Measuring IR with the Guardian 2530

The G2530 is capable of making IR measurements of a wide range of devices at applied voltages from 50V to 1000V in 2V steps with an accuracy equal to ± (2% of setting + 5V). The instrument's measurement range is 10kΩ to 2TΩ depending on voltage. Range accuracy is equal to ± (2%) for V/R > 10nA and ± (5%) for V/R < 10nA. The configuration of the instrument is critical to making the best possible IR measurement. This application note explains how to make fast, accurate insulation resistance measurements with the Guardian 2530 AC/DC/IR Hipot Tester.

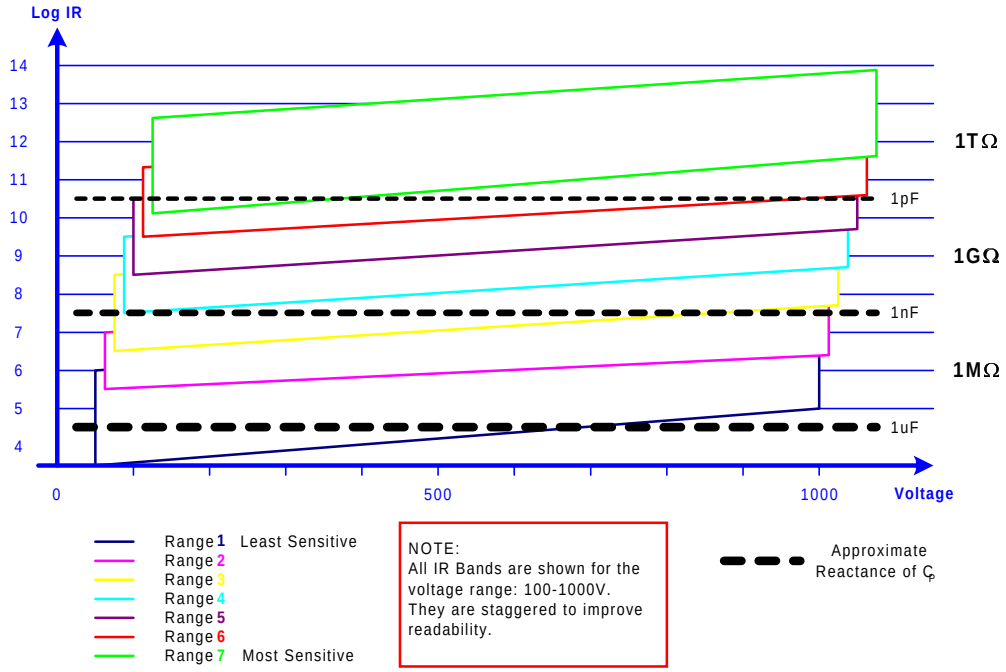

Figure 1: Current Ranges of Guardian 2530

For IR measurements, the G2530 will internally select one of seven input current ranges. Accurate measurement of a highly resistive DUT is possible only if the real current through the DUT is at least a few percent of the maximum current for the input range in use during the test time. Autoranging normally selects the most sensitive input range that will not cause an overload in the A/D converter. However, a number of factors can interfere with autoranging.

Because the G2530 was designed as "The Safe Choice", the firmware is designed to report a numerical answer ONLY when it meets the published specifications for accuracy and reproducibility. If the accuracy of the answer is degraded for any reason, the measurement display format is changed to indicate that the answer does not meet those specifications.

ERROR MESSAGES

If the input current is too low for the IR to be calculated accurately, one of two display formats will be used. The measurement result may be displayed as "> r.rrr [units]", where the numerical value may or may not be greater than the programmed limits for the test. An output in this format indicates that the actual input current was less than 1% of the maximum input current for the input range used during the TESTING phase of the measurement; however, the limit as stated can be relied on. If there is no HI limit for the test and the displayed value is greater than the low limit, this answer may be satisfactory, but it may still be possible to improve the accuracy of the testing.

In some cases, the G2530 will be unable to make ANY useful measurement of IR, and the result is displayed as a row of "???????". This is clearly not a useful answer. It indicates that the input current on the range selected is so low as to be indistinguishable from zero. Since resistance is (voltage/current) and the result of division by zero is undefined, it is not possible to report a resistance value under these conditions. It will normally be possible to reconfigure the G2530 to eliminate this condition as explained below.

If IR test results are unsatisfactory with your device, check the following:

UTILITY SETTINGS

Continue Voltage On Fail = OFF
GFI = OFF or ON
AUTORANGING = FULL
ADAPTIVE RAMP = ON
GET OFFSET = ON (Measure offset first with GET, refer to G2500 instruction manual)

TEST SETUP

DWELL TIME ≥ 2.0 seconds
Ground Continuity Lead: Disconnected
Ground Continuity Test: Disabled

FILTERING

Quieting Resistor: (equal to ~ 1% Configured low limit) in series with HV lead
Input Low Loss Filter: cutoff frequency below 1kHz
Install 2TΩ Option: to HV board if G2530 used exclusively for IR measurements

For a complete discussion on Utility Settings, Test Settings and Filtering possibilities continue reading this article. Capacitive devices require careful measurement technique consisting of a longer dwell (and ramp) time to fully charge the device to the test voltage. Sufficient discharge time after test is necessary to allow charge to drain from capacitive device.

UTILITY SETTINGS

In the Utility Menu check the five parameters “CONTINUE VOLTAGE ON FAIL”, GFI, AUTORANGING, ADAPTIVE RAMP, and OFFSET to clarify the insulation resistance measurement of your particular device.

1) When the utility setting "Continue Voltage On Fail" (CVOF) is turned ON, autoranging is disabled and the maximum measurable IR value is 20MΩ at 1000V, and proportionately less at lower voltages. For example, if the test voltage is set to 500V and a 1 GΩ device is tested, the output will read "> 10 MOhms" because this is the highest value which can be measured within the specified accuracy of the G2530 on the least sensitive current range.

2) Setting the GFI to "Off, Grounded DUT" has the same effect as CVOF; i.e., only the least sensitive input current range will be used. Set GFI to ON or OFF to allow autoranging.

3) The AUTORANGING utility has three settings. If it is OFF, only the least sensitive input current range will be used, as for CVOF. If it is set to LIMITED, the autoranging algorithm will not use a range higher than the one that would give the best answer for the programmed LOW LIMIT. If a device of considerably higher IR is measured, so that the input current is less than about 1% of the maximum for the selected range, the answer will be displayed as "> r.rrr [units]", as described above. In this case the answer may be all that is needed for production purposes, since the reported low limit will be HIGHER than the low limit programmed for the test.

   In principal, all IR measurements could be made with autoranging set to FULL. However, this is not always practical in a production environment, because it allows the G2530 to ramp up to a very high sensitivity, and transient conditions such as ambient electrical noise may then result in an overload condition which will cause the test to terminate with an ERROR message.

4) The ADAPTIVE RAMP setting selects the algorithm that is used while the voltage is being ramped up. This setting is only available on code versions 1.45 and later. When this is ON, the voltage is ramped up using a predictive algorithm designed to avoid overshooting the programmed test voltage; however, the applied voltage is never reduced, so it may overshoot slightly. (Increased ramp time can correct for this). This setting should be used when the DUT or the test fixture is capacitive, since the normal ramping algorithm may be defeated by the time constant resulting from the resistance of the voltage source and the impedance of the combined DUT and test fixture. It may be necessary to increase the ramp time to avoid overshooting the test voltage.

5) The OFFSET is a zero correction which is activated through the UTILITY menu but which can be measured, stored, and applied for each single test. If running an IR test with no DUT connected (open circuit) causes the "????????" answer to be displayed, perform the GET OFFSET operation for this test as described in the G2530 documentation.

TEST SETUP

When setting up your insulation resistance test consider the dwell time necessary for your particular device. To increase the accuracy of the IR measurement, disconnect the Ground Continuity test lead.

1) The G2530 starts to apply the autoranging algorithm at the end of the VOLTAGE RAMP. Normally, there is only time during RAMP to advance one or two ranges. This will not be enough for highly resistive DUTs. Autoranging continues during DWELL, so setting the DWELL TIME to 2 or more seconds will be necessary to allow the G2530 to range up to the most sensitive inputs.

2) For most accurate results on highly resistive devices, do not connect the ground continuity lead or attempt to measure ground continuity.

3) (DC tests, not actually applicable to IR) If ARC DETECT is enabled, the autoranging algorithm will not select the more sensitive DC range if the arc limit is too high to measure on this range (> 200uA).

FILTERING

Filtering may serve to sharpen your IR measurement particularly if you are using the Guardian 2530 exclusively for insulation resistance tests.

The DC output of the standard DC source in the G2530 has a superimposed AC ripple at about 1kHz which under open circuit conditions is about 1% of the amplitude of the DC signal. This does not interfere with the measurement of a purely resistive device. However, a device or fixture with significant parallel capacitance presents a path for the ripple signal to bypass the resistance of the DUT; the current input can thus be presented with a signal which has a relatively large AC (1kHz) component superimposed on a smaller DC component. The G2530 must use a current input range that will not overload the A/D converter when presented with the vector sum of these currents.

For example, consider a device consisting of a 1GΩ resistor in parallel with 10 pf. The reactance of the parallel capacitor at 1kHz is 16MΩ. Since the applied AC (ripple) signal is only about 1% of the DC test voltage, the real component of the input current will be 1uA/kV and the imaginary component will be 0.6uA/kV. A useful measurement can be made in this case, because the magnitude of the vector sum of the AC and DC signals is not significantly greater than that of the real component so autoranging will work correctly. However, now consider the parallel capacitance to be increased to 1nf. Now the imaginary component of the input current will be 60 times as large as the real current and the autoranging algorithm will not be able to select a range at which the actual IR can be measured accurately.

This situation results from a hardware design compromise that was necessary in view of the enormous operational flexibility of the G2530. There are three ways to address it:

Filtering Techniques

1) Use a "quieting resistor" in series with the HV lead. A good starting value is about 1% of the configured low limit. This resistor limits the AC current that can flow through the parallel capacitor, and allows autoranging to proceed normally. It will probably be necessary to turn on ADAPTIVE RAMPING. It will also in many cases be necessary to remove this resistor from the HV lead when AC or DC HIPOT tests are being performed.

2) Use an input low pass filter consisting of one or more R/C sections in series with the current return, putting the corners of the filter sections well below 1kHz. Consult QuadTech for further information on the design of a suitable filter.

3) If a G2530 is to be used exclusively for IR measurements, there is a "2 TOhm Option" which can be applied to the HV board. This modification greatly reduces the ripple percentage on the HV board permitting the measurement of high R and high C devices without external filtering, but the tradeoff is much slower discharge time from voltages above 3kV. ADAPTIVE RAMPING must be used when this option is installed.

Performing an IR Test

Okay, enough technical talk, let's program an IR Test on the Guardian 2530. First press the [1/0] toggle switch to [1] to apply power to the instrument. Connect the 2000-02 HV lead set, Silver BNC to RETURN and Black Banana to HV OUT. Do NOT connect the ground continuity cable to the GC terminal.

Press [TEST NUMBER] to select a test number (1-25) for this specific test.

Press [PROGRAM] to enter Program Mode. Program the G2530 unit for an IR Test as illustrated on the following page. Mode = IR, Voltage = 500V, High Limit = Off, Low Limit = 0.1MΩ, Ramp Time = 3.0sec, Dwell Time = 3.0sec, Test Time = 2.0sec, Fall Time = 3.0sec and Ground Continuity = Off. Press [PROGRAM] to exit Program Mode. Leave the test leads disconnected and make sure the HV lead is in a safe place.

Press the [UTILITY] button. The "Meas Offset" screen is displayed. Press [START] and the GET OFFSET function is initiated. After the offset has been measured, the OFFSET will automatically be set to ON. Press [▸] to toggle through Utility Menu until the "Enhanced Features" screen. Select "Enhanced Features" = ON. Press [▸] to toggle through Enhanced Feature Menu. Select "Continue Voltage On Fail" = OFF. Select "Ground Fault Stop" = OFF. Select "Autoranging" = ON. Select "Adaptive DC Ramp" = ON. Press the [UTILITY] button to exit Utility Mode.

Connect the DUT as illustrated in Figure 2. The test leads should be in the same position as when the offset function was performed. **Go to Figure 2, page 7 for completion of IR test.**

Programming Instructions

Press [Button]	Display will show:
Press [PROGRAM]	1 Program Mode: AC Total Current
Press [▲] until IR is displayed	1 Program Mode: IR
Press [▶] until Voltage = 0.500kV	1 Program Volt: 0.500kV
Press [▲] to select High Limit	1 Program High Limit: Off
Press [▶] until OFF is displayed	1 Program High Limit: Off
Press [▲] to select Low Limit	1 Program Low Limit: Off
Press [▶] until 0.1MΩ is displayed	1 Program Low Limit: 0.1MΩ
Press [▲] to select Ramp Time	1 Program Ramp Time: 5.0sec
Press [▶] until 3.0sec is displayed	1 Program Ramp Time: 3.0sec
Press [▲] to select Dwell Time	1 Program Dwell Time: 5.0sec
Press [▶] until 3.0sec is displayed	1 Program Dwell Time: 3.0sec
Press [▲] to select Test Time	1 Program Test Time: 5.0sec
Press [▶] until 2.0sec is displayed	1 Program Test Time: 2.0sec
Press [▲] to select Fall Time	1 Program Fall Time: 5.0sec
Press [▶] until 3.0sec is displayed	1 Program Fall Time: 3.0sec
Press [▲] to select Ground Continuity	1 Program Gnd Continuity: 0.10Ω
Press [▶] until OFF is displayed	1 Program Gnd Continuity: Off

Press [PROGRAM] to EXIT Program Mode

Connection to Device Under Test

Figure 2 illustrates the connection of the DUT to the Guardian 2530 front panel output terminals. Connect the 2000-02 HV lead set, Silver BNC to RETURN and Black HV connector to HV OUT. Do NOT connect the ground continuity cable to the GC terminal.

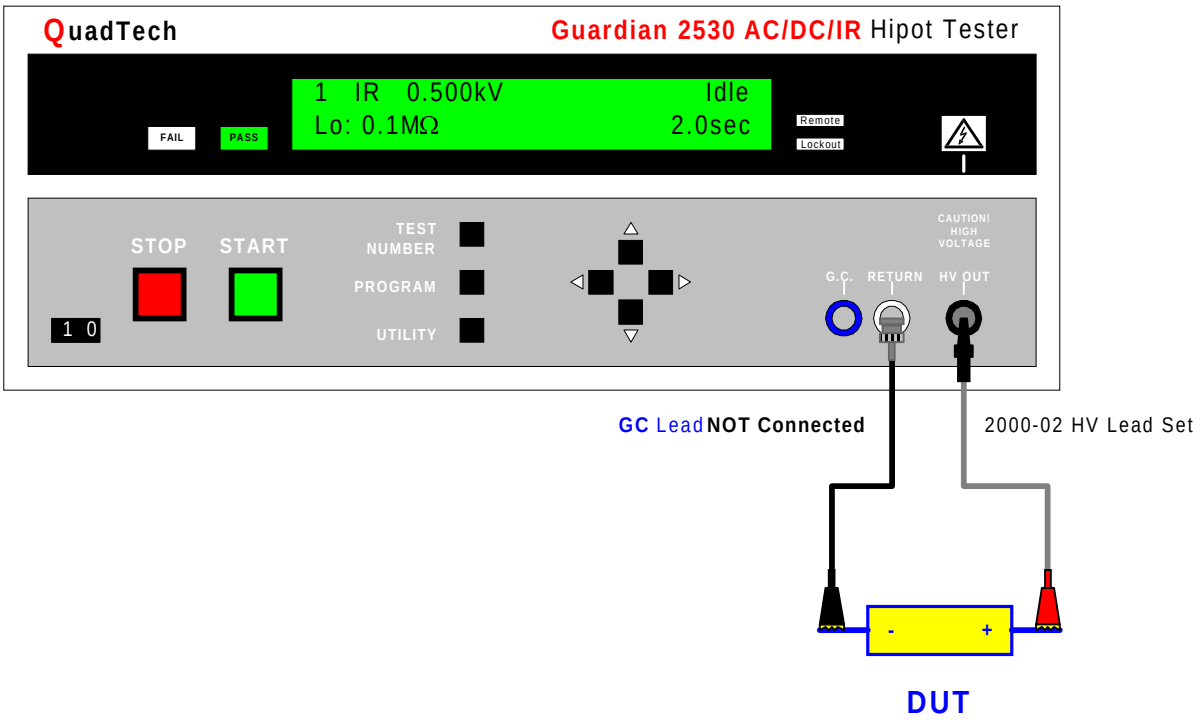

Figure 2: Connection of DUT for IR Test

Complete IR Test:

After programming is complete, the Utility functions are set and the DUT is connected properly, initiate the IR test by pressing the green [**START**] button. Press [**STOP**] at any time to terminate voltage at test terminals.

If Insulation Measurements are not satisfactory reevaluate the Utility Settings per the preceding discussion. For further Applications Assistance contact QuadTech at 1-800-253-1230.

For complete product specifications on the **Guardian 2530 AC/DC/IR Hipot Tester** or any of QuadTech's products, visit us at http://www.quadtech.com/resources/dataindex.html. Do you have an application specific testing need? Call us at 1-800-253-1230 or email engineering at rroetzer@quadtech.com and we'll work with you on a custom solution. Put QuadTech to the test because we're committed to solving your testing requirements.

Telephone: 1- 800-253-1230, Website: **http://www.quadtech.com**
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