

VITREK

951 to 957i, and 959i

OPERATING & MAINTENANCE MANUAL



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About this Manual

Throughout this document the instrument is referred to as the 95x, this applies to all instruments in the 95x series having a main firmware revision of 2.39, there may be differences if the 95x being operated has a different main firmware version. At the end of this manual is a section detailing the differences between v2.30 and earlier versions of the firmware (see [Migrating from Earlier Firmware Versions](#)).

Due to continuing product refinement and possible manufacturer changes to components used in this product, Vitrek reserves the right to change any or all specifications without notice.

This manual has been created with “clickable” links. Where a reference is made to another section of the manual, the user may click on the section name reference and the document will automatically go to that section.

The table of contents is “clickable”. The user may click on any of the entries to go to that section.

The table of contents is also made available as Bookmarks for Adobe Reader or Acrobat, allowing the user to permanently display the table of contents alongside the document and navigate by clicking on each section as needed.

Warranty Information

This Vitrek instrument is warranted against defects in material and workmanship for a period of 1 year after the date of purchase (extended up to a total of 3 years with registration and annual calibrations at Vitrek). Vitrek agrees to repair or replace any assembly or component (except batteries) found to be defective, under normal use, during the warranty period. Vitrek's obligation under this warranty is limited solely to repairing any such instrument, which in Vitrek's sole opinion proves to be defective within the scope of the warranty, when returned to the factory or to an authorized service center. Transportation to the factory or service center is to be prepaid by the purchaser. Shipment should not be made without prior authorization by Vitrek.

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In the interest of continued product development, Vitrek reserves the right to make changes to this document and the product it describes at any time, without notice or obligation.

Vitrek

12169 Kirkham Road,

Poway, CA 92064 USA

Telephone: 858-689-2755

Fax : 858-689-2760

Web : www.Vitrek.com

Email : info@Vitrek.com

SECTION 1 – PRODUCT INFORMATION

Features

The 95x is an advanced Electrical Safety Analyzer with many standard features which make it unique in this field.

- **Multiple Capabilities.** The 95x is capable of a very wide range of safety tests and is also capable of making specialty measurements on components – all in the same instrument.
- **Multiple Safety features.** The 95x has many built-in safety features, such as ground current detection, DUT safety ground disconnection detection, and more. The standard digital interface allows the user to use safety interlocks and remote safety indicators with ease.
- **No regrets.** With all of the features shown here, the 95x is capable of so much more than the typical users' present requirements, the user will not regret choosing the 95x when new more stringent requirements come up in the future.
- **Wide range of voltages and currents generated.** The 95x has a test voltage range from a few 10's of volts to several 10's of kilovolts (for withstand testing) and a test current range from a few microamps to 10's of amps (for chassis ground bond testing) at DC or over a frequency range from 20 to 500Hz. The 95x is not limited to just a few voltages, currents or frequencies, the user can specify the actual level and frequency they desire. The 95x is not weak either – loads up to 500VA can be accommodated.
- **Wide range of voltages and currents measured.** The 95x does not just have a wide range of generated voltages and currents – it can measure them too. From microvolts to 10's of kilovolts, and from 100's of picoamps to 100's of milliamps, all are measured by the 95x. Using its DSP based technology the 95x knows the difference between breakdown currents, leakage currents and arcing currents and gives you all of the results.
- **Advanced measurements.** When it comes to AC measurements the 95x does not just measure the basics - the 95x measures total, in phase and quadrature components all of the time and makes available more advanced results such as in phase resistance, quadrature reactance, capacitance and dissipation factors.
- **Result Analysis.** The 95x does not just measure, it analyses the measurements – after a test has been run the minimum, maximum, average, and final measurements are available, a running total of the passes and failures for each test step are also maintained across multiple runs.
- **Not just “does not breakdown” but “does breakdown” too.** The 95x is not only capable of testing that a DUT does not breakdown, but it is also capable of testing that a surge suppressor type device does breakdown at the correct voltage. Ever worried if that surge suppressor you disconnected while safety testing was correctly reconnected, does it work, is it in specification? Not a problem for the 95x – it can be tested after safety testing.
- **The 95x adapts itself to the load automatically.** The 95x does not have the load restrictions so often found (and so often hidden in the small print) in other safety analyzers – load capacitances up to a farad during DC withstand testing, highly inductive loads when low resistance testing, and more, are automatically accommodated by the 95x adapting itself to the actual load during each test. Measurements on DUTs like solar panels and computer system line filters are made by the 95x with ease.
- **Standalone operation.** The 95x can be programmed by the user to perform up to 254 test steps in a sequence. Each step is automatically performed by the 95x either with or without user intervention as the user desires. Up to 100 such sequences can be defined and maintained in the instrument; no

computer is required. The 95x is capable of controlling switch matrix units (also available from Vitrek) – up to 256 channels can be controlled without needing a computer or software. The 95x can even print a test report on a printer for you when a test sequence has completed.

- System operation - Wide range of interfaces available. If the user wishes to use the 95x with a computer, then RS232, GPIB or Ethernet interfacing can be chosen as the interfacing medium between them. Giving the user the flexibility to use the 95x in almost any computing environment. Software (QuickTest Pro and QuickTest Enterprise) is available from Vitrek to provide all the control needed for any system from the simple (just the 95x) to the most complex with the 95x terminals being multiplexed between DUTs and/or points within DUTs by up to 1024 channels in switch matrix units (also available from Vitrek).
- High Speed. The 95x is capable of performing very quickly, up to 100 tests per second can be performed with the test results being made available both during each test and after the entire sequence has been run. The 95x is also capable of chaining similar tests without needing to reduce the applied voltage or current to zero between test steps, this considerably speeds up testing when multiple test levels are required.
- All of the measurements, all of the time. The 95x does not just measure what the user has set limits for, all measurement results for the specific type of test being performed are made available to the user.
- Energy Efficient. The 95x uses direct line switching power supplies to provide a very energy efficient instrument, the 95x only draws significant power from the line when needed to power the load.

Available Models and Options

	AC Voltage Testing	DC Voltage Testing	AC Low Resistance Testing	
951i	20-6000V	30-6500V	No	951i
952i			0.1-40A @ 8V	952i
953i		50-11000V	No	953i
954i			0.1-40A @ 8V	954i
955i	40-10500V		No	955i
956i	No	30-6500V	No	956i
957i	20-6000V (40-10500V Opt AC10)	75-15000V	No (0.1-40A Opt GB40)	957i
959i	No	No	0.1-40A @ 8V	959i

In addition to the above, all models have 2- and 4-wire DC Low Resistance and Ground Leakage Testing capabilities, an RS232 interface, an Ethernet interface, a Digital I/O interface, and a VICL proprietary interface (for Vitrek switches).

Interfacing Options

The 95x always includes Digital I/O, RS232, Ethernet interfaces as standard.

These options may be fitted in any 95x.

Option **GPIB-9** adds a GPIB interface.

Option **UL-2** adds a USB printer interface.

Option **GUL-3** adds GPIB and USB printer interfaces.

DC Voltage Options

This option may be fitted in any 95x except the 959i.

Option **DCNEG** changes the polarity of the DC Voltage capability to negative but limits the minimum DC output voltage to 200V.

Internal AC Voltage Options

One or none of these options may be fitted in a 951i, 952i, 953i, 954i or 957i.

Option **AC-2** changes the AC Voltage capability to 10-2000V and has increased drive capability at all voltage output levels.

Option **500VA** (not available for the 952i or 954i) extends the AC voltage drive capability to 100mArms.

Option **AC-10** (only available for the 957i) extends the AC voltage drive capability to 10KVrms (same as standard in a 955i).

Internal GROUND BOND Option

This option may be fitted in a 957i and cannot be fitted if Opt. AC-10 is fitted.

Option **GB-40** adds ground bond testing capability to the 957i (same as standard in a 952i, 954i and 959i).

External AC Voltage Option

This option may be fitted in a 951i, 952i, 953i, 954i, 955i or 957i.

Option **AC-30** extends the maximum AC Voltage capability to 30KV by means of an external unit.

Pulse Testing Option

This option may be fitted in a 951i, 952i, 953i or 954i (not available with Option 500VA) or a 957i (not available with Opt. AC-10).

Option **PMT-1** adds pulsed voltage testing.

DUT Isolation Option

One of these options may be fitted in a 951i, 952i or 956i.

Option **HSS** adds the ability to measure AC or DC breakdown and/or leakage into a grounded DUT with down to 10nA resolution.

Option **HSS-2** adds the ability to measure DC breakdown and/or leakage into a grounded DUT with down to 1nA resolution.

Terminal Option

One or none of these options may be fitted in any 95x.

Option **RPO-95** adds rear panel terminals in parallel with the front panel terminals.

Option **RPOO-95** replaces the front panel terminals with rear panel terminals.

Power Input Option

Any of these options may be fitted in any 95x.

Option **LOLINE** changes the standard 105-245Vrms line voltage range to 80-125Vrms.

Option **INRUSH** reduces the power-on inrush current at 230V line from over 100Apk to nominally 40Apk but limits the line voltage range to 200-245Vrms.

Rack Mounting Option

This option may be fitted in any 95x.

Option **RM-1** allows for standard 19" rack mounting of the 95x.

Output Voltage/Current Limiting Options

The user may, at the time of order, specify that the DC and/or AC Voltage generated by the 95x may be limited to a user specified voltage less than that normally available from the specific unit model (but must be greater than 100V). Similarly, the user may specify that the Ground Bond current generated by a 952i, 954i or 959i is limited to a user specified current between 1 and 40Arms. The remainder of this manual assumes that these optional limits are at the maximum for the specific model.

Software

QT Pro II – 950 and **QT^{Enterprise}**. A 45-day free trial is available. Both software packages offer the following features:

- The user does not need to write software to use the 95x with a computer.
- Can control testing using very complex switching systems when used with Vitrek 964 Switch Matrix units.
- Easy to use fully graphical interface on a Windows based computer.
- Multi-level user login, enabling the configuration of tests to be locked except for certain users.
- Company wide use of test sequences using the company network.
- Test sequences can be downloaded into the 95x and run without the computer.
- Test results recorded on a computer or on the company network.
- Computer generated multi-level test reports.
- Compatibility with a wide range of Windows versions (Windows 7 through Windows 11).

Accessories

- **TL-115-95.** 115V Receptacle Hipot Test Adaptor
- **TL-115-GBR.** 115V Receptacle Ground Bond Test Adaptor
- **TL-115-95GBR.** 115V Receptacle Hipot and Ground Bond Test Adaptor
- **TL-IEC-95.** IEC320 Power Socket Lead set for HiPot
- **TL-IEC-GBR.** IEC320 Power Socket Lead set for Ground Bond
- **TL-IEC-95GBR.** IEC320 Power Socket Lead set for HiPot and Ground Bond
- **TL-209.** Standard HV/CONT Alligator Clip Test Lead Set (one supplied with each unit).
- **K-1R.** 4-Wire Kelvin Low Resistance Measurement Lead Set
- **K-2R.** 4-Wire 40A GB Test Lead Set (one supplied with each 952i, 954i, 959i, and 957i with Opt GB40).
- **RS-2.** 6ft RS232 null-modem cable (95x to Computer).
- **RSS-9.** Remote Start Switch.
- **RSF-9.** Remote Start Footswitch.

- **HVW-9.** High Voltage Warning Light.
- **RM-1.** Rack Mount Kit for the 95x series.
- **DIO-IS9.** DIO Isolator for the 95x series. Available in models for 3V, 5V, 12V, or 24V logic.

SECTION 2 – SAFETY

The user should be aware of these safety warnings at all times while using the 95x.

WARNING - THE 95x PRODUCES VOLTAGES AND CURRENTS WHICH MAY BE LETHAL, UNSAFE OPERATION MAY RESULT IN SEVERE INJURY OR DEATH.

WARNING - IF THE 95x IS USED IN A MANNER NOT SPECIFIED BY VITREK, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED AND SAFETY MAY BE COMPROMISED.

Power and Grounding

WARNING - THE 95x IS INTENDED TO BE POWERED FROM A POWER CORD HAVING A PROTECTIVE GROUND WIRE WHICH MUST BE INSERTED INTO A POWER OUTLET HAVING A PROTECTIVE GROUND TERMINAL. IF THE 95x IS NOT POWERED FROM A SUITABLE POWER SOURCE THEN THE CHASSIS GROUND TERMINAL LOCATED NEAR THE POWER ENTRY CONNECTOR ON THE REAR PANEL MUST BE PROTECTIVE GROUNDED.

WARNING - TURNING OFF OR OTHERWISE REMOVING POWER TO THE 95x WHILE IT IS GENERATING HIGH VOLTAGES WILL NOT ENABLE THE 95x TO DISCHARGE THE DUT AND MAY DAMAGE THE 95x. THE DUT MAY HAVE DANGEROUS VOLTAGES PRESENT FOR LONG PERIODS OF TIME AFTER THIS OCCURS.

WARNING - DO NOT REMOVE THE POWER CORD FROM THE 95x OR FROM THE SOURCE OF POWER WHILE IT IS OPERATING AT HIGH VOLTAGES. THIS WILL REMOVE THE PROTECTIVE GROUND FROM THE CHASSIS OF THE 95x AND THE DUT WHICH MAY RESULT IN HAZARDOUS VOLTAGES BEING ACCESSIBLE TO THE USER.

Terminals and Wiring

WARNING - THE 95x PRODUCES VOLTAGES AND CURRENTS WHICH MAY BE LETHAL, ENSURE NO VOLTAGE OR CURRENT IS PRESENT WHEN CONNECTING TO OR DISCONNECTING FROM THE TERMINALS OR DUT.

The **HIGH VOLTAGE OR HIGH CURRENT PRESENT** warning symbol on the front panel of the 95x is illuminated whenever an unsafe voltage is present on the **HV** terminal, or a high current is present between the **SOURCE** terminals.

WARNING - THE 95x PRODUCES VOLTAGES OF UP TO 10kVrms ON THE HV TERMINAL(S). THE USER MUST ENSURE THAT CONNECTIONS TO THESE TERMINALS HAVE SUFFICIENT INSULATION FOR THESE VOLTAGES. EVEN WHEN SUFFICIENT INSULATION IS PRESENT, THE USER SHOULD NOT PUT ANY PART OF THEIR BODY IN CLOSE PROXIMITY TO THE CONNECTIONS WHILE HIGH VOLTAGES ARE PRESENT.

The insulation of the wiring to the **HV** terminal of the 95x must be rated for at least the highest voltage expected during the test sequence.

The user should ensure that all personnel remain at a safe distance from the **HV** wiring during testing.

When using high voltages, even if there is sufficient insulation, there may be significant capacitive coupling which can cause an unsafe current to flow to nearby objects and corona can occur even outside of the insulation. This is made worse by sharp corners on objects or the wiring. In severe cases corona can cause interference with the measurements of the 95x and will reduce the capabilities of the wiring insulation over time, eventually resulting in insulation failure.

When using extremely high voltages, especially when using Opt. AC-30, there may be significant mechanical force between the **HV** wiring and nearby objects. Loose wiring can move several inches, and nearby loose objects (e.g., screws or papers) can be attracted to the high voltage wire.

All terminals of the 95x other than the HV terminal are always protected to be within a safe voltage of the 95x chassis ground, so high voltage wire is generally unnecessary for connections to them.

Should the DUT exhibit significant breakdown or arcing while being tested, there may be very high energy HF interference generated. Although this only lasts for a small period of time before the 95x shuts down, in severe cases this can damage nearby equipment, such as computers. The wiring between the 95x terminals and the DUT should be routed as far as possible away from other equipment and from all cabling connected to other equipment.

When charging high capacitance loads to high DC voltages the capacitor may be unsafe if it or the wiring to it exhibits breakdown while being tested. The energy in the breakdown is generated by the capacitor itself, so there can be no limit on this energy imposed by the 95x.

WARNING - SOME 95x MODELS PRODUCE CURRENTS OF UP TO 40Arms ON THE SOURCE + AND - TERMINALS. THE USER MUST ENSURE THAT CONNECTIONS TO THESE TERMINALS HAVE A SUFFICIENT CURRENT CARRYING RATING.

The current rating of all wiring must be sufficient for at least the highest current expected from that terminal during the test sequence.

Generally, all wiring should be rated for at least 100mA, but the **SOURCE+** and **SOURCE-** terminal wiring for a 952i, 954i, or 959i performing Ground Bond testing should be rated for the highest set test current (this may be up to 40A).

User Activated Safety Abort

- The user may depress the **STOP** button on the 95x front panel at any time while a test sequence is being run to remove the voltage or current as quickly as possible and abort the test sequence.
- The user can configure for a digital INTERLOCK signal to be input to the DIO Interface which will abort a high voltage or current test step if the interlock is opened. See [SECTION 8 – DIO INTERFACE](#).
- The user can configure for a digital ABORT signal to be input to the DIO Interface which will abort any type of test step if asserted. See [SECTION 8 – DIO INTERFACE](#).

- There are several interface commands which can be used to abort a running test sequence. See [SECTION 11 – PROGRAMMING VIA AN INTERFACE](#).

Automatic Safety Abort

- For AC or DC voltage test steps, if the breakdown current level is set to <7mA_{pk} and the HI SAFETY setting in the CNFG - TEST menu is enabled, the 95x will fail the test if excessive **HV** terminal current is detected. This effectively reduces the drive capability of the 95x to a safer level of current (nominally 7.5mA peak) during these test steps. See [Test Sequence Configuration](#).
- For AC or DC voltage test steps, the **RETURN** terminal of the 95x provides a protective ground to the DUT. The user may wish to take precautions to ensure its connection to the DUT. If the CONTINUITY SENSE setting in the CNFG - TEST menu is enabled, and the user connects a separate wire between the **SENSE+** terminal of the 95x and the portion of the DUT to which the **RETURN** terminal wire is connected, then if the **RETURN** terminal wire becomes disconnected from the DUT the test step will be immediately aborted and the high voltage removed, preventing a potentially unsafe condition. See [Test Sequence Configuration](#).
- If option HSS-2 is not fitted then for AC or DC voltage test steps, if the voltage present on the **HV** terminal is detected as being significantly different from that expected during the execution of a test step, then the test sequence is immediately aborted and any high voltage removed, preventing a potentially unsafe condition. This requires no specific configuration by the user.
- All processors in the 95x which participate in monitoring the output of the 95x and the condition of the load check each other nominally every 5ms, if any mis-operation is detected which lasts more than 10ms then the test sequence is immediately aborted and any high voltage removed, preventing a potentially unsafe condition. This requires no specific configuration by the user.
- The main processor utilizes a hardware “watchdog” which recovers a malfunctioning system within typically 100msec. If this occurs during a test then the test sequence is immediately aborted and any high voltage removed, preventing a potentially unsafe condition. This requires no specific configuration by the user.

SECTION 3 –INSTALLATION

General Specifications

Nominal Dimensions	89mmH x 432mmW x 457mmD (3.5" x 17" x 18")
Nominal Weight	951i,953i,957i,959i : 9kg (18lb) net, 12kg (25lb) shipping 956i : 5kg (11lb) net, 8kg (18lb) shipping 951i,953i Opt. 500VA : 13kg (27lb) net, 16kg (35lb) shipping 952i, 954i, 955i : 13kg (27lb) net, 16kg (35lb) shipping 957i Opt AC10 or GB40 : 13kg (27lb) net, 16kg (35lb) shipping Opt. AC-30 : additional 17kg (36lb) net, 21kg (46lb) shipping
Storage Environment	-20 to 75C (non-condensing)
Operating Environment	0 to 50C, <85% RH (non-condensing), Pollution Degree 2
Operating Altitude	0 to 7000ft ASL (10000ft with reduced output drive capability)
Line Power	Installation Category II Standard: 105-265Vrms (45 to 450Hz) or 160-300Vdc, having at least 500VA (750VA for Opt. 500VA) capability Opt. LOLINE: 85 to 130Vrms (45 to 450Hz) Opt. INRUSH : 200-265Vrms (45 to 450Hz) having at least 500VA (750VA for Opt. 500VA) capability
Measurement	Measurement Category I

THE 95x MUST NOT BE USED IN AN ENVIRONMENT WHERE CONDUCTIVE POLLUTION CAN OCCUR, E.G. IN AN OUTDOOR ENVIRONMENT.

IF FLUIDS OR OTHER CONDUCTIVE MATERIALS ARE ALLOWED TO ENTER THE UNIT ENCLOSURE, EVEN IF NOT POWERED, THEN THE UNIT SHOULD BE IMMEDIATELY TAKEN OUT OF OPERATION AND SERVICED AS SAFETY MAY HAVE BEEN COMPROMISED.

IF THE UNIT IS TRANSPORTED BETWEEN DIFFERING ENVIRONMENTS AND CONDENSATION IS SUSPECTED, THE UNIT SHOULD REMAIN UNPOWERED FOR SUFFICIENT TIME FOR CONDENSATION TO HAVE DISSIPATED.

Initial Inspection

After the 95x has been shipped or otherwise handled in an unknown manner, the user should visually inspect the 95x for damage before attempting to operate it. Particular attention should be taken to ensure that there are no significant dents or cracks in any outer surfaces and that all terminals are securely mounted to the unit. If any significant dents or cracks, or any loosely mounted terminals, are noted then it is recommended that the 95x be serviced prior to being placed into use, as safety may have been compromised.

Cooling

The 95x is cooled by means of a rear panel mounted fan and cooling vents in the top cover. Sufficient free air must be allowed behind the rear panel and above the top cover to allow sufficient airflow for cooling purposes. At least 2" of well-ventilated unrestricted space is recommended around the fan intake and above the vents.

The cooling fan has variable speed to save energy while the 95x is not in use or is not heavily loaded. The user may notice that the fan activates shortly after initial application of line power. This is normal; the fan should stop or

slow to low speed within 1 minute of application of power. If the fan maintains high speed operation for a long time, then the airflow may be overly restricted, or the fan filter may be blocked, the user should take corrective action.

The cooling fan has a removable filter. This is easily removed for cleaning or replacement without disassembling the 95x, see [SECTION 9 – PERIODIC MAINTENANCE](#)

The 95x is fully specified for operation in ambient temperatures between 0 and 50C, however best accuracy and full loading capability is obtained if the ambient temperature is maintained below 30C. For best results, the user may wish to operate the 95x in a conditioned environment.

Mounting Position and Orientation

The 95x may be installed as either a bench top instrument or installed into a standard 19” rack.

The 95x is primarily intended to be used in a horizontal, or close to horizontal position, oriented with the top cover (with the vent holes) uppermost. There are no known issues with mounting the 95x at any angle or orientation, as long as it is mounted in a secure and stable fashion taking into consideration its weight and weight distribution.

Installing in a 19” Rack Enclosure

Often when installing the 95x into a rack enclosure it is desired to remove the feet from the bottom of the 95x. This is easily achieved by simply removing the screws mounting the feet to the bottom of the unit. The user should place the removed feet and mounting hardware into a bag for safe keeping should they be needed at a later date for bench top usage. **DO NOT INSERT THE MOUNTING HARDWARE BACK INTO THE BOTTOM OF THE 95x WITHOUT THE FEET INSTALLED, THIS MAY DAMAGE THE UNIT.**

Option RM-1 provides the rack mount ears required for mounting in a standard 19” rack enclosure.

When installing the 95x into a rack enclosure it is recommended that the unit be supported through its depth. The use of a tray or angle brackets supporting the bottom edges of the unit is recommended.

Line Power

WARNING - THE 95x IS INTENDED TO BE POWERED FROM A POWER CORD HAVING A PROTECTIVE GROUND WIRE WHICH MUST BE INSERTED INTO A POWER OUTLET HAVING A PROTECTIVE GROUND TERMINAL. IF THE 95x IS NOT POWERED FROM A SUITABLE POWER SOURCE THEN THE CHASSIS GROUND TERMINAL LOCATED NEAR THE POWER ENTRY CONNECTOR ON THE REAR PANEL MUST BE PROTECTIVE GROUNDED.

The user may connect the 95x to any source of line power within the allowable range of voltages and frequencies (see above) without requiring any adjustment to the 95x.

The 95x line power input is fused with a 5mm x 20mm TT3.15A fuse mounted in the rear panel next to the line power entry. If the user needs to replace this fuse it must be replaced with an exact equivalent fuse, noting the time and current ratings. Although the 95x is fused at 3.15Arms, the unit can draw surges of up to 10Apk during normal operation and up to 100Apk during initial application of power. The user should ensure that the power cord is rated for at least 5Arms continuous operation.

Connecting Option AC-30 to the 95x

If the 95x has option AC-30 installed, the user must connect the external transformer unit to the 95x in order to be able to use it.

The user may use the 95x without the external transformer unit if the capabilities of option AC-30 are neither programmed nor required.

CAUTION – ENSURE THAT ALL CONNECTIONS ARE PROPERLY MADE BETWEEN THE OPTION AC-30 EXTERNAL TRANSFORMER UNIT AND THE 95x **BEFORE** ATTEMPTING TO PERFORM ANY TEST USING OPTION AC-30. EXTREMELY HIGH VOLTAGES CAN BE PRESENT WITHOUT WARNING IF MIS-WIRED.

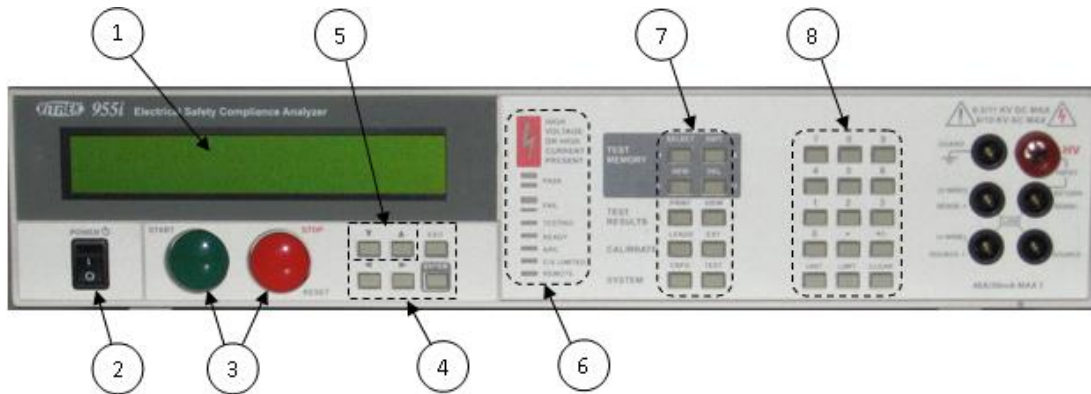
There are two cables from the option AC-30 external transformer unit which must be correctly connected to the 95x before attempting to perform any test using option AC-30.

- A shielded coaxial cable terminated in a BNC connector. This must be connected to the BNC connector marked **EXT FB** on the rear panel of the 95x. Ensure this connector is securely fastened to the rear panel connector on the 95x, if this should become disconnected while performing a test, extremely high voltages can exist on the output of the external transformer unit.
- A power line cord type cable terminated in three separate connections –
 - A spade lug. This must be securely connected to the Ground terminal located above the power connector on the rear panel of the 95x.
 - A pair of shrouded banana plugs. These must be connected to the safety banana sockets marked **EXT DRIVE** on the rear panel of the 95x. There is no polarity requirement regarding these connections.

SECTION 4 – GENERAL FRONT PANEL OPERATION

This section gives general information regarding using the front panel and its menus.

Front Panel



1. The display. This shows all menus during interactive data entries, all measurements during a test, and the present date/time when not performing any other duties.
2. The **POWER** switch. This turns on/off the power to the 95x.
3. The **START** and **STOP** buttons.
 - a. The **START** button allows the user to start performing a previously selected test sequence, or (while running a test sequence) select to continue a test step when it is waiting for the user to do so.
 - b. The **STOP** button aborts any test sequence in progress (while running a test sequence), aborts the menu activity in progress discarding any changes made (while performing a menu), or makes no test sequence selected (otherwise).
4. The menu selection keys. During all menus, the selected element of the menu is highlighted by flashing between the data and blocks. These keys allow the user to move the selection point within a menu.
 - a. The Left and Right Arrow keys are used to move the selection point within a menu.
 - b. The **ENTER** key is used to finish entry of a menu data and automatically move to the next menu item.
 - c. The **EXIT** key (labeled **EXIT/SAVE** on later units) is used to save all changes made within a menu and return to the previous menu (if any) or to the inactive display.
5. The edit keys. These allow the user to increase or decrease a selected menu items' value. During numeric entry these initiate "edit" mode of data entry, rather than "direct" mode of data entry (i.e., allow the user to adjust the existing entry using the Up/Down Arrow keys, rather than overwriting the existing value with a new value using the numeric keys). For convenience, these keys auto-repeat if the user maintains pressure on them.
6. The indicators.
 - a. **HIGH VOLTAGE OR HIGH CURRENT PRESENT**. This is illuminated whenever the 95x has a high voltage (>30V) or a high current (>5A) present on its terminals.

- b. **PASS.** This is illuminated whenever a test sequence is passing (while running a test sequence), or it has passed all test steps (following completion of the test sequence).
 - c. **FAIL.** This is illuminated whenever a test sequence is failing (while running a test sequence) or the previously run test sequence has failed any test steps (following completion of the test sequence).
 - d. **TESTING.** This is illuminated when the 95x is running a test sequence.
 - e. **READY.** This is illuminated after the user has selected a test sequence to run and the 95x is ready to perform that test sequence.
 - f. **ARC.** This is illuminated whenever the 95x is detecting an arc current while running a test sequence and the specific test step is enabled to detect arc current.
 - g. **C/V LIMITED.** This is illuminated when the 95x output is either current or voltage limited by the load while running a test sequence. This is only used in certain types of test steps.
 - h. **REMOTE.** This is illuminated when the 95x is under the control of an interface (i.e., RS232, Ethernet or GPIB). If the user wishes to return to front panel control of the 95x the CNFG key should be pressed to achieve this.
7. The menu keys. These initiate a menu allowing the user to perform certain activities via the front panel of the 95x. Many of these can be disabled by the user by requiring a password in order to utilize them.
- a. **SELECT.** Initiates a menu allowing the user to select a test sequence which has already been defined in the 95x. This never requires a password.
 - b. **EDIT.** Initiates a menu allowing the user to select an existing test sequence and then edit it. After editing it is automatically made ready to run. This optionally requires a password.
 - c. **NEW.** Initiates a menu allowing the user to select a presently undefined test sequence number and name, and then to create the sequence of tests to be performed. This optionally requires a password. While editing or creating a test sequence, this key is also used to insert a new test step into the test sequence.
 - d. **DEL.** Initiates a menu allowing the user to select an existing test sequence and delete it from the 95x. This optionally requires a password. While editing or creating a test sequence, this key is also used to delete a test step from the test sequence.
 - e. **PRINT.** If option UL-2 or GUL-3 are fitted and a suitable printer is attached, this key causes a printout to be generated. This never requires a password. The printout generated is dependent on the menu (if any) which is active when the key is pressed –
 - i. If pressed while no menu is active, or the configuration menu is active, a configuration printout is generated.
 - ii. If pressed while selecting an existing test sequence, a test sequence printout is generated.
 - iii. If pressed while reviewing the results of a completed test sequence, a test results report printout is generated. The 95x can also be configured to automatically produce this printout if desired.
 - f. **VIEW.** Initiates a menu allowing the user to either –

- i. If no test sequence is ready to run. View the pass and fail counts for any defined test sequence, and optionally to clear them. This never requires a password except (optionally) to clear the counts.
 - ii. If a test sequence has been run and is still selected. View the test results of each step within the previously run test sequence. This is automatically performed after a test sequence has been run. This never requires a password.
 - g. **LEADS**. Allows the user to run the presently selected test sequence in Lead Compensation mode. This allows the 95x to store any load offsets for each step in the test sequence and to correct all future tests using that test sequence for these load offsets. This optionally requires a password.
 - h. **EXT**. Allows the user to perform either an adjustment or verification calibration of the 95x against external standards. This optionally requires a password (this is separate from the other menu activity password).
 - i. **CNFG**. Initiates a menu allowing the user to configure the 95x. This uses a series of sub-menus. This optionally requires a password.
 - j. **TEST**. Shows the present operational status of the 95x and allows the user to perform internal operation verification (this optionally requires a password).
8. The data entry keys.
- a. The numeric keys (**0** through **9**), decimal point and change sign keys. These are used during numeric or character data entry. NOTE – during hexadecimal or character data entry, certain of the menu keys can be used for entry of the A through F characters.
 - b. The **UNIT** key. This is used to change the units during numeric data entry, and is also used while running a test, or while reviewing test results, to change the displayed test result measurement.
 - c. The **LIMIT** key. This is used during numeric data entry to set a value to the largest possible. When setting test dwell times this sets that the dwell should be user terminated rather than automatically terminated after the entered time. When setting a resistance type upper limit, this allows the user to set that there is no upper limit.
 - d. **CLEAR** key. This is used to clear an entry during numeric or character data entry.

Menu Operation and Data Entry

Most user activities using the front panel controls are performed using menus. All menus use the same general operating methods described in this section. The user should read this section before attempting to operate the 95x.

Base Menu State

When the 95x is not performing a menu and is not performing a test sequence, the display shows the model # in the uppermost display line and the date and time in the lower most display line, this is called the base menu state in this document. Most menus require the 95x to be in the base menu state to be initiated, an example of the base menu state display is -

```
Vitretek 951i  
9-Feb-10 9:08:51am
```

If the 95x is not in this state and the user is unsure how to return to this state, then pressing the **STOP** button will accomplish this (in some circumstances the **STOP** button may need to be pressed more than once).

Navigating Menus

- The present selection point in a menu is denoted by the displayed information flashing between the information and solid blocks.
- The user can move the selection point in a menu by using the Left and/or Right Arrow keys.
 - The Right Arrow key moves the selection point further down the menu. Moving the selection point past the last selectable item in a menu selects the first selectable item in the menu (a double beep sound is made when this occurs).
 - The Left Arrow key moves the selection point further up the menu. Moving the selection point before the first selectable item in a menu selects the last selectable item in the menu (a double beep sound is made when this occurs).
- Although the 95x display is limited to two lines, most menus have more lines than this. The display is automatically scrolled up and down the menu to display the menu line containing the present selection point.
- Not all menus or menu lines may be available.
 - Generally, items which are not pertinent to the specific model or option content of the 95x are not shown.
 - All menus in the 95x utilize a “top down” priority. Selections or entries made may affect subsequent entries in the menu. Entries may be limited in allowable values or may not be shown.
- If a menu line is an entry into a sub-menu, then the left side of the line shows descriptive text followed by an ellipsis character (...). The descriptive text is selectable. If the user presses the **ENTER** key while a sub-menu entry line is selected, then the sub-menu is opened.
 - When a sub-menu is terminated by pressing the **EXIT** key then the user is returned to the preceding level of menu.
 - If any level of sub-menu is terminated using the **STOP** button, then all levels of menus are aborted, and any changes made at any level are discarded.
 - Only when the base level menu is terminated by pressing the **EXIT** key are any changes actually saved.
- If a menu line is for informative purposes only, then the left side of the line shows descriptive text followed by a colon character with the informative data at the right end of the line. The descriptive text is selectable.
- If a menu line allows the user to edit its contents, then the left side of the line shows descriptive text followed by a colon character with the editable data at the right end of the line. The editable data is selectable; some menu lines may contain more than one editable data.

Modifying Menu Entries

- In many places the available contents of entries in different menu lines are inter-related. The 95x uses a “top down” menu approach; the topmost contents in a menu may limit the available entries in the menu below them, but not vice versa. Generally, the user cannot set a limit or an output which the specific model and option content of the 95x is not capable of achieving.

- **Changing Numeric Data.** After making the numeric data the selection point in the menu, the user can overwrite the data by using the data entry keys. While overwriting, the selection point becomes a single character position within the numeric data.
 - A numeric key replaces the corresponding character and moves the selection point to the right one position.
 - Certain numeric data allow the user to change the units of the data (e.g., between current and resistance) and/or change the multiplier for the data (e.g., select an entry in microamps or milliamps). To change the units, press the **UNIT** key while the entire numeric data is selected; to change the multiplier, press the **UNIT** key while entering the numeric data.
 - The Left Arrow key acts as a delete key, deleting the previously entered character.
 - The **CLR** key removes all of the existing entry and places the selection point in the rightmost character position.
 - The **LIMIT** key sets the numeric data to the highest possible value in most cases; while entering the lower limit in a range pair of data the **LIMIT** key sets the minimum value; in some other cases the **LIMIT** key has a special use denoted in the description for that specific data.
 - The Right Arrow or **ENTER** key terminates the numerical data entry and also moves the selection point to the right or downwards, as applicable.
- **Changing Multiple Choice Data.** After making the multiple-choice data the selection point in the menu, the user can change the selection by repeatedly pressing the Up Arrow or Down Arrow keys until the desired selection is displayed. The **ENTER** key terminates the multiple-choice data entry and also moves the selection point to the right or downwards, as applicable. The Left Arrow and Right Arrow keys automatically terminate the multiple-choice data entry prior to moving the selection point accordingly.
- **Changing Character Data.** After making the character data the selection point in the menu, the user can choose to either edit the existing data, or to overwrite it with new data. While overwriting or editing the data the selection point becomes a single character position within the character data.
 - **Editing Existing Character Data.** If the user presses the Up Arrow or Down Arrow key while the entire character data is selected, then the edit mode of entry is initiated, and the leftmost character of the existing data is selected. Character data uses a limited character set; A through Z, a through z, 0 through 9, the space character and most punctuation characters.
 - The Up Arrow and Down Arrow keys change the selected character to the next or previously available character in the character set.
 - The numeric keys and the **A** through **F** keys overwrite the selected character.
 - The Left Arrow and Right Arrow keys move the selection point within the character data area.
 - The **CLR** key aborts the edit, the character data is cleared, and the overwrite mode is initiated.
 - The **ENTER** key exits the edit mode retaining the changes made.
 - **Overwriting Character Data.** If the user presses any of the numeric keys or the **CLR** key then the overwrite mode of entry is initiated, starting with the corresponding character and with the leftmost character.

- The Up Arrow and Down Arrow keys change the selected character to the next or previously available character in the character set.
 - The numeric keys and the **A** through **F** keys replace the corresponding character and moves the selection point to the right one position.
 - The Left Arrow key acts as a delete key, deleting the previous character and moving the selection point to the left one position.
 - The Right Arrow key places a space character and moves the selection point to the right one position.
 - The **CLR** key removes all of the existing entry and places the selection point in the leftmost character position.
 - The **ENTER** key terminates the character data entry retaining the changes made and also moves the selection point in the menu to the right or downwards, as applicable.
- **Changing Hexadecimal Data.** Hexadecimal data is treated exactly the same as character data (see above) but with the available character set restricted to 0 through 9 and A through F.

Adjusting the Display Contrast

The user can adjust the display contrast while the 95x is in the base menu state (i.e., the display shows the model number and the time/date). An example display when the user can adjust the display contrast is –

```
vitrek 951i
9-Feb-10 9:08:51am
```

Using the Up and Down Arrows keys, select the display contrast which best suits the users normal viewing position.

NOTE – it may be possible to adjust the display contrast such that the display is not visible. If the display appears to be totally blank, then press and hold the Down Arrow key to return it to the visible state; if the display appears to have all of its dots “black” then press and hold the Up Arrow key to return it to the visible state.

NOTE – it may be best to select the contrast which shows the least “blurring” when the seconds digit in the displayed time changes. This has been found to produce the best adjustment for viewing angle as well as contrast.

Locking and Unlocking Menus

Many menus in the 95x can be locked by a user, preventing unauthorized changes to test sequences and configuration settings via the front panel of the 95x. When initially delivered from the factory, this capability is disabled.

The password is any combination of six 0 through 9 and A through F characters. The password 000000 indicates a cleared password, disabling this capability until a non-zero password is subsequently set by the user.

If a menu lock password has been set, the 95x always powers up with the menus locked.

Unlocking Menus

If the menu lock password has been set, a user must enter this password to unlock a menu. The user is prompted to enter the password when needed, which is accomplished by using the **0** through **9** and **A** through **F** keys as needed to match the previously set password, followed by the **ENTER** key. After successfully entering the password the front panel menus remain unlocked until the menus are relocked by the user or the 95x is power cycled. Note that the 95x display does not show the characters during unlock password entry for security reasons.

Setting, Changing or Clearing a Menu Lock Password

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key. If a password has been already set and the menus are not already unlocked, the user must enter the correct password to unlock the menu at this point.
- The display now shows the main configuration menu. An example of which is as follows –

```
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD:000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the LOCK PASSWORD line.
- Using the **0** through **9** keys and/or the **A** through **F** keys, enter a six-character password. If the password 000000 is set, then this clears the password and disables menu locking.
- Press the **ENTER** key.
- If a non-zero password was entered, the display now shows a message indicating that the front panel is now locked and returns to the base menu state. Otherwise, a message is displayed indicating that the menu lock is now disabled and the 95x stays in the main configuration menu.

Relocking Menus

If the menu lock password has been set but the menus are presently unlocked (i.e., they have been previously unlocked as described above) then the user may relock the menus as follows –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu. An example of which is as follows –

```
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD:000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the RELOCK line.
- Press the **ENTER** key.
- The display now shows a message indicating that the front panel is now locked and returns to the base menu state.

Unknown Menu Lock Password

If the 95x menus have been locked but the password is unknown, the user should contact Vitrek for assistance. The 95x has an internal set of “one time use” passwords for this circumstance.

Displaying Build Information

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –


```
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD:000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the BUILD line.
- Press the **ENTER** key.
- The 95x now displays the build configuration menu, an example of which is –


```
SERIAL#      123456
FIRMWARE:   v1.12
  FP:       v1.10
  MEAS:     v1.10
  DRIVE:    v1.10
BASE UNIT:   951i
DC OPTION:   NONE
AC2 OPTION:  NO
AC30 OPTION: NO
500VA OPTION: NO
PMT1 OPTION: YES
HSS OPTION:  NO
MAX DC:     6.5KV
MAX AC:     6.0KV
INTERFACE:  GUL-3
UPGRADE:000000000000
```
- The user may navigate this menu but may not make changes to it. The information available is as follows-
 - **SERIAL#.** This shows the serial number of this 95x.
 - **FIRMWARE.** This shows the main firmware revision number installed in this 95x. This can be upgraded (along with the MEAS and DRIVE firmware) by the user via the RS232, Ethernet or GPIB interface. Contact Vitrek or your local representative for details regarding this.
 - **FP.** This shows the front panel firmware revision number.
 - **MEAS.** This shows the Measurement DSP firmware revision number installed in this 95x.
 - **DRIVE.** This shows the Output Drive DSP firmware revision number installed in this 95x.
 - **BASE UNIT.** This shows the base model number of this 95x.

- **DC OPTION.** This shows if option NODC or DCNEG is installed in this 95x.
- **AC2 OPTION.** This shows if option AC-2 is installed in this 95x.
- **AC30 OPTION.** This shows if option AC-30 is installed in this 95x.
- **500VA OPTION.** This shows if option 500VA is installed in this 95x.
- **PMT1 OPTION.** This shows if option PMT-1 is installed in this 95x.
- **HSS OPTION.** This shows if option HSS or HSS-2 is installed in this 95x.
- **INTERFACE.** This shows if option UL-2 or GUL-3 is installed in this 95x.
- **MAX DC.** This shows the factory limit on the maximum DC Voltage generated by this unit.
- **MAX AC.** This shows the factory limit on the maximum AC Voltage generated by this unit.
- **MAX GB.** This shows the factory limit on the maximum Ground Bond current generated by this unit.
- **UPGRADE.** This allows the user to enter a factory supplied code to upgrade their instrument to enable additional options which were not enabled as originally purchased.
- When finished reviewing the build information, press the **EXIT** key to return to the main configuration menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu.

System Configuration Settings

There are several system configuration settings available which affect the overall operation. These can be viewed or set as follows –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –
 TEST...
 PRINTOUT...
 SYSTEM...
 INTERFACES...
 DIGITAL I/O...
 BUILD...
 SET TO DEFAULTS...
 LOCK PASSWORD: 000000
 RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the SYSTEM line.
- Press the **ENTER** key.
- The 95x now displays the system configuration settings menu, an example of which is –
 KEY BEEPS: SOFT
 TIME FORMAT: 12hr
 SET TIME: 9:18:06am
 SET DATE: 9-Feb-10
- The user may navigate this sub-menu and change the displayed settings as required.

- **KEY BEEPS.** This allows the user to set the volume of the beep sounds made by the 95x whenever a key is pressed.
- **TIME FORMAT.** This allows the user to select whether the 95x displays time in 12hour or 24hour format.
- **SET TIME.** This allows the user to adjust the presently displayed time. The hour, minute and second are separately adjusted using the Up and Down Arrow keys.
- **SET DATE.** This allows the user to adjust the presently displayed date. The day, month and year are separately adjusted using the Up and Down Arrow keys.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

Returning All Configuration Settings to Factory Defaults

The user may return all configuration settings to the factory default settings as follows –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD: 000000
RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the SET TO DEFAULTS line.
- Press the **ENTER** key.
- The 95x now displays a message temporarily and remains in the main configuration menu, allowing the user to override the factory settings as needed. If no further changes are needed, press the **EXIT** key to save the changes and return to the base menu state.

SECTION 5 – TEST SEQUENCES

All usage of the 95x for testing a DUT (Device under Test) uses test sequences. Although this section is primarily written for the front panel user, when programming the 95x via an interface the user should be conversant with the contents of this section.

A test sequence is a series of test steps which form a series of tests to perform on a DUT. Each step in a sequence can be configured to be one of several types of activity, including types for timing, waiting for user interaction, and controlling external switch units as well as types for performing a test on the DUT.

There are two types of test sequences which may be defined at the front panel –

- **MANUAL** test sequence (sequence #0).
 - This always contains a single test step which may only be a step type which performs a test on the DUT.
 - During testing the user is allowed to change the applied voltage, current and/or frequency as applicable for the specific step type being performed.
 - This test sequence cannot be deleted, it can only be overwritten.
- **Standard** test sequences (sequence #1 through 99 inclusive).
 - These may optionally have a name associated with each test sequence, and each may contain up to 254 steps.
 - All step types are available for use in this type of test sequence.
 - While testing using these the user may not alter the voltages, currents or frequencies being applied by the 95x.
 - Certain step types are able to be “chained”, the DUT does not need to be discharged between steps. This allows faster and smoother operation when testing certain types of DUT.

Test sequences defined at the front panel are automatically stored in internal non-volatile memory of the 95x. The user does not need to take any action to ensure that a front panel defined test sequence is saved. Note that the 95x is limited to having 1000 non-volatile test steps stored in total.

The user can also define a test sequence via an interface (see a later chapter for details regarding this). The interface defined test sequence differs from a front panel defined standard test sequence as follows –

- It is volatile, i.e., it exists until cleared, another sequence is defined or selected, or power is cycled on the 95x.
- It is numbered 100 and displayed as either **IN** or **I**
- It has no name associated with it.
- It cannot be edited or selected from the front panel, although it can be started, stopped and its results can be reviewed and/or printed at the front panel in the normal manner.
- It can have up to 999 steps. If the number of defined steps is within the maximum for a non-volatile store (1 for sequence #0, otherwise 254) then interface commands are provided to save it into a non-volatile sequence.

Test Sequence Configuration

There are settings in the 95x which apply to all test steps in all test sequences. To view or change these settings perform the following actions –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –


```
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD: 000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the TEST line.
- Press the **ENTER** key.
- The display now shows the test configuration menu. An example of the test configuration menu is as follows –


```
START BEEP:      MED
PASS BEEP:      MED
FAIL BEEPS:     LOUD
ARC:  FAIL ON DETECT
CONTINUITY SENSE: OFF
FAST RERUN:     ENABLED
USER MAX DCV:  10.0KV
USER MAX ACV:  10.0KV
HI SAFETY:      ENABLED
MIN LOAD:       ENABLED
MAX DISCHARGE: 200mA
```
- The user may navigate this sub-menu and change the displayed settings as required.
 - **START BEEP.** This allows the user to set the volume of the beep sound emitted by the 95x when a test sequence is started.
 - **PASS BEEP.** This allows the user to set the volume of the beep sound emitted by the 95x when a test sequence is completed with a PASS status.
 - **FAIL BEEP.** This allows the user to set the volume of the beep sounds emitted by the 95x when a test sequence is completed with a FAIL status.
 - **ARC.** This allows the user to select whether all test steps configured for arc detection will fail the test if an arc is detected (FAIL ON DETECT) or not (DETECT ONLY). Note that arc detection is enabled or disabled by a separate user setting in each individual test step.
 - **CONTINUITY SENSE.** This allows the user to turn on/off the Continuity Sense feature in certain types of test steps (see the specific test step type sections of this manual for details).
 - **FAST RERUN.** This allows the 95x to always allow the user to rerun a test sequence without having to terminate reviewing the results (ENABLED), or only allow it if all tests passed (IF PASS),

- or never allow it (DISABLED). If fast rerun is not enabled, the user must terminate reviewing results by using the **STOP** button before they can rerun the test sequence with the **START** button.
- **USER MAX DCV.** This allows the user to set a maximum DC Voltage which the 95x will produce. This limits all test steps subsequently defined and will not allow any existing test sequence containing a test step level outside of this limit to run. Note, the factory default setting for this is 10KV, some models and options may allow a higher setting than this.
 - **USER MAX ACV.** This allows the user to set a maximum AC Voltage which the 95x will produce. This limits all test steps subsequently defined and will not allow any existing test sequence containing a test step level outside of this limit to run. Note, the factory default setting for this is 10KV, some models and options may allow a higher setting than this.
 - **HI SAFETY.** This turns on/off the ability of the 95x to detect excessive **HV** terminal current in high voltage test step types (see the specific test type sections of this manual for details).
 - **MIN LOAD.** This turns on/off the ability to detect that there is a minimum load attached during DCW or DCIR type test steps (see the specific test type sections of this manual for details). If enabled in this menu, then each DCW and DCIR test step may be individually configured for minimum loading detection as needed.
 - **MAX DISCHARGE.** This sets the maximum current which will be used by the 95x when discharging a load at the end of a DCez, DCW or DCIR type test step. A value between 1 and 200mA may be configured.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

Creating a New Test Sequence

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **NEW** key.
- The display now shows the lowest presently empty test sequence number and a blank name field. An example is -

```
NEW TEST SEQUENCE
# 2
```
- Either change the test sequence number (using the numeric keys or the Up Arrow and Down Arrow keys) or press the **ENTER** key. The display now selects the name field. The user can enter a name by pressing the Up Arrow key followed using the Up, Down, Left and Right Arrow keys to change/select each character, and the user may use the numeric keys to directly enter numeric characters.
- Press the **ENTER** key. The display now shows the first test step (step #1) with no test type selected (NEW is displayed). An example is -

```
Seq 2 Step 1      NEW
```
- Using the Up or Down Arrow keys, select the desired first test step type.
- Using the information for the selected test step type shown later in this document, program the requirements for this test step.
- If no more test steps are required, press the **EXIT** key. The 95x stores the test sequence and makes it ready to be run.

- If further steps are required, then press the Up-arrow key once when the previously entered step # is selected, the next step # will be displayed with a NEW test type. Repeat as required for each test step. Note - if the user accidentally creates a NEW step after the end of the test sequence, press the **DEL** key to delete it while it is being displayed.

Editing an Existing Test Sequence

Note – editing a test sequence, even if no changes are made to the test sequence, will cause any Lead Compensation data for that sequence to be cleared. A “c” character is displayed after the test sequence# if the test sequence contains previously obtained Lead Compensation data.

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state. A test sequence may also be edited while the user is reviewing the results of a previously run test sequence.
- Press the **EDIT** key.
- The display now shows the last used test sequence number and the name associated with that test sequence. An example is -

```
EDIT TEST SEQUENCE
# 2 95x LINE HYPOT
```
- If needed, change the test sequence number to select the desired test sequence by using the Up Arrow or Down Arrow keys (or using the numeric keys), and then press the **ENTER** key. The display now selects the name field. The user can enter a name or alter the existing name by pressing the Up Arrow key followed using the Up, Down, Left and Right keys to change/select each character, and the user may use the numeric keys to directly enter numeric characters.
- Press the **ENTER** key. The display now shows the first test step (step #1) of the existing test sequence. An example is -

```
Seq 2 Step 1      ACW
LEVEL:1500.0V 60.0HZ
```
- To select a different test step # in the existing test sequence, as needed navigate the menu using the Left and Right Arrow keys to select the test step #, then press the Up or Down Arrow key until the desired test step # is shown.
- The user may edit the selected test step by navigating the menu and altering settings as needed. See [SECTION 6 – TEST STEPS](#).
- The user may add a test step to the end of the test sequence by pressing the Up Arrow key while the test step # is selected until a NEW test step type is shown. Note - if the user accidentally creates a NEW test step after the end of the sequence, press the **DEL** key to delete it while it is being displayed.
- The user may delete an existing test step by pressing the **DEL** key while the undesired test step is selected. All higher numbered test steps are automatically renumbered. The user cannot delete the only test step in a test sequence.
- The user may insert a new test step by pressing the **NEW** key. A new test step is inserted before the presently selected test step, and all higher numbered test steps are automatically renumbered. The user cannot insert an additional test step into a test sequence which already has all 254 test steps defined.
- When no more changes are required, press the **EXIT** key. The 95x stores the test sequence and makes it ready to be run.

Deleting an Existing Test Sequence

CAUTION – this operation cannot be undone, ensure that the correct test sequence # is selected before pressing the **ENTER** key.

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **DEL** key.
- The display shows the last used test sequence number and the name associated with that test sequence. An example is -
DELETE TEST SEQUENCE
2 95x LINE HYPOT
- As needed change the test sequence number to select the desired test sequence by using the Up Arrow or Down Arrow keys (or using the numeric keys), then press the **ENTER** key. The selected test sequence is now deleted from the 95x internal non-volatile memory.

Selecting and Running an Existing Test Sequence

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **SELECT** key.
- The display shows the last used test sequence number and the name associated with that test sequence. An example is -
SELECT TEST SEQUENCE
2 95x LINE HYPOT
- As needed change the test sequence number to select the desired test sequence by using the Up Arrow or Down Arrow keys (or using the numeric keys), then press the **ENTER** key. The selected test sequence is now made ready to be run.

NOTE - Whenever a test sequence has been selected and is ready to be run, the front panel **READY** indicator is illuminated. If the **READY** indicator is not illuminated then either no test sequence has been selected or it is not ready to run at that time (e.g., it is already running, or the user is viewing the results of a previous run and FAST RERUN has been disabled). Initiating any menu activity on the front panel always makes no test sequence ready to be run.

After an existing test sequence has been selected (either by using the **SELECT** or **EDIT** menus) the test may be run by –

- Press the **START** button. The **READY** indicator is extinguished, and the **TESTING** indicator is illuminated while the selected test sequence is run.
- While the test sequence is running the **PASS** and **FAIL** indicators show the present pass/fail status after the first test step is sufficiently completed, and throughout the test sequence the display shows the progress. An example is -
1.01d 1500V 60.0Hz
22s PASS 5.5nArms
 - The selected test sequence number and the present step # are shown in the upper left display. Following this, the **r** character is shown during the ramp period or **d** during the dwell period of

the test step being performed. During the discharge period an informative message is displayed in the lower line of the display.

- For most types of test step, the present output level and frequency are shown in the remainder of the upper display line. If the **MANUAL** test sequence is being run (the upper left shows **MAN**) then either the level or the frequency can be selected and edited using the arrow keys (start by pressing the Up Arrow key while selected) or may be directly overwritten (enter a new value using the numeric keys while it is selected).
- The time since the start of the present test step and test step period is shown in the lower left display. If this is flashing between the value and blocks then the unit is waiting for the user to press the **START** button to continue (e.g., if the dwell period has been programmed for user termination), otherwise the period will automatically end when it reaches the programmed time period.
- For most types of test step, the remainder of the lower display shows a measurement result. During the test dwell period the displayed measurements are automatically filtered with a rolling time constant. Initially the selected measurement is the first checked measurement but may be changed during the step by pressing the **UNIT** key which toggles between all measurement results available for that test type. See [Displayed Measurement Results](#). If certain types of failure occur, then a temporary display is shown similar to those shown when reviewing results (see below).
- While the test sequence is running it may be aborted by pressing the **STOP** button.
- When the test sequence has been completed, the **TESTING** indicator extinguishes, the **PASS** or **FAIL** indicator is illuminated, and the overall pass or failure status is temporarily displayed for approx. 2 seconds and then the measured results are reviewed, see the following section for details regarding reviewing results. An example temporary display is -


```
SEQUENCE 1 PASSED
      ALL TESTS
```
- Use the **EXIT** key or **STOP** key to return to the date/time display or use the **START** button (if **FAST RERUN** is enabled) to start another run of the same test sequence. The **READY** indicator is illuminated when the test sequence is ready to be run again.

Displayed Measurement Results

While running a test sequence the 95x allows the user to view measurement results. Generally, several different measurement results are available; the user may change between available results by pressing the **UNIT** key.

So that the user can distinguish between results, the 95x displays each with different units characters following the result as follows –

- Applied test voltage (V)
- Applied test frequency (Hz)
- DC current (A)
- DC resistance (Ω)
- RMS current (Arms)
- RMS Voltage (Vrms)
- RMS impedance (Ω rms)
- In-Phase current (Ainp)
- In-Phase Voltage (Vinp)

- In-Phase Resistance (Ω_{inp})
- Quadrature current (A_{qua})
- Quadrature Voltage (V_{qua})
- Quadrature impedance (Ω_{qua})
- Capacitance (F)
- Dissipation Factor (DF)
- Peak or breakdown current (A_{pk})
- Arc current (A_{arc})

- Many results are capable of having a negative polarity; a negative result is preceded by the – character. A positive result has no preceding polarity character.
- The 95x automatically formats the displayed result to give the best meaningful resolution using a multiplier character as needed (e.g., G, M, K, m, u, n, or p). Displayed results may have slightly limited resolution; full resolution is available via an interface.
- Impedance and resistance results are calculated from voltage and current measurements. For near zero and negative current measurements, the 95x displays the maximum meaningful resistance value preceded by the > character.

Reviewing Test Results after Running a Test Sequence

Immediately after running a test sequence and temporarily displaying an overall pass/fail status message the 95x automatically initiates reviewing the detailed test results. The results of a previously run test sequence can also be manually reviewed later by pressing the **VIEW** key if the **READY** indicator is illuminated, indicating that the test sequence is still ready to be run.

If the test sequence failed, then the review is initiated at the first failed step, otherwise it is initiated at the first test step in the test sequence.

The following table shows example displays of reviewed results and their meanings. See the descriptions following the table for a description of each of the fields in the display.

01.01d 1500V 60.0Hz 5.0s PASS 2.10mArms	The measurement being reviewed was within limits.
01.01d 1500V 60.0Hz 5.0s DET 28mAarc	Arcing was detected during the test but the 95x was not configured to fail on arc detection.
01.01d 1500V 60.0Hz 5.0s FAIL 28mAarc	Arcing was detected during the test which caused the step to fail.
01.01d 1500V 60.0Hz 1.5s >MAX 2.10mArms	The measurement being reviewed was above the maximum limit which caused the step to fail.
01.01d 1500V 60.0Hz 1.5s <MIN 12.3uArms	The measurement being reviewed was below the minimum limit which caused the step to fail.
01.01d 1500V 1.5s UNST 12.3uA	The measurement being reviewed was within limits but was unsteady with increasing leakage current (decreasing resistance) which caused the step to fail.
01.01d 1500V 60.0Hz HV TRIP EXCEEDED	The HV Trip safety feature was tripped which caused the step to fail. This is typically caused by a DUT or cable breakdown to ground.

01.01d 1500V 60.0HZ 1.5s BRKDN >50mApk	The peak voltage source current limit was exceeded which caused the step to fail. This is typically caused by a fast and severe DUT breakdown (e.g., a flashover).
01.01d 1500V 60.0HZ 1.5s BRKDN 11.3mApk	The user set breakdown current limit was exceeded which caused the step to fail.
01.01d 1500V 60.0HZ 1.5s OVER 11.3mA	The DUT current exceeded the 95x maximum ability for >10ms, this is typically a DUT breakdown whose peak was limited to below the configured breakdown limit but may also indicate that the configured ramp rate for a DC type step was too fast for the load capacitance (so the charging current was beyond the unit's ability).
01.01d 0.000A 60HZ WIRING FAULT	A wiring fault was detected during a GB, GBez or Low Ω type step which caused the step to fail.
01.01d 1500V 60.0HZ 1.5s ABORTED	The user aborted the test sequence.
01.01d 1500V 60.0HZ 1.5s CONTINUITY	The Continuity Sense safety feature was tripped which caused the step to fail.
01.01d 1500V 60.0HZ INTERLOCK OPENED	The INTERLOCK DIO interface signal became unasserted which caused the step to fail.
01.01r 1500V 60.0HZ UNSTABLE LOAD	The DUT load was too unstable preventing the 95x from providing a stable test voltage or current, or the line voltage was too low to achieve the programmed test voltage and load current.
01.01r 1500V <MIN LOAD	Minimum load detection is enabled and the configured minimum load for this test step was not achieved during ramp in a DCW or DCIR type step which caused the step to fail.
01.01d SWITCH SWITCH FAILED	The 95x could not communicate with an external switch matrix unit during execution of a SWITCH type step.
01.01d HOLD TIMEOUT	The user failed to continue the sequence within the programmed timeout period while executing a HOLD type step.
01.01d 1500V 60.0HZ INT FAULT	An internal fault was detected which caused the step to fail. The 95x may need to be power cycled to recover from this. This is often caused by extreme interference but may be caused by an unrecoverable failure in an internal circuit of the 95x.
01.01d 1500V 60.0HZ OVERHEATED	The 95x overheated which caused the step to fail. This can occur because the load current was too high for too long, or the airflow around the 95x was restricted, or the ambient temperature is too high around the 95x. The user should wait at least 15 seconds to allow it to cool down properly before either re-attempting the test or removing power from the 95x.

- The test sequence # and presently shown step # are shown in the upper left corner of the display. Following the step #, for test step types which have a ramp and a dwell period, a single character is shown which is either **r** indicating that the failure occurred during the ramp period of the step, or **d** indicating that either the failure occurred in the dwell period, or the test completed normally. The user can change the step number being reviewed by selecting the step # in the display using the Left Arrow or Right Arrow keys as needed, then using the Up Arrow or Down Arrow keys to step forwards or backwards through the

test steps in the test sequence. Note that test steps which do not have any measurements, i.e., switch unit control steps or timing test steps, are not reviewable and are skipped unless they contain a failure. Only test steps which have been performed can be reviewed, as an example if a 10-step test sequence was aborted during the 2nd test step, then only the 1st and 2nd test steps are reviewable as no others were performed.

- The remainder of the upper portion of the display shows the instantaneous applied voltage (or current) and frequency (if applicable) at the moment of the failure (if FAIL) or at the end of the dwell period (if PASS).
- The elapsed time in the period at the completion of the test step is shown in the lower left corner of the display.
- The displayed measurement result can be changed by pressing the **UNIT** key. This sequentially selects amongst the available results for the selected test step. When reviewing results, only those which have limits defined are available for review. See Displayed Measurement Results for more details on available results.
- The selected measurement result and the pass or fail result for that measurement is shown in the remainder of the lower portion of the display. If the step contained a failure, other than a simple checked measurement limit failure, then a failure message is displayed instead.
- By default, the final measurement result is shown in the lower portion of the display. This can be changed to the minimum (MIN), maximum (MAX) or average (AVG) value by selecting the elapsed time in the display using the Left Arrow or Right Arrow keys as needed, then using the Up Arrow or Down Arrow keys to change the selection.

Printing a Test Results Report

If the 95x has the USB interface option and a suitable printer is connected to the USB port, the user can configure the 95x to automatically print a test results report when a test sequence is completed, and/or the user can manually command the 95x to create a test results report. See [Printing from the 95x using the USB Interface](#) for details regarding connecting and configuring a printer and the display messages while performing a printout.

Configuring the Test Results Report

Before a test report can be printed, its format should be configured by the user. This is achieved by using the PRINTOUT sub-menu of the CNFG menu as follows –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –


```
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD:000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the PRINTOUT line.

- Press the **ENTER** key.
- The display now shows the test report printout configuration menu. An example of the test report printout configuration menu is as follows –
STATUS: ATTACHED
HEADING:
AUTO TEST REPORT: NO
TEST DETAIL: NORMAL
SERIAL #: NO
- The user may navigate this sub-menu and change the displayed settings as required.
 - **STATUS.** This shows the present status of the printer interface. The information shown is not editable and will automatically update should a change occur.
 - **NOT FITTED.** Indicates that the USB interface is not fitted, so there is no printout capability.
 - **DISABLED.** Indicates that the user has disabled the ability to perform printouts by setting the DISABLE USB setting in the CNFG – INTERFACES menu to YES.
 - **NOT FOUND.** Indicates that no valid printer has been detected as being connected to the 95x USB port.
 - **ATTACHED.** Indicates that a valid printer is attached to the 95x USB port and can be used for printouts.
 - **HEADING.** This allows the user to enter a global 2nd heading for all printouts. This can be up to 12 characters long and can be any alpha-numeric characters. If this is blank, then the 2nd heading is omitted from all printouts. Typically, this is used to allow the user to print their company name or department name on all printouts.
 - **AUTO TEST REPORT.** This allows the user to set whether the 95x will automatically print a test report when a test sequence terminates (YES) or not (NO). The user can also command a printout by pressing the **PRINT** button while reviewing test results independently of this setting.
 - **TEST DETAIL.** This sets the amount of detail to be included in the printed test report.
 - **BRIEF.** The pass/fail status, reason for failure (if any), and the level and frequency are printed for each test step having a result.
 - **NORMAL.** The pass/fail status, reason for failure (if any), the level and frequency, the test limits and the maximum, minimum, average, and last measurements are printed for each test step having a result.
 - **FULL.** The pass/fail status, reason for failure (if any), the level and frequency, the full test step settings and the maximum, minimum, average, and last measurements are printed for every test step.
 - **SERIAL #.** If set to YES, the 95x will prompt the user to enter a serial # when a test report is to be printed (either manually or automatically). The serial number can be any alpha-numeric characters; up to 12 characters can be included. This is included in the test report. If NO is selected, then the user will not be prompted for the serial # and it will not be included in the printed test report.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

Manually Commanding a Test Results Report

When reviewing the results of a completed test sequence, the user can manually command a test results report by pressing the **PRINT** key.

Compensating for External Lead Leakage and Impedance

Most test sequences can be run in a special mode which saves the measurement results for each test step and will apply these saved measurements as offsets when the test sequence is subsequently run in a normal fashion in order to provide lead error compensation. The details regarding the corrections available and the expected wiring for each test step within the sequence are contained in the respective sections of this manual for each type of test step.

NOTE – certain test step types are not suitable for lead compensation, see the respective sections of this manual for each type of test step for details.

To perform a lead compensation on a test sequence, perform the following –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **SELECT** key.
- The display shows the last used test sequence number and the name associated with that test sequence. An example is -

```
SELECT TEST SEQUENCE
# 2 95x LINE HYPOT
```
- As needed change the test sequence number to select the desired test sequence by using the Up Arrow or Down Arrow keys (or using the numeric keys), and then press the **ENTER** key. The selected test sequence is now made ready to be run.
- Press the **LEADS** key. The display now shows the test sequence is ready to be run in lead compensation mode, and the **READY** indicator flashes.
- Ensure that the wiring is suitable for lead compensation. See the respective sections of this manual for each type of test step in the selected test sequence for details.
- Press the **START** switch on the front panel. While the sequence is running the **TESTING** indicator flashes, and the selected test sequence is performed in the lead compensation mode.
 - Any pre-existing lead compensation data is discarded prior to the test sequence being run.
 - Each test step is performed in the normal manner, only the measurement results are used differently. See the respective sections of this manual for each type of test step in the test sequence for details.
 - Normal measurement limits are not enforced. Any programmed breakdown or arc detections are performed and if detected aborts the test sequence with a failure.
- After the test sequence has been run in this manner –
 - The display temporarily shows a message indicating that the lead compensation for this sequence is ready to be used.
 - The lead compensation measurements are saved internally in non-volatile memory and are automatically retrieved with the test sequence when the test sequence is later selected.

- The presence of lead compensation data in a test sequence is indicated on the display during test sequence selection by the presence of a **c** immediately after the test sequence number.
- Any saved lead compensation data for a test sequence is automatically discarded if the test sequence is selected for editing by using the **EDIT** key.

SECTION 6 – TEST STEPS

The previous section described how to use test sequences. This section describes how to choose and configure each step within a test sequence and the specifications and limitations for each step type.

The table below gives an overall summary of the various types of activities available for each step. After the table are individual sections giving full details for each of these activities. The user only needs to be conversant with the section for each specific activity which the user intends to perform. The levels shown for each model are those for the standard build, option content may change the available levels and/or frequencies.

Activity Required	Test Step Types	951i	952i	953i	954i	955i	956i	957i	959i
AC Voltage Withstand and Leakage Testing	ACez, ACW and ACCAP	20V-6kV, 20-500Hz	20V-6kV, 20-500Hz	20V-6kV, 20-500Hz	20V-6kV, 20-500Hz	50V-10kV, 40-500Hz	No	20V-6kV, 20-500Hz	No
DC Voltage Withstand and Leakage Testing	DCez, DCW and DCIR	30V-6.5kV	30V-6.5kV	50V-11kV	50V-11kV	50V-11kV	30V-6.5kV	75V-15kV	No
Pulsed Voltage Withstand Testing (Opt. PMT-1 only)	PULSE	50V-8kV	50V-8kV	50V-8kV	50V-8kV	100V-10kV	No	50V-8kV	No
DC Voltage Breakdown Device Testing	BRKDN	30V-6.5kV	30V-6.5kV	50V-11kV	50V-11kV	50V-11kV	30V-6.5kV	75V-15kV	No
DC Low Resistance Testing	LowΩ	1m Ω to 150K Ω	1m Ω to 150K Ω	1m Ω to 150K Ω	1m Ω to 150K Ω	1m Ω to 150K Ω	1m Ω to 150K Ω	1m Ω to 150K Ω	1m Ω to 150K Ω
AC Ground Bond Testing	GBez and GB	No	1u Ω -10 Ω @ 0.1-40A	No	1u Ω -10 Ω @ 0.1-40A	No	No	Opt. GB40 only	1u Ω -10 Ω @ 0.1-40A
Ground Leakage Testing	ACI and DCI	0.1nA-200mA	0.1nA-200mA	0.1nA-200mA	0.1nA-200mA	0.1nA-200mA	0.1nA-200mA	0.1nA-200mA	0.1nA-200mA
Switch Unit Control	SWITCH	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test Sequence Timing Control	PAUSE and HOLD	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

When the user is selecting testing against the requirements of a safety standard, the information given in this section should only be used as a guideline; the user should consult a safety testing professional for information regarding the specific standard and application. The voltage ranges shown above assume the most common option content for each model; see the specifications for each type of test step for the actual ranges.

CHOOSING WITHIN THE VOLTAGE WITHSTAND AND LEAKAGE TESTING GROUP

When Voltage Withstand and Leakage Testing is required, the user must first decide whether to perform this using an AC, DC or pulsed voltage, the frequency to use, the limits to use, and the actual test type(s) to perform.

The 95x makes no distinction between a DC insulation resistance test and any other type of Withstand and Leakage test; the user has the choice of performing a DC insulation resistance test at any test voltage within the capability of the 95x.

Many standards require the user to remove any over-voltage suppression devices which would affect Voltage Withstand testing. To check that such device(s) have been correctly re-installed after this test and to test that they are functioning correctly, see [DC Breakdown Voltage Device Testing \(BRKDN\)](#).

Choosing AC, DC, or PULSE Testing

When it is required to test a highly capacitive DUT (typically $>0.1\mu\text{F}$) the user must use DC testing, as the current flow would be too high if AC or pulse testing were attempted (see the applicable Specifications section for details).

Some standards require that testing be performed using an AC voltage waveform, others require a DC voltage, but others allow either to be used. Also, some DUTs may need to be tested using a DC voltage for other reasons (such as non-linearity). Generally, leakage testing is performed using a DC voltage; however, the 95x is also capable of accurately measuring resistive leakage using an AC voltage.

In some applications the DUT will not withstand the test voltage for an appreciable period of time because of the power dissipation caused by its leakage. In these applications the user should choose to perform pulse testing which can be performed in as little as a few milliseconds with the 95x. Note that this is different to “static discharge” pulse testing.

If AC testing is to be performed it is recommended that the frequency should be the expected line power frequency of the DUT (i.e., 50, 60 or 400Hz) unless this frequency cannot be used because of loading considerations. The frequency is generally not specified by standards.

To summarize, selecting the type of testing is dependent on the requirement; the following guidelines should be used in the order shown -

- If there is a specific requirement for the type of testing – follow the requirement.
- If the load is capacitive $>0.1\mu\text{F}$ – use DC Voltage Withstand Testing.
- If the load has power dissipation requirements which preclude DC or AC testing – use Pulse Voltage Withstand Testing.
- If the load is highly non-linear so cannot withstand AC voltages - use DC Voltage Withstand Testing.
- Otherwise – choose either AC or DC Voltage Withstand Testing.

Choosing the Limits

The 95x monitors three different types of DUT current - breakdown, leakage, and arc current. Detailed descriptions of these currents are given later in this section. Because the 95x monitors these currents in different ways and can enforce different limits on each in the same test, it can be set to differentiate between a DUT which exhibits any of the following –

- Meets all requirements
- Has excessive leakage, but withstands the applied voltage without breaking down
- Breaks down when the voltage is applied
- Exhibits arcing with any of the above

See the detailed description below for setting or disabling arc limits which are optionally enforced throughout the step. If only arc detection is required, the user must still set a breakdown limit.

The breakdown limit is always enforced throughout the step. Leakage limits are only enforced during the dwell period of the step. When performing DC Voltage Withstand Testing this allows the user to set different limits during the ramp (i.e., charging) and dwell periods of the step by using the breakdown and maximum leakage limits respectively.

A minimum leakage limit can be disabled by setting it to zero (or an unlimited resistance).

A summary of the guidelines for setting breakdown and leakage limits is –

- If Pulse Voltage Withstand Testing – set a breakdown limit (no leakage limits are available).
- If the user has both breakdown and maximum leakage limit requirements – set them both according to the requirements. ACez or DCez types cannot be used.
- If the user has no breakdown limit requirement, only a leakage limit – set the maximum leakage limit according to the requirement and set the breakdown limit significantly higher than this (but low enough to protect the DUT should it breakdown).
- If the user wishes to detect breakdown by using the averaged leakage measurement – set the maximum leakage limit according to the requirement (use the RMS equivalent for the AC types) and set the breakdown limit significantly higher than this (but low enough to protect the DUT, should it breakdown). ACez or DCez types cannot be used.
- Otherwise –
 - For the ACez or DCez types – set the maximum leakage current limit according to the breakdown limit requirement (use the RMS equivalent for the ACez type).
 - For all other types - set the breakdown limit according to the requirement and either disable the leakage limits entirely (only for the ACW type) or set the maximum leakage limit equal to or higher than the breakdown limit.

Breakdown Current

A breakdown of a DUT is a sudden, generally heavy, flow of current which does not cease without a reduction in the applied voltage. Many standards bodies (including UL) define breakdown as the sudden uncontrolled flow of current, this is effectively the same definition but is more ambiguous.

Often the user is testing products for compliance with safety standards which specify that the DUT “shall not breakdown” but does not specify a particular current level at which to detect breakdown. It is the industry norm to set a limit at some level above the normal leakage current level drawn by the DUT. Typically, this is a limit of 10mApk (or 7mArms), but this may need to be increased if the DUT has significant leakage or reduced if the DUT has little leakage.

There are four breakdown detectors in the 95x which are active throughout all types of Voltage Withstand tests; these are listed below in order of decreasing speed (the 3rd listed is set by the user breakdown limit, the others are fixed) -

- The 95x AC and DC voltage supplies have a protective trip mechanism which shuts down the voltage if a large peak current flows beyond its capability to supply surge current (for this limit see Surge Current Limiting and Shutdown in the relevant specifications section for the test type being run). Typically, this detected and shuts down the test within 30usec (this is indicated as BREAKDOWN).
- If a step is not set for DUT GROUNDED (option HSS only) and is set for a breakdown limit less than 7mApk, then the 95x continuously monitors the peak current in the **HV** terminal and shuts down the voltage if this

exceeds nominally 7.5mApk. Typically, this is detected within 30µsec and shuts down the test within 1msec (this is indicated as HV TRIP). This can be disabled in the CNFG-TEST menu.

- The 95x continuously monitors the instantaneous DUT current and shuts down the voltage if this exceeds the user set breakdown peak current limit for that step. Typically, this is detected within 30µsec and shuts down the test within 3msec (this is indicated as BREAKDOWN).
- The 95x monitors the RMS current for each cycle (for AC type steps) and the DC current for periods of nominally 5msec (for DC type steps). If this is above the loading capability of the 95x voltage source (for this limit see Loading Capability in the relevant specifications section for the test type being run) then this shuts down the voltage (this is indicated as OVERCURRENT).

Leakage Current

This is not applicable when pulse testing.

The leakage current of a DUT is a steady flow of current caused by leakage in the DUT, generally either intentionally by circuitry or unintentionally by inter-wiring leakage capacitance and resistances. Unlike breakdown current, leakage current is generally fairly linear vs. the applied voltage (i.e., doubling the voltage produces nominally twice the leakage current) but not necessarily so.

For DC there is only a single component of leakage current (the DC leakage current), whereas for AC there are two components –

- In-phase leakage is the component of the leakage current which is in phase with the applied voltage and is caused by the resistance of the DUT.
- Quadrature leakage is the component of the leakage current which is at 90° to the applied voltage and is caused by the reactance of the DUT (typically capacitance).

The total RMS AC current is the scalar formed by combining the in-phase and quadrature vector currents. In-phase and quadrature currents can be of either polarity, which is ignored when comparing against the user set limits.

The 95x measures the RMS AC current (in-phase, quadrature, and total RMS values) for every cycle of the applied voltage, or the mean DC current for every nominally 7.25ms (100ms for dwell times greater than 2 seconds). These values are compared against the user set maximum and minimum limits for leakage current. If enabled and the leakage current is outside the limits during the dwell period of the test, then the DUT fails. The 95x also offers a special variation of AC Voltage Withstand testing for testing the capacitance (and optionally Dissipation Factor) of a DUT – this uses the in-phase and quadrature measurements to internally compute the more advanced capacitance and DF results required for certain testing applications.

For the ACez and DCEz types the 95x uses the user configured maximum leakage limit as the breakdown limit. For all other types, the 95x allows the user to independently set both breakdown and leakage limits. In all cases, setting a minimum leakage limit of zero disables the minimum leakage limit.

Arc Current and Time

Arcing is similar to breakdown but rapidly “self-extinguishes” without requiring a reduction in the applied voltage (but typically rapidly re-occurs repeatedly). There are many ways in which arcing can occur and a thorough description of arcing is beyond the scope of this document. Generally, arc currents are AC currents in the frequency range of 1 to 2MHz and are fairly high amplitude (often tens of milliamps or more) and have no relationship to either breakdown or leakage currents. Generally arcing can only occur at higher voltages (>300V) and only in a gas or (in rare circumstances) across a surface.

Arcing should not be confused with flashover (which is a breakdown), arcing can be very slight and is often not easily visible, corona is a form of arcing, but the arcs do not extend entirely across the air gap and so is also called partial discharge or partial breakdown.

Some safety standards do not require detection of arcing; however, users often decide to include arc detection because the presence of arcing is often an indication that although the DUT passes breakdown detection at this time it may fail in the future. The 95x allows the user to select either-

- a) To not detect arc current.
- b) If arc current is detected, the DUT is not failed; only the presence of arcing is reported.
- c) If arc current is detected fail the DUT.

If enabled, the 95x continuously measures the AC (RMS) current with band-pass filtering of 50KHz to 5MHz over consecutive 4us periods and compares each measurement with the user set arc current limit. If the limit is exceeded for more than the user set number of consecutive 4us periods, arcing is detected.

If arc detection is required by the user, typically a limit setting of 10mA for 4us is used, a lower current limit increases the sensitivity, increasing the current and/or time decreases the sensitivity. Although a setting as low as 1mA may be made, this setting is particularly sensitive to pickup of RF interface (e.g., local radio stations) so is not recommended.

If arcing occurs and the DUT has significant capacitance, the DUT capacitance may provide most of the energy for the arcing and there may be little, if any, HF current flow from the DUT. In these cases, it may not be possible to detect arcing by current flow. This is generally not the case for DUT capacitances below a few nF, and generally is the case above a few 100nF, but this is very dependent on the DUT and wiring.

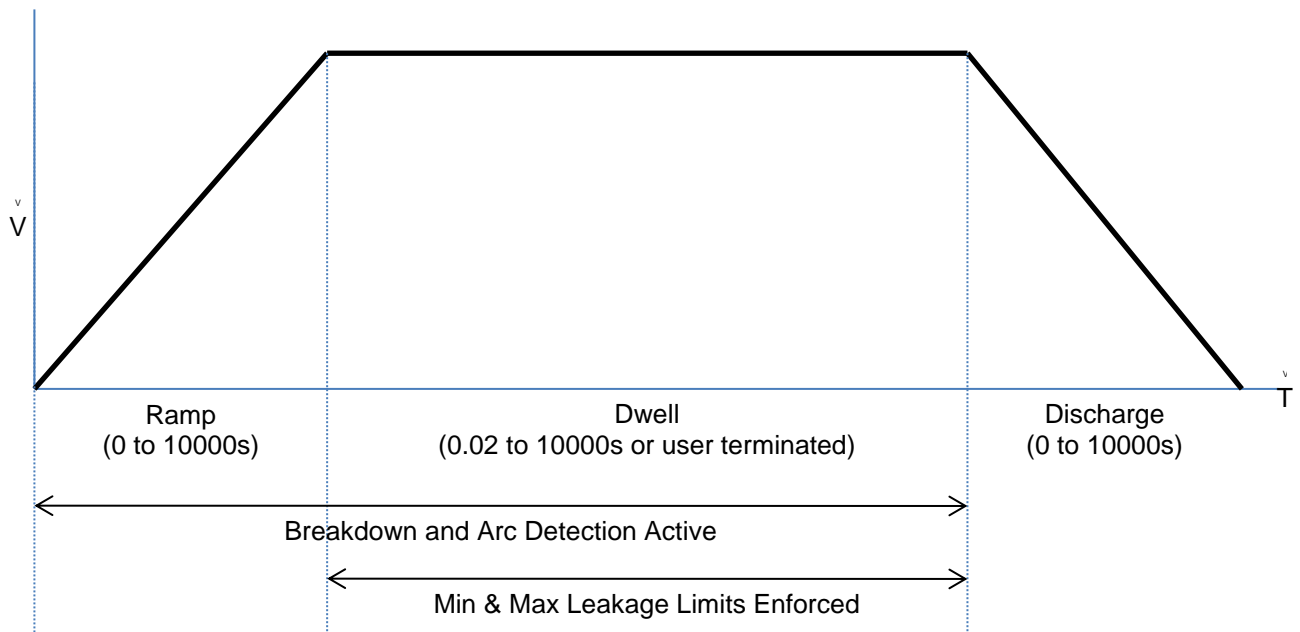
AC Voltage Withstand and Leakage Testing (ACez, ACW and ACCAP)

These are used to test that a DUT does not exhibit breakdown or (optionally) arcing in the presence of an applied AC voltage, and optionally to test that the DUT leakage current, impedance or capacitance is within user set limits.

All are performed in the same manner; the difference between them is in the amount and form of configuration available. The ACez type is intended for basic breakdown detection; the ACW type for comprehensive breakdown, arcing and leakage testing; the ACCAP type for breakdown and capacitance value testing. The ACW type can be configured to provide the same testing as the ACez type.

	ACez	ACW	ACCAP
Separate Breakdown and Leakage Current Limits	No	Yes	Yes
Immediate FAIL on Breakdown detection throughout step	Yes	Yes	Yes
Dual Leakage Current and/or Impedance Min/Max Limits	No	Optional	No
RMS Leakage Current and/or Impedance Min/Max Limits	Yes	Optional	No
In-Phase and/or Quadrature Leakage Current and/or Impedance Min/Max Limits	No	Optional	No
Capacitance and optional Dissipation Factor Min/Max Limits	No	No	Yes
Immediate FAIL on Min/Max Limit detection during dwell	Yes	Yes	Yes
Detect Arcing	No	Optional	Optional
Immediate FAIL on arc current detection throughout step	No	Optional	Optional
Timed Discharge	No	Optional	Optional
Smooth Transition to next test step if also AC withstand type	No	Optional	Optional

Actions While Running



- On any failure the step is immediately aborted, and optionally the entire test sequence may be aborted.
- For the ACez type, the discharge period is of zero length, arc detection is not enabled and only RMS leakage limits may be specified.
- If the step is the MANUAL sequence, then the user may manually change the voltage and/or frequency during the dwell period.
- For the ACW or ACCAP type, the discharge period can be programmed to be skipped and the next step started at this steps' dwell voltage level if the next step is an ACez, ACW or ACCAP type.

Configuring

An example ACez type menu is as follows –

```
Seq 1 Step 1    ACez
LEVEL:1500.0V 60.0HZ
SOURCE:        INT
RAMP:          1.00sec
DWELL:         30.0sec
Lim:          0n-35.00mA
ON FAIL:      ABORT SEQ
```

An example ACW type menu is as follows –

```
Seq 1 Step 1    ACW
LEVEL:1500.0V 60.0HZ
SOURCE:        INT
BREAKDOWN:    49.50mApk
RAMP:          1.00sec
DWELL:         30.0sec
Test 1:        RMS
Lim:          0n-35.00mA
Test 2:        INPHS
Lim:          0n-5.000mA
ARC DETECT: 4us 10mA
```

DISCHARGE: AS RAMP
ON FAIL: ABORT SEQ

An example ACCAP menu is as follows –

```
Seq 1 Step 1 ACCAP
LEVEL:1500.0V 60.0Hz
BREAKDOWN: 49.50mApk
RAMP:      1.00sec
DWELL:     30.0sec
C: 0.488p-1.512pF
DF: 0.0000-0.0005
ARC DETECT:4us 10mA
DISCHARGE: AS RAMP
ON FAIL: ABORT SEQ
```

- **LEVEL.** Allows the test voltage level and frequency to be programmed. Values cannot be set beyond the range of possible output voltages and frequencies from the specific 95x or above the maximum voltage limit set by the user in the CNFG – TEST – USER MAX ACV setting.
- **SOURCE.** Only available if Opt. AC-30 is installed. Allows the user to select whether to use the standard internal source at the front panel **HV** terminal (INT) or the higher voltage source from the external AC-30 (EXT). This selection is automatically made and is not editable if the programmed level or frequency is beyond the capability of the other source.
- **DUT GROUNDED.** Only available if option HSS is installed (and INT is selected in the SOURCE line above if option AC-30 is also installed). This selection allows the user to select either –
 - **NO.** This selection indicates that the DUT is isolated from ground, the 95x will use the current in the **RETURN** terminal to measure leakage and detect breakdown. This is as if option **HSS** were not installed.
 - **YES.** This selection indicates that the DUT is grounded, and the breakdown and/or leakage currents are to be measured to ground. The 95x will use the current in the **HV** terminal to measure leakage and detect breakdown.
- **BREAKDOWN.** Not available for the ACez type. Allows breakdown detection to be programmed as a maximum instantaneous peak current level. Pressing the **LIMIT** key while this setting is selected causes it to be set to the maximum value. See [Breakdown Current](#) for further details regarding breakdown currents.
 - The minimum value which can be set is 1uA.
 - The maximum value which can be set is as specified in the Peak Shutdown Current portion of Surge Current Limiting and Shutdown.
- **RAMP.** Allows the ramp time period to be programmed either as a time or rate. The **UNIT** key toggles the selection between these two methods.
- **DWELL.** Allows the dwell time period to be programmed to the desired time, or it may be set to be user terminated by pressing the **LIMIT** key while this setting is selected.
- **Test 1 and Test 2.** Only available for the ACW type (the ACez type has a single leakage limit range, which is always enabled and is always the RMS leakage current, the ACCAP type has limits set in different units to ACez and ACW). These allow the user to define none, 1 or 2 leakage measurements to be checked against limits. For the test step to successfully pass when run, both the Test 1 and Test 2 measurements must pass their respective range checks or be disabled. The available selections for each are –

- **NONE.** Disables the leakage measurement.
- **RMS.** Selects that the leakage check is performed on the RMS current measurement.
- **INPHS.** Selects that the leakage check is performed on the in-phase (i.e., resistive loading) current measurement.
- **QUAD.** Selects that the leakage check is performed on the quadrature (i.e., reactive loading) current measurement.
- **Lim.** Not available for the ACCAP type (it has limits set in different units to ACez and ACW). Allows the user to define ranges within which each selected current measurement is considered a PASS during the dwell period. The range can be entered in units of current or impedance, the **UNIT** key toggles the selection. For the impedance selection the user may optionally disable the upper limit by pressing the **LIMIT** key while the upper limit is selected. For the current selection, the user may optionally disable the lower limit by entering a zero value for it.
 - Setting a 0 minimum current limit disables the minimum limit and only applies the maximum limit.
 - The maximum current limit (or the minimum impedance limit) is the maximum loading current which the specific 95x model and option content can continuously supply at the configured test voltage and frequency (see [Loading Capability](#)).
 - For the ACez type the breakdown detection limit is automatically set to 2 times the maximum RMS leakage current limit with a minimum of 1uApk.
- **C.** Only available for the ACCAP type. Allows the user to define the range within which the capacitance measurement is considered a PASS during the dwell period.
 - The highest maximum limit which can be entered is determined by the maximum loading current which the specific 95x model and option content can continuously supply at the configured test voltage and frequency (see [Loading Capability](#)).
- **DF.** Only available for the ACCAP type. Allows the user to define the range within which the dissipation factor measurement is considered a PASS during the dwell period. The limits are applied without regard to the polarity of the measured dissipation factor.
 - Setting a DF range of 0.0000->1.0000 will effectively ignore the dissipation factor measurement as all dissipation factors lay within this range by definition.
- **ARC DETECT.** Not available for the ACez type and not available if DUT GROUNDED is set to YES. Allows the user to program arc detection during this step. Both the time and current level can be independently programmed. See [Arc Current and Time](#) for details. Arc detection can also be disabled by setting the leftmost (time) setting to OFF. The 95x can be configured to not fail a test step when arcing is detected by setting the ARC setting in the CNFG – TEST sub-menu to DETECT ONLY.
- **DISCHARGE.** Not available for the ACez type. Allows the user to program whether the discharge period should use the same timing as the ramp period (AS RAMP), be as fast as possible (FAST) or skipped (NONE). If NONE is selected but the next step is not of an AC Voltage Withstand type, then the FAST selection is used when the sequence is run. In the majority of cases, FAST should be used.
- **ON FAIL.** Allows the user to program the 95x to abort the entire sequence (ABORT SEQ) or only this step (CONT SEQ) if this step fails any of its checks. A safety related failure or a user abort (**STOP** button) always aborts the entire sequence.

Connecting to the DUT

See [Terminals and Wiring](#) for general wiring and safety recommendations.

The 95x requires that the DUT (at least that portion which is being measured) is isolated from ground unless –

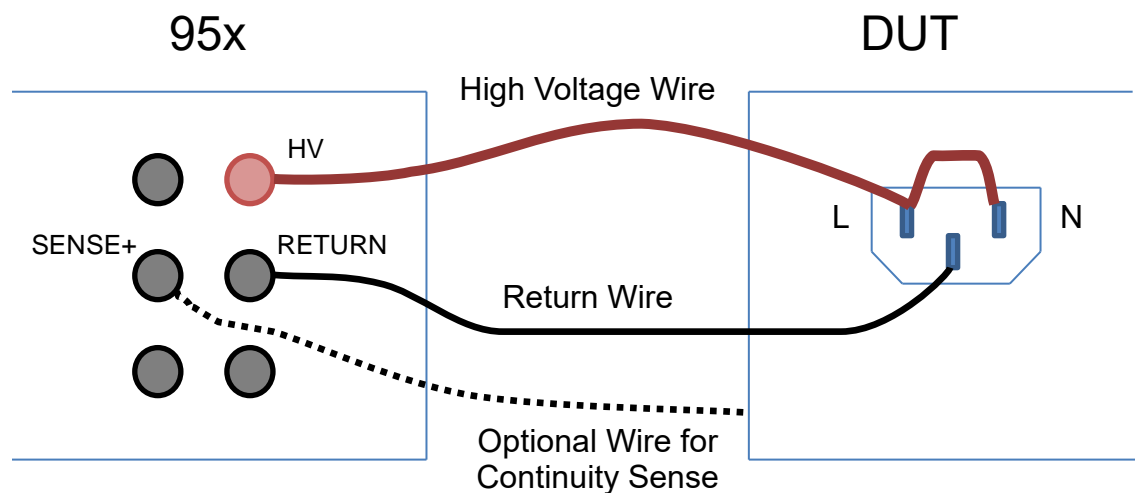
- Option HSS is fitted
- And, the SOURCE setting is set to INT (or AC-30 is not fitted)
- And, the DUT GROUNDED setting is set to YES.

Testing a DUT without option HSS or with DUT GROUNDED set to NO

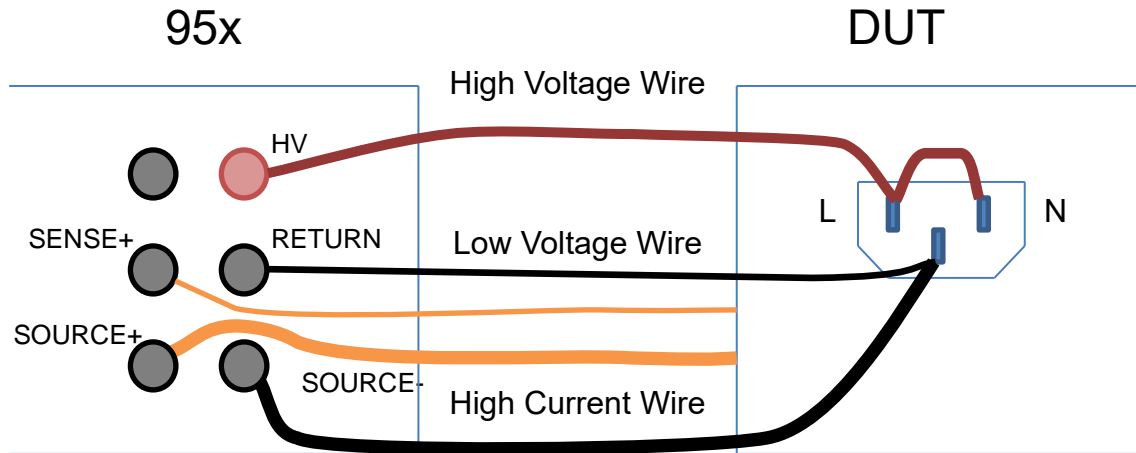
The DUT should be wired between the **HV** and **RETURN** terminals of the 95x; if Opt. AC-30 is being used (SOURCE setting is set to EXT) then the DUT should be wired between the output of the external AC-30 unit and the **RETURN** terminal of the 95x.

The 95x provides a safety ground for the DUT during the test via its **RETURN** terminal. The Continuity Sense feature may be used to ensure that the **RETURN** connection is correctly made by connecting the **SENSE+** terminal to a point on the DUT which is connected to the **RETURN** connection. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RETURN** terminal, the user should consider that only the voltage on the **RETURN** terminal is safe at all times.

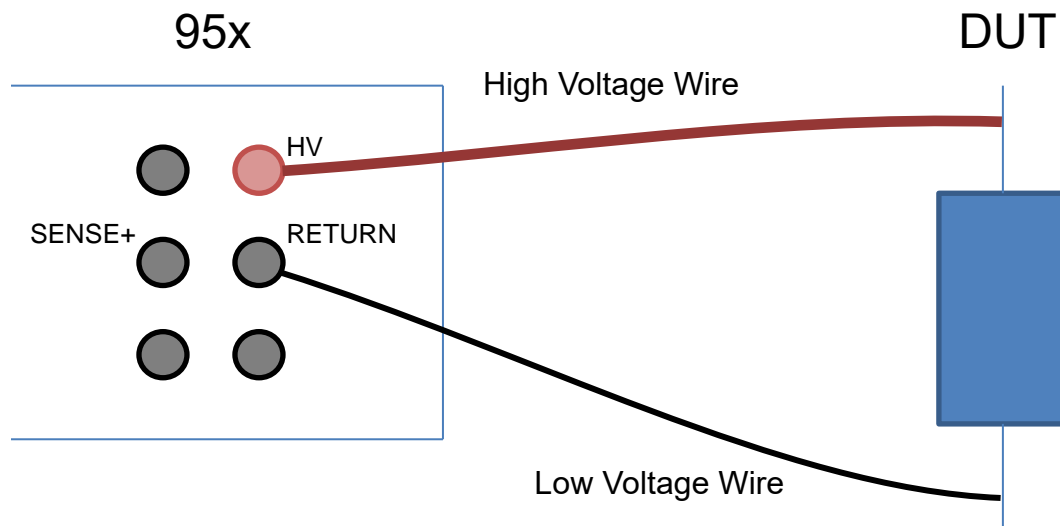
For best high impedance load performance there should be low capacitance and leakage between the wires and for low level current measurements there should be little interference pickup in the **RETURN** wire. In extreme circumstances the **RETURN** wire should be the inner wire of a coaxial cable, with the shield connected to the **GUARD** terminal of the 95x. This will significantly reduce the capacitance and leakage between the **HV** and **RETURN** wires. A cable such as RG174 is a suitable choice. If the Continuity Sense feature is being used, then the **SENSE+** connection should similarly be a coaxial cable.



The example above shows the connections for performing AC voltage withstand testing of Line/Neutral connections to the chassis of a DUT. The optional wire from the DUT chassis to the **SENSE+** terminal of the 95x is used when the user wishes to use the Continuity Sense safety feature.



The example above shows the connections to a DUT to perform both an AC withstand test on the Line/Neutral line power input, and an AC Ground Bond or DC Low Ω test on the chassis of the DUT in the same sequence. If wired in this manner, then no changes in connections are needed. This will increase the capacitive coupling between the **HV** wire and the other wires, which may need to be compensated for in highly sensitive applications. The Continuity Sense feature may also be used with this wiring configuration.



The example above shows the connections for performing an ACCAP type step to check a capacitor for value and breakdown.

Testing a Grounded DUT (option HSS only)

In this case the user only need connect the **HV** terminal of the 95x to the point on the DUT which is to be tested. It is expected that the DUT is grounded and that the breakdown and/or leakage is being tested to ground. For safety reasons or if unsure if the DUT is grounded, it may be desirable to also connect the DUT ground to either the **RETURN** or **GUARD** terminals of the 95x, however the user should ensure that the ground of the 95x and that of the DUT are within 5Vrms of each other otherwise excessive ground loop currents may flow, potentially damaging the 95x.

It should be noted that the 95x will measure the leakage current to ground from the **HV** terminal and the wiring in addition to the leakage current in the DUT itself. Particularly when performing AC Withstand testing, the wiring leakage current may be large because of capacitance between the wiring and nearby grounded objects or surfaces.

Checking that the DUT is Connected

When testing a DUT using AC Voltage Withstand testing there is the possibility that a disconnected DUT will erroneously pass a test. There is always some amount of capacitance within the load which will always cause an amount of current to flow when properly connected, so the user is recommended to set a minimum RMS or QUAD current setting in one of the two allowed test limit ranges for the ACW type of step. If not configured for a grounded load, the user may also use the Continuity Sense feature to detect a disconnected RETURN path.

Lead Compensation

For many applications lead compensation is not necessary for these types of test steps, as the wiring leakage is generally smaller than the DUT leakage limit and so can be ignored. However, for the more sensitive requirements (e.g., the more stringent levels of medical safety leakage testing) and/or when long lengths of wiring are required, particularly if DUT GROUNDED is set to YES, then lead compensation may be needed.

If the capacitance of loose wiring is to be corrected for and an isolated DUT is being tested, then it is recommended to use shielding of the **RETURN** wiring rather than Lead Compensation as the capacitance between loose unshielded wiring is very dependent on the exact routing of the wires.

Performing a lead compensation compensates for the resistive and capacitive leakage currents in the wiring to the 95x in all future runs of this test step. When performing a lead compensation, the normal connections to the 95x should be in place, with the wiring positioned normally, only the DUT itself should not be connected. **CAUTION** High voltages will be present on the wiring while running in lead compensation mode. Ensure that the wiring and the (unused) DUT connections are safely positioned.

When performing a lead compensation, the leakage limits are not enforced, otherwise the test step is executed normally.

Examples

Example 1 -

A DUT is to have its Line/Neutral power connections tested to its chassis for “no breakdown” at 2000Vrms/60Hz using a 1 second ramp and a 30 second dwell. It is known that the DUT leakage is less than 5mArms at this voltage level and frequency (if this is not known, then start by using 5mArms as the limit and adjust it as needed).

This is accomplished in a single step as follows –

Seq 1 Step 1	ACez	Only breakdown detection is needed, so use the ACez type
LEVEL:	2000.0V 60.0HZ	As required
RAMP:	1.00sec	As required
DWELL:	30.0sec	As required
Lim:	0n-5.000mA	As required
ON FAIL:	ABORT SEQ	

Example 2 -

It is required to test a 2-conductor cable which has a specification of >100Mohm resistive leakage and <100pF capacitance at 500Vrms, and a minimum breakdown voltage of 2000Vrms. A decision is made to test for breakdown using a 1 second ramp and a 1 second dwell time since the requirement does not specify it.

Optionally, the Lead Compensation feature could be used to adjust for the DUT wiring capacitance, allowing accurate measurement of the 100pF limit. Otherwise, the measurement will include the capacitance of the wiring between the 95x and the DUT.

All of these tests are accomplished by two ACW test steps in a test sequence –

Firstly, test the lower voltage resistance and capacitance leakage.

Seq 1 Step 1	ACW	Different breakdown and leakage limits needed, so use ACW
LEVEL:	500.0V 60.0HZ	As required
BREAKDOWN:	5.000mApk	Since the DUT is known to have little leakage this could be set lower
RAMP:	0.02sec	No timing requirement, so set for fast testing
DWELL:	0.10sec	No timing requirement, so set for fast testing
Test 1:	INPHS	Test the resistive leakage
Lim:	100.0M-no maxΩ	As required
Test 2:	QUAD	Test the capacitive leakage
Lim:	26.50M-no maxΩ	$26.5\text{Mohm} = 1/(2\pi\text{FC}) = \text{the impedance of } 100\text{pF at } 60\text{Hz}$
ARC DETECT:	4us 10mA	Optional
DISCHARGE:	NONE	No need to discharge between this and the next step
ON FAIL:	ABORT SEQ	No further test steps if this step fails

Secondly test the high voltage withstand capability.

Seq 1 Step 2	ACW	Could use ACEz if arc detection not needed
LEVEL:	2000.0V 60.0HZ	As required
BREAKDOWN:	5.000mApk	Since the DUT is known to have little leakage this could be set lower
RAMP:	1.00sec	As required
DWELL:	1.00sec	As required
Test 1:	NONE	No leakage testing required
Test 2:	NONE	No leakage testing required
ARC DETECT:	4us 10mA	Optional
DISCHARGE:	FAST	Immediately discharge as this is the last step
ON FAIL:	ABORT SEQ	

Example 3 -

A 0.033uF 1000Vac capacitor is to be tested against its tolerance ($0.033\text{uF} \pm 5\%$) and DF (<1%) specifications.

A nominal capacitor at 1000V/60Hz will draw 12.4mArms, so this is within the capabilities of all 95x models so the capacitor can be tested at its maximum voltage rating.

This is accomplished in a single step as follows –

Seq 1 Step 1	ACCAP	
LEVEL:	1000.0V 60.0HZ	As required
BREAKDOWN:	25.00mApk	As required
RAMP:	1.00sec	Slow ramp to better measure breakdown voltage
DWELL:	5.0sec	Optional, could be faster
C:	31.35n-34.65nF	As required
DF:	0.0000-0.0100	As required
ARC DETECT:	OFF	Optional
DISCHARGE:	FAST	
ON FAIL:	ABORT SEQ	

Specifications

Specifications are valid at the 95x terminals for 1 year at ambient temperatures within $\pm 5\text{C}$ of calibration temperature (add 5% of accuracy specification per C outside of this). All specifications are relative to the

calibration standards used. Add ½ digit to all accuracies for displayed results (results available with enhanced resolution from interfaces).

Loading Capability

The listings below show the maximum loading current and power capabilities of the 95x at ambient temperatures $\leq 30^{\circ}\text{C}$. For ambient temperatures above 30°C linearly reduce the maximum loading current and power by 1%/C.

For frequencies above 100Hz other than 400Hz, the user should linearly interpolate using the $<100\text{Hz}$ and 400Hz capabilities shown in the applicable listing.

Where both a current and power limit is shown, the most stringent limit applies.

951i-954i and 957i, $<100\text{Hz}$:	50mArms (40mArms resistive), reduce by 0.08mA per V above 5525Vrms
951i-954i and 957i, 400Hz :	35mArms, reduce by 0.065mA per V above 5600Vrms
Option AC-2, $<100\text{Hz}$:	200mArms (135mArms resistive), reduce by 0.67mA per V above 1750Vrms
Option AC-2, 400Hz :	140mArms, reduce by 0.4mA per V above 1700Vrms
Option 500VA, $<100\text{Hz}$:	100mArms (50mArms resistive), reduce by 0.14mA per V above 5425Vrms 500VA Above 65mArms has a limited test time (e.g., 1sec at 100mArms)
Option 500VA, 400Hz :	85mArms (50mArms resistive), reduce by 0.11mA per V above 5375Vrms Above 65mArms has a limited test time (e.g., 1sec at 100mArms)
955i and 957i Opt. AC-10, $<100\text{Hz}$:	30mArms (20mArms resistive)
955i and 957i Opt. AC-10, 400Hz :	22mArms
Option AC-30 :	10mArms (7mArms resistive) 250VA

Surge Current Limiting and Shutdown

Impedance Limiting	951-4i and 957i (standard build) : $12\text{K}\Omega + 0.5\text{H}$ Opt. 500VA : $7\text{K}\Omega + 0.25\text{H}$ Opt. AC2 : $1.4\text{K}\Omega + 0.2\text{H}$ 955i and 957i Opt. AC10 : $25\text{K}\Omega + 1.0\text{H}$ SOURCE set to EXT : $200\text{K}\Omega$
Peak Shutdown Current	951-4i and 957i (standard build) : 120mA Opt. 500VA : 145mA Opt. AC2 : 280mA 955i and 957i Opt. AC10 : 60mA SOURCE set to EXT : 21mA DUT GROUNDED set to YES : 50mA

Test Voltage and Frequency

Test Voltage Range	951-4i and 957i (standard build or Opt. 500VA) : 20 to 6000Vrms, reduce maximum voltage by 0.6V per Hz above 100Hz 955i and 957i Opt. AC-10 : 50 to 10000Vrms, reduce maximum voltage by 1V per Hz above 100Hz Opt. HSS or HSS-2 : 20 to 4000Vrms Opt. AC-2 : 10 to 2000Vrms, reduce maximum voltage by 0.2V per Hz above 100Hz
--------------------	--

	Opt. AC-30 : 120 to 30000Vrms For line voltages below 115V linearly reduce the maximum test voltage by 1%/V unless Opt. LOLINE is fitted (there is no reduction for Opt. LOLINE).
Test Voltage Accuracy	<(± 0.5% ± 1.5V ± (0.01% + 0.2V) per mArms load ± 0.01% per Hz above 100Hz) 955i and 957i Opt. AC10 : Add ±0.1% above 7000Vrms Opt. AC-30 : <(± 1.5% ± 5V ± (0.05% + 1V) per mArms load)
Test Voltage Overshoot	<5% (<0.5s ramp time) <2% (>0.5s ramp time) Settling to <±0.5% of final value in <0.1sec + 2 cycles
Test Voltage Waveform	Sinewave, 1.35 – 1.46 Crest Factor
Test Frequency Range	951-4i and 957i : 20 to 500Hz 955i and 957i Opt. AC10 : 40 to 500Hz Opt. AC-30 : 40 to 80Hz
Test Frequency Accuracy	<±0.1%

Current Measurements (DUT Isolated)

Measurements are performed in the **RETURN** terminal of the 95x.

Breakdown Current	1uA to 280mApk (DC-50kHz bandwidth) <(± 1% ± 1uA) accuracy <30usec detection time, <3msec response time (typically <500usec)
Leakage Current	0.0nA to 200mArms (RMS, In-phase or Quadrature) Greater of 1 cycle or 10ms measurement period RMS : <(± 0.5% ± 10nA ± 0.15nA per kV*Hz) accuracy InPhs : <(± 0.5% ± 10nA ± 0.01nA per kV*Hz) accuracy Quad : <(± 0.5% ± 10nA ± 0.15nA per kV*Hz) accuracy Add 0.005% per Hz above 100Hz 955i and 957i Opt. AC10 : Add 50nA (RMS, InPhs and Quad) above 7000Vrms <±0.005° per Hz phase relative to test voltage (InPhs, Quad)
Arc Current	1 to 30mArms (50KHz-5MHz bandwidth) <(± 10% ± 1mA) accuracy at 1MHz 4us, 10us, 15us, 20us, 30us or 40us measurement period
Cable Compensation	<(± 1% of error ± 0.01pF)

Current Measurements (DUT Grounded, option HSS only)

Measurements are performed in the **HV** terminal of the 95x.

Breakdown Current	1uA to 50mApk (DC-50kHz bandwidth) <(± 1.5% ± 1uA) accuracy <30usec detection time, <3msec response time (typically <500usec)
Leakage Current	0.0nA to 35mArms (RMS, In-phase, or Quadrature) Greater of 1 cycle or 10ms measurement period RMS or Quad : <(± 1.5% ± 100nA ± 10nA per kV*Hz) accuracy InPhs : <(± 1.5% ± 100nA ± 1nA per kV*Hz) accuracy

Add 0.005% per Hz above 100Hz
 $\leq \pm 0.005^\circ$ per Hz phase relative to test voltage (InPhs, Quad)

Cable Compensation $< (\pm 1\% \text{ of error} \pm 0.1\text{pF})$

Capacitance and Dissipation Factor Measurements (ACCAP type)

Capacitance Add Test Voltage, Frequency, and Quad Leakage Current Accuracies as percentages
 Examples at 1000V/60Hz with an isolated DUT -
 1pF (= 377nA) : $0.65\% + 0.1\% + 4.73\% = \pm 5.48\%$
 10pF (= 3.77uA) : $0.65\% + 0.1\% + 0.92\% = \pm 1.67\%$
 100pF (= 37.7uA) : $0.65\% + 0.1\% + 0.54\% = \pm 1.29\%$
 1nF (= 377uA) : $0.65\% + 0.1\% + 0.5\% = \pm 1.25\%$
 10nF (= 3.77mA) : $0.65\% + 0.1\% + 0.5\% = \pm 1.25\%$
 100nF (= 37.7mA) : $0.65\% + 0.1\% + 0.5\% = \pm 1.25\%$

Dissipation Factor For test voltages >100V at 60Hz and capacitive load currents >200uA, the DF accuracy is ± 0.005 . For accuracy under other circumstances please contact Vitrek.

Test Timing

Ramp 0.00 to 9999sec
 $< (\pm 1\% \pm 0.1\text{sec} \pm 1 \text{ cycle})$ accuracy

Dwell 0.02 to 9999sec or user terminated
 $< (\pm 0.05\% \pm 20\text{ms} \pm 1 \text{ cycle})$ accuracy

Fast Discharge $< (20\text{ms} + 1 \text{ cycle})$

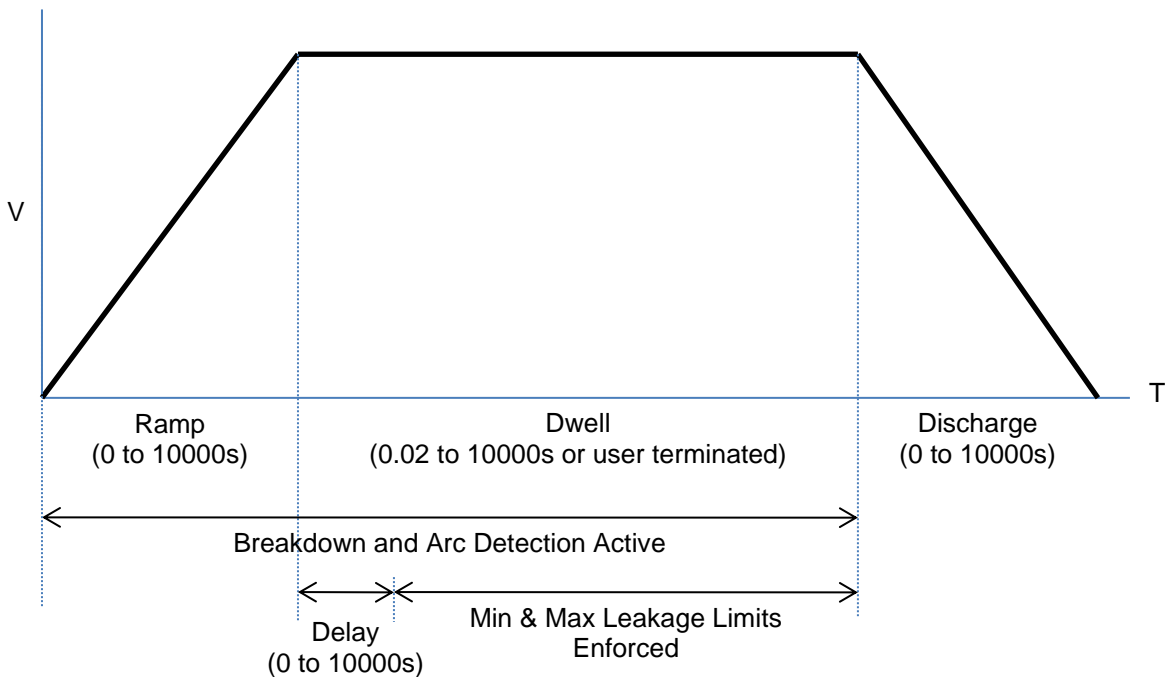
DC Voltage Withstand and Leakage Testing (DCez, DCW and DCIR)

These are used to test that a DUT does not exhibit breakdown or (optionally) arcing in the presence of an applied DC voltage and optionally to test that the DUT leakage current or impedance is within user set limits.

All of these are performed in the same manner; the difference between them is in the amount of configuration available. The DCez type is intended for basic breakdown detection, the DCW and DCIR types for comprehensive breakdown, arcing and leakage testing.

	DCez	DCW	DCIR
Use with High Capacitance Loads	Yes	Yes	Yes
Separate Breakdown and Leakage Limits	No	Yes	Yes
Detect Minimum Loading during ramp	No	Optional	Optional
Immediate FAIL on Breakdown detection throughout step	Yes	Yes	Yes
Delay after charging prior to applying leakage limits	No	Optional	Optional
Immediate FAIL on Leakage Failure	Yes	Yes	Optional
End Test on Passing Leakage current or impedance	No	No	Optional
End Test on Steady or improving Leakage current or impedance	No	No	Optional
Detect Arcing	No	Optional	Optional
Immediate FAIL on arc current detection throughout step	No	Optional	Optional
Timed Discharge	No	Optional	Optional
Smooth Transition to next test step if DC Withstand type	No	Optional	Optional

Actions While Running



- For the DCez and DCW types, on any failure the step is immediately aborted, and optionally the entire test sequence may be aborted.
- For the DCW and DCIR types, the loading current is analyzed during the last $\frac{3}{4}$ of the ramp phase and compared to the configured minimum load capacitance for the step (if enabled to do so).
- If the step is the MANUAL sequence, then the user may manually change the voltage during the dwell period if the load capacitance is low.
- For the DCIR type, on any failure other than leakage limit testing the step is immediately aborted. The operation of the leakage limit test is dependent on the “End On” setting.
- For the DCez type, the delay is of zero length, the discharge period is of zero length and arc detection is not enabled.
- For the DCW and DCIR types, the discharge period can be programmed to be skipped and the next step started at this steps’ dwell voltage level if the next step is of the DCez, DCW or DCIR type.
- During the discharge period the voltage is reduced to zero in the programmed time or at the programmed rate. If the actual voltage significantly lags the expected voltage during the discharge, then discharge circuitry is automatically engaged to speed up the discharge. The test step will not fully complete until the actual voltage is reduced to a safe level. The discharge circuitry is a combination of fixed and controlled loading. Refer to Discharge in the Specifications section for details. The controlled loading has energy limitations which may prevent it engaging until the voltage has been reduced by the fixed loading, and the user may restrict this further by setting a lower maximum discharge current setting in the CNFG – TEST menu. The **HIGH VOLTAGE OR HIGH CURRENT PRESENT** warning symbol on the front panel of the 95x is illuminated whenever an unsafe voltage is present on the **HV** terminal. If this is the last step in a sequence, then the discharge circuitry remains engaged after the test step has fully terminated. It is not disengaged until the user finishes reviewing the results of this sequence.

Configuring

An example DCez menu is as follows –

```
Seq 1 Step 1    DCez
LEVEL:         1500.0V
RAMP:          1.00sec
DWELL:         30.0sec
Lim:           0n-15.00mA
ON FAIL:       ABORT SEQ
```

An example DCW menu is as follows –

```
Seq 1 Step 1    DCW
LEVEL:         1500.0V
BREAKDOWN:     30.00mApk
RAMP:          1.00sec
DWELL:         30.0sec
Delay:         0.25sec
Lim:           0n-15.00mA
ARC DETECT:    4us 10mA
DISCHARGE:     AS RAMP
ON FAIL:       ABORT SEQ
```

An example DCIR menu is as follows –

```
Seq 1 Step 1    DCIR
LEVEL:         1500.0V
BREAKDOWN:     30.00mApk
RAMP:          1.00sec
DWELL:         30.0sec
Delay:         0.25sec
End On:        PASS
Lim:           100.0K-no maxΩ
ARC DETECT:    4us 10mA
DISCHARGE:     AS RAMP
ON FAIL:       ABORT SEQ
```

- **LEVEL.** Allows the test voltage level to be programmed. Note that a value cannot be set which is beyond the range of possible output voltages from the specific 95x or above the maximum voltage limit set by the user in the CNFG – TEST – USER MAX DCV setting.
- **DUT GROUNDED.** Only available if option HSS or HSS-2 is installed. This selection allows the user to select either –
 - **NO.** This selection indicates that the DUT is isolated from ground, the 95x will use the current in the **RETURN** terminal to measure leakage and detect breakdown. This is as if option **HSS or HSS-2** were not installed.
 - **YES.** This selection indicates that the DUT is grounded, the 95x will use the current in the **HV** terminal to measure leakage and detect breakdown.
- **BREAKDOWN.** Not available for the DCez type. Allows breakdown detection to be programmed as a maximum instantaneous peak current level. Pressing the **LIMIT** key while this setting is selected causes it to be set to the maximum value. See [Breakdown Current](#) for further details regarding breakdown currents.
 - The minimum value which can be set is 1uA.

- The maximum value which can be set is as specified in the Peak Shutdown Current portion of Surge Current Limiting and Shutdown.
- **RAMP.** Allows the ramp time period to be programmed either as a time or rate. The **UNIT** key toggles the selection between these two methods.
 - For loads having >0.03uF capacitance the test ramp time should be >0.1sec. The ramp time may need to be extended beyond this to ensure the charging current is less than the desired breakdown detection current. For reference, the charging current (in microamps) = $C \cdot (dV/dT)$ where C is the capacitance in uF and (dV/dT) is the ramp rate in Volts per second (e.g., 1000V/sec ramp into a 10uF load is 10000uA =10mA charging current). For optimum results –
 - For loads >0.05uF the ramp time should be >0.5sec.
 - For loads >2uF the ramp time should be >1sec.
 - For loads >20uF the ramp time should be >2sec.
 - If a load has significant resistance in series with capacitance, then ensure that the charging current is within the capability of the series resistance to avoid it being damaged. If necessary, reduce the charging current by using a slower ramp rate.
- **Min Load.** Not available for the DCez type. This is only available if CNFG–TEST–MIN LOAD is set to YES. This allows the user to specify a minimum capacitance load which should be encountered during ramp. If this loading is not encountered during ramp, then the test is failed with a <MIN LOAD status. This provides an easy to use and very sensitive determination of whether the load is properly connected. Please note the following –
 - For settings of below 1nF there must be enough charging current flow during ramp for the set minimum capacitive load to be successfully detected. For a DUT GROUNDED setting of NO (or option HSS or HSS-2 not fitted), then the ramp rate should be >1000V/sec for a 1pF setting reducing to >1V/sec (and lower) for a 1nF (and higher) setting. For a DUT GROUNDED setting of YES, a setting below 1nF is not recommended.
 - For settings of over 1nF then the actual load capacitance is estimated during ramp and compared to the Min Load setting (this has no minimum ramp time requirement). This is not an accurate DUT capacitance measurement, the accuracy is typically 10%.
 - If there is sufficient resistive load, then this is automatically detected and there will be no <MIN LOAD failure.
 - If the expected capacitive load is known, then a setting of half the expected capacitance is recommended.
- **DWELL.** Allows the dwell time period to be programmed to the desired time, or it may be set to be user terminated by pressing the **LIMIT** key while this setting is selected.
- **Delay.** Not available for the DCez type. Allows the user to program a delay within the dwell period before the leakage range check is to be performed.
 - The 95x series uses a “strong voltage source” method for the DCez, DCW and DCIR types. This enables the use of much shorter test times when performing testing into capacitive loads since it is being both charged and tested from a low impedance source, unlike the “classical” approach of using a high source impedance to reduce the effects of voltage source noise but needing very long test times into capacitive loads. For the 95x, there is a short stabilization period required after the end of ramp when making very low leakage current tests (e.g., 10’s of nA) with

significant capacitance, typically this is less than 0.5sec for loads up to 1uF extending to 5sec for loads of 10uF and above, which should be accommodated by setting the delay setting accordingly. After this there is no further settling time required for the 95x at any leakage current level. If performing breakdown testing at higher current levels (e.g., 100's of uA and above) then no delay is typically required.

- Some capacitive loads have a significant dielectric storage effect. Because of this there may be significant leakage current flowing for some time after the dwell period starts. Depending on the materials, dielectric storage effects can last from a fraction of a second to many tens of seconds or even longer.
- **End On.** Only available for the DCIR type. Allows the user to select when the dwell period will be ended –
 - **PASS.** The dwell period will be immediately terminated with a PASS status if the leakage measurement is within limits continuously for at least 2% of the dwell period. If the dwell period ends without this being detected, then the pass/fail status for leakage is based upon the final measurement taken at the end of the dwell period.
 - **FAIL.** The dwell period will be immediately terminated with a FAIL status if the leakage measurement is outside of limits continuously for at least 2% of the dwell period. If the dwell period ends, then the test step will have a PASS status for leakage. This selection produces similar results to the DCez and DCW types (which terminate dwell immediately on a FAIL condition).
 - **TIME.** The dwell period always extends for the entire programmed period. The pass/fail status for leakage is based upon the final measurement taken at the end of the dwell period.
 - **STDY.** The dwell period will be automatically terminated when the leakage is within the allowable limits and the current is steady or decreasing (i.e., steady or increasing resistance). If the dwell period ends, then the test step will have a FAIL status for leakage.
- **Lim.** Allows the user to define the range within which the leakage current is considered a PASS during the dwell period. The range can be entered in units of current or impedance for any type of test step, the **UNIT** key toggles the selection. For the impedance selection the user may optionally disable the upper limit by pressing the **LIMIT** key while the upper limit is selected.
 - Setting a zero minimum current limit disables the minimum limit and only applies the maximum limit.
 - The maximum allowed current limit (or the minimum impedance limit) is the maximum loading current which the specific 95x model and option content can continuously supply at the configured test voltage (see [Loading Capability](#)).
 - Setting a zero minimum and maximum leakage currents for the DCW type disables leakage current testing entirely, only the breakdown and (optionally) the arc current limits are used.
 - Setting a very small minimum leakage current (or maximum leakage resistance) limit to attempt to detect a disconnected DUT is not recommended, the Min Load setting should be used instead.
 - For the DCez type the breakdown detection limit is automatically set to the maximum leakage current limit with a minimum of 1uApk.
- **ARC DETECT.** Not available for the DCez type and not available if DUT GROUNDED is set to YES. Allows the user to program arc detection during this step. Both the time and current level can be independently programmed. See [Arc Current and Time](#) for details. Arc detection can also be disabled by setting the

leftmost (time) setting to OFF. The 95x can be configured to not fail a test step when arcing is detected by setting the ARC setting in the CNFG – TEST sub-menu to DETECT ONLY.

- **DISCHARGE.** Not available for the DCez type. Allows the user to program whether the discharge period should use the same timing as the ramp period (AS RAMP), be as fast as possible (FAST) or skipped (NONE). If NONE is selected but the next step is not of a DCez, DCW, or DCIR type then the FAST selection is used when the sequence is run.
 - If a load has significant resistance in series with capacitance, then ensure that the discharging current is within the capability of the series resistance to avoid it being damaged. If necessary, reduce the maximum discharging current by reducing the CNFG – TEST – MAX DISCHARGE setting.
- **ON FAIL.** Allows the user to program the 95x to abort the entire sequence (ABORT SEQ) or only this step (CONT SEQ) if this step fails any of its checks. A safety related failure or a user abort (**STOP** button) always aborts the entire sequence.

Performing a multi-stage Ramp or Multiple Voltage Tests

The 95x allows the user to skip the discharge phase if desired in DCW and DCIR types. If a step has DISCHARGE set to NONE and the next step is also a DC Voltage Withstand type and is at a higher voltage than the preceding step, then the discharge phase is skipped automatically. This enables the user to perform a multi-stage ramp with optional dwell phases between each ramp stage.

If each step in such a series has non-zero dwell times then their leakage currents tests are performed normally, however if the dwell time is set to zero in any but the final step then the dwell phase is also skipped in those steps and any dwell leakage current (or resistance) limits defined in such a step will be ignored and the ramp phase of the next step is immediately started after the end of the preceding stage ramp.

There are several scenarios where this capability assists the user, for example –

- If it is desired to perform leakage measurements at several voltages but it is not desirable to discharge to zero between each voltage. The user can configure several steps, each with DISCHARGE set to NONE. In this case there is no discharge phase between each step, only for the final step or if a failure occurs.
- If it is desired to perform leakage current tests at timed intervals, e.g., at 10-minute intervals, then the user may configure many steps, all set for the same voltage and leakage current limits and with DISCHARGE set to NONE. The first step would be configured with the desired ramp settings, all remaining steps are configured with the desired interval between leakage checks as the ramp time. All steps should have a short (but not zero) dwell time configured during which the leakage current will be measured and checked against the limits. Up to 255 such steps can be configured in this manner in a sequence.
- If ramping to a final voltage near the maximum ability of the 95x but the maximum current of the 95x at the final voltage is limiting the ability to charge the load in a timely manner, then the user should consider using a multi-stage ramp by using two (or more) steps. The first step should be configured with a final voltage less than the desired final voltage and with a faster ramp rate and a higher breakdown setting than would have otherwise been possible in a single step because of the lower final voltage. This first step should be configured with DISCHARGE set to NONE and a 0sec dwell period. The second step will be configured as required in all regards, having a slower ramp rate associated with the lower possible breakdown current setting.

- Most materials have a higher dielectric storage effect when the ramp charging current is higher. It may be desirable to perform a faster, higher current ramp to a voltage lower than required in one step, followed by a slower, lower current ramp to the required final voltage to assist in reducing these effects.

Connecting to the DUT

See [Terminals and Wiring](#) for general wiring and safety recommendations.

The 95x requires that the DUT (at least that portion which is being measured) is isolated from ground unless –

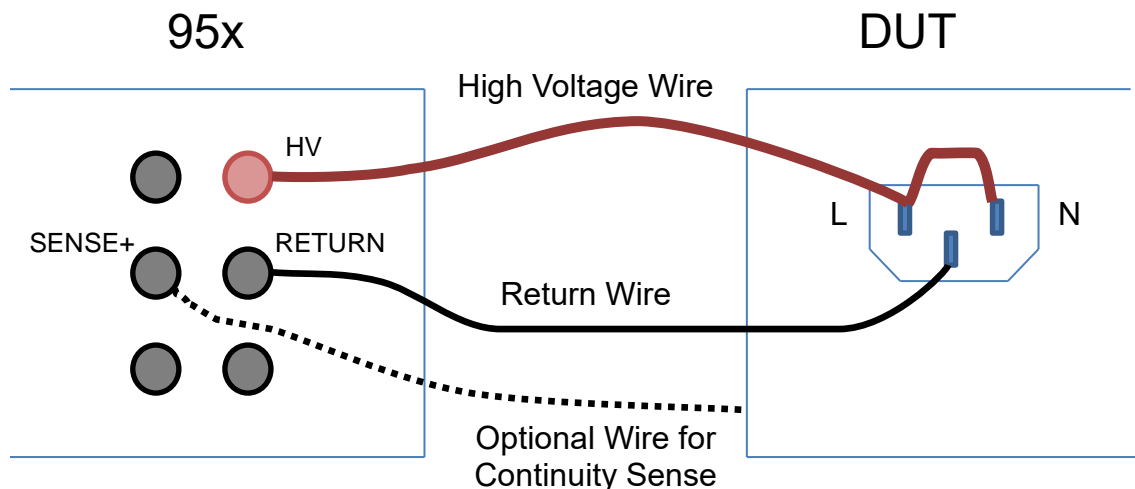
- Option HSS or HSS-2 is fitted
- And, the DUT GROUNDED setting is set to YES.

Testing a DUT without option HSS, without option HSS-2, or with DUT GROUNDED set to NO

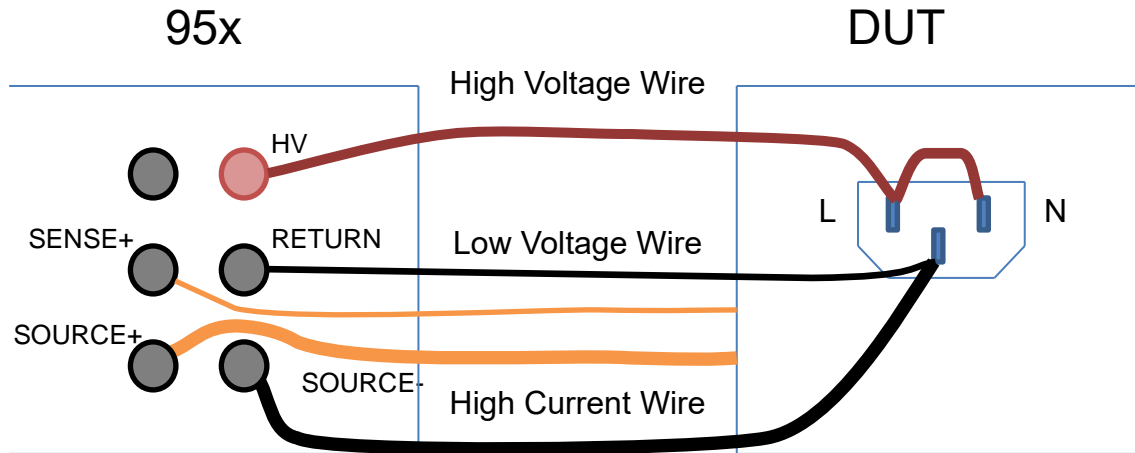
The DUT should be wired between the **HV** and **RETURN** terminals of the 95x.

The 95x provides a safety ground for the DUT during the test via its **RETURN** terminal. The Continuity Sense feature may be used to ensure that the **RETURN** connection is correctly made by connecting the **SENSE+** terminal to a point on the DUT which is connected to the **RETURN** connection. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RETURN** terminal, the user should consider that only the voltage on the **RETURN** terminal is safe at all times.

For best high impedance load performance there should be low leakage between the wires and for low level current measurements there should be little interference pickup in the **RETURN** wire. In extreme circumstances the **RETURN** wire should be the inner wire of a coaxial cable, with the shield connected to the **GUARD** terminal of the 95x. This will significantly reduce the capacitance and leakage between the **HV** and **RETURN** wires. A cable such as RG174 is a suitable choice. If the Continuity Sense feature is being used, then the **SENSE+** connection should similarly be a coaxial cable.



The example above shows the connections for performing DC voltage withstand testing of Line/Neutral connections to the chassis of a DUT. The optional wire from the DUT chassis to the **SENSE+** terminal of the 95x is used when the user wishes to use the Continuity Sense safety feature.



The example above shows the connections to a DUT to perform both a DC withstand test on the Line/Neutral line power input, and an AC Ground Bond or DC Low Ω test on the chassis of the DUT in the same sequence. If wired in this manner, then no changes in connections are needed. This will increase the capacitive coupling between the **HV** wire and the other wires, which may need to be compensated for in highly sensitive applications. The Continuity Sense feature may also be used with this wiring configuration.

Testing a Grounded DUT (option HSS or HSS-2 only)

In this case the user only need connect the **HV** terminal of the 95x to the point on the DUT which is to be tested. It is expected that the DUT is grounded and that the breakdown and/or leakage is being tested to ground. For safety reasons or if unsure if the DUT is grounded, it may be desirable to also connect the DUT ground to either the **RETURN** or **GUARD** terminals of the 95x however the user should ensure that the ground of the 95x and that of the DUT are within 5Vrms of each other otherwise excessive ground loop currents may flow, potentially damaging the 95x.

Checking that the DUT is Connected

When testing a DUT during DC Voltage Withstand testing there is the possibility that a disconnected DUT will erroneously pass a test. There is always some amount of capacitance within the load which will always cause an amount of current to flow during ramp when properly connected, so the user is recommended to set a MIN LOAD setting for this type of step. If not configured for a grounded load, the user may also use the Continuity Sense feature to detect a disconnected RETURN path.

Using the MIN LOAD setting is preferred over setting a minimum leakage current or maximum leakage impedance, particularly when the load has very little leakage and is capacitive, as this method is both more reliable and more sensitive.

Lead Compensation

For many applications lead compensation is not necessary for these types of test steps, as the wiring leakage is generally smaller than the DUT leakage limit and so can be ignored. However, for the more sensitive requirements lead compensation may be needed.

Performing a lead compensation compensates for any leakage currents in the wiring to the 95x in all future runs of this test step. When performing a lead compensation, the normal connections to the 95x should be in place, with the wiring positioned normally, only the DUT itself should not be connected. **CAUTION** High voltages will be present on the wiring while running in lead compensation mode. Ensure that the wiring and the (unused) DUT connections are safely positioned.

When performing a lead compensation, the leakage limits are not enforced, otherwise the test step is executed normally.

Examples

Example 1 -

A DUT is to have its Line/Neutral power connections tested to its chassis for “no breakdown” at 2000Vdc using a 1 second ramp and a 30 second dwell. It is known that the DUT leakage is less than 5mA at this voltage level (if this is not known, then start by using 5mA as the limit and adjust it as needed).

This is accomplished in a single step as follows –

Seq 1 Step 1	DCEZ	Only breakdown detection is needed, so use the DCEz type
LEVEL:	2000.0V	As required
RAMP:	1.00sec	As required
DWELL:	30.0sec	As required
Lim:	0n-5.000mA	As required
ON FAIL:	ABORT SEQ	

Example 2 –

A solar panel is to be tested for “no breakdown” at 2500Vdc using a 1 second ramp and a 5 second dwell time. The panel is estimated to have between 1 and 4uF of capacitance. The test limit for breakdown has been decided to be 1mA and it has been decided to not test for arcing in the panel because of its capacitance.

This is accomplished in a single step as follows –

Seq 1 Step 1	DCW	Different breakdown and leakage limits, so use DCW
LEVEL:	2500.0V	As required
BREAKDOWN:	20.00mApk	Must be greater than the charging current
RAMP:	1.00sec	As required
DWELL:	5.00sec	As required
Delay:	1.00sec	Allow for dielectric storage in the panel
Lim:	0n-1.000mA	As required
ARC DETECT:	OFF	As required
DISCHARGE:	FAST	
ON FAIL:	ABORT SEQ	

Example 3 –

The solar panel used in example 2 above is also required to be tested for insulation resistance at 500Vdc, the specification requires the panel to have >100Mohm resistance. A ramp time of 1 second and a dwell time of 5 seconds have been chosen.

The DCIR test is performed first since if the DCIR were performed after the breakdown test then there would be much longer settling time required because the panel is settling from 2500V to 500V, i.e., a 2000V change rather than a 500V change prior to the very sensitive DCIR measurement.

This is accomplished in two steps as follows –

Seq 1 Step 1	DCIR	This could also be a DCW test with the same results
LEVEL:	500.0V	As required
BREAKDOWN:	5.000mApk	Must be greater than the charging current
RAMP:	1.00sec	As required
DWELL:	5.00sec	As required

Delay:	2.00sec	Allow for dielectric storage in the panel
End On:	FAIL	As required
Lim:	100.0M-no max Ω	As required
ARC DETECT:	OFF	As required
DISCHARGE:	NONE	No need to discharge before the next step, reduces test time
ON FAIL:	ABORT SEQ	Optional, could continue testing if fails
Seq 1 Step 2	DCW	Different breakdown and leakage limits, so use DCW
LEVEL:	2500.0V	As required
BREAKDOWN:	20.00mApk	Must be greater than the charging current
RAMP:	1.00sec	As required
DWELL:	5.00sec	As required
Delay:	1.00sec	Allow for dielectric storage in the panel
Lim:	0n-1.000mA	As required
ARC DETECT:	OFF	As required
DISCHARGE:	FAST	
ON FAIL:	ABORT SEQ	

Example 4 –

In example 3 above, it is required to ensure that the panel is connected to the 95x during the tests. Since the panel has very little DC leakage but has significant capacitance, this is easily achieved by adding a low voltage AC test at the start of the sequence. Since the load has a minimum capacitance of 1uF and a maximum of 4uF, the current at 10V/20Hz will be between 1.25 and 5mArms. This requires that the Opt.AC-2 option be installed.

This is accomplished in three steps as follows –

Seq 1 Step 1	ACez	Simple RMS min and breakdown, so use ACez
LEVEL:	10.0V 20.0HZ	As required
RAMP:	0.02sec	Use a fast time to reduce test time
DWELL:	0.10sec	Use a fast time to reduce test time
Lim:	1.000m-5.000mA	As required
ON FAIL:	ABORT SEQ	No need for further tests if fails
Seq 1 Step 2	DCIR	This could also be a DCW test with the same results
LEVEL:	500.0V	As required
BREAKDOWN:	5.000mApk	Must be greater than the charging current
RAMP:	1.00sec	As required
DWELL:	5.00sec	As required
Delay:	2.00sec	Allow for dielectric storage in the panel
End On:	FAIL	As required
Lim:	100.0M-no max Ω	As required
ARC DETECT:	OFF	As required
DISCHARGE:	NONE	No need to discharge before the next step, reduces test time
ON FAIL:	ABORT SEQ	Optional, could continue testing if fails
Seq 1 Step 3	DCW	Different breakdown and leakage limits, so use DCW
LEVEL:	2500.0V	As required
BREAKDOWN:	20.00mApk	Must be greater than the charging current
RAMP:	1.00sec	As required
DWELL:	5.00sec	As required

Delay:	1.00sec	Allow for dielectric storage in the panel
Lim:	0n-1.000mA	As required
ARC DETECT:	OFF	As required
DISCHARGE:	FAST	
ON FAIL:	ABORT SEQ	

Specifications

Specifications are valid at the 95x terminals for 1 year at ambient temperatures within $\pm 5C$ of calibration temperature (add 5% of accuracy specification per C outside of this). All specifications are relative to the calibration standards used. Add $\frac{1}{2}$ digit to all accuracies for displayed results (results available with enhanced resolution from interfaces).

Loading Capability

The listings below show the loading capabilities of the 95x at ambient temperatures $\leq 30C$. For ambient temperatures above 30C linearly reduce the maximum loading power and current by 1%/C.

Output powers above 200W have a limited test time (e.g., 4 seconds at 250W).

If option HSS-2 is fitted, then the maximum loading is restricted to a maximum of 5mA.

Capacitive loading is only limited by the maximum ramp time (9999.9sec) and the maximum load current, typically this is a 1F load.

951i, 952i and 956i :	<50mA, reduce by 0.05mA per V above 6000V
953i, 954i and 955i :	<9000V : <30mA, reduce by 0.0067mA per V above 6000V >9000V : <10mA, reduce by 0.0025mA per V above 9000V
957i :	<10mA, reduce by 0.001mA per V above 10000V

Surge Current Limiting and Shutdown

Impedance Limiting	951i, 952i and 956i : 6.5K Ω 953i, 954i and 955i : 12.5K Ω 957i : 24 K Ω
Peak Shutdown Current	951i, 952i and 956i : 80mA (50mA if DUT GROUNDED set to YES) 953i, 954i and 955i : 40mA 957i : 20mA Option HSS-2: 5mA

Test Voltage

Test Voltage Range	951i, 952i and 956i : 20 to 6500V 953i, 954i and 955i : 40 to 11000V 957i : 75 to 15000V Opt. HSS or HSS-2 : 20 to 5000V For line voltages below 115V linearly reduce the maximum test voltage by 1%/V unless Opt. LOLINE is fitted (there is no reduction for Opt. LOLINE).
Test Voltage Accuracy	Except 957i: $<(\pm 0.25\% \pm 1.25V \pm (0.01\% + 0.05V) \text{ per mA load})$ 957i: $<(\pm 0.75\% \pm 2V \pm (0.01\% + 0.05V) \text{ per mA load})$, add 0.5% above 10000V Opt. HSS-2: $<(\pm 1\% \pm 2V \pm 1V \text{ per mA load})$

Test Voltage Overshoot <5% (<0.25s ramp time)
<1%
Settling to <±0.1% of final value in <0.5sec

Current Measurements (DUT Isolated)

Measurements are performed in the **RETURN** terminal of the 95x.

Breakdown Current 1uA to 280mApk (DC-50kHz bandwidth)
<(± 1% ± 1uA) accuracy
<30usec detection time
<3msec response time (typically <500usec)

Leakage Current 0.0nA to 200mA
7.25msec measurement period (100ms for dwell time >2 sec)
<(± 0.25% ± 0.5nA) accuracy
Capacitive Loading Effects :
951i, 952i and 956i : add X * (± 0.2nA ± (2.5nA per KV))
953i, 954i and 955i : add X * (± 0.3nA ± (3.5nA per KV))
957i : add X * (± 0.5nA ± (5nA per KV))
X = (C/0.01uF) below 0.01uF, or X = √(C/1uF) above 1uF, or otherwise X = 1.0

Arc Current 1 to 30mArms (50KHz-5MHz bandwidth)
<(± 10% ± 1mA) accuracy at 1MHz
4us, 10us, 15us, 20us, 30us or 40us measurement period

Cable Compensation <(± 1% of error)

Resistance Measurements (DUT Isolated)

Measurements are performed between the **HV** and **RETURN** terminals of the 95x.

For applied voltage, breakdown current and arc current accuracies see above.

In the chart below R is the reading in Ohms, C is the capacitive loading. Interpolate between voltages as needed, for accuracies at capacitances above 5uF consult Vitrek. Accuracies are shown as the percentage of the reading.

Test Voltage	C < 0.01uF	C = 0.01uF to 1uF	C = 1uF to 5uF
951i, 952i or 956i			
50V	10K-30GΩ : ±0.8%±(R/1GΩ)%	10K-20GΩ : ±0.8%±(R/600MΩ)%	10K-10GΩ : ±0.8%±(R/400MΩ)%
100V	10K-60GΩ : ±0.7%±(R/2GΩ)%	10K-30GΩ : ±0.7%±(R/1GΩ)%	10K-20GΩ : ±0.7%±(R/600MΩ)%
250V	10K-150GΩ : ±0.6%±(R/5GΩ)%	10K-60GΩ : ±0.6%±(R/1.5GΩ)%	10K-30GΩ : ±0.6%±(R/1GΩ)%
500V	10K-300GΩ : ±0.6%±(R/10GΩ)%	10K-80GΩ : ±0.6%±(R/2.5GΩ)%	10K-40GΩ : ±0.6%±(R/1GΩ)%
1000V	20K-600GΩ : ±0.6%±(R/20GΩ)%	20K-100GΩ : ±0.6%±(R/3GΩ)%	20K-50GΩ : ±0.6%±(R/1.5GΩ)%
2500V	50K-1.5TΩ : ±0.6%±(R/50GΩ)%	50K-100GΩ : ±0.6%±(R/3GΩ)%	50K-50GΩ : ±0.6%±(R/1.5GΩ)%
5000V	100K-3TΩ : ±0.6%±(R/100GΩ)%	100K-100GΩ : ±0.6%±(R/3GΩ)%	100K-50GΩ : ±0.6%±(R/1.5GΩ)%
953i, 954i or 955i			

50V	10K-30GΩ : ±0.8%±(R/1GΩ)%	10K-15GΩ : ±0.8%±(R/500MΩ)%	10K-10GΩ : ±0.8%±(R/300MΩ)%
100V	10K-60GΩ : ±0.7%±(R/2GΩ)%	10K-25GΩ : ±0.7%±(R/800MΩ)%	10K-15GΩ : ±0.7%±(R/500MΩ)%
250V	10K-150GΩ : ±0.6%±(R/5GΩ)%	10K-40GΩ : ±0.6%±(R/1.3GΩ)%	10K-25GΩ : ±0.6%±(R/750MΩ)%
500V	17K-300GΩ : ±0.6%±(R/10GΩ)%	17K-60GΩ : ±0.6%±(R/1.75GΩ)%	17K-30GΩ : ±0.6%±(R/900MΩ)%
1000V	34K-600GΩ : ±0.6%±(R/20GΩ)%	34K-75GΩ : ±0.6%±(R/2GΩ)%	34K-35GΩ : ±0.6%±(R/1GΩ)%
2500V	84K-1.5TΩ : ±0.6%±(R/50GΩ)%	84K-80GΩ : ±0.6%±(R/2.5GΩ)%	84K-40GΩ : ±0.6%±(R/1GΩ)%
5000V	167K-3TΩ : ±0.6%±(R/100GΩ)%	167K-90GΩ : ±0.6%±(R/2.5GΩ)%	167K-40GΩ : ±0.6%±(R/1GΩ)%
10000V	1.34M-6TΩ : ±0.6%±(R/200GΩ)%	1.34M-90GΩ : ±0.6%±(R/2.5GΩ)%	1.34M-40GΩ : ±0.6%±(R/1GΩ)%
957i			
100V	10K-60GΩ : ±1.2%±(R/2GΩ)%	10K-20GΩ : ±1.2%±(R/500MΩ)%	10K-10GΩ : ±1.2%±(R/300MΩ)%
250V	25K-150GΩ : ±1.1%±(R/5GΩ)%	25K-30GΩ : ±1.1%±(R/1GΩ)%	25K-15GΩ : ±1.1%±(R/500MΩ)%
500V	50K-300GΩ : ±1.1%±(R/10GΩ)%	50K-40GΩ : ±1.1%±(R/1.3GΩ)%	50K-20GΩ : ±1.1%±(R/650MΩ)%
1000V	100K-600GΩ : ±1.1%±(R/20GΩ)%	100K-50GΩ : ±1.1%±(R/1.5GΩ)%	100K-25GΩ : ±1.1%±(R/700MΩ)%
2500V	250K-1.5TΩ : ±1.1%±(R/50GΩ)%	250K-60GΩ : ±1.1%±(R/1.75GΩ)%	250K-25GΩ : ±1.1%±(R/800MΩ)%
5000V	500K-3TΩ : ±1.1%±(R/100GΩ)%	500K-60GΩ : ±1.1%±(R/1.8GΩ)%	500K-25GΩ : ±1.1%±(R/800MΩ)%
10000V	1M-6TΩ : ±1.1%±(R/200GΩ)%	1M-60GΩ : ±1.1%±(R/1.8GΩ)%	1M-25GΩ : ±1.1%±(R/800MΩ)%
15000V	3M-10TΩ : ±1.6%±(R/300GΩ)%	3M-60GΩ : ±1.6%±(R/1.8GΩ)%	3M-25GΩ : ±1.6%±(R/800MΩ)%

Current Measurements (DUT Grounded, option HSS only)

Measurements are performed in the **HV** terminal of the 95x.

Breakdown Current	1uA to 50mApk (DC-50kHz bandwidth) <(± 1% ± 1uA) accuracy <30uSec detection time <3mSec response time (typically <500uSec)
Leakage Current	0.00uA to 50mA 7.25mSec measurement period (100ms for dwell time >2 sec) <(± 1% ± 50nA ± (10nA per KV)) accuracy Capacitive Loading Effects : Add X * (± 0.2nA ± (2.5nA per KV)) X = (C/0.01uF) below 0.01uF, or X = √(C/1uF) above 1uF, or otherwise X = 1.0
Cable Compensation	<(± 1% of error)

Current Measurements (DUT Grounded, option HSS-2 only)

Measurements are performed in the **HV** terminal of the 95x.

Breakdown Current	1uA to 5mApk (DC-50kHz bandwidth) <(± 1% ± 1uA) accuracy <30uAsec detection time <3msec response time (typically <500uAsec)
Leakage Current	0.000uA to 5mA 7.25msec measurement period (100ms for dwell time >2 sec) <(± 1% ± 5nA ± (1nA per KV)) accuracy Capacitive Loading Effects : Add X * (± 0.2nA ± (2.5nA per KV)) X = (C/0.01uF) below 0.01uF, or X = √(C/1uF) above 1uF, or otherwise X = 1.0
Cable Compensation	<(± 1% of error)

Resistance Measurements (DUT Grounded, option HSS only)

Measurements are performed between the **HV** terminal of the 95x and ground.

For applied voltage, breakdown current and arc current accuracies see above.

In the chart below R is the reading in Ohms, C is the capacitive loading. Interpolate between voltages as needed, for accuracies at capacitances above 5uF consult Vitrek.

Test Voltage	C < 0.01uF	C = 0.01uF to 1uF	C = 1uF to 5uF
50V	10K-300MΩ : ±1.5%±(R/10MΩ)%	10K-300MΩ : ±1.5%±(R/10MΩ)%	10K-300MΩ : ±1.5%±(R/10MΩ)%
100V	10K-600MΩ : ±1.4%±(R/20MΩ)%	10K-600MΩ : ±1.4%±(R/19MΩ)%	10K-600MΩ : ±1.4%±(R/18MΩ)%
250V	10K-1.5GΩ : ±1.3%±(R/45MΩ)%	10K-1.5GΩ : ±1.3%±(R/45MΩ)%	10K-1.4GΩ : ±1.3%±(R/40MΩ)%
500V	10K-3GΩ : ±1.3%±(R/90MΩ)%	10K-2.75GΩ : ±1.3%±(R/80MΩ)%	10K-2.6GΩ : ±0.6%±(R/80MΩ)%
1000V	20K-5GΩ : ±1.3%±(R/160MΩ)%	20K-5GΩ : ±1.3%±(R/150MΩ)%	20K-4.5GΩ : ±1.3%±(R/130MΩ)%
2500V	50K-11GΩ : ±1.3%±(R/300MΩ)%	50K-9GΩ : ±1.3%±(R/250MΩ)%	50K-8GΩ : ±1.3%±(R/240MΩ)%
4000V	80K-14.5GΩ : ±1.3%±(R/400MΩ)%	80K-12GΩ : ±1.3%±(R/350MΩ)%	80K-9.5GΩ : ±1.3%±(R/280MΩ)%

Resistance Measurements (DUT Grounded, option HSS-2 only)

Measurements are performed between the **HV** terminal of the 95x and ground.

For applied voltage, breakdown current and arc current accuracies see above.

In the chart below R is the reading in Ohms, C is the capacitive loading. Interpolate between voltages as needed, for accuracies at capacitances above 5uF consult Vitrek.

Test Voltage	C < 0.01uF	C = 0.01uF to 1uF	C = 1uF to 5uF
50V	50K-3GΩ : ±3.5%±(R/100MΩ)%	50K-3GΩ : ±3.5%±(R/100MΩ)%	50K-3GΩ : ±3.5%±(R/100MΩ)%

100V	50K-6GΩ : ±2.5%±(R/200MΩ)%	50K-6GΩ : ±2.5%±(R/190MΩ)%	50K-6GΩ : ±2.5%±(R/180MΩ)%
250V	50K-15GΩ : ±2.5%±(R/450MΩ)%	50K-15GΩ : ±2.5%±(R/450MΩ)%	50K-14GΩ : ±2.5%±(R/400MΩ)%
500V	100K-30GΩ : ±2.5%±(R/900MΩ)%	100K-27.5GΩ : ±2.5%±(R/800MΩ)%	100K-26GΩ : ±2.5%±(R/800MΩ)%
1000V	200K-50GΩ : ±2%±(R/1.6GΩ)%	200K-50GΩ : ±2%±(R/1.5GΩ)%	200K-45GΩ : ±2%±(R/1.5GΩ)%
2500V	500K-90GΩ : ±2%±(R/3GΩ)%	500K-75GΩ : ±2%±(R/2.5GΩ)%	500K-45GΩ : ±2%±(R/1.5GΩ)%
4000V	800K-120GΩ : ±2%±(R/4GΩ)%	800K-75GΩ : ±2%±(R/2.5GΩ)%	800K-30GΩ : ±2%±(R/1GΩ)%

Test Timing

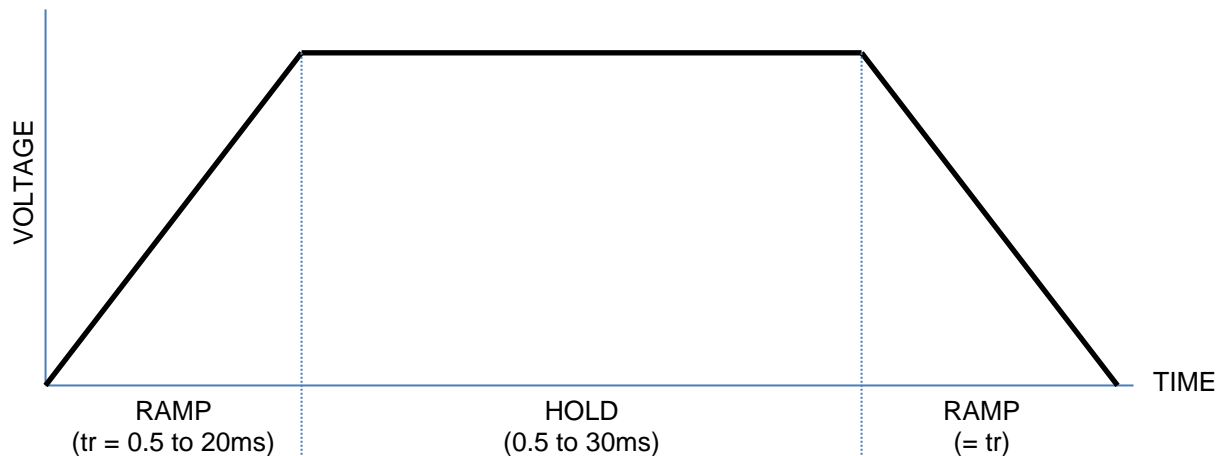
Ramp	0.01 to 9999sec 50kV/sec max slew rate <(± 1% ± 0.1sec) accuracy with typical loads 0.5sec minimum for 957i only
Dwell	0.02 to 9999sec or user terminated <(± 0.05% ± 20ms) accuracy (add 100ms for dwell time >2 sec)
Delay	0.00 to 9999sec <(± 0.05% ± 20ms) accuracy

Discharge

Fixed Discharge	Always selected 951i,952i,956i : Nominal loading 7MΩ 953-5i : Nominal loading 13MΩ 957i : Nominal loading 17MΩ
Controlled Discharge	Auto-selected resistance values in real-time during discharge Selection Criteria : <400W power, <400J energy, <7500V, current <CNFG-TEST-MAX DISCHARGE setting 951i,952i,956i : Nominal loading 9.5KΩ or 40KΩ 953-4i and 957i : Nominal loading 9.5KΩ or 40KΩ or 240KΩ 955i : Nominal loading 15KΩ or 40KΩ or 240KΩ
Minimum Discharge Time	<(20ms + 10ms per kV) (below 7500V)

Pulsed Voltage Withstand Testing (PULSE)

This type of testing is performed whenever it is required to test that a device can withstand a voltage without breakdown or arcing, but the device will not withstand the voltage for significant periods of time. An example of this is in the testing of the voltage withstand capability of physically small resistors, in this case the resistor may not be able to withstand the power dissipation if the voltage is applied for lengthy periods of time, so normal AC or DC Voltage Withstand testing cannot be performed.

Actions While Running


- Breakdown and (optionally) arc detection are performed throughout the test. On any failure the pulse is immediately aborted.
- A UNIPOLAR+ pulse is shown above, a UNIPOLAR- pulse has the same timing but has the opposite voltage polarity, a BIPOLAR pulse is a pair of opposite polarity pulses (positive first) with no delay between them.
- A delay is enforced following the pulse(s) to allow any stored energy in the 95x or the DUT caused by asymmetry in the waveform to dissipate.
 - After a unipolar pulse of either polarity or after an abnormally terminated bipolar pulse, this delay is 500ms.
 - After a normally terminated bipolar pulse, this delay is 40ms.

Configuring

An example PULSE menu is as follows –

```
Seq 1 Step 1  PULSE
LEVEL:       200.0V
POLARITY:    UNIPOLAR+
BREAKDOWN:   150.0mApk
RAMP:        1.0msec
HOLD:        1.5msec
ARC DETECT:  4us  10mA
ON FAIL:     ABORT SEQ
```

- **LEVEL.** Allows the test voltage level to be programmed. For a bipolar pulse, both polarities have nominally the same voltage amplitude.
 - The amplitude of the pulse is not accurately controlled by the 95x during this type. The actual peak voltage amplitude is displayed for review after a test step has been run, enabling the user to adjust the peak test voltage for a specific DUT. Alternatively, the 95x can do this semi-automatically by using the Lead Compensation feature.
- **POLARITY.** Allows the polarity of the pulse to be selected.
 - **UNIPOLAR+.** A single, positive polarity, pulse of voltage is produced.
 - **UNIPOLAR-.** A single, negative polarity, pulse of voltage is produced.

- **BIPOLAR.** A pair of opposite polarity pulses of voltage is produced.
- **BREAKDOWN.** Allows breakdown detection to be programmed as a maximum peak current level. Note that the maximum drive current during testing is limited by the test voltage and the 95x output impedance (see [Specifications](#)), entering a value higher than can be achieved renders this setting inactive.
- **RAMP.** See figures in Actions While Running. The minimum value is 1ms (0.5ms if Opt. AC-2 if installed), and the maximum value is 20ms.
- **HOLD.** See figures in Actions While Running. The minimum value is 1ms (0.5ms if Opt. AC-2 if installed), and the maximum value is 30ms.
- **ARC DETECT.** Allows the user to program arc detection during this step. Both the time and current level can be independently programmed. Arc detection can also be disabled by setting the leftmost (time) setting to OFF. The 95x can be configured to not fail a test step when arcing is detected by setting the ARC setting in the CNFG – TEST sub-menu to DETECT ONLY.
- **ON FAIL.** This allows the user to program the 95x to abort the entire sequence (ABORT SEQ) or only this step (CONT SEQ) if this step fails any of its checks. A safety related failure or a user abort (**STOP** button) always aborts the entire sequence.

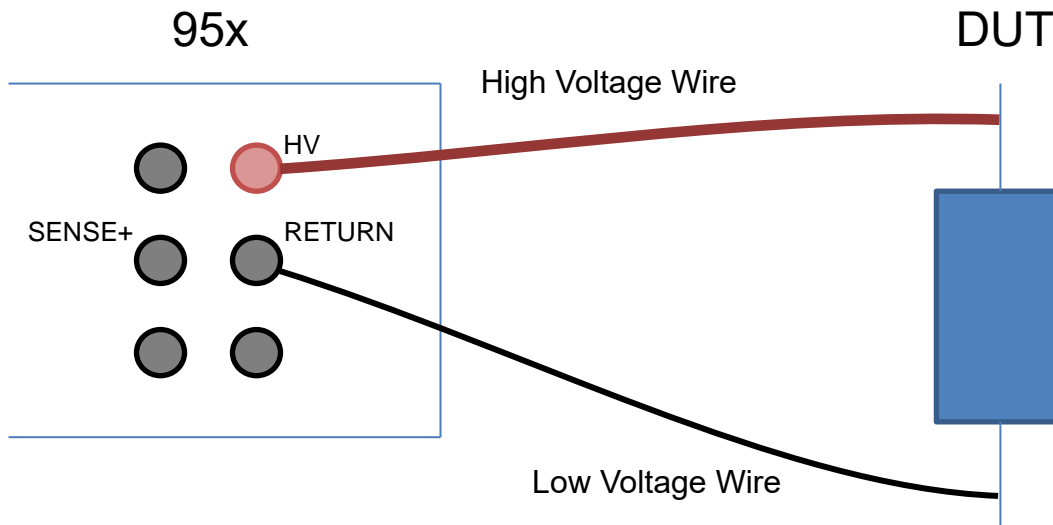
Connecting to the DUT

See [Terminals and Wiring](#) for general wiring and safety recommendations.

The 95x requires that the DUT (at least that portion which is being measured) is isolated from ground.

The DUT should be wired between the **HV** and **RETURN** terminals of the 95x.

The 95x provides a safety ground termination for the DUT during the test via its **RETURN** terminal. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RETURN** terminal, the user should consider that only the voltage on the **RETURN** terminal is safe at all times.



Lead Compensation

This type of test step uses the Lead Compensation feature of the 95x in a different way to all other types as it does not compensate for any cabling effects, but instead compensates for the loading effect on the 95x caused by the load resistance. The output voltage level from the 95x cannot be accurately controlled for this type. The output impedance when running this type is of significance, refer to Specifications.

The 95x reports the actual highest voltage applied across the DUT following the end of this type of test step. Using the reported actual voltage, the user can manually adjust the programmed test voltage level to accommodate loading effects for future runs. Alternatively, the user can run a Lead Compensation with an example DUT connected normally, in which case the 95x will save the measured highest voltage and automatically adjust the output level in subsequent runs. Both of these methods assume that the load resistance does not vary significantly with voltage; if the resistance does vary significantly then the user may need to manually adjust the test voltage accordingly.

Examples

A nominally 10Kohm NTC thermistor is to be tested for breakdown at 400Vpk. The thermistor will only withstand 400V for a maximum of 100msec and will exhibit self-heating very quickly.

This is accomplished in a single step as follows –

Seq 1 Step 1	PULSE	
LEVEL:	400.0V	As required
POLARITY:	UNIPOLAR+	As required
BREAKDOWN:	100.0mApk	Must be greater than the peak load current
RAMP:	1.0msec	Performed as fast as possible, the load has little capacitance
HOLD:	1.5msec	Performed as fast as possible, the load has little capacitance
ARC DETECT:	4us 10mA	Optional
ON FAIL:	ABORT SEQ	

The actual test voltage may not have achieved the required test voltage with sufficient accuracy. When reviewing the results, the actual test voltage is displayed, as an example this may be 366V. The user may adjust the programmed test voltage from the original 400V setting, to $400 * (400/366) = 437V$. Then the next time the step is run the applied test voltage into this load will be closer to 400V. Alternatively, the user could run the test sequence using the Lead Compensation feature with a nominal load connected; the 95x will then automatically apply this in future runs of the test.

Specifications

Specifications are valid at the 95x terminals for 1 year at ambient temperatures within $\pm 5C$ of calibration temperature (add 5% of accuracy specification per C outside of this). All specifications are relative to the calibration standards used. Add $\frac{1}{2}$ digit to all accuracies for displayed results (results available with enhanced resolution from interfaces).

Test Voltage and Loading Capability

Test Voltage	951-4i (standard build): 50V to 8000V 951-4i (opt. AC2): 20V to 2750V
Output Impedance	951-4i (standard build): 12Kohm + 0.5H nominal output impedance 951-4i (opt. AC2): 1.4Kohm + 0.2H nominal output impedance
Max Load Current	Limited by the lesser of - a) the test voltage and output impedance b) 145mA (288mA for Opt. AC-2).

Measured Test Voltage Accuracy

Test Voltage Accuracy	<($\pm 0.5\% \pm 5V \pm (0.2V \text{ per mA load})$)
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Load Current Measurements

Measurements are performed in the **RETURN** terminal of the 95x.

Breakdown Current	1uA to 280mApk (DC-50kHz bandwidth) <(± 1% ± 1uA) accuracy <30usec detection time <3msec response time (typically <500usec)
Arc Current	1 to 30mA rms (50kHz-5MHz bandwidth) <(± 10% ± 1mA) accuracy at 1MHz 4us, 10us, 15us, 20us, 30us or 40us measurement period

Test Timing

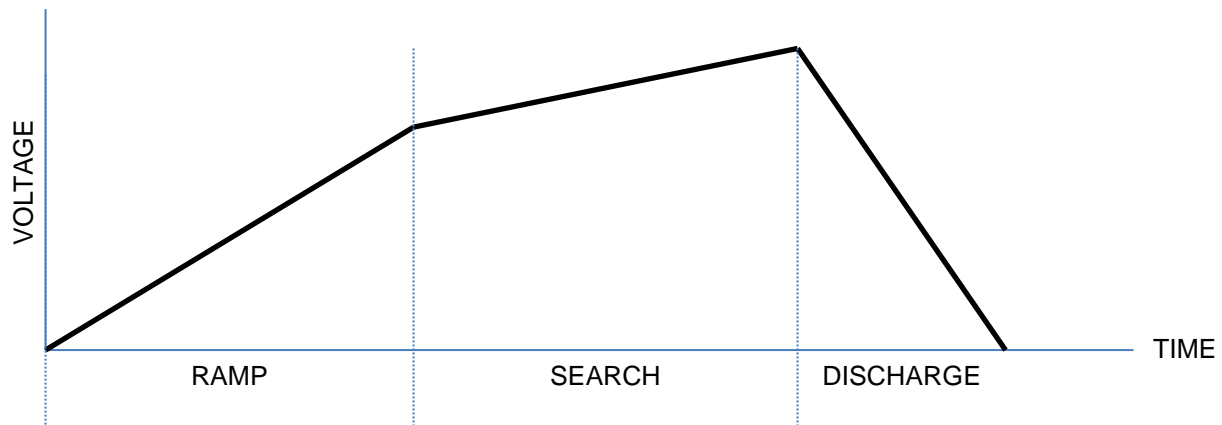
The ramp and dwell times are those specified ± 100us

DC Breakdown Voltage Device Testing (BRKDN)

This tests that a DUT exhibits breakdown when tested with a user set DC current. The measured breakdown voltage is checked against an allowable range.

The BRKDN type is commonly used for testing high voltage protection devices such as spark gap surge arrestors and MOV style voltage limiters.

Actions while Running



- RAMP.** During this period, the test voltage is ramped at the user set maximum ramp rate to an automatically selected voltage level between 50 and 90% of the minimum breakdown voltage limit setting. If the user set breakdown current limit occurs during this period, then the DUT is failed, and the highest voltage and current are recorded, and the DISCHARGE period is started (i.e., the SEARCH period is skipped).
- SEARCH.** During this period, the test voltage is ramped at an automatically selected slower rate than during the RAMP period. The search ramp rate is selected to give best accuracy within the set breakdown voltage limits. If the user set breakdown current limit occurs during this period, then the highest voltage is recorded as the DUT breakdown voltage, and the DISCHARGE period is started. If a voltage significantly higher than the maximum breakdown voltage limit is reached before the load current achieves the user breakdown current limit, then the DUT is failed, and the final voltage and current are recorded, and the DISCHARGE period is started.

- **DISCHARGE.** During this period, the DUT is discharged as fast as possible.

NOTE – the actual reported test current in breakdown may be slightly higher than expected because of the characteristics of the breakdown of the DUT. If this is excessive then the user should select a slower maximum ramp rate.

Configuring

An example BRKDN menu is as follows –

```
Seq 1 Step 1 BRKDN
CURRENT:    5.000mA
RAMP:       5.00KV/s
Lim:        800.0-850.0V
ON FAIL:    ABORT SEQ
```

- **DUT GROUNDED.** Only available if option HSS or HSS-2 is installed. This selection allows the user to select either –
 - **NO.** This selection indicates that the DUT is isolated from ground, the 95x will use the current in the **RETURN** terminal to detect breakdown. This is as if option **HSS** or HSS-2 were not installed.
 - **YES.** This selection indicates that the DUT is grounded, the 95x will use the current in the **HV** terminal to detect breakdown.
- **CURRENT.** Allows the DC test current to be programmed. The entry is limited to a minimum value of 1uA.
- **RAMP.** Allows the maximum ramp rate to be programmed.
 - The accuracy of the breakdown voltage measurement may be limited by the ramp rate at high rates. It is not recommended to set ramp rates of more than 10 times the lowest expected breakdown voltage per second (e.g., if the lowest expected breakdown voltage is 500V then the highest recommended rate setting is 5000V/s).
 - If the DUT and cables connected to it have any significant capacitance then a significant portion of the test current may be consumed by the charging current. In this case the DUT will be measured as having a considerably lower breakdown voltage than expected. The user should consider using a lower maximum ramp rate setting in these circumstances.
- **Lim.** This allows the user to define the range within which the breakdown voltage measurement is considered a PASS.
- **ON FAIL.** This allows the user to program the 95x to abort the entire sequence (ABORT SEQ) or only this step (CONT SEQ) if this step fails any of its checks. A safety related failure or a user abort (**STOP** button) always aborts the entire sequence.

Connecting to the DUT

See [Terminals and Wiring](#) for general wiring and safety recommendations.

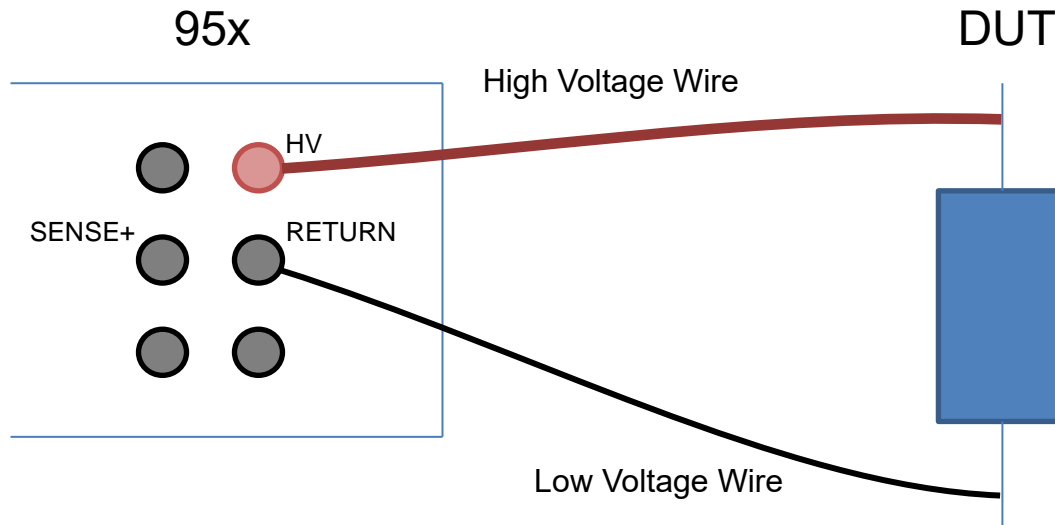
The 95x requires that the DUT (at least that portion which is being measured) is isolated from ground unless –

- Option HSS or HSS-2 is fitted
- And, the DUT GROUNDED setting is set to YES.

Testing a DUT without option HSS, without option HSS-2, or with DUT GROUNDED set to NO

The DUT should be wired between the **HV** and **RETURN** terminals of the 95x.

The 95x provides a safety ground termination for the DUT during the test via its **RETURN** terminal. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RETURN** terminal, the user should consider that only the voltage on the **RETURN** terminal is safe at all times.



Testing a Grounded DUT (option HSS or HSS-2 only)

In this case the user only need connect the **HV** terminal of the 95x to the point on the DUT which is to be tested. It is expected that the DUT is grounded, and that the breakdown is being tested to ground. For safety reasons or if unsure if the DUT is grounded, it may be desirable to also connect the DUT ground to either the **RETURN** or **GUARD** terminals of the 95x however the user should ensure that the ground of the 95x and that of the DUT are within 5Vrms of each other otherwise excessive ground loop currents may flow, potentially damaging the 95x.

Lead Compensation

Performing a lead compensation for this type of test step has no effect; the test step is performed normally during lead compensation mode.

Examples

A MOV is to be tested against its breakdown specifications. The specifications are at a current of 10mA and the breakdown voltage shall be between 405 and 495V. The specifications state that a maximum ramp rate of 100000V/sec is to be used. The MOV has <1000pF capacitance.

This is achieved by using a single test step as follows -

```
Seq 1 Step 1  BRKDN
CURRENT:      10.00mA      As required
RAMP:         2.00KV/s     As recommended (<10*Vmin/sec)
Lim:          405.0-495.0V As required
ON FAIL:      ABORT SEQ
```

The total test time will be less than 350ms. After the sequence is run the actual highest voltage and load current are available for review.

Specifications

Specifications are as for the DC Voltage Withstand Test types except as shown below.

The BRKDN type must not be used with loads having >0.05uF capacitance.

Voltage and Current Accuracy

- Breakdown Voltage Accuracy <math> <(\pm 0.5\% \pm 1.5V)</math> (add an additional $\pm 5V$ if option HSS-2 installed)
 <math> <30\mu\text{sec}</math> detection time
 <math> <10\text{msec}</math> response time
- Breakdown Current Accuracy <math> <(\pm 1.5\% \pm 3\mu\text{A})</math>
 <math> <30\mu\text{sec}</math> detection time
 <math> <10\text{msec}</math> response time

Test Timing

Ramp and Search <math> <50\text{kV/sec}</math> , $\pm 15\% \pm 10\text{ms}</math> accuracy$

CHOOSING WITHIN THE Resistance TESTING GROUP

The user may choose for the 95x to test the resistance of a DUT using one of three activities-

- If the resistance to be tested is more than 100K Ω - use the DC Voltage Withstand capability of the 95x to measure the resistance of the DUT. This can accommodate resistances of below 10K Ω to over 1T Ω using a fixed DC Voltage across the DUT. Typical applications for this include insulation resistance and higher value resistor component testing. See DC Voltage Withstand and Leakage Testing (DCez, DCW and DCIR).
- If the resistance is between 1m Ω and 100K Ω and it is allowable to measure using DC at a current of up to 50mA and voltages up to 5V - use the DC Low Resistance capability of the 95x. Typical applications for this include component testing, cable resistance testing, and (if allowed by the safety standard) chassis ground bond testing. See DC Low Resistance Testing (Low Ω).
- If the resistance is between 1 $\mu\Omega$ and 10 Ω and it is allowable (or required) to measure using AC at a user defined current between 0.1A and 40Arms and a voltage up to 8Vrms (11.5Vpk) - use the AC Ground Bond capability of the 95x (not all models have this capability). Typical applications for this include chassis ground bond testing and cable resistance testing at high currents. The 95x also offers the ability to independently measure the in-phase (resistance) and quadrature (reactance) components of the DUT while maintaining stability with inductive loads for component testing applications. See AC Ground Bond Testing (GBez and GB).

DC Low Resistance Testing (Low Ω)

This type is primarily for testing resistance values from a few milliohms up to 100K Ω using either 2-wire or 4-wire measurement methods.

Actions while Running

This type of test step is performed using a single measurement period. The user may program for a delay at the start of the test period before the resistance measurement is checked against the limits. This can be used to allow for capacitance in parallel with the DUT.

When programmed to perform a 4-terminal measurement, the 95x continuously performs a set of checks that the DUT is correctly wired to the 95x throughout the test period.

Configuring

An example Low Ω menu is as follows –

```
Seq 1 Step 1   LOW  $\Omega$ 
2/4-WIRE:     4-WIRE
```

TIME: 1.00sec
Delay: 0.05sec
Lim: 0.0m–150.0K Ω
ON FAIL: ABORT SEQ

- **2/4-WIRE.** Allows the user to program whether the 2-wire or 4-wire measurement technique is to be employed.
- **TIME.** Allows the test time period to be programmed (in seconds) or set to be user terminated (with the **START** button) by pressing the **LIMIT** key while this setting is selected.
- **Delay.** Allows the user to program a delay in the test period before the measurement range check is performed.
- **Lim.** Allows the user to define the range within which the resistance measurement is considered a PASS during the dwell period.
- **ON FAIL.** Allows the user to program the 95x to abort the entire sequence (ABORT SEQ) or only this step (CONT SEQ) if this step fails any of its checks. A user abort (**STOP** button) always aborts the entire sequence.

Connecting to the DUT

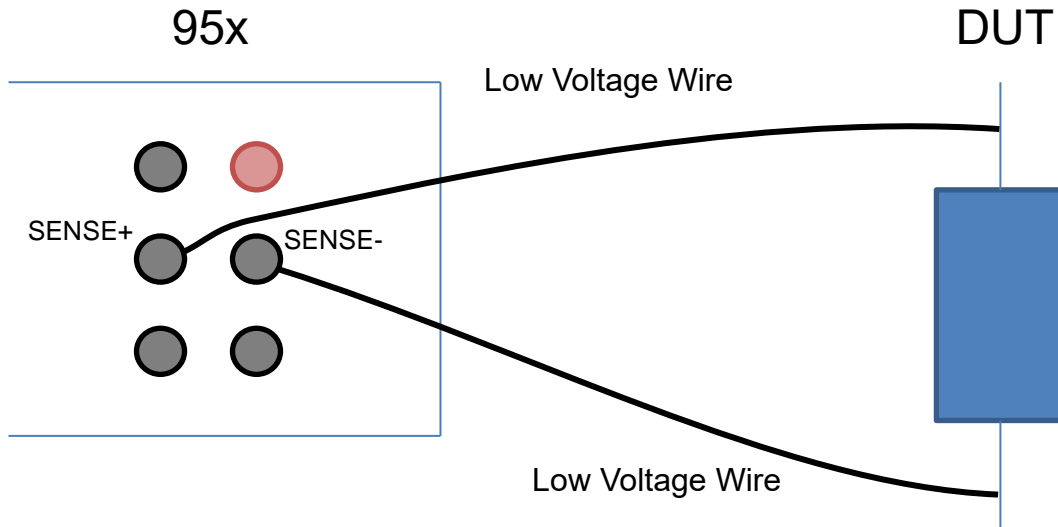
See [Terminals and Wiring](#) for general wiring and safety recommendations.

The 95x requires that the DUT (at least that portion which is being measured) is floating with respect to ground.

2-Wire Measurement Connections

When making 2-terminal measurements the resistance of the wires, the contact resistance to the DUT, and the contact resistance within the 95x front panel terminals are all included in the result, use the following recommendations to reduce these effects –

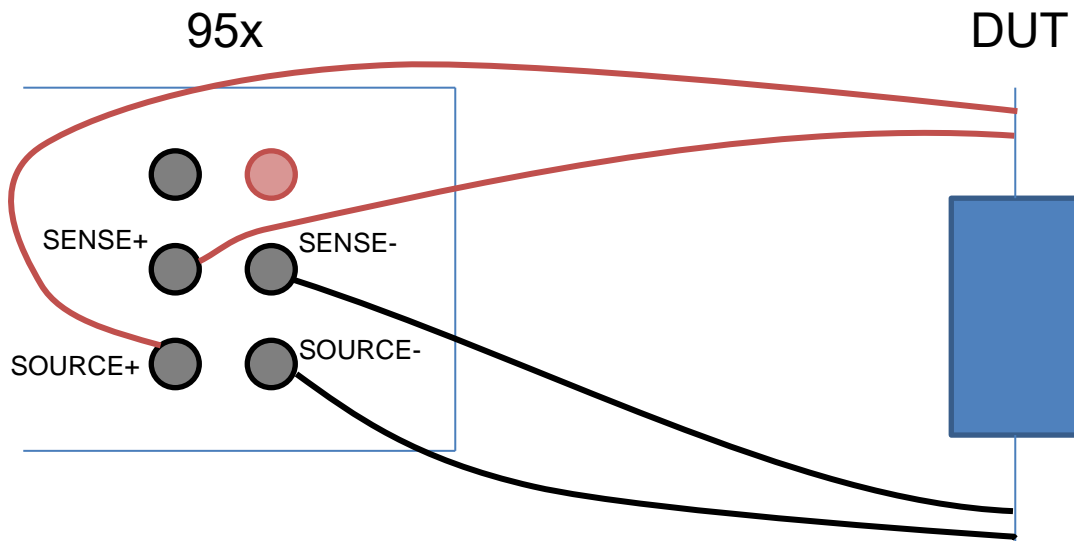
- Use heavy gage wires.
- Ensure that the connections to the DUT are clean and are solidly made.
- Ensure that the connectors on the wires to the 95x are clean and are not loose. If the connectors are left inserted into the sockets of the 95x front panel for an extended period of time (e.g., a few weeks or more) then they should be occasionally removed, cleaned, and re-inserted into the 95x to prevent build-up of corrosion on the connectors.



4-Wire Measurement Connections

When making 4-terminal measurements the resistance of the wires, the contact resistance to the DUT, and the contact resistance within the 95x front panel terminals are not included in the result, the only recommendation is that the **SOURCE+** and **SOURCE-** wires be of sufficient gage to withstand the 50mA test current. When wired as shown below, the actual resistance measured is that between the innermost connection points to the DUT (i.e., between the **SENSE+** and **SENSE-** connections).

If any wire has more than nominally 100Ω of resistance, then the test is failed with a WIRING FAULT condition.



Lead Compensation (2-Wire)

Performing a lead compensation for this type of test step compensates for lead resistance.

During a lead compensation the **SENSE+** and **SENSE-** wires should be solidly shorted together at the DUT end, the 95x will then measure the lead resistance and automatically subtract it from all future measurements.

Lead Compensation (4-Wire)

Lead Compensation is not usually performed when using a 4-wire measurement since lead resistance is automatically eliminated. If a 4-wire test is configured but the DUT is connected in a 2-wire manner (e.g., separate wires for SOURCE and SENSE, but they are shorted together before the connection to the DUT) then a Lead Compensation may be performed in the same manner as for the 2-wire configuration above.

Examples

Example 1 -

A DUT has a 50Ω input and it is desired to check that the input impedance is within 5% of the nominal 50Ω value.

This is accomplished in a single step as follows –

```
Seq 1 Step 1   LOW Ω
2/4-WIRE:      2-WIRE           Lead resistance is well below 2.5ohm, so 2-wire is chosen
TIME:          0.10sec         Load has very little capacitance so use a fast time
Delay:         0.00sec         Load has very little capacitance so no delay needed
Lim:           47.50-52.50Ω     As required
ON FAIL:       ABORT SEQ
```

Example 2 -

It is required to test that a DUT chassis is bonded to its grounding terminal with no more than 0.1ohm of resistance.

This is accomplished in a single step as follows –

```
Seq 1 Step 1   LOW Ω
2/4-WIRE:      4-WIRE           Lead resistance is significant, so 4-wire is chosen
TIME:          0.10sec         Load has very little capacitance so use a fast time
Delay:         0.00sec         Load has very little capacitance so no delay needed
Lim:           0u- 100mΩ       As required
ON FAIL:       ABORT SEQ
```

Specifications

Specifications are valid at the 95x terminals for 1 year at ambient temperatures within ±5C of calibration temperature (add 5% of accuracy specification per C outside of this). All specifications are relative to the calibration standards used. Add ½ digit to all accuracies for displayed results (results available with enhanced resolution from interfaces).

Test Current Source

Test Current	55mAdc max Opt. LRE-10 : 10mAdc max
Open Circuit Voltage	5V (nominal)
Source Resistance	130Ω (nominal) Opt. LRE-10 : 530 Ω (nominal)

Measurement Accuracy (2-Wire)

Measurement Period	7.25msec measurement period (100ms for test time >2 sec)
Accuracy	<30KΩ : 0.8% + 0.02Ω 30-100KΩ : 1.5%

100-150KΩ : 5%
 Opt. LRE-10 : add 0.001Ω
 Using rear terminals (option RPO only) : add 0.3Ω

Lead Compensation <(±1% of error ± 0.005Ω)

Measurement Accuracy (4-Wire)

Measurement Period 7.25msec measurement period (100ms for test time >2 sec)

Accuracy <30KΩ : 0.8% + 0.002Ω
 30-100KΩ : 1.5%
 100-150KΩ : 5%
 Opt. LRE-10 : add 0.001Ω

Lead Compensation <(±1% of error ± 0.001Ω)

4-wire Compensation SOURCE <(±1% total lead impedance, 100Ω max)
 SENSE <(±0.1% total lead impedance, 100Ω max)

Test Timing

Test Time 0.02 to 9999sec or user terminated
 <(0.05% + 20ms) accuracy (add 100ms for test time >2 sec)

Delay 0.00 to 9999sec
 <(0.05% + 20ms) accuracy (add 100ms for test time >2 sec)

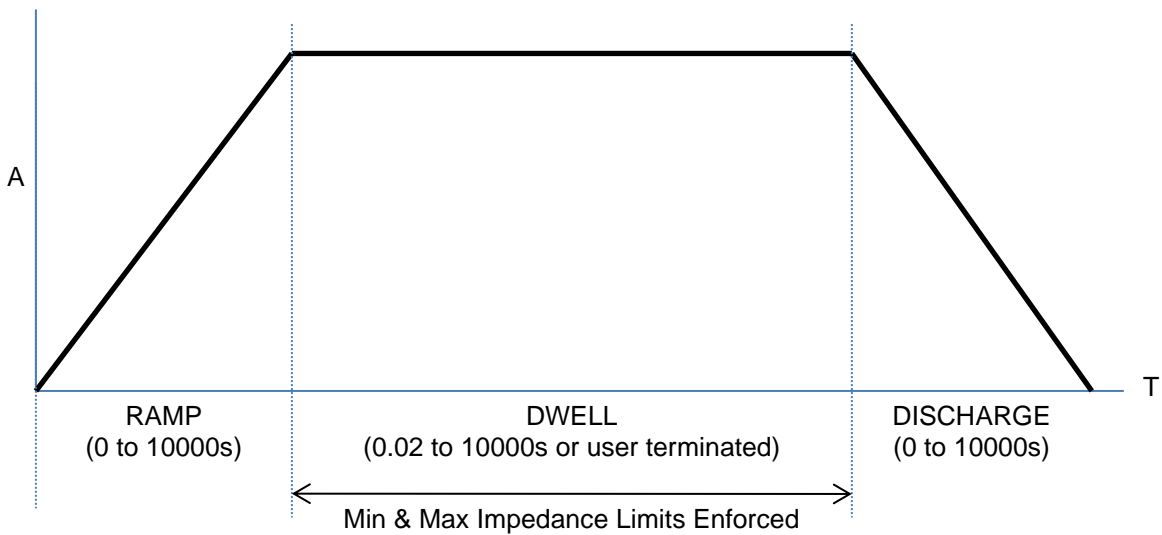
AC Ground Bond Testing (GBez and GB)

These types are primarily for testing resistance values from a few microohms up to 8Ω at a user set AC test current between 0.1 and 40Arms, typically for ground bond testing requirements of safety standards and also for high current connector, cabling, or component testing.

Both GBez and GB are performed in the same manner; the difference between them is in the amount of configuration available. The GBez type is intended for basic applications, the GB type for comprehensive testing. The GB type can be configured to provide the same testing as the GBez type.

	GBez	GB
User set open circuit voltage limit	No	Yes
RMS Impedance Min/Max Limits	Yes	Optional
In-Phase or Quadrature Impedance Min/Max Limits	No	Optional
Timed Ramp	No	Optional
Timed Discharge	No	Optional
Smooth Transition to next test step if GB type	No	Optional

Actions While Running



- Throughout the entire test the actual compliance voltage is measured, and the test current reduced to maintain a constant voltage if above the user set limit – in this situation the front panel **C/V LIMITED** indicator is illuminated. NOTE – if this limiting occurs during the dwell period but the impedance measurement is within limits then the test is failed with a WIRING FAULT condition.
- On any failure the step is immediately aborted, and optionally the entire test sequence may be aborted.
- For the GBez type, the ramp and discharge periods are of zero length.
- For the GB type the discharge period can optionally be skipped if the next step is also a GB type.

Configuring

An example GBez type menu is as follows –

```
Seq 1 Step 1    GBez
LEVEL:25.000A 60.0HZ
DWELL:         30.0sec
Lim:  0.0u-100.0mΩ
ON FAIL:  ABORT SEQ
```

An example GB type menu is as follows –

```
Seq 1 Step 1    GB
LEVEL:25.000A 60.0HZ
V CLAMP:        8.0V
RAMP:           1.00sec
DWELL:          30.0sec
Test:           RMS
Lim:  0.0u-100.0mΩ
DISCHARGE:     FAST
ON FAIL:  ABORT SEQ
```

- **LEVEL.** Allows the test current level and frequency to be programmed.
- **V CLAMP.** Only available for the GB type. Allows the open circuit voltage limit to be programmed as a maximum RMS voltage level.
 - The open circuit voltage limit is automatically set to 8Vrms for the GBez type.

- **RAMP.** Only available for the GB type. Allows the ramp time period to be programmed either as a time or rate. The **UNIT** key toggles the selection between these two methods. In the majority of cases a zero setting should be used.
- **DWELL.** Allows the dwell time period to be programmed or set to be user terminated (with the **START** button) by pressing the **LIMIT** key while this setting is selected.
- **Test.** Only available for the GB type (the GBez type is always set to test the RMS impedance). Allows the user to define the impedance measurements to be checked against range limits. The available selections are –
 - **RMS.** Selects that the impedance check is performed on the RMS impedance measurement.
 - **INPHS.** Selects that the impedance check is performed on the in-phase (i.e., resistance) impedance measurement.
 - **QUAD.** Selects that the impedance check is performed on the quadrature (i.e., reactance) impedance measurement.
- **Lim.** Allows the user to define ranges within which the selected impedance measurement is considered a PASS during the dwell period. The range can be entered in units of impedance or voltage, the **UNIT** key toggles the selection. The user may optionally disable the lower limit by entering a zero value for it.
 - In-Phase and Quadrature measurements can be of either polarity; the limits are applied to the measurement without regard to polarity.
- **DISCHARGE.** Only available for the GB type. Allows the user to program whether the discharge period should use the same timing as the ramp period (AS RAMP), be as fast as possible (FAST) or skipped (NONE). If NONE is selected but the next step is not of a GB type, then the FAST selection is used when the sequence is run. In the majority of cases, FAST should be used.
- **ON FAIL.** Allows the user to program the 95x to abort the entire sequence (ABORT SEQ) or only this step (CONT SEQ) if this step fails any of its checks. A safety related failure or a user abort (**STOP** button) always aborts the entire sequence.

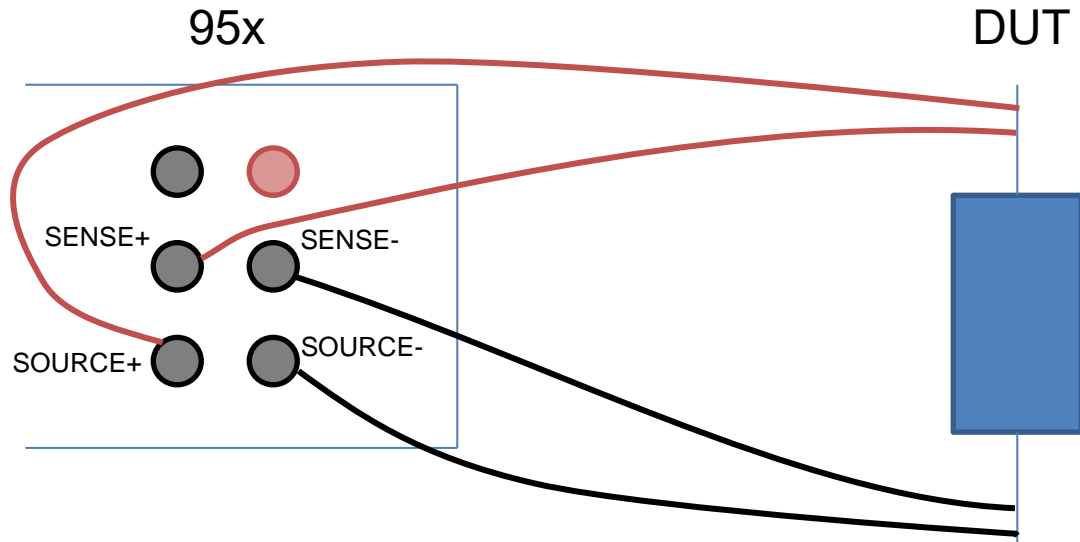
Connecting to the DUT

See [Terminals and Wiring](#) for general wiring and safety recommendations.

The 95x requires that the DUT (at least that portion which is being measured) is floating with respect to ground.

When making 4-terminal measurements the resistance of the wires, the contact resistance to the DUT, and the contact resistance within the 95x front panel terminals are not included in the result, the only recommendation is that the **SOURCE+** and **SOURCE-** wires be of sufficient gage to withstand the user set test current.

When wired as shown below, the actual resistance measured is that between the innermost connection points to the DUT (i.e., between the **SENSE+** and **SENSE-** connections).



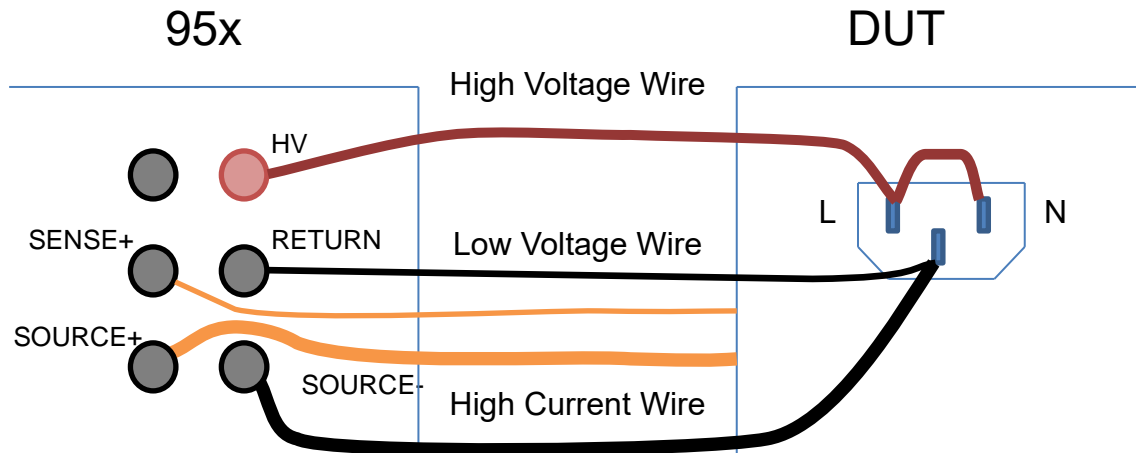
If there is more than nominally 1.5V peak between the respective **SOURCE** and **SENSE** terminals of the 95x then the test is failed with a **WIRING FAULT** condition – the user must ensure that sufficient wire gage is used for the **SOURCE** wires (there is very little current flow in the **SENSE** wires).

If the user needs to make optimum measurements of low impedances, particularly less than a few 10's of mΩ, then the following points should be considered -

- The user should be aware that inductive coupling between the current flow in the **SOURCE** wires and the respective **SENSE** wires will cause errors in the measurement results. If the wires are longer than a few feet and/or are tightly coupled then these errors can be 10's of milliohms at 60Hz and significantly more at 400Hz, particularly when high test currents are being used. This effect is not specific to the 95x, it applies to any high current, low impedance AC measurement.
- When making very low-level measurements or when using long lengths of wiring, the user is recommended to couple (e.g., use a twisted pair) the **SOURCE** wires together and/or couple the **SENSE** wires together for at least the majority of the wire length. Alternatively, if the user maintains at least a $\frac{3}{4}$ " spacing between each wire and all other wires then these effects are also reduced.
- Similarly, there will be some inductive coupling between the DUT and the **SENSE** wires if they are not separated from the DUT sufficiently, to reduce this the **SENSE** wires should not rest on or close to the DUT but should be routed nominally 90° away from the DUT for at least several inches.
- The coupling effects described above will almost always yield a higher-than-expected measurement. If the users' test passes with the measurement within the allowable range of impedances, then, even if these are not accounted for, the DUT is guaranteed to have passed the test – the above effects may only cause a false failure of the test.

Use caution when handling the connections to the DUT after performing a test. If high currents are being used then the power in the contact resistance between the DUT and the **SOURCE** wires, particularly when using clips, may be high, causing the contacts to become hot – at 40A the power in 1mΩ is 1.6Watts. Similarly, the user should ensure that the connections to the front panel **SOURCE** terminals are fully secure – the user is recommended to use lugs and not plug-in connectors for currents above 10A.

The example below shows the connections to a DUT to perform a DC or AC withstand test on the Line/Neutral line power input, and an AC Ground Bond test on the chassis of the DUT in the same sequence. If wired in this manner, then no changes in connections are needed.



Lead Compensation

Lead Compensation is not usually performed when using a 4-wire measurement since lead resistance is automatically eliminated. If the DUT is connected in a 2-wire manner (e.g., separate wires for SOURCE and SENSE, but they are shorted together before the connection to the DUT) then a Lead Compensation may be performed to offset the resistance of the common wiring in future runs.

Lead Compensation should be used with caution to offset errors caused by inductive coupling between the wiring; the inductive coupling effect is not strictly an offset error as it varies with the DUT resistance and reactance, and the use of Lead Compensation could introduce significant errors.

When performing a lead compensation, the impedance limits are not enforced, otherwise the test step is executed normally.

During a lead compensation the **SOURCE+**, **SENSE+**, **SOURCE-** and **SENSE-** wires should be solidly shorted together at the DUT end, the 95x will then measure the resistance and reactance and will automatically subtract them from all future measurements.

For reference, a near perfect 4-terminal short circuit can be created by connecting the leads to the same short, straight, length of heavy gage conductor in the order **SOURCE+**, **SOURCE-**, **SENSE+** and then **SENSE-**. This creates the situation where there is no current flow in the DUT between the SENSE terminals, so there is no measurable impedance between them. The effective impedance of this connection is well below 1uΩ at line frequencies.

Examples

Example 1 -

It is required to test that a DUT chassis is bonded to its grounding terminal with no more than 2.5V drop at 25Arms when tested for at least 30 seconds.

This is accomplished in a single step as follows –

Seq 1 Step 1	GBez	No ramp or discharge, RMS limits, so use GBez
LEVEL:	25.000A 60.0HZ	As required
DWELL:	30.0sec	As required
Lim:	0u-2.5000V	As required
ON FAIL:	ABORT SEQ	

Example 2 -

It is required to test that a DUT chassis is bonded to its grounding terminal with no more than 0.1Ω impedance at 40Arms when tested for at least 30 seconds. The source of the test current must be maintained below 5Vrms at all times to avoid corrosion breakthrough.

This is accomplished in a single step as follows –

Seq 1 Step 1	GB	Require a voltage limit, so use GB
LEVEL:	40.000A 60.0Hz	As required
V CLAMP:	5.0V	As required
DWELL:	30.0sec	As required
Test:	RMS	As required
Lim:	0.0u-100.0mΩ	As required
DISCHARGE:	FAST	
ON FAIL:	ABORT SEQ	

Example 3 –

It is required to test that a line filter inductor is within ±10% of its 1mH nominal inductance and <10mΩ resistance at both 1A @ 60Hz and 10Arms @ 60Hz. At 60Hz the reactance of 1mH is given by $2\pi \cdot F \cdot L = 2 \cdot 3.1416 \cdot 60.0 \cdot 0.001 = 0.37699\Omega$, which is a voltage drop of nominally 3.7699V at 10A so is within the capabilities of the 95x. It has been decided to only test the resistance at the 10A level as that test is the most demanding. It is desired to perform all tests within less than 0.5 second to ensure production throughput.

This is accomplished in three steps as follows –

Seq 1 Step 1	GB	Not testing RMS impedance, so use GB
LEVEL:	1.000A 60.0Hz	As required, perform the 1A test of inductance first
V CLAMP:	8.0V	Not needed, so set to the maximum
DWELL:	0.1sec	No timing requirement, so perform a fast test
Test:	QUAD	Test the inductance
Lim:	339.3m-414.7mΩ	As required
DISCHARGE:	NONE	Don't discharge before the next test, saves test time
ON FAIL:	ABORT SEQ	
Seq 1 Step 2	GB	Not testing RMS impedance, so use GB
LEVEL:	10.000A 60.0Hz	As required
V CLAMP:	8.0V	Not needed, so set to the maximum
DWELL:	0.1sec	No timing requirement, so perform a fast test
Test:	QUAD	Test the inductance
Lim:	339.3m-414.7mΩ	As required
DISCHARGE:	NONE	Don't discharge before the next test, saves test time
ON FAIL:	ABORT SEQ	
Seq 1 Step 3	GB	Not testing RMS impedance, so use GB
LEVEL:	10.000A 60.0Hz	As required
V CLAMP:	8.0V	Not needed, so set to the maximum
DWELL:	0.1sec	No timing requirement, so perform a fast test
Test:	INPHS	Test the resistance
Lim:	0.0u-10.00mΩ	As required
DISCHARGE:	FAST	
ON FAIL:	ABORT SEQ	

The total test time is nominally 0.3 seconds, which could be reduced to 0.15 second with ease.

Specifications

Specifications are valid at the 95x terminals for 1 year at ambient temperatures within $\pm 5\text{C}$ of calibration temperature (add 5% of accuracy specification per C outside of this). All specifications are relative to the calibration standards used. Add $\frac{1}{2}$ digit to all accuracies for displayed results (results available with enhanced resolution from interfaces).

Test Current Source

The following apply at the SOURCE terminals.

Test Current Range	0.100 to 40.000Arms
Test Current Accuracy	$<(\pm 0.5\% \pm 0.005\text{A} \pm 0.005\%$ per Hz above 100Hz) accuracy
Test Current Overshoot	$<10\%$ ($<0.2\text{s}$ ramp time) $<5\%$ ($<0.5\text{s}$ ramp time) $<2\%$ ($>0.5\text{s}$ ramp time) Settling to $<\pm 0.5\%$ of final value in $<0.1\text{sec} + 2$ cycles
Test Frequency	40Hz to 500Hz $<0.1\%$ accuracy
Test Waveform	Sinewave, 1.3 – 1.5 Crest Factor
Compliance	$(8\text{Vrms} - 0.015\text{V/A})$ max compliance at test frequencies $<75\text{Hz}$. For line voltages below 115V linearly reduce the maximum compliance by 1%/V unless Opt. LOLINE is fitted (there is no reduction for Opt. LOLINE).
Loading	10ohm max impedance (any phase, within compliance limits) 250W maximum load power

Voltage Measurements

The following apply at the SENSE terminals.

Range	0uV to 8.0000Vrms (RMS, In-phase and quadrature)
Accuracy	$<(\pm 0.5\% \pm 30\text{uV} \pm 0.5\text{uV} \cdot \text{A})$ accuracy (add $0.005\% + 0.05\text{uV} \cdot \text{A}$ per Hz above 100Hz) $<\pm 0.005^\circ$ per Hz phase relative to test current
Cable Compensation	$<(1\%$ of error)

Impedance Measurements

Accuracy	Add Test Current and Voltage Accuracies as percentages Examples at 50 or 60Hz - 0.1ohm at 1A : $1\% + 0.53\% = 1.53\%$ 0.1ohm at 10A : $0.55\% + 0.5\% = 1.05\%$ 0.1ohm at 40A : $0.51\% + 0.5\% = 1.01\%$ 0.01ohm at 1A : $1\% + 0.8\% = 1.8\%$ 0.01ohm at 10A : $0.55\% + 0.53\% = 1.08\%$ 0.01ohm at 40A : $0.51\% + 0.51\% = 1.02\%$ 0ohm at 1A : 30.5uohm
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0ohm at 10A : 3.5uohm
 0ohm at 40A : 1.25uohm

Test Timing

Ramp	0.00 to 9999sec <(± 1% ± 0.1sec ± 1 cycle) accuracy
Dwell	0.02 to 9999sec or user terminated <(± 0.05% ± 20ms ± 1 cycle) accuracy
Fast Discharge	<(20ms + 1 cycle)

Ground Leakage Testing (DCI and ACI)

These types are intended for testing that a product does not exceed ground leakage requirements, usually of safety standards.

Both types are similar, the difference being that the DCI type tests for DC ground leakage current while the ACI type tests for AC ground leakage current.

Actions While Running

During the test step the 95x measures the ground leakage current and checks that the result is within the user set range. The 95x also measures the voltage on the **HV** terminal relative to ground and makes the result of this measurement available to the user, if not required then this can be ignored.

Optionally, the user can also detect arc currents and fail the DUT if they are found over the user set limit.

The user can set for there to be a delay at the beginning of the test step before the limits are enforced on the ground leakage current measurement.

Configuring

An example DCI menu is as follows –

```
Seq 1 Step 1    DCI
TIME:          25.0sec
Delay:         0.05sec
Lim:           0n-35.00mA
ARC DETECT:4us 10mA
ON FAIL:      ABORT SEQ
```

An example ACI menu is as follows –

```
Seq 1 Step 1    ACI
TIME:          25.0sec
Delay:         0.05sec
Lim:           0n-35.00mA
ARC DETECT:4us 10mA
ON FAIL:      ABORT SEQ
```

- **TIME.** Allows the user to program the total test time.
- **Delay.** Allows the user to set a delay time before which the limits are not enforced.
- **Lim.** Allows the user to set a minimum and maximum limit for the ground leakage current beyond which the DUT will be failed.

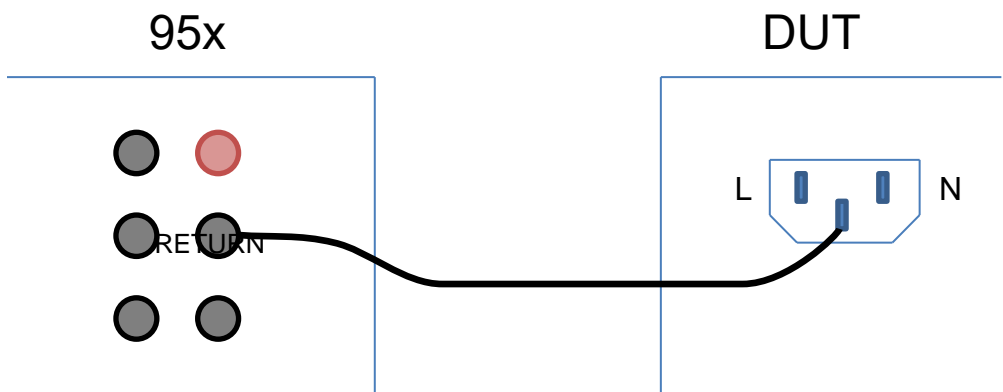
- **ARC DETECT.** Allows the user to program arc detection during this step. Both the time and current level can be independently programmed. ARC detection can also be disabled by setting the leftmost (time) setting to OFF.
 - The 95x can be configured to not fail a test step when arcing is detected. This is configured by the ARC setting in the CNFG – TEST sub-menu.
- **ON FAIL.** This allows the user to program the 95x to abort the entire sequence (ABORT SEQ) or only this step (CONT SEQ) if this step fails any of its checks. A safety related failure or a user abort (**STOP** button) always aborts the entire sequence.

Connecting to the DUT

The 95x measures the current flowing into the **RETURN** terminal to the 95x ground during these tests.

The **RETURN** terminal of the 95x provides a safety ground to the DUT during these tests.

NOTE – since the 95x does not control the source of power to the DUT, there is no automatic shutdown if an excessive current flows. The 95x contains a low voltage (<30V) MOV type protection device from the **RETURN** terminal to its chassis ground if excessive current flows, but the user should take additional measures to protect the system from high current flows in the event of a DUT failure.



The example above shows a typical DUT ground leakage connection between the DUT and the 95x. The DUT line and neutral connections would normally be connected to a line and neutral line power source. The 95x is used to check that the DUT does not have excessive ground leakage using the ACI type test step.

For this type of testing, it is often also required to test the ground leakage of several exposed portions of the DUT as well as the ground connection of the DUT. In those cases, the same connection to the 95x would be used, but the connection to the DUT would be to each required test point on the DUT.

This type of testing is often used for testing that the patient connections of a medical device meet ground leakage safety standards. In these cases, the DUT would be connected normally, either with or without its power ground connection as required by the standard, and each patient connection would be tested for ground leakage by connecting it to the 95x RETURN terminal.

Lead Compensation

Lead Compensation is not usually performed on these types. If needed, then Lead Compensation can be used to reduce the effects of external leakage current.

When performing lead compensation, the ground leakage current limits are not enforced, otherwise the test step is executed normally.

During a lead compensation the **RETURN** wire should not be connected to the DUT.

Examples

Example 1 -

It is required to test that a DUT ground leakage from its chassis is less than 5mA when line powered. The DC leakage current is not required to be tested.

It is assumed that the connection is made prior to the start of the test.

This is accomplished in a single step as follows –

Seq 1 Step 1	ACI	AC RMS leakage required, so use ACI
TIME:	0.10sec	No timing requirement, so perform quickly
Delay:	0.00sec	Already connected, so no delay needed
Lim:	0n-5.000mA	Per the requirement
ARC DETECT:	OFF	Not required so disabled
ON FAIL:	ABORT SEQ	

Example 2 -

The same requirement as in example 1 but both AC and DC leakage currents are to be tested.

This is accomplished in two steps as follows –

Seq 1 Step 1	ACI	AC RMS leakage required, so use ACI
TIME:	0.10sec	No timing requirement, so perform quickly
Delay:	0.00sec	Already connected, so no delay needed
Lim:	0n-5.000mA	Per the requirement
ARC DETECT:	OFF	Not required so disabled
ON FAIL:	ABORT SEQ	
Seq 1 Step 2	DCI	DC leakage required, so use DCI
TIME:	0.10sec	No timing requirement, so perform quickly
Delay:	0.00sec	Already connected, so no delay needed
Lim:	0n-5.000mA	Per the requirement
ARC DETECT:	OFF	Not required so disabled
ON FAIL:	ABORT SEQ	

Example 3 -

It is required to test that a medical device patient connection has less than 50uA ground leakage. The test is to be performed over a 10 second period to ensure that any periodic current is detected.

This is accomplished in a single step as follows –

Seq 1 Step 1	ACI	AC RMS leakage required, so use ACI
TIME:	10.0sec	Per the timing requirement
Delay:	0.00sec	Already connected, so no delay needed
Lim:	0n-50.00uA	Per the requirement
ARC DETECT:	OFF	Not required so disabled
ON FAIL:	ABORT SEQ	

Example 4 -

It is required to test the leakage current of material sample over a range of voltages. This is to be performed manually, using an external source of voltage. This could be a DC or AC test, for this example DC is used.

The external voltage source is connected to one end of the material sample, with its common terminal grounded, and the 95x RETURN terminal is connected to the other end of the material sample.

If the voltage being used is within the measurement capability of the 95x, then the output of the external voltage source could also be connected to the HV terminal of the 95x, in which case the 95x display would also show the actual applied voltage to the material sample.

A single step is used as follows –

Seq 1 Step 1	DCI	DC leakage required, so use DCI
TIME:	user sec	Use manual timing, press the START button when finished
Delay:	0.00sec	Already connected, so no delay needed
Lim:	0n-5.000mA	Set wide limit, the user will manually check the results
ARC DETECT:	OFF	Not required so disabled
ON FAIL:	ABORT SEQ	

Specifications

Specifications are valid at the 95x terminals for 1 year at ambient temperatures within $\pm 5\text{C}$ of calibration temperature (add 5% of accuracy specification per C outside of this). All specifications are relative to the calibration standards used. Add $\frac{1}{2}$ digit to all accuracies for displayed results (results available with enhanced resolution from interfaces).

HV Voltage Measurements

DC Voltage Range	951i,952i,956i : 0.0 to +/-8000V 953i,954i,955i : 0.0 to +/-11000V Option HSS or HSS-2 : 0.0 to +/-5000V
AC Voltage Range	951-4i,956i : 0.0 to 6000Vrms 955i : 0.0 to 10000Vrms Option HSS or HSS-2 : 0.0 to 4000Vrms
DC Accuracy	<($\pm 0.25\% \pm 0.5\text{V}$)
AC Accuracy	<($\pm 0.5\% \pm 0.5\text{V} \pm 0.01\%$ per Hz above 100Hz)
Input Impedance	Nominally 100M Ω

RETURN Current Measurements

Current Range	0.0nA to 200mA (DC or ACrms)
DC Current Accuracy	<($\pm 0.25\% \pm 0.5\text{nA}$)
AC Current Accuracy	<($\pm 0.5\% \pm 20\text{nA} \pm 0.005\%$ per Hz above 100Hz)
Input Impedance	<150uA : Nominally 5K Ω >150uA : Nominally 37 Ω
Arc Current	1 to 30mArms (50KHz-5MHz bandwidth) <($\pm 10\% \pm 1\text{mA}$) accuracy at 1MHz 4us, 10us, 15us, 20us, 30us or 40us measurement period
Cable Compensation	<($\pm 1\%$ of error)

Test Timing

Test	0.02 to 9999sec or user terminated <(± 0.05% ± 100ms) accuracy
Delay	0.00 to 9999sec <(± 0.05% ± 100ms) accuracy

Switch Unit Control (SWITCH)

This type is used to control one or more external Switch Matrix Units (either Vitrek 948 or 964 units).

NOTE – to be able to define or edit a SWITCH test step the 95x must already be configured to control one or more switch matrix units, see [Controlling External Switch Matrix Units](#).

Actions While Running

The external switch matrix units are controlled by the 95x in three periods as follows –

1. **Pre-switch Period.** During this period, the 95x checks for the presence of each configured switch matrix unit and also delays for at least the user set pre-switch delay period. If a configured switch matrix unit fails to be detected, then the sequence is aborted. As soon as all units have been detected and the minimum delay has expired, the switch command period is started.
2. **Switch Command Period.** During this period all configured switch matrix units have their relays commanded into the user set states. As soon as this is completed the post-switch period is started.
3. **Post-switch Period.** The 95x stays in this period until the user set post-switch delay has expired. This period allows for relay and wiring settling after changing the relay states. As soon as the delay has expired the next test step in the test sequence is started.

Configuring

An example SWITCH type menu is as follows –

```
Seq 1 Step 1 SWITCH
PRE-DELAY: 0.00sec
POST-DELAY: 0.25sec
#1: 0000000000000000
```

- **PRE-DELAY.** Allows the pre-switch delay to be specified.
- **POST-DELAY.** Allows the post-switch delay to be specified. When controlling a Vitrek 948 this should be set to a minimum of 0.20sec, for a Vitrek 964 this can be set to zero if there are negligible wiring settling requirements.
- **#1.** Allows the user to specify, using a hexadecimal code, the required relay states for switch matrix unit #1. If configured for more than one switch matrix unit, there are further menu lines added for each additional switch matrix unit. If configured for a Vitrek 948 then this menu line has 14 characters, for a Vitrek 964 it has 16 characters. The hexadecimal code sets a binary code defining the required states of relays #64 through 1 (for a 964) or #56 through 1 (for a 948) in left-to-right order. A '1' in this code indicates that the relay is to be in the ON state. See the relevant switch matrix manual for further details regarding setting these codes. The user should ensure that the state of any relay which is not actually fitted in the switch matrix unit is '0'.

NOTE – the 95x does not change the states of switch matrix units unless commanded to do so by a SWITCH test step. It is recommended to finish a test sequence using switch matrix units with a SWITCH type step setting the relays to best “quiescent” state for the users’ specific system (generally the OFF state for all relays).

Examples

Example 1 -

The user wishes to set a single Vitrek 964 to engage (ON) relays #1, 28 and 47; all other relays are to be disengaged (OFF).

Since a Vitrek 964 is being used, no delays are needed.

The 64-bit code for the required state is (splitting the binary into groups of 8 bits for easier viewing) –

```
00000000 00000000 10000000 00000000 00010000 00000000 00000000 00000001
```

In hexadecimal this is 00 00 80 00 10 00 00 01 (keeping the same grouping as above)

The SWITCH step is configured as –

```
Seq 1 Step 1 SWITCH
PRE-DELAY: 0.00sec
POST-DELAY: 0.00sec
#1: 0000800010000001
```

Example 2 -

This is the same as example 1 above but using a Vitrek 948.

Since a Vitrek 948 is being used, a 0.25sec post-switch delay is needed.

The 56-bit code for the required state is (splitting the binary into groups of 8 bits for easier viewing) –

```
00000000 10000000 00000000 00010000 00000000 00000000 00000001
```

In hexadecimal this is 00 80 00 10 00 00 01 (keeping the same grouping as above)

The SWITCH step is configured as –

```
Seq 1 Step 1 SWITCH
PRE-DELAY: 0.00sec
POST-DELAY: 0.25sec
#1: 00800010000001
```

Specifications

Pre- or Post-Switch Delay	0.00 to 9999sec
	<(± 0.05% ± 20ms) accuracy

Test Sequence Timing Control (PAUSE and HOLD)

The PAUSE type is generally used when the user needs to have a fixed delay inserted into a test sequence to allow for wiring or DUT settling between two test steps.

The HOLD type is generally used when the user needs to have some user interaction to occur prior to continuing the test sequence. A timeout is provided which, if it occurs, will abort the entire sequence if the user does not provide user interaction (e.g., pressing the **START** button, asserting the DIO interface START signal, or sending the interface CONT command).

Configuring

An example PAUSE type menu is as follows –

Seq 1 Step 1 PAUSE
TIME: 0.00sec

- **TIME.** Allows the user to set the desired pause time. Any value between 0.00 and 9999 seconds may be entered.

An example HOLD type menu is as follows –

Seq 1 Step 1 HOLD
TIMEOUT: 30.0sec

- **TIMEOUT.** Allows the user to set the desired hold timeout. Any value between 0.00 and 9999 seconds may be entered. Setting a zero value disables the timeout entirely; the 95x will wait “forever” for user interaction to occur.

Examples

Example 1 -

The user wishes to program a 1 second pause into a test sequence to allow for wiring settling between two steps.

A PAUSE step is configured as –

Seq 1 Step 28 PAUSE
TIME: 1.00sec

Example 2 -

The user wishes to program a step to have the sequence wait for user interaction before proceeding. This will be used to allow the user to manually alter the DUT wiring. It is desired to time out the sequence if the user does not respond within 1 minute.

A HOLD step is configured as –

Seq 1 Step 28 HOLD
TIME: 60.0sec

Specifications

Delay or Timeout	0.00 to 9999sec <(± 0.05% ± 20ms) accuracy
------------------	---

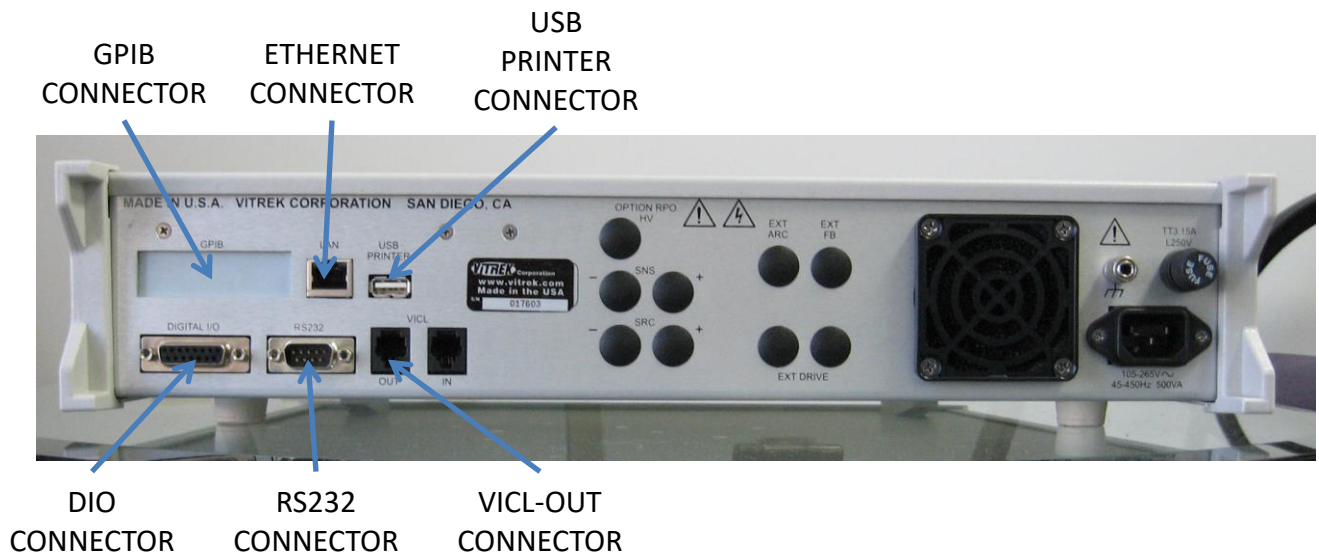
SECTION 7 – CONNECTING AND CONFIGURING INTERFACES

The 95x contains several interfaces, some of which are options. This section describes how to configure and connect to each interface. Each description of menus only includes the settings pertinent to the section being described.

For the DIO interface, see [SECTION 8 – DIO INTERFACE](#)

For programming information using an interface to control the 95x see [SECTION 11 – PROGRAMMING VIA AN INTERFACE](#).

NOTE – The user is recommended to disable all unused interfaces to avoid interference effects.



LOCAL and REMOTE Operation

When the 95x receives a command from an enabled interface the front panel **REMOTE** indicator is illuminated, and the user may not use the front panel menus. To attempt to return the 95x into the local state the user should press the **CNFG** key on the 95x front panel. If the 95x has been enabled to return to the local state by the controlling interface, then the **REMOTE** indicator will extinguish, and a message is displayed on the 95x front panel.

Controlling External Switch Matrix Units

The 95x can be configured to control one Vitrek 948i or up to 4 Vitrek 964i Switch Matrix units.

NOTE – the 95x must be configured to control an external Switch Matrix unit before a test sequence can be created which contains steps to control it.

Configuration

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is – TEST...

```

PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD:000000
RELOCK...
    
```

- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.
- The 95x now displays the base interfaces configuration settings menu, an example of which is –

```

RS232 BAUD:    115200
SWITCH:        NONE
DISABLE USB:    NO
DISABLE GPIB:  NO
DISABLE ENET:  NO
ETHERNET...
GPIB ADDR:     2
    
```

- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting controlling external switch matrix units are –
 - **RS232 BAUD.** This setting is only used when controlling an external 964i Switch Matrix unit via the RS232 interface. Its setting should match the baud rate setting in the attached 964i.
 - **SWITCH.** This allows the user to select the method by which external switch matrix units are interfaced to the 95x. The available selections are –
 - **NONE.** No switch matrix units are controlled by the 95x.
 - **948 (SERIAL).** A single Vitrek 948i Switch Matrix unit is being controlled by the 95x via the RS232 serial interface. The RS232 BAUD setting is ignored if this is selected.
 - **964 (SERIAL).** A single Vitrek 964i Switch Matrix unit is being controlled by the 95x via the RS232 serial interface.
 - **964 (VICLx1).** A single Vitrek 964i Switch Matrix unit is being controlled by the 95x via the VICL interface. The 964i must be configured for VICL and set to address 1.
 - **964 (VICLx2).** Two Vitrek 964i Switch Matrix units are being controlled by the 95x via the VICL interface. All 964i's must be configured for VICL and set to addresses 1 and 2.
 - **964 (VICLx3).** Three Vitrek 964i Switch Matrix units are being controlled by the 95x via the VICL interface. All 964i's must be configured for VICL and set to addresses 1, 2 and 3.
 - **964 (VICLx4).** Four Vitrek 964i Switch Matrix units are being controlled by the 95x via the VICL interface. All 964i's must be configured for VICL and set to addresses 1, 2, 3 and 4.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. NOTE – the settings are not active until all menus have been exited.

Connections

Refer to the instructions received with the specific Switch Matrix unit(s) for details regarding connecting the terminals of the 95x to those of the Switch Matrix Units.

RS232 Interface

Using an RS232 cable supplied by Vitrek, connect the RS232 port on the 95x rear panel to the RS232 (Serial) port of the Vitrek 948i or 964i. The user may supply their own cable, in which case it should be a 9-wire female-female null modem cable capable of full handshake 115200baud operation.

VICL

Using a VICL cable supplied by Vitrek, connect the VICL – OUT port on the 95x to a Vitrek 964i VICL – IN port. If using more than one 964i, then connect each additional Vitrek 964i VICL – IN port to the preceding 964i's VICL – OUT port. The 964i's do not need to be wired together in any specific order when using the VICL interface.

Controlling the 95x by the RS232 Interface

NOTE – the RS232 interface can only be used for a single purpose, it cannot be used for both controlling an external Switch Matrix unit and controlling the 95x.

Specifications

Baud Rate	9600, 19200, 57600 or 115200
Handshake	Bi-directional, hardware (RTS/CTS)
Data Bits	8
Parity	None
Start/Stop Bits	1
Connector	9-pin Male Dsub
Interface Pinout Type	DTE (same as PC computer)
Cable required	9-wire female-female null modem cable, fully wired
Cable Length	<50ft (per standard)

Configuration

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –


```
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD:000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.

- Press the **ENTER** key.
- The 95x now displays the base interfaces configuration settings menu, an example of which is –


```
RS232 BAUD: 115200
SWITCH: NONE
DISABLE USB: NO
DISABLE GPIB: NO
DISABLE ENET: NO
ETHERNET...
GPIB ADDR: 2
```
- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting using the RS232 to control the 95x are -
 - **RS232 BAUD.** This setting must match the baud rate setting of the attached computer.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. NOTE – the settings are not active until all menus have been exited.

Connections

Using an RS232 cable supplied by Vitrek, connect the RS232 port on the 95x rear panel to the RS232 (Serial) port of a computer. The user may supply their own cable, in which case it should be a 9-wire female-female null modem cable capable of full handshake 115200baud operation.

Controlling the 95x by the GPIB Interface

Configuration

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –


```
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD:000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.
- The 95x now displays the base interfaces configuration settings menu, an example of which is –


```
RS232 BAUD: 115200
SWITCH: NONE
DISABLE USB: NO
DISABLE GPIB: NO
DISABLE ENET: NO
ETHERNET...
GPIB ADDR: 2
```

- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting using the RS232 to control the 95x are –
 - **DISABLE GPIB.** This must be set to NO to enable the GPIB interface in the 95x.
 - **GPIB ADDR.** This must be set to a chosen address for the 95x on the GPIB bus. Addresses in the range 1 through 29 may be used if there is no other device on the bus at that address. Software on the computer will need to be set to match this address in order for it to communicate with the 95x.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

Connections

Using a standard GPIB cable connect the GPIB port on the 95x rear panel to the GPIB port of a computer. It is recommended to use a high quality, shielded GPIB cable. Cables may be purchased from Vitrek.

Controlling the 95x by the Ethernet Interface

Specifications

Speed	10baseT or 100baseTX, auto-selected
Duplex	Half or full-duplex, auto-selected
MDI/MDIX	Auto-selected
Protocols	ICMP, ARP, DHCP, TCP/IP (IPv4 only)
TCP Port	10733
Remote Connections	Only one remote connection is allowed at any given time
Connector	RJ45
Cable required	CAT5 or CAT5e, UTP or STP
Cable Length	<100m (per standard)

Configuration

Prior to configuring the 95x or connecting the 95x to a network, the user must have knowledge of certain aspects of the network –

- The user must ascertain if the network uses DHCP or not for allocation of IP addresses.
- If the network does not use DHCP for allocation of IP addresses, then the user must choose a suitable unused IP address within the local network subnet, the subnet mask of the local network, and the gateway IP address to additional networks.
- Some networks which use DHCP allocation of IP addresses limit the allocation of addresses to known devices by means of a list of known MAC addresses. In this case the user must ascertain the MAC address of the 95x and correctly configure the DHCP server prior to connecting the 95x to the local network.

Configure the Ethernet Interface of the 95x as follows -

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.

- The display now shows the main configuration menu, an example of which is –
 - TEST...
 - PRINTOUT...
 - SYSTEM...
 - INTERFACES...
 - DIGITAL I/O...
 - BUILD...
 - SET TO DEFAULTS...
 - LOCK PASSWORD:000000
 - RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.
- The 95x now displays the base interfaces configuration settings menu, an example of which is –
 - RS232 BAUD: 115200
 - SWITCH: NONE
 - DISABLE USB: NO
 - DISABLE GPIB: NO
 - DISABLE ENET: NO
 - ETHERNET...
 - GPIB ADDR: 2
- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting using the RS232 to control the 95x are –
 - **DISABLE ENET.** This must be set to NO to enable the Ethernet interface in the 95x.
 - **ETHERNET...** This selection is the entry point to the sub-menu for configuring the Ethernet interface. The user should navigate to select this menu line and press then **ENTER** key.
- The Ethernet sub-menu allows the user to configure the 95x for the local network. An example of this sub-menu is as follows –
 - USE DHCP: YES
 - IP: 000.000.000.000
 - SNET:000.000.000.000
 - GTWY:000.000.000.000
 - MAC: 1234567890AB
- The user may navigate this sub-menu and change the displayed settings as required. The settings are –
 - **USE DHCP.** Allows the user to configure the 95x to use DHCP for IP address allocation (YES) or not (NO).
 - **IP.** If using DHCP, this shows the IP address which the 95x has been allocated. If not using DHCP this allows the user to enter an IP address for the 95x on the local network.
 - **SNET.** If using DHCP, this shows the IP subnet mask which the 95x has been given. If not using DHCP this allows the user to enter the subnet mask for the local network.
 - **GTWY.** If using DHCP, this shows the IP of the gateway to additional networks which the 95x has been given. If not using DHCP this allows the user to enter the IP address of the gateway.
 - **MAC.** This is not editable and shows the MAC address of the 95x. This may be needed to configure the local network to allow connection of the 95x to it. In most networks this is not needed.

- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. NOTE – the settings are not active until all menus have been exited.
- If using DHCP the user should re-enter the ETHERNET configuration sub-menu and note the IP address allocated to the 95x. This will be needed to configure the TCP/IP client software used to communicate with the 95x.

Connections

The 95x connects to the local network using a standard CAT5 or CAT5e Ethernet cable and RJ45 connector.

When initially connected to the network the 95x display shows a message for 2 seconds detailing the actual speed and duplex used for the connection.

Printing from the 95x using the USB Interface

Specifications

Printer Class	Printer must be a “Printer” USB Class device
Printer Language	PJL/PCL (HP)
USB Speed	Full Speed
Hub	Not supported

Many printers meet the requirements above; Vitrek has tested the 95x with the HP OfficeJet Pro 8000 Series and the HP LaserJet 2420. The 95x is generally not compatible with multi-purpose printers (e.g., “All-in-One” types).



The USB interface option must be installed and enabled.

Connecting

The printer should be connected to the 95x USB Host port using a standard USB cable of any suitable length. The printer must be directly connected to the 95x, a hub must not be used.

When the printer is initially plugged in to the 95x, or when the printer is initially powered (for some printers) the 95x displays an informative message for 2 seconds detailing the status of the printer connection.

The user may also view the status of the connection to the printer at any time by using the following procedure –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD: 000000
RELOCK...

- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the PRINTOUT line.
- Press the **ENTER** key.
- The display now shows the test report printout configuration menu. An example of the test report printout configuration menu is as follows –

```
STATUS:    ATTACHED
HEADING:
AUTO TEST REPORT: NO
TEST DETAIL:  NORMAL
SERIAL #:    NO
```

- The STATUS line shows the status of the present connection to the printer. See later in this document regarding the remainder of this menu.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

Printing

While printing the display of the 95x shows the progress and any errors which occur –

- **PRINTING.** This is displayed while the printout is being performed. The user may press the **STOP** button on the 95x front panel to abort a printout.
- **PRINTER DISCONNECTED.** Indicates that the USB cable became disconnected.
- **PRINTER USB BUS ERROR.** Indicates that an unrecoverable USB bus error occurred. The 95x automatically reinitializes the USB bus after this, but the printout is aborted. This is typically caused by severe interference on the USB cable.
- **PRINTER TIMEOUT.** This occurs after a printout is suspended by the printer for over 10 minutes.
- **PRINT ABORTED.** This occurs when the user aborts a printout using the front panel **STOP** button.

Configuration Printout

This is commanded by pressing the **PRINT** key while the 95x is in the base menu state (i.e., displaying the date and time). The printout contains a complete listing of all the configuration settings and the build state of the unit.

Test Sequence Printout

This is commanded by pressing the **PRINT** key while the user is selecting a test sequence using the **SELECT** key. The printout contains a full listing of all the settings for each defined step in the selected test sequence.

Test Results Report Printout

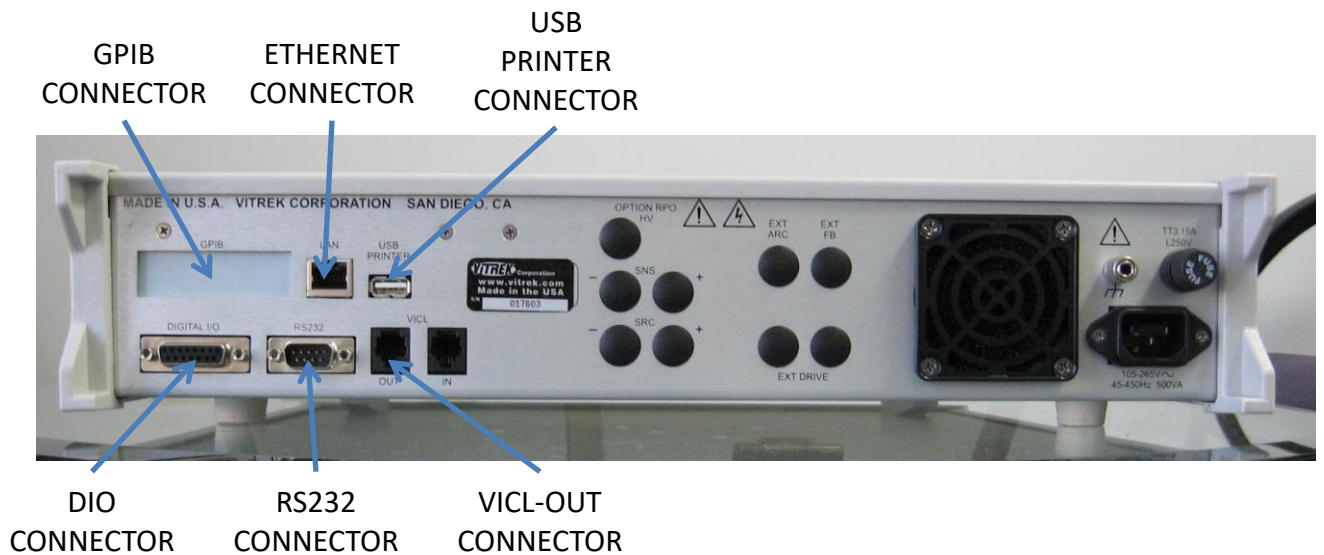
See [Printing a Test Results Report](#).

SECTION 8 – DIO INTERFACE

Using the 95x Digital Input & Output (DIO) interface the user may perform any combination of the following –

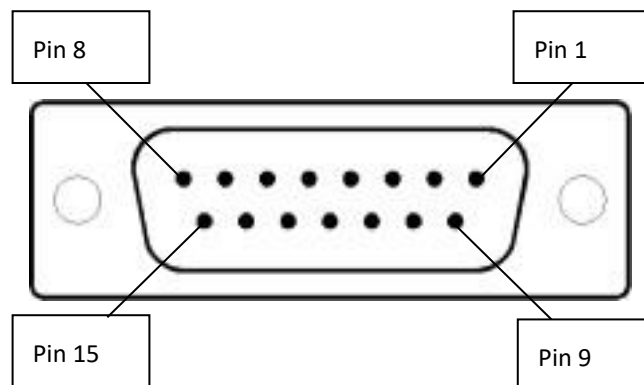
- Control the 95x using a PLC type device, starting, stopping, selecting a sequence, and determining the pass/fail status
- Control the 95x using external start and/or stop switches
- Abort a test sequence when a safety interlock is opened
- Allow the 95x to illuminate external safety indicators

Connector and Pinout



The DIO signals are available at the rear panel of the 95x in the 15-pin connector identified as “DIGITAL I/O” as shown in the photograph above. The 95x connector is a standard two-row 15-pin female Dsub connector; any suitable male mating connector may be used.

The diagram below shows the pin locations within the connector as viewed from the rear panel of the 95x.



The following table contains a description of the signal on each pin in the connector. Each input and output signal can be configured as the active level being low or high, or each input may be disabled.

Pin 1	+12VDC		Internal +12VDC power source, internally fused 100mA (self-resetting)
Pin 2	HV PRESENT	Output	Active whenever an unsafe voltage or current is present on the 95x terminals
Pin 3	COMMON		Common Reference signal for all digital inputs and outputs (Digital Ground, internally connected to the 95x chassis ground)
Pin 4	START	Input	Starts a test sequence when transitions inactive to active. This may also be used to continue a test sequence when it is waiting for user interaction (e.g., in a HOLD step, or programmed for a user terminated test step). If the SEQUENCE input signals are not used to select a sequence, then a sequence must have been already manually selected at the front panel. If the 95x is waiting for the front panel START button to be pressed while running a test sequence (i.e., waiting for user interaction) then an inactive to active transition of the START signal will also continue the sequence.
Pin 5	ABORT	Input	Aborts a test sequence when active. This signal has priority over the START signal; disabling it while ABORT is active.
Pin 6	INTERLOCK	Input	Aborts a test sequence (high voltage or current steps only) when inactive
Pin 7	PRINT	Input	Initiates a Test Results Printout Note – as of v2.02 firmware, this capability has not been implemented in the 95x
Pin 8	SEQUENCE 1	Input	These signals are only used at the instant of the START signals' transition which starts a sequence; they are ignored at all other times. Sequence # 0 through 15 is selected and run according to the state of these signals.
Pin 9	SEQUENCE 2		
Pin 10	SEQUENCE 4		
Pin 11	SEQUENCE 8		
Pin 12	PASS	Output	Active after the end of a sequence if passed
Pin 13	FAIL	Output	Active after the end of a sequence if failed
Pin 14	TESTING	Output	Active while running a sequence
Pin 15	DWELL	Output	Active during the dwell period of a measurement type of test

Configuring

The DIO interface may be configured from the front panel by using the DIGITAL I/O sub-menu of the CNFG menu as follows –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CNFG** key.
- The display now shows the main configuration menu, an example of which is –
TEST...
PRINTOUT...
SYSTEM...
INTERFACES...
DIGITAL I/O...


```
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD: 000000
RELOCK...
```

- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the DIGITAL I/O line.
- Press the **ENTER** key.
- The display now shows the Digital I/O configuration menu. An example of the Digital I/O configuration menu is as follows –

```
START:          IGNORE
ABORT:          IGNORE
INTERLOCK:      IGNORE
PRINT:          IGNORE
SEQUENCE:       IGNORE
PASS:           ACTIVE LO
FAIL:           ACTIVE LO
TESTING:        ACTIVE HI
DWELL:          ACTIVE HI
HV:             ACTIVE HI
```

- The user may navigate this sub-menu and change the displayed settings as required.
 - **START, ABORT, INTERLOCK, PRINT** and **SEQUENCE**. These allow the user to select whether the respective digital input is to be ignored, active low or active high.
 - If either the INTERLOCK signal is enabled and set for active low, or the ABORT signal is enabled and set for active high, then the 95x will be prevented from running any test sequence if the DIO signals are removed (e.g., the cable is unplugged). If this is not intended, then these signals should be used with the opposite polarity (i.e., active high for INTERLOCK and active low for ABORT).
 - CAUTION – changing the active level of the START signal may cause the 95x to detect a change in the START signal from the inactive to the active state (e.g., if the signal is high and the configuration is changed from active low to active high). This may cause a previously selected sequence to be run and high voltages to become present on the 95x terminals. The user should ensure that no sequence is selected and that the START signal will end up being in the inactive state when changing the polarity of the START signal.
 - **PASS, FAIL, TESTING, DWELL** and **HV**. These allow the user to select whether the respective digital output is to be active low or active high.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. The settings are not used until they are saved.

Signal Levels

Each input signal has the following characteristics –

- Each is referenced to the COMMON signal, which is internally connected to the 95x chassis ground.
- The maximum input level guaranteed to be recognized as a low level is +1V, the minimum guaranteed to be recognized as a high level is +2.3V.

- Each has an internal pull-up resistor of nominally 1.8K Ω to an internal 4V level and is protected to 5V.
- Each has a nominally 10nF capacitance to the COMMON signal.
- Each can be directly interfaced to a contact closure or a TTL, CMOS or LVCMOS logic source. If the input is to be actively driven from a higher voltage logic signal than 5V (e.g., 12V) then one of the following should be used –
 - A suitable value series resistance should be placed in each input signal line to limit the current in the 5V protection to a maximum of 30mA (for 12V logic signals the recommended series resistance is 390 Ω). The maximum series resistance value allowable is nominally 600 Ω to achieve the guaranteed low voltage level.
 - A diode should be placed in series with the signal with its anode connected towards the 95x connector. This will effectively change the high voltage digital signal to a contact closure type, only being able to pull the 95x input to the low state and relying on the 95x internal pull-up resistor to select the high state.
 - A suitable logic level translation circuit should be employed between the high voltage logic and the 95x.
 - An isolation circuit must be employed between the high voltage logic signal and the 95x input.

Each output signal has the following characteristics –

- Each has an open-drain drive with >12V withstand and >500mA sink capability (<1.3 Ω impedance) with a pull-up resistor of nominally 2.2K Ω to an internal 5V level.
- Each is internally clamped to nominally 16V (14V minimum) so may be used to directly drive a relay. When using a digital output to drive a 12V relay coil or indicator the user should consider that each output has a nominally 3.2mA current flow into the 95x when the output is in the off state at +12V. The user must ensure that this current is insufficient to operate the relay or indicator. If this current is not acceptable then the signal must be buffered by a suitable driver, e.g., a NPN transistor, N-channel MOSFET, buffer IC, or an isolation device.

Signal Isolation

When operating the 95x in adverse environments having a large amount of ground noise, or when the 95x is being at very high-test voltage levels, it is recommended to provide isolation between the 95x DIO signals and the remote device if that is also grounded or has significant capacitance to ground. This avoids transient ground voltages during DUT breakdown from causing improper operation of the interface. The user should consider using relays (mechanical or solid state) or logic type optical couplers to provide the isolation. In extreme conditions, the user may need to take steps to ensure that there is minimum capacitance across the isolation barrier formed by these components and also that they are specified for the high voltage transients which could occur – it is recommended that isolation devices with a capacitance of <20pF and a voltage withstand capability of >2.5KVpk be used.

Signal Timing

In this section there are several references to signals needing to be active or inactive for minimum periods of time. The time shown is the minimum guaranteed time for the action described to occur, times less than shown may also function correctly but they are not guaranteed to be reliable.

Starting with the START signal

The following timing constraints on the DIO signals must be observed when starting a test sequence using the START signal –

- The TESTING output signal from the 95x must have been inactive for >5ms before a sequence may be started.
- If enabled, the ABORT signal must be inactive for >5ms before the inactive to active transition of the START signal.
- The START signal must have been inactive for >5ms before attempting to start.
- The START signal must be active for >10ms, there is no maximum time.
- If enabled, the SEQUENCE signals must all be stable in the required state for >5ms before and after the inactive to active transition of the START signal.

The test sequence is started within <(10ms + 1ms per test step in the sequence commanded by the SEQUENCE input signals if enabled) after recognition of the inactive to active transition of the START signal. At that time the PASS, FAIL and TESTING output signals are set by the 95x to the following states with <±100us skew between them-

- PASS and FAIL – both made inactive if the sequence is valid and started correctly, otherwise PASS is made inactive and FAIL is made active.
- TESTING – made active if the sequence is valid and started correctly, otherwise remains inactive.

Aborting with the ABORT or INTERLOCK signals

If enabled and the ABORT signal is active for >5ms then any running test sequence is aborted.

If enabled and the INTERLOCK signal is inactive for >5ms then a test sequence is aborted if it is presently running an ACez, ACW, ACCAP, ACI, BRKDN, DCez, DCW, DCIR, DCI, GBez, GB or PULSE type step. It has no effect on any other type of step or if a test sequence is not being run.

PASS, FAIL and TESTING signals at the end of a Test Sequence

Within <5ms after a test has completed the PASS, FAIL and TESTING output signals are set by the 95x to the following states with <±100us skew between them –

- PASS and FAIL – one is made active and the other remains inactive depending on the status of the sequence.
- TESTING – made inactive.

HV PRESENT and DWELL Output Signals

These are asynchronous signals which indicate their respective conditions. They do not have any relevant timing specifications.

Examples

Example 1 -

It is desired to drive a TESTING IN PROGRESS warning indicator, external to the 95x. The indicator is illuminated when driven with 12Vdc and draws less than 100mA. The indicator does not illuminate at a current of 3.2mA.

In this case the indicator may be driven directly from the 95x DIO TESTING signal and the 95x internal 12V power source from the DIO connector. The indicator is simply wired between the DIO connector pin 1 (+12V) and pin 14

(TESTING), and the TESTING output should be configured to be ACTIVE LO to cause the indicator to be illuminated when testing.

Note – if instead the user wished to have a High Voltage warning indicator, then this is similarly accomplished by using the HV DETECT signal instead of the TESTING signal.

Example 2 -

It is desired to use an external mechanical switch to start a sequence rather than the 95x front panel START button. The test sequence will be manually selected at the 95x front panel. The switch will be momentarily actuated to start a sequence.

In this case the mechanical switch should be connected between DIO connector pin 3 (COMMON) and pin 4 (START). Assuming that the switch is to be closed to start a sequence, the user should configure the START input as ACTIVE LO and the SEQUENCE inputs as IGNORE.

Example 3 -

This is the same as example 2, but the external switch will be held closed during the test sequence. If the switch is released during the sequence, then it will be aborted.

In this case the mechanical switch should be connected between DIO connector pin 3 (COMMON) and both pins 4 (START) and 5 (ABORT). The user should configure the START input as ACTIVE LO, the ABORT input as ACTIVE HI as and the SEQUENCE inputs as IGNORE.

Example 4 -

This is the same as example 2 but the user wishes to always run sequence #3 when the external start switch is activated. The user will not need to select a test sequence from the front panel.

In this case the mechanical switch should be connected between DIO connector pin 3 (COMMON) and pin 4 (START), and also pins 10 and 11 (SEQUENCE 4 and 8) should be connected directly to pin 3 (COMMON). Assuming that the switch is closed to start a sequence, the user should configure the START input as ACTIVE LO and the SEQUENCE inputs as ACTIVE HI. Note, the connections to the SEQUENCE inputs will select sequence #3 since SEQUENCE 1 and 2 are open circuit (so will be high = active) while SEQUENCE 4 and 8 are grounded (so will be low = inactive).

Example 5 –

The user wishes to use a mechanical safety hood enclosure over the DUT, which must be maintained closed during testing for safety reasons. A magnetic switch is mounted on the hood which is closed when the hood is in position.

In this case the magnetic switch is used with the INTERLOCK capability of the 95x and should be connected between DIO connector pin 3 (COMMON) and pin 6 (INTERLOCK).

If the safety hood is opened while the 95x is producing high (i.e., unsafe) voltages then the test will be immediately aborted. However, the user can still open the hood (e.g., to make wiring changes to the DUT) during the test sequence as long as they are made while there are no unsafe voltages present (e.g., a HOLD step could be programmed in the sequence to allow the user to make the changes and then press the START button to continue testing).

SECTION 9 – PERIODIC MAINTENANCE

THE 95x CONTAINS NO INTERNAL USER SERVICABLE PARTS AND REQUIRES NO INTERNAL PERIODIC MAINTENANCE. THE COVERS OF THE 95x SHOULD ONLY BE REMOVED BY Vitrek OR ITS SERVICE CENTERS – REMOVAL OF THE COVERS MAY AFFECT WARRANTY AND CALIBRATION CERTIFICATION.

The following procedures are recommended to be performed at monthly intervals. These require no special tools or equipment and take the average user about ten minutes to perform.

Cleaning and Inspection

Cable Inspection

Carefully inspect the power cord, any high voltage cabling and (if Opt. AC-30 is fitted) all cables to the external AC-30 transformer, for breaks, abrasions, or cracks in the outer insulation. Replace any cable found to be damaged.

If a high voltage cable has become excessively dirty then the user should clean it by wiping it with a wetted cloth, with a cleaning agent if needed. If a high voltage cable is wetted ensure it is fully dried before returning it to use.

Fan Filter Cleaning

With power completely removed from the 95x, visually inspect the cleanliness of the fan filter. The fan filter is located on the rear panel of the 95x, near the power entry socket. **DO NOT REMOVE THE FOUR SCREWS SURROUNDING THE FILTER.**



FAN FILTER

To remove the filter, pull on one of the tabs on the filter cover to remove the cover and then remove the filter itself. Carefully brush off or blow out any dirt which may have accumulated on the filter. Replacement filters can be purchased from Vitrek if needed. **DO NOT OPERATE THE 95x WITHOUT A FAN FILTER INSTALLED.** If the filter is damaged, e.g., is torn, then it must be replaced. When placing the filter into the cover, take care to ensure the filter is installed flat and does not impair operation of the fan.

Front Panel Display Cleaning

Visually inspect the cleanliness of the front panel display screen. If it is excessively dirty then it should be carefully wiped with a soft, lint free cloth wetted with a weak solution of dish soap. Commercially available pre-wetted wipes may also be used, however under no circumstances should alcohol-based cleaners be used on the front panel screen as it may damage the surface.

Terminal Inspection

Visually inspect the terminals and the area immediately around them in the front and/or rear panels and clean them if required. IF THE INTERNAL SURFACES OF TERMINALS ARE WETTED DURING CLEANING, THEN ENSURE THAT THEY ARE FULLY DRIED BEFORE OPERATING THE 95x AT HIGH VOLTAGES, OTHERWISE SAFETY MAY BE COMPROMISED.

Carefully visually inspect the high voltage terminal shrouds for mechanical damage. If there is any cracking in the shroud, then safety may be compromised, and the terminal should be replaced. Replacement of high voltage terminals should only be carried out at Vitrek or one of its certified repair establishments.

Self Test

Prior to performing a self-test, the 95x must have been continuously powered and turned on for at least 5 minutes.

The user may press the **STOP** button at any time during the self-test procedure to abort it. The **HIGH VOLTAGE OR HIGH CURRENT PRESENT** warning symbol is illuminated whenever high voltages are present on the 95x terminals during this procedure.

Perform the following to command an automatic self-test procedure –

- Ensure that the display indicates that the 95x is in the base menu state, i.e., the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **TEST** key.
- The display now shows a series of temporary messages indicating the status of certain portions of the 95x. If any of these indicate a failure of the 95x, then the self-test is halted at the failing test.
- The display now shows a message indicating that the user should remove all leads to the 95x. The user must remove all connections to the terminals of the 95x before continuing with the self-test. **CAUTION** – high voltages may be present on the **HV** terminal of the 95x during the remainder of the self-test procedure, the user should ensure that there are no connections and that the terminals are not touched during the procedure. When sure that all connections have been removed, the user should press the **START** button to continue the procedure.
- The display now shows a series of messages indicating the progress as several active circuitry tests are performed automatically by the 95x. If any of these indicate a failure of the 95x, then the self-test is halted at the failing test.
- When all tests have successfully completed, a temporary message is displayed, and the display is returned to the base menu state.

SECTION 10 – PERFORMANCE VERIFICATION AND ADJUSTMENT

The 95x has been designed to give many years of service without needing calibration. However, particularly for devices used to test for product safety, it is important to periodically ensure that the device is properly working within its specifications.

There are three strategies recommended for periodic performance verification/adjustment of the 95x. Which one is selected by the user depends on the user's specific requirements regarding quality level and the availability of equipment.

- **Periodic Adjustment Calibration Only.** This is the simplest of the strategies, while it gives the typical user a reasonable degree of certainty that the 95x is performing to its specifications, it does not cross-check that the calibration technique was performed correctly and does not account for some (rare) possible malfunctions in the 95x.
- **Periodic Adjustment followed by Verification.** With this strategy the user ensures that the 95x was within specification as received by performing the adjustment calibration and checking that the adjustments are within the product specification, then checking that the calibration was correctly performed and checking for the rare possible 95x malfunctions by means of the post-adjustment verification. This completely ensures that the outgoing 95x meets its specifications but leaves the possibility of an error made during the adjustment calibration leading to the incorrect indication that the incoming 95x did not meet specifications.
- **Periodic Verification – Adjustment – Verification.** This is the most complete strategy but is also the costliest in time. The time cost can be reduced by performing the initial verification and then only performing the Adjustment – Verification components if the initial verification indicates that it is necessary (as an example, only perform if beyond some percentage of specification in the initial verification).

Adjustment Calibration

The 95x employs internal software calibration adjustments, there are no physical adjustments required. These adjustments are needed to correct for manufacturing tolerances in the components used in the 95x, it is important to note that there is no calibration of design defects allowed for, giving the end user a high degree of certainty that the 95x maintains its specifications. Typically, adjustment should be rarely needed; however, the user may wish to perform it at periodic intervals to ensure optimal performance.

The adjustment calibration procedure for the 95x is an internally prompted sequence dependent on the actual product model being calibrated.

Please take note of the following–

- The 95x should be fully powered and turned on for at least 10 minutes (1 hour is recommended) prior to being calibrated. Initially there should be no connections to any of the 95x terminals and it is recommended to not have any connections to the interface ports during the procedure.
- In many cases the same accuracy determining circuitry is used in several different modes of operation. As an example, there is no difference between the DC and AC voltage modes of operation in the accuracy determining circuitry of the 95x. Because of this the entire product can be calibrated with complete certainty by only a few fairly simple calibrations.

- The combination of the adjustment calibration and the internal self-test ensures the performance of the 95x in all but the most unusual of circumstances. Even if a formal calibration verification procedure is not performed, the user can have a very high degree of certainty that the 95x is performing to its capabilities.
- The adjustment calibration procedure has been designed to use widely available equipment, such as the multi-function calibrators available from Fluke. No voltages over 1000V are needed during this procedure. This document describes the equipment needed and provides details regarding the use of the 95x during this procedure; it does not describe how to use that equipment.
- The user can press the **STOP** button to abort the procedure. This discards any changes which have been made during the procedure. **DO NOT REMOVE POWER FROM THE 95x DURING THE ADJUSTMENT CALIBRATION PROCEDURE.** If a failure occurs during the procedure, the 95x will automatically halt the procedure and discard any changes made.
- In several steps the 95x display prompts the user to make connection to the **GND** terminal; this is also denoted as the **GUARD** terminal on the 95x front panel.
- The front panel High Voltage warning light is illuminated whenever there are high voltages or currents present on the 95x terminals. When illuminated the user should not touch the connections to the 95x.

Equipment Required

1. (All models) A shorting plug suitable for use between the **SENSE+** and **SENSE-** terminals. This must have a resistance of less than 5m Ω at a nominal 30mAdc current for a 4:1 accuracy ratio (the 95x specification is 20m Ω).
2. (All models) A true 4-wire short circuit having a 4-terminal resistance of less than 0.5m Ω at a nominal 30mAdc current for a 4:1 accuracy ratio (the 95x specification is 2m Ω) and (952i/4i/9i only) an impedance of less than 1.625u Ω at 5Arms/60Hz current for a 4:1 accuracy ratio (the 952i/4i/9i specification is 6.5u Ω).
3. (All models except the 959i) A source of 100Vdc, 500Vdc and 1000Vdc capable of driving a 100M Ω load with an accuracy of better than $\pm 0.075\%$ for a 4:1 accuracy ratio (the 95x specification is $\pm 0.3\%$).
4. (All models) A source of 100uA, 1mA, 10mA and 50mAdc capable of driving at least 1.5V compliance with an accuracy of better than $\pm 0.0625\%$ for a 4:1 accuracy ratio (the 95x specification is $\pm 0.25\%$).
5. (All models) A 10K Ω resistance with an accuracy of better than $\pm 0.2\%$ at a nominal 0.5mAdc current (the 95x specification is $\pm 0.8\%$). Preferably this resistor should be a 4-terminal device.
6. (959i only) A 10 Ω resistance with an accuracy of better than $\pm 0.2\%$ at a nominal 30mAdc current (the 95x specification is $\pm 0.8\%$). This resistor should be a 4-terminal device.
7. (952i/4i/9i only) A nominally 1 Ω 4-wire impedance with an accuracy of better than $\pm 0.375\%$ at 1Arms/60Hz current for a 4:1 accuracy ratio (the 952i/4i/9i specification is $\pm 1.5\%$). The actual value must be known to within the accuracy limits and must be in the range 0.9 to 1.1 Ω .
8. (Option HSS or HSS-2 only) A nominal 1M Ω $\pm 20\%$ resistor capable of withstanding 1000V and a milli-ammeter with an accuracy of better than $\pm 0.25\%$ at 1mAdc for a 4:1 accuracy ratio (the 95x specification is $\pm 1\%$).

Items #3 through 7 are generally available in the same multi-function calibrator and can be cabled using standard wire of heavy enough gauge for the current and with sufficient insulation for the voltage. For equipment #2 the user may construct their own 4-wire zero resistance standard and use short lengths of heavy gauge wire (contact Vitrek for details if uncertain on how to construct this). Equipment #1 must be a low resistance short at the 95x terminals. Since the 95x is internally grounded, the equipment listed here must not have grounded terminals.

Procedure

Follow the prompts in the display of the 95x for the actual procedure as it varies between models and option content.

- Press **EXT**.
- Press the UP-arrow key to display “ADJUST CAL” on the lower display line, and then press **ENTER**. The 95x now prompts the user to enter the calibration password.
 - If the user has not locked the calibration previously then there is no password in the 95x, so the user may just press **ENTER** again to continue.
 - Otherwise, the user must enter the previously defined numeric password (using the numeric keys on the front panel) prior to pressing **ENTER**.
 - If the calibration has previously been locked by a password, but it is no longer known to the user, then please contact Vitrek for details regarding how to proceed.
- The user is now prompted to enter a new calibration lock password.
 - If no change is required, then press **ENTER** (all zero digits is the selection for no password protection of calibration).
 - If no password protection for calibration is desired but a password was previously defined, the user should overwrite the password with all zero digits and then press **ENTER**.
 - If the password is to be changed, then enter the new password using the numeric keys on the front panel and then press **ENTER**.
- The user is now prompted to remove all leads. Ensure there are no connections to the front panel and (if any) rear panel terminals then press **START**.
- The 95x now performs a series of internal adjustments which require no user equipment or intervention.
- When the internal adjustments have completed, the display prompts the user to provide a short between the **SENSE+** and **SENSE-** terminals. This is equipment #1 listed above. NOTE – this short circuit must have less than 5uV of thermally induced voltage, the user may need to wait for some time after making connections. Ensure that the short circuit is properly inserted into the terminals and then press **START** to continue the procedure.
- The 95x now automatically performs both a voltage zero and a 2-wire resistance zero adjustment. When the 95x has completed its 2-wire zero adjustments, the user is prompted to provide a 4-wire zero. This is equipment #2 listed above. NOTE – this short circuit must have less than 5uV of thermally induced voltage, the user may need to wait for some time after making connections. Ensure that the short circuit is properly inserted into the terminals and then press **START** to continue the procedure.
- The 95x now automatically performs a 4-wire resistance zero adjustment. When the 95x has completed its 4-wire zero adjustments, the user is prompted to remove the 4-wire short circuit. When it has been removed press **START** to continue the procedure.
- The user is now prompted to provide a source of 1000Vdc (equipment #3 listed above) between the **HV (+)** and **GND/GUARD (-)** terminals of the 95x. Apply the connections to the 95x terminals ensuring the connections are to the correct terminals and with the correct polarity, and then set the source to provide the voltage. DO NOT TOUCH TERMINALS OR CONNECTORS WHILE VOLTAGE IS APPLIED. When the voltage is correctly applied press **START** to continue the procedure. The user is now shown the difference in calibration at 1000Vdc between this calibration and the last calibration of the 95x. If the change is acceptable then press **START** to accept it and continue the procedure, otherwise abort the calibration by pressing **STOP**. NOTE – the 95x specification at this level is $\pm 0.3\%$. The 95x display will show FAILED if the calibration is out of range for calibration, not if the change is beyond the specification.

- The above step is repeated at levels of 500V then 100Vdc. The 95x specification is $\pm 0.35\%$ at 500Vdc and $\pm 0.75\%$ at 100Vdc.
- The user is now prompted to provide a source of 50mAdc (equipment #4 listed above) between the **SENSE-** (+) and **GND/GUARD** (-) terminals of the 95x. Apply the connections to the 95x terminals ensuring the connections are to the correct terminals and with the correct polarity, and then set the source to provide the current. When the current is correctly applied press **START** to continue the procedure. The user is now shown the difference in calibration at 50mAdc between this calibration and the last calibration of the 95x. If the change is acceptable then press **START** to accept it and continue the procedure, otherwise abort the calibration by pressing **STOP**. NOTE – the 95x specification at this level is $\pm 0.25\%$. The 95x display will show FAILED if the calibration is out of range for calibration, not if the change is beyond the specification.
- The above step is repeated at levels of 10mA, 1mA then 100uAdc.
- The user is now prompted to connect a 4-wire 10K Ω resistance (equipment #5 listed above) to the 95x terminals. The 95x internal current source is from the **SOURCE** terminals, and the voltage sense uses the **SENSE** terminals, ensure that the resistor is connected with the + terminals and – terminals correctly paired for a 4-wire measurement. When the 10K Ω resistance is correctly applied press **START** to continue the procedure. The user is now shown the difference in calibration at 10K Ω between this calibration and the last calibration of the 95x. If the change is acceptable then press **START** to accept it and continue the procedure, otherwise abort the calibration by pressing **STOP**. NOTE – the 95x specification at this level is $\pm 0.8\%$. The 95x display will show FAILED if the calibration is out of range for calibration, not if the change is beyond the specification.
- The user is now prompted to connect a 4-wire 10 Ω resistance (equipment #6 listed above) to the 95x terminals. The 95x internal current source is from the **SOURCE** terminals, and the voltage sense uses the **SENSE** terminals, ensure that the resistor is connected with the + terminals and – terminals correctly paired for a 4-wire measurement. When the 10 Ω resistance is correctly applied press **START** to continue the procedure. The user is now shown the difference in calibration at 10 Ω between this calibration and the last calibration of the 95x. If the change is acceptable then press **START** to accept it and continue the procedure, otherwise abort the calibration by pressing **STOP**. NOTE – the 95x specification at this level is $\pm 0.8\%$. The 95x display will show FAILED if the calibration is out of range for calibration, not if the change is beyond the specification.
- The user is now prompted to connect a 4-wire 1 Ω impedance (equipment #7 listed above) to the 95x terminals. The 95x internal current source is from the **SOURCE** terminals, and the voltage sense uses the **SENSE** terminals, ensure that the resistor is connected with the + terminals and – terminals correctly paired for a 4-wire measurement. The use of short leads is recommended, and steps should be taken to reduce the potential for coupling between the SOURCE and SENSE wires. Ideally, the SOURCE wires should be a twisted pair, and the SENSE wires a separate twisted pair spaced away from the SOURCE pair. When the 1 Ω impedance is correctly applied press **START** to continue the procedure.
- The user is now prompted for the actual, calibrated value of the 1 Ω . The user should enter the correct value using the numeric keys and then press **ENTER**. The user is now shown the difference in calibration at 1 Ω between this calibration and the last calibration of the 95x. If the change is acceptable then press **START** to accept it and continue the procedure, otherwise abort the calibration by pressing **STOP**. NOTE – the 95x specification at this level is $\pm 1.5\%$. The 95x display will show FAILED if the calibration is out of range for calibration, not if the change is beyond the specification.
- (Option HSS or HSS-2 only). The user is now prompted to attach a 1Mohm resistor and a milli-ammeter (equipment #8 listed above). The resistor should be connected between the HV terminal of the 95x and

the HI terminal of the milli-ammeter, the LO terminal of the milli-ammeter should be connected to the RETURN terminal of the 95x. When the equipment is correctly connected press **START** to continue the procedure. The user is now shown the reading as measured by the 95x (nominally 1mA). The user should use the UP and DOWN arrow keys located below the display of the 95x to adjust the 95x reading to be within the allowable tolerance of the milli-ammeter reading (the 95x specification is $\pm 0.01\text{mA}$). When completed satisfactorily then press **START** to continue the procedure, otherwise abort the calibration by pressing **STOP**.

- If all steps above were completed successfully then the calibration is completed and the 95x display shows "FINISHED CALIBRATION" for a short time. The user should remove all equipment and connections from the 95x. **DO NOT REMOVE POWER FROM THE 95x OR TURN OFF THE POWER SWITCH FOR AT LEAST 5 SECONDS AFTER COMPLETING THE CALIBRATION PROCEDURE.**

Verifying Calibration

Prior to performing a verification procedure, the user should first perform the self-test procedure as described in [Self Test](#).

The 95x has a built-in automatic verification sequence which may be followed by the user. In some circumstances the user may wish to not use this built-in sequence but use their own sequence. The user can use any verification sequence which they wish by building a special "test sequence" in the 95x and then using external equipment to monitor the voltages and/or current during the execution of the sequence. This document does not cover the details regarding how to do this but is limited to the steps in the internal automatically sequenced verification procedure.

Please note the following -

- In several steps the equipment needed to perform performance verification is highly specialized and may not be available to many users. Making very high voltage measurements with high precision requires special skills and equipment, particularly when performing high AC voltage testing. If there are any doubts regarding the correct methods to use, consult the manufacturer of the test equipment being used.
- The 95x should be fully powered and turned on for at least 10 minutes (1 hour is recommended) prior to being calibrated. Initially there should be no connections to any of the 95x terminals and it is recommended to not have any connections to the interface ports during the procedure.
- In the various steps shown in this procedure, if a step is specific to certain models, then it is denoted as such. In all cases, follow the prompts in the display of the 95x for the actual procedure.
- The user can press **STOP** to abort the procedure.
- The front panel High Voltage warning light is illuminated whenever there are high voltages or currents present on the 95x terminals. When illuminated the user should not touch the connections to the 95x.
- Several of the verification steps are performed at very high voltages, the user must ensure that the wiring used has sufficient insulation for the voltages.
- Although the sequence is similar between the 95x series products and options, there are differences depending on the voltages, currents, and modes which each model and option is capable of. The 95x automatically accounts for the actual model and option content when guiding the user through the sequence. Individual steps and/or entire groups of steps may not be present in the actual product being verified. Any optional customer requested factory voltage and current generation limitations are applied during verification and so will also affect the procedure.
- Since the 95x is internally grounded, the measurement equipment, current sources and test loads used during verification must not be grounded.

- The user can skip verification steps by simply not connecting a measurement device during that step and immediately continuing the step by pressing **START** again to proceed to the next.

Equipment Required

1. (All except the 959i). A measurement device capable of measuring DC voltages of 100V to 1000V, 6000V, 10000V and 14000V (actual voltages depend on the model being verified), having an input impedance of 10M Ω or greater, and an accuracy which yields the desired error ratio to the 95x series accuracy (see the DC Voltage Verification portion for the accuracies). At voltages at or below 1000V there is a great range of products available which easily achieve very high ratios (e.g., a bench-top 6 ½ digit DMM has a typical DC voltage accuracy of $\pm 0.005\%$, producing more than a 50:1 error ratio). At voltages above 1000V however, there are a very limited number of products available.
2. (All models) A source of DC currents in the range 1 μ A to 50mA capable of driving at least 1.5V compliance with an accuracy which yields the desired error ratio to the 95x series accuracy (see the DC Current Scaling Verification portion for the accuracies). This is achievable with most multi-function calibration products (e.g., Fluke).
3. (All except the 956i and 959i). A measurement device capable of measuring AC RMS voltages of 100V to 1900V, 6000V or 10000V (depending on the model being verified), with a frequency range of at least 60 to 400Hz, having an input impedance of 10M Ω or greater, and an accuracy which yields the desired error ratio to the 95x series accuracy (see the AC Voltage Verification portion for the accuracies). At all but the 100V level there is a very limited number of products available.
4. (All models). A set of DC resistance standards of values 100K Ω , 10K Ω , 100 Ω and 1 Ω , capable of being connected using a 4-wire configuration, and accuracies which yield the desired error ratio to the 95x series accuracy (see the Low Ohms Resistance Verification portion for the accuracies). This is achievable with most multi-function calibration products (e.g., Fluke) or Resistance Decade Boxes (e.g., ESI).
5. (All models) A shorting plug suitable for use between the **SENSE+** and **SENSE-** terminals. This must have a resistance of less than 5m Ω at a nominal 30mA current for a 4:1 accuracy ratio (the 95x series specification is 20milliohms).
6. (All models) A true 4-wire short circuit having a 4-terminal resistance of less than 0.5m Ω at a nominal 30mA current for a 4:1 accuracy ratio (the 95x series specification is 2m Ω) and (952i/4i/9i only) an impedance of less than 1.625 $\mu\Omega$ at 5Arms/60Hz current for a 4:1 accuracy ratio (the 952i/4i/9i specification is 6.5 $\mu\Omega$).
7. (952i, 954i and 959i only). A set of AC resistance standards of values 1 Ω , 100m Ω and 50m Ω , calibrated for use at 60Hz, capable of being connected using a 4-wire configuration, and accuracies which yield the desired error ratio to the 95x series accuracy at the currents used in the 95x (see the Ground Bond Verification portion for the accuracies and current levels). These may have to be custom built.
8. (Option HSS only) Nominal 100K Ω , 1M Ω and 10M Ω \pm 20% resistors capable of withstanding 1000V and a milli-ammeter with an accuracy of better than $\pm 0.25\%$ at 100 μ A, 1mA and 10mA for a 4:1 accuracy ratio (the 95x specification is $\pm 1\%$).
9. (Option HSS-2 only) Nominal 1M Ω , 10M Ω and 100M Ω \pm 20% resistors capable of withstanding 1000V and a micro-ammeter with an accuracy of better than $\pm 0.25\%$ at 10 μ A, 100 μ A and 1mA for a 4:1 accuracy ratio (the 95x specification is $\pm 1\%$).

Starting Verification

To start the internal verification procedure press **EXT**. The user prompts the user to select the VERIFY (or ADJUST) calibration procedure. Since the VERIFY procedure is always initially selected, press **ENTER** to start the procedure.

The 95x then performs a few internal tests to ensure basic functionality of the product then starts the actual verification procedure which is described in the following sub-sections in the order shown -

DC Voltage Verification

The user should connect a DC Voltage measuring device (equipment #1 in the equipment list above) to the **HV (+)** and the **GND/GUARD (-)** terminals of the 95x. While the 95x prompts whether to verify the voltage, there are no unsafe voltages present so the user may safely make connections and configure the measurement device as needed. In some circumstances a different measuring device may be used depending on the voltage being measured. ENSURE THAT THE MEASURING DEVICE AND WIRING IS CAPABLE OF WITHSTANDING THE VOLTAGE LEVEL PRIOR TO PRESSING THE START SWITCH AT EACH STEP.

The table below shows the fullest listing of the voltages requested for verification and the 95x specification at each level. When prompted for each step the user should either –

- Press **START** to perform the verification (the output voltage will be present after pressing this switch).
- Press **STOP** to abort the entire sequence.

During each step, the user should measure the actual voltage and record it, checking against the 95x specification. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Voltage Level	95x Models	95x Accuracy
14000V	957i only	±0.764% (107V)
10000V	953i,954i,955i and 957i only	957i : ±0.77% (77V) Others: ±0.255% (25.5V)
6000V	All except 959i	957i: ±0.783% (47V) Others: ±0.258% (15.5V)
1900V	All except 959i	957i: ±0.855% (16.25V) Others: ±0.276% (5.25V)
1000V	All except 959i	957i: ±0.95% (9.5V) Others: ±0.3% (3V)
500V	All except 959i	957i: ±1.15% (5.75V) Others: ±0.35% (1.75V)
100V	All except 959i	957i: ±2.75% (2.75V) Others: ±0.75% (0.75V)

DC Current Scaling Verification

The user should connect a DC current source (equipment #2 in the list above) between the **SENSE- (+)** and the **GND/GUARD (-)** terminals of the 95x.

The table below shows the listing of the currents prompted for verification and the 95x specification at each level. When prompted for each step the user should either –

- Press **START** to perform the verification (the user should ensure that the requested current is present prior to pressing this switch).
- Press **STOP** to abort the entire sequence.

During each step, the user should note the displayed current and record it, checking against the 95x specification. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Current Level	95x Accuracy
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100mA	±0.25% (0.25mA)
10mA	±0.25% (0.025mA)
1mA	±0.25% (2.5uA)
100uA	±0.25% (0.25uA)
10uA	±0.255% (0.0255uA)
1uA	±0.3% (3nA)

DC Current Zero Verification

No connections to any terminals should be present during these steps. The product prompts for the DC current zero to be verified at a zero-output voltage level and at a 5000V output level. When prompted for each step the user should either –

- Press **START** to perform the verification.
- Press **STOP** to abort the entire sequence.

During each step, the user should note the displayed current and record it, checking against the 95x specification of ±0.5nA. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

AC Voltage Verification

The user should connect an AC Voltage measuring device (equipment #3 in the list above) to the **HV (+)** terminal and the **GND/GUARD (-)** terminal of the 95x. While the 95x prompts whether to verify the voltage there is no unsafe voltages present so the user may safely make connections and configure the measurement device as needed. In some circumstances a different measuring device may be used depending on the voltage being measured. ENSURE THAT THE MEASURING DEVICE AND WIRING IS CAPABLE OF WITHSTANDING THE VOLTAGE LEVEL PRIOR TO PRESSING THE START SWITCH AT EACH STEP.

The table below shows the fullest listing of the voltages and frequencies requested for verification and the 95x specification at each level/frequency. When prompted for each step the user should either –

- Press **START** to perform the verification (the output voltage will be present after pressing this switch).
- Press **STOP** to abort the entire sequence.

During each step, the user should measure the actual voltage and record it, checking against the 95x specification. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Voltage Level/Frequency	95x Models	95x Accuracy
10000V/60Hz	955i only	±0.515% (51.5V)
6000V/60Hz	All except 956i, 959i and if opt. AC2 not fitted	±0.525% (31.5V)
1900V/60Hz	All except 956i, 959i	±0.579% (11V)
1000V/60Hz	All except 956i, 959i	±0.65% (6.5V)
1000V/400Hz	All except 956i, 959i	±3.65% (36.5V)
300V/60Hz	All except 956i, 959i	±1% (3V)
100V/60Hz	All except 956i, 959i	±2% (2V)

AC Current Zero Verification

No connections to any terminals should be present during these steps. The 95x prompts for the AC current zero to be verified at several different output voltage voltages and frequencies. When prompted for each step the user should either –

- Press **START** to perform the verification.
- Press **STOP** to abort the entire sequence.

During each step, the user should note the displayed current and record it, checking against the 95x specification shown in the table below. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Voltage Level/Frequency/Parameter	95x Models	95x Accuracy
Zero/Zero/RMS	All except 956i, 959i	10nA
2000V/60Hz/RMS	All except 956i, 959i	28nA
2000V/60Hz/InPhase	All except 956i, 959i	±11.2nA
5000V/60Hz/RMS	All except 956i, 959i and if opt. AC2 not fitted	55nA
9000V/60Hz/RMS	955i only	141nA

Low Ohms Resistance Verification

The user should connect the prompted value resistance standard (equipment #4, 5 and 6 in the equipment list above) to the **SENSE** and **SOURCE** terminals of the 95x using a 4-wire connection method for all but the final step in this part of the sequence (which should be a 2-wire connection to the **SENSE** terminals only). For all 4-wire connections the 95x internal current source is from the **SOURCE** terminals, and the voltage sense uses the **SENSE** terminals, ensure that the resistor is connected with the + terminals and – terminals correctly paired for a 4-wire measurement.

The table below shows the listing of the resistances requested for verification and the 95x specification at each resistance value. When prompted for each step the user should either –

- Press the **START** switch to perform the verification.
- Press the **STOP** switch to abort the entire sequence.

During each step, the user should note the displayed resistance measurement on the 95x display and record it, checking against the 95x specification shown in the table below. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Resistance	95x Accuracy
100K Ω	±1.5% (1.5K Ω)
10K Ω	±0.8% (0.08K Ω)
100 Ω	±0.8% (0.8 Ω)
1 Ω	±1% (10m Ω)
Zero Ω (4-wire)	±2m Ω
Zero Ω (2-wire)	±20m Ω

Ground Bond Verification

This series of steps is only included in the 952i, 954i and 959i models.

The user should connect the prompted value resistance standard (equipment #7 in the equipment list above) to the **SENSE** and **SOURCE** terminals of the 95x using a 4-wire connection method. For all 4-wire connections the 95x internal current source is from the **SOURCE** terminals, and the voltage sense uses the **SENSE** terminals, ensure that the resistor is connected with the + terminals and – terminals correctly paired for a 4-wire measurement. The user should also ensure that the cabling to the **SOURCE** terminals of the 95x is capable of handling the measurement current shown. To reduce cross-coupling between the **SOURCE** and **SENSE** wiring, the user is recommended to use one twisted pair for the **SOURCE** connections and a separate twisted pair for the **SENSE** connections.

The table below shows the listing of the resistances requested for verification, the measurement current levels, and the 95x specification at each resistance value and current level. When prompted for each step the user should either –

- Press **START** to perform the verification.
- Press **STOP** to abort the entire sequence.

During each step, the user should note the displayed resistance measurement on the 95x display and record it, checking against the 95x specification shown in the table below. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Resistance/Current	95x Accuracy
1Ω/0.1A	±6.03% (0.0603Ω)
1Ω/1A	±1.5% (0.015Ω)
100mΩ/1A	±1.53% (1.53mΩ)
100mΩ/10A	±1.05% (1.05mΩ)
50mΩ/25A	±1.02% (0.51mΩ)

Option HSS Current Verification

This series of steps is only included if option HSS is fitted.

The first step in this series requires no external equipment, all 95x terminals should be disconnected. For the remaining steps in this series the user should connect the prompted value resistance (equipment #8 in the equipment list above) between the **HV** terminal of the 95x and the HI terminal of the milli-ammeter. The LO terminal of the milli-ammeter should be connected to the RETURN terminal of the 95x. The milli-ammeter is used to determine the actual load current, the 95x displays the value which it is measuring.

The table below shows the listing of the resistances requested for verification, the measurement current levels, and the 95x specification at each current level. When prompted for each step the user should either –

- Press **START** to perform the verification.
- Press **STOP** to abort the entire sequence.

During each step, the user should note the displayed measurement on the 95x display and record the difference between this measurement and the milli-ammeter reading, checking against the 95x specification shown in the table below. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Resistance/Current	95x Accuracy
Open/0uA	±0.05uA
100KΩ/10mA	±1% (0.1mA)
1MΩ/1mA	±1.005% (0.01005mA)
10MΩ/100uA	±1.05% (1.05uA)

Option HSS-2 Current Verification

This series of steps is only included if option HSS-2 is fitted.

The first step in this series requires no external equipment, all 95x terminals should be disconnected. For the remaining steps in this series the user should connect the prompted value resistance (equipment #9 in the equipment list above) between the **HV** terminal of the 95x and the HI terminal of the micro-ammeter. The LO terminal of the micro-ammeter should be connected to the RETURN terminal of the 95x. The micro-ammeter is used to determine the actual load current, the 95x displays the value which it is measuring.

The table below shows the listing of the resistances requested for verification, the measurement current levels, and the 95x specification at each current level. When prompted for each step the user should either –

- Press **START** to perform the verification.
- Press **STOP** to abort the entire sequence.

During each step, the user should note the displayed measurement on the 95x display and record the difference between this measurement and the micro-ammeter reading, checking against the 95x specification shown in the table below. When the user is satisfied that the step has been completed, the user should press **START** to continue or **STOP** to abort the sequence.

Resistance/Current	95x Accuracy
Open/0uA	±5nA
1MΩ/1mA	±1% (10uA)
10MΩ/100uA	±1.005% (1.005uA)
100MΩ/10uA	±1.05% (0.105uA)

SECTION 11 – PROGRAMMING VIA AN INTERFACE

The 95x may be programmed via the RS232, GPIB or Ethernet interface. All use the same general format for commands and query responses. All data uses the standard 7-bit ASCII character set. In general, all activities are independent for each interface.

There are two types of command –

- Commands which do not have a response. These always cause the 95x to take an action.
- Commands which have a response (these are named Query commands in this document). These generally do not cause the 95x to take an action other than sending back the response. These all have a keyword which ends with the ? character.

Throughout this section reference is made to several special ASCII characters –

<CR> the carriage return character

<LF> the line feed character

<FF> the form feed character

<TAB> the tab character

<SPACE> the space character

Throughout this section reference is made to whitespace characters, the <SPACE> and <TAB> characters are considered whitespace characters.

Throughout this section reference is made to data field formats, these are described in more detail later in this section –

<EMPTY> is an empty field, containing nothing other than optional whitespace characters

<STRING> is a general string of ASCII characters

<NR1> is an integer numeric

<NR3> is a floating point numeric

<BOOL> is a boolean, indicating true or false

General Command Syntax

Every command takes the form of a set of one or more fields; each field is separated from the next by a field separator. The first field is always the command keyword, the remaining fields and their syntax depend on the command keyword and in some cases the content of a preceding field in the command.

Multiple commands can be transferred as a single set of commands; each command is separated from the next by a command separator. If there are multiple query commands in a single set then each response is given as separate fields in the overall response, which is not transmitted until all commands in the set have been successfully actioned. The maximum overall length of a response set is 19999 characters (except for the Ethernet interface which is limited to 1500). Commands are always carried out in the same order as they are received.

The end of a set of commands is denoted by the inclusion of a command terminator. Sets of commands are always actioned in the same order as they are received.

Received characters on each interface are buffered from the actual communications stream, the contents of the buffer being decoded and actioned when a command terminator is found in the stream. The maximum length of a set of commands is 1023 characters.

The 95x does not raise an error if an empty set of commands is received, i.e., if there are two or more consecutive command terminators. This is effectively a “do nothing” set of commands.

The 95x does not raise an error if an empty command is received in a set of commands, i.e., there are two or more consecutive command separators, or a command separator is immediately followed by a command terminator. This is effectively a “do nothing” command.

If an error is found in a set of commands, then processing of the set of commands is terminated and the remainder of the set of commands is not decoded or actioned. There is never any response from a set of commands which contains an error, even if the erroneous command was after a query command in the set.

Field Syntax

Except for the **<STRING>** format data field (see below), any field may optionally start and/or end with one or more whitespace characters.

Fields within a command are position dependent, i.e., the exact order is defined for each command. There are two types of fields in a command -

1. **COMMAND KEYWORD.** Although all command keywords are shown using uppercase characters in this document, lowercase characters may also be used if desired. Command keywords must exactly match the defined set for the 95x. The first field in a command is always the command keyword; some commands have a second command keyword in the second field.
2. **DATA.** There are several types of data, the type used is dependent on the field -
 - a. **<EMPTY>.** This is a field containing no, or only whitespace, characters between the enclosing separators. In many commands the user may give an empty field where another format is expected, this generally has a specific effect defined in the description for each command.
 - b. **<BOOL>.** This can be the single character “Y” or ‘1’ denoting a true state, or the single character ‘N’ or ‘0’ denoting the false state (the Y or N may be upper- or lower-case).
 - c. **<NR1>.** One of three methods may be used to define a **<NR1>** field-
 - i. **Decimal value.** A string of numeric (0 through 9) characters defining a decimal number without polarity or decimal point (e.g., “123” defines the decimal number one hundred and twenty-three). A value greater than 4294967295 is a syntax error.
 - ii. **Hexadecimal value.** The user can optionally start this field with the characters “0X” or the single character “X” (in both cases the “X” character can also be lowercase), in which case the following data defines the number in hexadecimal format using the numeric characters and the letters A through F (either upper- or lowercase), as an example 0x12 defines the decimal numeric value 18. A value greater than 0xffffffff is a syntax error.
 - iii. **Binary value.** The user can optionally start this field with the characters “0B” or the single character “B” (in both cases the “B” character can also be lowercase), in which case the following data defines the number in binary format using the “0” and “1” characters only with the most-significant bit being defined first, as an example 0b00010010 defines the decimal numeric value 18 or hexadecimal value 0x12. In all cases, leading digits or bits which are not defined are assumed to be zero (e.g., 0b00010010 is the same as 0b10010). A value greater than 32 bits is a syntax error.
 - d. **<NR3>.** This is a string of characters defining a floating-point numeric value, optionally having a polarity, and/or a decimal point, and/or an exponent. Within the limitations of the 95x command input buffer, there is no limitation on the number of numeric characters before the decimal, after the decimal or in the exponent. There may be none or one polarity character and,

if present, it must be the first character in the field. If an exponent is required then it may be defined immediately following the mantissa in one of two ways, either a) an upper- or lowercase 'E' character followed by an optional exponent polarity character (+ or -) followed by the integer exponent (in **<NR1>** format), or b) a single character (case sensitive) explicitly defining the exponent which may be one of the characters T (+12), G (+9), M (+6), K (+3), k (+3), m (-3), u (-6), n (-9) or p (-12). Examples include –

- i. "12". Defines the floating-point value +12.0. A **<NR1>** syntax numeric can always be used to define a **<NR3>** value.
 - ii. "-12". Defines the floating-point value -12.0.
 - iii. "1.2345". Defines the floating-point value +1.2345.
 - iv. "12.45e+1". Defines the floating-point value +124.5.
 - v. "12.45e+01". Defines the floating-point value +124.5.
 - vi. "12.45e1". Defines the floating-point value +124.5.
 - vii. "12.345K". Defines the floating-point value +12345.0.
- e. **<STRING>**. This can be any combination of printable ASCII characters (including whitespace characters). To include a separator character in a **<STRING>** the user must immediately precede the character with the / character. Any character immediately following a / character is taken "literally" and included in the **<STRING>** and the / character is discarded.

Field Separator

Fields are separated by the comma character.

Command Separator

Commands are separated by the semi-colon character.

Command Terminator

A command (or set of commands) is terminated by any of the following-

- A line-feed character (shown in this document as <LF>).
- A carriage return character (shown in this document as <CR>).
- A form feed character (shown in this document as <FF>).
- (GPIB only) Any data byte with EOI asserted.
- (GPIB only) Reception of the GET bus command.

General Response Syntax

Multiple query commands may be included in the same set of commands, in which case the overall response will include each requested response, separated by the comma character, in the order defined in the set of commands. A response is always terminated with a <CR> character followed by a <LF> character (with EOI asserted for the GPIB interface). If the response is over 19999 characters in total length, then an error is raised, and no response is given. For the GPIB interface only, a space character is appended to the start of each set of responses (including a blank response).

On the RS232 and Ethernet interfaces any response is transmitted as soon as the set of commands containing one or more query commands is completely decoded.

On the GPIB interface the user must take some action to receive the response from the 95x (i.e., a READ bus operation). If a read operation is performed when there is no data to be transmitted, then a blank data is transmitted (i.e., a single space character followed by <CR><LF>).

If another set of commands is decoded containing a query command prior to the 95x fully transmitting a prior response, then the new response is not provided, and an error is raised.

The following types of responses are given-

- **<BOOL>**. This is a single character '0' indicating the false condition or '1' indicating the true condition. This is always 1 character in length.
- **<STRING>**. This is one or more printable ASCII characters. This has a variable number of characters in length and may be of no length.
- **<NR1>**. This is one or more decimal characters defining a decimal numeric value. If the polarity is positive then no polarity character is included, otherwise the data starts with the minus character. This has a variable number of characters in length.
- **<NR3>**. This is always 12 characters in length, and is of the following format (in the order shown)-
 - A single polarity character (either + or -).
 - Six decimal characters with a decimal point character contained within them (i.e., a total of seven characters) indicating the mantissa value.
 - The single 'E' (always uppercase) character.
 - A single polarity character (either + or -) indicating the polarity of the exponent.
 - Two decimal digit characters indicating the value of the exponent. For clarity in engineering use the exponent is always divisible by 3.

Delays and Timeouts

The user does not need to perform any delays between sets of commands, or between a set of commands containing query commands and reading the response. The 95x automatically handshakes the commands as needed. The only exception to this is following application of power to the 95x in which case a minimum delay of 3 seconds is required prior to operation of the interfaces.

The maximum length of time for which the 95x will "hold-off" a set of commands (e.g., waiting for a previous set of commands to be decoded) is 100ms.

For all interfaces, responses to query commands are generally transmitted within a very short period of time, however in some circumstances there may be some delay enforced by the 95x. The user should use a timeout of no less than 100ms for responses.

Multiple Interface Operation

Generally, operation of the 95x via multiple interfaces is not recommended but is possible. The 95x will decode sets of commands in the order in which they were terminated (each interface has separate receive and transmit buffers). Any query responses will only be transmitted via the interface from which the query command originated.

Front Panel Operation While Using Interfaces

It is possible to inter-mix front panel and interface operation of the 95x however the user should be aware of the following-

- The front panel has three states associated with interface operation-
 - **LOCAL**. The front panel operates normally. When any command from an interface is decoded, the front panel enters either the **REMOTE** or **REMOTE LOCK-OUT** state (depending on the interface and the commands executed) and any menu in progress is aborted.
 - **REMOTE**. The front panel is locked out other than the **STOP** button (and the **START** button in some circumstances) but the user can return to the LOCAL state by pressing the **CNFG** key.
 - **REMOTE LOCK-OUT**. The front panel is completely locked-out except for the **STOP** button (and the **START** button in some circumstances). The user cannot return the front panel to any other state by front panel action.
- The GPIB interface also has a set of remote states associated with it as defined by IEEE488.1 and IEEE488.2. The 95x does NOT decode commands while in the GPIB LOCAL or GPIB LOCAL LOCK-OUT states (as required by IEEE488.2). Transitions between the GPIB interface states are controlled by specific GPIB bus commands as defined by the standards.
- A LOCKOUT command is provided on the RS232 and Ethernet interfaces to allow the user to command the front panel to the REMOTE LOCK-OUT state; this command raises an error if received via the GPIB interface.
- A LOCAL command is provided on the RS232 and Ethernet interfaces to allow the user to remotely return the front panel to the LOCAL state. This command must be the last command in a set of commands.

GPIB Bus Commands

Most standard GPIB bus commands are implemented in the normal fashion; however, some cause a special activity in the 95x-

Device Clear (SDC and DCL)

Either of these cause the 95x to clear all interface buffers, abort any test sequence in progress, return to the no test sequence selected state and clear all interface status registers.

Interface Clear (IFC)

This causes the 95x to clear all interface buffers and clear all interface status registers. It does NOT affect any test sequence in progress or affect the selected test sequence.

Group Execute Trigger (GET)

This can be used as a GPIB interface command terminator.

Ethernet Sessions

The Ethernet interface uses TCP/IP as its transport protocol which is a session-based protocol. The computer is the session client and the 95x is the session server, so each session is managed by the computer.

The 95x is only allowed to have one session active at a time. The active session is established between the 95x and the opening combination of the client IP address and TCP port (this combination is often called a “socket”).

With most operating systems (e.g., Windows) the management of sessions is transparent to the user, being entirely handled by the OS. The user only needs to program –

- Initiating a session (opening the connection).
- Sending and receiving ASCII data to and from the respective streams.
- Closing the session.

If the 95x is power cycled, then it will power up with no active session; the user should employ timeouts to detect that the 95x has become off-line and restart the session.

If a session is inactive for more than 1 minute then the 95x will allow a session to be initiated from a different source, automatically closing the inactive session. This prevents a potential lockup if the user does not close an active session properly.

Status Registers

There are several status registers associated with the 95x interfaces.

STB and SRE Registers

These are specifically used to show the status of and control the assertion of the GPIB SRQ signal. The value of the STB register is logically ANDed with the value of the SRE register; if the result is non-zero then the GPIB SRQ line is asserted. The STB register is read by the GPIB interface when a serial poll bus command is performed.

These are common to all interfaces. They are 8-bit registers (i.e., have values from 0 to 255). Each bit is defined as follows –

- Bit 0, decimal value 1, binary value 00000001 – set if a high voltage is currently present on the HV terminal. The value of this status bit is “dynamic” – i.e., its value can change without user interaction.
- Bit 1, decimal value 2, binary value 00000010 – set when a test step dwell period is completed, cleared when read, when a test sequence is started, when a different test sequence is selected, or when reset.
- Bit 2, decimal value 4, binary value 00000100 – set if a test sequence is currently being performed. The value of this status bit is “dynamic” – i.e., its value can change without user interaction.
- Bit 3, decimal value 8, binary value 00001000 – set when a test sequence is completed, cleared when read, when a test sequence is started, when a different test sequence is selected, or when reset.
- Bit 4, decimal value 16, binary value 00010000 – set when a test failure has been detected, cleared when read, when a test sequence is started, when a different test sequence is selected, or when reset.
- Bit 5, decimal value 32, binary value 00100000 – set when an ARC current over limit has been detected, cleared when read, when a test sequence is started, when a different test sequence is selected, or when reset.
- Bit 6, decimal value 64, binary value 01000000 – as defined by IEEE488.1, set if the 95x is asserting the SRQ line, otherwise it is cleared. Always zero for the SRE register.
- Bit 7, decimal value 128, binary value 10000000 – not used, always 0.

OPC Register

This is separate within each interface. This is an 8-bit register (i.e., has values from 0 to 255). All of the bits in this register are cleared when read by the user. Each bit is defined as follows –

- Bit 0, decimal value 1, binary value 00000001 – set when a command set is decoded without error.
- Bit 1, decimal value 2, binary value 00000010 – set when a command is decoded with a field count error.
- Bit 2, decimal value 4, binary value 00000100 – set when a command is decoded with an internal memory error.
- Bit 3, decimal value 8, binary value 00001000 – set when a command is decoded with a field syntax or data range error.
- Bit 4, decimal value 16, binary value 00010000 – set when a command is decoded with a compatibility error (e.g., this 95x variant is incapable of performing the requested operation).

- Bit 5, decimal value 32, binary value 00100000 – set when a query command is decoded but there is insufficient room in the output buffer for the response.
- Bit 6, decimal value 64, binary value 01000000 – set when the command buffer is overflowed.
- Bit 7, decimal value 128, binary value 10000000 – set when a command is received with a command word that is not known to the 95x, or the command cannot be processed at this time.

ESR Register

This is separate within each interface. This is an 8-bit register (i.e., has values from 0 to 255). All of the bits in this register are cleared when read by the user. Each bit is defined as follows –

- Bit 0, decimal value 1, binary value 00000001 – set when a command is decoded, and an error occurred during decode.
- Bit 1, decimal value 2, binary value 00000010 – set when a query command is decoded but the response is too long for the response buffer.
- Bit 2, decimal value 4, binary value 00000100 – set when a test failure has been detected.
- Bit 3, decimal value 8, binary value 00001000 – set when the internal temperature of the 95x is above limits.
- Bit 4, decimal value 16, binary value 00010000 – set when an internal fault is detected.
- Bit 5, decimal value 32, binary value 00100000 – set when an ARC current over limit has been detected.
- Bit 6, decimal value 64, binary value 01000000 – not used, always 0.
- Bit 7, decimal value 128, binary value 10000000 – not used, always 0.

ERR Register

This is separate within each interface. This is a numeric value register. The value is cleared to zero when read by the user. The value is set according to the success or failure of the last decoded command on this interface. The possible values of this register are defined as follows –

0. The command was decoded without error.
1. The command could not be decoded at this time.
2. The command attempted to create an invalid test step number.
3. The command attempted to create or access an invalid test sequence number.
4. The command created a test step which is not compatible with this specific instruments' capability.
5. The command contained a numeric value field which was outside of the allowable range.
6. The command contained a field which did not have the correct syntax.
7. The command did not contain an expected field.
8. The command contained more additional fields than expected.
9. The command keyword was not recognized.
10. The 95x had an internal memory error while executing the command.
11. The previous response had not yet been transmitted when this query command was executed.
12. The set of commands was too long, over 1023 characters.

Commands

Command	Description
Register Commands	
*CLS	Clears the STB, SRE, OPC, ESR and ERR registers. Resets the front panel to the LOCAL state.
*ERR?	Responds with a <NR1> field value of the ERR register then clears the ERR register
*ESR?	Responds with a <NR1> field value of the ESR register then clears the ESR register
*OPC?	Responds with a <NR1> field value of the OPC register then clears the OPC register
*SRE,<NR1>	Sets the SRE register
*SRE?	Responds with a <NR1> field value of the SRE register
*STB?	Responds with a <NR1> field value of the STB register then certain bits of the STB register are cleared
Commands to create, edit, recall, or save the Active Test Sequence (Cannot be used while a test sequence is running)	
ADD,...	Add a test step to the end of the active sequence. See – ACez Configuration Fields ACW Configuration Fields DCez Configuration Fields DCW Configuration Fields DCIR Configuration Fields GBez Configuration Fields GB Configuration Fields LowΩ Configuration Fields ACCAP Configuration Fields ACI Configuration Fields DCI Configuration Fields PULSE Configuration Fields BRKDN Configuration Fields PAUSE Configuration Fields HOLD Configuration Fields SWITCH (948i configuration) Configuration Fields SWITCH (964i configuration) Configuration Fields
CLRLEADS	Clears the lead compensation data from the active test sequence
NAME,<STRING>	Names the active test sequence
NOSEQ	Clears the active test sequence
RCL,<NR1>	Recalls a test sequence from the requested store # and makes it the active test sequence
SAVE,<NR1>	Saves the active test sequence into the requested store #
SET,<NR1>, ...	Overwrite a step in the active sequence (see also ADD,...)
Commands to Run the Active Test Sequence (Can only be used while a test sequence is not running)	
READY	Makes the active test sequence ready to be run by the START button
RUN	Runs the active test sequence
RUN,LEADS	Runs the active test sequence in Lead Compensation mode
Running Test Sequence Control Commands (Can only be used while a test sequence is running)	
ABORT	Aborts a running test sequence.

Command	Description
ABORT-FORCE	Aborts a running test sequence when executing an ACW step, forces the instrument to exit the discharge phase prematurely. This command should only be used when the DUT setup cannot provide reliable high voltage measurements.
CONT	Continues a running test sequence
Commands changing the test level or frequency while running a MANUAL sequence	
AMPS,<NR3>	Sets the current test level of a running MANUAL test sequence
FREQ,<NR3>	Sets the test frequency of a running MANUAL test sequence
VOLTS,<NR3>	Sets the voltage test level of a running MANUAL test sequence
Active Test Sequence Information Query Commands (Can only be used while not running a test sequence)	
LEADS?	Responds with a <BOOL> indicating if the active test sequence contains lead compensation data
NAME?	Responds with a <STRING> which is the name of the active test sequence
Active Test Sequence Status Query Commands	
RUN?	Responds with a <BOOL> indicating if the active test sequence is being run (1) or not (0)
SEQ?	Responds with a <NR1> which is the active test sequence # (-1 if none, 100 if defined by an interface, otherwise 0 through 99)
STEP?	Responds with a <NR1> indicating the step # presently being actioned in a running test sequence (0 if none, otherwise 1 through 999)
PHASE?	Responds with a <NR1> indicating the step phase presently being actioned. 0 - Not performing a step 1 - Ramping in a single controlled ramp (to within 5%) 2 - Settling to within 1% and pre-check delay 3 - Dwell, performing limit checks 4 - Discharging in a ramped manner to a safe level 5 - Discharging in a fast manner to a safe level 6 - Discharging in to a safe level at the fastest possible rate 7 - The only phase during a HOLD or PAUSE step 8 - The pre-switch identification phase of a SWITCH step 9 - The pre-switch delay phase of a SWITCH step 10 - Commanding the required switches 11 - The post-switch delay phase of a SWITCH step
Test Result Query Commands (While running a test sequence)	

Command	Description
MEASRSLT?,<STRING>	Responds with a <NR3> measurement result during execution of a test step. <STRING> is – FREQ – frequency (in Hz) AMPS – DC or RMS current (in Amps) INPHSA – In-phase current (in Amps) QUADA – quadrature current (in Amps) VOLTS – DC or RMS voltage (in Volts) INPHSV – In-phase voltage (in Volts) QUADV – quadrature voltage (in Volts) OHMS – DC or RMS impedance (in Ω) INPHSO – In-phase impedance (in Ω) QUADO – quadrature impedance (in Ω) ARC – arc current (in Amps) ARCC – arc counter in counts BRKDN – breakdown current (in Amps) CAP – capacitance (in F) DF – dissipation factor (unitless)
Test Result Query Commands (After running a test sequence)	
RSLT?	Responds with a <NR1> indicating the overall test sequence fail status and reason. This is the logical OR of all individual step status flags. This can also be used while running a test sequence. See Test Step Status Flags
STAT?	Responds with a <STRING> indicating the pass/fail state of each test step. This can also be used while running a test sequence. The response contains one character for each defined test step- P passed F failed - Not performed ? In process
STEPRSLT?,<NR1>	Responds with a set of fields giving the complete set of results for the specified test step. See STEPRSLT? Response Fields
ARCCRSLT?,<NR1>	Responds with an NR1 carrying the arc count for the specified test step.
Configuration Settings Commands	
BEEP,START,<NR1>	Configures the start beep sounds to 0 (off) to 4 (loud)
BEEP?,START	Responds with the <NR1> setting of the start beep sound
BEEP,PASS,<NR1>	Configures the pass beep sounds to 0 (off) to 4 (loud)
BEEP?,PASS	Responds with the <NR1> setting of the pass beep sound
BEEP,FAIL,<NR1>	Configures the fail beep sounds to 0 (off) to 4 (loud)
BEEP?,FAIL	Responds with the <NR1> setting of the fail beep sound
BEEP,KEY,<NR1>	Configures the key press beep sounds to 0 (off) to 4 (loud)
BEEP?,KEY	Responds with the <NR1> setting of the key press beep sound
CONTSENSE,<BOOL>	Configures the Continuity Sense feature
CONTSENSE?	Responds with the <BOOL> Continuity Sense feature setting
DATE,<NR1>,<NR1>,<NR1>	Sets the present date (month, date, year)
DHCP,<BOOL>	Configures the Ethernet DHCP setting
DHCP?	Responds with the <BOOL> Ethernet DHCP setting

Command	Description
DIO,START,<STRING>	Configures the START DIO input to OFF, HI or LO
DIO?,START	Responds with the <STRING> setting for the START DIO input
DIO,ABORT,<STRING>	Configures the ABORT DIO input to OFF, HI or LO
DIO?,ABORT	Responds with the <STRING> setting for the ABORT DIO input
DIO,INTERLOCK,<STRING>	Configures the INTERLOCK DIO input to OFF, HI or LO
DIO?,INTERLOCK	Responds with the <STRING> setting for the INTERLOCK DIO input
DIO,SEQUENCE,<STRING>	Configures the SEQUENCE DIO inputs to OFF, HI or LO
DIO?,SEQUENCE	Responds with the <STRING> setting for the SEQUENCE DIO inputs
DIO,PASS,<STRING>	Configures the PASS DIO output to HI or LO
DIO?,PASS	Responds with the <STRING> setting for the PASS DIO output
DIO,FAIL,<STRING>	Configures the FAIL DIO output to HI or LO
DIO?,FAIL	Responds with the <STRING> setting for the FAIL DIO output
DIO,TESTING,<STRING>	Configures the TESTING DIO output to HI or LO
DIO?,TESTING	Responds with the <STRING> setting for the TESTING DIO output
DIO,DWELL,<STRING>	Configures the DWELL DIO output to HI or LO
DIO?,DWELL	Responds with the <STRING> setting for the DWELL DIO output
DIO,HV,<STRING>	Configures the HV PRESENT DIO output to HI or LO
DIO?,HV	Responds with the <STRING> setting for the HV PRESENT DIO output
FAILARC,<BOOL>	Configures if the 95x is to fail on arc detection
FAILARC?	Responds with the <BOOL> fail on arc detection setting
FASTRERUN,<NR1>	Configures how a test sequence may be rerun from the front panel 0 – enable fast rerun 1 – enable fast rerun if pass 2 – disable fast rerun
FASTRERUN?	Responds with the <NR1> fast rerun setting
GATEWAY,<NR1>,<NR1>,<NR1>,<NR1>	Configures the Ethernet Gateway IP Address setting
GATEWAY?	Responds with the Ethernet Gateway IP address setting as four <NR1>
GPIB,<NR1>	Configures the GPIB address setting
GPIB?	Responds with the <NR1> GPIB address setting
HVSAFETY,<BOOL>	Configures the HV Detect safety feature
HVSAFETY?	Responds with the <BOOL> HV Detect safety feature setting
IP,<NR1>,<NR1>,<NR1>,<NR1>	Configures the Ethernet IP Address setting
IP?	Responds with the Ethernet IP address setting as four <NR1>
MAXDISCHARGE,<NR3>	Configures the maximum allowed discharge current during DCez, DCW and DCIR type steps to the <NR3> value in amps, values between 1mA and 200mA are valid
MAXDISCHARGE?	Responds with the <NR3> value of the maximum allowed discharge current setting
MINLOAD,<BOOL>	Configures the enable for minimum loading detection during the ramp period of DCW and DCIR steps - 0 or N – Minimum loading is not detected 1 or Y – Minimum loading is detected as configured in each individual test step
MINLOAD?	Responds with the <BOOL> minimum loading detection enable setting
RS232,<NR1>	Configures the RS232 baud rate setting
RS232?	Responds with the <NR1> RS232 baud rate setting
SUBNET,<NR1>,<NR1>,<NR1>,<NR1>	Configures the Ethernet IP Subnet Mask setting
SUBNET?	Responds with the Ethernet IP Subnet Mask setting as four <NR1>

Command	Description																		
SWITCHES,<STRING>	Configures the switch matrix unit control setting. NONE – no external switch matrix units 948 – a single 948i using RS232 964SER – a single 964i using RS232 964VICL1 – a single 964i using VICL 964VICL2 – two 964i using VICL 964VICL3 – three 964i using VICL 964VICL4 – four 964i using VICL																		
SWITCHES?	Responds with the <STRING> switch matrix unit control setting																		
TIME,<NR1>,<NR1>,<NR1>	Sets the present time (hours, minutes, seconds)																		
TIME12,<BOOL>	Configures the clock 12/24hr configuration setting																		
TIME12?	Responds with the <BOOL> clock 12/24hr configuration setting																		
VLIMIT,DC,<NR3>	Configures the maximum DC Voltage available during future test sequences																		
VLIMIT?,DC	Responds with the <NR3> maximum DC Voltage setting																		
VLIMIT,AC,<NR3>	Configures the maximum AC Voltage available during future test sequences																		
VLIMIT?,AC	Responds with the <NR3> maximum AC Voltage setting																		
Identification Commands																			
*IDN?	Responds with a set of fields describing the product, see *IDN? Response Fields .																		
*OPT?	Responds with a comma separated list of keywords listing the instrument options. There may be no options, so the string may be empty. See Available Models and Options for details.																		
SERNUM?	Responds with a <STRING> indicating the serial number of the product																		
Misc. Commands																			
DATE?	Responds with the present date as a <STRING> (mm/dd/yy)																		
LOCAL	Sets the front panel into the LOCAL state																		
LOCKOUT	Sets the front panel into the REMOTE LOCK-OUT state																		
*RST	Resets all interfaces Aborts a running test sequence Clears the active test sequence																		
TIME?	Responds with the present time as a <STRING> (hh:mm:ss) This is always in 24hr format																		
CALDATE?	Responds with the last calibration date as a <STRING> (mm/dd/yy)																		
DIOSTATES?	Responds with the <NR1> representing the DIO inputs in a bit map: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bit #</th> <th>Signal</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Start</td> </tr> <tr> <td>1</td> <td>Abort</td> </tr> <tr> <td>2</td> <td>Interlock</td> </tr> <tr> <td>3</td> <td>Unused</td> </tr> <tr> <td>4</td> <td>Sequence 1</td> </tr> <tr> <td>5</td> <td>Sequence 2</td> </tr> <tr> <td>6</td> <td>Sequence 4</td> </tr> <tr> <td>7</td> <td>Sequence 8</td> </tr> </tbody> </table> <p>Note the report is the logical state of the signal, meaning that if an input is configured as active-low the physical input will be inverted when reported.</p>	Bit #	Signal	0	Start	1	Abort	2	Interlock	3	Unused	4	Sequence 1	5	Sequence 2	6	Sequence 4	7	Sequence 8
Bit #	Signal																		
0	Start																		
1	Abort																		
2	Interlock																		
3	Unused																		
4	Sequence 1																		
5	Sequence 2																		
6	Sequence 4																		
7	Sequence 8																		

*IDN? Response Fields

Field #	Field Format	Description
1	<STRING>	Manufacturer (e.g., VITREK)
2	<STRING>	Model (e.g., 951i).
3	<STRING>	Serial number (e.g., 123456)
4	<STRING>	Main firmware version (e.g., v1.45)
5	<STRING>	Front panel firmware version (e.g., v1.21)
6	<STRING>	Measurement DSP firmware version (e.g., v1.21)
7	<STRING>	Drive DSP firmware version (e.g., v1.21)

ACez Configuration Fields

Field #	Field Format	Value
1	<STRING>	ACEZ
2	<NR3>	Test Voltage (in Vrms)
3	<NR3>	Test Frequency (in Hz)
4	<NR3>	Ramp Time (in seconds)
5	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
6	<NR3>	Minimum Leakage Limit (in Arms)
7	<NR3>	Maximum Leakage Limit (in Arms)
8	<STRING>	ABORT - Abort on failure CONT - Continue on failure
9	<EMPTY>	Option AC-30 is not used, may only be <MISSING> if field 10 is also <MISSING>
	<MISSING>	
	<STRING>	INT : Option AC-30 is not used EXT : Option AC-30 is to be used (valid if option AC-30 is fitted)
10	<EMPTY>	Load is not grounded
	<MISSING>	
	<STRING>	GND : Load is grounded (valid if option HSS is fitted) ISO : Load is not grounded

Example –

ADD,ACEZ,1000.0,60.0,1.5,60.0,0.0,0.005,ABORT

Configures the following (in order) –

- An ACez type test step
- 1000V test voltage
- 60Hz test frequency
- 1.5 second ramp time
- 60 second dwell time
- No minimum leakage current limit
- 5mArms maximum leakage current limit (i.e., 7.07mApk breakdown limit)
- Abort test sequence if fails

HV Terminal used (AC-30 not used or not installed) since both fields 9 and 10 are missing
 DUT is isolated since both fields 9 and 10 are missing

ACW Configuration Fields

Field #	Field Format	Value
1	<STRING>	ACW
2	<NR3>	Test Voltage (in Vrms)
3	<NR3>	Test Frequency (in Hz)
4	<NR3>	Breakdown Limit (in Apk)
5	<NR3>	Ramp Time (in seconds)
6	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
7	<STRING>	NONE - No 1 st checked leakage RMSA - 1 st checked value is RMS leakage current INPHSA - 1 st checked value is In-Phase leakage current QUADA - 1 st checked value is Quadrature leakage current RMSO - 1 st checked value is RMS leakage impedance INPHSO - 1 st checked value is In-Phase leakage impedance QUADO - 1 st checked value is Quadrature leakage impedance
8	<NR3>	1 st Minimum Leakage Limit (in A or Ω)
	<EMPTY>	Only valid if no 1 st checked leakage
9	<NR3>	1 st Maximum Leakage Limit (in A or Ω)
	<EMPTY>	No 1 st maximum limit (only valid for impedance or no 1 st checked leakage)
10	<STRING>	NONE - No 2 nd checked leakage RMSA - 2 nd checked value is RMS leakage current INPHSA - 2 nd checked value is In-Phase leakage current QUADA - 2 nd checked value is Quadrature leakage current RMSO - 2 nd checked value is RMS leakage impedance INPHSO - 2 nd checked value is In-Phase leakage impedance QUADO - 2 nd checked value is Quadrature leakage impedance
11	<NR3>	2 nd Minimum Leakage Limit (in A or Ω)
	<EMPTY>	Only valid if no 2 nd checked leakage
12	<NR3>	2 nd Maximum Leakage Limit (in A or Ω)
	<EMPTY>	No 2 nd maximum limit (only valid for impedance or no 2 nd checked leakage)
13	<NR1>	Time period for arc detection (4, 10, 15, 20, 30 or 40)
	<EMPTY>	Arc detection disabled
14	<NR1>	Arc detection limit (in mA)
	<EMPTY>	Only valid if arc detection disabled in field 13
15	<STRING>	NONE - No discharge if next step compatible FAST - Fast discharge RAMP - Discharge same as ramp
16	<STRING>	ABORT - Abort on failure CONT - Continue on failure
17	<EMPTY>	Option AC-30 is not used, may only be <MISSING> if field 18 is also <MISSING>
	<MISSING>	
	<STRING>	INT : Option AC-30 is not used EXT : Option AC-30 is to be used (valid if option AC-30 is fitted)
18	<EMPTY>	Load is not grounded
	<MISSING>	

<STRING>	GND : Load is grounded (valid if option HSS is fitted) ISO : Load is not grounded
----------	--

Example –

ADD,ACW,1000.0,60.0,0.01,1.5,60.0,RMSA,0.0,0.005,NONE,,,,FAST,ABORT

Configures the following (in order) –

- An ACW type test step
- 1000V test voltage
- 60Hz test frequency
- 10mApk breakdown limit
- 1.5 second ramp time
- 60 second dwell time
- 1st checked value is rms leakage current
- No minimum 1st leakage current limit
- 5mArms maximum 1st leakage current limit
- No 2nd checked limit (so following two fields are <EMPTY>)
- No arc detection (so following field is also <EMPTY>)
- Fast discharge
- Abort test sequence if fails
- HV Terminal used (AC-30 not used or not installed) since both fields 17 and 18 are missing
- DUT is isolated since both fields 17 and 18 are missing

DCEz Configuration Fields

Field #	Field Format	Value
1	<STRING>	DCEZ
2	<NR3>	Test Voltage (in V)
3	<NR3>	Ramp Time (in seconds)
4	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
5	<NR3>	Minimum Leakage Limit (in A)
6	<NR3>	Maximum Leakage Limit (in A)
7	<STRING>	ABORT - Abort on failure CONT - Continue on failure
8	<EMPTY>	Load is not grounded
	<MISSING>	
	<STRING>	GND : Load is grounded (only valid if option HSS or HSS-2 is fitted) ISO : Load is not grounded

Example –

ADD,DCEZ,1000.0,1.5,60.0,0.0,0.005,ABORT

Configures the following (in order) –

A DCez type test step
 1000V test voltage
 1.5 second ramp time
 60 second dwell time
 No minimum leakage current limit
 5mA maximum leakage current limit
 Abort test sequence if fails
 DUT is isolated since field 8 is missing

DCW Configuration Fields

Field #	Field Format	Description
1	<STRING>	DCW
2	<NR3>	Test Voltage (in V)
3	<NR3>	Breakdown Limit (in A)
4	<NR3>	Ramp Time (in seconds)
5	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
6	<NR3>	Pre-check delay (in seconds)
7	<STRING>	AMPS - Leakage limits are in Amps OHMS - Leakage limits are in Ω
	<NR3>	Minimum Leakage Limit (in A or Ω)
9	<NR3>	Maximum Leakage Limit (in A or Ω)
	<EMPTY>	No maximum limit (only valid for impedance)
10	<NR1>	Time period for arc detection (4, 10, 15, 20, 30 or 40)
	<EMPTY>	Arc detection disabled
11	<NR1>	Arc detection limit (in mA)
	<EMPTY>	Only valid if arc detection disabled in field 10
12	<STRING>	NONE - No discharge if next step compatible FAST - Fast discharge RAMP - Discharge same as ramp
	<STRING>	ABORT - Abort on failure CONT - Continue on failure
	<NR3>	Min Load (in Farads), may be <MISSING> if field 15 is also <MISSING>
15	<EMPTY>	Load is not grounded
	<MISSING>	
	<STRING>	GND : Load is grounded (only valid if option HSS or HSS-2 is fitted) ISO : Load is not grounded

Example –

ADD,DCW,1000.0,0.015,1.5,60.0,0.0,AMPS,0.0,25e-6,4,10,FAST,ABORT

Configures the following (in order) –

A DCW type test step
 1000V test voltage
 15mA breakdown limit
 1.5 second ramp time
 60 second dwell time

0 second delay
 Define leakage limits in Amps
 No minimum leakage current limit
 25uA maximum leakage current limit
 4us arc detection time
 10mA arc detection limit
 Fast discharge
 Abort test sequence if fails
 Minimum load during ramp is set to 0 since both fields 14 and 15 are missing
 DUT is isolated since both fields 14 and 15 are missing

DCIR Configuration Fields

Field #	Field Format	Value
1	<STRING>	DCIR
2	<NR3>	Test Voltage (in V)
3	<NR3>	Breakdown Limit (in A)
4	<NR3>	Ramp Time (in seconds)
5	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
6	<NR3>	Pre-check delay (in seconds)
7	<STRING>	PASS - Test is ended as soon as passes
		FAIL - Test is ended as soon as fails
		TIME - Test always extends for the full time
		STDY – Test is ended if the load is within limits and is steady or improving
8	<STRING>	AMPS - Leakage limits are in Amps
		OHMS - Leakage limits are in Ω
9	<NR3>	Minimum Leakage Limit (in A or Ω)
10	<NR3>	Maximum Leakage Limit (in A or Ω)
	<EMPTY>	No maximum limit (only valid for impedance)
11	<NR1>	Time period for arc detection (4, 10, 15, 20, 30 or 40)
	<EMPTY>	Arc detection disabled
12	<NR1>	Arc detection limit (in mA)
	<EMPTY>	Only valid if arc detection disabled in field 11
13	<STRING>	NONE - No discharge if next step compatible
		FAST - Fast discharge
		RAMP - Discharge same as ramp
14	<STRING>	ABORT - Abort on failure
		CONT - Continue on failure
15	<NR3>	Min Load (in Farads), may be <MISSING> if field 16 is also <MISSING>
16	<EMPTY>	Load is not grounded
	<MISSING>	
	<STRING>	GND : Load is grounded (valid if option HSS or HSS-2 is fitted) ISO : Load is not grounded

Example –

ADD,DCIR,1000.0,0.015,1.5,60.0,0.0,FAIL,AMPS,0.0,25e-6,4,10,FAST,ABORT

Configures the following (in order) –

A DCW type test step
 1000V test voltage
 15mA breakdown limit
 1.5 second ramp time
 60 second dwell time
 0 second delay
 Test is terminated as soon as a failure is detected
 Define leakage limits in Amps
 No minimum leakage current limit
 25uA maximum leakage current limit
 4us arc detection time
 10mA arc detection limit
 Fast discharge
 Abort test sequence if fails
 Minimum load during ramp is set to 0 since both fields 15 and 16 are missing
 DUT is isolated since both fields 15 and 16 are missing

GBez Configuration Fields

Field #	Field Format	Value
1	<STRING>	GBEZ
2	<NR3>	Test Current (in Arms)
3	<NR3>	Test Frequency (in Hz)
4	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
5	<NR3>	Minimum Voltage Drop Limit (in Vrms)
6	<NR3>	Maximum Voltage Drop Limit (in Vrms)
7	<STRING>	ABORT - Abort on failure
		CONT - Continue on failure

Example –

ADD,GBEZ,25.0,60.0,60.0,0.0,0.1,ABORT

Configures the following (in order) –

A GBez type test step
 25A test current
 60Hz test frequency
 60 second dwell time
 No minimum voltage drop
 0.1V maximum voltage drop
 Abort test sequence if fails

GB Configuration Fields

Field #	Field Format	Value
1	<STRING>	GB

2	<NR3>	Test Current (in Arms)
3	<NR3>	Test Frequency (in Hz)
4	<NR3>	Maximum open circuit drive (in Vrms)
5	<NR3>	Ramp Time (in seconds)
6	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
7	<STRING>	RMSV - Checked value is RMS voltage drop INPHSV - Checked value is In-phase voltage drop QUADV - Checked value is quadrature voltage drop RMSO - Checked value is RMS impedance INPHSO - Checked value is in-phase impedance QUADO - Checked value is quadrature impedance
8	<NR3>	Minimum Limit (in V or Ω)
9	<NR3>	Maximum Limit (in V or Ω)
10	<STRING>	NONE - No discharge if next step compatible
		FAST - Fast discharge
		RAMP - Discharge same as ramp
11	<STRING>	ABORT - Abort on failure
		CONT - Continue on failure

Example –

ADD,GB,25.0,60.0,5.0,0.0,60.0,RMSO,0.0,0.1,FAST,ABORT

Configures the following (in order) –

- A GB type test step
- 25A test current
- 60Hz test frequency
- 5V max open circuit voltage
- 0 second ramp time
- 60 second dwell time
- Check RMS impedance
- No minimum impedance
- 0.1 Ω maximum impedance
- Fast discharge
- Abort test sequence if fails

Low Ω Configuration Fields

Field #	Field Format	Value
1	<STRING>	LOWOHM
2	<BOOL>	1 or Y - Test using 2-wire mode
		0 or N - Test using 4-wire mode
3	<NR3>	Test time (in seconds)
	<EMPTY>	Step is to be user terminated
4	<NR3>	Check delay (in seconds)
5	<NR3>	Minimum Resistance Limit (in Ω)
6	<NR3>	Maximum Resistance Limit (in Ω)

7	<STRING>	ABORT - Abort on failure CONT - Continue on failure
---	----------	--

Example –

ADD,LOWOHM,0,5.0,0.0,1.25,1.75,ABORT

Configures the following (in order) –

- A Low Ω type test step
- Use 4-wire mode
- 5 second test time
- 0 second delay
- 1.25 Ω minimum resistance
- 1.75 Ω maximum resistance
- Abort test sequence if fails

ACCAP Configuration Fields

Field #	Field Format	Value
1	<STRING>	ACCAP
2	<NR3>	Test Voltage (in Vrms)
3	<NR3>	Test Frequency (in Hz)
4	<NR3>	Breakdown Limit (in Apk)
5	<NR3>	Ramp Time (in seconds)
6	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
7	<NR3>	Minimum Capacitance Limit (in F)
8	<NR3>	Maximum Capacitance Limit (in F)
9	<NR3>	Minimum DF Limit (no units)
10	<NR3>	Maximum DF Limit (no units)
11	<NR1>	Time period for arc detection (4, 10, 15, 20, 30 or 40)
	<EMPTY>	Arc detection disabled
12	<NR1>	Arc detection limit (in mA)
	<EMPTY>	Only valid if arc detection disabled in field 11
13	<STRING>	NONE - No discharge if next step compatible FAST - Fast discharge RAMP - Discharge same as ramp
14	<STRING>	ABORT - Abort on failure CONT - Continue on failure
15	<EMPTY>	Option AC-30 is not used, may only be <MISSING> if field 16 is also <MISSING>
	<MISSING>	
	<STRING>	INT : Option AC-30 is not used EXT : Option AC-30 is to be used (only valid if option AC-30 is fitted)
16	<EMPTY>	Load is not grounded
	<MISSING>	
	<STRING>	GND : Load is grounded (only valid if option HSS is fitted) ISO : Load is not grounded

Example –

ADD,ACCAP,1000.0,60.0,0.01,1.5,60.0,0.9e-9,1.1e-9,0.0,1.0,,,FAST,ABORT

Configures the following (in order) –

- An ACCAP type test step
- 1000V test voltage
- 60Hz test frequency
- 10mApk breakdown limit
- 1.5 second ramp time
- 60 second dwell time
- 0.9nF minimum capacitance
- 1.1nF maximum capacitance
- No minimum dissipation factor
- No maximum dissipation factor (1.0 disables the maximum)
- No arc detection (so following field is also <EMPTY>)
- Fast discharge
- Abort test sequence if fails
- HV Terminal used (AC-30 not used or not installed) since both fields 15 and 16 are missing
- DUT is isolated since both fields 15 and 16 are missing

ACI Configuration Fields

Field #	Field Format	Value
1	<STRING>	ACI
2	<NR3>	Test time (in seconds)
	<EMPTY>	Step is to be user terminated
3	<NR3>	Delay time (in seconds)
4	<NR3>	Minimum Leakage Current Limit (in Arms)
5	<NR3>	Maximum Leakage Current Limit (in Arms)
6	<NR1>	Time period for arc detection (4, 10, 15, 20, 30 or 40)
	<EMPTY>	Arc detection disabled
7	<NR1>	Arc detection limit (in mA)
	<EMPTY>	Only valid if arc detection disabled in field 6
8	<STRING>	ABORT - Abort on failure
		CONT - Continue on failure

Example –

ADD,ACI,5.0,0.0,0.0,50e-6,,,ABORT

Configures the following (in order) –

- An ACI type test step
- 5 second test time
- 0 second delay time
- No minimum leakage current
- 50uA maximum leakage current
- No arc detection (so following field is also <EMPTY>)
- Abort test sequence if fails

DCI Configuration Fields

Field #	Field Format	Value
1	<STRING>	DCI
2	<NR3>	Test time (in seconds)
	<EMPTY>	Step is to be user terminated
3	<NR3>	Delay time (in seconds)
4	<NR3>	Minimum Leakage Current Limit (in A)
5	<NR3>	Maximum Leakage Current Limit (in A)
6	<NR1>	Time period for arc detection (4, 10, 15, 20, 30 or 40)
	<EMPTY>	Arc detection disabled
7	<NR1>	Arc detection limit (in mA)
	<EMPTY>	Only valid if arc detection disabled in field 6
8	<STRING>	ABORT - Abort on failure
		CONT - Continue on failure

Example –

ADD,DCI,5.0,0.0,0.0,50e-6,,,ABORT

Configures the following (in order) –

- A DCI type test step
- 5 second test time
- 0 second delay time
- No minimum leakage current
- 50uA maximum leakage current
- No arc detection (so following field is also <EMPTY>)
- Abort test sequence if fails

PULSE Configuration Fields

Field #	Field Format	Value
1	<STRING>	PULSE
2	<NR3>	Level (in V)
3	<STRING>	POSITIVE - Unipolar +ve
		NEGATIVE – Unipolar –ve
		BIPOLAR - Bipolar
4	<NR3>	Ramp time (in seconds)
5	<NR3>	Hold Time (in seconds)
6	<NR3>	Breakdown Current Limit (in A)
7	<NR1>	Time period for arc detection (4, 10, 15, 20, 30 or 40)
	<EMPTY>	Arc detection disabled
8	<NR1>	Arc detection limit (in mA)
	<EMPTY>	Only valid if arc detection disabled in field 7
9	<STRING>	ABORT - Abort on failure
		CONT - Continue on failure

Example –

ADD,PULSE,250.0,POSITIVE,1e-3,10e-3,0.05,4,10,ABORT

Configures the following (in order) –

- A PULSE type test step
- 250V level
- A single positive pulse
- 1ms ramp time
- 10ms hold time
- 50mA maximum current
- 4us arc detection
- 10mA arc detection limit
- Abort test sequence if fails

BRKDN Configuration Fields

Field #	Field Format	Value
1	<STRING>	BRKDN
2	<NR3>	Test Current Level (in A)
3	<NR3>	Initial Ramp Rate (in V/sec)
4	<NR3>	Minimum Breakdown Voltage (in V)
5	<NR3>	Maximum Breakdown Voltage (in V)
6	<STRING>	ABORT - Abort on failure CONT - Continue on failure
7	<EMPTY>	Load is not grounded
	<MISSING>	
	<STRING>	GND : Load is grounded (only valid if option HSS or HSS-2 is fitted) ISO : Load is not grounded

Example –

ADD,BRKDN,0.001,1000.0,500.0,600.0,ABORT

Configures the following (in order) –

- A BRKDN type test step
- 1mA test current level
- 1000V/sec initial ramp rate
- 500V minimum breakdown voltage
- 600V minimum breakdown voltage
- Abort test sequence if fails
- Load is not grounded (field 7 is missing)

PAUSE Configuration Fields

Field #	Field Format	Value
1	<STRING>	PAUSE
2	<NR3>	Pause time (in seconds)

Example –

ADD,PAUSE,5.0

Configures the following (in order) –

A PAUSE type test step
5 second pause time

HOLD Configuration Fields

Field #	Field Format	Value
1	<STRING>	HOLD
2	<NR3>	Timeout (in seconds)

Example –

ADD,HOLD,60.0

Configures the following (in order) –

A HOLD type test step
60 second timeout

SWITCH (948i configuration) Configuration Fields

Field #	Field Format	Value
1	<STRING>	SWITCH
2	<NR3>	Pre-switch delay (in seconds)
3	<NR3>	Post-switch delay (in seconds)
4-10	<NR1>	Switch bank data banks 6-0 resp.

Example –

ADD,SWITCH,0.0,0.25,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00

Configures the following (in order) –

A SWITCH type test step
0 second pre-switch delay
0.25 second post-switch delay
Bank #6 set to hexadecimal 00
Bank #5 set to hexadecimal 00
Bank #4 set to hexadecimal 00
Bank #3 set to hexadecimal 00
Bank #2 set to hexadecimal 00
Bank #1 set to hexadecimal 00
Bank #0 set to hexadecimal 00

SWITCH (964i configuration) Configuration Fields

Field #	Field Format	Value
1	<STRING>	SWITCH
2	<NR3>	Pre-switch delay (in seconds)
3	<NR3>	Post-switch delay (in seconds)
4-11	<NR1>	964 #1 Switch bank data banks 7-0 resp.
12-19	<NR1>	964 #2 Switch bank data banks 7-0 resp. (only if configured for >1x964)

20-27	<NR1>	964 #3 Switch bank data banks 7-0 resp. (only if configured for >2x964)
28-35	<NR1>	964 #4 Switch bank data banks 7-0 resp. (only if configured for 4x964)

Example –

ADD,SWITCH,0.0,0.25,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00

Configures the following (in order) –

- A SWITCH type test step
- 0 second pre-switch delay
- 0.25 second post-switch delay
- Bank #7 set to hexadecimal 00
- Bank #6 set to hexadecimal 00
- Bank #5 set to hexadecimal 00
- Bank #4 set to hexadecimal 00
- Bank #3 set to hexadecimal 00
- Bank #2 set to hexadecimal 00
- Bank #1 set to hexadecimal 00
- Bank #0 set to hexadecimal 00

Test Step Status Flags

This is a <NR1> value formed by the addition (or logical OR) of the values shown in the table below. Note that a zero total value indicates that no failure occurred.

Bit #	Value	Description
0	1	95x Internal Fault
1	2	Unstable load
2	4	Breakdown detected (> setting)
3	8	HOLD Step timeout exceeded
4	16	User abort
5	32	Continuity Sense failure detected
6	64	Wiring fault detected
7	128	Arc detected
8	256	1 st check <minimum setting
9	512	1 st check >maximum setting
10	1024	2 nd check <minimum setting
11	2048	2 nd check >maximum setting
12	4096	INTERLOCK failure
13	8192	HV TRIP activated
14	16384	Switch Matrix unit did not communicate
15	32768	Breakdown detected (> surge drive ability limit for test type)
16	65536	95x Overheated
17	131072	Step type incompatible with the model and option content
18	262144	Minimum Loading was not encountered during ramp in a DCW or DCIR type step
19	524288	Breakdown detected (> sustained drive ability limit for test type)
20	1048576	A steady or decreasing current was not detected during dwell but the load was otherwise within the limits in a DCIR type step configured to terminate in this manner
21	2097152	User forced abort

STEPRSLT? Response Fields

Field #	Field Format	Value
1	<NR1>	0 – Not executed 1 – Terminated during Ramp 2 – Terminated during Dwell (during delay) 3 – Terminated during Dwell (after delay) Others – Terminated
2	<NR3>	Elapsed time of last executed period (in seconds)
3	<NR1>	Status of this step, see Test Step Status Flags
4	<NR3> or <EMPTY>	Final test level (in Volts or Amps)
5	<NR3> or <EMPTY>	Final test frequency (in Hz)
6	<NR3> or <EMPTY>	Highest breakdown current (in Amps, peak)
7	<NR3> or <EMPTY>	Highest voltage (in Volts)
8	<NR3> or <EMPTY>	Highest 1 st check result
9	<NR3> or <EMPTY>	Lowest 1 st check result
10	<NR3> or <EMPTY>	Average 1 st check result
11	<NR3> or <EMPTY>	Last 1 st check result
12	<NR3> or <EMPTY>	Highest 2 nd check result
13	<NR3> or <EMPTY>	Lowest 2 nd check result
14	<NR3> or <EMPTY>	Average 2 nd check result
15	<NR3> or <EMPTY>	Last 2 nd check result
16	<NR3> or <EMPTY>	Highest arc current (in Amps)
17	<NR3> or <EMPTY>	Lowest arc current (in Amps)
18	<NR3> or <EMPTY>	Average arc current (in Amps)
19	<NR3> or <EMPTY>	Last arc current (in Amps)

Not all of the above fields are valid for each step type; fields which are not used for a step type are empty. The table below shows the valid fields for each step type. The Check Result fields are empty if no check was defined or performed; otherwise, they have the same units as used for the check limits (i.e., Volts, Amps, Ohms, Farads etc.).

Field #	ACez, ACW	DCez, DCW, DCIR	GBez, GB	LowΩ	ACCAP	ACI	DCI	BRKDN	PULSE	PAUSE, HOLD, SWITCH
1	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
2	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
3	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid	Valid
4	Valid (in V)	Valid (in V)	Valid (in A)	Empty	Valid (in V)	Valid (in V)	Valid (in V)	Empty	Valid	Empty
5	Valid	Empty	Valid	Empty	Valid	Valid	Empty	Empty	Empty	Empty
6	Valid	Valid	Empty	Empty	Valid	Empty	Empty	Valid	Valid	Empty
7	Empty	Empty	Empty	Empty	Empty	Empty	Empty	Valid	Valid	Empty
8	Valid or Empty	Valid	Valid	Valid	Valid	Valid	Valid	Empty	Empty	Empty
9	Valid or Empty	Valid	Valid	Valid	Valid	Valid	Valid	Empty	Empty	Empty
10	Valid or Empty	Valid	Valid	Valid	Valid	Valid	Valid	Empty	Empty	Empty
11	Valid or Empty	Valid	Valid	Valid	Valid	Valid	Valid	Empty	Empty	Empty

12	Valid or Empty	Empty	Empty	Empty	Valid	Empty	Empty	Empty	Empty	Empty
13	Valid or Empty	Empty	Empty	Empty	Valid	Empty	Empty	Empty	Empty	Empty
14	Valid or Empty	Empty	Empty	Empty	Valid	Empty	Empty	Empty	Empty	Empty
15	Valid or Empty	Empty	Empty	Empty	Valid	Empty	Empty	Empty	Empty	Empty
16	Valid or Empty	Valid or Empty	Empty	Empty	Valid or Empty	Valid or Empty	Valid or Empty	Empty	Valid or Empty	Empty
17	Valid or Empty	Valid or Empty	Empty	Empty	Valid or Empty	Valid or Empty	Valid or Empty	Empty	Valid or Empty	Empty
18	Valid or Empty	Valid or Empty	Empty	Empty	Valid or Empty	Valid or Empty	Valid or Empty	Empty	Valid or Empty	Empty
19	Valid or Empty	Valid or Empty	Empty	Empty	Valid or Empty	Valid or Empty	Valid or Empty	Empty	Valid or Empty	Empty
Field #	ACez, ACW	DCez, DCW, DCIR	GBez, GB	LowΩ	ACCAP	ACI	DCI	BRKDN	PULSE	PAUSE, HOLD, SWITCH

Programming Example

If the user wishes to be able to send a command to the 95x to test that the interface is active and functioning, then the following could be used –

Example 1

- Send ***IDN?**<CR><LF> (don't type the <CR><LF> just ensure that your application sends a carriage return and/or line feed)
- Read the response back from the 95x, it should be similar to **VITREK,952i,000000,v1.45,v1.23,v1.23,v1.23**
- Refer to
-
-
- ***IDN?** Response Fields for details regarding the response.

Example 2

- Ensure there are no connections to any terminals on the 95x, this example is not applicable to the 959i.
- Send **NOSEQ; ADD,ACEZ,1000.0,60.0,1.5,5.0,0.0,0.005,ABORT;RUN**<CR><LF>
- The 95x will perform an ACez test at 1000Vrms/60Hz with a 1.5sec ramp and 5sec dwell.
- After completion send **STEPRSLT?,1**<CR><LF>
- The 95x responds with the results for the step which should be similar to
3,+5.01700E+00,0,+1.00012E+03,+60.0000E+00,+82.3600E-09,,+2.22916E-09,+2.10947E-09,+2.18633E-09,+2.17637E-09,,,,,,,,
- Refer to

- **STEPRSLT?** Response Fields for details regarding the response.

Programming Guidelines

Avoid Interface Specific Methods

The 95x can be operated over the RS232, GPIB or Ethernet interfaces. It is recommended that the programmer not use interface specific methods, e.g., serial polling over GPIB, to ease the migration between interfaces at a later date. Similarly, it is recommended to always terminate commands with either the <CR> or <LF> characters (or both) rather than using the GPIB specific EOI or GET methods. The command set and response formats are identical between interfaces, so migration between interfaces is simple if this guideline is followed.

Start by Initializing the 95x

When a user application is started on the controlling computer the status of the 95x is unknown, it may have a response waiting to be read, it may have a partial command in its input buffer. It is recommended that the user always perform an interface clear when the application is started to ensure that there are no pending or partially programmed activities in the 95x. This can be achieved by sending the ***RST** command.

Employ a Timeout on all Activities

On all interfaces, the 95x has full handshake capabilities, so both commands and responses can be held up for short periods of time. The user must employ timeouts for both transmit and receive operations and take any desired corrective action should a timeout occur.

Fully Configure the 95x

If there are any configuration settings in the 95x which are relied upon by the programmer, then these should be explicitly set by the user application when it is first started. Commands are provided to set the 95x configuration settings.

Checking for errors

Often the user wishes to ensure that a command was correctly received by the 95x and that the command was not rejected by the 95x. This is easily achieved by always sending the ***ERR?** command after sending any non-query command, waiting for the response, and checking that it is "0". There are other registers which could be used also, but the ERR register provides the most information regarding the nature of the error.

For example –

```
BEEP,START,2<CR><LF>
```

```
*ERR?<CR><LF>
```

This would cause the response to be **0**<CR><LF>

As another example –

```
BEEP,START,9;*ERR?<CR><LF>
```

This would not function as expected. The "9" field in the BEEP command is in error, which makes the 95x reject the entire set of commands. This should be –

```
BEEP,START,9<CR><LF>
```

```
*ERR?<CR><LF>
```

This would cause the response to be **5**<CR><LF>

Program and run a Sequence rather than Individual Steps

When setting up and running a test sequence the user is recommended to run it as a sequence in the 95x, rather than running individual steps one at a time.

The 95x will remember the sequence, even if it is not stored, as long as power is not removed from the 95x. The user only needs to program the sequence once; it can then be run multiple times as needed. There is no need to store the sequence into non-volatile memory; although the user may do so if needed (stored sequences are limited in length to a maximum of 254 steps whereas the interface sequence is limited to a maximum of 999 steps).

The 95x remembers the results of each step performed; the user can extract all of the test results as needed after completion of the test sequence.

By running a sequence, the 95x can operate at its own speed, the computer does not have to “keep up” with the 95x.

The recommended flow is as follows –

- Send a **NOSEQ** command to ensure there is no active test sequence.
- Send **ADD,...** commands as needed to program the desired sequence. After each command send the ***ERR?** command to check for any incompatibility between the requested test step operation and the 95x. The 95x will append each **ADD,...** test step to the active sequence, so the user should send each desired step in the correct order.
- Send the **RUN** command. The 95x will now run the sequence.
- Poll the 95x at intervals to detect completion of the sequence. The selection of the polling interval is up to the user, for short test sequences this could be as fast as every millisecond, for long sequences perhaps every 100milliseconds or longer would suffice. Either the **STEP?** or **RUN?** Commands can be used, the **STEP?** command is recommended as it provides more information in the response. If needed, the user could also program **MEASRSLT?** Command(s) to extract actual measurements during execution of the sequence. If multiple measurement results are required during execution, the user should send multiple **MEASRSLT?** Commands as a set of commands, the 95x responds with all of the measurement results as a single set in the same order as requested. In this manner some interface time is saved, and it is guaranteed that all of the measurement results are consistent in time with each other. When using asynchronous timed polling the user should be careful as the OS may cause undesired operation –
 - If the user calls for an asynchronous timed event from the OS which is handled by the user code sending the query command(s) and fetching the response(s) then command overrun can occur if polling is too fast. The 95x may slightly delay either the command or the response to beyond the time interval being used for polling, also the OS itself may delay the transmission or reception. In some OS's calls are made regardless of the completion of the preceding call – so the second call will cause commands to be transmitted even though the responses from the first call have not been received yet. The user should use some sort of software interlock to prevent this if needed.
 - This issue does not occur if the user uses synchronous coding – i.e., send the query command(s) – wait for the response(s) – wait for a delay – repeat.
- Once the test sequence has completed (e.g., the response to the **STEP?** command is 0) the user should request for the test results. There are various methods of achieving this, which the user chooses is dependent on the level of detail which is needed. The following query commands are recommended –
 - **RSLT?** – responds with the overall test status, giving overall pass/fail information.

- **STEPRSLT?** for each defined step – giving very detailed information regarding each step.
- If the user requires to run the sequence again (usually with a different DUT) – then simply repeat the process starting with the **RUN** command – there is no need to reprogram the sequence itself unless changes are needed.

If the user needs to synchronize the execution of the sequence to external events, the HOLD type step can be used to cause the 95x to suspend execution of the sequence until the **CONT** command is received from the computer. As an example, if the computer is controlling switching which needs to be altered during execution the user would program the following during execution –

- Detect that the HOLD step is being performed by the response to the polled **STEP?** command.
- If the HOLD step is being performed, then program the required change(s) to switches and send the command **CONT** to the 95x to command it on to the next step in the sequence. The user may need to perform a slight delay after sending the **CONT** command as it will take the 95x about 1ms to actually continue on to the next step – if another **STEP?** command is received during that time then it will still report that the HOLD step is being executed.

Migrating from Earlier Firmware Versions

NOTE – if the user upgrades their 95x from an earlier version to v2.02 then a self-test MUST be run after the upgrade and before attempting to operate the 95x (see [Self Test](#)).

NOTE – users of QuickTest Pro need not make any changes to either the 95x, QuickTest Pro or their test sequences because of these changes. An updated version of QuickTest Pro using some of the new features may be available, contact Vitrek for details.

If the user has been using an earlier version of firmware in a 95x and is now using v2.02 then there are some differences which the user should be aware of –

- Added additional bit values to the Test Status Flags data which may be read via an interface during or after a sequence has been run (see

- **Test Step Status** Flags for details).
 - This causes no change to front panel use of the 95x.
 - The user may wish to extend their software to utilize these newly added bits.
- This version has added the ability to limit the maximum load current which will flow during discharge when executing a DCEz, DCW or DCIR type step. By default, this limit is set to 200mA following an upgrade from pre-v2.02 or when shipped from Vitrek, which yields the same actions as in previous versions. This setting is located in the CNFG - TEST menu. Interface commands MAXDISCHARGE? and MAXDISCHARGE,<NR3> have been added to support this capability should the user wish to change from the standard setting.
 - The user may wish to extend their software (if using an interface) to use this additional capability. No changes are needed if the new capability is not needed.
- DCW and DCIR type steps now have an additional menu setting for each step which allows the user to configure for minimum load detection during ramp. There is also a new setting in the CNFG – TEST menu which allows the user to enable (or disable) this capability in all steps. By default, the overall setting is set to disable the capability, which yields the same actions as in previous versions. If this is enabled then all sequences defined when running a version prior to v2.02 will have the minimum ramp load set to 0pF, which effectively disables it. In this manner the addition of this capability is transparent to the user unless the user specifically requires it. Interface commands MINLOAD? and MINLOAD,<BOOL> have been added to support the overall enable setting, and the individual commands for the DCW and DCIR type steps have an extra field added to support setting a minimum load for each step (see [DCW Configuration Fields](#) or [DCIR Configuration Fields](#) for details). If the extra field is missing (i.e., the user has not altered their software to support v2.02) then the minimum load detection capability is automatically disabled for that step, so the actions are as previously.
 - Users using the DCW or DCIR type steps using a maximum leakage resistance or a minimum leakage current setting to detect a disconnected load may wish to change to using the minimum ramp method instead as this offers a more reliable check.
- The “End On” termination setting for the DCIR type step has been extended to add a STDY selection. This selection is compatible with the commonly used practice of terminating a DCIR measurement when the measurement is within limits and is steady or improving.
- The maximum loading at low voltages and the minimum test voltage during DCEz, DCW and DCIR type steps have been slightly altered. See [Specifications](#) for details.
- The DCCAP and IRCAP type steps are no longer available. The user should convert to using the DCW or DCIR types instead. Recalling a sequence containing these step types created in an earlier version will cause the 95x to automatically convert them to DCW or DCIR steps respectively; however, the user should carefully check the conversion as it might not yield exactly the same test as the original step types.
 - The previous types differ from the DCW and DCIR types in the way in which the ramp is defined, the user will have to convert from defining the ramp as a target charging current with a maximum ramp rate and a ramp timeout to an actual ramp rate (or time) and a breakdown current, and otherwise the types are the same.
 - Previously the DCCAP and IRCAP types produced less initial current surge when starting the ramp into a capacitive load, this version provides a significant improvement in this surge in the DCW and DCIR types so that difference is no longer of concern.

- Previously the DCCAP and IRCAP types offered limiting the discharge current to that set for the ramp. This version allows the user to independently set a maximum discharge current if desired.
- The ACIR type step is no longer available. Recalling a sequence containing this step type created in an earlier version will cause the 95x to automatically convert it to an identical ACW step.
- The local line frequency setting has been removed from the CNFG – SYSTEM menu. The commands affecting that setting (LINE50? and LINE50,<BOOL>) are still available but do only affect a “dummy” setting.
 - The user need not alter their software if they were previously using that setting, however these commands may be removed in the future.
- A new option has been made available (option HSS or HSS-2) which enables the user to select whether leakage and breakdown currents are to be detected in the HV or RETURN terminal. Without this option only the RETURN terminal is used. This enables the 95x to be used to test DUT's which are grounded. Several of the test types have been extended to enable the user to select whether the DUT is grounded or not if this option is fitted.
 - If option HSS or HSS-2 is not fitted then no changes are needed.
 - If option HSS or HSS-2 is fitted, then the user should note that several menus and interface commands have altered to enable the user to control its usage, and that option HSS or HSS-2 restricts the maximum voltages from the 95x.
- The specifications for leakage current measurements when performing a DCez, DCW or DCIR type step with a capacitive load have been significantly improved and settling is faster in these situations. This yields more reliable low leakage (or high leakage resistance) measurements with capacitive loading.
 - The user may wish to change the test step timing to make use of the improved settling performance, otherwise no changes are needed.
- Added the capability of performing two DCW or DCIR ramp phases without any intermediate “gap”. Previously the user could perform two DCW or DCIR steps using a discharge setting of NONE in the first step, but there was always a dwell period in the first step which could unsettle a capacitive load during the overall ramp. This revision also supports setting a zero dwell time for the first such step, which eliminates the intermediate level dwell period.
 - The user may wish to change the test step timing to make use of the improved settling performance, otherwise no changes are needed.
- Breakdown limits can now be set to higher currents than previously allowed.
 - The user may wish to change the test step limits to make use of the changes, otherwise no changes are needed.