

ViTrek

V7X SERIES

OPERATING & MAINTENANCE MANUAL



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ABOUT THIS MANUAL

This applies to all V7X Series instruments having a main firmware revision of 1.03; there may be minor differences if the V7X being operated has a different main firmware version.

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.

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 needed.

SECTION 2 should be read and understood by all operators of the V7X.

SECTION 3 should be read when the V7X is first unpacked or installed.

SECTION 4 firstly summarizes the operation of the V7X from the front panel, and then gives details regarding each screen.

SECTION 5 only needs to be read by users of the Digital I/O interface.

SECTION 6 only needs to be read by users of the RS232 or USB interface.

SECTION 7 should be read by users performing calibration of the V7X.

APPENDIX A should be read by all inexperienced users, particularly those inexperienced in safety testing.

APPENDIX B gives full specifications for each type of test capable of being performed by the V7X.

WARRANTY INFORMATION

This ViTREK instrument is warranted against defects in material and workmanship for a period of 2 years 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 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.

This warranty does not apply to any products repaired or altered by persons not authorized by ViTREK or not in accordance with instructions provided by ViTREK. If the instrument is defective as a result of misuse, improper repair, improper shipment, or abnormal conditions or operations, repairs will be billed at cost.

ViTREK assumes no responsibility for its products being used in a hazardous or dangerous manner, either alone or in conjunction with other equipment. Special disclaimers apply to this instrument. ViTREK assumes no liability for secondary charges or consequential damages, and, in any event, ViTREK's liability for breach of warranty under any contract or otherwise, shall not exceed the original purchase price of the specific instrument shipped and against which a claim is made.

Any recommendations made by ViTREK or its representatives for uses of its products are based on tests believed to be reliable but ViTREK makes no warranties of the results to be obtained. This warranty is in lieu of all other warranties, expressed or implied, and no representative or person is authorized to represent or assume for ViTREK any liability in connection with the sale of our products other than set forth herein.

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

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SECTION 1 – PRODUCT INFORMATION

FEATURES

- Easy to Use
 - 4.3" High Resolution Color Touch Display - Intuitive Graphical User Interface
 - Large High Reliability START and STOP switches
 - Large easy to see PASS/FAIL Indicators
- Easy to Own
 - Low Cost of Ownership - 2 Year Calibration Interval, 2 Year Parts & Labor Warranty
 - In-Field Updating of Firmware
 - Compact and Lightweight
 - Only consumes 5W when not testing
- High Quality
 - Made in the USA - Designed & Built in San Diego CA
- Reliable
 - Rugged Construction
 - Fan free, vent free Design
 - High Efficiency Switch-Mode Drive with low temperature rise
- Full Function
 - Fast (100ms min test time) and Accurate (1%)
 - 5 Functions - AC/DC Hipot, Insulation Resistance, Ground Bond & Low Resistance
 - 5KV AC/DC Hipot, 20mA max source current, 100nA Leakage Current Resolution
 - Continuously Variable Insulation Resistance 20-5000V up to 450GΩ
 - Ground Bond 1-30A RMS, 100μΩ Resolution
 - Wide range (0 to 60KΩ) low resistance measurements with 1mΩ resolution
 - Ramped Discharge Capability
 - Selectable ARC Detection
 - Multi-Mode IR with Steady or Rising Pass Mode
 - Able to test either grounded or non-grounded DUTs
 - Wide range of capacitive loads can be tested (up to several μF)
- Built-In Verification
 - Completely Internal Self-Test Fully Exercises Output and Verifies Current Accuracy
 - Pre-Programmed Daily Verification Test With Optional PVD Test Load
- Safe
 - 150μs Safety Shutdown
 - Automatic DUT Discharge
 - Meets UL, CSA, IEC Safety Tester Requirements
 - CE Safety Mark Certified to EN61010
- Equally at home in simple and complex systems
 - USB 2.0, Serial RS232 and Digital I/O Interfaces are Standard
 - Able to be used in Complex Multi-Point Scanning Systems
 - Test Memory Stores up to 999 Steps and 60 Test Sequences which can be named by the user
 - Test steps for on-screen prompted user actions
 - On-screen review of complete test results for every test step

AVAILABLE MODELS, OPTIONS, SOFTWARE AND ACCESSORIES

MODELS

All models have USB 2.0, Serial RS232, Digital I/O and External Switch System (VICL) interfaces as standard.

- **V70.** ACW and CONT modes.
- **V71.** ACW, DCW and CONT modes.
- **V73.** ACW, DCW, IR and CONT modes.
- **V74.** ACW, DCW, IR, CONT and GB modes.
- **V79.** CONT and GB modes.

OPTIONS

- **V7X-230V.** Factory Set 230V Line Operation.
- **RPOO-7.** Rear Panel Mounted Terminals instead of standard Front Panel Terminals.

SOFTWARE

QTV Pro-7. A 45 day free trial included with each unit. This software provides-

- The user does not need to write software to use the V7X 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 V7X 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 XP through Windows 8 as a Desktop Application).
- Upwards Compatibility to other ViTREK products.
- Easy upgrade for users with ViTREK V6X and V4 products and QTPro-V software.

ACCESSORIES

- **TL-115-95.** 115V Receptacle Hipot Test Adaptor
- **TL-115-GBR.** 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 HiPot and Ground Bond
- **TL-209.** HV/CONT Test Lead Set (one supplied with each unit).
- **K-2R.** Ground Bond Test Lead Set (one supplied with each V74 and V79).
- **RS-2.** 6ft RS232 cable (V7X to Computer).
- **USB-1.** 6ft USB 2.0 A-B Cable (V7X to Computer).
- **RSS-7.** Remote Start Switch.
- **RSF-7.** Remote Start Footswitch.
- **HVW-7.** High Voltage Warning Light.
- **DIO-X2.** Allows multiple accessories to be connected to the Digital I/O port.

- **RM-7.** Rack mount kit for the V7X.
- **APVD-7X.** PVD for performing automatic HiPot and Low Resistance verification tests.
- **APVD-74.** PVD for performing automatic HiPot, Low Resistance and Ground Bond verification tests.

SECTION 2 – SAFETY

The user should be aware of these safety warnings at all times while using the V7X Series.

DANGER - THE V7X PRODUCES VOLTAGES AND CURRENTS WHICH MAY BE LETHAL; UNSAFE OPERATION MAY RESULT IN SEVERE INJURY OR DEATH.

WARNING - IF THE V7X IS USED IN A MANNER NOT SPECIFIED BY VITREK THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED AND SAFETY MAY BE COMPROMISED.

TERMINALS AND WIRING

DANGER - THE V7X 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 **CAUTION TESTING** warning on the front panel of the V7X is illuminated whenever an unsafe voltage or current may be present on the terminals of the V7X.

WARNING - THE V7X PRODUCES VOLTAGES OF UP TO 5kVrms ON THE HV TERMINAL. THE USER MUST ENSURE THAT CONNECTIONS TO THIS TERMINAL HAS 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 V7X 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 V7X and will reduce the capabilities of the wiring insulation over time, eventually resulting in insulation failure.

All terminals of the V7X other than the HV terminal are always protected to be within a safe voltage of the V7X 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 V7X shuts down, in severe cases this can damage nearby equipment, such as computers. The wiring between the V7X terminals and the DUT should be routed as far as possible away from other equipment and from all cabling connected to other equipment.

WARNING - SOME V7X MODELS PRODUCES CURRENTS OF UP TO 30Arms ON THE GB 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 50mA continuous, but the **GB** terminal wiring should be rated for the highest set test current (this may be up to 30A).

USER ACTIVATED SAFETY ABORT

- The user may depress the **STOP** button on the V7X 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 5.
- The user can configure for a digital STOP signal to be input to the DIO Interface which will abort any type of test step if asserted. See SECTION 5.
- There are several interface commands which can be used to abort a running test sequence. See SECTION 6.

AUTOMATIC SAFETY ABORT

- 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 V7X which participate in monitoring the output of the V7X 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.
- All processors in the V7X have an associated hardware “watchdog” which recovers a mis-operating processor 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, STORAGE AND SHIPPING

DIMENSIONAL SPECIFICATIONS

137mmH x 248mmW x 284mmD (5.4" x 9.75" x 11.2")

V70, 71, 73, 79 : 6.8kg (15lb) net, 7.9kg (17.5lb) shipping

V74 : 7.9kg (17.5lb) net, 9.1kg (20lb) shipping

Dimensions and weights shown are nominal

ENVIRONMENTAL SPECIFICATIONS

Storage Environment -20 to 75C (non-condensing)

Operating Environment 0 to 40C, <85% RH (non-condensing), Pollution Degree 2

Operating Altitude 0 to 10000ft ASL, reduced maximum voltage capability above 5000ft

CAUTION – THE V7X SHOULD NOT BE USED IN AN ENVIRONMENT WHERE CONDUCTIVE POLLUTION CAN OCCUR, E.G. IN AN OUTDOOR ENVIRONMENT.

CAUTION – 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.

WARNING - 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.

POWER SOURCE SPECIFICATIONS

Internally set for 105-125Vrms or 210-250Vrms, 45 to 65Hz, 200VA maximum

DANGER - THE V7X 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 V7X 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.

DANGER - TURNING OFF OR OTHERWISE REMOVING POWER TO THE V7X WHILE IT IS GENERATING HIGH VOLTAGES WILL NOT ENABLE THE V7X TO DISCHARGE THE DUT AND MAY DAMAGE THE V7X. THE DUT MAY HAVE DANGEROUS VOLTAGES PRESENT FOR LONG PERIODS OF TIME AFTER THIS OCCURS.

DANGER - DO NOT REMOVE THE POWER CORD FROM THE V7X OR FROM THE SOURCE OF POWER WHILE IT IS OPERATING AT HIGH VOLTAGES. THIS WILL REMOVE THE PROTECTIVE GROUND FROM THE CHASSIS OF THE V7X AND THE DUT WHICH MAY RESULT IN HAZARDOUS VOLTAGES BEING ACCESSIBLE TO THE USER.

CHANGING THE POWER SUPPLY VOLTAGE SETTING

CAUTION – THE V7X IS INTERNALLY WIRED FOR A SPECIFIC POWER SOURCE VOLTAGE RANGE. THE USER MAY CHANGE THIS BY FOLLOWING THE PROCEDURE DESCRIBED BELOW. THE V7X MAY BE DAMAGED BY ATTEMPTING TO OPERATE IT FROM AN INCORRECT VOLTAGE POWER SOURCE.

A qualified user may change the power supply voltage setting in the V7X as follows-

1. Ensure that all power has been removed from the V7X before attempting this procedure.
2. Set the V7X on a flat surface with sufficient clear space around the V7X.
3. Remove and set aside the front and rear rubber bezels. Each bezel is engaged on a tab which runs around the majority of the respective front or rear panel. Each bezel needs to be stretched away from this tab while removing it. CAUTION – ENSURE THAT NO PART OF THE USERS BODY (E.G. HAND OR FINGER) BECOMES TRAPPED BETWEEN THE RUBBER BEZEL AND THE RAISED TAB, OTHERWISE INJURY MAY RESULT.
4. Remove the top cover from the instrument, setting aside the cover, screws, handle and handle covers while doing so.
 - a. Remove and set aside the two flat head screws centrally located next to the upper front and rear panels in the uppermost surface of the top cover.
 - b. Remove and set aside the two pan head screws holding the lower edge of the cover to the side of the V7X on the left side when viewed from the front of the V7X.
 - c. Remove and set aside the two flat head screws retaining the handle to the V7X located on the lower right side when viewed from the front of the V7X. The handle and its two covers should be removed and set aside.
 - d. The cover may now be removed by sliding it upwards until it is clear of the V7X and placing it aside.
5. At all times while the cover is removed from the V7X, do not unnecessarily handle the PCB(s) in the V7X and ensure that no foreign objects enter the chassis of the V7X.
6. Locate the cable and connector near the front left corner of the inside of the V7X which engages into either the 115V LINE or 230V LINE connector on the front most edge of the large horizontal PCB in the V7X. Confirming which location is required for the local power source voltage, disengage the connector from its present location and engage the connector to the required location. Ensure that the ramp on the female socket correctly engages with the lock on the male part located on the PCB.
7. Re-assemble the handle, handle covers and top cover to the V7X by following the reverse of steps 3 and 4 above ensuring all screws are securely tightened.
8. Replace the fuse in the rear panel fuse holder with the correctly rated fuse for the local power supply voltage-
 - a. 115V nominal power : 2A Slow-Blo (T) fuse, 230V rated, 5x20mm
 - b. 230V nominal power : 1A Slow-Blo (T) fuse, 230V rated, 5x20mm
 - c. DO NOT OPERATE THE V7X WITH AN INCORRECTLY RATED FUSE.
9. Erase the marking on the rear panel indicating the present line voltage setting, and mark it with the setting just performed.

INITIAL INSPECTION

After the V7X has been shipped or otherwise handled in an unknown manner, the user should visually inspect the V7X 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, there are no marks or scratches on the front panel LCD touchscreen and that all terminals are securely mounted to the unit. If any significant dents or any loosely

mounted terminals are noted then it is recommended that the V7X be serviced prior to being placed into use, as safety may have been compromised.

Before applying power to the V7X the user should ensure that the V7X is wired for the same voltage as the local power supply, this is indicated on the rear panel of the V7X. See CHANGING THE POWER SUPPLY VOLTAGE SETTING regarding changing the setting if needed.

SECTION 4 – USING THE V7X FROM THE FRONT PANEL

THE V7X TOUCHSCREEN

The V7X LCD panel touchscreen is used for most manual user interaction with the V7X.

- Do not use a pen or pencil, or a sharp object, or a fingernail on the touchscreen, this may damage the screen.
- Do not apply excessive pressure to the touchscreen otherwise it may be damaged.
- It is not recommended to use gloves when using the touchscreen.
- The touchscreen has been designed to not require the use of a stylus; however one can be used if desired. If a stylus is used then ensure that it has a smooth surface where it touches the screen and do not apply excessive force, otherwise it may damage the screen.
- In normal operation, the display shows the areas which may be used as buttons or controls with the touchscreen.

TEST SEQUENCES AND STEPS

All usage of the V7X for testing a DUT (Device under Test) uses test sequences. 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 (some of these may not be available for the specific V7X series model being used) –

- ACW. This performs an AC Voltage Withstand test on a DUT; generally testing for the absence of breakdown and optionally that the leakage current is within user specified limits.
- DCW. This performs a DC Voltage Withstand test on a DUT; generally testing for the absence of breakdown and optionally that the leakage current is within user specified limits.
- IR. This performs a leakage resistance test on a DUT when subjected to a user set DC voltage; generally testing that the leakage resistance is within user specified limits.
- CONT. This performs a resistance measurement using a low DC voltage (<4.1V) and current (<11mA); generally testing that a resistance is within user specified limits.
- GB. This performs a resistance measurement using a user set current of up to 30Arms; generally testing that a resistance is within user specified limits.
- PAUSE. This is generally only used as part of a complex user defined sequence; allowing the test sequence to be paused for a user defined period of time.
- HOLD. This is generally only used as part of a complex user defined sequence; allowing the test sequence to be held with a user defined message displayed on the screen, waiting for user interaction before continuing.
- SWITCH. This is generally only used as part of a complex user defined sequence; allowing the V7X to command between 1 and 4 external switch units (e.g. Vitrek 964) to be set to a user specified set of switch states.

Each test sequence (up to 61 may be defined) may contain up to 999 test steps, however the user is limited to a maximum of 1000 test steps across all test sequences other than sequence #0. All test sequences other than sequence #0 are stored in non-volatile memory; i.e. their contents are retained while the V7X is not powered. Do

not turn the V7X power off while it is displaying that it is storing a test sequence, otherwise that sequence may be corrupted.

A SUMMARY OF SETTING UP THE TESTS TO PERFORM AND RUNNING THEM

The inexperienced user will find APPENDIX A useful reading as it contains many hints regarding how to configure the test step types, this appendix also contains details regarding how to connect to the DUT. APPENDIX B contains the full specifications for each test step type.

It is recommended that the user plan ahead and decide what steps are needed and in what order, before attempting to setup a test sequence. This will save you time and effort. The user may alter a sequence later by essentially following the procedure describe here, but should note that an existing sequence can be extended later with additional steps or can be shortened by deleting any step from a sequence, but the user cannot insert a step within an existing sequence.

1. On the MAIN MENU screen of the V7X select an empty test sequence in which the tests will be programmed by using the PREV or NEXT buttons as needed. Note that Sequence #0 is volatile (i.e. will not be stored when power is removed) so generally would not be used for other than interface defined sequences.
2. If it is wished to give the sequence a name, press the CREATE NAME button and enter the desired name (up to 15 characters).
3. Press the EDIT STEPS button. The display will now change to a screen allowing the user to define one or more test steps for the selected sequence as described below.
4. For each step required –
 - a. Press the TYPE button as needed until the desired test type is shown on the screen.
 - b. Press each button across the bottom of the screen as needed to change/configure each setting for this test step. If needed, see APPENDIX A for details regarding selecting settings or values.
5. If more steps are required, press the ADD STEP button and repeat 4 above.
6. When completed, press the SAVE + RETURN button to save the sequence and return to the MAIN MENU screen. Pressing the STOP button discards all changes made.
7. As described on the screen, use the START (and possibly the STOP key) to run the sequence.
8. After completion a screen is shown which contains the overall test result. If only one test was performed, then the full results for that step are displayed, otherwise a summary of the entire sequence is displayed and the user may use a button to review the individual step results. Depending on configuration settings, the user may not need to return to the MAIN MENU screen to start another run of the sequence.

TEST FAILURE MESSAGES

The following are the possible test failure messages-

- BREAKDOWN DETECTED. This indicates that a breakdown was detected within the DUT.
- BELOW MIN LIMIT. This indicates that the measurement result for the test step was below the configured minimum limit for that step.
- ABOVE MAX LIMIT. This indicates that the measurement result for the test step was above the configured maximum limit for that step.

- **ARCING DETECTED.** This indicates that arcing was detected in the DUT and a maximum ARC current limit was defined and was exceeded.
- **IR UNSTEADY.** This indicates that the IR measurement result is decreasing but within the limits.
- **OVER COMPLIANCE.** This indicates that the V7X had insufficient compliance voltage to drive the configured test current during a GB test step. This may indicate that the load was excessively over the maximum for the configured GB test step current, or that there is excessive series resistance in the high current wiring.
- **WIRING INCORRECT.** This indicates that the wiring during a GB test was not correct for 4-wire measurements. The user should check the wiring and take corrective action as needed.
- **USER HOLD TIMEOUT.** This indicates that the user did not continue a HOLD test step within the configured timeout period for that step.
- **UNSTABLE LOAD.** This indicates that the applied voltage (or current) to the DUT during a test step could not be controlled, typically this is caused by the leakage current (or resistance) rapidly wildly varying (but remaining within limits).
- **ABORTED BY USER.** This indicates that the test sequence was aborted by the user.
- **INTERLOCK OPENED.** This indicates that the Digital I/O Interlock signal was enabled and was opened during a test sequence so the sequence was aborted for safety reasons.
- **OVERHEATED.** This indicates that the internal temperature of the V7X exceeded preset limits and so a preventative shutdown occurred. It is recommended to wait a few minutes and re-attempt the test sequence. If the condition persists then the ambient temperature of the V7X is beyond the specified operating limits and the user should take corrective action.
- **LINE TOO LOW.** This indicates that the line power supply voltage was too low to allow the V7X to generate the configured voltage or current into the present DUT. The user should check the local supply voltage and take corrective action as needed.
- **OVER VOLTAGE.** This indicates that the output voltage from the V7X was excessively over the configured voltage. This may be caused by a fault in the V7X or that there is an external voltage source connected to the DUT.
- **SWITCH UNIT FAILED.** This indicates that an external switch unit failed to communicate, or a specific switch within it was configured in the step to be closed but was not present in the actual switch unit.
- **INTERNAL FAULT.** This generally indicates that there is an internal fault within the V7X, it is recommended to perform a SELF TEST from the UTILITY MENU screen to gain more details regarding this.

THE V7X SCREENS

MAIN MENU SCREEN

After the V7X is turned on and the introductory screen has been shown, the V7X shows the Main Menu Screen, an example of which is shown below.

- The terminals of the V7X are always in a safe condition while on this screen.
- Generally, this is the screen from which all test sequences are created, edited and/or started.
- The main part of the screen shows the last selected test sequence # (with name if defined), the number of test steps defined in that sequence, and a summary of the first few steps within that sequence.

- The buttons down the left side of the screen provide access to the auxiliary function menus and allow the user to LOCK/UNLOCK the contents of the sequences and the configuration of the V7X (if enabled in the CONFIG MENU screen).
- The buttons across the bottom of the screen allow you to select a different test sequence or to modify the selected test sequence (if not locked).
 - PREV or NEXT. Selects the next lower, or higher, numbered sequence.
 - EDIT STEPS. Initiates editing the selected sequence. If the selected sequence has no steps then starts with creating the first step, otherwise it starts with allowing the user to edit the existing first step.
 - CREATE NAME (or EDIT NAME). Allows the user to create a new name or edit an existing name, associated with the presently selected sequence. A sequence name can contain up to 15 characters and (if defined) is displayed on the MAIN SCREEN just under the respective selected sequence number information. Naming a sequence makes it easier to decide which sequence is to be selected and run for a specific DUT, or a specific series of tests, rather than just a number.
- The area just above the buttons across the bottom of the screen describes the usage of the START and STOP buttons located on the front panel to the left of the screen.



EDIT SEQUENCE SCREEN

If the EDIT STEPS button on the MAIN MENU screen is pressed, then this screen is shown, some examples of which are shown below.

- The terminals of the V7X are always in a safe condition while on this screen.
- The main part of the screen shows the present settings for the selected step in the presently selected sequence.
- The buttons down the left side of the screen allow the user to save the sequence, select which step is being edited, delete steps, or extend the sequence by adding additional steps to the end of the sequence.
- If changes are made, they do not become effective until the SAVE + RETURN button is pressed.
- The STOP button may be used to discard any changes made while on this screen, returning to the MAIN MENU screen.
- The buttons across the bottom of the screen allow you to change each setting for this step. The available buttons are dependent on the step type selected. The individual selections are –

- TYPE. This sets which type of activity will be performed when running this step. The type chosen is changed each time the button is pressed. The inexperienced user will find APPENDIX A useful reading as it contains many hints regarding how to configure the test step types, this appendix also contains details regarding how to connect to the DUT. APPENDIX B contains the full specifications for each test step type.
- LEVEL (ACW, DCW, IR and GB type steps only). This allows the user to enter the voltage or current level at which the step will be performed. When pressed, a temporary screen is shown allowing the level to be entered.
- DUT (ACW, DCW and IR type steps only). This sets the type of DUT which will be tested when the step is performed. The type chosen is changed each time the button is pressed.
 - Isolated. This is the generally used selection. This selection should be made if the DUT is not earth grounded and has negligible leakage to earth ground to/from the RET terminal connection.
 - Grounded. This is rarely used. This selection should be made if the DUT is earth grounded or has significant leakage to earth ground to/from the RET terminal connection.
 - Resistive (DCW and IR types only). This is the most commonly used selection. This selection should be made if it is known that the load has negligible capacitance (typically less than 0.02uF). This enables the V7X to produce the highest accuracy and resolution results when performing the test.
 - Capacitive (DCW and IR types only). This selection should be made if it is known that the load has significant capacitance (typically more than 0.05uF) or it is unknown if the load has significant capacitance. This enables the V7X to produce the most stable results when performing the test, but prohibits the highest accuracies and resolutions.
- RAMP (ACW and DCW type steps only). This allows the user to enter the amount of time over which the V7X will linearly ramp the voltage to the set test voltage level at the start of the step. When pressed, a temporary screen is shown allowing the ramp time to be entered.
- DWELL (ACW, DCW, IR, CONT and GB type steps only). This allows the user to enter the length of time over which the step will be fully active (it does not include the ramp time). When pressed, a temporary screen is shown allowing the dwell time to be entered, or allowing the user to select USER in which case the step will run indefinitely until continued by the user.
- DELAY (IR type steps only). This allows the user to enter the delay within the dwell period before the minimum and maximum resistance limits will be imposed. When pressed, a temporary screen is shown allowing the delay time to be entered.
- DELAY (PAUSE type steps only). This allows the user to enter the time for which the sequence will be delayed when this step is performed. When pressed, a temporary screen is shown allowing the delay time to be entered.
- LIMITS (ACW, DCW, IR, CONT and GB type steps only). This allows the user to set a range of measurement results which will cause a PASS condition. When MIN LIMIT or MAX LIMIT is pressed, a temporary screen is shown allowing the respective limit value (or NONE if able) to be entered.

- For ACW and DCW type steps the user can set minimum and maximum leakage currents, only a minimum, only a maximum, or neither. Note – the user does not need to enter leakage limits to detect breakdown, if both the minimum and maximum limits are set to NONE the V7X will still detect breakdown in accordance with most standards.
 - For IR type steps the user can set minimum and maximum leakage resistances, or only a minimum.
 - For CONT type steps the user can set minimum and maximum resistances, only a minimum, only a maximum, or neither.
 - For GB type steps the user can set minimum and maximum resistances, or only a maximum.
- ZERO (CONT and GB type steps only). This allows the user to set a fixed resistance offset which will be applied to (subtracted from) all resistance measurements during this step. When pressed, a temporary screen is shown allowing the offset value to be entered.
 - SWITCH n (SWITCH steps only). This allows the user to specify the external switch conditions within each switch unit which will be set when this step is performed. When pressed, a temporary screen is shown allowing the switch states to be entered.
 - MSG n. This allows the user to set a message which will be displayed to the user when this step is performed. Each message line may be up to 16 characters long. When pressed, a temporary screen is shown allowing the message line to be entered or edited.

SAVE + RETURN	Sequence #1 Step 1 of 1					
PREV STEP	TYPE:	ACW				
ADD STEP	LEVEL:	2250V				
DEL STEP	DUT:	Isolated				
	RAMP:	1sec				
	DWELL:	60sec				
	LIMITS:	Breakdown Only				
TYPE	LEVEL	DUT	RAMP	DWELL	MIN LIMIT	MAX LIMIT

SAVE + RETURN	Sequence #1 Step 1 of 1					
PREV STEP	TYPE:	DCW				
ADD STEP	LEVEL:	1000V				
DEL STEP	DUT:	Resistive, Isolated				
	RAMP:	1sec				
	DWELL:	10sec				
	LIMITS:	5mA max				
TYPE	LEVEL	DUT	RAMP	DWELL	MIN LIMIT	MAX LIMIT

SAVE + RETURN	Sequence #1 Step 1 of 1					
PREV STEP	TYPE:	IR				
ADD STEP	LEVEL:	1000V				
DEL STEP	DUT:	Resistive, Isolated				
	DWELL:	10sec				
	DELAY:	1sec				
	LIMITS:	10M Ω min				
TYPE	LEVEL	DUT	DWELL	DELAY	MIN LIMIT	MAX LIMIT

SAVE + RETURN	Sequence #1 Step 1 of 1					
PREV STEP	TYPE:	GB				
ADD STEP	LEVEL:	25A				
DEL STEP	DWELL:	10sec				
	LIMITS:	100m Ω max				
	ZERO:	0m Ω				
TYPE	LEVEL	DWELL	MIN LIMIT	MAX LIMIT	ZERO	

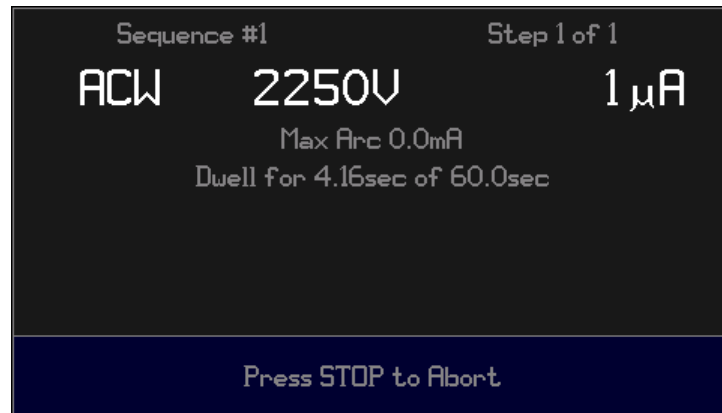
SAVE + RETURN	Sequence #1 Step 1 of 1					
PREV STEP	TYPE:	CONT				
ADD STEP	DWELL:	10sec				
DEL STEP	LIMITS:	0.1 Ω max				
	ZERO:	0 Ω				
TYPE	DWELL	MIN LIMIT	MAX LIMIT	ZERO		

SEQUENCE RUNNING RESULTS SCREEN

While running a test sequence (i.e. after pressing the START button, but before the entire sequence has completed) the Sequence Results Screen is shown, an example of which is shown below.

- The top of the screen shows the sequence # being run, and the step # within the sequence presently being run.
- The second line shows the type of step being run, with the test voltage or current level and the measurement result at this time (as applicable for the type of step being run).
- For ACW and DCW type steps the next line shows the highest detected arcing current during this step.

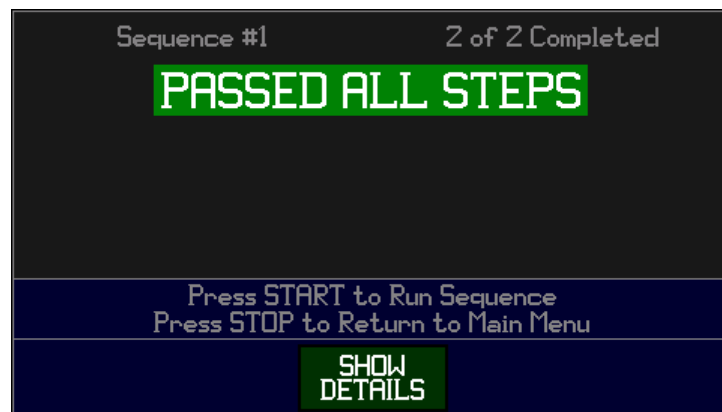
- The next line shows the phase of the present step, the amount of time expired, and the remaining time (as applicable).
- The bottom portion of the screen shows the usage of the START and STOP buttons during this step.



SEQUENCE MULTI-STEP REVIEW SCREEN

After a sequence containing multiple steps has been run, this screen is shown, an example of which is shown below. The overall status of the tests and a summary listing of the first few failing steps (if any) are shown on this screen.

- The terminals of the V7X are always in a safe condition while on this screen.
- Depending on the relevant configuration setting, the user may be able to start a further run of this sequence from this screen.
- The individual results for each step may be reviewed by pressing the SHOW DETAILS button at the bottom of this screen.



SEQUENCE SINGLE STEP REVIEW SCREEN

After a sequence has been run which resulted in only a single step being executed then this screen is shown, an example of which is shown below. This screen is also shown if the SHOW DETAILS button is pressed on the Sequence Multi-step Review Screen.

- The terminals of the V7X are always in a safe condition while on this screen.
- The information shown is that present when the selected step was completed (whether pass or fail).

- The second line shows the type of step being run, with the test voltage or current level and the measurement result at this time (as applicable for the type of step being run).
- For ACW and DCW type steps the next line shows the highest detected arcing current during this step.
- The next line shows the phase of the present step, the amount of time expired, and the remaining time (as applicable).
- Below this is an indication of the pass/fail status for this step only. If a FAIL was detected, then (as applicable) the relevant data on this screen is shown in red.
- Depending on the relevant configuration setting, the user may be able to start a further run of this sequence from this screen.



CONFIG MENU SCREEN

If the CONFIG MENU button on the MAIN MENU screen is pressed, then this screen is shown, an example of which is shown below.

- The terminals of the V7X are always in a safe condition while on this screen.
- The main part of the screen shows the present configuration settings for the V7X.
- The buttons down the left side of the screen allow the user to save the configuration settings, or to set them to factory defaults.
- The buttons across the bottom of the screen allow you to change each setting. The MORE and BACK buttons allow the user to switch between the available buttons.
- If changes are made, they do not become effective until the SAVE + RETURN button is pressed.
- The STOP button may be used to discard any changes made while on this screen, returning to the MAIN MENU screen.
- These settings affect operation of the V7X for all sequences being run.
- The available settings are-
 - IFACE. This allows the user to select whether the RS232 or the USB interface (or neither) will be used to control the V7X.
 - VICL. This allows the user to select how many ViTREK 964 Switch Matrix units are attached to the V7X (if any).
 - DIO. This allows the user to enable the Digital I/O inputs as needed.
 - START. This allows the user to restrict how the front panel START switch is used.

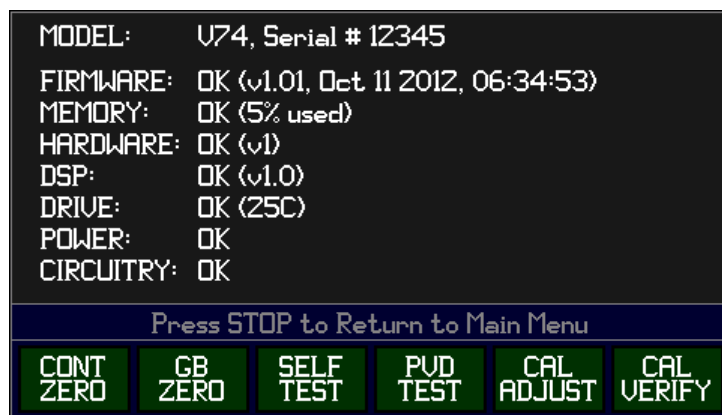
- BEEP. This allows the user to select when the V7X will emit a beep sound.
- LOCK. The user may set that a password is required to make future changes to the configuration and sequences stored in the V7X. This selection enables this operation. When initially enabled, the user may enter a password containing up to 5 digits which will be needed to be entered in the future to make changes.
 - If a password has been previously set, but has been forgotten, the please contact Vitrek for details regarding recovering from this.
- FREQ. This allows the user to select whether ACW and GB test steps will be performed at 50Hz or 60Hz.
- ARC. This allows the user to set an arc current limit, above which steps will be failed. If set to 0 (No limit) then arc current is still measured, and the result is still made available, but arc current will not cause a failure of a test step.
- IR END ON. This only applies to IR type test steps and sets the condition(s) under which an IR type test step may be terminated prior to the test time expiring.
 - Fail. This is the most commonly used setting. The V7X will terminate IR steps as soon as a leakage resistance is measured which falls outside the limits set for that step. If the dwell time for that step is reached prior to this occurring then the step is considered a PASS.
 - Pass. This is a rarely used setting. The V7X will terminate IR steps as soon as a leakage resistance is measured which falls inside the limits set for that step. If the dwell time for that step is reached prior to this occurring then the step is considered a FAIL.
 - Time Expired. This is an often used setting. The V7X will only terminate IR steps when the dwell time for that step is reached, the pass/fail decision is entirely based on the measured leakage resistance at that time.
 - Pass and Steady or Increasing. This is an often used setting. The V7X will terminate IR steps as soon as a leakage resistance is measured which falls inside the limits set for that step and is either steady or increasing in value. If the dwell time for that step is reached prior to this occurring then the pass/fail decision is entirely based on the measured leakage resistance at that time.
- RAMP DOWN. This only applies to DCW and ACW type test steps and selects whether these type tests will quickly discharge when completed or will ramp down using the same time as set for that steps Ramp setting.
- ON FAIL. Usually the user wishes to stop running the sequence as soon as a failure occurs, however in some situations the user may wish to continue testing. This allows it to be configured by the user.



UTILITY MENU SCREEN

If the UTILITY MENU button on the MAIN MENU screen is pressed, then this screen is shown, an example of which is shown below.

- The main portion of the screen shows the present status of the V7X. The results of the internal tests shown on this screen are for those continuously run at all appropriate times while the V7X is powered.
 - If the temperature shown on the DRIVE line is significantly higher than expected then this generally indicates that the V7X has insufficient cooling space around it, or is being heated by other equipment, or a combination of these. Corrective action may need to be taken by the user.
 - If the POWER line shows that the applied line power source is beyond (or close to beyond) the allowable range then corrective action should be taken by the user.
 - If any of the indicated test results on this screen show an error or warning, then corrective action should be taken. In most case this indicates that service is required.
- The buttons across the bottom of the screen allow you to perform one of several utility operations on the V7X –
 - CONT ZERO. This allows the user to measure the impedance of a pair of leads connected between the CONT terminals and use the measured resistance of these leads as an offset in all future CONT type resistance measurements. See APPENDIX A for further details.
 - GB ZERO. This allows the user to measure the impedance of leads connected to the GB terminals and use the measured resistance of these leads as an offset in all future GB type resistance measurements. Note – generally this function should not be used unless the user needs to use a length of 2-wire connection when performing GB type steps. See APPENDIX A for further details.
 - SELF TEST. When pressed, this commands the V7X to perform a series of active circuitry tests within the unit, which, if successful, provides confidence that the V7X is operating correctly. It is recommended that this test be performed at regular intervals (e.g. weekly). No external equipment, wiring or tools are required to perform a SELF TEST.
 - AUTO PVD. Under construction.
 - CAL ADJUST. This enables the user to adjust the calibration of the V7X; this is described later in this manual and should only be performed by qualified personnel.
 - CAL VERIFY. This enables the user to adjust the calibration of the V7X; this is described later in this manual and should only be performed by qualified personnel.



DATA ENTRY SCREENS

Many configuration settings are of the multiple choice type. These settings are changed without leaving the screen in which they appear by pressing (repeatedly if needed) the associated button across the bottom of the screen.

Other configuration settings require user data entry; by pressing the associated button across the bottom of the screen the user is presented with a data entry screen to set the desired data. Pressing the ENTER button on a data entry screen saves the data and returns to the original screen, pressing the STOP button discards any changes made and returns to the original screen. In all cases, the user must enter a valid entry on a data entry screen. The screen prompts the user if the data entered is not acceptable.

Numerical entries follow the industry standard methods for data entry, extended to allow for a selection of units if applicable (e.g. μA or mA) and entry of a special condition if applicable (e.g. USER terminated dwell period, or NONE as a measurement limit).

Entry of a name or message uses left and right cursor keys to select each available character position, allowing the user to modify the existing character in that position by pressing the UP or DOWN keys to select a different character. Hint – when the selected character is blank, pressing the UP key selects alphabetic letters while pressing the DOWN key selects digit characters. The available characters are listed below (in the UP order from left-to-right) -

ABCDEFGHIJKLMNOPQRSTUVWXYZ#%&:()*+,-./<=>@0123456789 and a blank character

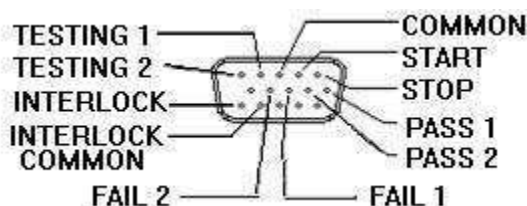
SECTION 5 – USING THE DIGITAL I/O INTERFACE

The Digital I/O interface available on the rear panel of the V7X enables the user to-

- Optionally control starting and stopping test sequences using contact closures.
- Optionally prevent test operation without a Safety Interlock contact closure being present.
- Optionally use contact closure outputs to signal or indicate the present state of a test sequence.

DIGITAL I/O CONNECTOR PINOUT

The connector on the rear panel of the V7X is a DB sized, 15-pin, female connector. This is the same physical connector as used for computer “VGA” interfaces.



STOP Input	Pin 1 : Connecting STOP to COMMON will stop the V7X from running a test sequence and abort it if one is running.
START Input	Pin 2 : Changing from disconnection to connecting START to COMMON will start a test sequence running. The state of this signal is ignored if the STOP signal is in the connected state.
INTERLOCK Input	Pin 14 : Connecting INTERLOCK to INTERLOCK COMMON (or COMMON) will abort a test sequence with an INTERLOCK OPENED failure. This is typically connected to a safety hood (or similar) to abort a test sequence and remove high voltages should the safety hood be opened. Note that this signal does not prevent a sequence from being started (e.g. using the START input), it will immediately fail the sequence should it be enabled but not closed at the time a sequence is started.
COMMON & INTERLOCK COMMON	Pins 3 and 15 : These are the COMMON signal for the RESET, START and INTERLOCK input signals. These two pins are internally connected together and are internally grounded.
TESTING 1, 2 Output	Pins 4 and 5 : While running a test sequence the “TESTING” lines are closed.
PASS 1, 2 Output	Pins 6 and 7 : After a test sequence has been run with a pass status the “PASS” lines are closed.
FAIL 1, 2 Output	Pins 8 and 9 : After a test sequence has been run with a fail status the “FAIL” lines are closed.

Note that the input signals are contact closure with parallel capacitance of nominally 0.1 μ F. Even with this capacitive loading it is possible to falsely trigger these inputs with extremely adverse interference. The user is recommended to not locate the cable(s) the Digital I/O interface close to any DUT test connections or use well shielded cables if this cannot be achieved.

Although the common signal for all Digital I/O interface inputs is ground, it is recommended that these be driven either from an isolated contact closure or from a grounded reference which is directly connected to the V7X chassis ground. Very large inter-ground voltages can occur during catastrophic load breakdown failures, which can damage either the V7X Digital I/O Input or the output of the driving device.

Each Digital I/O output pair is isolated from the other output pairs and from ground.

SPECIFICATIONS FOR THE DIGITAL I/O INTERFACE

Input Levels	Contact Closure to ground 10K Ω nominal internal pull-up to 3.3Vdc, 0.1 μ F to ground Clamped at +5Vdc, -0.7Vdc to ground
Input Timing	Contact must be open or closed for >5ms for the state to be recognized <1ms per step delay between closing START and actually starting the sequence
Output Levels	Contact closure <16 Ω 60V max open voltage (either polarity) 100mA max continuous (350mA for <10ms) load current (either polarity) 500Vpk max isolation from ground and between signals
Output Timing	Contact change of state relative timing between outputs : <5ms

CONFIGURING THE DIGITAL I/O INTERFACE

The DIO setting in the CONFIG MENU screen allows the user to configure the inputs (STOP, START and INTERLOCK) of the Digital I/O, the outputs are always enabled.

DIGITAL I/O SIGNAL TIMING

The Digital I/O inputs are intended to be used in concert with the Digital I/O outputs using the following example-

STARTING A TEST SEQUENCE

1. Open both STOP and START inputs and wait at least 5ms.
2. Close START input and wait at least 5ms.
3. Wait until any output of TESTING, PASS or FAIL is closed – this step is needed to accommodate the start delay when starting a very long sequence or when starting a sequence which only runs for a very short time.
4. Open START input - the test sequence is now running or has already terminated. This step can be omitted if desired because the timing of opening the START input is not critical, so it can be opened at any time as long as it is closed for at least 5ms.
5. Wait until TESTING output is open – the test sequence has now completed but there may be a slight delay before the pass or fail status is available.
6. Wait until either PASS or FAIL output is closed – the test sequence has completed and the pass/fail status may be determined. After a test sequence has been run in this manner, the PASS or FAIL output will remain closed until the user either starts running the same test sequence, presses the front panel STOP button, or selects another test sequence.

SECTION 6 – USING THE V7X FROM AN INTERFACE

The V7X may be programmed via the RS232 or USB interface. Both use the same format for commands and query responses. All data uses the standard 7-bit ASCII character set.

There are a great many software languages, compilers and development platforms. It is beyond the scope of this document to attempt to provide the user with complete assistance regarding writing software to control the V7X, so it is described in general form. Examples, where given, use the Microsoft Visual Studio Express 2010 development platform and the VB.NET language.

USING THE RS232 INTERFACE

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)

CONFIGURING THE RS232 INTERFACE

The V7X is enabled to be controlled by the RS232 interface by using the CONFIG MENU -> INTERFACE configuration setting, which must be set to one of the RS232 selections to enable the RS232 interface to be used. The V7X and the software controlling the V7X via the RS232 interface must both be set for the same baud rate. The software must also be set to use hardware handshaking via the RS232 RTS and CTS lines.

CONNECTING TO THE RS232 INTERFACE

The RS232 connector located on the rear panel of the V7X must be connected to the computer. For a standard PC type computer this requires a 9-pin female-female null modem cable, the pinout on the V7X connector is identical to that on a standard PC, so the data and handshake lines must cross-over in the cable. Suitable cables are available from ViTREK.

Many computers do not have a RS232 interface available; in these cases the user may need to use a USB-to-RS232 convertor to provide the RS232 interface. Many such convertors are available; ViTREK offers a fully tested convertor which is recommended if this method is desired by the user. Although the use of a convertor may not appear to alter the software written by the user, the majority of USB-to-RS232 convertors have a fairly severe latency delay for each transmitted and received string of characters, typically this is 10ms or more. In high speed applications this may severely restrict the overall speed, so in those applications the direct use of the USB interface of the V7X is recommended.

WRITING SOFTWARE TO CONTROL THE V7X VIA RS232

Before the users' software can communicate with the V7X it generally must create an object for the specific serial port and configure it.

As an example the following lines of code configure and open the port for communications (SerialPort1 is defined as a System.IO.Ports.SerialPort object)-

```
SerialPort1.BaudRate = 115200
SerialPort1.PortName = "COM1"
SerialPort1.Handshake = IO.Ports.Handshake.RequestToSend
SerialPort1.ReadTimeout = 1000
SerialPort1.WriteTimeout = 1000
SerialPort1.DtrEnable = True
SerialPort1.Open()
```

Since the V7X communicates entirely using the standard ASCII character set, methods for sending and receiving character strings must be used, remembering to always terminate both transmitted and received strings with the <CR> and/or <LF> characters. Examples-

```
SerialPort1.WriteLine(TransmitString) ; Transmit the TransmitString to the V7X, terminating as required by the V7X
Dim ReadString as String = SerialPort1.ReadLine(); Receive ReadString from the V7X, terminating as required by the V7X
```

In practice the user may need to provide handlers for recovering from timeout errors in addition to the examples shown above.

USING THE USB INTERFACE

SPECIFICATIONS

Connector	Standard USB B connector
Cable required	Standard USB 2.0 A-B Cable
Compatibility	Compatible with Windows XP and later operating systems
USB Speed	Full-speed
USB Device	Enumerates as a Human Interface Device (HID) of the Vendor-specific type
Driver	None required

CONFIGURING THE USB INTERFACE

The V7X is be enabled to be controlled by the USB interface by the CONFIG MENU -> INTERFACE configuration setting, which must be set to the USB selection to enable the USB interface to be used. On the CONFIG MENU screen of the V7X the connection status of the USB interface is also shown to provide assistance with detecting if the V7X has correctly connected to the computer.

CONNECTING TO THE USB INTERFACE

The V7X connects to a USB 2.0 or later USB port on a computer using a standard USB 2.0 A-B cable, which may be purchased from ViTREK if desired. The V7X has been tested with USB 3.0 and high speed USB 2.0 ports when used with the cables supplied by ViTREK, but note that the V7X does not support high speed nor OTG activities on the USB bus (these become automatically disabled in the computer during enumeration of the V7X).

The V7X does not require a vendor supplied driver, so no installation is required. When the V7X is first connected to a computer (sometimes to each specific USB port of a computer) the operating system of the computer must load the native HID device driver, this may take a short while. During that time the V7X cannot be communicated with via the USB. The V7X appears as a standard HID Input Device with Vendor-specific properties, it is shown in the Windows Device Manager as a Human Interface Device -> USB Input Device.

WRITING SOFTWARE TO CONTROL THE V7X VIA USB

Since the V7X appears as a standard HID Device with Vendor-specific properties, the user must communicate through the standard Windows® interface for such devices. This can be a difficult task, so ViTREK includes a pair of

DLL files to ease this communication (SLABHIDtoUART.dll and SLABHIDDevice.dll, both of which must be accessible to the users program). All attempts to open the port, transmit strings through the port, receive strings through the port and close the port should be directly made through simple calls to these DLL files. Header files defining these calls for VB.NET and for C/C++/C# are also provided (SLABCP2110.vb and SLABCP2110.h respectively). When compiling applications using the Visual Studio development platform the user must compile for x86 processors, otherwise there will be conflicts with the supplied DLL files.

Note, most communications require knowledge of the USB VID (Vendor ID) and PID (Product ID) numbers used by the V7X. These are 4292 and 34869 respectively for all V7X units, this combination is registered and is unique to the V7X.

As an example the following lines of code configure and open the port for communications-

```
Private usbdevice as System.IntPtr ' Defines the object for communications via USB
Dim num_devices as Integer
HidUart_GetNumDevices(num_devices, 4292, 34869) ' Set num_devices to number of V7X found
' User should provide handler for situation where no V7X devices are found
HidUart_Open(usbdevice, 0, 4292, 34869) ' Opens the first found V7X
' The user should provide handling of failure to open the device following this call
' The user may use other functions available to check the serial number of the V7X opened by this call
' e.g. HidUart_GetString (see header file for details)
HidUart_SetUartConfig(usbdevice, 115200, HID_UART_EIGHT_DATA_BITS, HID_UART_NO_PARITY,
                     HID_UART_SHORT_STOP_BIT, HID_UART_RTS_CTS_FLOW_CONTROL)
HidUart_SetTimeouts(usbdevice, 100, 1000) ' Set transmit and receive timeouts
```

Since the V7X communicates entirely using the standard ASCII character set, methods for sending and receiving character strings may be used, remembering to always terminate both transmitted and received strings with the <CR><LF> characters. Examples-

```
' cmd_string is the string to be transmitted
Dim send_data As Byte() = System.Text.Encoding.ASCII.GetBytes(cmd_string + Chr(10)) ' Convert to byte array and append <LF>
Dim written As Integer
HidUart_Write(usbdevice, send_data, send_data.Length, written)
```

```
Dim response as String      ' String used for the received data
Dim bytearray(1) As Byte    ' Single byte buffer used to receive data
Dim rx_bytes(1000) As Byte  ' Byte array used to collect received data
Dim bytes_read As Integer
Dim rx_pos As Integer = 0
Do
    HidUart_Read(usbdevice, bytearray, 1, bytes_read) ' Read a single byte from the V7X
    If (bytes_read <> 0) Then
        rx_bytes(rx_pos) = bytearray(0) ' Append byte to end of the receive data array
        rx_pos += 1
    End If
Loop Until bytearray(0) = 10 Or bytes_read = 0 Or rx_pos >= rx_bytes.Length ' Loop until terminated
response = System.Text.Encoding.ASCII.GetChars(rx_bytes) ' Convert byte array to an ASCII string
```

In practice the user may need to provide handlers for recovering from timeout errors in addition to the examples shown above.

As can be seen from the above examples, the USB calls operate using a "handle" to the opened V7X. Should the V7X become disconnected (and possibly re-connected) then the handle may no longer be valid. In general the user should employ methods to ensure that this is detected in the program and a valid handle reformed if possible to

avoid difficult to find runtime errors. Most of the calls return error values, these should be checked and corrective action taken as needed. This is particularly important when the V7X is operated at high voltages and DUT breakdown occurs. Unfortunately the USB bus is sensitive to interference in the range from 1MHz to 100MHz and this is exactly the frequency range generated by a catastrophic breakdown in a typical DUT (the instantaneous power in such breakdowns is typically many KW), it has been found that this can interfere with the USB and cause a disconnect/reconnect cycle, leading to the established handle to become invalid. This can be mitigated by ensuring that the ground of the V7X and the ground of the computer are interconnected as closely as possible.

SUMMARY OF PROVIDED DLL FUNCTIONS

In all function calls requiring a PID and/or VID, the user must use the values noted above for the V7X.

The definitions for the function shown below use a C language form for clarity; do not use the calls exactly as shown instead use the header provided for the specific language being used.

CAUTION – the provided DLL files also contain other functions, the user must not call these other functions otherwise it may render the V7X permanently inoperative.

HidUart_GetNumDevices

This function returns the number of devices connected to the host with matching vendor and product ID (VID, PID).

```
HID_UART_STATUS HidUart_GetNumDevices (DWORD* numDevices, WORD vid,
WORD pid)
```

numDevices—Returns the number of devices connected on return.

vid—Filter device results by vendor ID.

pid—Filter device results by product ID.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_PARAMETER

HidUart_GetString

This function returns a null-terminated vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string for the device specified by an index passed in *deviceNum*. The index for the first device is 0 and the last device is the value returned by *HidUart_GetNumDevices()* – 1.

```
HID_UART_STATUS HidUart_GetString (DWORD deviceNum, WORD vid, WORD pid,
char* deviceString, DWORD options)
```

deviceNum—Index of the device for which the string is desired.

vid—Filter device results by vendor ID.

pid—Filter device results by product ID.

deviceString—Variable of type `HID_UART_DEVICE_STRING` which will contain a NULL terminated ASCII device string on return. The string is 260 bytes.

options—Determines if *deviceString* contains a vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_DEVICE_NOT_FOUND, HID_UART_INVALID_PARAMETER, HID_UART_DEVICE_ACCESS_ERROR

HidUart_GetOpenedString

This function returns a null-terminated vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string for the device specified by *device*.

```
HID_UART_STATUS HidUart_GetOpenedString (HID_UART_DEVICE device, char* deviceString, DWORD options)
```

device—Device object pointer as returned by *HidUart_Open()*.

deviceString—Variable of type `HID_UART_DEVICE_STRING` which will contain a NULL terminated ASCII device string on return. The string is 260 bytes.

options—Determines if *deviceString* contains a vendor ID string, product ID string, serial string, device path string, manufacturer string, or product string.

Return Value: `HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_INVALID_PARAMETER, HID_UART_DEVICE_ACCESS_ERROR`

HidUart_Open

Opens a device using a device number between 0 and *HidUart_GetNumDevices()*–1 and returns a device object pointer which will be used for subsequent accesses.

```
HID_UART_STATUS HidUart_Open (HID_UART_DEVICE* device, DWORD deviceNum, WORD vid, WORD pid)
```

device—Returns a pointer to a V7X device object. This pointer will be used by all subsequent accesses to the device.

deviceNum —Zero-based device index, between 0 and (*HidUart_GetNumDevices()* – 1).

vid—Filter device results by vendor ID.

pid—Filter device results by product ID.

Return Value: `HID_UART_STATUS= HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_DEVICE_NOT_FOUND, HID_UART_INVALID_PARAMETER, HID_UART_DEVICE_IO_FAILED, HID_UART_DEVICE_ACCESS_ERROR, HID_UART_DEVICE_NOT_SUPPORTED`

Note - Be careful when opening a device. Any HID device may be opened by this library. However, if the device is not actually a V7X, use of this library will cause undesirable results. The V7X PID and VID must always be used.

HidUart_Close

Closes an opened device using the device object pointer provided by *HidUart_Open()*.

```
HID_UART_STATUS HidUart_Close (HID_UART_DEVICE device)
```

Device object pointer as returned by *HidUart_Open()*.

Return Value: `HID_UART_STATUS= HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_INVALID_HANDLE, HID_UART_DEVICE_ACCESS_ERROR`

Note - *device* is invalid after calling *HidUart_Close()*. It is recommended to set *device* to NULL after this call.

HidUart_IsOpened

Returns the device opened status.

```
HID_UART_STATUS HidUart_IsOpened (HID_UART_DEVICE device, BOOL* opened)
```

device—Device object pointer as returned by *HidUart_Open()*.

opened—Returns *TRUE* if the device object pointer is valid and the device has been opened using *HidUart_Open()*.

Return Value: HID_UART_STATUS= HID_UART_SUCCESS, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_INVALID_PARAMETER

HidUart_Read

Reads the available number of bytes into the supplied buffer and returns the number of bytes read which can be less than the number of bytes requested. This function returns synchronously after reading the requested number of bytes or after the timeout duration has elapsed. Read and write timeouts can be set using *HidUart_SetTimeouts()*.

```
HID_UART_STATUS HidUart_Read (HID_UART_DEVICE device, BYTE* buffer,
DWORD numBytesToRead, DWORD* numBytesRead)
```

device—Device object pointer as returned by *HidUart_Open()*.

buffer—Address of a buffer to be filled with read data.

numBytesToRead—Number of bytes to read from the device into the buffer (1–32768). This value must be less than or equal to the size of *buffer*.

numBytesRead—Returns the number of bytes actually read into the buffer on completion.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_READ_ERROR, HID_UART_INVALID_PARAMETER, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_READ_TIMED_OUT, HID_UART_INVALID_REQUEST_LENGTH

Note - *HidUart_Read()* returns HID_UART_READ_TIMED_OUT if the number of bytes read is less than the number of bytes requested. This will only occur after the read timeout has elapsed. If the number of bytes read matches the number of bytes requested, this function will return HID_UART_SUCCESS.

HidUart_Write

Write the specified number of bytes from the supplied buffer to the device. This function returns synchronously after writing the requested number of bytes or after the timeout duration has elapsed. Read and write timeouts can be set using *HidUart_SetTimeouts()*.

```
HID_UART_STATUS HidUart_Write (HID_UART_DEVICE device, BYTE* buffer,
DWORD numBytesToWrite, DWORD* numBytesWritten)
```

device—Device object pointer as returned by *HidUart_Open()*.

buffer—Address of a buffer to be sent to the device.

numBytesToWrite—Number of bytes to write to the device (1–4096 bytes). *This value must be less than or equal to the size of buffer.*

numBytesWritten—Returns the number of bytes actually written to the device.

Return Value: HID_UART_STATUS = HID_UART_SUCCESS, HID_UART_WRITE_ERROR, HID_UART_INVALID_PARAMETER, HID_UART_INVALID_DEVICE_OBJECT, HID_UART_WRITE_TIMED_OUT, HID_UART_INVALID_REQUEST_LENGTH

Note - *HidUart_Write()* returns HID_UART_WRITE_TIMED_OUT if the number of bytes written is less than the number of bytes requested.

HidUart_FlushBuffers

This function flushes the receive buffer in the V7X and the HID driver.

```
HID_UART_STATUS HidUart_FlushBuffers (HID_UART_DEVICE device, BOOL
flushTransmit, BOOL flushReceive)
```

device—Device object pointer as returned by *HidUart_Open()*.

flushTransmit —Set to *TRUE* to flush the device transmit buffer.

flushReceive —Set to *TRUE* to flush the device receive buffer and HID receive buffer.

Return Value: *HID_UART_STATUS* = *HID_UART_SUCCESS*, *HID_UART_INVALID_DEVICE_OBJECT*, *HID_UART_DEVICE_IO_FAILED*

HidUart_CancelIo

This function cancels any pending HID reads and writes.

HID_UART_STATUS *HidUart_CancelIo* (*HID_UART_DEVICE* *device*)

device—Device object pointer as returned by *HidUart_Open()*.

Return Value: *HID_UART_STATUS* = *HID_UART_SUCCESS*, *HID_UART_INVALID_DEVICE_OBJECT*, *HID_UART_DEVICE_IO_FAILED*

HidUart_SetTimeouts

Sets the read and write timeouts. Timeouts are used for *HidUart_Read()* and *HidUart_Write()*. The default value for timeouts is 1000 ms, but timeouts can be set to wait for any number of milliseconds between 0 and 0xFFFFFFFF.

HID_UART_STATUS *HidUart_SetTimeouts* (*HID_UART_DEVICE* *device*, *DWORD* *readTimeout*, *DWORD* *writeTimeout*)

device—Device object pointer as returned by *HidUart_Open()*.

readTimeout—*HidUart_Read()* operation timeout in milliseconds.

writeTimeout—*HidUart_Write()* operation timeout in milliseconds.

Return Value: *HID_UART_STATUS* = *HID_UART_SUCCESS*, *HID_UART_INVALID_DEVICE_OBJECT*

Note - If read timeouts are set to a large value and no data is received, then the application may appear unresponsive. It is recommended to set timeouts appropriately before using the device.

HidUart_SetUartConfig

Sets the baud rate, data bits, parity, stop bits, and flow control. Caution, this sets parameters within the V7X – do NOT alter these settings from those shown below.

HidUart_SetUartConfig(*device*, 115200, *HID_UART_EIGHT_DATA_BITS*, *HID_UART_NO_PARITY*, *HID_UART_SHORT_STOP_BIT*, *HID_UART_RTS_CTS_FLOW_CONTROL*)

device—Device object pointer as returned by *HidUart_Open()*.

Return Value: *HID_UART_STATUS* = *HID_UART_SUCCESS*, *HID_UART_INVALID_PARAMETER*, *HID_UART_INVALID_DEVICE_OBJECT*, *HID_UART_DEVICE_IO_FAILED*

GENERAL FORMAT INFORMATION

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

There are two types of command –

- Commands which do not have a response. These always cause the V7X to take an action.
- Commands which have a response (these are named Query commands in this document). These generally do not cause the V7X to take an action other than sending back the response. These all have a keyword which ends with the ? character.

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 depends on the command keyword and in some cases the content of a preceding field in the command. The last field does not require a field separator but must be followed by a command separator (indicating that what follows is another command) or a command terminator (indicating that no further commands follow at this time).

Multiple commands can be transferred as a single set of commands; each command is separated from the next by a command separator. Commands are always actioned 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 V7X 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 V7X 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 V7X. 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>.** This is an extension to the standard **<NR1>** defined by standards. 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 an extension to the standard **<NR3>** defined by standards. 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 V7X 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 either (or both) of the following-

- A line-feed character (shown in this document as <LF>).
- A carriage return character (shown in this document as <CR>).

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. If the response is over 4093 characters in total length then an error is raised and no response is given. The entire response is not transmitted until all commands in the set have been successfully actioned.

If another set of commands is decoded containing a query command prior to the V7X fully transmitting a prior response then the new response is not provided and an error is raised.

The user may notice small differences between the measurement results reported on the front panel screen of the V7X and via the interface, there are three reasons for this –

- All interface reported data use the "pure" units (e.g. A rather than μA). This is to ease the use of standard ASCII string to numeric result library functions present in most languages.
- All front panel results are restricted from showing negative values, whereas the interface results are not restricted. This is to ease any filtering of results required by the user.
- The resolution of front panel results is dynamically adjusted to provide stable results (typically 3, 4 or 5 digits), the interface results are always resolution limited to 5 digits. Both results are rounded to the nearest least significant digit. The excess resolution in the interface results enables the user to provide their own formatting of the results without encountering issues caused by successive rounding and also eases any filtering which may be required by the user.

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 11 characters in length, and is of the following format (in the order shown)-
 - A single polarity character (either + or -).
 - Five decimal characters with a decimal point character contained within them (i.e. a total of six 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 V7X automatically handshakes the commands as needed. The only exception to this is following application of power to the V7X 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 V7X will "hold-off" a set of commands (e.g. waiting for a previous set of commands to be decoded) is 500ms.

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 V7X. The user should use a timeout of no less than 100ms for responses.

FRONT PANEL OPERATION WHILE USING INTERFACES

It is possible to inter-mix front panel and interface operation of the V7X 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 LOCKOUT** state (depending on 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 key labeled accordingly.
 - **REMOTE LOCKOUT**. 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.
- When entering the **REMOTE** or **REMOTE LOCKOUT** states, any front panel menu entry or editing in progress is abandoned.
- A **LOCKOUT** command is provided to allow the user to command the front panel to the **REMOTE LOCKOUT** state.
- A **LOCAL** command is provided to allow the user to remotely return the front panel to the **LOCAL** state.

COMMANDS

Command	Description
Interface Clear Command	
*CLS	Clears the ERR register, resets the front panel to the LOCAL state.
Register Query Commands	
*ERR?	Responds with a <NR1> field value of the ERR register then clears the ERR register. The ERR register contains any command errors since last read. See ERR? Responses
Commands to create, edit, recall or save a Test Sequence (Cannot be used while a test sequence is running)	
NOSEQ	Clears test sequence #0 and sets it as the active test sequence
ADD,...	Add a test step to the end of test sequence #0. See – ACW Configuration Fields DCW Configuration Fields IR Configuration Fields GB Configuration Fields CONT Configuration Fields PAUSE Configuration Fields HOLD Configuration Fields SWITCH Configuration Fields
NAME,<STRING>	Names the active test sequence
FETCH,<NR1>	Responds with a set of fields describing the settings in the active test sequence, using the <NR1> value as the step number. The fields returned are the same as for the ADD,... command above but extended with step type NONE, indicating that the step is not defined (no further fields are given for this step) At the time of writing, this command has not been implemented in the V7X
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 #
Commands to Run the Active Test Sequence (Can only be used while a test sequence is not running)	
RUN	Runs the active test sequence
Running Test Sequence Control Commands (Can only be used while a test sequence is running)	
ABORT	Aborts a running test sequence
CONT	Continues a running test sequence (during a HOLD step only)
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 #
STEP?	Responds with a <NR1> indicating the step # presently being actioned in a running test sequence (0 if none, otherwise 1 through 999)
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

Command	Description
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
Test Result Query Commands (While running a test sequence)	
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) VOLTS – DC or RMS voltage (in Volts) OHMS – DC or RMS impedance (in Ω) ARC – highest arc current (in Amps)
Configuration Settings Commands	
VICL,<NR1>	Configures the number of switch units (0 to 4)
VICL?	Responds with the <NR1> setting of the configured number of switch units
DIO,<NR1>	Configures the Digital I/O Inputs to- 0 – All disabled 1 – Only INTERLOCK enabled 2 – Only START and STOP enabled 3 – All enabled
DIO?	Responds with the <NR1> setting of the configured Digital I/O Input enable
START,<NR1>	Configures the action of the front panel START switch- 0 – Requires STOP before START 1 – Does not require STOP before START 2 – START is disabled, can only remotely start sequences
START?	Responds with the <NR1> START switch configuration
BEEP,<NR1>	Configures the action of the beeper- 0 – Off 1 – Only beep on sequence start and stop 2 – Only beep on front panel key presses 3 – Beep for all reasons
BEEP?	Responds with the <NR1> BEEP setting
FREQ,<NR1>	Configures the test frequency for ACW and GB steps Only values of 50 or 60 are valid
FREQ?	Responds with the <NR1> FREQ setting
ARC,<NR1>	Configures the ARC current limit (0 = disabled)
ARC?	Responds with the <NR1> ARC setting
IREND,<NR1>	Configures the IR End On setting 0 – End on FAIL 1 – End on PASS 2 – End on time only 3 – End on PASS and steady or increasing IR result
IREND?	Responds with the <NR1> IREND setting
RAMPDOWN,<BOOL>	Configures the Ramp down setting (0 = none, 1 = as ramp)

Command	Description																						
RAMPDOWN?	Responds with the <BOOL> RAMPDOWN setting																						
CONTFAIL,<BOOL>	Configures the Continue sequence on failure setting (0 = no, 1 = yes)																						
CONTFAIL?	Responds with the <BOOL> CONTFAIL setting																						
Identification Commands																							
*IDN?	Responds with a set of fields describing the product, see ERR? Responses																						
	<table><tr><th>Response</th><th>Description</th></tr><tr><td>0</td><td>The command was decoded without error</td></tr><tr><td>1</td><td>The command could not be decoded at this time</td></tr><tr><td>2</td><td>The command created a test step which is not compatible with this specific instruments' capability</td></tr><tr><td>3</td><td>The command contained a numeric value field which was outside of the allowable range</td></tr><tr><td>4</td><td>The command contained a field which did not have the correct syntax</td></tr><tr><td>5</td><td>The command did not contain an expected field</td></tr><tr><td>6</td><td>The command contained more fields than expected</td></tr><tr><td>7</td><td>The command keyword was not recognized</td></tr><tr><td>8</td><td>The previous response had not yet been transmitted when this query command was executed</td></tr><tr><td>9</td><td>The set of commands was too long, over 1023 characters</td></tr></table>	Response	Description	0	The command was decoded without error	1	The command could not be decoded at this time	2	The command created a test step which is not compatible with this specific instruments' capability	3	The command contained a numeric value field which was outside of the allowable range	4	The command contained a field which did not have the correct syntax	5	The command did not contain an expected field	6	The command contained more fields than expected	7	The command keyword was not recognized	8	The previous response had not yet been transmitted when this query command was executed	9	The set of commands was too long, over 1023 characters
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*IDN? Response Fields																							
Misc. Commands																							
LOCAL	Sets the front panel into the LOCAL state																						
LOCKOUT	Sets the front panel into the REMOTE LOCK-OUT state																						
*RST	Resets the interface																						
	Aborts a running test sequence																						
	Clears the active test sequence																						

ERR? RESPONSES

Response	Description
0	The command was decoded without error
1	The command could not be decoded at this time
2	The command created a test step which is not compatible with this specific instruments' capability
3	The command contained a numeric value field which was outside of the allowable range
4	The command contained a field which did not have the correct syntax
5	The command did not contain an expected field
6	The command contained more fields than expected
7	The command keyword was not recognized
8	The previous response had not yet been transmitted when this query command was executed
9	The set of commands was too long, over 1023 characters

*IDN? RESPONSE FIELDS

Field #	Field Format	Description
1	<STRING>	Manufacturer (e.g. VITREK)
2	<STRING>	Model (e.g. V73).

3	<STRING>	Serial number (e.g. 123456)
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ACW CONFIGURATION FIELDS

Field #	Field Format	Value
1	<STRING>	ACW
2	<NR3>	Test Voltage (in Vrms)
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 Arms)
	<EMPTY>	No min leakage limit
6	<NR3>	Maximum Leakage Limit (in A)
	<EMPTY>	No max leakage limit
7	<MISSING>	Isolated DUT
	<STRING>	GND – Grounded DUT

Example –

ADD,ACW,1000.0,1.5,60.0,,0.005

Configures the following (in order) –

- An ACW type test step
- 1000V test voltage
- 1.5 second ramp time
- 60 second dwell time
- No minimum leakage current limit since is an empty field
- 5mA maximum leakage current limit
- DUT is isolated since field 7 is missing

DCW CONFIGURATION FIELDS

Field #	Field Format	Description
1	<STRING>	DCW
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 Arms)
	<EMPTY>	No min leakage limit
6	<NR3>	Maximum Leakage Limit (in A)
	<EMPTY>	No max leakage limit
7	<EMPTY>	Isolated DUT (may also be missing if field 8 also missing)
	<STRING>	GND – Grounded DUT
8	<EMPTY>	Resistive DUT (may also be missing)
	<STRING>	CAP – Capacitive DUT

Example –

ADD,DCW,1000.0,1.5,60.0,,25e-6

Configures the following (in order) –

A DCW type test step
 1000V test voltage
 1.5 second ramp time
 60 second dwell time
 No minimum leakage current limit since is empty field
 25uA maximum leakage current limit
 DUT is isolated and resistive since both fields 7 and 8 are missing

IR CONFIGURATION FIELDS

Field #	Field Format	Value
1	<STRING>	IR
2	<NR3>	Test Voltage (in V)
3	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
4	<NR3>	Pre-check delay (in seconds)
5	<NR3>	Minimum Leakage Limit (in Ω)
6	<NR3>	Maximum Leakage Limit (in Ω)
	<EMPTY>	No maximum limit
7	<EMPTY>	Isolated DUT (may also be missing if field 8 also missing)
	<STRING>	GND – Grounded DUT
8	<EMPTY>	Resistive DUT (may also be missing)
	<STRING>	CAP – Capacitive DUT

Example –

ADD,IR,1000.0,60.0,0.0,100e6,

Configures the following (in order) –

A IR type test step
 1000V test voltage
 60 second dwell time
 0 second delay
 100M Ω minimum IR limit
 No max IR limit since field is blank
 DUT is isolated and resistive since both fields 7 and 8 are missing

GB CONFIGURATION FIELDS

Field #	Field Format	Value
1	<STRING>	GB
2	<NR3>	Test Current (in Arms)
3	<NR3>	Dwell time (in seconds)
	<EMPTY>	Step is to be user terminated
4	<NR3>	Minimum Limit (in Ω)
	<EMPTY>	No min limit
5	<NR3>	Maximum Limit (in Ω)

Example –

ADD,GB,25.0,5.0,,0.1

Configures the following (in order) –

A GB type test step
 25A test current
 5 second dwell time
 No minimum impedance since field is blank
 0.1 Ω maximum impedance

CONT CONFIGURATION FIELDS

Field #	Field Format	Value
1	<STRING>	CONT
2	<NR3>	Test time (in seconds)
	<EMPTY>	Step is to be user terminated
3	<NR3>	Minimum Limit (in Ω)
	<EMPTY>	No min limit
4	<NR3>	Maximum Limit (in Ω)
	<EMPTY>	No max limit (may also be missing)

Example –

ADD,CONT,5.0,1.25,1.75

Configures the following (in order) –

A CONT type test step
 5 second test time
 1.25 Ω minimum resistance
 1.75 Ω maximum resistance

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)
3	<STRING>	1 st message line
4	<STRING>	2 nd message line

Example –

ADD,HOLD,60.0,LINE 1,LINE 2

Configures the following (in order) –

A HOLD type test step
 60 second timeout

1st line displays "LINE 1"

2nd line displays "LINE 2"

SWITCH CONFIGURATION FIELDS

Field #	Field Format	Value
1	<STRING>	SWITCH
2-9	<NR1>	964 #1 Switch bank data banks 7-0 resp.
10-17	<NR1>	964 #2 Switch bank data banks 7-0 resp. (only if configured for >1x964)
18-25	<NR1>	964 #3 Switch bank data banks 7-0 resp. (only if configured for >2x964)
26-33	<NR1>	964 #4 Switch bank data banks 7-0 resp. (only if configured for 4x964)

Example –

ADD,SWITCH,0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00

Configures the following (in order) –

A SWITCH type test step
 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	V7X Internal Fault
1	2	Over voltage output
2	4	Line too low to implement configured voltage or current
3	8	DUT Breakdown detected
4	16	HOLD step timeout occurred
5	32	User aborted the sequence
6	64	GB step was over-compliance
7	128	Arc detected
8	256	< minimum limit
9	512	> maximum limit
10	1024	A steady or decreasing current was not detected during dwell but the load was otherwise within the limits in a IR type step configured to terminate in this manner
11	2048	INTERLOCK failure
12	4096	Switch Matrix unit did not communicate
13	8192	V7X Overheated
14	16384	DUT voltage or current could not be controlled
15	32768	Wiring error detected in GB step

STEPRSLT? RESPONSE FIELDS

Field #	Field Format	Value
1	<NR1>	0 – Not executed 1 – Terminated before fully started 2 – Terminated during Ramp 3 – Terminated during Dwell 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>	Highest breakdown current (in Amps, peak)
6	<NR3> or <EMPTY>	Measurement result (in A or Ω)
7	<NR3> or <EMPTY>	Highest ARC current (in A)

PROGRAMMING EXAMPLE

If the user wishes to be able to send a command to the V7X 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 V7X, it should be similar to **VITREK,V74,000000,v1.45**

Example 2

- Ensure there are no connections to any terminals on the V7X, this example is not applicable to the V79.
- Send **NOSEQ; ADD,ACW,1000.0,1.5,60.0,,0.005;RUN<CR><LF>**
- The V7X will perform an ACW test at 1000Vrms with a 1.5sec ramp and 60sec dwell.
- After completion send **STEPRSLT?,1<CR><LF>**
- The V7X responds with the results for the step which should be similar to **3,+60.017E+00,0,+1.0001E+03,+82.360E-09,+2.2291E-09,+156.42E-03**

PROGRAMMING GUIDELINES

START BY INITIALIZING THE V7X

When a user application is started on the controlling computer the status of the V7X 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 V7X. This can be achieved by sending the ***RST** command.

EMPLOY A TIMEOUT ON ALL ACTIVITIES

On all interfaces, the V7X 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 V7X

If there are any configuration settings in the V7X 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 V7X configuration settings.

CHECKING FOR ERRORS

Often the user wishes to ensure that a command was correctly received by the V7X and that the command was not rejected by the V7X. 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".

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 V7X, rather than running individual steps one at a time.

The V7X will remember the sequence as long as power is not removed from the V7X. 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.

The V7X 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 V7X can operate at its' own speed, the computer does not have to "keep up" with the 95x. Also, by running the tests as a sequence the user can fully recall the results from the front panel of the V7X if desired.

The recommended flow is as follows –

- Send a **NOSEQ** command to clear and set active sequence #0.
- 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 V7X. The V7X will append each **ADD,...** test step to sequence #0, so the user should send each desired step in the correct order.
- Send the **RUN** command. The V7X will now run the sequence.
- Poll the V7X 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 for polling, 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 V7X 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 V7X 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 some delay – repeat.
- Once the test sequence has completed (e.g. the response to the **STEP?** command is 0) the user may request for the test results. There are various methods of achieving this, which the user chooses is dependent on the level of detail 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 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 V7X 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 then send the command **CONT** to the V7X 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 V7X 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.

SECTION 7 – CALIBRATING THE V7X

The V7X 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 V7X. Which one is selected by the user depends on the users 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 V7X 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 V7X.
- **Periodic Adjustment followed by Verification.** With this strategy the user ensures that the V7X 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 V7X malfunctions by means of the post-adjustment verification. This completely ensures that the outgoing V7X meets its' specifications but leaves the possibility of an error made during the adjustment calibration leading to the incorrect indication that the incoming V7X did not meet specifications.
- **Periodic Verification – Adjustment – Verification.** This is the most complete strategy, but is also the most costly 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 V7X 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 V7X, 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 V7X 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 V7X is an internally prompted sequence dependent on the actual product model being calibrated.

Please take note of the following–

- The V7X 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 V7X terminals and it is recommended to not have any connections to the interface ports during the procedure.
- The frequency used for all AC calibration points is that configured in the CONFIG MENU. Ensure the correct frequency is configured prior to initiating the calibration 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 V7X. 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 V7X 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 V7X is performing to its capabilities.
- 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 V7X DURING THE ADJUSTMENT CALIBRATION PROCEDURE.** If a failure occurs during the procedure, the 95x will automatically halt the procedure and discard any changes made.
- The front panel High Voltage warning light is illuminated whenever there are high voltages or currents present on the V7X terminals. When illuminated the user should not touch the connections to the V7X.

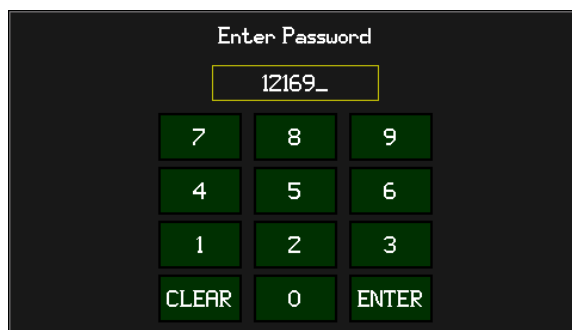
EQUIPMENT REQUIRED

1. (All models except V79) An AC Voltmeter with at least 100M Ω input impedance capable of measuring 1000Vrms at 50/60Hz to within 0.275% for a 4:1 accuracy ratio (the V7X specification is 1.1%). Note – most bench-top and hand-held voltmeters do not meet these requirements (most do not have 1000V capability and almost all only have 10M Ω or 1M Ω input impedance). The inputs of this equipment must not be grounded.
2. (All models except V79) A nominally 100K Ω resistor having a value at a voltage of 1000Vrms 50/60Hz known to within 0.325% for a 4:1 accuracy ratio (the V7X specification is 1.3%). The resistor must not be grounded.
3. (All models except V79) A nominally 1M Ω resistor having a value at a voltage of 1000Vrms 50/60Hz known to within 0.375% for a 4:1 accuracy ratio (the V7X specification is 1.5%). The resistor must not be grounded.
4. (V73 and V74 only) A nominally 100M Ω resistor having a value at a voltage of 1000Vdc known to within 0.5% for a 4:1 accuracy ratio (the V7X specification is 2%). The resistor must not be grounded.
5. (All models) A shorting plug suitable for use between the **CONT+** and **CONT-** terminals and capable of withstanding a test current of 10mAdc. This must have a resistance of less than 3.75m Ω at a nominal 10mAdc current for a 4:1 accuracy ratio (the V7X specification is 15m Ω). The resistance includes leads and contact resistance in the connectors, care must be taken when constructing this. The short circuit must not be grounded.
6. (All models) A 2-wire 10 Ω nominal value resistor suitable for use between the **CONT+** and **CONT-** terminals and capable of withstanding a test current of 10mAdc. This must have a value known to within 0.425% for a 4:1 accuracy ratio (the V7X specification is 1.7%). The resistance includes leads and contact resistance in the connectors, care must be taken when constructing this. The resistor must not be grounded.
7. (All models) A 2-wire 1K Ω nominal value resistor suitable for use between the **CONT+** and **CONT-** terminals and capable of withstanding a test current of 4mAdc. This must have a value known to within 0.775% for a 4:1 accuracy ratio (the V7X specification is 3.1%). The resistance includes leads and contact resistance in the connectors, care must be taken when constructing this. The resistor must not be grounded.
8. (V74 and V79 only) A 4-wire 0.1 Ω nominal value resistor capable of withstanding a test current of 10Arms. This must have a value known to within 0.875% at a frequency of 50/60Hz for a 4:1 accuracy ratio (the V7X specification is 3.5%). The resistor should not be grounded.

PROCEDURE

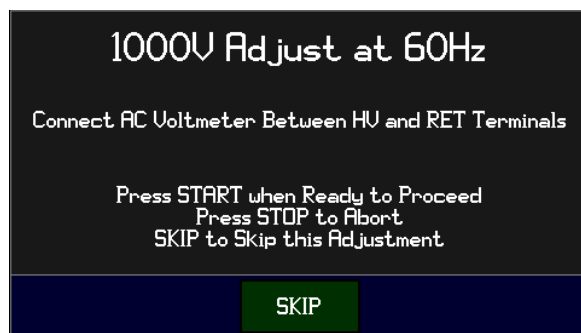
Follow the prompts in the display of the V7X for the actual procedure as it varies between models and option content.

- Press the UTILITY MENU button.
- The user is recommended to perform a SELF TEST prior to performing a calibration adjustment. This ensures that the V7X is correctly functioning. This is accomplished by pressing the SELF TEST button and following the prompts on the screen. After performing successfully performing a SELF TEST the user should return to the UTILITY MENU screen.
- Press the CAL ADJUST button.
- The unit now prompts the user for entry of the calibration password to prevent unauthorized users from attempting a calibration of the V7X. The correct password is 12169.



- The remainder of this procedure adjusts the V7X to produce the correct readings for voltages, currents and resistances. Please note the following common items –
 - The user presses the START button to progress through the procedure.
 - The user may press the STOP button to abort the procedure at any time and discard all changes made to the calibration of the V7X.
 - As described on the screen, the user may adjust the displayed reading by using the INCR or DECR buttons as needed (increasing and decreasing the displayed reading respectively). Each press changes the calibration by nominally 0.05%.
 - In some cases the external calibration equipment may not be the exact nominal value, in those cases the user should adjust the displayed reading to correspond to the known calibrated value of the calibration equipment being used for that specific step.
 - Do not remove power from the V7X at any time during the procedure.

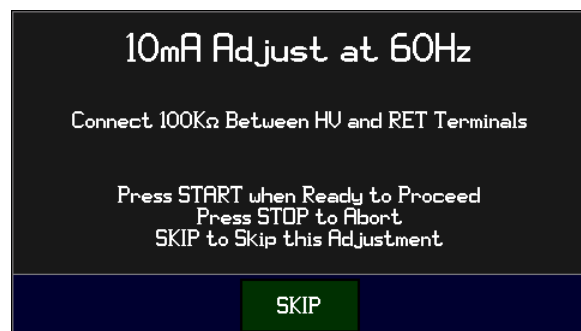
- (All models except V79) The V7X now prompts the user to connect the AC Voltmeter (equipment #1) as described on the screen.



- Press START after connecting the AC Voltmeter and ensuring the leads are safely positioned. The user can now adjust the output voltage to create the correct reading on the AC Voltmeter for 1000Vrms. The percentage figure shown on the display is the amount by which the user has adjusted the voltage output. The user should press the START key when the adjustment has been completed.



- (All models except V79) The V7X now prompts the user to connect a 100K Ω load resistor (equipment #2) as described on the screen.

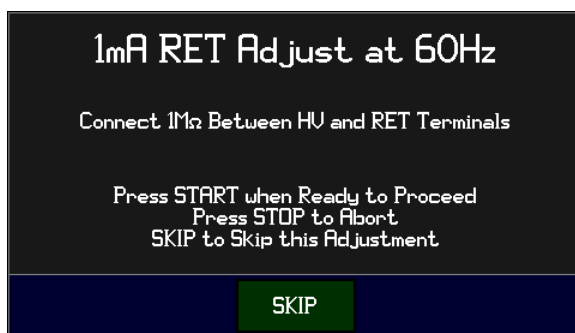


- Press START after connecting the load resistor and ensuring the leads are safely positioned. The user can now adjust the V7X to create the correct current readings. The percentage figures shown on the display are the amount by which the user has adjusted the measurements. The user should press the START key when the adjustment has been completed.
 - If the load resistor is not exactly 100K Ω then the user should use Ohms Law ($I = 1000 / R$) to compute the correct current reading rather than using 10mA.

- This step adjusts both the HV and RET terminal current measurements at the same time, the screen should always show the same current (within 1 digit), the percentages may be different however.



- (All models except V79) The V7X now prompts the user to connect a 1M Ω load resistor (equipment #3) as described on the screen.



- Press START after connecting the load resistor and ensuring the leads are safely positioned. The user can now adjust the V7X to create the correct current reading. The percentage figure shown on the display is the amount by which the user has adjusted the measurement. The user should press the START key when the adjustment has been completed.
 - If the load resistor is not exactly 1M Ω then the user should use Ohms Law ($I = 1000 / R$) to compute the correct current reading rather than using 1mA.



- (V73 and V74 only) The V7X now prompts the user to connect a 100M Ω load resistor (equipment #4) as described on the screen.



- Press START after connecting the load resistor and ensuring the leads are safely positioned. The user can now adjust the V7X to create the correct resistance reading. The percentage figure shown on the display is the amount by which the user has adjusted the measurement. The user should press the START key when the adjustment has been completed.
 - High resistance measurements can be sensitive to movement around the resistor and leads. The user should remain as still as possible during this step, particularly if long leads are being used.



- (All models) The V7X now prompts the user to connect a short circuit (equipment #5) as described on the screen.



- Press START after connecting the short circuit. The V7X now automatically adjusts the CONT zero to create a zero reading, the displayed reading is the corrected reading and the value in braces is the amount of correction which has been applied. The user should press the START key when the adjustment has been completed.

- As described in the equipment list, the displayed value includes any lead and contact resistances. The user must ensure that these are within the allowed tolerance.



- (All models) The V7X now prompts the user to connect a 10Ω load resistor (equipment #6) as described on the screen.



- Press START after connecting the load resistor. The user can now adjust the V7X to create the correct resistance reading. The percentage figure shown on the display is the amount by which the user has adjusted the measurement. The user should press the START key when the adjustment has been completed.

- As described in the equipment list, the displayed value includes any lead and contact resistances. The user must ensure that these are within the allowed tolerance.



- (All models) The V7X now prompts the user to connect a 1K Ω load resistor (equipment #7) as described on the screen.



- Press START after connecting the load resistor. The user can now adjust the V7X to create the correct resistance reading. The percentage figure shown on the display is the amount by which the user has adjusted the measurement. The user should press the START key when the adjustment has been completed.

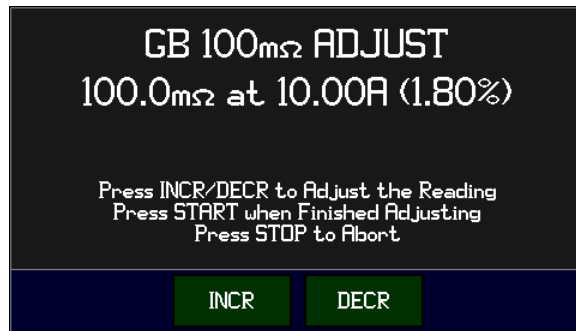


- (V74 and V79 only) The V7X now prompts the user to connect a 100m Ω load resistor (equipment #8) as described on the screen.
 - The test current during this step is nominally 10Arms. The user must ensure that the leads connecting the SOURCE terminals to the resistor have sufficient current handling capability.
 - This is an AC low resistance measurement. Proper 4-terminal techniques should be used, and the user should ensure that the leads are not tightly coupled in any manner. Best results are obtained with four independent wires with at least ½ inch spacing between the wires through the majority of their length. Using short leads is recommended.



- Press START after connecting the load resistor. The user can now adjust the V7X to create the correct resistance reading. The percentage figure shown on the display is the amount by which

the user has adjusted the measurement. The user should press the START key when the adjustment has been completed.



- After the last calibration step the final screen is shown. The user should press START to save the adjustments or STOP to discard them. The V7X then returns to the MAIN MENU screen.

VERIFYING CALIBRATION

The V7X 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 V7X 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 V7X 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 V7X terminals and it is recommended to not have any connections to the interface ports during the procedure.
- The frequency used for all AC verification points is that configured in the CONFIG MENU. Ensure the correct frequency is configured prior to initiating the verification 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 V7X for the actual procedure.
- Although the sequence is similar between the V7X series products and options, there are differences depending on the voltages, currents, and modes which each model and option is capable of. The V7X 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.
- 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 V7X terminals. When illuminated the user should not touch the connections to the V7X.
- 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.

EQUIPMENT REQUIRED

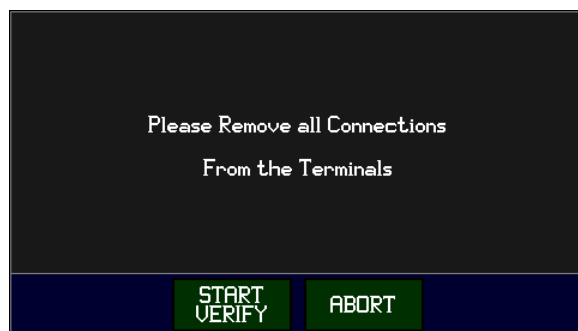
1. (All models except V79) An AC Voltmeter with at least 100M Ω input impedance capable of measuring voltages of 100Vrms, 1000Vrms and 5000Vrms at 50/60Hz to within 1.5%, 0.375% and 0.275% resp. for a 4:1 accuracy ratio (the V7X specifications are 6%, 1.5% and 1.1% resp.). The inputs of this equipment must not be grounded.
2. (All models except V79) A nominally 100K Ω resistor having a value at a voltage of 1000Vrms 50/60Hz known to within 0.325% for a 4:1 accuracy ratio (the V7X specification is 1.3%). The resistor must not be grounded.
3. (All models except V79) A nominally 1M Ω resistor having a value at a voltage of 1000Vrms 50/60Hz known to within 0.375% for a 4:1 accuracy ratio (the V7X specification is 1.5%). The resistor must not be grounded.
4. (All models except V70 and V79) A DC Voltmeter with at least 100M Ω input impedance capable of measuring voltages of 100V, 1000V and 5000V to within 1.5%, 0.375% and 0.275% resp. for a 4:1 accuracy ratio (the V7X specifications are 6%, 1.5% and 1.1% resp.). The inputs of this equipment must not be grounded.
5. (V73 and V74 only) A nominally 100M Ω resistor having a value at a voltage of 1000Vdc known to within 0.5% for a 4:1 accuracy ratio (the V7X specification is 2%). The resistor must not be grounded.
6. (All models) A shorting plug suitable for use between the **CONT+** and **CONT-** terminals and capable of withstanding a test current of 10mAdc. This must have a resistance of less than 3.75m Ω at a nominal 10mAdc current for a 4:1 accuracy ratio (the V7X specification is 15m Ω). The resistance includes leads and contact resistance in the connectors, care must be taken when constructing this. The short circuit must not be grounded.
7. (All models) A 2-wire 10 Ω nominal value resistor suitable for use between the **CONT+** and **CONT-** terminals and capable of withstanding a test current of 10mAdc. This must have a value known to within 0.425% for a 4:1 accuracy ratio (the V7X specification is 1.7%). The resistance includes leads and contact resistance in the connectors, care must be taken when constructing this. The resistor must not be grounded.
8. (All models) A 2-wire 10K Ω nominal value resistor suitable for use between the **CONT+** and **CONT-** terminals and capable of withstanding a test current of 0.4mAdc. This must have a value known to within 1.25% for a 4:1 accuracy ratio (the V7X specification is 5%). The resistance includes leads and contact resistance in the connectors, care must be taken when constructing this. The resistor must not be grounded.
9. (V74 and V79 only) A 4-wire short circuit capable of handling test currents between 1Arms and 30Arms. The best method of constructing this is to use a short length (a few inches) of heavy gage bus wire mounted directly between the SOURCE terminals of the V7X and connecting the two SENSE terminals to one end of the bus wire (both terminals to the same end) outside the portion which connects together the two SOURCE terminals. The short circuit should not be grounded.
10. (V74 and V79 only) A 4-wire 0.1 Ω nominal value resistor capable of withstanding a test current of between 1A and 30Arms. This must have a value known to within 0.875% at a frequency of 50/60Hz for a 4:1 accuracy ratio (the V7X specification is 3.5%). The resistor should not be grounded.

PROCEDURE

Follow the prompts in the display of the V7X for the actual procedure as it varies between models and option content.

- Press the UTILITY MENU button.

- The user is recommended to perform a SELF TEST prior to performing a calibration verification. This ensures that the V7X is correctly functioning. This is accomplished by pressing the SELF TEST button and following the prompts on the screen. After performing successfully performing a SELF TEST the user should return to the UTILITY MENU screen.
- Press the CAL VERIFY button. The V7X then prompts the user to remove all connections to the V7X terminals and press the START key to initiate the procedure.



- The remainder of this procedure sets the V7X to produce the voltages or currents as required with the loading indicated on the display. Please note the following common items –
 - The user presses the START button to progress through the procedure.
 - The user may press the STOP button to abort the procedure at any time.
 - If the user wishes to skip a specific verification point then the SKIP button should be pressed when the user is requested to provide the desired load instead of the START button.
- (All models except V79) The V7X now prompts the user to connect the AC Voltmeter (equipment #1) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage into the voltmeter.
 - Allowing the AC Voltmeter reading to settle and recording the indication, press the START button to continue the procedure.



- (All models except V79) The V7X now prompts the user to connect the AC Voltmeter (equipment #1) as described on the screen.
 - Generally the user will be using the same AC Voltmeter and connections as for the preceding step.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage into the voltmeter.

- Allowing the AC Voltmeter reading to settle and recording the indication, press the START button to continue the procedure.



- (All models except V79) The V7X now prompts the user to connect the AC Voltmeter (equipment #1) as described on the screen.
 - Generally the user will be using the same AC Voltmeter and connections as for the preceding step.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage into the voltmeter.
 - Allowing the AC Voltmeter reading to settle and recording the indication, press the START button to continue the procedure.



- (All models except V79) The V7X now prompts the user to connect the 1M Ω load resistance (equipment #2) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage across the load resistance.
 - Allowing the V7X current reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.

- When recording the indicated current, the user may need to correct the nominal current for the actual resistance of the load resistor (using Ohms law, $\text{current} = 1000 / R$).

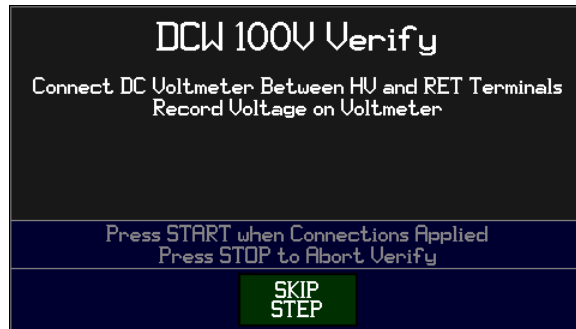


- (All models except V79) The V7X now prompts the user to connect the 100K Ω load resistance (equipment #3) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage across the load resistance.
 - Allowing the V7X current reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.
 - When recording the indicated current, the user may need to correct the nominal current for the actual resistance of the load resistor (using Ohms law, $\text{current} = 1000 / R$).



- (All models except V70 and V79) The V7X now prompts the user to connect the DC Voltmeter (equipment #4) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage into the voltmeter.

- Allowing the DC Voltmeter reading to settle and recording the indication, press the START button to continue the procedure.



- (All models except V70 and V79) The V7X now prompts the user to connect the DC Voltmeter (equipment #4) as described on the screen.
 - Generally the user will be using the same DC Voltmeter and connections as for the preceding step.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage into the voltmeter.
 - Allowing the DC Voltmeter reading to settle and recording the indication, press the START button to continue the procedure.



- (All models except V70 and V79) The V7X now prompts the user to connect the DC Voltmeter (equipment #4) as described on the screen.
 - Generally the user will be using the same DC Voltmeter and connections as for the preceding step.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage into the voltmeter.

- Allowing the DC Voltmeter reading to settle and recording the indication, press the START button to continue the procedure.



- (V73 and V74 only) The V7X now prompts the user to connect the 100M Ω load resistance (equipment #5) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step, the V7X will then output the voltage across the load resistance.
 - Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.



- (All models) The V7X now prompts the user to connect a 2-wire short circuit (equipment #6) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step.
 - Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.



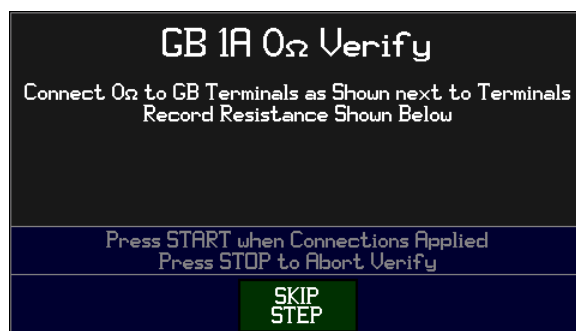
- (All models) The V7X now prompts the user to connect the 10 Ω load resistance (equipment #7) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step.
 - Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.



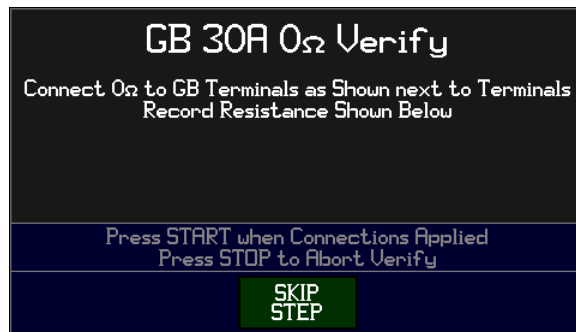
- (All models) The V7X now prompts the user to connect the 10K Ω load resistance (equipment #8) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step.
 - Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.



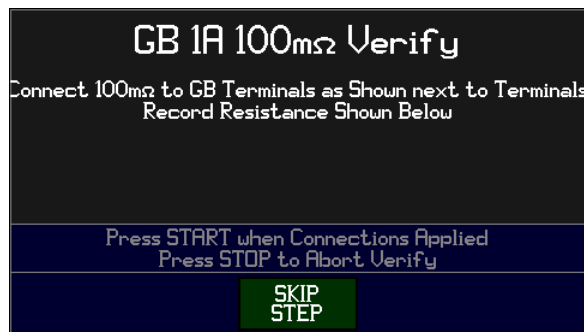
- (V74 and V79 only) The V7X now prompts the user to connect a 4-wire short circuit (equipment #9) as described on the screen.
 - After making the indicated connections, press the START button to start the verification step.
 - Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.



- (V74 and V79 only) The V7X now prompts the user to connect a 4-wire short circuit (equipment #9) as described on the screen.
 - Generally the user will be using the same 4-wire short circuit and connections as for the preceding step.
 - After making the indicated connections, press the START button to start the verification step.
 - Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.



- (V74 and V79 only) The V7X now prompts the user to connect a 4-wire 0.1Ω (equipment #10) as described on the screen.
 - Note that the current flowing in the SOURCE terminal connections is 1Arms in this step and 30Arms in the following step. The user should ensure that the wiring is capable of handling these currents.
 - After making the indicated connections, press the START button to start the verification step.
 - Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.

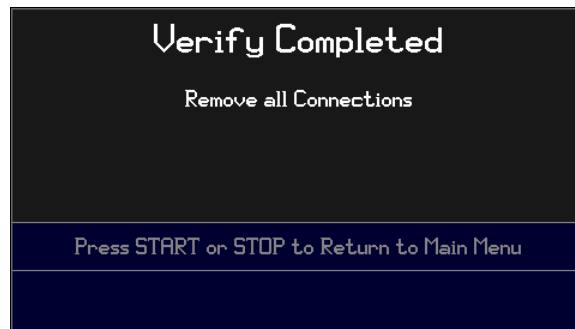


- (V74 and V79 only) The V7X now prompts the user to connect a 4-wire 0.1Ω (equipment #10) as described on the screen.
 - Note that the current flowing in the SOURCE terminal connections is 30Arms in this step. The user should ensure that the wiring is capable of handling these currents.
 - Generally the user will be using the same 4-wire 0.1Ω and connections as for the preceding step.
 - After making the indicated connections, press the START button to start the verification step.

- Allowing the V7X resistance reading to settle and recording the indication on the V7X screen, press the START button to continue the procedure.



- The procedure is now completed and the V7X screen prompts the user to remove any connections to the V7X terminals and then press the START or STOP button to terminate the procedure and return to the MAIN MENU.



APPENDIX A – GUIDELINES FOR TESTING

When the user is configuring testing against the requirements of a safety standard, the information given in this appendix should only be used as a guideline; the user should consult a safety testing professional for information regarding the specific standard and application.

The V7X has capabilities which exceed the majority of user requirements, however ViTREK also manufactures other safety testing products with a wider range of capabilities, please consult us regarding your specific requirements.

ACW AND DCW TEST STEPS

These types of test steps are typically called Voltage Withstand Tests and are used to test that a DUT does not exhibit breakdown or (optionally) arcing in the presence of an applied AC or DC voltage, and optionally to test that the DUT leakage current is within user set limits at that voltage.

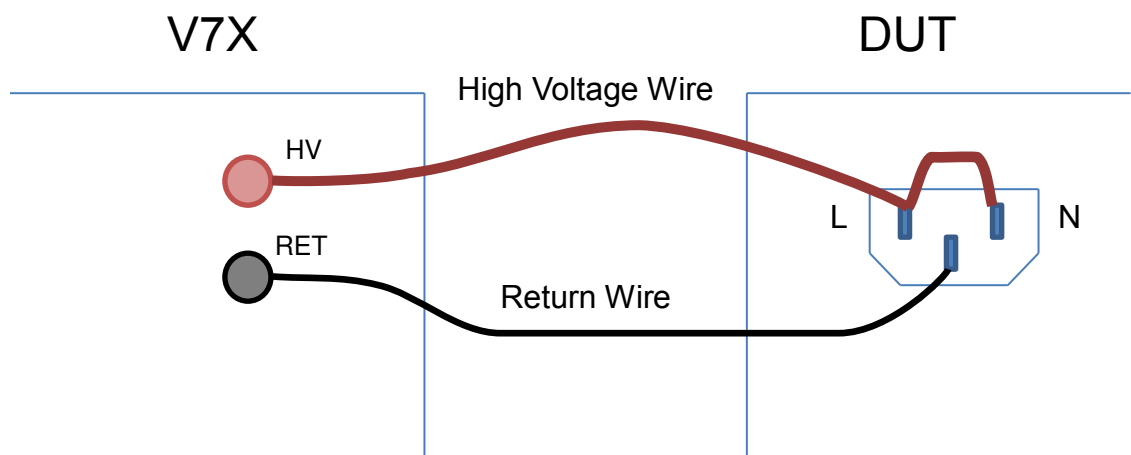
The user may optionally perform testing at more than one voltage by defining a series of test steps. The V7X automatically detects when two (or more) similar steps follow each other and does not discharge the DUT between such steps, starting each successive step at the voltage set for the preceding step. This capability saves both considerable total test time and also stress on the DUT in some applications.

ACW AND DCW TEST STEP CONNECTIONS

The figure below shows a typical application. The V7X always provides a safety ground for the DUT during the test via its **RET** terminal. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RET** terminal, the user should consider that only the voltage on the **RET** terminal is safe at all times.

See SECTION 2 – SAFETY for safety warnings regarding these connections. The wire attached to the HV terminal should be rated for at least 5KVrms working voltage.

For best high impedance load performance there should be low capacitance (for ACW tests) and/or leakage (for DCW tests) 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 ground. This will significantly reduce the capacitance and leakage between the **HV** and **RETURN** wires. A cable such as RG174 is a suitable choice. It is not recommended to use shielded coaxial cable for the **HV** connection, even if it is rated for the voltage.



CHOOSING BETWEEN ACW AND DCW TESTING

When Voltage Withstand Testing is required, the user must first decide whether to perform this using an AC or DC applied voltage.

Some standards require that testing be performed using an AC voltage waveform, others require a DC voltage, but others allow either to be used. If either AC or DC testing is allowed then in most applications AC testing is performed, however the user should take into account the following information when deciding which to use.

1. If it is required to test a highly capacitive DUT the user must use DC testing, as the current flow would be too high if AC were attempted. For reference, $\text{Load Current (in mA)} = 2 * \pi * f(\text{in Hz}) * C(\text{in } \mu\text{F}) * V(\text{in KV})$
As an example, at 60Hz and 2KV, a 0.1 μ F capacitance would draw 75.4mA load current, which is well beyond the capabilities of the V7X.
2. If the load is highly non-linear, so cannot withstand AC voltages, the user must use DC testing (e.g. semiconductor devices).
3. DC testing is typically performed at a voltage which is equivalent to the peak of the AC voltage. This means a 41.4% higher voltage is used for DC testing than AC testing, which may be beyond the allowed range of voltages which the V7X can produce, so AC testing must be performed.
4. DC testing often has a cumulative deterioration effect, particularly in solids (such as insulators). This slowly degrades its ability to withstand voltage depending on the total length of time that the insulator has had the voltage applied during its lifespan. If a DUT is to be repeatedly tested, then generally AC testing should be performed.
5. If the DUT is grounded then the capacitance of the HV wiring to ground is additive to the leakage load current. In grounded DUT applications where the wiring is extensive or where very low leakage current limits are required, improved accuracy can be achieved by using DC testing.

SETTING THE FREQUENCY FOR ACW TESTS

If AC testing is to be performed then it is recommended that the frequency used is that of the expected line power frequency of the DUT. If either 50 or 60Hz can be used, then it is recommended to use the actual local line frequency at the testing site.

SETTING THE VOLTAGE LEVEL FOR ACW AND DCW TESTS

All safety standards define the test voltage to be used, whether AC or DC. However there are some circumstances where the user may not be testing to specific standard and so needs to select a voltage to use.

Generally, line powered equipment is tested using an AC test voltage of 1000V+(5 times the highest line voltage), or a DC voltage 41.4% higher than this. As an example, for equipment to be powered from line up to 250Vrms, the test voltage is often 2250Vrms (or 3182Vdc).

CHOOSING DUT GROUNDED OR ISOLATED FOR ACW AND DCW TESTS

Most AC or DC Voltage Withstand testers either monitor the current flow in the high voltage lead or in the low voltage return lead (sadly many manufacturers do not actually specify which). The V7X allows the user to configure for either method; when configured for DUT Grounded the V7X monitors the current flowing in the high voltage supply lead, whereas when configured for DUT Isolated it monitors the current in the low voltage return lead. In the V7X the choices are-

1. If the DUT is firmly grounded (e.g. attached to grounded, or placed on a grounded surface) the select DUT Grounded. Note, when configured for DUT Grounded and the DUT is firmly grounded (e.g. physically attached to ground) then it is not necessary to use the RETURN terminal of the V7X to perform tests.

2. If DUT has significant ground leakage (e.g. is in an environment with ground leakage such as in a fluid tank) then select DUT Grounded.
3. Otherwise, select DUT Isolated since it results in the highest resolution most accurate current measurements

CHOOSING DUT RESISTIVE OR CAPACITIVE FOR DCW TESTS

The V7X can be used with quite highly capacitive DUTs (e.g. solar panels, large computer power supplies, etc.) when performing DCW tests, but this capability restricts its abilities when used in the more common applications having relatively low capacitance. The V7X can be configured for highly capacitive DUTs (DUT Capacitive) or for more common DUTs (DUT Resistive) so that the V7X is not compromised by having to cope with both situations. In the V7X the choices are-

1. If it is known that the DUT has a capacitance greater than 0.05 μ F then select DUT Capacitive, otherwise select DUT Resistive.
2. If DUT Resistive has been selected but it is noted that there is an undesirable "Settling" period displayed while transitioning between the RAMP and DWELL periods, as shown on the V7X display, then change to selecting DUT Capacitive.
3. If DUT Capacitive is selected but it is noted that the leakage current displayed on the V7X during RAMP is not significantly higher than the leakage current displayed during DWELL, then the DUT Resistive selection can be used instead.

SETTING MAXIMUM CURRENT LIMITS FOR ACW AND DCW TESTS

Generally the user is testing to a standard which requires that a DUT is tested to ensure that it does not breakdown at a certain applied voltage. This leaves the user to decide what maximum leakage current limit to use to detect the presence of breakdown, which is not an obvious decision. In reality there are three basic types of current which may (or may not) flow through the DUT –

- 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. Breakdown current is usually only limited by impedance in the voltage source and wiring. Note that a flashover, commonly called an arc, is usually actually a breakdown – it extinguishes because the voltage source and wiring is unable to drive the extremely high current in the flashover or because a portion of the physical part becomes destroyed by the flashover. Generally, at any given instant of time there either is very significant breakdown current flowing or there is none.
- Arc current. 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 can be very slight and is often not visible, corona is a form of arcing where the arcs do not extend entirely across the gap and so is also called partial discharge or partial breakdown.
- Leakage current. The leakage current of a DUT is a steady flow of current, generally caused 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. Leakage current flows with

the same frequency as the applied voltage, or a harmonic of it. Note that leakage current also contains a component which is dependent on breakdown current-

- When performing AC testing. Breakdown which is only occurring at the peaks of the waveform has a considerably attenuated effect on the leakage current measurement, for this reason this form of breakdown is often not detected by “classical” leakage current limit methods.
- In either DC or AC testing. Leakage current measurements are, by definition, relatively slow averages of the physical current, so breakdown detection is by necessity slow if only leakage current is used. In some circumstances, flashovers are not detected because they extinguish too fast.

In the V7X the choices are-

1. Disable the Max Leakage limit and the ARC Limit. The V7X only detects breakdown (and flashover) – the user does not have to make any decisions regarding limits and needs no prior experience with the specific DUT. Some standards however require a specific leakage current limit, or the user may wish to impose a very low leakage limit, so choices 2 or 4 need to be taken.
2. Set a Max Leakage limit. The V7X detects breakdown as choice 1 above, but also checks that the leakage current is within the limit. Generally, where there is no specific leakage current requirement in the standard, this is set to a little higher than the normal range of leakage currents encountered in that specific DUT as gathered from experience with testing many such DUTs.
3. Set an ARC Limit. The V7X detects breakdown as choice 1 above, but is also able to detect if any arcing is occurring. Generally, the limit level is set according to experience with the specific DUT, but a limit of 10mA is generally applicable.
4. Set both a Max Leakage Limit and an ARC Limit, the combination of choices 2 and 3 above.

SETTING A MINIMUM CURRENT LIMIT FOR ACW AND DCW TESTS

Generally, there is no requirement to set a minimum leakage current limit in a standard. Sometimes a user may be concerned about ensuring that the DUT is properly connected when performing ACW or DCW tests, in which case the most common method used is to set a minimum leakage current because there is always some amount of capacitance within the DUT which will always cause an amount of current to flow when properly connected. The actual value to use is usually set slightly higher than the leakage current measured when a test is run with no DUT connected (but with the wires attached to the V7X). Setting a minimum limit has no effect on the choice of maximum limit, other than the maximum (if enabled) must be higher than the lower limit.

Performing DCW tests using a minimum leakage limit to detect DUT connection is often problematic if set to very small currents, particularly with capacitive loads, generally due to induced currents in the wires caused by moving objects or by slight variations in current which flow when the DUT is highly capacitive. In these cases it is recommended to precede the DCW test with a very short ACW test at a low AC voltage (e.g. 10Vrms) with a minimum leakage limit defined.

SETTING RAMP AND DWELL TIMES FOR ACW AND DCW TESTS

These are usually set according to the requirements in a standard. Note that the V7X can also produce a slow ramp down at the end of the test if desired, as configured in the CONFIG MENU.

IR TEST STEPS

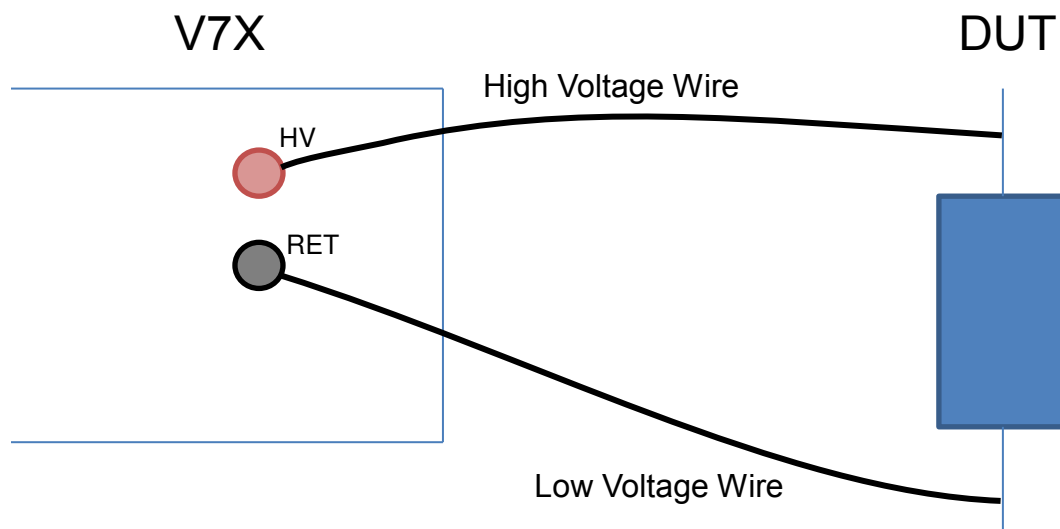
This type of test step is typically used to test that a DUT has a safe amount of leakage resistance in the presence of an applied DC voltage.

Note – the V7X detects and fails a DUT which breaks down, and all safety measures are operational, during IR test steps

IR TEST STEP CONNECTIONS

The figure below shows a typical application. The V7X always provides a safety ground for the DUT during the test via its' **RET** terminal. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RET** terminal, the user should consider that only the voltage on the **RET** terminal is safe at all times. See SECTION 2 – SAFETY for safety warnings regarding these connections. The wire attached to the HV terminal should be rated for at least 5KVrms working voltage.

For best high impedance load performance there should be low leakage between the wires and 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 ground. This will significantly reduce the leakage between the **HV** and **RETURN** wires. A cable such as RG174 is a suitable choice. It is not recommended to use shielded coaxial cable for the **HV** connection, even if it is rated for the voltage.



PERFORMING BOTH DCW AND IR TESTING

When it is required to perform both IR and DCW testing on a DUT it is recommended that the user perform the IR testing before performing the DCW testing. This is because there will be some storage of charge internal to the DUT during DCW testing, which will drastically affect the accuracy of subsequent IR testing, typically for many tens of seconds. By performing the IR testing and then the DCW testing this affect is eliminated. There is also a total test time benefit from performing the tests in this order with the V7X because it automatically detects that the test step following an IR test is a DCW step with a higher voltage level and so does not perform a discharge at the end of the IR step and starts the DCW ramp at the test voltage of the IR step.

SETTING THE VOLTAGE LEVEL FOR IR TESTS

All safety standards define the test voltage to be used for IR testing. Generally IR testing is performed at a voltage a little higher than the expected working voltage of the DUT, but significantly less than the DCW testing voltage.

CHOOSING DUT GROUNDED OR ISOLATED FOR IR TESTS

As all IR testers, the V7X computes the IR value by supplying a known voltage and measures the leakage current flowing in the DUT at that voltage. From the voltage and current, the resistance value can be computed and displayed.

When configured for DUT Grounded the V7X monitors the current flowing in the high voltage supply lead, whereas when configured for DUT Isolated it monitors the current in the low voltage return lead. In the V7X the choices are-

1. If the DUT is firmly grounded (e.g. attached to grounded, or placed on a grounded surface) the select DUT Grounded. Note, when configured for DUT Grounded and the DUT is firmly grounded (e.g. physically attached to ground) then it is not necessary to use the RETURN terminal of the V7X to perform tests.
2. If DUT has significant ground leakage (e.g. is in an environment with ground leakage such as in a fluid tank) then select DUT Grounded.
3. Otherwise, select DUT Isolated since it results in the highest resolution most accurate IR measurements

CHOOSING DUT RESISTIVE OR CAPACITIVE FOR IR TESTS

The V7X can be used with quite highly capacitive DUTs (e.g. solar panels, large computer power supplies, etc.) when performing IR tests, but this capability restricts its abilities when used in the more common applications having relatively low capacitance. The V7X can be configured for highly capacitive DUTs (DUT Capacitive) or for more common DUTs (DUT Resistive) so that the V7X is not compromised by having to cope with both situations. In the V7X the choices are-

1. If it is known that the DUT has a capacitance greater than 0.05 μ F then select DUT Capacitive, otherwise select DUT Resistive.
2. If DUT Resistive has been selected but it is noted that there is an undesirable overshoot of the test voltage, as shown on the V7X display, then change to selecting DUT Capacitive.

SETTING THE TIMING FOR IR TESTS

The test time to be used for IR tests is usually determined by the standard being used. When performing IR testing on capacitive DUTs, or when testing for very high minimum IR results, the user should also consider the minimum time taken for the load and V7X to settle. Generally, the V7X takes 1 or 2 seconds to settle into moderately capacitive DUTs (e.g. 0.1 μ F), but this can be 3 to 5 seconds into highly capacitive DUTs (e.g. 2 μ F), the test time should be longer than these values and the user may need to set the Delay to longer than these values also.

In the V7X the user can also configure to allow the IR test to be terminated earlier than the configured test time under some circumstances as allowed in many standards—

1. If it is required that the test always be performed for the entire test time, then configure the V7X for IR END ON – Time Expired in the CONFIG MENU. The Delay setting is ignored when configured in this manner. The pass or fail decision is based solely on the IR at the end of the test time – IR readings prior to the end are ignored. Generally, this method is used when the requirement uses wording such as “After 60 seconds the IR must be greater than...” particularly with capacitive DUTs.
2. If the test may be terminated early if a passing IR occurs during the test time, then configure the V7X for IR END ON – Pass in the CONFIG MENU. The Delay setting can be used to enforce a minimum test time before a pass will terminate the test, should this be desired. If the entire test time passes without having a pass indication then the DUT is given a fail indication. Generally, this method is used when the requirement uses wording such as “IR must be greater than... within 60 seconds”.

3. If the test may be terminated early if a failing IR occurs during the test time, then configure the V7X for IR END ON – Fail in the CONFIG MENU. The Delay setting can be used to enforce a minimum test time before a fail will terminate the test, should this be desired. If the entire test time passes without having a fail indication then the DUT is given a pass indication. Generally, this method is used when the requirement uses wording such as “After 60 seconds the IR must be greater than...” and the load is purely resistive.
4. If the test may be terminated early if a passing and steady or increasing IR occurs during the test time, then configure the V7X for IR END ON – Pass and Steady or Increasing in the CONFIG MENU. The Delay setting can be used to enforce a minimum test time before the test will be terminated, should this be desired. If the entire test time passes without being terminated then the pass or fail decision is solely based on the IR at the end of the test time. Generally, this method is used when the requirement uses wording such as “IR must be greater than... within the earlier of 60 seconds or when the IR is steady or increasing”.

SETTING A MAXIMUM LIMIT FOR IR TESTS

Although the minimum limit is always defined by the standard or requirement, there is not usually a maximum limit. Usually the user will set for no maximum limit, but some users use a maximum limit to check that the DUT is actually connected when performing the IR test. Particularly with capacitive DUTs, this is not recommended, instead it is recommended to precede the IR test with a very short ACW test at a low AC voltage (e.g. 10Vrms) and with a minimum leakage limit defined. This method yields more reliable results, particularly if the DUT can have a very high IR result so the maximum IR limit would have been near (or beyond) the upper limit of the ability of the V7X.

CONT TEST STEPS

This type of test step is typically used to test that a DUT has resistance within an allowable range of values. Typical uses include checking for the presence or absence of continuity, but the wide range of values capable of being measured by the V7X (up to 60KΩ) also allows for component value testing in many circumstances. Some standards allow the low DC current (10mA) used in this type of test step to be used for production chassis ground bond integrity testing.

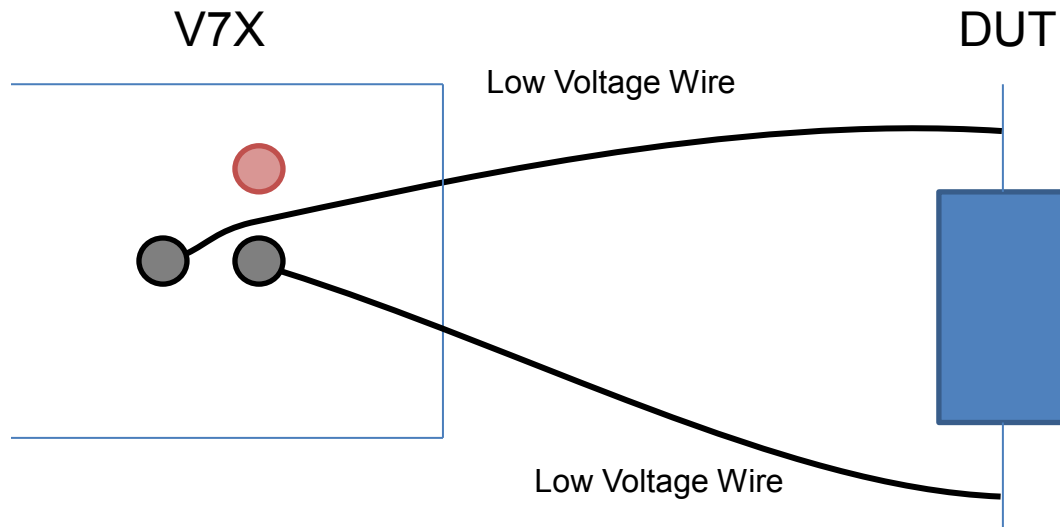
The V7X also has the capability of having no limits set by the user, so the test step will never fail. This is useful in applications requiring that a resistance be measured and recorded during DUT testing, but not checked against limits.

CONT TEST STEP CONNECTIONS

The figure below shows a typical application. These connections may remain in place during ACW, DCW and/or IR type test steps if desired, assuming that high voltage cannot be connected to the CONT terminals during that testing.

Note –

- The DUT (or the portion of it being measured) must be isolated from ground during CONT test steps.
- The GB terminals of the V7X must not be connected to the DUT while performing a CONT test step.



SETTING THE TIMING FOR CONT TESTS

The test time to be used for CONT tests may be configured to a wide range of values in the V7X, from 0.1s upwards. The V7X includes time delays for its' internal settling, however under some circumstances the user may need to extend the test time to allow for DUT settling, particularly when testing higher impedance values. Since the test current is low, generally there is no DUT self-heating so there is little advantage to performing extended test times.

SETTING THE LIMITS FOR CONT TESTS

The user may freely set any minimum and maximum limit in the range of 0.000Ω to 60KΩ, or may disable either (or both) limits. Setting a limit has no effect on the choice of the other limit, other than the maximum limit (if enabled) must be higher than the lower limit (if enabled).

ALLOWING FOR RESISTANCE OFFSETS EXTERNAL TO THE V7X

The V7X uses a 2-wire measurement method for CONT test steps, so the resistance of external wiring will add to the measurement result. There are two methods which can be used to provide offsets allowing for external wiring resistance, the user is recommended to either use one or the other method, although both can be used if desired.

1. If the same (or very similar) leads are to be used for every CONT test step, then the user may connect those leads, shorting them together with a very low resistance, then have the V7X measure the resulting resistance, and then use that resistance to offset all future measurements. This is accomplished by using the UTILITY MENU -> CONT ZERO -> MEASURE menu. If this method is solely being used then all CONT test steps should have the ZERO setting set to 0Ω.
2. If the external resistance is likely to be significantly different for each CONT test step, then the user should set the ZERO setting for each CONT test step to the expected resistance for that specific step, this value will be used to offset all measurements made for that specific test step only. If the measured offset capability described in 1 above is not desired, then any existing offset can be eliminated by using the UTILITY MENU -> CONT ZERO -> CLEAR menu. Note, if the expected resistance for each step is unknown, then the user may set all steps ZERO to 0Ω, run the sequence with a known (usually zero) resistance DUT, note the offset resistances for each CONT step, and then edit the CONT steps using the previously measured offset resistances as the ZERO setting for each respective step.

GB TEST STEPS

This type of test step is typically used to test that a DUT has resistance lower than a certain value when tested at high AC currents. Typically this is used for DUT chassis ground bond integrity testing, but is also used for wire resistance testing on power cables, or for conduit integrity testing.

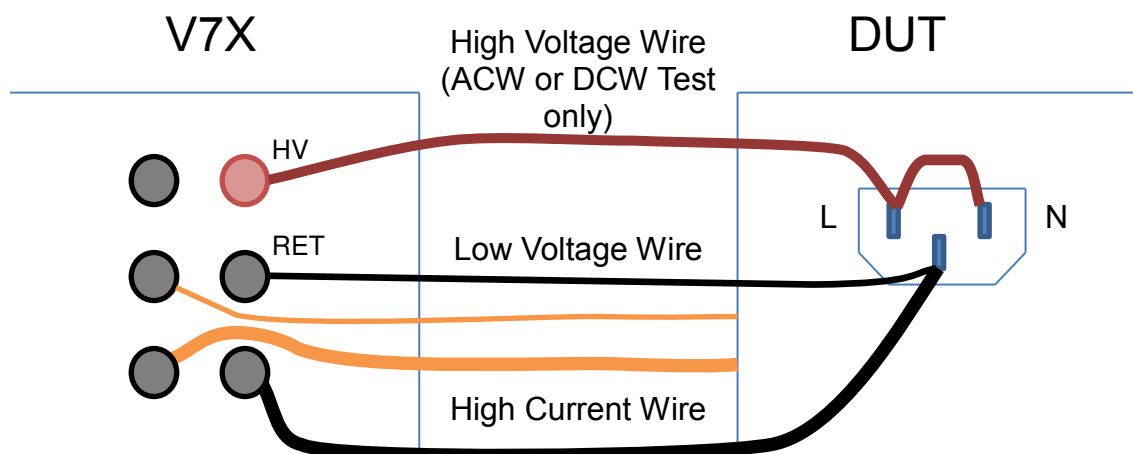
Note that the DUT (or the portion of it being measured) may be grounded by the user during GB test steps, allowing it to be used for additional testing purposes such as conduit continuity testing.

GB TEST STEP CONNECTIONS

The figure below shows a typical application where both Voltage Withstand and GB testing is to be performed. These connections may remain in place during ACW, DCW and/or IR type test steps if desired (as shown in the figure), assuming that high voltage cannot be connected to the GB terminals during that testing.

See SECTION 2 – SAFETY for safety warnings regarding these connections. The wires attached to the lowermost terminals should be rated for at least 30Arms current and should be firmly attached to the terminals, otherwise overheating of the terminals and/or wire can occur. Similarly, these wires must be firmly attached to the DUT to reduce self-heating. If “clips” are used to attach to the DUT then the user should use caution when removing these as they may have been heated during testing.

When selecting the wire to use for the high current connections, the user should also consider the maximum DUT resistance limit and the V7X maximum voltage compliance for the current source. For example, if the user is using a 25Arms test current, with a maximum DUT resistance limit of 0.1Ω , then the maximum voltage drop across the DUT itself could be $2.5V_{rms}$ (or more). The minimum compliance voltage limit of the V7X is $4.5V_{rms}$ (see APPENDIX B), so the absolute maximum wiring resistance in this example is $(4.5V - 2.5V) / 25A = 0.08\Omega$. In practice the total resistance of the high current connections must be less than this as the wires will self-heat during the test (raising their resistance) and also this does not include any terminal and DUT contact resistance. For this example, allowing a maximum total wiring resistance of 0.05Ω would be reasonable (note that this is $31.25W$ of power in the wires alone). Using 10AWG wire (approx. $0.0037\Omega/m$) this limits the total wire length to $13.5m$ (i.e. $6.75m$ or $22ft$ per wire).



If the user needs to make optimum measurements of low impedances, particularly less than a few 10 's of $m\Omega$, then the following points should also 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 $m\Omega$, particularly when high test currents

are being used. This effect is not specific to the V7X, it applies to any high current, low impedance AC measurement. The user is recommended to maintain at least a 3/4" spacing between each wire.

- 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 be 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.

SETTING THE FREQUENCY FOR GB TESTS

If GB testing is to be performed then it is recommended that the frequency used is that of the expected line power frequency of the DUT. If either 50 or 60Hz can be used, then it is recommended to use the actual local line frequency at the testing site. Note that GB testing is always performed at the same frequency as ACW testing.

SETTING THE CURRENT LEVEL FOR GB TESTS

All safety standards define the test current to be used; often this may be a lower current for production testing of DUTs than that specified for type testing of the DUT. However there are some circumstances where the user may not be testing to specific standard and so needs to select a current to use.

Generally, line powered DUTs are tested using a current of (5 times the maximum line power current demand of the DUT) with a minimum of 25Arms for type testing. As an example, for equipment to be powered from line with a maximum demand of 3Arms, the test current is often 25Arms.

SETTING THE TIMING FOR GB TESTS

Most safety standards require a specific test time, although it is often specified that a shorter time can be used for production testing than for type testing of the DUT. Since GB testing is often carried out using large test currents, the DUT may exhibit self-heating, which should be taken into account when setting the test time.

SETTING THE LIMITS FOR GB TESTS

The user may freely set any minimum and maximum limit in the range allowed by the choice of test current and the specified maximum compliance voltage of the V7X (see APPENDIX B for the V7X specification). The minimum limit may be disabled. Setting a maximum limit has no effect on the choice of the minimum limit, other than the maximum limit must be higher than the lower limit (if enabled).

For DUT chassis ground bond testing specified by a safety standard, the maximum limit is always specified by the standard.

ALLOWING FOR RESISTANCE OFFSETS EXTERNAL TO THE V7X

The V7X uses a 4-wire measurement method for GB test steps, so the resistance of external wiring will not add to the measurement result. However the user may include a short portion of common wiring which, although not recommended, will cause a small zero offset, the resistance of which will be included in the measurement result.

CAUTION – the specification of the V7X does not rely on the user removing zero offsets in the manner described here. Compensation of any zero offset seen while making true 4-wire measurements is not recommended, and will actually reduce the accuracy of results, not improve it. Any offset seen while making 4-wire AC measurements is generally caused by inter-wire inductive coupling and noise, which is not a constant offset being very dependent on the characteristics of the DUT being measured.

There are two methods which can be used to provide offsets allowing for external wiring resistance, the user is recommended to either use one or the other method, although both can be used if desired.

1. The user may connect the GB leads, shorting them together with a very low resistance, and have the V7X measure the resulting resistance, and then use that resistance to offset all future measurements. This is accomplished by using the UTILITY MENU -> GB ZERO -> MEASURE menu. If this method is solely being used then all GB test steps should have the ZERO setting set to 0Ω.
2. If the external resistance is likely to be different for each GB test step, then the user should set the ZERO setting for each GB test step to the expected resistance for that specific step, this value will be used to offset all measurements made for that specific test step only. If the measured offset capability described in 1 above is not desired, then any existing offset can be eliminated by using the UTILITY MENU -> GB ZERO -> CLEAR menu. Note, if the expected resistance for each step is unknown, then the user may set all steps ZERO to 0Ω, run the sequence with a known (usually zero) resistance DUT, note the offset resistances for each GB step, and then edit the GB steps using the previously measured value as the ZERO setting for each respective step.

PAUSE AND HOLD TEST STEPS

These types of test step are used to temporarily suspend operation of a test sequence.

CHOOSING BETWEEN PAUSE AND HOLD TEST STEP TYPES

Although they both may appear to operate similarly, they are actually very different.

- The PAUSE step performs a timed suspension of the sequence without the ability to continue it during the PAUSE. It is intended to be used when the user desired a timed pause in the sequence. CAUTION – DO NOT USE A PAUSE STEP TO ENABLE THE USER TO MAKE CHANGES TO THE CONNECTIONS, THE PAUSE DELAY MAY EXPIRE WHILE THE USER IS HANDLING CONNECTIONS, WHICH IS VERY DANGEROUS AND POTENTIALLY LETHAL. A special use of the PAUSE step type is to prevent the automatic skipping of the discharge at the end of a ACW or DCW or IR test step type if the next step is of a similar type, placing a minimum time PAUSE step between two test steps always disables this.
- The HOLD step performs a suspension of the sequence, allowing the user perform an operation (e.g. change the position of wiring) and then continue it by pressing the START button. A timeout is provided to allow the sequence to fail if the user takes too long to accomplish the operation. Up to two lines of 15 characters each may be displayed to assist the user in knowing what operation to perform, a message is also displayed informing the user to continue by pressing the START button.

SWITCH TEST STEPS

These are to enable the user to control up to four external ViTREK 964 type switch units as part of a test sequence. The user only has to program the state of each relay switch in each unit in this type of step, all timing is automatically performed by the V7X.

APPENDIX B – TEST STEP SPECIFICATIONS

Accuracy specifications shown are valid at temperatures within $\pm 5^{\circ}\text{C}$ of the calibration temperature. Outside of this range add 10% of the specification per $^{\circ}\text{C}$.

Decrease maximum ACW, DCW and IR voltages by 2.5%/1000ft above 5000ft ASL altitude.

All accuracy specifications are valid at the V7X terminals, and as such do not include any effects due to user wiring resistances, leakages or coupling, or other user generated leakages or interference.

Resolutions shown are for displayed measurements, limits and settings. Internally all measurements have typically 10x better resolution and all limits and settings are implemented with the same resolution as entered by the user. Via an interface, all measurements are reported with 5 digit resolution.

Generally, user settings can be defined with up to 4 digit resolution and a selection of units (e.g. μA or mA) from the front panel; or with up to 6 digit resolution from an interface.

Unless otherwise specified, user terminated dwell/test periods can extend for up to 2 days.

Not all test types are available in all models of V7X.

ACW TEST STEPS

Voltage	10 to 5000Vrms (1V resolution) sinewave at 50 or 60Hz +/- 0.05% 1%+5V accuracy under all allowed loading conditions
Max. Load	20mArms (10mArms max resistive for >10sec), reduced by $20\mu\text{A}$ per V below 1000V, reduced by $10\mu\text{A}$ per V above 4000V
Leakage Accuracy	DC coupled, true RMS, 10Hz-4KHz 3dB bandwidth DUT isolated (<1.1mA) : 1%+5 μA (1 μA resolution) DUT isolated (>1.1mA) : 1%+30 μA (10 μA resolution) DUT grounded : 1%+30 μA +(4 μA per KV) (10 μA resolution)
ARC Limit	Disabled or up to 30mA (1mA resolution)
Ramp	0 to 99.9sec (0.02sec resolution)
Dwell	0.1 to 9999sec (0.1sec resolution) or user terminated
Shutdown	Excessive HV terminal current : within 1ms User Stop : within 2ms Interlock opened (if enabled) : within 2ms Load Breakdown (sudden uncontrolled increase of load current): within 150 μs Leakage Limit (if enabled) : within 100ms ARC Limit (if enabled) : within 1ms
User Settings	Voltage Level Frequency DUT Isolated/Grounded Min. Leakage Limit (can be disabled) Max. Leakage Limit (can be disabled) ARC Limit (can be disabled) Ramp Period Dwell Period Ramp Down Fast/As Ramp Stop/Continue Sequence on Failure

DCW TEST STEPS

Voltage	20 to 5000V (1V resolution) 1%+5V accuracy under all allowed loading conditions
Max. Load	<2000V : 10mA (reduce by 10 μ A per Volt below 1000V), <0.25 μ F capacitance 2000-3000V : 7mA (reduce by 4 μ A per volt above 2000V), <0.1 μ F capacitance 3000-4000V : 3mA (reduce by 1 μ A per volt above 3000V), <0.05 μ F capacitance >4000V : 2mA (reduce by 0.5 μ A per volt above 4000V), <0.03 μ F capacitance
Leakage Accuracy	DUT resistive, isolated (<200 μ A) : 1%+1 μ A (0.1 μ A resolution) DUT resistive, isolated (0.2-1.5mA) : 1%+2 μ A (1 μ A resolution) Otherwise : 1%+20 μ A (10 μ A resolution)
ARC Limit	Disabled or up to 30mA (1mA resolution)
Ramp	DUT resistive : 0.1 to 99.9sec (0.02sec resolution) DUT capacitive : 1.0 to 99.9sec (0.02sec resolution)
Dwell	0.1 to 9999sec (0.02sec resolution) or user terminated
Ramp Down	0sec or as defined for ramp
Discharge	Internal 50K Ω discharge load and 0.03 μ F capacitive energy
Shutdown	Excessive HV terminal current : within 1ms User Stop : within 2ms Interlock opened (if enabled) : within 2ms Load Breakdown (sudden uncontrolled increase of load current): within 150 μ s Leakage Limit (if enabled) : within 100ms ARC Limit (if enabled) : within 1ms
User Settings	Voltage Level DUT Isolated/Grounded DUT Resistive/Capacitive Min. Leakage Limit (can be disabled) Max. Leakage Limit (can be disabled) ARC Limit (can be disabled) Ramp Period Dwell Period Ramp Down Fast/As Ramp Stop/Continue Sequence on Failure

IR TEST STEPS

Voltage	20 to 5000V (1V resolution) 2.5%+5V accuracy under all allowed loading conditions
Lowest IR	<1000V : 150K Ω 1000-2000V : 400K Ω 2000-3000V : 2M Ω >3000V : 10M Ω
Highest IR	DUT resistive, isolated : 90M Ω per V DUT capacitive, isolated : 2M Ω per V DUT grounded : 0.1M Ω per V
Max Capacitance	<1000V : 2 μ F 1000-2000V : 0.25 μ F 2000-3000V : 0.1 μ F

	>3000V : 0.03 μ F
	5mA maximum charging current
IR Accuracy	<5% of Highest IR: 2% (0.1% resolution) 5-15% of Highest IR: 5% (1% resolution) 15-30% of Highest IR: 10% (1% resolution) >30% of Highest IR: 20% (1% resolution)
Test Time	0.1 to 9999sec (0.1sec resolution) or user terminated
Test Delay	0.0 to 9999sec (0.1sec resolution)
Discharge	Internal 50K Ω discharge load and 0.03 μ F capacitive energy
Shutdown	Excessive HV terminal current : within 1ms User Stop : within 2ms Interlock opened (if enabled) : within 2ms Load Breakdown (sudden uncontrolled increase of load current): within 150 μ s IR Limit (if enabled) : within 100ms ARC Limit (if enabled) : within 1ms
User Settings	Voltage Level DUT Isolated/Grounded DUT Resistive/Capacitive Min. IR Limit Max. IR Limit (can be disabled) Ramp Period Dwell Period Delay Period Dwell End On Pass/Fail/Time/Steady or Rising Ramp Down Fast/As Ramp Stop/Continue Sequence on Failure

CONT TEST STEPS

Method	2 terminal measurement (DC)
Test Current	<10.5mA
Test Voltage	<4.15V
Range	0 Ω to 60K Ω
Accuracy	<0.75 Ω : 1.5% + 0.015 Ω (0.001 Ω resolution) <13 Ω : 1.5%+0.02 Ω (0.01 Ω resolution) 13-1000 Ω : 3%+1 Ω (1 Ω resolution) 1K-4K Ω : 4% (10 Ω resolution) 4K-13K Ω : 5% (100 Ω resolution) >13K Ω : 10% (1K Ω resolution)
Test Time	0.06 to 9999sec (0.02sec resolution) or user terminated
CONT Leakage	DCW or IR test steps : <0.1 μ A ACW test steps : <2.5 μ A per KV setting (DUT isolated), <5 μ A (DUT grounded)
User Settings	Min. Limit (can be disabled) Max. Limit (can be disabled) Resistance Offset Test Time Stop/Continue Sequence on Failure

GB TEST STEPS

Method	4 terminal measurement (AC)
Current	1 to 30Arms (0.01A resolution) sinewave at 50 or 60Hz +/- 0.05% 3%+10mA accuracy
Compliance	>4.5Vrms at all currents
Open Circuit	<10Vpk
DUT Ground	DUT may be isolated from ground or be grounded. If grounded, must be within 3Vpk of V7X ground.
Range	Max resistance determined by max compliance and test current
Accuracy	<2A : 3.5%+3mΩ (1mΩ resolution) 2-6.5A : 3%+2mΩ (1mΩ resolution) >6.5A : 2.5%+1mΩ (0.1mΩ resolution)
Test Time	<20A : 0.1 to 9999sec (0.02sec resolution) or user terminated 20-25A : 0.1 to 499sec (0.02sec resolution) or user terminated >25A : 0.1 to 120sec (0.02sec resolution) or user terminated (50% max duty cycle)
GB Leakage	DCW or IR test steps : <1μA ACW test steps : <5μA per KV setting (DUT isolated), <10μA (DUT grounded)
User Settings	Current Level Frequency Min. Limit (can be disabled) Max. Limit Resistance Offset Test Time Stop/Continue Sequence on Failure

PAUSE TEST STEPS

Pause Delay	0.1 to 9999sec (0.02sec resolution)
User Settings	Pause Delay

HOLD TEST STEPS

Timeout	0.1 to 9999sec (0.02sec resolution) or none
User Settings	Timeout (can be disabled) Message (two lines)

SWITCH TEST STEPS

Execution Time	<0.04sec per Switch unit + switch unit switching time (see 964 specifications)
User Settings	Relay states for each relay in each switch unit (4 max switch units)