplitude of the signal. The Wave for is displayed on the screen. That it, it draws an electrical wave signal. And allows observing the frequency and amplitude of the Wave Signal. The oscilloscope is a supplemental feature of the FADOS9F1; therefore, the maximum measuring frequency is 400 KHz and the measurement voltage is 50 V when the probe is set to 10X.

The FADOS9F1 may also be used as a Square Wave Generator and Analog Voltage Output. The Square Wave Signal Output applies a signal to the electronic circuit board and the other channels display the output signals on the oscilloscope screen.

All the control keys used for the Oscilloscope screen are placed at the left side of the panel.

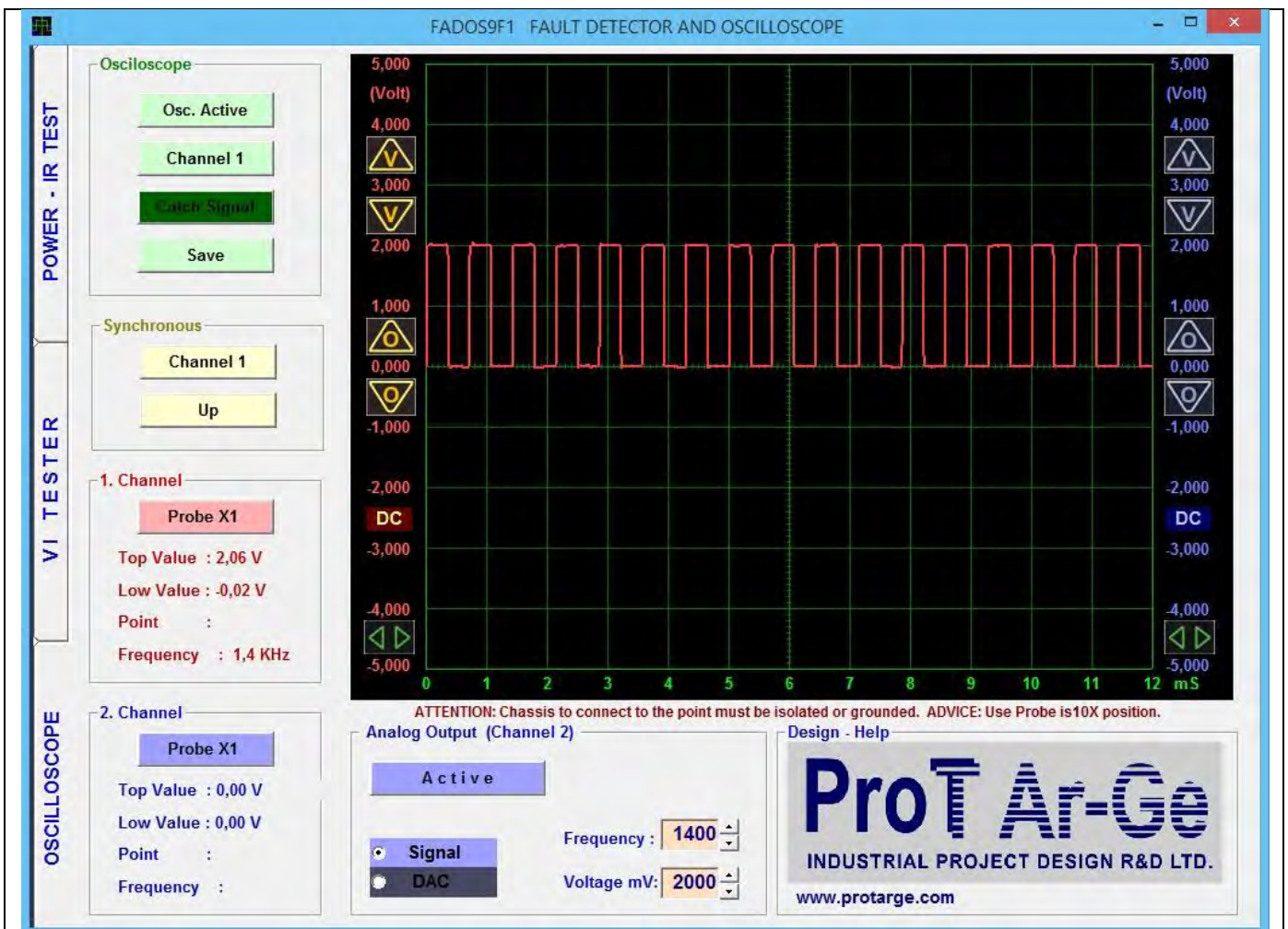
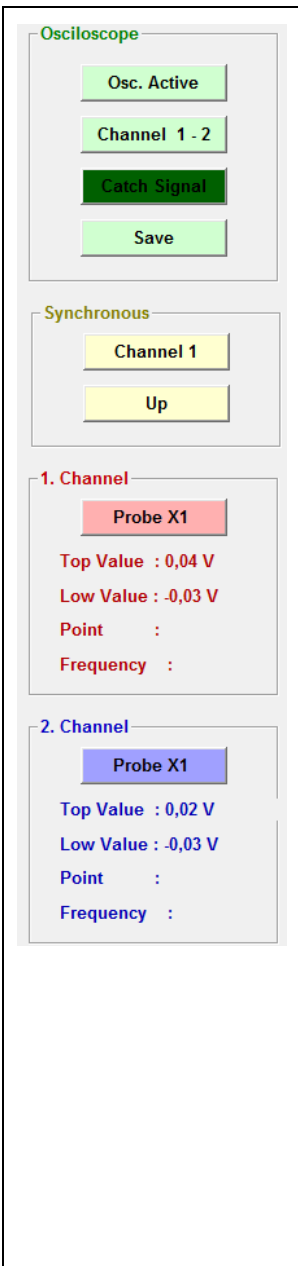


Figure 239: Oscilloscope Screen



Osc. Active/Passive: The Oscilloscope button activates the oscilloscope or freezes the current image and records the image to the memory when the recording button is clicked.

Channel: Channel1, Channel2 and both channels are selected consecutively.

Manual/Auto: When the Manual mode is selected, the signal is captured within the lower limit (mV) and upper limit (mV) values. In the Automatic mode, the last signal is captured when the signal ends.

Save: Records the Oscilloscope data or opens the recorded data.

Channel1: Selects the channel with the starting synchronization.

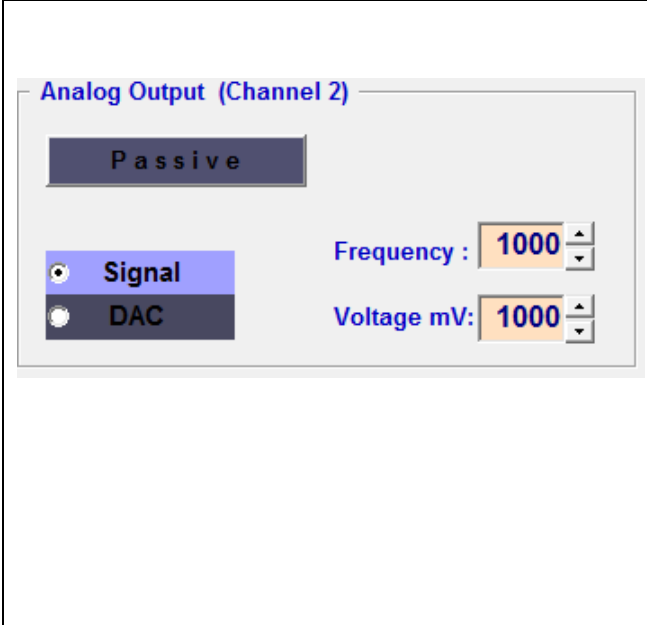
Up/Down: Starts synchronizing from the rising or falling edge.

Probe X1: Sets the voltage value according to the Probe X1 or X10 factor. If the Probes are set to the 10X stage and X1 is clicked from the software to set the Probe at the 10X stage.

Top and Low Values: These are the largest and smallest values in the section displayed.

Point: Shows the voltage value at the vertical line of the cursor in the memory mode.

Frequency: Shows the frequency if the incoming signal can be detected.







Active/Passive: When this button is clicked, Channel2 generates a "Square Wave" or "Analog Output".

Signal/DAC: Selects Square Wave or Analog Voltage.

Frequency: Determines the frequency of the Square Wave Signal Output.

Voltage mV: Determines the voltage of the Square Wave or Analog Output.

	<p>Voltage Display Sensitivity: Adjusts the Voltage display sensitivity. The data received from the product does not change the sensitivity. Pressed once or continuously. The figures show the voltage values. If the figures are dual clicked, the "0 V" reference for the associated channel starts at the point clicked.</p>	
	<p>Zero Adjustment: Shifts the location of the "0 V" of the image up or down. The figures show the voltage values. If the figures are dual clicked, the "0 V" reference for the associated channel starts at the point clicked.</p>	
	<p>Starting Adjustment: Set the starting location of the section of the data to be displayed in the 'Memory' mode.</p>	 <p>Speed Adjustment: This is the Time/Division setting. The Horizontal axis (time axis) sets the time per square.</p>

The Dual Channel Oscilloscope may also be used as a Square Wave Generator and Analog Voltage Output. The Square Wave Signal Output applies a signal to the electronic circuit board and the other channels display the output signals on the oscilloscope screen.

While measuring a signal with the Oscilloscope, using the Probe at the 10X stage is recommended. The chassis must be isolated or grounded. The Com Probe is connected to the chassis of the board. The Probes are set to the 10X stage and X1 is clicked from the software to set the Probe at the 10X stage. Then the probe is touched to the material to be tested and the material's voltage and frequency are measured.

Note: Please use the probe at 10X stage for the signal measurements above 5 V.

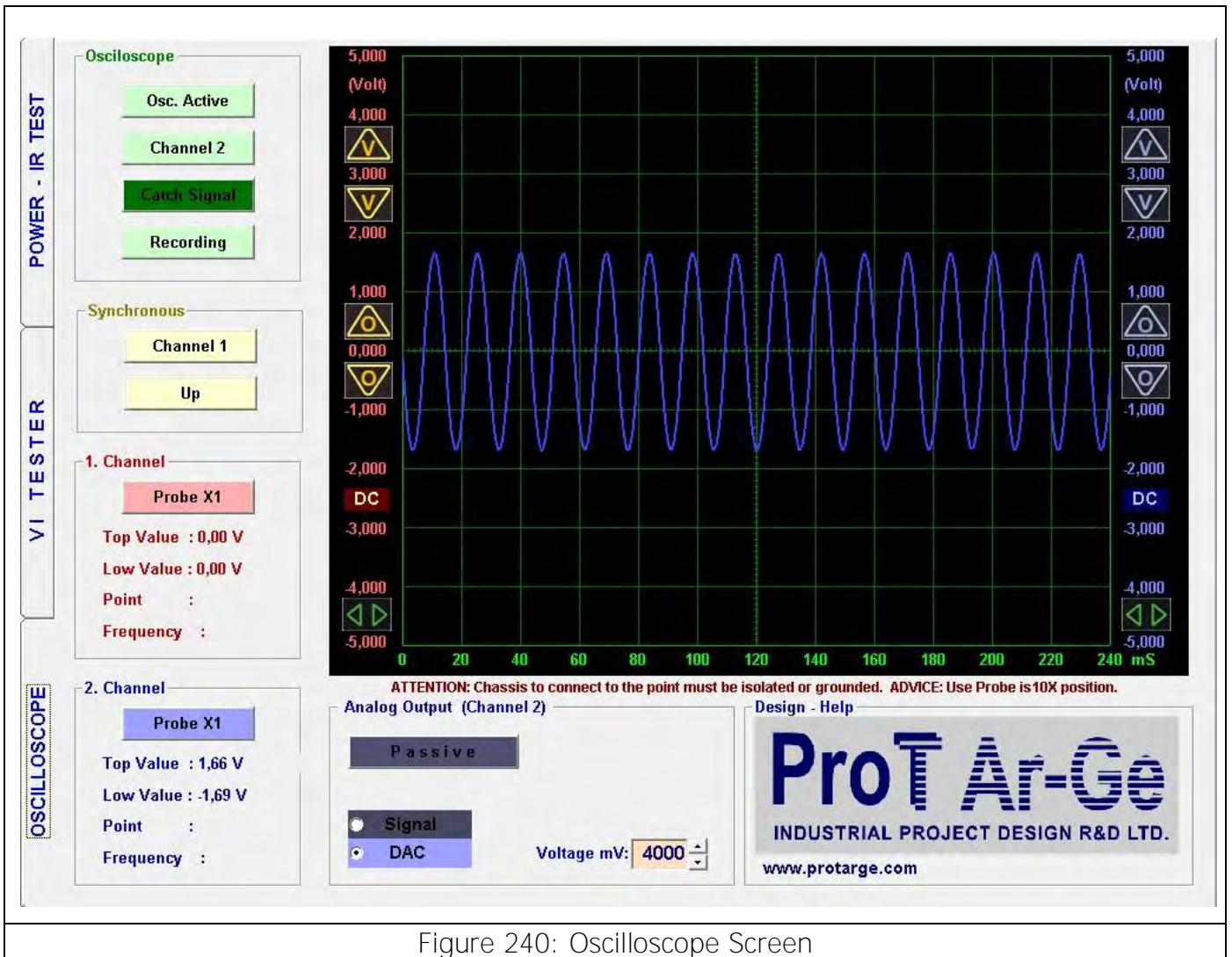


Figure 240: Oscilloscope Screen

DAC - Square Wave Generator

The FADOS9F1 may also be used as a Square Wave Generator and Analog Voltage Output. The Square Wave Signal Output applies a signal to the electronic circuit board and the other channels display the output signals on the oscilloscope screen. Channel2 Probe is used for Analog Voltage Output or Square Wave Signal output.

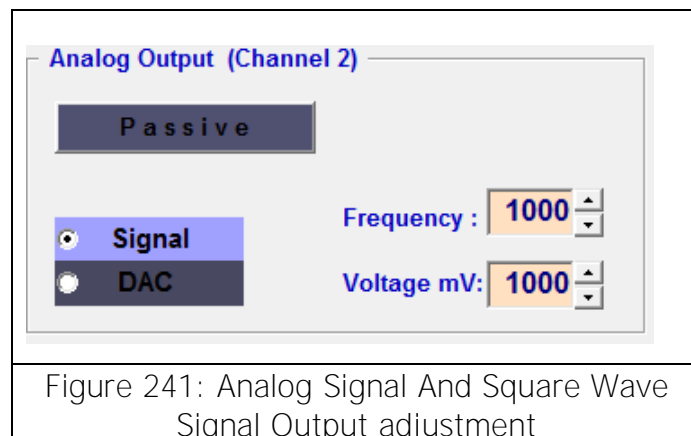


Figure 241: Analog Signal And Square Wave Signal Output adjustment

Figure 241 shows the Analog Signal and Square Wave Signal Output adjustment. For example; if we want to obtain a Square Wave Signal output, the signal is selected, the frequency of the is selected from Frequency and the voltage is selected from the Voltage setting. The Passive button is clicked for activating. The Channel2 probe generates the Square Wave Signal Output we can measure the signal generated by touching the Channel1 probe to the Channel2 probe.

Figure 242 shows the measurement of the square wave signal generated by Channel2 using Channel1.

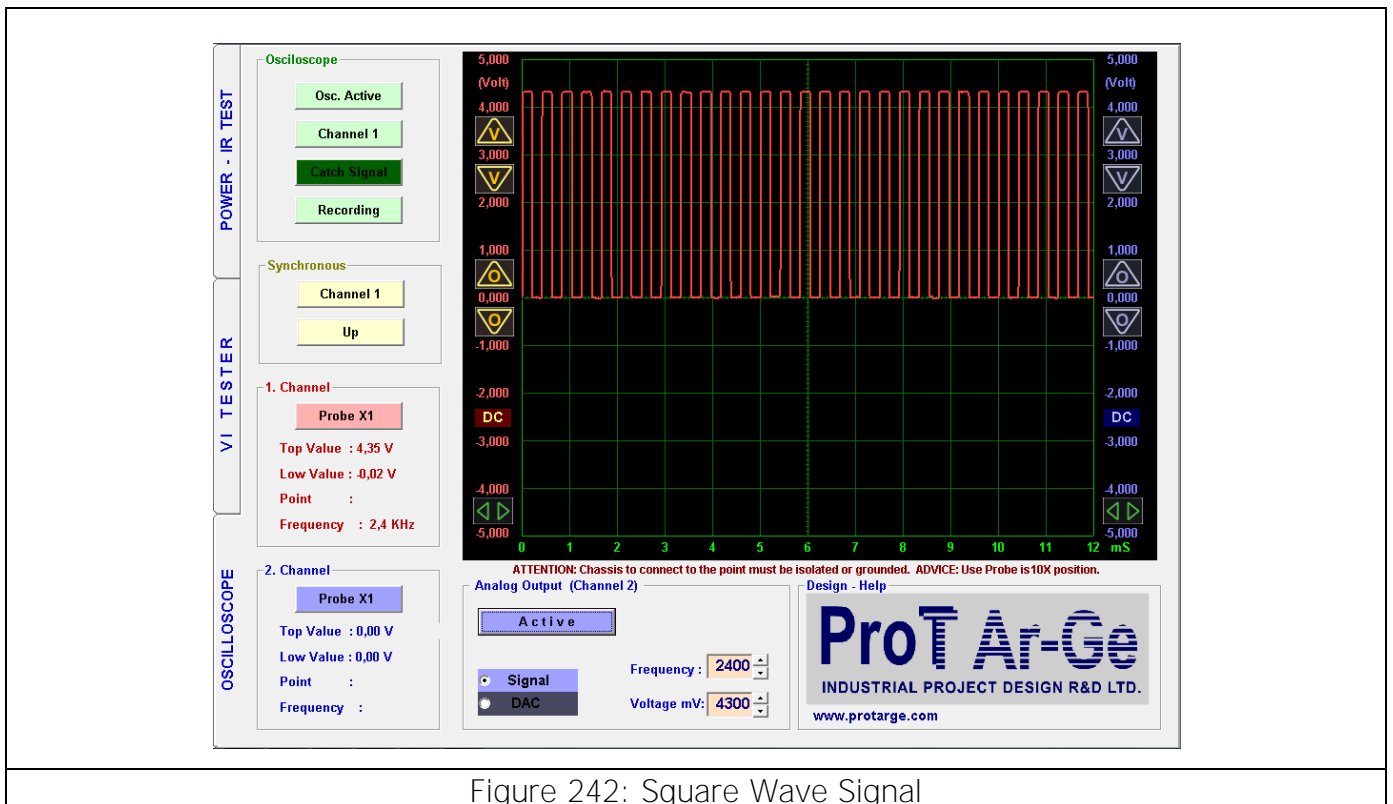


Figure 242: Square Wave Signal

For example; if we want a digital output of an Analog signal, the DAC is selected. The voltage of the signal is adjusted from Voltage mV. The Passive button is clicked for activating; Channel2 generates an output. We can measure the signal generated by touching the Channel1 probe to the Channel2 probe.

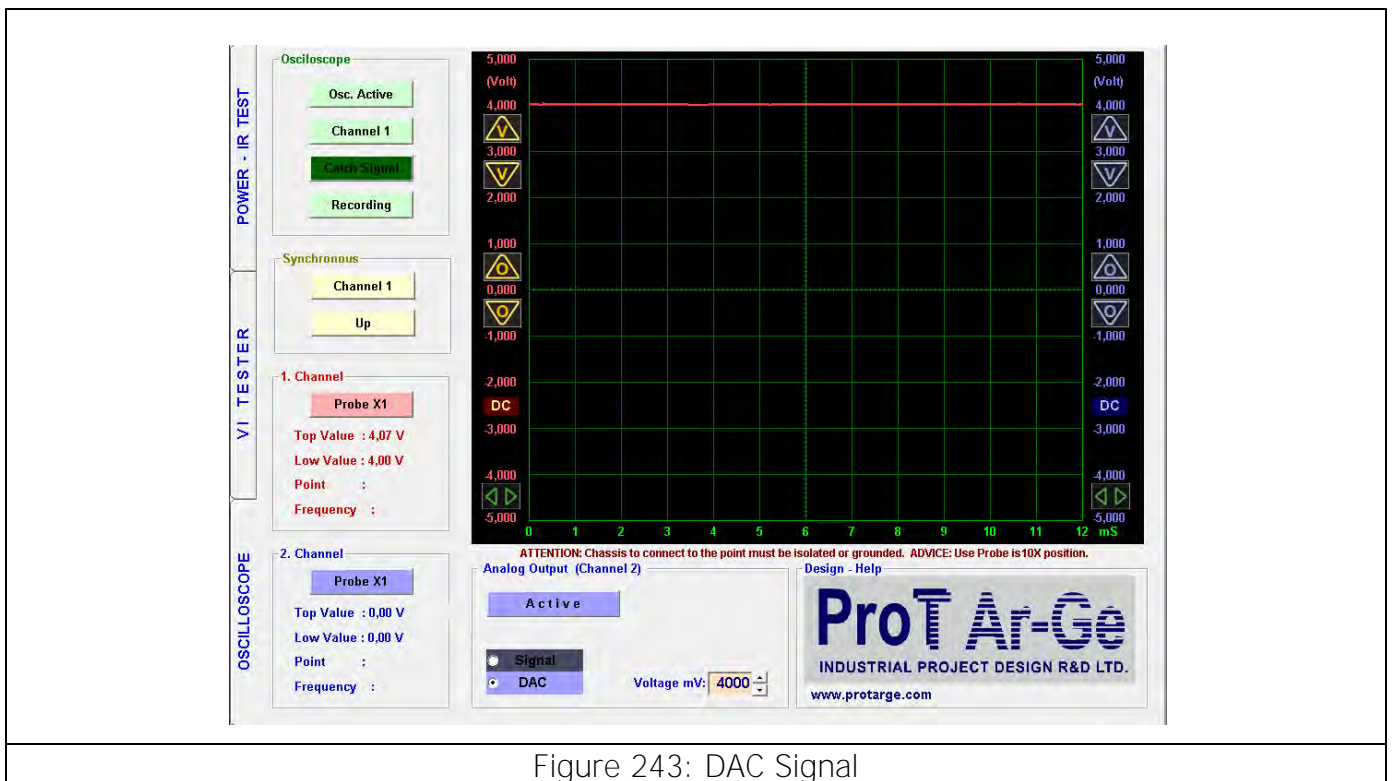


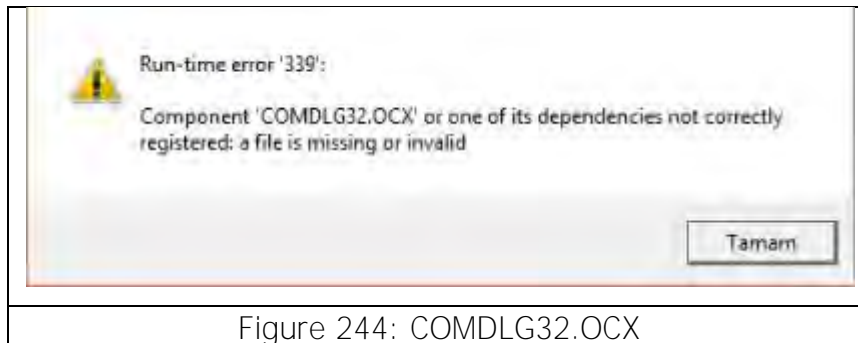
Figure 243: DAC Signal

ISSUES TO KEEP IN MIND - RECOMMENDATIONS

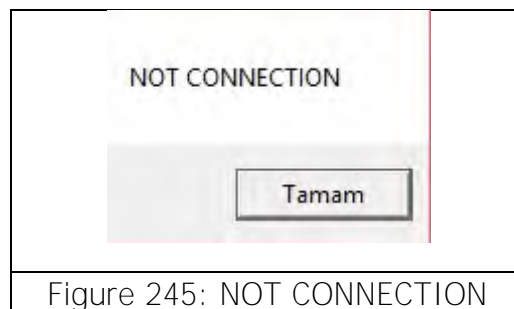
1. The probes have to be at the 1X setting for troubleshooting (fault detection).
2. The essential point in troubleshooting is the perfect matching of the graphs. The equivalent circuit diagram and values at the bottom are helping tools. The values shown in the circuit are for comparison purposes and not for measurement. Wrong indications are also possible due to the effects of the other components on the board.
3. Use the medium current stage for troubleshooting generally. Select the low current stage only where necessary (High value resistor or low value capacitor).
4. The 1X position of the probe in the Oscilloscope mode measures up to 5V, and the 10X setting up to 50 volts. Measuring High voltage circuits is not recommended.
5. The calibration setting of each product is different and the calibration file can be found in the CD under the program installation folder. Please do not lose the Program CD.

ERROR CODES

- 1) Run - Time Error '339':** Some other programs in the computer may use some common files with the FADOS9F1 software. If we delete any program from the computer, the file used by FADOS9F1 may also be deleted. When the above error is displayed, it means that the 'COMDLG32.OCX' file was deleted. If you uninstall and re-install the FADOS9F1 software to the computer, the 'COMDLG32.OCX' file will be reloaded as well.



- 2) Not Connection:** When a USB connection is made to the FADOS9F1 device, it will be noted that the USB connection was not made or the driver was not installed. Please check the USB cable or install the FADOS9F1 driver.



- 3) Run - Time Error '6':** When you record the Electronic materials' data with their photos, if the resolution and dimensions are too high for the software, the above error will be displayed. Please reduce the resolution of the photo.



CONDITIONS OF WARRANTY

1. The warranty period is 1 year (12 months) starting from the delivery date of the product.
2. The repair period is seven (7) business days.
3. Any malfunctions arising out of using the product in violation of the issues specified in the user manual are excluded from the warranty. If higher voltages than those specified for the device are applied to the probes, the series resistors connected to the probes inside the device will burn out. Burn out of that resistor will indicate a user error such as not discharging a high voltage capacitor etc. Such conditions are excluded from the warranty coverage.
4. The device is placed in an aluminium casing, which protects the electronic circuit board against any damage. Breaking the case or the electronic circuit board, getting the insides wet etc. are excluded from the warranty coverage.
5. The probes may be damaged during use; hence the probe failures are not covered by the warranty.
6. In case of a device failure, please send the product to Prot Ar-Ge Ltd. **Şti. or authorized** distributor without trying any operation on the product.

ProT Ar-Ge Endüstriyel Proje Tasarım Ar-Ge Ltd. Şti.
Industrial Project Design R&D Co. Ltd.

Address: Reyhan Mah. Mantıcı Cad. Aydı İşhanı No: 21/15B Postcode: 16030 Osmangazi/BURSA - TURKEY
Phone: 00 90 224 223 17 45 Fax: 00 90 224 221 74 53
export@protarge.com www.protarge.com