

# VITREK

981i and 983i

## OPERATING & MAINTENANCE MANUAL



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## ABOUT THIS MANUAL

Throughout this document the instrument is referred to as the 981/3i, this applies to all instruments in the 980 series having a main firmware revision of 1.00, there may be differences if the 981/3i 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.

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

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

## WARRANTY INFORMATION

This ViTREK instrument is warranted against defects in material and workmanship for a period of 1 year after the date of purchase (extended up to a total of 3 years with registration and annual calibrations at ViTREK). ViTREK agrees to repair or replace any assembly or component (except batteries) found to be defective, under normal use, during the warranty period. ViTREKs obligation under this warranty is limited solely to repairing any such instrument, which in ViTREKs 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.

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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

The 981/3i is an advanced Teraohmometer and Insulation Resistance Tester with many standard features which make it unique in this field.

- Wide range of test voltages. The 981/3i has a test voltage range from a few 10's of volts to over 10kilovolts and a measured current range from 1pA up to 4mA.
- Result Analysis. The 981/3i does not just measure, it analyses the measurements – after a test has been run the minimum, maximum, average and final measurements are available, a running total of the passes and failures for each test step are also maintained across multiple runs.
- Stand alone operation. The 981/3i can be programmed by the user to perform up to 254 test steps in a sequence. Each step is automatically performed by the 981/3i either with or without user intervention as the user desires. Up to 100 such sequences can be defined and maintained in the instrument, no computer is required. The 981/3i is capable of controlling switch matrix units (also available from ViTREK) – up to 256 channels can be controlled without needing a computer or software.
- System operation - Wide range of interfaces available. If the user wishes to use the 981/3i with a computer, then RS232, GPIB or Ethernet interfacing can be chosen as the interfacing medium between them. Giving the user the flexibility to use the 981/3i in almost any computing environment. Software (QuickTest Pro) is available from ViTREK to provide all the control needed for any system from the simple (just the 981/3i) to the most complex with the 981/3i terminals being multiplexed between DUTs and/or points within DUTs by up to 1024 channels in switch matrix units (also available from ViTREK).

### AVAILABLE MODELS AND OPTIONS

#### 981i

The 981i offers test voltages between 30V and 6500Vdc with 1V resolution. With a 1pA to 4mA measurement current range this allows insulation resistances from 100kΩ up to 1000TΩ to be measured.

#### 983i

The 983i offers test voltages between 60V and 11000Vdc with 1V resolution. With a 1pA to 4mA measurement current range this allows insulation resistances from 100kΩ up to 10000TΩ to be measured.

#### DUT ISOLATION OPTION

This option may be fitted in a 981i.

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

#### INTERFACING OPTION

This option may be fitted in any 981/3i.

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

The 981/3i has ViCL, Digital I/O, RS232 and Ethernet interfaces as standard.

#### POWER INPUT OPTION

One of these options may be fitted in any 981/3i.

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

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

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#### RACK MOUNTING OPTION

This option may be fitted in any 981/3i.

Option **RM-1** allows for standard 19" rack mounting of the 981/3i.

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#### OUTPUT VOLTAGE LIMITING OPTIONS

The user may, at the time of order, specify that the voltage generated by the 981/3i may be limited to a user specified voltage less than that normally available from the specific unit model (but must be greater than 100V). The remainder of this manual assumes that these optional limits are at the maximum for the specific model.

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#### ACCESSORIES

- **TL-980.** Test Lead Set (one supplied with each unit).
- **RS-2.** 6ft RS232 null-modem cable (981/3i to Computer).
- **USB-2.** USB A to RS232 (Serial) Adapter Cable (Requires RS-2)
- **GP-1.** 1 Meter Shielded GPIB (IEEE-488) Cable
- **RSS-95.** Remote Start/Stop Switch
- **RFS-95.** Remote Start Foot Switch

## SECTION 2 – SAFETY

The user should be aware of these safety warnings at all times while using the 981/3i.

**WARNING** - THE 981/3i PRODUCES VOLTAGES WHICH MAY BE LETHAL, UNSAFE OPERATION MAY RESULT IN SEVERE INJURY OR DEATH.

**WARNING** - IF THE 981/3i IS USED IN A MANNER NOT SPECIFIED BY VITREK, THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED AND SAFETY MAY BE COMPROMISED.

### POWER AND GROUNDING

**WARNING** - THE 981/3i 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 981/3i IS NOT POWERED FROM A SUITABLE POWER SOURCE THEN THE CHASSIS GROUND TERMINAL LOCATED NEAR THE POWER ENTRY CONNECTOR ON THE REAR PANEL MUST BE PROTECTIVE GROUNDED.

**WARNING** - TURNING OFF OR OTHERWISE REMOVING POWER TO THE 981/3i WHILE IT IS GENERATING HIGH VOLTAGES WILL NOT ENABLE THE 981/3i TO DISCHARGE THE DUT AND MAY DAMAGE THE 981/3i. THE DUT MAY HAVE DANGEROUS VOLTAGES PRESENT FOR LONG PERIODS OF TIME AFTER THIS OCCURS.

**WARNING** - DO NOT REMOVE THE POWER CORD FROM THE 981/3i OR FROM THE SOURCE OF POWER WHILE IT IS OPERATING AT HIGH VOLTAGES. THIS WILL REMOVE THE PROTECTIVE GROUND FROM THE CHASSIS OF THE 981/3i AND THE DUT WHICH MAY RESULT IN HAZARDOUS VOLTAGES BEING ACCESSIBLE TO THE USER.

### TERMINALS AND WIRING

**WARNING** - THE 981/3i PRODUCES VOLTAGES WHICH MAY BE LETHAL, ENSURE NO VOLTAGE IS PRESENT WHEN CONNECTING TO OR DISCONNECTING FROM THE TERMINALS OR DUT.

The **HIGH VOLTAGE PRESENT** warning symbol on the front panel of the 981/3i is illuminated whenever an unsafe voltage is present on the **HV** terminal.

**WARNING** - THE 981/3i PRODUCES VOLTAGES OF UP TO 11kV ON THE HV TERMINAL(S). THE USER MUST ENSURE THAT CONNECTIONS TO THESE TERMINALS HAVE SUFFICIENT INSULATION FOR THESE VOLTAGES. EVEN WHEN SUFFICIENT INSULATION IS PRESENT, THE USER SHOULD NOT PUT ANY PART OF THEIR BODY IN CLOSE PROXIMITY TO THE CONNECTIONS WHILE HIGH VOLTAGES ARE PRESENT.

The insulation of the wiring to the **HV** terminal of the 981/3i 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 981/3i and will reduce the capabilities of the wiring insulation over time, eventually resulting in insulation failure.

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

All terminals of the 981/3i other than the HV terminal are always protected to be within a safe voltage of the 981/3i 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 981/3i shuts down, in severe cases this can damage nearby equipment, such as computers. The high voltage wiring between the 981/3i terminals and the DUT should be routed as far as possible away from other equipment, from table surfaces, and from all other cabling.

## DUT SAFETY

During each test, the **HIGH VOLTAGE PRESENT** warning light is illuminated if the voltage across the DUT is above 30V.

At the end of a test, the test is not completed, and the **HIGH VOLTAGE PRESENT** warning light is not extinguished, until the voltage has been discharged to and maintained below 30V from ground by the 981/3i for at least 300ms, after which time the 981/3i may be used normally but the DUT is still maintained in discharge. During discharge the DUT is discharged by a dynamically selected resistance to ground.

When charging high capacitance loads to high DC voltages the capacitor may be unsafe if it or the wiring to it exhibits breakdown while being tested. The energy in the breakdown is generated by the capacitor itself, so there can be no limit on this energy imposed by the 981/3i.

## USER ACTIVATED SAFETY ABORT

- The user may depress the **STOP** button on the 981/3i front panel at any time while a test sequence is being run to remove the voltage 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 test step if the interlock is opened. See [SECTION 8 – DIO INTERFACE](#).
- The user can configure for a digital ABORT signal to be input to the DIO Interface which will abort any type of test step if asserted. See [SECTION 8 – DIO INTERFACE](#).
- There are several interface commands which can be used to abort a running test sequence. See [SECTION 11 – PROGRAMMING VIA AN INTERFACE](#).

## AUTOMATIC SAFETY ABORT

- The 981/3i will immediately fail the test if excessive **HV** terminal current is detected (typically >6mA). This requires no specific configuration by the user.
- 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 981/3i which participate in monitoring the output of the 981/3i 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 981/3i 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

### GENERAL SPECIFICATIONS

Nominal Dimensions	89mmH x 432mmW x 457mmD (3.5" x 17" x 18")
Nominal Weight	9kg (18lb) net, 12kg (25lb) shipping
Storage Environment	-20 to 75C (non-condensing)
Operating Environment	0 to 50C, <80% RH (non-condensing), Pollution Degree 2
Operating Altitude	0 to 2000m ASL
Line Power	Installation Category II Standard: 105-265Vrms (45 to 450Hz) or 160-300Vdc, having at least 100VA capability Opt. LOLINE: 85 to 130Vrms (45 to 450Hz) Opt. INRUSH : 200-265Vrms (45 to 450Hz) having at least 100VA capability
Measurement	Uncategorized Measurement – terminals must not be connected to mains

THE 981/3i MUST NOT BE USED IN AN ENVIRONMENT WHERE CONDUCTIVE POLLUTION CAN OCCUR, E.G. IN AN OUTDOOR ENVIRONMENT.

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

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

### LINE POWER

**WARNING** - THE 981/3i 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 981/3i IS NOT POWERED FROM A SUITABLE POWER SOURCE THEN THE CHASSIS GROUND TERMINAL LOCATED NEAR THE POWER ENTRY CONNECTOR ON THE REAR PANEL MUST BE PROTECTIVE GROUNDED.

The user may connect the 981/3i to any source of line power within the allowable range of voltages and frequencies (see above) without requiring any adjustment to the 981/3i.

The 981/3i line power input is fused with a 5mm x 20mm TT3.15A fuse mounted in the rear panel next to the line power entry. If the user needs to replace this fuse it must be replaced with an exact equivalent fuse, noting the time and current ratings. Although the 981/3i is fused at 3.15Arms, the unit can draw surges of up to 10Apk during normal operation and up to 100Apk during initial application of power. The user should ensure that the power cord is rated for at least 5Arms continuous operation.

### INITIAL INSPECTION

After the 981/3i has been shipped or otherwise handled in an unknown manner, the user should visually inspect the 981/3i for damage before attempting to operate it. Particular attention should be taken to ensure that there are no significant dents or cracks in any outer surfaces and that all terminals are securely mounted to the unit. If any significant dents or cracks, or any loosely mounted terminals, are noted then it is recommended that the 981/3i be serviced prior to being placed into use, as safety may have been compromised.

## **MOUNTING POSITION AND ORIENTATION**

The 981/3i may be installed as either a bench top instrument or installed into a standard 19" rack.

The 981/3i is primarily intended to be used in a horizontal, or close to horizontal position, oriented with the top cover (with the vent holes) uppermost. There are no known issues with mounting the 981/3i at any angle or orientation, as long as it is mounted in a secure and stable fashion taking into consideration its' weight and weight distribution.

## **INSTALLING IN A 19" RACK ENCLOSURE**

Often when installing the 981/3i into a rack enclosure it is desired to remove the feet from the bottom of the 981/3i. This is easily achieved by simply removing the screws mounting the feet to the bottom of the unit. The user should place the removed feet and mounting hardware into a bag for safe keeping should they be needed at a later date for bench top usage. **DO NOT INSERT THE MOUNTING HARDWARE BACK INTO THE BOTTOM OF THE 981/3i WITHOUT THE FEET INSTALLED, THIS MAY DAMAGE THE UNIT.**

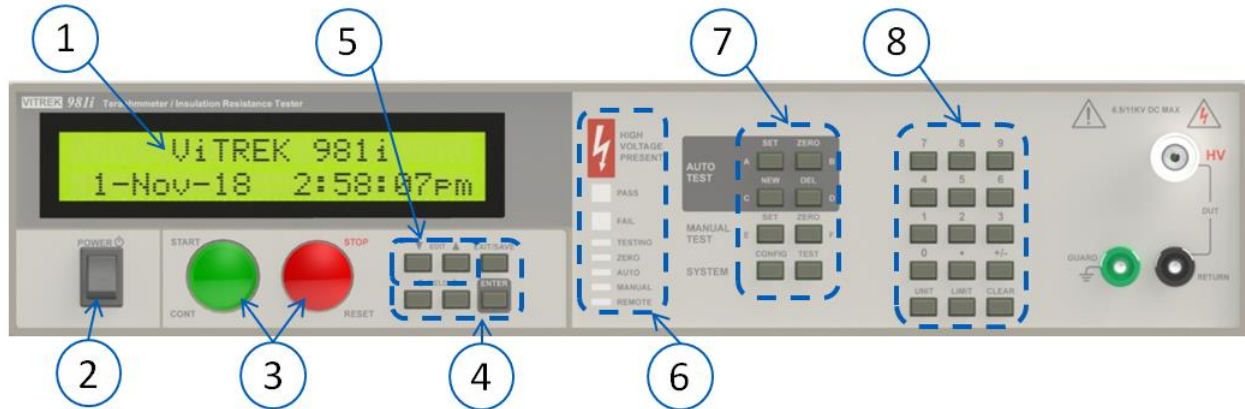
Option RM-1 provides the rack mount ears required for mounting in a standard 19" rack enclosure.

When installing the 981/3i into a rack enclosure it is recommended that the unit be supported through its' depth. The use of a tray or angle brackets supporting the bottom edges of the unit is recommended.

## SECTION 4 – GENERAL FRONT PANEL OPERATION

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

### FRONT PANEL



1. The display. This shows all menus during interactive data entries, all measurements during a test, and the present date/time when not performing any other duties.
2. The **POWER** switch. This turns on/off the power to the 981/3i.
3. The **START** and **STOP** buttons.
  - a. The **START** button –
    - i. Allows the user to start performing a previous selected AUTO or MANUAL TEST.
    - ii. Allows the user to continue a test step when it is waiting for the user to do so while running an AUTO TEST PAUSE step.
    - iii. Allows the user to terminate a MANUAL TEST.
    - iv. Allows the user to continue a SELF TEST, CAL VERIFY or CAL ADJUST activity when prompted to do so.
  - b. The **STOP** button –
    - i. Allows the user to abort performing a previous selected AUTO TEST or to stop performing a MANUAL TEST.
    - ii. Allows the user to abort a menu activity in progress discarding any changes made.
    - iii. Allows the user to select that neither AUTO TEST or MANUAL TEST is selected.
4. The menu selection keys. During all menus, the selected element of the menu is highlighted by flashing between the data and blocks. These keys allow the user to move the selection point within a menu.
  - a. The Left and Right Arrow keys are used to move the selection point within a menu.
  - b. The **ENTER** key is used to finish entry of a menu data and automatically move to the next menu item.
  - c. The **EXIT/SAVE** key is used to save all changes made within a menu and return to the previous menu (if any) or to the inactive display.



5. The edit keys. These allow the user to decrement or increment a selected menu items' value. During numeric entry these initiate "edit" mode of data entry, rather than "direct" mode of data entry (i.e. allow the user to adjust the existing entry using the Up/Down Arrow keys, rather than overwriting the existing value with a new value using the numeric keys). For convenience, these keys auto-repeat if the user maintains pressure on them.
6. The indicators.
  - a. **HIGH VOLTAGE PRESENT.** This is illuminated whenever the 981/3i has a high voltage (>30V) present on its' terminals.
  - b. **PASS.** This is illuminated whenever an AUTO TEST or MANUAL TEST is passing, or it has passed when terminated.
  - c. **FAIL.** This is illuminated whenever an AUTO TEST or MANUAL TEST is failing, or it has failed when terminated.
  - d. **TESTING.** This is illuminated when the 981/3i is running an AUTO TEST or MANUAL TEST.
  - e. **ZERO.** This is illuminated when the 981/3i is running, or has been selected to run, an AUTO TEST in ZERO mode.
  - f. **AUTO.** This is illuminated when the 981/3i is running, or has been selected to run, an AUTO TEST.
  - g. **MANUAL.** This is illuminated when the 981/3i is running, or has been selected to run, a MANUAL TEST.
  - h. **REMOTE.** This is illuminated when the 981/3i is under the control of an interface (i.e. RS232, Ethernet or GPIB). If the user wishes to return to front panel control of the 981/3i the **CONFIG** key should be pressed to achieve this.
7. The menu keys. These initiate a menu allowing the user to perform certain activities via the front panel of the 981/3i. Many of these can be disabled by the user by requiring a password in order to utilize them.
  - a. **AUTO TEST** Group-
    - i. **SET.** Allows the user to select and edit an existing AUTO TEST sequence. This never requires a password. After selecting and editing (if desired) an existing AUTO TEST sequence the 981/3i is set to be ready to run it in normal mode.
    - ii. **ZERO.** Allows the user to select and edit an existing AUTO TEST sequence. This never requires a password. After selecting and editing (if desired) an existing AUTO TEST sequence the 981/3i is set to be ready to run it in ZERO mode.
    - iii. **NEW.** Initiates a menu allowing the user to select a presently undefined AUTO TEST sequence number, optionally name it, and then to create the sequence of tests to be performed. This optionally requires a password.
    - iv. **DEL.** Initiates a menu allowing the user to select an existing test sequence and delete it from the 981/3i. This optionally requires a password. While editing or creating a test sequence, this key is also used to delete a test step from the test sequence.
  - b. **MANUAL TEST** Group-
    - i. **SET.** Allows the user to select the MANUAL TEST mode and to configure the test voltage and test parameters for it.

- ii. **ZERO.** Allows the user to set the zero offset for the MANUAL TEST presently being performed to the present current measurement.
  - c. **SYSTEM** Group-
    - i. **CONFIG.** Initiates a menu allowing the user to configure the 981/3i. This optionally requires a password. This uses a series of sub-menus –
      1. **AUTO TEST.** Allows the user to configure settings common to all steps in an AUTO TEST.
      2. **SYSTEM.** Allows the user to configure settings for general operation of the 981/3i.
      3. **INTERFACES.** Allows the user to configure settings for the interfaces in the 981/3i other than digital I/O.
      4. **DIGITAL I/O.** Allows the user to configure settings for the digital I/O interface.
      5. **BUILD.** Allows the user to view the physical configuration of this specific 981/3i.
      6. **SET TO DEFAULTS.** Allows the user to return all configurations settings to their respective factory settings (AUTO TEST sequence contents are unaffected by this).
      7. **LOCK PASSWORD.** Allows the user to set a lock password to prevent users from reconfiguring the 981/3i.
      8. **RELOCK.** Allows the user to relock a 981/3i which has previously been unlocked.
    - ii. **TEST.** Initiates a menu allowing the user to select to perform-
      1. **SELF TEST.** Performs a series of internal tests to ensure that the 981/3i is functioning normally (requires that all HV and RETURN terminal cables be removed). This never requires a password.
      2. **CAL VERIFY.** Performs a prompted series of tests which, with external calibration devices, allows the user to verify the accuracy of the 981/3i. This never requires a password.
      3. **CAL ADJUST.** Performs a prompted series of tests which, with external calibration devices, allows the user to adjust the calibration of the 981/3i. This always requires a password.
8. The data entry keys.
- a. The numeric keys (**0** through **9**), decimal point and change sign keys. These are used during numeric or character data entry. NOTE – during hexadecimal or character data entry, certain of the menu keys can be used for entry of the A through F characters as marked adjacent to those keys.
  - b. The **UNIT** key. This is used to change the units during numeric data entry, and is also used while running a test, or while reviewing test results, to change the displayed test result measurement.
  - c. The **LIMIT** key. This is used during numeric data entry to set a value to the largest possible. When setting a resistance type upper limit, this allows the user to set that there is no upper limit.

- d. **CLEAR** key. This is used to clear an entry during numeric or character data entry.
9. The terminals.
- a. The **HV** terminal. This provides the high voltage to the DUT being measured, it should be wired to one end of the DUT.
  - b. The **RETURN** terminal. This should usually be wired to the opposite end of the DUT to that which the HV terminal is wired. If option HSS-2 is installed and the user has selected for the measurement of a grounded DUT then this terminal should not be used.
  - c. The **GUARD** terminal. This may be used to guard the RETURN wire against leakage current, in some cases the DUT may have a guard terminal in which case this should also be wired to that terminal. If option HSS-2 is installed and the user has selected for the measurement of a grounded DUT then this terminal should not be used. **CAUTION** – this terminal is connected to the 981/3i chassis ground, external voltages must not be applied to this terminal, this terminal should not be used as a safety ground.

## ADJUSTING THE DISPLAY CONTRAST

The user can adjust the display contrast while the 981/3i is in the base menu state (i.e. the display shows the model number and the time/date). An example display when the user can adjust the display contrast is –

```
ViTREK 981i
9-Feb-18 9:08:51am
```

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

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

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

## MENU OPERATION AND DATA ENTRY

Most user activities using the front panel controls are performed using menus. All menus use the same general operating methods described in this section. The user should read this section before attempting to operate the 981/3i.

### BASE MENU STATE

When the 981/3i is not performing a menu and is not selected to perform, or is not performing, either a MANUAL or AUTO TEST, the display shows the model # in the uppermost display line and the date and time in the lower most display line, this is called the base menu state in this document. Most menus require the 981/3i to be in the base menu state to be initiated, an example of the base menu state display is -

```
ViTREK 981i
9-Feb-18 9:08:51am
```

If the 981/3i is not in this state and the user is unsure how to return to this state, then pressing the **STOP** button will accomplish this (in some circumstances the **STOP** button may need to be pressed more than once).

### NAVIGATING MENUS

- The present selection point in a menu is denoted by the displayed information flashing between the information and solid blocks.

- The user can move the selection point in a menu by using the Left and/or Right Arrow keys.
  - The Right Arrow key moves the selection point further down the menu. Moving the selection point past the last selectable item in a menu selects the first selectable item in the menu (a double beep sound is made when this occurs).
  - The Left Arrow key moves the selection point further up the menu. Moving the selection point before the first selectable item in a menu selects the last selectable item in the menu (a double beep sound is made when this occurs).
- Although the 981/3i display is limited to two lines, most menus have more lines than this. The display is automatically scrolled up and down the menu to display the menu line containing the present selection point.
- Not all menus or menu lines may be available.
  - Generally, items which are not pertinent to the specific model or option content of the 981/3i are not shown.
  - All menus in the 981/3i utilize a “top down” priority. Selections or entries made may affect subsequent entries in the menu. Entries may be limited in allowable values or may not be shown.
- If a menu line is an entry into a sub-menu, then the left side of the line shows descriptive text followed by an ellipsis character (...). The descriptive text is selectable. If the user presses the **ENTER** key while a sub-menu entry line is selected, then the sub-menu is opened.
  - When a sub-menu is terminated by pressing the **EXIT** key then the user is returned to the preceding level of menu.
  - If any level of sub-menu is terminated using the **STOP** button, then all levels of menus are aborted, and any changes made at any level are discarded.
  - Only when the base level menu is terminated by pressing the **EXIT** key are any changes made saved.
- If a menu line is for informative purposes only, then the left side of the line shows descriptive text followed by a colon character with the informative data at the right end of the line. The descriptive text is selectable.
- If a menu line allows the user to edit its’ contents, then the left side of the line shows descriptive text followed by a colon character with the editable data at the right end of the line. The editable data is selectable; some menu lines may contain more than one editable data.

---

#### MODIFYING MENU ENTRIES

- In many places the available contents of entries in different menu lines are inter-related. The 981/3i uses a “top down” menu approach; the topmost contents in a menu may limit the available entries in the menu below them, but not vice versa. Generally, the user cannot set a limit or an output which the specific model and option content of the 981/3i is not capable of achieving.
- **Changing Numeric Data.** After making the desired numeric data the selection point in the menu, the user can overwrite that data by using the data entry keys. While overwriting, the selection point becomes a single character position within the numeric data.
  - A numeric key places the corresponding character and moves the selection point to the right one position.

- Certain numeric data allow the user to change the units of the data (e.g. between current and resistance) and/or change the multiplier for the data (e.g. enter data in microamps or milliamps). To change the units, press the **UNIT** key while the entire numeric data is selected but not being entered; to change the multiplier, press the **UNIT** key while entering the numeric data.
- The Left Arrow key acts as a delete key, deleting the previously entered character.
- The **CLR** key removes all of the existing entry and places the selection point in the rightmost character position.
- The **LIMIT** key sets the numeric data to the highest possible value in most cases; while entering the lower limit in a range pair of data the **LIMIT** key sets the minimum value; in some other cases the **LIMIT** key has a special use denoted in the description for that specific data.
- The Right Arrow or **ENTER** key terminates the numerical data entry and moves the selection point to the right or downwards, as applicable.
- **Changing Multiple-Choice Data.** After making the multiple-choice data the selection point in the menu, the user can change the selection by repeatedly pressing the Up Arrow or Down Arrow keys until the desired selection is displayed. The **ENTER** key terminates the multiple-choice data entry and moves the selection point to the right or downwards, as applicable. The Left Arrow and Right Arrow keys automatically terminate the multiple-choice data entry prior to moving the selection point accordingly.
- **Changing Character Data.** After making the character data the selection point in the menu, the user can choose to either edit the existing data, or to overwrite it with new data. While overwriting or editing the data the selection point becomes a single character position within the character data.
  - **Editing Existing Character Data.** If the user presses the Up Arrow or Down Arrow key while the entire character data is selected, then the edit mode of entry is initiated, and the leftmost character of the existing data is selected. Character data uses a limited character set; A through Z, a through z, 0 through 9, the space character and most punctuation characters.
    - The Up Arrow and Down Arrow keys change the selected character to the next or previous available character in the character set.
    - The numeric keys and the **A** through **F** keys overwrite the selected character.
    - The Left Arrow and Right Arrow keys move the selection point within the character data area.
    - The **CLR** key aborts the edit, the character data is cleared, and the overwrite mode is initiated.
    - The **ENTER** key exits the edit mode retaining the changes made.
  - **Overwriting Character Data.** If the user presses any of the numeric keys or the **CLR** key then the overwrite mode of entry is initiated, starting with the corresponding character and with the leftmost character.
    - The Up Arrow and Down Arrow keys change the selected character to the next or previous available character in the character set.
    - The numeric keys and the **A** through **F** keys places the corresponding character and moves the selection point to the right one position.
    - The Left Arrow key acts as a delete key, deleting the previous character and moving the selection point to the left one position.

- The Right Arrow key places a space character and moves the selection point to the right one position.
  - The **CLR** key removes all the existing entry and places the selection point in the leftmost character position.
  - The **ENTER** key terminates the character data entry retaining the changes made and moves the selection point in the menu to the right or downwards, as applicable.
- **Changing Hexadecimal Data.** Hexadecimal data is treated the same as character data (see above) but with the available character set restricted to 0 through 9 and A through F.

## LOCKING AND UNLOCKING MENUS

Many menus in the 981/3i can be locked by a user, preventing unauthorized changes to test sequences and configuration settings via the front panel. When initially delivered from the factory, this capability is disabled.

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

If a menu lock password has been set, the 981/3i always powers up with the menus locked.

### UNLOCKING MENU

If the menu lock password has been set, a user must enter this password to unlock a menu. The user is prompted to enter the password when needed; which is accomplished by using the **0** through **9** and **A** through **F** keys as needed to match the previously set password, followed by the **ENTER** key. After successfully entering the password the front panel menus remains unlocked until the menus are relocked by the user or the 981/3i is power cycled. Note that the display does not show the characters during unlock password entry for security reasons.

### SETTING, CHANGING OR CLEARING A MENU LOCK PASSWORD

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key. If a password has been already set and the menus are not already unlocked, the user must enter the correct password to unlock the menu at this point.
- The display now shows the main configuration menu. An example of which is as follows –  
AUTO TEST...  
SYSTEM...  
INTERFACES...  
DIGITAL I/O...  
BUILD...  
SET TO DEFAULTS...  
LOCK PASSWORD: 000000  
RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the LOCK PASSWORD line.
- Using the **0** through **9** keys and/or the **A** through **F** keys, enter a six character password. If the password 000000 is set then this clears the password and disables menu locking.
- Press the **ENTER** key.

- If a non-zero password was entered, the display now shows a message indicating that the front panel is now locked and returns to the base menu state. Otherwise, a message is displayed indicating that the menu lock is now disabled and the 981/3i stays in the main configuration menu.

---

#### RELOCKING MENUS

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

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu. An example of which is as follows –  
AUTO TEST...  
SYSTEM...  
INTERFACES...  
DIGITAL I/O...  
BUILD...  
SET TO DEFAULTS...  
LOCK PASSWORD: 000000  
RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the RELOCK line.
- Press the **ENTER** key.
- The display now shows a message indicating that the front panel is now locked and returns to the base menu state.

---

#### UNKNOWN MENU LOCK PASSWORD

If the 981/3i menus have been locked but the password is unknown, the user should contact Vitrek for assistance. The 981/3i has an internal set of “one-time use” passwords for this circumstance.

### SYSTEM AUTO-TEST CONFIGURATION SETTINGS

These settings allow the user to select the beeper sounds during auto-test and whether the STOP button is required to be pressed to repeat an auto-test.

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
AUTO TEST...  
SYSTEM...  
INTERFACES...  
DIGITAL I/O...  
BUILD...  
SET TO DEFAULTS...  
LOCK PASSWORD: 000000  
RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the AUTO TEST line.
- Press the **ENTER** key.

- The display now shows the AUTO-TEST configuration menu, an example of which is –
  - START BEEP: MED
  - PASS BEEP: MED
  - FAIL BEEPS: LOUD
  - FAST RERUN: ENABLED
- The user may navigate this sub-menu and change the displayed settings as required.
  - **START BEEP.** This allows the user to set the volume of the beep sound emitted by the 981/3i when a test sequence is started.
  - **PASS BEEP.** This allows the user to set the volume of the beep sound emitted by the 981/3i when a test sequence is completed with a PASS status.
  - **FAIL BEEP.** This allows the user to set the volume of the beep sounds emitted by the 981/3i when a test sequence is completed with a FAIL status.
  - **FAST RERUN.** This allows the 981/3i to always allow the user to rerun a test sequence without having to terminate reviewing the results (ENABLED), or only allow it if all tests passed (IF PASS), or never allow it (DISABLED). If fast rerun is not enabled, the user must terminate reviewing results by using the **STOP** button before they can rerun the test sequence with the **START** button.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

## SYSTEM CONFIGURATION SETTINGS

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

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –
  - AUTO TEST...
  - SYSTEM...
  - INTERFACES...
  - DIGITAL I/O...
  - BUILD...
  - SET TO DEFAULTS...
  - LOCK PASSWORD: 000000
  - RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the SYSTEM line.
- Press the **ENTER** key.
- The 981/3i now displays the system configuration settings menu, an example of which is –
  - KEY BEEPS: SOFT
  - TIME FORMAT: 12hr
  - SET TIME: 9:18:06am
  - SET DATE: 9-Feb-10
- The user may navigate this sub-menu and change the displayed settings as required.
  - **KEY BEEPS.** This allows the user to set the volume of the beep sounds made by the 981/3i whenever a key is pressed.



- **TIME FORMAT.** This allows the user to select whether the 981/3i displays time in 12hour or 24hour format.
- **SET TIME.** This allows the user to adjust the presently displayed time. The hour, minute and second are separately adjusted using the Up and Down Arrow keys.
- **SET DATE.** This allows the user to adjust the presently displayed date. The day, month and year are separately adjusted using the Up and Down Arrow keys.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

## INTERFACE CONFIGURATION SETTINGS

There are several interface configuration settings available. These can be viewed or set as follows –

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
 AUTO TEST...  
 SYSTEM...  
 INTERFACES...  
 DIGITAL I/O...  
 BUILD...  
 SET TO DEFAULTS...  
 LOCK PASSWORD:000000  
 RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.
- The 981/3i now displays the base interfaces configuration settings menu, an example of which is –  
 RS232 BAUD: 115200  
 SWITCH: NONE  
 DISABLE GPIB: NO  
 DISABLE ENET: NO  
 ETHERNET...  
 GPIB ADDR: 2
- The user may navigate this sub-menu and change the displayed settings as required. The settings are -
  - **RS232 BAUD.** This setting should match the baud rate setting in the attached device/computer.
  - **SWITCH.** This allows the user to select the method by external switch matrix unit(s) are interfaced to the 981/3i, if any. The available selections are –
    - **NONE.** No ViTREK 964i or 948i switch matrix units are controlled by the 981/3i.
    - **948 (SERIAL).** A single ViTREK 948i Switch Matrix unit is being controlled by the 981/3i via the RS232 serial interface. The RS232 BAUD setting is ignored if this is selected.
    - **964 (SERIAL).** A single ViTREK 964i Switch Matrix unit is being controlled by the 981/3i via the RS232 serial interface.
    - **964 (VICLx1).** A single ViTREK 964i Switch Matrix unit is being controlled by the 981/3i via the VICL interface. The 964i must be configured for VICL and set to address 1.

- **964 (VICLx2).** Two ViTREK 964i Switch Matrix units are being controlled by the 981/3i via the VICL interface. All 964i's must be configured for VICL and set to addresses 1 and 2.
    - **964 (VICLx3).** Three ViTREK 964i Switch Matrix units are being controlled by the 981/3i via the VICL interface. All 964i's must be configured for VICL and set to addresses 1, 2 and 3.
    - **964 (VICLx4).** Four ViTREK 964i Switch Matrix units are being controlled by the 981/3i via the VICL interface. All 964i's must be configured for VICL and set to addresses 1, 2, 3 and 4.
  - **DISABLE GPIB.** This is only present if the 981/3i has the GPIB interface installed. This allows the user to disable the GPIB interface, preventing interference on an unused GPIB interface from affecting other interface operation.
  - **DISABLE ENET.** This allows the user to disable the ENET interface, preventing interference on an unused ENET interface from affecting other interface operation.
  - **ETHERNET.** If selected then this initiates a sub-menu allowing the user to configure the ethernet interface (see below for details).
  - **GPIB ADDR.** This allows the user to set the GPIB address of the 981/3i. This should be set to an address which is not presently set on any other equipment attached to the GPIB.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. NOTE – the settings are not active until all menus have been exited.

---

#### CONFIGURING THE ETHERNET INTERFACE

As shown above, the user may initiate a sub-menu which allows the configuration of the Ethernet interface.

- The Ethernet sub-menu allows the user to configure the 981/3i for the local network. An example of this sub-menu is as follows –
 

```

USE DHCP:      YES
IP:  000.000.000.000
SNET:000.000.000.000
GTWY:000.000.000.000
MAC:   1234567890AB
      
```
- The user may navigate this sub-menu and change the displayed settings as required. The settings are –
  - **USE DHCP.** Allows the user to configure the 981/3i to use DHCP for IP address allocation (YES) or not (NO).
  - **IP.** If using DHCP, this shows the IP address which the 981/3i has been allocated. If not using DHCP this allows the user to enter an IP address for the 981/3i on the local network.
  - **SNET.** If using DHCP, this shows the IP subnet mask which the 981/3i has been given. If not using DHCP this allows the user to enter the subnet mask for the local network.
  - **GTWY.** If using DHCP, this shows the IP of the gateway to additional networks which the 981/3i has been given. If not using DHCP this allows the user to enter the IP address of the gateway.
  - **MAC.** This is not editable and shows the MAC address of the 981/3i. This may be needed by the users' IT department to configure the local network to allow connection of the 981/3i to it. In most networks this is not needed.

- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. NOTE – the settings are not active until all menus have been exited.
- If using DHCP the user should re-enter the ETHERNET configuration sub-menu and note the IP address allocated to the 981/3i. This will be needed to configure the TCP/IP client software used to communicate with the 981/3i.

## DIGITAL I/O CONFIGURATION SETTINGS

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

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
AUTO TEST...  
SYSTEM...  
INTERFACES...  
DIGITAL I/O...  
BUILD...  
SET TO DEFAULTS...  
LOCK PASSWORD: 000000  
RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the DIGITAL I/O line.
- Press the **ENTER** key.
- The display now shows the Digital I/O configuration menu. An example of the Digital I/O configuration menu is as follows –  
START:            IGNORE  
ABORT:           IGNORE  
INTERLOCK:      IGNORE  
PASS:            ACTIVE LO  
FAIL:            ACTIVE LO  
TESTING:        ACTIVE HI  
DWELL:           ACTIVE HI  
HV:              ACTIVE HI
- The user may navigate this sub-menu and change the displayed settings as required.
  - **START, ABORT, INTERLOCK.** These allow the user to select whether the respective digital input is to be ignored, active low or active high.
    - If either the INTERLOCK signal is enabled and set for active low, or the ABORT signal is enabled and set for active high, then the 981/3i will be prevented from running any test sequence if the DIO signals are removed (e.g. the cable is unplugged). If this is not intended, then these signals should be used with the opposite polarity (i.e. active high for INTERLOCK and active low for ABORT).
    - CAUTION – changing the active level of the START signal may cause the 981/3i to detect a change in the START signal from the inactive to the active state (e.g. if the signal is high and the configuration is changed from active low to active high). This may cause a

previously selected sequence to be run and high voltages to become present on the 981/3i terminals. The user should ensure that no sequence is selected and that the START signal will end up being in the inactive state when changing the polarity of the START signal.

- **PASS, FAIL, TESTING, DWELL** and **HV**. These allow the user to select whether the respective digital output is to be active low or active high.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. The settings are not used until they are saved.

## DISPLAYING BUILD INFORMATION

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
 AUTO TEST...  
 SYSTEM...  
 INTERFACES...  
 DIGITAL I/O...  
 BUILD...  
 SET TO DEFAULTS...  
 LOCK PASSWORD : 000000  
 RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the BUILD line.
- Press the **ENTER** key.
- The 981/3i now displays the build configuration menu, an example of which is –  
 SERIAL#           123456  
 FIRMWARE:        v1.12  
     FP:            v1.10  
     MEAS:         v1.10  
     DRIVE:        v1.10  
 BASE UNIT:        981i  
 HSS OPTION:      NO  
 MAX DC:          6.5KV  
 INTERFACE:       GUL-3
- The user may navigate this menu but may not make changes to it. The information available is as follows-
  - **SERIAL#**. This shows the serial number of this 981/3i.
  - **FIRMWARE**. This shows the main firmware revision number installed in this 981/3i. This can be upgraded (along with the MEAS and DRIVE firmware) by the user via the RS232, Ethernet or GPIB interface. Contact Vitrek or your local representative for details regarding this.
  - **FP**. This shows the front panel firmware revision number.
  - **MEAS**. This shows the Measurement DSP firmware revision number installed in this 981/3i.
  - **DRIVE**. This shows the Output Drive DSP firmware revision number installed in this 981/3i.
  - **BASE UNIT**. This shows the base model number of this 981/3i.

- **HSS OPTION.** This shows if option HSS-2 is installed in this 981/3i.
- **INTERFACE.** This shows if option UL-2 or GUL-3 is installed in this 981/3i.
- **MAX DC.** This shows the factory limit on the maximum DC Voltage generated by this unit.
- When finished reviewing the build information, press the **EXIT** key to return to the main configuration menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu.

## RETURNING ALL CONFIGURATION SETTINGS TO FACTORY DEFAULTS

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

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
AUTO TEST...  
SYSTEM...  
INTERFACES...  
DIGITAL I/O...  
BUILD...  
SET TO DEFAULTS...  
LOCK PASSWORD: 000000  
RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the SET TO DEFAULTS line.
- Press the **ENTER** key.
- The 981/3i now displays a message temporarily and remains in the main configuration menu, allowing the user to override the factory settings as needed. If no further changes are needed, press the **EXIT** key to save the changes and return to the base menu state.
- NOTE – this also resets the MANUAL TEST configuration to defaults but does not affect any configured AUTO TEST sequences.

## SECTION 5 – PERFORMING TESTS

Although this section is primarily written for the front panel user, however when programming the 981/3i via an interface the user should also be conversant with the contents of this section.

The 981/3i can perform tests in one of three modes –

- **MANUAL TEST.** In this mode the 981/3i applies the configured test voltage to the DUT and measures the leakage resistance/current once the test voltage has settled, i.e. the charging time has expired. The charging time is configurable. While testing, the user can change the applied test voltage by using the UP, DOWN, LEFT and RIGHT arrow keys to adjust the voltage in steps of 1, 10 or 100V in either direction. The measured resistance or current is compared against the configured limits and a pass or >max or <min result is indicated as appropriate. When finished, the user must press either the START or STOP switch, at which time the DUT is discharged and the test is terminated. The settings for the MANUAL TEST are non-volatile, i.e. they remain as configured after a power cycle.
- **AUTO TEST.** In this mode the user can configure for a series of test steps to be sequentially performed, each of which is automatically timed. Each AUTO TEST sequence can have a user set name associated with it. Up to 99 such sequences can be stored in the unit (numbered 1 through 99 inclusive), each of which can contain up to 254 test steps (numbered 1 through 254 inclusive) but limited to a total of 1000 test steps in all AUTO TEST sequences. The settings for each AUTO TEST sequence are non-volatile, i.e. they remain as configured after a power cycle. Each test step can be one of the following-
  - **DCIR.** An automatically timed leakage resistance or current test performed at the configured voltage level for each step. The leakage resistance or current is checked against limits for each step and the step or sequence is aborted if failed as configured. If the following step is also a DCIR step, then the DUT is not discharged between steps.
  - **SWITCH.** This is only available if the unit has been configured to control an external Vitrek 964 unit. This commands up to 4 external 964 units to set their switches to the configured pattern. If the 981/3i is not configured to control external 964 units then this step is automatically skipped if it had been previously defined in a sequence.
  - **PAUSE.** This performs a fixed time delay before continuing to the next step.
  - **HOLD.** This forces the 981/3i to hold until the START switch is pressed. A timeout is provided.
- **INTERFACE TEST.** This mode is very similar to the AUTO TEST mode, with the following exceptions –
  - There is only one INTERFACE TEST sequence.
  - The INTERFACE TEST sequence can have up to 999 steps.
  - The INTERFACE TEST sequence does not have a name associated with it.
  - The INTERFACE TEST sequence is only selectable and may only be defined, via an interface. It can be run from the front panel once defined and selected via an interface however.
  - The INTERFACE TEST sequence settings are volatile, i.e. they do not persist following a power cycle.
  - Throughout the remainder of this section, all references to using AUTO TEST also apply to using INTERFACE TEST.

## MANUAL TEST

### CONNECTING THE DUT

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

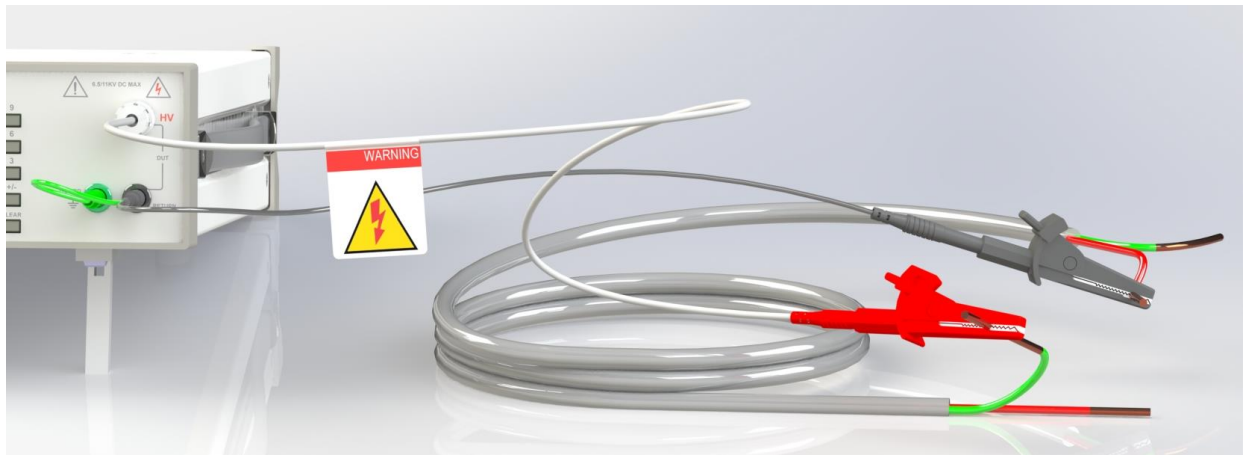
The 981/3i requires that the DUT (at least that portion which is being measured) is isolated from ground unless option HSS-2 is fitted and the DUT GROUNDED setting is set to YES.

### CONNECTING TO AN UNGROUNDED DUT (WITHOUT OPTION HSS-2, OR WITH DUT GROUNDED SET TO NO)

The DUT should be wired between the **HV** and **RETURN** terminals of the 981/3i.

The 981/3i provides a safety ground for the DUT during the test via its' **RETURN** terminal. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RETURN** terminal, the user should consider that only the voltage on the **RETURN** terminal is safe at all times.

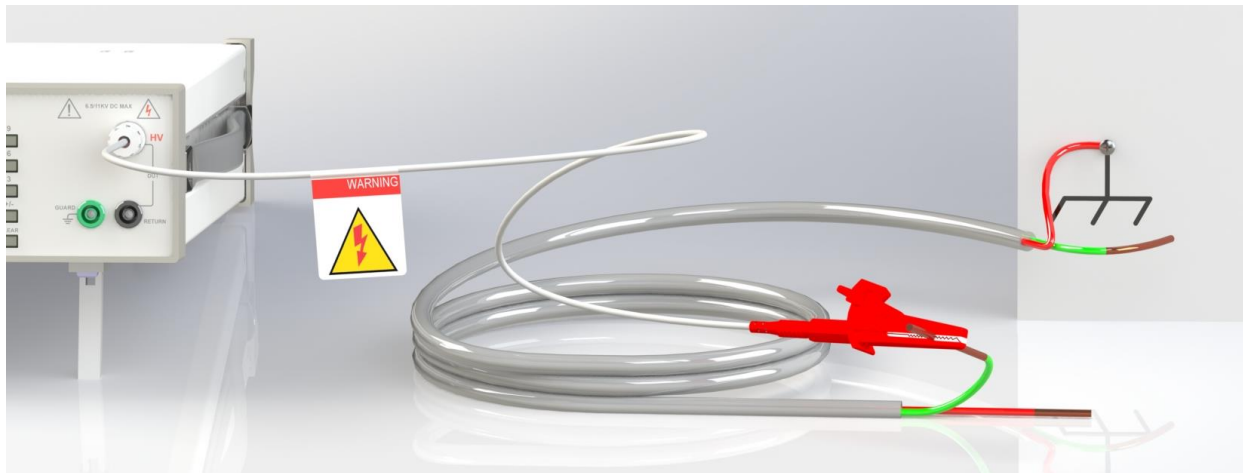
For best high impedance load performance there should be low leakage between the wires there should be little interference pickup in the **RETURN** wire. In many circumstances the **RETURN** wire should be the inner wire of a coaxial cable, with the shield connected to the **GUARD** terminal of the 981/3i. This will significantly reduce the capacitance and leakage between the **HV** and **RETURN** wires.



The example above shows the connections for performing leakage current or insulation resistance testing of one conductor of a multi-conductor cable to another conductor.

### CONNECTING TO A GROUNDED DUT (OPTION HSS-2 ONLY)

In this case the user should only connect the **HV** terminal of the 981i to the point on the DUT which is to be tested. It is expected that the DUT is grounded and that the leakage is being tested to ground.



## CONFIGURING A MANUAL TEST

A MANUAL TEST can be configured and selected to be performed as follows if the 981/3i is not presently performing a test or a configuration menu –

- Press the **MANUAL TEST** group **SET** key. The 981/3i now displays the present settings for a MANUAL TEST, an example of which is-
  - LEVEL :           1000V
  - CHARGE :        1.0sec
  - DUT GROUNDED:   YES
  - LIMIT: no min→4.000mA
  - OFFSET:           +0pA
- Using the LEFT and RIGHT arrow keys select each setting and change it as needed.
  - **LEVEL.** Sets the test voltage level. Note that this can be changed while performing the test and doing so does not change this setting.
  - **CHARGE.** Sets the time during which the DUT is charged. Times between 1 and 9999 seconds may be entered. The DUT will be linearly charged to the configured test voltage in this time; the user should ensure that the charging current is significantly less than 4mA when driving a capacitive load. Note that the 4mA limit is the only limit on supplied current during the charge period.
  - **DUT GROUNDED.** This is only present when a 981 has option HSS-2 installed. This allows the user to select whether the DUT is grounded (**YES**) or not (**NO**). If set for a grounded DUT then only the HV terminal is used and the DUT current is measured in that terminal, otherwise the HV and RETURN terminals (and optionally the GUARD terminal) are used and the DUT current is measured in the RETURN terminal.
  - **LIMIT.** The user may set minimum and/or maximum limits as either leakage current or insulation resistance. These limits are only applied after charging and only control the display of the pass/fail information. The UNIT key alternates between leakage current or insulation resistance, the actual values being automatically translated between them. While entering either value the UNIT key can be used to change between the available multipliers for that value (e.g. p, n,  $\mu$  or m for the A unit).
    - **Insulation Resistance.** The user can enter a minimum value and (optionally) a maximum value. If the maximum value is selected, pressing the LIMIT key selects the “no max” value – which configures the 981/3i to ignore the maximum value and only test for a minimum value. The minimum value cannot be set below a value which would result in a current of over 4mA at the configured test voltage.
    - **Leakage Current.** The user can enter a maximum value and (optionally) a minimum value. If the minimum value is selected, pressing the LIMIT key selects the “no min” value (as does entering a zero value) – which configures the 981/3i to ignore the minimum value and only test for a maximum value. The maximum value cannot be set above 4mA; the minimum current cannot be set at or below a value of 0pA. Note that for a leakage current minimum limit with a non-zero value the polarity of the measured



leakage current is taken into consideration, so for example a measurement of -10pA would be below a minimum setting of 1pA.

- **OFFSET.** The user may enter a value which will be subtracted from all current measurements, and the insulation resistance is that calculated after this current offset subtraction. Note that this can be set to the actual measured leakage current during a manual test by pressing the MANUAL – ZERO key during a test.

When the configuration is completed the user should press the EXIT/SAVE key, which will cause the configured settings to be saved internally (non-volatile) and the 981/3i made ready to perform MANUAL tests, with the MANUAL LED illuminated and the display showing (for example) –

```
MANUAL  READY
9-Feb-18  9:08:51am
```

---

#### PERFORMING A MANUAL TEST

For MANUAL TEST the user can configure for a single insulation resistance/leakage current test to be performed over a manually controlled period, which can extend for as short as a second to as long as several years. The user can change the applied test voltage during the test.

---

#### STARTING A MANUAL TEST

After connecting the DUT to be measured and configuring the MANUAL TEST (in either order) and with the 981/3i ready to perform a MANUAL TEST as indicated by the 981/3i illuminating the MANUAL LED and displaying (for example) –

```
MANUAL  READY
9-Feb-18  9:08:51am
```

Press the START button to initiate charging and testing of the DUT.

The TESTING LED is illuminated while performing a MANUAL TEST.

While charging the DUT the 981/3i indicates this by displaying, for example –

```
MANUAL  1000V  chrg
1.3s           +5nA
```

The elapsed charging time and the measured current or impedance is displayed in the lower line during charging.

After the DUT charging period has elapsed then the display changes to, for example –

```
MANUAL  1000V
1.3s  pass      +5nA
```

The elapsed testing time and the measured current or impedance is displayed in the lower line while testing. A “pass” or “>max” or “<min” indicates if the measured value is within the limits, above the maximum limit, or below the minimum limit respectively (translated as needed between insulation resistance and leakage current) and either the PASS or FAIL LED is illuminated as appropriate.

Note -

- At any time during the test the user can toggle between displaying the leakage current and the insulation resistance by pressing the UNIT key.
- The comparison of the measured value to the configured limits is independent of the measurement selected for viewing.
- While displaying the insulation resistance, if the measured value is above the value which can be reliably measured by the 981/3i under the actual voltage and loading conditions present then it is displayed as a

greater than character (“>”) followed by a value (for example “>20GΩ”). This indicates that the actual insulation resistance is at least the value shown, and probably much higher.

- If the leakage current is measured as negative then this is always taken as the maximum possible insulation resistance.
- The maximum possible insulation resistance is automatically varied accordingly for the present applied voltage and capacitive loading.
- The resolution displayed for either leakage current or insulation resistance is automatically varied accordingly for the present applied voltage, leakage current, and capacitive loading.

#### CHANGING THE APPLIED VOLTAGE

After the charging time has elapsed while performing a MANUAL TEST the user can modify the applied voltage as follows –

- Press either the UP or DOWN arrow key to initiate modification of the applied voltage. A digit in the voltage will alternate between the numeric value and all the pixels as a block, this indicates the decade which is being modified.
- Press the LEFT and/or RIGHT keys as needed to select the desired voltage increment decade (this can be 1, 10 or 100V).
- Press the UP or DOWN keys to increment or decrement the applied voltage by the selected voltage increment. Note that these keys auto-repeat, i.e. holding them down will automatically repeat the action.
- NOTE – the 981/3i will almost immediately change the applied voltage, if the load is heavily capacitive this may cause the load current to exceed 4mA which will abort the test. If the load is heavily capacitive then the user should not adjust the applied voltage while testing.

#### CHANGING THE ZERO OFFSET

After the charging time has elapsed the user can overwrite the configured zero leakage current offset with the presently measured value by pressing the MANUAL – ZERO key. The configured zero offset will be immediately overwritten and stored for both present and later use. Note –

- This only affects MANUAL TEST measurements.
- This is not required to enable the 981/3i to meet the published specifications; it is intended to allow the user to remove the leakage current of external wiring and fixtures.

#### STOPPING A MANUAL TEST

At any time during the test the user may press either the START or STOP buttons to stop the test. The 981/3i will immediately start discharging the DUT using a dynamically controlled discharge to achieve the fastest possible discharge of the DUT. The 981/3i automatically monitors the discharge and will not terminate the test until the voltage has dropped below 30V continuously for at least 100ms.

Once completed discharging the DUT the display shows the final result of the test, showing for example –

```
MANUAL 1000V  
1.3s PASS +5nA
```

After completion, the TESTING LED is extinguished and the PASS or FAIL LED provides an indication of the comparison of the final result against the configured limits.

The time elapsed while testing is displayed at the left end of the lower display line.

The user can toggle between displaying the leakage current and the insulation resistance by pressing the UNIT key. While displaying the insulation resistance, if the last measured value was above the value which could be reliably measured by the 981/3i under the actual voltage and loading conditions present then it is displayed as a greater than character (“>”) followed by a value (for example “>20GΩ”). This indicates that the actual insulation resistance was at least the value shown, and probably was much higher.

After a MANUAL TEST has completed and the 981/3i is displaying the previous MANUAL TEST result, the user can start another MANUAL TEST (at the configured test voltage) by pressing the START button.

If the STOP button is pressed while displaying the previous MANUAL TEST result then the display is changed to the MANUAL READY display, and then pressing the STOP button again will change the display to the base state, thus disabling the ability to start another test by pressing the START button.

## AUTO TEST

For AUTO TEST the user can configure for a series of test steps to be sequentially performed, each of which is automatically timed. Up to 99 such sequences can be stored in the unit (numbered 1 through 99 inclusive), each of which can contain up to 254 test steps (numbered 1 through 254 inclusive), but limited to a total of 1000 test steps in all sequences. The settings for each AUTO TEST sequence are non-volatile, i.e. they remain as configured after a power cycle. Each AUTO TEST sequence can have a user set name associated with it. Each test step can be one of the following-

- **DCIR.** An automatically timed leakage resistance or current test performed at the configured voltage level for each step. The leakage resistance or current is checked against limits for each step and the step or sequence is aborted if failed as configured. If the following step is also a DCIR step then the DUT is not discharged between steps.
- **SWITCH.** This is only available if the unit has been configured to control an external Vitrek 964 unit. This commands up to 4 external 964 units to set their switches to the configured pattern. If the 981/3i is not configured to control external 964 units then this step is automatically skipped if it had been previously defined in a sequence.
- **PAUSE.** This performs a fixed time delay before continuing to the next step.
- **HOLD.** This forces the 981/3i to hold until the START switch is pressed. A timeout is provided.

---

## CONNECTING THE DUT

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

The 981/3i requires that the DUT (at least that portion which is being measured) is isolated from ground unless option HSS-2 is fitted and the DUT GROUNDED setting is set to YES.

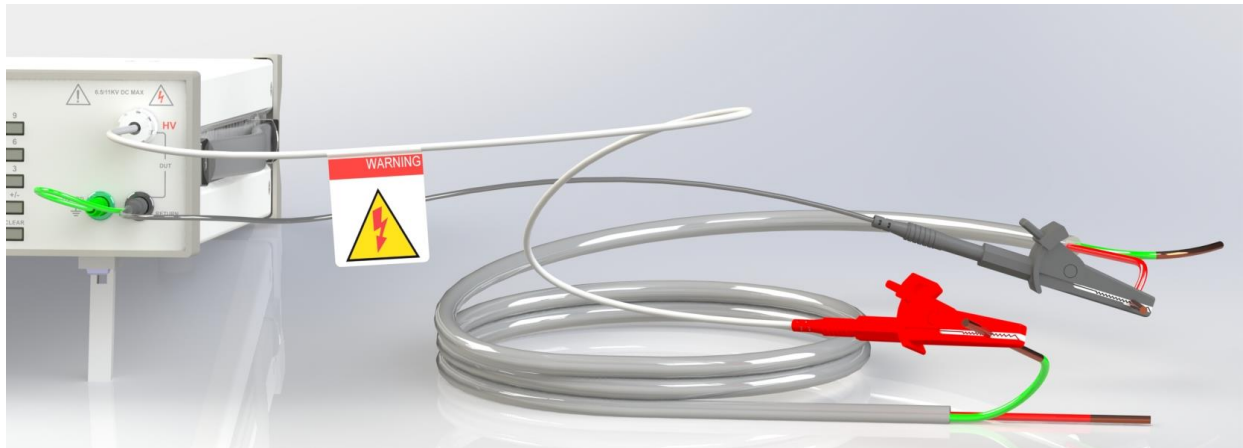
---

## CONNECTING TO A DUT WITHOUT OPTION HSS-2, OR WITH DUT GROUNDED SET TO NO

The DUT should be wired between the **HV** and **RETURN** terminals of the 981/3i.

The 981/3i provides a safety ground for the DUT during the test via its’ **RETURN** terminal. When deciding which point on the DUT to connect to the **HV** terminal and which point to connect to the **RETURN** terminal, the user should consider that only the voltage on the **RETURN** terminal is safe at all times.

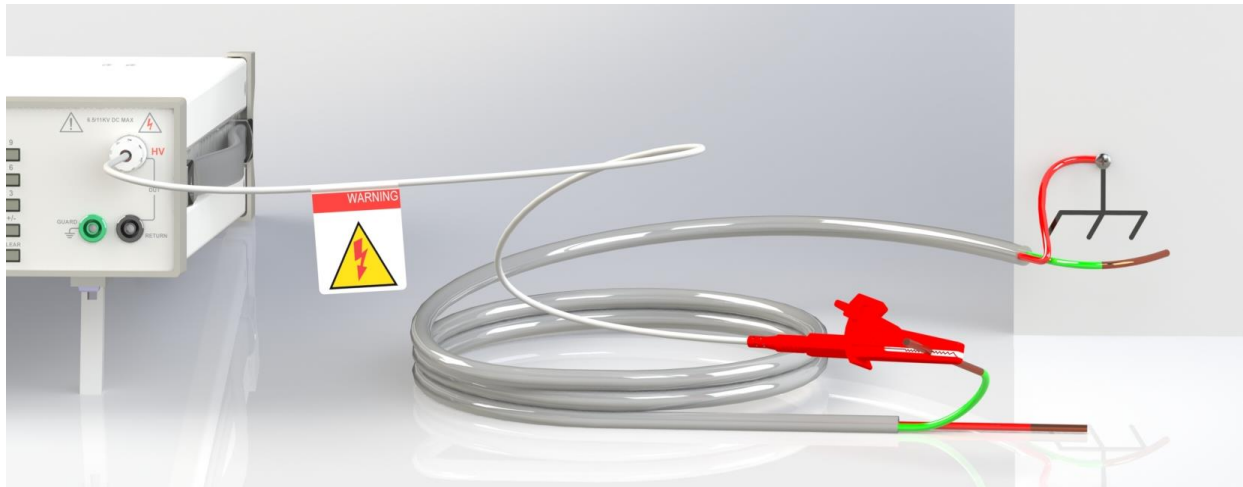
For best high impedance load performance there should be low leakage between the wires and for low level current measurements there should be little interference pickup in the **RETURN** wire. In many circumstances the **RETURN** wire should be the inner wire of a coaxial cable, with the shield connected to the **GUARD** terminal of the 981/3i. This will significantly reduce the capacitance and leakage between the **HV** and **RETURN** wires.



The example above shows the connections for performing leakage current or insulation resistance testing of one conductor of a multi-conductor cable to another conductor.

#### TESTING A GROUNDED DUT (OPTION HSS-2 ONLY)

In this case the user should only connect the **HV** terminal of the 981i to the point on the DUT which is to be tested. It is expected that the DUT is grounded and that the leakage is being tested to ground.



#### CREATING A NEW AUTO TEST SEQUENCE

A new AUTO TEST sequence can be created as follows if the 981/3i is not presently performing a test or a configuration menu –

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **AUTO TEST – NEW** key. The display now shows the lowest presently empty test sequence number and a blank name field. An example is -  
NEW TEST SEQUENCE  
# 2

- Either change the test sequence number (using the numeric keys or the Up Arrow and Down Arrow keys) or press the **ENTER** key. The display now selects the name field. The user can enter a name by pressing the Up Arrow key followed using the Up, Down, Left and Right Arrow keys to change/select each character, and the user may use the numeric keys to directly enter numeric characters.
- Press the **ENTER** key. The display now shows the first test step (step #1) which has no test type selected (NEW is displayed). An example is -  
Seq 2 Step 1        NEW
- Using the Up or Down Arrow keys, select the desired first test step type.
- Using the information for the selected test step type shown later in this document, program the requirements for this test step.
- If no more test steps are required, press the **EXIT** key. The 981/3i stores the test sequence and makes it ready to be run.
- If further steps are required, then press the Up arrow key once when the previously entered step # is selected, the next step # will be displayed with a NEW test type. Repeat as required for each test step. Note - if the user accidentally creates a NEW step at the end of the test sequence, press the **DEL** key to delete it while it is being displayed.

---

#### EDITING AN EXISTING AUTO TEST SEQUENCE

An existing AUTO TEST sequence can be edited as follows if the 981/3i is not presently performing a test or a configuration menu –

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **AUTO TEST – SET** key. The display now shows the last used AUTO TEST sequence number and its' name (if any). An example is -  
SET TEST SEQUENCE  
# 2 Example Test
- Either change the test sequence number (using the numeric keys or the Up Arrow and Down Arrow keys) or press the **ENTER** key. The display now selects the name field. The user can enter or edit the name by pressing the Up Arrow key followed using the Up, Down, Left and Right Arrow keys to change/select each character, and the user may use the numeric keys to directly enter numeric characters.
- Press the **ENTER** key. The display now shows the first test step (step #1). An example is -  
Seq 2 Step 1        DCIR
- The user can change the selected step by pressing the Up or Down arrow keys.
- Press the **ENTER** key or the Right arrow key to select the test step type. The test type can be changed by using the Up and Down arrow keys if needed. If a step is to be deleted then press the **DEL** key with that step number selected.
- Using the information for the selected test step type shown later in this document, program the requirements for this test step.
- If no more test steps are required, press the **EXIT** key. The 981/3i stores the test sequence and makes it ready to be run.

---

### SELECTING AN EXISTING AUTO TEST SEQUENCE

An existing AUTO TEST sequence can be selected and made ready to be run as follows if the 981/3i is not presently performing a test or a configuration menu –

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **AUTO TEST – SET** key. The display now shows the last used AUTO TEST sequence number and its' name (if any). An example is -  

```
SET TEST SEQUENCE
# 2 Example Test
```
- If required, change the test sequence number using the numeric keys or the Up Arrow and Down Arrow keys.
- Press the **EXIT** key. The 981/3i makes the selected AUTO TEST sequence ready to be run, the AUTO LED is illuminated, and the displays shows (for example) –

```
AUTO 1 READY
9-Feb-18 9:08:51am
```

---

### DELETING AN EXISTING AUTO TEST SEQUENCE

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

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary press the **STOP** button to abort a menu and return to the base menu state.
- Press the **DEL** key.
- The display shows the last used test sequence number and the name associated with that test sequence. An example is -  

```
DELETE TEST SEQUENCE
# 2 981/3i LINE HYPOT
```
- As needed change the test sequence number to select the desired test sequence by using the Up Arrow or Down Arrow keys (or using the numeric keys), then press the **ENTER** key. The selected test sequence is now deleted from the 981/3i internal non-volatile memory.

---

### DCIR AUTO TEST STEPS

This is an automatically timed leakage resistance or current test performed at the configured voltage level. The leakage resistance or current is checked against limits. If the following step is also a DCIR step then the DUT is not discharged between steps.

An example of an AUTO TEST DCIR test step menu and an explanation on each entry for it is shown below –

```
Seq 2 Step 1   DCIR
LEVEL:        1000V
DUT GROUNDED: NO
CHARGE:       1.0sec
DWELL:        60.0sec
DELAY:        0.0sec
END ON:       FAIL
LIMIT:10.00M→no maxΩ
OFFSET:       +0pA
ON FAIL:      CONTINUE
```

- **LEVEL.** Sets the test voltage level.
- **DUT GROUNDED.** This is only present when a 981 has option HSS-2 installed. This allows the user to select whether the DUT is grounded (**YES**) or not (**NO**). If set for a grounded DUT then only the HV terminal is used and the DUT current is measured in that terminal, otherwise the HV and RETURN terminals (and optionally the GUARD terminal) are used and the DUT current is measured in the RETURN terminal.
- **CHARGE.** Sets the time during which the DUT is charged. Times between 1 and 9999 seconds may be entered. The DUT will be linearly charged to the configured test voltage in this time; the user should ensure that the charging current is significantly less than 4mA when driving a capacitive load. The test limits are not imposed while charging.
- **DWELL.** Sets the time during which the DUT is continuously tested with the configured voltage applied. Times between 1.0 seconds and 99999 days may be entered (press the UNIT key during entry to select the unit as either “sec”, “min”, “hr”, or “day”). Note that this time includes the DELAY time (see below), the test limits are imposed within the DWELL time, but after the DELAY time.
- **DELAY.** Sets the time delay between starting the DWELL time and starting to impose the test limits. Times between 1.0 seconds and the setting for DWELL may be entered (press the UNIT key during entry to select the unit as either “sec”, “min”, “hr”, or “day”).
- **END ON.** Sets the method of imposing the test limits and the action required in this test step upon failure. The available selections are –
  - **PASS.** The test step will be immediately terminated with a PASS status if the leakage measurement is within limits continuously for at least 2% of the dwell period. If the dwell period ends without this being detected, then the pass/fail status for leakage is based upon the final measurement taken at the end of the dwell period.
  - **FAIL.** The test step will be immediately terminated with a FAIL status if the leakage measurement is outside of limits continuously for at least 2% of the dwell period. If the dwell period ends, then the test step will have a PASS status for leakage.
  - **TIME.** The dwell period always extends for the entire programmed period. The pass/fail status for leakage is based upon the final measurement taken at the end of the dwell period.
  - **STDY.** The dwell period will be automatically terminated when the leakage is within the allowable limits and the current is steady or decreasing (i.e. steady or increasing resistance). If the dwell period ends prior to detecting steady or increasing insulation resistance, then the test step will have a FAIL status for leakage.
- **LIMIT.** The user may set minimum and/or maximum limits as either leakage current or insulation resistance. The UNIT key alternates between these, the actual values being automatically translated between them. While entering either value the UNIT key can be used to change between the available multipliers for that value (e.g. p, n,  $\mu$  or m for the A unit).
  - **Insulation Resistance.** The user can enter a minimum value and (optionally) a maximum value. If the maximum value is selected, pressing the LIMIT key selects the “no max” value – which configures the 981/3i to ignore the maximum value and only test for a minimum value. The minimum value cannot be set below a value which would result in a current of over 4mA at the configured test voltage.

- **Leakage Current.** The user can enter a maximum value and (optionally) a minimum value. If the minimum value is selected, pressing the LIMIT key selects the “no min” value (as does entering a zero value) – which configures the 981/3i to ignore the minimum value and only test for a maximum value. The maximum value cannot be set above 4mA; the minimum current cannot be set at or below a value of 0pA. Note that for a leakage current minimum limit with a non-zero value the polarity of the measured leakage current is taken into consideration, so for example a measurement of -10pA would be below a minimum setting of 1pA.
- **OFFSET.** The user may enter a value which will be subtracted from all current measurements in this test step, and the insulation resistance is that calculated after this current offset subtraction.
- **ON FAIL.** Allows the user to program the 981/3i to either abort the entire sequence (ABORT AUTO) or only this test step (CONTINUE) if this test step fails. A safety related failure or a user abort (**STOP** button) always aborts the entire sequence.

---

#### PAUSE AUTO TEST STEPS

This performs a fixed time delay before continuing to the next step.

An example of an AUTO TEST PAUSE test step menu and an explanation on each entry for it is shown below –

```
Seq 1 Step 1  PAUSE
TIME:         0.00sec
```

- **TIME.** Allows the user to set the desired pause time. Any value between 0.0 and 99999 seconds may be entered.

---

#### HOLD AUTO TEST STEPS

This forces the 981/3i to hold until the START switch is pressed, with a configurable timeout.

An example of an AUTO TEST HOLD test step menu and an explanation on each entry for it is shown below –

```
Seq 1 Step 1  HOLD
TIMEOUT:      30.0sec
```

- **TIMEOUT.** Allows the user to set the desired hold timeout. Any value between 0.0 and 99999 seconds may be entered. Setting a zero value disables the timeout entirely; the 981/3i will wait “forever” for user interaction to occur.

---

#### SWITCH AUTO TEST STEPS

This is only available if the unit has been configured to control an external Vitrek 964 unit. This commands up to 4 external 964 units to set their switches to the configured pattern. If the 981/3i is not configured to control external 964 units then this step is automatically skipped if it had been previously defined in a sequence.

An example of an AUTO TEST SWITCH test step menu and an explanation on each entry for it is shown below –

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

- **PRE-DELAY.** Allows the pre-switch delay to be specified. Generally this should be set to zero, but may need to be extended if external circumstances require a delay between the preceding step and the relays being changed in this step.



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

NOTE – the 981/3i does not change the states of switch matrix units unless commanded to do so by a SWITCH test step. It is recommended to finish a test sequence using switch matrix units with a SWITCH type step setting the relays to best “quiescent” state for the users’ specific system (generally the OFF state for all relays).

---

#### PERFORMING AN AUTO TEST SEQUENCE

After configuring the AUTO TEST sequence and selecting the desired AUTO TEST sequence the 981/3i displays (for example) -

```
AUTO 1 READY
9-Feb-18 9:08:51am
```

Connect the DUT to be tested.

Press the START button to start the AUTO TEST sequence running.

The TESTING LED is illuminated while performing an AUTO TEST.

- While the test sequence is running, the **PASS** and **FAIL** indicators show the present pass/fail status after the first test step is sufficiently completed, and throughout the test sequence the display shows the progress. An example is -
 

```
1.01 1000V
22s PASS 5.5nA
```

  - The selected test sequence number and the present step # are shown in the upper left display. During a DCIR discharge period an informative message is displayed in the lower line of the display.
  - For a DCIR type of test step the present output level is shown in the remainder of the upper display line.
  - The time since the start of the present test step and test step period is shown in the lower left display. If this is flashing between the value and blocks then the unit is waiting for the user to press the **START** button to continue in a HOLD type test step, otherwise the period will automatically end when it reaches the programmed time period.
  - For a DCIR type of test step the remainder of the lower display shows the measurement result. During the test dwell period the displayed measurements are automatically filtered with a rolling time constant. At any time during a DCIR test step the user can toggle between displaying the leakage current and the insulation resistance by pressing the UNIT key. While displaying the insulation resistance, if the measured value is above the value which can be reliably measured by the 981/3i under the actual voltage and loading conditions present then it is displayed as a

greater than character (“>”) followed by a value (for example “>20GΩ”). This indicates that the actual insulation resistance is at least the value shown, and probably much higher.

- While the test sequence is running it may be aborted by pressing the **STOP** button.
- While performing a HOLD step the AUTO TEST sequence can be continued by pressing the START button.
- When the test sequence has been completed, the **TESTING** LED extinguishes, the **PASS** or **FAIL** LED is illuminated, and the overall pass or failure status is temporarily displayed for approx. 2 seconds and then the measured results are reviewed, see the following section for details regarding reviewing results. An example temporary display is -

SEQUENCE 1 PASSED  
ALL TESTS

#### REVIEWING TEST RESULTS AFTER RUNNING AN AUTO TEST SEQUENCE

Immediately after running a test sequence and temporarily displaying an overall pass/fail status message the 981/3i automatically initiates reviewing the detailed test results.

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

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

01.01 1500V 1.5s UNST 12.3uA	The measurement being reviewed was within limits but was unsteady with increasing leakage current (decreasing resistance) which caused the step to fail.
01.01 1500V HV TRIP EXCEEDED	The HV Trip safety feature was tripped which caused the step to fail. This is typically caused by a DUT or cable breakdown to ground.
01.01 1500V 1.5s OVER 11.3mA	The DUT current exceeded the 981/3i maximum ability for >10ms, this is typically a DUT breakdown whose peak was limited to below the configured breakdown limit, but may also indicate that the configured charging rate was too fast for the load capacitance (so the charging current was beyond the units' ability).
01.01 1500V 1.5s ABORTED	The user aborted the test sequence.
01.01 1500V INTERLOCK OPENED	The INTERLOCK DIO interface signal became unasserted which caused the step to fail.
01.01 1500V UNSTABLE LOAD	The DUT load was too unstable preventing the 981/3i from providing a stable test voltage, or the line voltage was too low to achieve the programmed test voltage and load current.
01.01 SWITCH SWITCH FAILED	The 981/3i could not communicate with an external switch matrix unit during execution of a SWITCH type step. In some circumstances this can also indicate that an attempt was made to close a relay in a switch unit which was not actually installed in that unit.
01.01 HOLD TIMEOUT	The user failed to continue the sequence within the programmed timeout period while executing a HOLD type step.
01.01 1500V INT FAULT	An internal fault was detected which caused the step to fail. The 981/3i may need to be power cycled to recover from this. This is often caused by extreme interference but may be caused by an unrecoverable failure in an internal circuit of the 981/3i.

<p>01.01 1500V OVERHEATED</p>	<p>The 981/3i overheated which caused the step to fail. This can occur because the load current was too high for too long, or the airflow around the 981/3i was restricted, or the ambient temperature is too high around the 981/3i. The user should wait at least 15 seconds to allow it to cool down properly before either re-attempting the test or removing power from the 981/3i.</p>
-----------------------------------	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

- The test sequence # and presently shown step # are shown in the upper left corner of the display. The user can change the step number being reviewed by selecting the step # in the display using the Left Arrow or Right Arrow keys as needed, then using the Up Arrow or Down Arrow keys to step forwards or backwards through the test steps in the test sequence. Note that test steps which do not have any measurements, i.e. switch unit control steps or timing test steps, are not reviewable unless they contain a failure. Only test steps which have been performed can be reviewed, as an example if a 10-step test sequence was aborted during the 2<sup>nd</sup> test step, then only the 1<sup>st</sup> and 2<sup>nd</sup> test steps are reviewable as no others were performed.
- The remainder of the upper portion of the display shows the instantaneous applied voltage at the moment of the failure (if FAIL) or at the end of the dwell period (if PASS).
- The elapsed time in the period at the completion of the test step is shown in the lower left corner of the display.
- The measurement result and the pass or fail result for that measurement is shown in the remainder of the lower portion of the display. If the step contained a failure, other than a simple checked measurement limit failure, then a failure message is displayed instead.
- By default, the final measurement result is shown in the lower portion of the display. This can be changed to the minimum (MIN), maximum (MAX) or average (AVG) value by selecting the elapsed time in the display using the Left Arrow or Right Arrow keys as needed, then using the Up Arrow or Down Arrow keys to change the selection.

---

#### CORRECTING FOR LEAKAGE CURRENTS IN AN AUTO TEST SEQUENCE

As previously described, within each DCIR test step the user can configure for a set leakage current offset which is subtracted from all leakage current measurements during that step, with the insulation resistance being calculated using the current after applying this offset.

This configured offset current in each step can be automatically overwritten by running the AUTO TEST sequence in zero mode. When this is performed, the sequence is run normally except that the final measured leakage current in each step will overwrite the configured offset current for that step and that offset will be saved in a non-volatile manner. Typically, this would involve having no DUT connected but with all the wiring and fixturing in place during this zero-correction run of the sequence. In this manner all future normally run DCIR steps in this sequence will use the measured leakage current in that step.

To run the AUTO TEST sequence in the zero mode, press the ZERO button after selecting the sequence but before running the sequence.

## SECTION 6 – DCIR SPECIFICATIONS

Specifications are valid at the 981/3i terminals for 1 year at ambient temperatures within  $\pm 5\text{C}$  of calibration temperature (add 5% of accuracy specification per C outside of this). All specifications are relative to the calibration standards used. Add  $\frac{1}{2}$  digit to all accuracies for displayed results (results available with enhanced resolution from interfaces).

### LOADING CAPABILITY

The listings below show the loading capabilities of the 981/3i at ambient temperatures  $\leq 30\text{C}$ . For ambient temperatures above  $30\text{C}$  linearly reduce the maximum loading power and current by  $1\%/C$ .

Capacitive loading is only limited by the maximum ramp time (99999sec) and the maximum load current.

Maximum Load Current :       4mA  
                                           Min. loading impedance  $100\text{k}\Omega$

### SURGE CURRENT LIMITING AND SHUTDOWN

Source Impedance Limiting     $12.5\text{k}\Omega$   
 Peak Shutdown Current        5mA

### TEST VOLTAGE

Test Voltage Range            981i: 30 to 6500V  
                                           983i: 60 to 11000V  
                                           Opt. HSS-2: 30 to 5000V

Test Voltage Accuracy        981i:  $<\pm(0.25\% \text{rdg} + 0.1\text{V})$   
                                           983i:  $<\pm(0.25\% \text{rdg} + 0.2\text{V})$   
                                           Opt. HSS-2:  $<\pm(0.25\% \pm 0.1\text{V} \pm 1\text{V per mA load})$

Test Voltage Overshoot       Typically  $<1\%$   
                                           Settling to  $<\pm 0.1\%$  of final value in  $<1\text{sec}$

### CURRENT MEASUREMENTS (DUT ISOLATED)

Measurements are performed in the **RETURN** terminal of the 981/3i.

Measurement Range             $<4\text{mA}$

Resolution                      1pA or 5 digits

Accuracy                         $<1000\text{pF Load: } <\pm(0.5\% \pm 10\text{pA} \pm (2\text{pA per kV}))$   
                                            $1000\text{pF to } 50\text{nF Load: } <\pm(0.5\% \pm 100\text{pA} \pm (20\text{pA per kV}))$   
                                            $>50\text{nF Load: } <\pm(0.5\% \pm 1\text{nA} \pm (200\text{pA per kV}))$

Measurement Period          7.25msec during charge, 100ms during dwell

### RESISTANCE MEASUREMENTS (DUT ISOLATED)

Measurements are performed between the **HV** and **RETURN** terminals of the 981/3i.

981i Accuracy                  $<1\text{nF Load: } <(\pm 0.4\% \pm (R/(1\text{T}\Omega \text{ per kV}))\% \pm (10/V)\% \pm (20\Omega \text{ per kV}))$ , valid for R  $<50\text{T}\Omega$

	1-50nF Load: $<(\pm 0.5\% \pm (R/(100G\Omega \text{ per kV}))\% \pm (10/V)\% \pm (100\Omega \text{ per kV}))$ , valid for $R < 5T\Omega$ >50nF Load: $<(\pm 0.5\% \pm (R/(10G\Omega \text{ per kV}))\% \pm (10/V)\% \pm (1k\Omega \text{ per kV}))$ , valid for $R < 500G\Omega$
Opt. HSS-2 Accuracy	As 981i plus 1k $\Omega$
983i Accuracy	<1nF Load: $<(\pm 0.4\% \pm (R/(1T\Omega \text{ per kV}))\% \pm (20/V)\% \pm (40\Omega \text{ per kV}))$ , valid for $R < 50T\Omega$ 1-50nF Load: $<(\pm 0.5\% \pm (R/(100G\Omega \text{ per kV}))\% \pm (20/V)\% \pm (200\Omega \text{ per kV}))$ , valid for $R < 5T\Omega$ >50nF Load: $<(\pm 0.5\% \pm (R/(10G\Omega \text{ per kV}))\% \pm (20/V)\% \pm (2k\Omega \text{ per kV}))$ , valid for $R < 500G\Omega$
Comparative Accuracy	Valid for measurement of multiple values within 10% at the same test voltage, in the same environmental conditions within +/-1C, within a 1 hour period, no intervening ZERO operations, and with the 981/3 constantly powered during the entire time. <1nF Load: $<(\pm 0.05\% \pm (R/(5T\Omega \text{ per kV}))\% \pm (1/V)\% \pm (2\Omega \text{ per kV}))$ , valid for $R < 150T\Omega$

### RESISTANCE MEASUREMENTS (DUT GROUNDED, 981i WITH OPTION HSS-2 ONLY)

Measurements are performed between the **HV** terminal of the 981i and ground.

Accuracy	<1nF Load: $<(\pm 0.5\% \pm (R/(2G\Omega \text{ per kV}))\% \pm (10/V)\% \pm (20\Omega \text{ per kV}) \pm 1k\Omega)$ , valid for $R < 100G\Omega$ 1-50nF Load: $<(\pm 0.6\% \pm (R/(2G\Omega \text{ per kV}))\% \pm (10/V)\% \pm (100\Omega \text{ per kV}) \pm 1k\Omega)$ , valid for $R < 100G\Omega$ >50nF Load: $<(\pm 0.75\% \pm (R/(1G\Omega \text{ per kV}))\% \pm (10/V)\% \pm (1k\Omega \text{ per kV}) \pm 1k\Omega)$ , valid for $R < 50G\Omega$
----------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

### TEST TIMING

Charge	1.0 to 99999sec <( $\pm 1\% \pm 0.1\text{sec}$ ) accuracy with typical loads
Dwell	1.0 to 99999 days <( $\pm 0.05\% \pm 100\text{ms}$ ) accuracy
Delay	0.0 to 99999sec <( $\pm 0.05\% \pm 100\text{ms}$ ) accuracy

### DISCHARGE

981i	From >5kV down to 5kV: 7M $\Omega$ Below 5kV: 70k $\Omega$
983i	From >7.5kV down to 7.5kV: 14M $\Omega$ From 7.5kV down to 5kV: 270k $\Omega$ Below 5kV: 70k $\Omega$

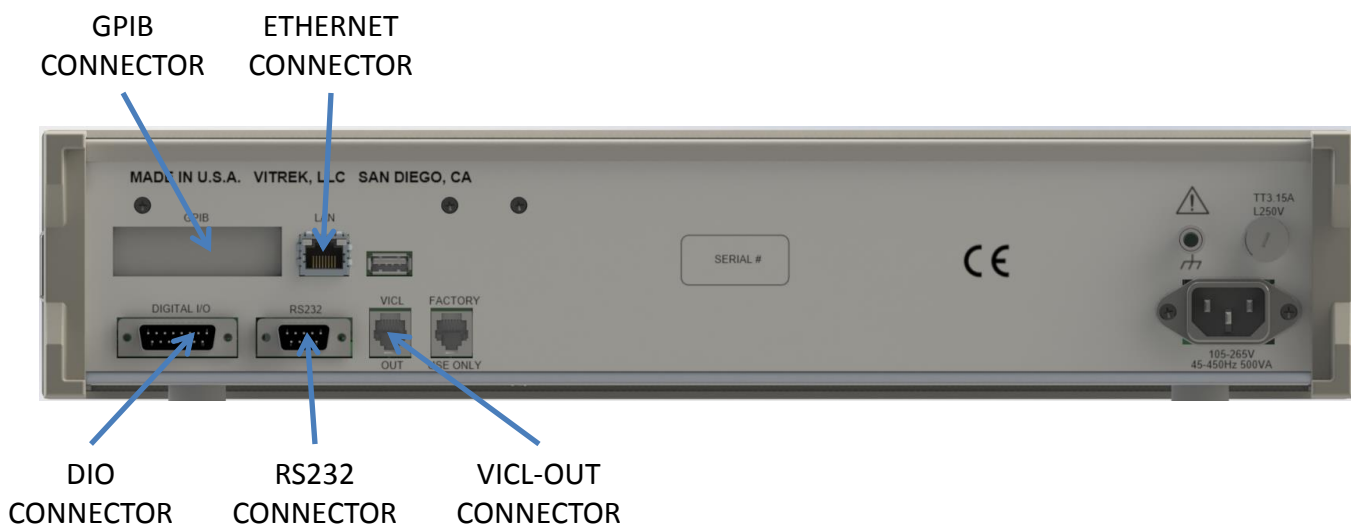
## SECTION 7 – CONNECTING AND CONFIGURING INTERFACES

The 981/3i contains several interfaces, some of which are options. This section describes how to configure and connect to each interface. Each description of menus only includes the settings pertinent to the section being described.

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

For programming information using an interface to control the 981/3i see [SECTION 11 – PROGRAMMING VIA AN INTERFACE](#).

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



### LOCAL AND REMOTE OPERATION

When the 981/3i receives a command from an enabled interface the front panel **REMOTE** indicator is illuminated and the user may not use the front panel menus. To attempt to return the 981/3i into the local state the user should press the **CONFIG** key on the 981/3i front panel. If the 981/3i has been enabled to return to the local state by the controlling interface then the **REMOTE** indicator will extinguish and a message is displayed on the 981/3i front panel.

### CONTROLLING EXTERNAL SWITCH MATRIX UNITS

The 981/3i can be configured to control one Vitrek 948i or up to 4 Vitrek 964i Switch Matrix units.

NOTE – the 981/3i must be configured to control an external Switch Matrix unit before a test sequence can be created which contains steps to control it.

### CONFIGURATION

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.

- The display now shows the main configuration menu, an example of which is –
  - AUTO TEST...
  - SYSTEM...
  - INTERFACES...
  - DIGITAL I/O...
  - BUILD...
  - SET TO DEFAULTS...
  - LOCK PASSWORD: 000000
  - RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.
- The 981/3i now displays the base interfaces configuration settings menu, an example of which is –
  - RS232 BAUD: 115200
  - SWITCH: NONE
  - DISABLE USB: NO
  - DISABLE GPIB: NO
  - DISABLE ENET: NO
  - ETHERNET...
  - GPIB ADDR: 2
- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting controlling external switch matrix units are –
  - **RS232 BAUD.** This setting is only used when controlling an external 964i Switch Matrix unit via the RS232 interface. Its setting should match the baud rate setting in the attached 964i.
  - **SWITCH.** This allows the user to select the method by which external switch matrix units are interfaced to the 981/3i. The available selections are –
    - **NONE.** No switch matrix units are controlled by the 981/3i.
    - **948 (SERIAL).** A single ViTREK 948i Switch Matrix unit is being controlled by the 981/3i via the RS232 serial interface. The RS232 BAUD setting is ignored if this is selected.
    - **964 (SERIAL).** A single ViTREK 964i Switch Matrix unit is being controlled by the 981/3i via the RS232 serial interface.
    - **964 (VICLx1).** A single ViTREK 964i Switch Matrix unit is being controlled by the 981/3i via the VICL interface. The 964i must be configured for VICL and set to address 1.
    - **964 (VICLx2).** Two ViTREK 964i Switch Matrix units are being controlled by the 981/3i via the VICL interface. All 964i's must be configured for VICL and set to addresses 1 and 2.
    - **964 (VICLx3).** Three ViTREK 964i Switch Matrix units are being controlled by the 981/3i via the VICL interface. All 964i's must be configured for VICL and set to addresses 1, 2 and 3.
    - **964 (VICLx4).** Four ViTREK 964i Switch Matrix units are being controlled by the 981/3i via the VICL interface. All 964i's must be configured for VICL and set to addresses 1, 2, 3 and 4.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. **NOTE** – the settings are not active until all menus have been exited.

## CONNECTIONS

Refers to the instructions received with the specific Switch Matrix unit(s) for details regarding connecting the terminals of the 981/3i to those of the Switch Matrix Units.

## RS232 INTERFACE

Using a RS232 cable supplied by ViTREK, connect the RS232 port on the 981/3i rear panel to the RS232 (Serial) port of the ViTREK 948i or 964i. The user may supply their own cable, in which case it should be a 9-wire female-female null modem cable capable of full handshake 115200baud operation.

## VICL

Using a VICL cable supplied by ViTREK, connect the VICL – OUT port on the 981/3i to a ViTREK 964i VICL – IN port. If using more than one 964i, then connect each additional ViTREK 964i VICL – IN port to the preceding 964i's VICL – OUT port. The 964i's do not need to be wired together in any specific order when using the VICL interface.

## CONTROLLING THE 981/3i BY THE RS232 INTERFACE

NOTE – the RS232 interface can only be used for a single purpose, it cannot be used for both controlling an external Switch Matrix unit and controlling the 981/3i.

## SPECIFICATIONS

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

## CONFIGURATION

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
 AUTO TEST...  
 SYSTEM...  
 INTERFACES...  
 DIGITAL I/O...  
 BUILD...  
 SET TO DEFAULTS...  
 LOCK PASSWORD: 000000  
 RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.



- The 981/3i now displays the base interfaces configuration settings menu, an example of which is –
 

```
RS232 BAUD:    115200
SWITCH:        NONE
DISABLE GPIB:   NO
DISABLE ENET:   NO
ETHERNET...
GPIB ADDR:     2
```
- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting using the RS232 to control the 981/3i are -
  - **RS232 BAUD.** This setting must match the baud rate setting of the attached computer.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. NOTE – the settings are not active until all menus have been exited.

## CONNECTIONS

Using a RS232 cable supplied by ViTREK, connect the RS232 port on the 981/3i rear panel to the RS232 (Serial) port of a computer. The user may supply their own cable, in which case it should be a 9-wire female-female null modem cable capable of full handshake 115200baud operation.

## CONTROLLING THE 981/3i BY THE GPIB INTERFACE

### CONFIGURATION

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –
 

```
AUTO TEST...
SYSTEM...
INTERFACES...
DIGITAL I/O...
BUILD...
SET TO DEFAULTS...
LOCK PASSWORD: 000000
RELOCK...
```
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.
- The 981/3i now displays the base interfaces configuration settings menu, an example of which is –
 

```
RS232 BAUD:    115200
SWITCH:        NONE
DISABLE GPIB:   NO
DISABLE ENET:   NO
ETHERNET...
GPIB ADDR:     2
```
- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting using the RS232 to control the 981/3i are –
  - **DISABLE GPIB.** This must be set to NO to enable the GPIB interface in the 981/3i.

- **GPIB ADDR.** This must be set to a chosen address for the 981/3i on the GPIB bus. Addresses in the range 1 through 29 may be used if there is no other device on the bus at that address. Software in the computer will need to be set to match this address in order for it to communicate with the 981/3i.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings.

---

## CONNECTIONS

Using a standard GPIB cable connect the GPIB port on the 981/3i rear panel to the GPIB port of a computer. It is recommended to use a high quality, shielded GPIB cable. Cables may be purchased from ViTREK.

## CONTROLLING THE 981/3i BY THE ETHERNET INTERFACE

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### SPECIFICATIONS

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

---

### CONFIGURATION

Prior to configuring the 981/3i or connecting the 981/3i to a network, the user must have knowledge of certain aspects of the network –

- The user must ascertain if the network uses DHCP or not for allocation of IP addresses.
- If the network does not use DHCP for allocation of IP addresses, then the user must choose a suitable unused IP address within the local network subnet, the subnet mask of the local network, and the gateway IP address to additional networks.
- Some networks which use DHCP allocation of IP addresses limit the allocation of addresses to known devices by means of a list of known MAC addresses. In this case the user must ascertain the MAC address of the 981/3i and correctly configure the DHCP server prior to connecting the 981/3i to the local network.

Configure the Ethernet Interface of the 981/3i as follows -

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
 AUTO TEST...  
 SYSTEM...  
 INTERFACES...

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

- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the INTERFACES line.
- Press the **ENTER** key.
- The 981/3i now displays the base interfaces configuration settings menu, an example of which is –

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

- The user may navigate this sub-menu and change the displayed settings as required. The settings affecting using the RS232 to control the 981/3i are –
  - **DISABLE ENET.** This must be set to NO to enable the Ethernet interface in the 981/3i.
  - **ETHERNET...** This selection is the entry point to the sub-menu for configuring the Ethernet interface. The user should navigate to select this menu line and press then **ENTER** key.
- The Ethernet sub-menu allows the user to configure the 981/3i for the local network. An example of this sub-menu is as follows –
- ```
USE DHCP: YES
IP: 000.000.000.000
SNET:000.000.000.000
GTWY:000.000.000.000
MAC: 1234567890AB
```
- The user may navigate this sub-menu and change the displayed settings as required. The settings are –
  - **USE DHCP.** Allows the user to configure the 981/3i to use DHCP for IP address allocation (YES) or not (NO).
  - **IP.** If using DHCP, this shows the IP address which the 981/3i has been allocated. If not using DHCP this allows the user to enter an IP address for the 981/3i on the local network.
  - **SNET.** If using DHCP, this shows the IP subnet mask which the 981/3i has been given. If not using DHCP this allows the user to enter the subnet mask for the local network.
  - **GTWY.** If using DHCP, this shows the IP of the gateway to additional networks which the 981/3i has been given. If not using DHCP this allows the user to enter the IP address of the gateway.
  - **MAC.** This is not editable and shows the MAC address of the 981/3i. This may be needed to configure the local network to allow connection of the 981/3i to it. In most networks this is not needed.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. NOTE – the settings are not active until all menus have been exited.

- If using DHCP the user should re-enter the ETHERNET configuration sub-menu and note the IP address allocated to the 981/3i. This will be needed to configure the TCP/IP client software used to communicate with the 981/3i.

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## CONNECTIONS

The 981/3i connects to the local network using a standard CAT5 or CAT5e Ethernet cable and RJ45 connector.

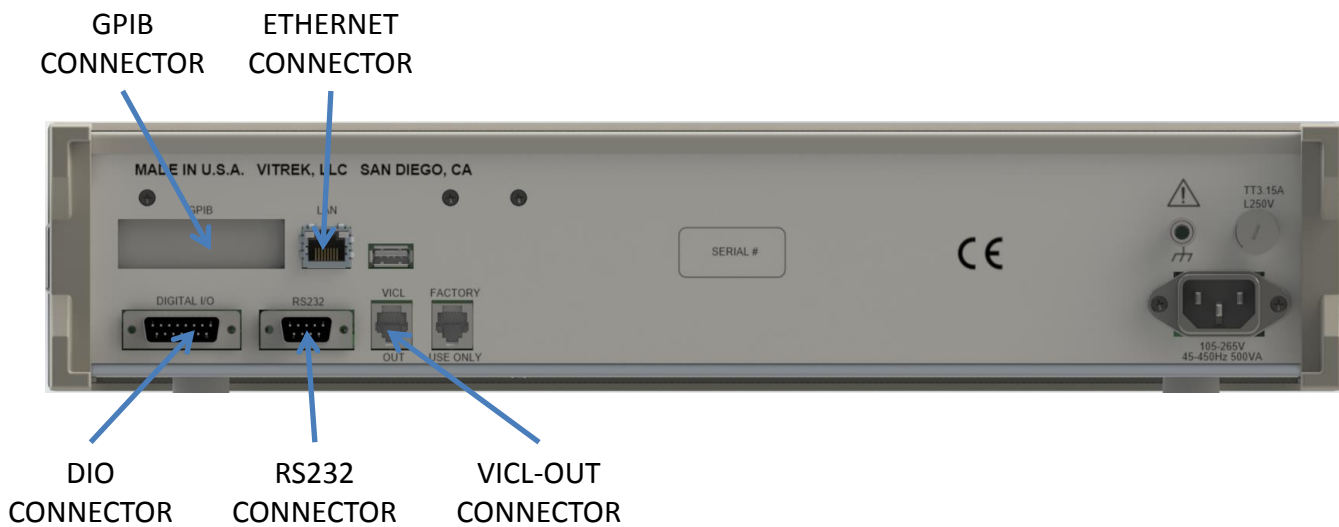
When initially connected to the network the 981/3i display shows a message for 2 seconds detailing the actual speed and duplex used for the connection.

## SECTION 8 – DIO INTERFACE

Using the 981/3i Digital Input & Output (DIO) interface the user may perform any combination of the following –

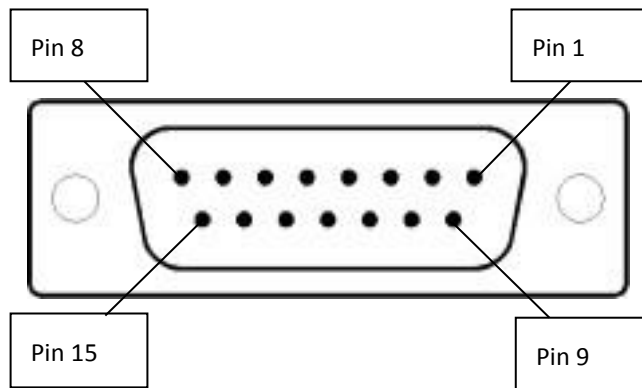
- Control the 981/3i using a PLC type device, starting and stopping a sequence, and determining the pass/fail status
- Control the 981/3i using external start and/or stop switches
- Abort a test sequence when a safety interlock is opened
- Allow the 981/3i to illuminate external safety indicators

### CONNECTOR AND PINOUT



The DIO signals are available at the rear panel of the 981/3i in the 15-pin connector identified as “DIGITAL I/O” as shown the photograph above. The 981/3i connector is a standard two-row 15-pin female Dsub connector; any suitable male mating connector may be used.

The diagram below shows the pin locations within the connector as viewed from the rear panel of the 981/3i.



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

|              |            |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------|------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pin 1        | +12VDC     |        | Internal +12VDC power source, internally fused 100mA (self-resetting)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Pin 2        | HV PRESENT | Output | Active whenever an unsafe voltage or current is present on the 981/3i terminals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Pin 3        | COMMON     |        | Common Reference signal for all digital inputs and outputs (Digital Ground, internally connected to the 981/3i chassis ground)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Pin 4        | START      | Input  | Starts a test sequence when transitions inactive to active. This may also be used to continue a test sequence when it is waiting for user interaction (e.g. in a HOLD step or if programmed for a user terminated test step). If the SEQUENCE input signals are not used to select a sequence, then a sequence must have been already manually selected at the front panel.<br>If the 981/3i is waiting for the front panel START button to be pressed while running a test sequence (i.e. waiting for user interaction) then an inactive to active transition of the START signal will also continue the sequence. |
| Pin 5        | ABORT      | Input  | Aborts a test sequence when active. This signal has priority over the START signal; disabling it while ABORT is active.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Pin 6        | INTERLOCK  | Input  | Aborts a test sequence (high voltage or current steps only) when inactive                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Pins 7 to 11 | UNUSED     | Input  | These pins should be left disconnected.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Pin 12       | PASS       | Output | Active after the end of a sequence if passed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Pin 13       | FAIL       | Output | Active after the end of a sequence if failed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Pin 14       | TESTING    | Output | Active while running a sequence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Pin 15       | DWELL      | Output | Active during the dwell period of a measurement type of test                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

## INPUT SIGNAL CHARACTERISTICS

- Each is referenced to the COMMON signal, which is internally connected to the 981/3i chassis ground.
- The maximum input level guaranteed to be recognized as a low level is +1V, the minimum guaranteed to be recognized as a high level is +2.3V. Each input has an internal pull-up resistor of nominally 1.8K $\Omega$  to an internal +4V level and is protectively clamped to +5V and has a nominal capacitance to COMMON of 10nF.  
**WARNING: Do not exceed -0.5V or +5V on any DIO input otherwise the 981/3i may be damaged.**
- Each can be directly interfaced to either a contact closure to COMMON, or a COMMON referenced TTL/CMOS/LVCMOS logic source. If the input is to be actively driven from a higher voltage logic signal than 5V (e.g. 12V) then one of the following should be used –
  - An isolation circuit may be employed between the high voltage logic signal and the 981/3i input. This is always required if the source of the digital is not explicitly referenced to the COMMON pin of the DIO interface. Typically, this is a PhotoMOS type isolator “shorting” the respective input pin to COMMON with <500 $\Omega$  resistance when the LED in the isolator is turned on (typically through a resistor to the digital output of a PLC).
  - A diode should be placed in series with the signal with its anode connected towards the 981/3i connector. This will effectively change the high voltage digital signal to a contact closure type, only being able to pull the 981/3i input to the low state and relying on the 981/3i internal pull-up resistor

to select the high state. This is the preferred method for interfacing to 12 or 24V PLC logic output signals when isolation is not required.

- A suitable value series resistance should be placed in each input signal line to limit the current in the 5V protection to a maximum of 30mA (for 12V logic signals the recommended series resistance is 390Ω). The maximum series resistance value allowable is nominally 600Ω to achieve the guaranteed low voltage level.
- A suitable logic level translation circuit should be employed between the high voltage logic and the 981/3i.

## OUTPUT SIGNAL CHARACTERISTICS

- Each has an open-drain drive with >12V withstand and >500mA sink capability (<1.3Ω impedance) with a pull-up resistor of nominally 2.2KΩ to an internal 5V level.

**WARNING: Do not exceed -0.5V or +12V on any DIO output otherwise the 981/3i may be damaged.**

**WARNING: Do not exceed 500mA into any DIO output otherwise the 981/3i may be damaged.**

- Each is internally clamped to nominally 16V (14V minimum) so may be used to directly drive a relay. When using a digital output to drive a 12V relay coil or indicator the user should consider that each output has a nominally 3.2mA current flow into the 981/3i when the output is in the off state at +12V. The user must ensure that this current is insufficient to operate the relay or indicator. If this current is not acceptable then the signal must be buffered by a suitable driver, e.g. a NPN transistor, N-channel MOSFET, buffer IC, or an isolation device.

## SIGNAL ISOLATION

When operating the 981/3i in adverse environments having a large amount of ground noise, or when the 981/3i is being at very high test voltage levels, it is recommended to provide isolation between the 981/3i DIO signals and the remote device if that is also grounded or has significant capacitance to ground. This avoids transient ground voltages during DUT breakdown from causing improper operation or possibly damage to the DIO interface. The user should consider using relays (mechanical or solid state) or logic type optical couplers to provide the isolation. In extreme conditions, the user may need to take steps to ensure that there is minimal capacitance across the isolation barrier formed by these components and that they are specified for the high voltage transients which could occur – it is recommended that isolation devices with a capacitance of <20pF and a voltage withstand capability of >2.5KVpk be used.

## SIGNAL TIMING

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

### STARTING WITH THE START SIGNAL

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

- The TESTING output signal from the 981/3i must have been inactive for >5ms before a sequence may be started.
- If enabled, the ABORT signal must be inactive for >5ms before the inactive to active transition of the START signal.

- The START signal must have been inactive for >5ms before attempting to start.
- The START signal must be active for >10ms, there is no maximum time.

The test sequence is started within <(10ms + 1ms per test step in the sequence) after recognition of the inactive to active transition of the START signal. At that time the PASS, FAIL and TESTING output signals are set by the 981/3i to the following states with <±100us skew between them-

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

---

#### ABORTING WITH THE ABORT OR INTERLOCK SIGNALS

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

If enabled and the INTERLOCK signal is inactive for >5ms then a test sequence is aborted if it is presently running a DCIR type step. It has no effect on any other type of step or if a test sequence is not being run.

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#### PASS, FAIL AND TESTING OUTPUT SIGNALS

Within <5ms after a test has completed the PASS, FAIL and TESTING output signals are set by the 981/3i to the following states with <±100us skew between them –

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

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#### HV PRESENT AND DWELL OUTPUT SIGNALS

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

### CONFIGURING

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

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary, press the **STOP** button to abort a menu and return to the base menu state.
- Press the **CONFIG** key.
- The display now shows the main configuration menu, an example of which is –  
AUTO TEST...  
SYSTEM...  
INTERFACES...  
DIGITAL I/O...  
BUILD...  
SET TO DEFAULTS...  
LOCK PASSWORD: 000000  
RELOCK...
- Using the Left Arrow or Right Arrow keys as needed, change the selection point to the DIGITAL I/O line.
- Press the **ENTER** key.
- The display now shows the Digital I/O configuration menu. An example of the Digital I/O configuration menu is as follows –



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

- The user may navigate this sub-menu and change the displayed settings as required.
  - **START, ABORT, INTERLOCK.** These allow the user to select whether the respective digital input is to be ignored, active low or active high.
    - If either the INTERLOCK signal is enabled and set for active low, or the ABORT signal is enabled and set for active high, then the 981/3i will be prevented from running any test sequence if the DIO signals are removed (e.g. the cable is unplugged). If this is not intended, then these signals should be used with the opposite polarity (i.e. active high for INTERLOCK and active low for ABORT).
    - CAUTION – changing the active level of the START signal may cause the 981/3i to detect a change in the START signal from the inactive to the active state (e.g. if the signal is high and the configuration is changed from active low to active high). This may cause a previously selected sequence to be run and high voltages to become present on the 981/3i terminals. The user should ensure that no sequence is selected and that the START signal will end up being in the inactive state when changing the polarity of the START signal.
  - **PASS, FAIL, TESTING, DWELL and HV.** These allow the user to select whether the respective digital output is to be active low or active high.
- When finished, press the **EXIT** key to exit this sub-menu, and then press **EXIT** again (if no additional configuring is to be performed) to exit the main configuration menu and save the settings. The settings are not used until they are saved.

## EXAMPLES

### Example 1 -

It is desired to drive a TESTING IN PROGRESS warning indicator, external to the 981/3i. The indicator is illuminated when driven with 12Vdc and draws less than 100mA. The indicator does not illuminate at a current of 3.2mA.

In this case the indicator may be driven directly from the 981/3i DIO TESTING signal and the 981/3i internal 12V power source from the DIO connector. The indicator is simply wired between the DIO connector pin 1 (+12V) and pin 14 (TESTING), and the TESTING output should be configured to be ACTIVE LO to cause the indicator to be illuminated when testing.

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

### Example 2 -

It is desired to use an external mechanical switch to start a sequence rather than the 981/3i front panel START button. The test sequence will be manually selected at the 981/3i front panel. The switch will be momentarily actuated to start a sequence.

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

Example 3 -

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

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

Example 4 –

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

In this case the magnetic switch is used with the INTERLOCK capability of the 981/3i and should be connected between DIO connector pin 3 (COMMON) and pin 6 (INTERLOCK).

If the safety hood is opened while the 981/3i is producing high (i.e. unsafe) voltages then the test will be immediately aborted. However, the user can still open the hood (e.g. to make wiring changes to the DUT) during the test sequence as long as they are made while there are no unsafe voltages present (e.g. a HOLD step could be programmed in the sequence to allow the user to make the changes and then press the START button to continue testing).

## SECTION 9 – PERIODIC MAINTENANCE

THE 981/3i CONTAINS NO INTERNAL USER SERVICABLE PARTS AND REQUIRES NO INTERNAL PERIODIC MAINTENANCE. THE COVERS OF THE 981/3i SHOULD ONLY BE REMOVED BY VITREK OR ITS SERVICE CENTERS – REMOVAL OF THE COVERS MAY AFFECT WARRANTY AND CALIBRATION CERTIFICATION.

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

### CLEANING AND INSPECTION

#### CABLE INSPECTION

Carefully inspect the power cord, and any high voltage cabling for breaks, abrasions or cracks in the outer insulation. Replace any cable found to be damaged.

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

#### DISPLAY FILTER CLEANING

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

#### TERMINAL INSPECTION

Visually inspect the terminals and the area immediately around them in the front and/or rear panels and clean them if required. IF THE INTERNAL SURFACES OF TERMINALS ARE WETTED DURING CLEANING THEN ENSURE THAT THEY ARE FULLY DRIED BEFORE OPERATING THE 981/3i AT HIGH VOLTAGES, OTHERWISE SAFETY MAY BE COMPROMISED.

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

### SELF TEST

Prior to performing a self-test, the 981/3i must have been continuously powered and turned on for at least 5 minutes.

The user may press the **STOP** button at any time during the self-test procedure to abort it. The **HIGH VOLTAGE OR HIGH CURRENT PRESENT** warning symbol is illuminated whenever high voltages are present on the 981/3i terminals during this procedure.

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

- Ensure that the display indicates that the 981/3i is in the base menu state, i.e. the display shows the date and time. If necessary press the **STOP** button to abort a menu and return to the base menu state.
- Press the **TEST** key.
- Select the SELF TEST line.

- The display now shows a series of temporary messages indicating the status of certain portions of the 981/3i. If any of these indicate a failure of the 981/3i, then the self-test is halted at the failing test.
- The display now shows a message indicating that the user should remove all leads to the 981/3i. **The user MUST remove all connections to the terminals of the 981/3i before continuing with the self-test. CAUTION – high voltages may be present on the HV terminal of the 981/3i during the remainder of the self-test procedure, the user should ensure that there are no connections and that the terminals are not touched during the procedure.** When sure that all connections have been removed, the user should press the **START** button to continue the procedure.
- The display now shows a series of messages indicating the progress as several active circuitry tests are performed automatically by the 981/3i. If any of these indicate a failure of the 981/3i, then the self-test is halted at the failing test.
- When all tests have successfully completed, a temporary message is displayed and the display is returned to the base menu state.

If any of the SELF-TEST steps indicate a failure then the 981/3i may need to be returned to Vitrek for repair. Contact Vitrek for assistance.

## SECTION 10 – PERFORMANCE VERIFICATION AND ADJUSTMENT

The 981/3i 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 981/3i. 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 981/3i 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 981/3i.
- **Periodic Adjustment followed by Verification.** With this strategy the user ensures that the 981/3i 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 981/3i malfunctions by means of the post-adjustment verification. This completely ensures that the outgoing 981/3i meets its' specifications but leaves the possibility of an error made during the adjustment calibration leading to the incorrect indication that the incoming 981/3i did not meet specifications.
- **Periodic Verification – Adjustment – Verification.** This is the most complete strategy but is also the costliest in time. The time cost can be reduced by performing the initial verification and then only performing the Adjustment – Verification components if the initial verification indicates that it is necessary (as an example, only perform if beyond some percentage of specification in the initial verification).

### ADJUSTMENT CALIBRATION

The 981/3i 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 981/3i, 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 981/3i 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 981/3i is an internally prompted sequence dependent on the actual product model being calibrated.

Please take note of the following–

- The 981/3i 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 981/3i terminals and it is recommended to not have any connections to the interface ports during the procedure.
- The combination of the adjustment calibration and the internal self-test ensures the performance of the 981/3i 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 981/3i 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 981/3i DURING THE ADJUSTMENT**

CALIBRATION PROCEDURE. If a failure occurs during the procedure, the 981/3i will automatically halt the procedure and discard any changes made.

- Several of the adjustment steps are performed at very high voltages, the user must ensure that the wiring used has sufficient insulation for the voltages.
- The front panel High Voltage warning light is illuminated whenever there are high voltages or currents present on the 981/3i terminals. When illuminated the user should not touch the connections to the 981/3i.

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#### EQUIPMENT REQUIRED

1. A DC voltage meter capable of measuring voltages between 100V and 5000V with an input impedance of  $>10M\Omega$ . The accuracy of this meter must be  $<0.0625\% + 0.025V$  (or  $+ 0.05V$  for a 983i) at these voltages for a 4:1 accuracy ratio. This may be achieved by using different meters depending on the voltage point.
2. A nominal  $100k\Omega \pm 10\%$  resistor capable of withstanding 300V (0.9W) and having a known value with an accuracy of better than  $\pm 0.11\%$  for a 4:1 accuracy ratio.
3. A nominal  $1M\Omega \pm 10\%$  resistor capable of withstanding 500V and having a known value with an accuracy of better than  $\pm 0.1\%$  for a 4:1 accuracy ratio.
4. A nominal  $10M\Omega \pm 10\%$  resistor capable of withstanding 500V and having a known value with an accuracy of better than  $\pm 0.1\%$  for a 4:1 accuracy ratio.
5. A nominal  $100M\Omega \pm 10\%$  resistor capable of withstanding 500V and having a known value with an accuracy of better than  $\pm 0.1\%$  for a 4:1 accuracy ratio.

Since the 981/3i is internally grounded, the equipment listed here must not have grounded terminals.

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#### PROCEDURE

Follow the prompts in the display of the 981/3i for the actual procedure as it varies between models and option content.

- Press the **TEST** key.
- Select "CAL ADJUST" and then press **ENTER**. The 981/3i now prompts the user for entry of the calibration password.
  - The calibration password is 092126. All digits must be entered.
- The user is now prompted to remove all leads. Ensure there are no connections to the front panel terminals then press **START**.
- The 981/3i now performs a series of internal adjustments which require no user equipment or intervention.
- The 981/3i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 981/3i, the meter should be suitable for measuring 100V. Press **START** when the meter is connected.
- The 981/3i now provides nominally 100V to the meter. Use the UP or DOWN arrow keys as needed to adjust the 981/3i output to produce an output voltage as indicated by the meter of 100V to within 0.0875V or better. The 981/3i display shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- The 981/3i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 981/3i, the meter should be suitable for measuring 1000V. Press **START** when the meter is connected.
- The 981/3i now provides nominally 1000V to the meter. Use the UP or DOWN arrow keys as needed to adjust the 981/3i output to produce an output voltage as indicated by the meter of 1000V to within 0.65V

or better. The 981/3i display shows the amount (in %) of adjustment which has been applied. Press **START** when completed.

- The 981/3i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 981/3i, the meter should be suitable for measuring 5000V. Press **START** when the meter is connected.
- The 981/3i now provides nominally 5000V to the meter. Use the UP or DOWN arrow keys as needed to adjust the 981/3i output to produce an output voltage as indicated by the meter of 5000V to within 3.1V or better. The 981/3i display shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- The 981/3i now prompts the user to connect a 100k $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 300V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance. Use the UP or DOWN arrow keys as needed to adjust the 981/3i displayed resistance to within 0.11% or better of the known value of the resistor. The 981/3i display also shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- The 981/3i now prompts the user to connect a 1M $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance. Use the UP or DOWN arrow keys as needed to adjust the 981/3i displayed resistance to within 0.105% or better of the known value of the resistor. The 981/3i display also shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- (If option HSS-2 is installed) The 981/3i now prompts the user to connect a 1M $\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981/3i, the resistor should be capable of withstanding 1000V. Press **START** when the resistor is connected.
- (If option HSS-2 is installed) The 981/3i now displays the measured resistance. Use the UP or DOWN arrow keys as needed to adjust the 981/3i displayed resistance to within 0.15% or better of the known value of the resistor. The 981/3i display also shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- (If option HSS-2 is installed) The 981/3i now prompts the user to connect a 1M $\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981/3i, the resistor should be capable of withstanding 300V. Press **START** when the resistor is connected.
- (If option HSS-2 is installed) The 981/3i now displays the measured resistance. Use the UP or DOWN arrow keys as needed to adjust the 981/3i displayed resistance to within 0.15% or better of the known value of the resistor. The 981/3i display also shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- The 981/3i now prompts the user to connect a 10M $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance. Use the UP or DOWN arrow keys as needed to adjust the 981/3i displayed resistance to within 0.105% or better of the known value of the resistor. The 981/3i display also shows the amount (in %) of adjustment which has been applied. Press **START** when completed.

- (If option HSS-2 is installed) The 981/3i now prompts the user to connect a 10M $\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- (If option HSS-2 is installed) The 981/3i now displays the measured resistance. Use the UP or DOWN arrow keys as needed to adjust the 981/3i displayed resistance to within 0.135% or better of the known value of the resistor. The 981/3i display also shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- The 981/3i now prompts the user to connect a 100M $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance. Use the UP or DOWN arrow keys as needed to adjust the 981/3i displayed resistance to within 0.105% or better of the known value of the resistor. The 981/3i display also shows the amount (in %) of adjustment which has been applied. Press **START** when completed.
- If all steps above were completed successfully then the calibration is completed and the 981/3i display shows "FINISHED CALIBRATION" for a short time. The user should remove all equipment and connections from the 981/3i. DO NOT REMOVE POWER FROM THE 981/3i OR TURN OFF THE POWER SWITCH FOR AT LEAST 5 SECONDS AFTER COMPLETING THE CALIBRATION PROCEDURE.

## VERIFYING CALIBRATION

The 981/3i 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 981/3i 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. If there are any doubts regarding the correct methods to use, consult the manufacturer of the test equipment being used.
- The 981/3i 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 981/3i terminals and it is recommended to not have any connections to the interface ports during the procedure.
- In the various steps shown in this procedure, if a step is specific to certain models then it is denoted as such. In all cases, follow the prompts in the display of the 981/3i for the actual procedure.
- The user can press **STOP** to abort the procedure.
- The front panel High Voltage warning light is illuminated whenever there are high voltages or currents present on the 981/3i terminals. When illuminated the user should not touch the connections to the 981/3i.
- Several of the verification steps are performed at very high voltages, the user must ensure that the wiring used has sufficient insulation for the voltages.
- Although the sequence is similar between the 981/3i series products and options, there are differences depending on the voltages, currents, and modes which each model and option is capable of. The 981/3i



automatically accounts for the actual model and option content when guiding the user through the sequence. Individual steps and/or entire groups of steps may not be present in the actual product being verified. Any optional customer requested factory voltage and current generation limitations are applied during verification and so will also affect the procedure.

- Since the 981/3i is internally grounded, the measurement equipment, current sources and test loads used during verification must not be grounded.
- The user can skip verification steps by simply not connecting a measurement device during that step and continuing the step by pressing **START** again to proceed to the next.

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#### EQUIPMENT REQUIRED

1. A DC voltage meter capable of measuring voltages between 100V and 9000V with an input impedance of >10M $\Omega$ . The accuracy of this meter must be <0.06% + 0.025V at these voltages for a 4:1 accuracy ratio. This may be achieved by using different meters depending on the voltage point.
2. A nominal 100k $\Omega$   $\pm$  10% resistor capable of withstanding 300V (0.9W) and having a known value with an accuracy of better than  $\pm$ 0.11% for a 4:1 accuracy ratio.
3. A nominal 1M $\Omega$   $\pm$  10% resistor capable of withstanding 1000V and having a known value with an accuracy of better than  $\pm$ 0.105% for a 4:1 accuracy ratio.
4. A nominal 10M $\Omega$   $\pm$  10% resistor capable of withstanding 500V and having a known value with an accuracy of better than  $\pm$ 0.105% for a 4:1 accuracy ratio.
5. A nominal 100M $\Omega$   $\pm$  10% resistor capable of withstanding 3000V and having a known value with an accuracy of better than  $\pm$ 0.1% for a 4:1 accuracy ratio.
6. A nominal 1G $\Omega$   $\pm$  10% resistor capable of withstanding 500V and having a known value with an accuracy of better than  $\pm$ 0.106% for a 4:1 accuracy ratio.
7. A nominal 100G $\Omega$   $\pm$  10% resistor capable of withstanding 3000V and having a known value with an accuracy of better than  $\pm$ 0.109% for a 4:1 accuracy ratio.
8. A nominal 1T $\Omega$   $\pm$  10% resistor capable of withstanding 1000V and having a known value with an accuracy of better than  $\pm$ 0.35% for a 4:1 accuracy ratio.
9. A nominal 10T $\Omega$   $\pm$  10% resistor capable of withstanding 3000V and having a known value with an accuracy of better than  $\pm$ 0.93% for a 4:1 accuracy ratio.

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#### PROCEDURE

Follow the prompts in the display of the 981/3i for the actual procedure as it varies between models and option content.

- Press the **TEST** key.
- Select "CAL VERIFY" and then press **ENTER**.
- The user is now prompted to remove all leads. Ensure there are no connections to the front panel terminals then press **START**.
- The 981/3i now performs a series of internal tests which require no user equipment or intervention.
- The 981/3i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 981/3i, the meter should be suitable for measuring 100V. Press **START** when the meter is connected.
- The 981/3i now provides nominally 100V to the meter, the meter reading should be checked and recorded when fully settled (the 981i accuracy specification at this level is 0.35V or 0.45V for a 983i). Press **START** when completed.
- The 981/3i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 981/3i, the meter should be suitable for measuring 300V. Press **START** when the meter is connected.

- The 981/3i now provides nominally 300V to the meter, the meter reading should be checked and recorded when fully settled (the 981i accuracy specification at this level is 0.85V or 0.95V for a 983i). Press **START** when completed.
- The 981/3i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 981/3i, the meter should be suitable for measuring 1000V. Press **START** when the meter is connected.
- The 981/3i now provides nominally 1000V to the meter, the meter reading should be checked and recorded when fully settled (the 981i accuracy specification at this level is 2.6V or 2.7V for a 983i). Press **START** when completed.
- The 981/3i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 981/3i, the meter should be suitable for measuring 5000V. Press **START** when the meter is connected.
- The 981/3i now provides nominally 5000V to the meter, the meter reading should be checked and recorded when fully settled (the 981i accuracy specification at this level is 12.6V or 12.7V for a 983i). Press **START** when completed.
- (983i only) The 983i now prompts the user to connect a DC voltmeter between the HV (+) and RET (-) terminals of the 983i, the meter should be suitable for measuring 9000V. Press **START** when the meter is connected.
- (983i only) The 983i now provides nominally 9000V to the meter, the meter reading should be checked and recorded when fully settled (the 983i accuracy specification at this level is 22.7V). Press **START** when completed.
- The 981/3i now prompts the user to connect a 100k $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 300V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is 0.439k $\Omega$  or 0.479k $\Omega$  for the 983i or 1.439k $\Omega$  for a 981i with HSS-2). Press **START** when completed.
- The 981/3i now prompts the user to connect a 1M $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is 4.21k $\Omega$  or 4.42k $\Omega$  for a 983i or 5.21k $\Omega$  for a 981i with HSS-2). Press **START** when completed.
- (Opt. HSS-2 only) The 981i now prompts the user to connect a 1M $\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981i, the resistor should be capable of withstanding 1000V. Press **START** when the resistor is connected.
- (Opt. HSS-2 only) The 981i now displays the measured resistance which should be checked and recorded when fully settled (the accuracy specification at this resistance is 6.11k $\Omega$ ). Press **START** when completed.
- (Opt. HSS-2 only) The 981i now prompts the user to connect a 1M $\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981i, the resistor should be capable of withstanding 600V. Press **START** when the resistor is connected.
- (Opt. HSS-2 only) The 981i now displays the measured resistance which should be checked and recorded when fully settled (the accuracy specification at this resistance is 6.18k $\Omega$ ). Press **START** when completed.

- (Opt. HSS-2 only) The 981i now prompts the user to connect a  $1\text{M}\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981i, the resistor should be capable of withstanding 300V. Press **START** when the resistor is connected.
- (Opt. HSS-2 only) The 981i now displays the measured resistance which should be checked and recorded when fully settled (the accuracy specification at this resistance is  $6.35\text{k}\Omega$ ). Press **START** when completed.
- The 981/3i now prompts the user to connect a  $10\text{M}\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is  $42\text{k}\Omega$  or  $44\text{k}\Omega$  for a 983i or  $43\text{k}\Omega$  for a 981i with HSS-2). Press **START** when completed.
- (Opt. HSS-2 only) The 981i now prompts the user to connect a  $10\text{M}\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981i, the resistor should be capable of withstanding 300V. Press **START** when the resistor is connected.
- (Opt. HSS-2 only) The 981i now displays the measured resistance which should be checked and recorded when fully settled (the accuracy specification at this resistance is  $56\text{k}\Omega$ ). Press **START** when completed.
- The 981/3i now prompts the user to connect a  $100\text{M}\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is  $420\text{k}\Omega$  or  $440\text{k}\Omega$  for a 983i or  $421\text{k}\Omega$  for a 981i with HSS-2). Press **START** when completed.
- (Opt. HSS-2 only) The 981i now prompts the user to connect a  $100\text{M}\Omega$  resistor between the HV (+) and GUARD (-) terminals of the 981i, the resistor should be capable of withstanding 300V. Press **START** when the resistor is connected.
- (Opt. HSS-2 only) The 981i now displays the measured resistance which should be checked and recorded when fully settled (the accuracy specification at this resistance is  $701\text{k}\Omega$ ). Press **START** when completed.
- The 981/3i now prompts the user to connect a  $100\text{M}\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 3000V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is  $403\text{k}\Omega$  or  $407\text{k}\Omega$  for a 983i or  $404\text{k}\Omega$  for a 981i with HSS-2). Press **START** when completed.
- The 981/3i now prompts the user to connect a  $1\text{G}\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is  $4.22\text{M}\Omega$  or  $4.42\text{M}\Omega$  for a 983i). Press **START** when completed.
- The 981/3i now prompts the user to connect a  $100\text{G}\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 500V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is  $620\text{M}\Omega$  or  $640\text{M}\Omega$  for a 983i). Press **START** when completed.

- The 981/3i now prompts the user to connect a 100G $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 3000V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is 437M $\Omega$  or 440M $\Omega$  for a 983i). Press **START** when completed.
- The 981/3i now prompts the user to connect a 1T $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 1000V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the 981i accuracy specification at this resistance is 14.1G $\Omega$  or 14.2G $\Omega$  for a 983i). Press **START** when completed.
- The 981/3i now prompts the user to connect a 10T $\Omega$  resistor between the HV (+) and RET (-) terminals of the 981/3i, the resistor should be capable of withstanding 3000V. Press **START** when the resistor is connected.
- The 981/3i now displays the measured resistance which should be checked and recorded when fully settled (the accuracy specification at this resistance is 374G $\Omega$ ). Press **START** when completed.
- The 981/3i now prompts the user to verify the OPEN measurement at 1000V, this is achieved using no connections to the 981/3i terminals. Press **START** when the terminals have no connections.
- The 981/3i now displays the measured leakage current which should be checked and recorded when fully settled (the accuracy specification is 12pA). Press **START** when completed.
- The 981/3i now prompts the user to verify the OPEN measurement at 5000V, this is achieved using no connections to the 981/3i terminals. Press **START** when the terminals have no connections.
- The 981/3i now displays the measured leakage current which should be checked and recorded when fully settled (the 981/3i accuracy specification is 20pA). Press **START** when completed.
- (983i only) The 983i now prompts the user to verify the OPEN measurement at 9000V, this is achieved using no connections to the 983i terminals. Press **START** when the terminals have no connections.
- (983i only) The 983i now displays the measured leakage current which should be checked and recorded when fully settled (the 983i accuracy specification is 28pA). Press **START** when completed.
- (Opt. HSS-2 only) The 981i now prompts the user to verify the OPEN measurement at 300V, this is achieved using no connections to the 981i terminals. Press **START** when the terminals have no connections.
- (Opt. HSS-2 only) The 981i now displays the measured leakage current which should be checked and recorded when fully settled (the 981i accuracy specification is 5.3nA). Press **START** when completed.
- (Opt. HSS-2 only) The 981i now prompts the user to verify the OPEN measurement at 4000V, this is achieved using no connections to the 981i terminals. Press **START** when the terminals have no connections.
- (Opt. HSS-2 only) The 981i now displays the measured leakage current which should be checked and recorded when fully settled (the 981i accuracy specification is 9nA). Press **START** when completed.
- If all steps above were completed successfully then the calibration is completed and the 981/3i display shows "FINISHED CALIBRATION" for a short time. The user should remove all equipment and connections from the 981/3i.

## SECTION 11 – PROGRAMMING VIA AN INTERFACE

The 981/3i may be programmed via the RS232, GPIB or Ethernet interface. All use the same general format for commands and query responses. All data uses the standard 7-bit ASCII character set. In general all activities are independent for each interface.

There are two types of command –

- Commands which do not have a response. These always cause the 981/3i to take an action.
- Commands which have a response (these are named Query commands in this document). These generally do not cause the 981/3i to take an action other than sending back the response. These all have a keyword which ends with the ? character.

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

**<CR>** the carriage return character

**<LF>** the line feed character

**<FF>** the form feed character

**<TAB>** the tab character

**<SPACE>** the space character

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

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

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

**<STRING>** is a general string of ASCII characters

**<NR1>** is an integer numeric

**<NR3>** is a floating point numeric

**<BOOL>** is a boolean, indicating true or false

### GENERAL COMMAND SYNTAX

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

Multiple commands can be transferred as a single set of commands; each command is separated from the next by a command separator. If there are multiple query commands in a single set then each response is given as separate fields in the overall response, which is not transmitted until all commands in the set have been successfully actioned. The maximum overall length of a response set is 19999 characters (except for the Ethernet interface which is limited to 1500). Commands are always 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 981/3i 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 981/3i 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.

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## 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 981/3i. The first field in a command is always the command keyword; some commands have a second command keyword in the second field.
2. **DATA.** There are several types of data, the type used is dependent on the field -
  - a. **<EMPTY>.** This is a field containing no, or only whitespace, characters between the enclosing separators. In many commands the user may give an empty field where another format is expected, this generally has a specific effect defined in the description for each command.
  - b. **<BOOL>.** This can be the single character “Y” or ‘1’ denoting a true state, or the single character ‘N’ or ‘0’ denoting the false state (the Y or N may be upper- or lower-case).
  - c. **<NR1>.** One of three methods may be used to define a **<NR1>** field-
    - i. **Decimal value.** A string of numeric (0 through 9) characters defining a decimal number without polarity or decimal point (e.g. “123” defines the decimal number one hundred and twenty-three). A value greater than 4294967295 is a syntax error.
    - ii. **Hexadecimal value.** The user can optionally start this field with the characters “0X” or the single character “X” (in both cases the “X” character can also be lowercase), in which case the following data defines the number in hexadecimal format using the numeric characters and the letters A through F (either upper- or lowercase), as an example 0x12 defines the decimal numeric value 18. A value greater than 0xffffffff is a syntax error.
    - iii. **Binary value.** The user can optionally start this field with the characters “0B” or the single character “B” (in both cases the “B” character can also be lowercase), in which case the following data defines the number in binary format using the “0” and “1” characters only with the most-significant bit being defined first, as an example 0b00010010 defines the decimal numeric value 18 or hexadecimal value 0x12. In all cases, leading digits or bits which are not defined are assumed to be zero (e.g. 0b00010010 is the same as 0b10010). A value greater than 32 bits is a syntax error.
  - d. **<NR3>.** This is a string of characters defining a floating point numeric value, optionally having a polarity, and/or a decimal point, and/or an exponent. Within the limitations of the 981/3i 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.

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#### FIELD SEPARATOR

Fields are separated by the comma character.

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#### COMMAND SEPARATOR

Commands are separated by the semi-colon character.

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#### COMMAND TERMINATOR

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

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

### GENERAL RESPONSE SYNTAX

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

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

On the GPIB interface the user must take some action to receive the response from the 981/3i (i.e. a READ bus operation). If a read operation is performed when there is no data to be transmitted then a blank data is transmitted (i.e. a single space character followed by <CR><LF>).

If another set of commands is decoded containing a query command prior to the 981/3i fully transmitting a prior response then the new response is not provided and an error is raised.

The following types of responses are given-

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

## DELAYS AND TIMEOUTS

The user does not need to perform any delays between sets of commands, or between a set of commands containing query commands and reading the response. The 981/3i automatically handshakes the commands as needed. The only exception to this is following application of power to the 981/3i 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 981/3i will "hold-off" a set of commands (e.g. waiting for a previous set of commands to be decoded) is 100ms.

For all interfaces, responses to query commands are generally transmitted within a very short period of time, however in some circumstances there may be some delay enforced by the 981/3i. The user should use a timeout of no less than 100ms for responses.

## MULTIPLE INTERFACE OPERATION

Generally operation of the 981/3i via multiple interfaces is not recommended but is possible. The 981/3i will decode sets of commands in the order in which they were terminated (each interface has separate receive and transmit buffers). Any query responses will only be transmitted via the interface from which the query command originated.

## FRONT PANEL OPERATION WHILE USING INTERFACES

It is possible to inter-mix front panel and interface operation of the 981/3i however the user should be aware of the following-



- The front panel has three states associated with interface operation-
  - **LOCAL**. The front panel operates normally. When any command from an interface is decoded, the front panel enters either the **REMOTE** or **REMOTE LOCK-OUT** state (depending on the interface and the commands executed) and any menu in progress is aborted.
  - **REMOTE**. The front panel is locked out other than the **STOP** button (and the **START** button in some circumstances) but the user can return to the LOCAL state by pressing the **CONFIG** key.
  - **REMOTE LOCK-OUT**. The front panel is completely locked-out except for the **STOP** button (and the **START** button in some circumstances). The user cannot return the front panel to any other state by front panel action.
- The GPIB interface also has a set of remote states associated with it as defined by IEEE488.1 and IEEE488.2. The 981/3i does NOT decode commands while in the GPIB LOCAL or GPIB LOCAL LOCK-OUT states (as required by IEEE488.2). Transitions between the GPIB interface states are controlled by specific GPIB bus commands as defined by the standards.
- A LOCKOUT command is provided on the RS232 and Ethernet interfaces to allow the user to command the front panel to the REMOTE LOCK-OUT state; this command raises an error if received via the GPIB interface.
- A LOCAL command is provided on the RS232 and Ethernet interfaces to allow the user to remotely return the front panel to the LOCAL state. This command must be the last command in a set of commands.

## GPIB BUS COMMANDS

Most standard GPIB bus commands are implemented in the normal fashion, however some cause a special activity in the 981/3i-

### DEVICE CLEAR (SDC AND DCL)

Either of these cause the 981/3i to clear all interface buffers, abort any test sequence in progress, return to the no test sequence selected state and clear all interface status registers.

### INTERFACE CLEAR (IFC)

This causes the 981/3i to clear all interface buffers and clear all interface status registers. It does NOT affect any test sequence in progress or affect the selected test sequence.

### GROUP EXECUTE TRIGGER (GET)

This can be used as a GPIB interface command terminator.

## ETHERNET SESSIONS

The Ethernet interface uses TCP/IP as its' transport protocol which is a session based protocol. The computer is the session client and the 981/3i is the session server, so each session is managed by the computer.

The 981/3i is only allowed to have one session active at a time. The active session is established between the 981/3i and the opening combination of the client IP address and TCP port (this combination is often called a "socket").

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

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

- Closing the session.

If the 981/3i is power cycled then it will power up with no active session; the user should employ timeouts to detect that the 981/3i has become off-line and restart the session.

If a session is inactive for more than 1 minute then the 981/3i will allow a session to be initiated from a different source, automatically closing the inactive session. This prevents a potential lockup if the user does not close an active session properly.

## STATUS REGISTERS

There are several status registers associated with the 981/3i interfaces.

### STB AND SRE REGISTERS

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

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

- Bit 0, decimal value 1, binary value 00000001 – set if a high voltage is currently present on the HV terminal. The value of this status bit is “dynamic” – i.e. its’ value can change without user interaction.
- Bit 1, decimal value 2, binary value 00000010 – set when a test step dwell period is completed, cleared when read, when a test sequence is started, when a different test sequence is selected, or when reset.
- Bit 2, decimal value 4, binary value 00000100 – set if a test sequence is currently being performed. The value of this status bit is “dynamic” – i.e. its’ value can change without user interaction.
- Bit 3, decimal value 8, binary value 00001000 – set when a test sequence is completed, cleared when read, when a test sequence is started, when a different test sequence is selected, or when reset.
- Bit 4, decimal value 16, binary value 00010000 – set when a test failure has been detected, cleared when read, when a test sequence is started, when a different test sequence is selected, or when reset.
- Bit 6, decimal value 64, binary value 01000000 – as defined by IEEE488.1, set if the 981/3i is asserting the SRQ line, otherwise it is cleared. Always zero for the SRE register.
- Bit 7, decimal value 128, binary value 10000000 – not used, always 0.

### OPC REGISTER

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

- Bit 0, decimal value 1, binary value 00000001 – set when a command set is decoded without error.
- Bit 1, decimal value 2, binary value 00000010 – set when a command is decoded with a field count error.
- Bit 2, decimal value 4, binary value 00000100 – set when a command is decoded with an internal memory error.
- Bit 3, decimal value 8, binary value 00001000 – set when a command is decoded with a field syntax or data range error.
- Bit 4, decimal value 16, binary value 00010000 – set when a command is decoded with a compatibility error (e.g. this 981/3i variant is incapable of performing the requested operation).
- Bit 5, decimal value 32, binary value 00100000 – set when a query command is decoded but there is insufficient room in the output buffer for the response.

- Bit 6, decimal value 64, binary value 01000000 – set when the command buffer is overflowed.
- Bit 7, decimal value 128, binary value 10000000 – set when a command is received with a command word that is not known to the 981/3i, or the command cannot be processed at this time.

#### ESR REGISTER

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

- Bit 0, decimal value 1, binary value 00000001 – set when a command is decoded and an error occurred during decode.
- Bit 1, decimal value 2, binary value 00000010 – set when a query command is decoded but the response is too long for the response buffer.
- Bit 2, decimal value 4, binary value 00000100 – set when a test failure has been detected.
- Bit 3, decimal value 8, binary value 00001000 – set when the internal temperature of the 981/3i is above limits.
- Bit 4, decimal value 16, binary value 00010000 – set when an internal fault is detected.
- Bit 6, decimal value 64, binary value 01000000 – not used, always 0.
- Bit 7, decimal value 128, binary value 10000000 – not used, always 0.

#### ERR REGISTER

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

0. The command was decoded without error.
1. The command could not be decoded at this time.
2. The command attempted to create an invalid test step number.
3. The command attempted to create or access an invalid test sequence number.
4. The command created a test step which is not compatible with this specific instruments' capability.
5. The command contained a numeric value field which was outside of the allowable range.
6. The command contained a field which did not have the correct syntax.
7. The command did not contain an expected field.
8. The command contained additional fields than expected.
9. The command keyword was not recognized.
10. The 981/3i had an internal memory error while executing the command.
11. The previous response had not yet been transmitted when this query command was executed.
12. The set of commands was too long, over 1023 characters.

### COMMANDS

| Command                  | Description                                                                                    |
|--------------------------|------------------------------------------------------------------------------------------------|
| <b>Register Commands</b> |                                                                                                |
| *CLS                     | Clears the STB, SRE, OPC, ESR and ERR registers.<br>Resets the front panel to the LOCAL state. |

| Command                                                                                                                                 | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *ERR?                                                                                                                                   | Responds with a <NR1> field value of the ERR register then clears the ERR register                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| *ESR?                                                                                                                                   | Responds with a <NR1> field value of the ESR register then clears the ESR register                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| *OPC?                                                                                                                                   | Responds with a <NR1> field value of the OPC register then clears the OPC register                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| *SRE,<NR1>                                                                                                                              | Sets the SRE register                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| *SRE?                                                                                                                                   | Responds with a <NR1> field value of the SRE register                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| *STB?                                                                                                                                   | Responds with a <NR1> field value of the STB register then certain bits of the STB register are cleared                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Commands to create, edit, recall or save an AUTO TEST Sequence<br/>(Cannot be used while an AUTO TEST or MANUAL TEST is running)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| NOSEQ                                                                                                                                   | Selects that neither AUTO TEST nor MANUAL TEST is active.<br>Clears the INTERFACE TEST sequence.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| ADD,...                                                                                                                                 | Adds a test step to the end of the active AUTO TEST sequence.<br>If there is no active AUTO TEST sequence then this automatically creates an INTERFACE TEST sequence which is a single step as defined by this command and any additional ADD... commands will be appended to the end of it.<br>See –<br><a href="#">DCIR Configuration Fields</a> (note that this is for backwards compatibility purposes only)<br><a href="#">IR Configuration Fields</a><br><a href="#">PAUSE Configuration Fields</a><br><a href="#">HOLD Configuration Fields</a><br><a href="#">SWITCH (948i configuration) Configuration Fields</a><br><a href="#">SWITCH (964i configuration) Configuration Fields</a>                                                                                                                                                                                                                                                 |
| NAME,<STRING>                                                                                                                           | Names the active AUTO TEST sequence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| RCL,<NR1>                                                                                                                               | Recalls an AUTO TEST sequence from the requested store # and makes it active                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| SAVE,<NR1>                                                                                                                              | Saves the active AUTO TEST sequence into the requested store #                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| SET,<NR1>, ...                                                                                                                          | Overwrite a step in the active AUTO TEST sequence (see also ADD,...)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Commands to edit the MANUAL TEST<br/>(Cannot be used while an AUTO TEST or MANUAL TEST is running)</b>                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| MANUAL,...                                                                                                                              | Defines the MANUAL TEST and makes it ready to be run. The fields are as follows (in order) –<br>1 <sup>st</sup> field: <NR3> Test voltage in V<br>2 <sup>nd</sup> field: <NR3> Charge time in seconds<br>3 <sup>rd</sup> field: <STRING> Either AMPS or OHMS defining whether the limits are in the units of amps or ohms resp.<br>4 <sup>th</sup> field: <NR3> The minimum limit in amps or ohms as set above (note that setting zero amps sets for no minimum)<br>5 <sup>th</sup> field: <NR3> The maximum limit in amps or ohms as set above (note that leaving this field blank sets for no maximum)<br>6 <sup>th</sup> field: <NR3> Zero offset in amps (taken as zero if blank)<br>7 <sup>th</sup> field: <STRING> Either ISO or GND indicating if the DUT is isolated or grounded resp.. Note that leaving this field blank or entirely eliminating it selects ISO, which is the only valid selection if option HSS-2 is not installed) |

| Command                                                                                                                                        | Description                                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Commands to Make Ready or to Run an AUTO TEST Sequence or MANUAL TEST<br/>(Cannot be used while an AUTO TEST or MANUAL TEST is running)</b> |                                                                                                                                                                                                       |
| READY                                                                                                                                          | Makes the active AUTO TEST sequence ready to be run by the START button                                                                                                                               |
| RUN                                                                                                                                            | If the MANUAL TEST is selected: starts the MANUAL TEST<br>Otherwise: last or presently selected AUTO TEST (or the INTERFACE TEST as applicable)                                                       |
| RUN,MANUAL                                                                                                                                     | Starts a MANUAL TEST                                                                                                                                                                                  |
| RUN,AUTO                                                                                                                                       | Starts the last or presently selected AUTO TEST (or the INTERFACE TEST as applicable)                                                                                                                 |
| RUN,ZERO                                                                                                                                       | Start the last or presently selected AUTO TEST (or the INTERFACE TEST as applicable) in ZERO mode                                                                                                     |
| <b>AUTO TEST Status Query</b>                                                                                                                  |                                                                                                                                                                                                       |
| READY?                                                                                                                                         | Responds with a <BOOL> indicating if an AUTO TEST is ready to be run (1) or not (0)                                                                                                                   |
| <b>Running AUTO TEST or MANUAL TEST Control Commands<br/>(Can only be used while an AUTO TEST or MANUAL TEST is running)</b>                   |                                                                                                                                                                                                       |
| ABORT or STOP                                                                                                                                  | Aborts an AUTO TEST or stops a MANUAL TEST                                                                                                                                                            |
| CONT                                                                                                                                           | Continues a running AUTO TEST sequence while performing a programmed HOLD step                                                                                                                        |
| <b>Command to modify a MANUAL TEST while running a MANUAL TEST after charging</b>                                                              |                                                                                                                                                                                                       |
| MANZERO                                                                                                                                        | Sets the zero offset for the running MANUAL TEST to the actual current measurement at the time of this command.                                                                                       |
| VOLTS,<NR3>                                                                                                                                    | Sets the voltage test level of a running MANUAL TEST. Note that this does not change the configured setting, only the test voltage for this test.                                                     |
| <b>Active AUTO TEST Sequence Information Query Commands<br/>(Can only be used while not running an AUTO TEST Sequence)</b>                     |                                                                                                                                                                                                       |
| NAME?                                                                                                                                          | Responds with a <STRING> which is the name of the active AUTO TEST sequence                                                                                                                           |
| <b>Active AUTO TEST Sequence Status Query Commands</b>                                                                                         |                                                                                                                                                                                                       |
| RUN?                                                                                                                                           | Responds with a <BOOL> indicating if an AUTO TEST or MANUAL TEST is being run (1) or not (0)                                                                                                          |
| SEQ?                                                                                                                                           | Responds with a <NR1> which is –<br>If an AUTO TEST is selected or running: the sequence # (1 through 99, or 100 for the INTERFACE TEST)<br>If MANUAL TEST is selected or running: 0<br>Otherwise: -1 |
| STEP?                                                                                                                                          | Responds with a <NR1> indicating –<br>If an AUTO TEST is being run: the step # presently being performed<br>If a MANUAL TEST is being performed: 1<br>Otherwise: 0                                    |
| <b>Test Result Query Commands<br/>(While running a test sequence)</b>                                                                          |                                                                                                                                                                                                       |

| Command                                                               | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| MEASRSLT?,<STRING>                                                    | Responds with a <NR3> measurement result during execution of an AUTO TEST or MANUAL TEST. <STRING> is one of –<br>AMPS – leakage current (in Amps)<br>VOLTS – voltage (in Volts)<br>OHMS – impedance (in $\Omega$ )<br>Note – this can also be used after completion of a MANUAL TEST in which case the selected final measurement data in that test is returned.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Test Result Query Commands<br/>(After running a test sequence)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| RSLT?                                                                 | Responds with a <NR1> indicating the overall fail status and reason of the presently running, or last completed AUTO TEST or MANUAL TEST (0 if neither). This is the logical OR of all individual step status flags.<br><a href="#">See Test Step Status Flags</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| STAT?                                                                 | Responds with a <STRING> indicating the pass/fail state of each test step in the presently running, or last completed AUTO TEST. The response contains one character for each defined test step-<br>P passed<br>F failed<br>- Not performed<br>? In process<br>Returns a single – character if no AUTO TEST is running or has been run, or if a MANUAL TEST is running or was last run.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| STEPRSLT?,<NR1>                                                       | Responds with a set of fields giving the complete set of results for the specified test step in the previously completed AUTO TEST. <a href="#">See STEPRSLT? Response Fields</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| MANRSLT?                                                              | Responds with a set of fields giving the complete set of results for the either presently running or the last run MANUAL TEST. The returned data fields are as follows (in order) –<br>1 <sup>st</sup> field: <NR1> indicating if the MANUAL TEST has not been run or is charging (0) or otherwise (1).<br>2 <sup>nd</sup> field: <NR1> indicating the status of the MANUAL TEST (same as for RSLT? above)<br>3 <sup>rd</sup> field: <NR1> indicating the present or last completed stage of the MANUAL TEST. If this is 0 then indicates that the MANUAL TEST has not been run, 1 indicates it is presently charging, otherwise indicates that it is either running or has been completed.<br>4 <sup>th</sup> field: <NR3> indicating the time (in seconds) in the charging or post-charging phase of the MANUAL TEST<br>5 <sup>th</sup> field: <NR3> indicating the voltage (in V)<br>6 <sup>th</sup> field: <NR3> indicating the leakage current (in A)<br>7 <sup>th</sup> field: <NR3> indicating the insulation resistance (in ohms) |
| <b>Configuration Settings Commands</b>                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| BEEP,START,<NR1>                                                      | Configures the start beep sounds to 0 (off) to 4 (loud)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| BEEP?,START                                                           | Responds with the <NR1> setting of the start beep sound                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| BEEP,PASS,<NR1>                                                       | Configures the pass beep sounds to 0 (off) to 4 (loud)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| BEEP?,PASS                                                            | Responds with the <NR1> setting of the pass beep sound                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| BEEP,FAIL,<NR1>                                                       | Configures the fail beep sounds to 0 (off) to 4 (loud)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| BEEP?,FAIL                                                            | Responds with the <NR1> setting of the fail beep sound                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| BEEP,KEY,<NR1>                                                        | Configures the key press beep sounds to 0 (off) to 4 (loud)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| BEEP?,KEY                                                             | Responds with the <NR1> setting of the key press beep sound                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

| Command                         | Description                                                                                                                                                                                                                                                                                                           |
|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DATE,<NR1>,<NR1>,<NR1>          | Sets the present date (month, date, year)                                                                                                                                                                                                                                                                             |
| DHCP,<BOOL>                     | Configures the Ethernet DHCP setting                                                                                                                                                                                                                                                                                  |
| DHCP?                           | Responds with the <BOOL> Ethernet DHCP setting                                                                                                                                                                                                                                                                        |
| DIO,START,<STRING>              | Configures the START DIO input to OFF, HI or LO                                                                                                                                                                                                                                                                       |
| DIO?,START                      | Responds with the <STRING> setting for the START DIO input                                                                                                                                                                                                                                                            |
| DIO,ABORT,<STRING>              | Configures the ABORT DIO input to OFF, HI or LO                                                                                                                                                                                                                                                                       |
| DIO?,ABORT                      | Responds with the <STRING> setting for the ABORT DIO input                                                                                                                                                                                                                                                            |
| DIO,INTERLOCK,<STRING>          | Configures the <b>INTERLOCK</b> DIO input to OFF, HI or LO                                                                                                                                                                                                                                                            |
| DIO?,INTERLOCK                  | Responds with the <STRING> setting for the <b>INTERLOCK</b> DIO input                                                                                                                                                                                                                                                 |
| DIO,PASS,<STRING>               | Configures the <b>PASS</b> DIO output to HI or LO                                                                                                                                                                                                                                                                     |
| DIO?,PASS                       | Responds with the <STRING> setting for the <b>PASS</b> DIO output                                                                                                                                                                                                                                                     |
| DIO,FAIL,<STRING>               | Configures the <b>FAIL</b> DIO output to HI or LO                                                                                                                                                                                                                                                                     |
| DIO?,FAIL                       | Responds with the <STRING> setting for the <b>FAIL</b> DIO output                                                                                                                                                                                                                                                     |
| DIO,TESTING,<STRING>            | Configures the <b>TESTING</b> DIO output to HI or LO                                                                                                                                                                                                                                                                  |
| DIO?,TESTING                    | Responds with the <STRING> setting for the <b>TESTING</b> DIO output                                                                                                                                                                                                                                                  |
| DIO,DWELL,<STRING>              | Configures the <b>DWELL</b> DIO output to HI or LO                                                                                                                                                                                                                                                                    |
| DIO?,DWELL                      | Responds with the <STRING> setting for the <b>DWELL</b> DIO output                                                                                                                                                                                                                                                    |
| DIO,HV,<STRING>                 | Configures the <b>HV PRESENT</b> DIO output to HI or LO                                                                                                                                                                                                                                                               |
| DIO?,HV                         | Responds with the <STRING> setting for the <b>HV PRESENT</b> DIO output                                                                                                                                                                                                                                               |
| FASTRERUN,<NR1>                 | Configures how a test sequence may be rerun from the front panel<br>0 – enable fast rerun<br>1 – enable fast rerun if pass<br>2 – disable fast rerun                                                                                                                                                                  |
| FASTRERUN?                      | Responds with the <NR1> fast rerun setting                                                                                                                                                                                                                                                                            |
| GATEWAY,<NR1>,<NR1>,<NR1>,<NR1> | Configures the Ethernet Gateway IP Address setting                                                                                                                                                                                                                                                                    |
| GATEWAY?                        | Responds with the Ethernet Gateway IP address setting as four <NR1>                                                                                                                                                                                                                                                   |
| GPIB,<NR1>                      | Configures the GPIB address setting                                                                                                                                                                                                                                                                                   |
| GPIB?                           | Responds with the <NR1> GPIB address setting                                                                                                                                                                                                                                                                          |
| IP,<NR1>,<NR1>,<NR1>,<NR1>      | Configures the Ethernet IP Address setting                                                                                                                                                                                                                                                                            |
| IP?                             | Responds with the Ethernet IP address setting as four <NR1>                                                                                                                                                                                                                                                           |
| MANZERO?                        | Returns the <NR3> MANUAL TEST zero offset (in amps). This can be used at any time.                                                                                                                                                                                                                                    |
| RS232,<NR1>                     | Configures the RS232 baud rate setting                                                                                                                                                                                                                                                                                |
| RS232?                          | Responds with the <NR1> RS232 baud rate setting                                                                                                                                                                                                                                                                       |
| SUBNET,<NR1>,<NR1>,<NR1>,<NR1>  | Configures the Ethernet IP Subnet Mask setting                                                                                                                                                                                                                                                                        |
| SUBNET?                         | Responds with the Ethernet IP Subnet Mask setting as four <NR1>                                                                                                                                                                                                                                                       |
| SWITCHES,<STRING>               | Configures the switch matrix unit control setting.<br>NONE – no external switch matrix units<br>948 – a single 948i using RS232<br>964SER – a single 964i using RS232<br>964VICL1 – a single 964i using VICL<br>964VICL2 – two 964i using VICL<br>964VICL3 – three 964i using VICL<br>964VICL4 – four 964i using VICL |
| SWITCHES?                       | Responds with the <STRING> switch matrix unit control setting                                                                                                                                                                                                                                                         |
| TIME,<NR1>,<NR1>,<NR1>          | Sets the present time (hours, minutes, seconds)                                                                                                                                                                                                                                                                       |
| TIME12,<BOOL>                   | Configures the clock 12/24hr configuration setting                                                                                                                                                                                                                                                                    |
| TIME12?                         | Responds with the <BOOL> clock 12/24hr configuration setting                                                                                                                                                                                                                                                          |
| <b>Identification Commands</b>  |                                                                                                                                                                                                                                                                                                                       |

| Command        | Description                                                                                                                                                                                                                                                               |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| *IDN?          | Responds with a set of fields describing the product, see<br><br><b>*IDN? Response Fields</b>                                                                                                                                                                             |
| *OPT?          | Responds with a set of <STRING> fields indicating each installed option                                                                                                                                                                                                   |
| SERNUM?        | Responds with a <STRING> indicating the serial number of the product                                                                                                                                                                                                      |
| Misc. Commands |                                                                                                                                                                                                                                                                           |
| DATE?          | Responds with the present date as a <STRING> (mm/dd/yy)                                                                                                                                                                                                                   |
| LOCAL          | Sets the front panel into the LOCAL state                                                                                                                                                                                                                                 |
| LOCKOUT        | Sets the front panel into the REMOTE LOCK-OUT state                                                                                                                                                                                                                       |
| DIOSTATES?     | Responds with a <NR1> indicating the state of the START (1), STOP (2) and INTERLOCK (4) digital inputs. The returned value is additive for each active input                                                                                                              |
| PHASE?         | Responds with the present running AUTO TEST step or MANUAL TEST phase as a <NR1>                                                                                                                                                                                          |
| *RST           | Resets all interfaces, and -<br>If a MANUAL TEST was running: stops it<br>If an AUTO TEST was running: aborts it<br>If neither an AUTO TEST or MANUAL TEST is running: makes neither an AUTO TEST or MANUAL TEST actively selected and clears the INTERFACE TEST sequence |
| TIME?          | Responds with the present time as a <STRING> (hh:mm:ss)<br>This is always in 24hr format                                                                                                                                                                                  |

**\*IDN? RESPONSE FIELDS**

| Field # | Field Format | Description                                   |
|---------|--------------|-----------------------------------------------|
| 1       | <STRING>     | Manufacturer (e.g. VITREK)                    |
| 2       | <STRING>     | Model (e.g. 981i).                            |
| 3       | <STRING>     | Serial number (e.g. 123456)                   |
| 4       | <STRING>     | Main firmware version (e.g. v1.45)            |
| 5       | <STRING>     | Front panel firmware version (e.g. v1.21)     |
| 6       | <STRING>     | Measurement DSP firmware version (e.g. v1.21) |
| 7       | <STRING>     | Drive DSP firmware version (e.g. v1.21)       |

**DCIR CONFIGURATION FIELDS**

Note that this format is included in the 981/3i for backwards compatibility with the Vitrek 950 series products. Users solely using the 981/3i should use the IR type configuration method in the section following this one.

| Field # | Field Format | Value                              |
|---------|--------------|------------------------------------|
| 1       | <STRING>     | DCIR                               |
| 2       | <NR3>        | Test Voltage (in V)                |
| 3       | <NR3>        | Any value in this field is ignored |
| 4       | <NR3>        | Ramp Time (in seconds)             |
| 5       | <NR3>        | Dwell time (in seconds)            |
| 6       | <NR3>        | Pre-check delay (in seconds)       |



|    |           |                                                                                                                                                                                                                 |
|----|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7  | <STRING>  | PASS - Test is ended as soon as passes<br>FAIL - Test is ended as soon as fails<br>TIME - Test always extends for the full time<br>STDY – Test is ended if the load is within limits and is steady or improving |
| 8  | <STRING>  | AMPS - Leakage limits are in Amps<br>OHMS - Leakage limits are in $\Omega$                                                                                                                                      |
| 9  | <NR3>     | Minimum Leakage Limit (in A or $\Omega$ )                                                                                                                                                                       |
| 10 | <NR3>     | Maximum Leakage Limit (in A or $\Omega$ )                                                                                                                                                                       |
|    | <EMPTY>   | No maximum limit (only valid for impedance)                                                                                                                                                                     |
| 11 | <NR1>     | Any value in this field is ignored                                                                                                                                                                              |
| 12 | <NR1>     | Any value in this field is ignored                                                                                                                                                                              |
| 13 | <STRING>  | Any value in this field is ignored                                                                                                                                                                              |
| 14 | <STRING>  | ABORT - Abort on failure<br>CONT - Continue on failure                                                                                                                                                          |
| 15 | <NR3>     | Any value in this field is ignored                                                                                                                                                                              |
| 16 | <EMPTY>   | Load is not grounded                                                                                                                                                                                            |
|    | <MISSING> |                                                                                                                                                                                                                 |
|    | <STRING>  | GND : Load is grounded (valid if option HSS-2 is fitted)<br>ISO : Load is not grounded                                                                                                                          |

Example –

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

Configures the following (in order) –

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

IR CONFIGURATION FIELDS

| Field # | Field Format | Value                        |
|---------|--------------|------------------------------|
| 1       | <STRING>     | IR                           |
| 2       | <NR3>        | Test Voltage (in V)          |
| 3       | <NR3>        | Charge Time (in seconds)     |
| 4       | <NR3>        | Dwell time (in seconds)      |
| 5       | <NR3>        | Pre-check delay (in seconds) |

|    |           |                                                                                                                                                                                                                 |
|----|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6  | <STRING>  | PASS - Test is ended as soon as passes<br>FAIL - Test is ended as soon as fails<br>TIME - Test always extends for the full time<br>STDY – Test is ended if the load is within limits and is steady or improving |
| 7  | <STRING>  | AMPS - Leakage limits are in Amps<br>OHMS - Leakage limits are in $\Omega$                                                                                                                                      |
| 9  | <NR3>     | Minimum Leakage Limit (in A or $\Omega$ )                                                                                                                                                                       |
| 10 | <NR3>     | Maximum Leakage Limit (in A or $\Omega$ )                                                                                                                                                                       |
|    | <EMPTY>   | No maximum limit (only valid for impedance)                                                                                                                                                                     |
| 11 | <STRING>  | ABORT - Abort on failure<br>CONT - Continue on failure                                                                                                                                                          |
| 12 | <NR3>     | Zero offset current (in A)                                                                                                                                                                                      |
| 13 | <EMPTY>   | Load is not grounded                                                                                                                                                                                            |
|    | <MISSING> |                                                                                                                                                                                                                 |
|    | <STRING>  | GND : Load is grounded (valid if option HSS-2 is fitted)<br>ISO : Load is not grounded                                                                                                                          |

Example –

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

Configures the following (in order) –

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

---

PAUSE CONFIGURATION FIELDS

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

Example –

ADD,PAUSE,5.0

Configures the following (in order) –

- A PAUSE type test step
- 5 second pause time

---

**HOLD CONFIGURATION FIELDS**

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

Example –

ADD,HOLD,60.0

Configures the following (in order) –

- A HOLD type test step
- 60 second timeout

---

**SWITCH (948I CONFIGURATION) CONFIGURATION FIELDS**

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

Example –

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

Configures the following (in order) –

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

---

**SWITCH (964I CONFIGURATION) CONFIGURATION FIELDS**

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

|       |       |                                                                         |
|-------|-------|-------------------------------------------------------------------------|
| 12-19 | <NR1> | 964 #2 Switch bank data banks 7-0 resp. (only if configured for >1x964) |
| 20-27 | <NR1> | 964 #3 Switch bank data banks 7-0 resp. (only if configured for >2x964) |
| 28-35 | <NR1> | 964 #4 Switch bank data banks 7-0 resp. (only if configured for 4x964)  |

Example –

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

Configures the following (in order) –

- A SWITCH type test step
- 0 second pre-switch delay
- 0.25 second post-switch delay
- Bank #7 set to hexadecimal 00
- Bank #6 set to hexadecimal 00
- Bank #5 set to hexadecimal 00
- Bank #4 set to hexadecimal 00
- Bank #3 set to hexadecimal 00
- Bank #2 set to hexadecimal 00
- Bank #1 set to hexadecimal 00
- Bank #0 set to hexadecimal 00

#### TEST STEP STATUS FLAGS

This is a <NR1> value formed by the addition (or logical OR) of the values shown in the table below. Note that a zero total value indicates that no failure occurred.

| Bit # | Value  | Description                                                        |
|-------|--------|--------------------------------------------------------------------|
| 0     | 1      | 981/3i Internal Fault                                              |
| 1     | 2      | Unstable load                                                      |
| 2     | 4      | Breakdown detected (> setting)                                     |
| 3     | 8      | HOLD Step timeout exceeded                                         |
| 4     | 16     | User abort                                                         |
| 5     | 32     | Not used – ignore if present                                       |
| 6     | 64     | Not used – ignore if present                                       |
| 7     | 128    | Not used – ignore if present                                       |
| 8     | 256    | Check <minimum setting                                             |
| 9     | 512    | Check >maximum setting                                             |
| 10    | 1024   | Not used – ignore if present                                       |
| 11    | 2048   | Not used – ignore if present                                       |
| 12    | 4096   | INTERLOCK failure                                                  |
| 13    | 8192   | HV TRIP activated                                                  |
| 14    | 16384  | Switch Matrix unit did not communicate                             |
| 15    | 32768  | Breakdown detected (> surge drive ability limit for test type)     |
| 16    | 65536  | 981/3i Overheated                                                  |
| 17    | 131072 | Step type incompatible with the model and option content           |
| 18    | 262144 | Not used – ignore if present                                       |
| 19    | 524288 | Breakdown detected (> sustained drive ability limit for test type) |

|    |         |                                                                                                                                                                      |
|----|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 20 | 1048576 | A steady or decreasing current was not detected during dwell but the load was otherwise within the limits in a DCIR type step configured to terminate in this manner |
|----|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|

#### STEPRSLT? RESPONSE FIELDS

| Field # | Field Format     | Value                                                                                                                                                            |
|---------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | <NR1>            | 0 – Not executed<br>1 – Terminated during Ramp<br>2 – Terminated during Dwell (during delay)<br>3 – Terminated during Dwell (after delay)<br>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), only present if applicable                                                                                                          |
| 5       | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 6       | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 7       | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 8       | <NR3> or <EMPTY> | Highest check result, only present if applicable                                                                                                                 |
| 9       | <NR3> or <EMPTY> | Lowest check result, only present if applicable                                                                                                                  |
| 10      | <NR3> or <EMPTY> | Average check result, only present if applicable                                                                                                                 |
| 11      | <NR3> or <EMPTY> | Last check result, only present if applicable                                                                                                                    |
| 12      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 13      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 14      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 15      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 16      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 17      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 18      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |
| 19      | <NR3> or <EMPTY> | Not used – ignore if present                                                                                                                                     |

#### PROGRAMMING EXAMPLE

If the user wishes to be able to send a command to the 981/3i 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 981/3i, it should be similar to **VITREK,981i,000000,v1.45,v1.23,v1.23,v1.23**
- Refer to \*IDN? Response Fields for details regarding the response.

## PROGRAMMING GUIDELINES

### AVOID INTERFACE SPECIFIC METHODS

The 981/3i can be interfaced to with RS232, GPIB or Ethernet interfaces. It is recommended that the programmer not use interface specific methods (e.g. serial polling over GPIB) to ease the migration between interfaces at a later date. Similarly, it is recommended to always terminate commands with either the <CR> or <LF> characters (or both) rather than using the GPIB specific EOI or GET methods. The command set and response formats are identical between interfaces, so migration between interfaces is simple if this guideline is followed.

### START BY INITIALIZING THE 981/3I

When a user application is started on the controlling computer the status of the 981/3i 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 981/3i. This can be achieved by sending the **\*RST** command.

### EMPLOY A TIMEOUT ON ALL ACTIVITIES

On all interfaces, the 981/3i 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 981/3I

If there are any configuration settings in the 981/3i 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 981/3i configuration settings.

### CHECKING FOR ERRORS

Often the user wishes to ensure that a command was correctly received by the 981/3i and that the command was not rejected by the 981/3i. This is easily achieved by always sending the **\*ERR?** command after sending any non-query command, waiting for the response and checking that it is "0". There are other registers which could be used also, but the ERR register provides the most information regarding the nature of the error.

For example –

```
BEEP,START,2<CR><LF>
```

```
*ERR?<CR><LF>
```

This would cause the response to be **0**<CR><LF>

As another example –

```
BEEP,START,9;*ERR?<CR><LF>
```

This would not function as expected. The "9" field in the BEEP command is in error, which makes the 981/3i reject the entire set of commands. This should be –

```
BEEP,START,9<CR><LF>
```

```
*ERR?<CR><LF>
```

This would cause the response to be **5**<CR><LF>

## PROGRAM AND RUN A SEQUENCE RATHER THAN INDIVIDUAL STEPS

When setting up and running a test sequence the user is recommended to run it as a sequence in the 981/3i, rather than running individual steps one at a time.

The 981/3i will remember the sequence, even if it is not stored, as long as power is not removed from the 981/3i. The user only needs to program the sequence once; it can then be run multiple times as needed. There is no need to store the sequence into non-volatile memory; although the user may do so if needed (stored sequences are limited in length to a maximum of 254 steps whereas the interface sequence is limited to a maximum of 999 steps).

The 981/3i 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 981/3i can operate at its' own speed, the computer does not have to "keep up" with the 981/3i.

The recommended flow is as follows –

- Send a **NOSEQ** command to ensure there is no active test sequence.
- Send **ADD,...** commands as needed to program the desired sequence. After each command send the **\*ERR?** command to check for any incompatibility between the requested test step operation and the 981/3i. The 981/3i will append each **ADD,...** test step to the active sequence, so the user should send each desired step in the correct order.
- Send the **RUN** command. The 981/3i will now run the sequence.
- Poll the 981/3i at intervals to detect completion of the sequence. The selection of the polling interval is up to the user, for short test sequences this could be as fast as every millisecond, for long sequences perhaps every 100milliseconds or longer would suffice. Either the **STEP?** or **RUN?** Commands can be used, the **STEP?** command is recommended as it provides more information in the response. If needed, the user could also program **MEASRSLT?** Command(s) to extract actual measurements during execution of the sequence. If multiple measurement results are required during execution, the user should send multiple **MEASRSLT?** Commands as a set of commands, the 981/3i 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 981/3i may slightly delay either the command or the response to beyond the time interval being used for polling, also the OS itself may delay the transmission or reception. In some OS's calls are made regardless of the completion of the preceding call – so the second call will cause commands to be transmitted even though the responses from the first call have not been received yet. The user should use some sort of software interlock to prevent this if needed.
  - This issue does not occur if the user uses synchronous coding – i.e. send the query command(s) – wait for the response(s) – wait for a delay – repeat.
- Once the test sequence has completed (e.g. the response to the **STEP?** command is 0) the user should request for the test results. There are various methods of achieving this, which the user chooses is dependent on the level of detail which is needed. The following query commands are recommended –

- **RSLT?** – responds with the overall test status, giving overall pass/fail information.
- **STEPRSLT?** for each defined step – giving very detailed information regarding each step.
- If the user requires to run the sequence again (usually with a different DUT) – then simply repeat the process starting with the **RUN** command – there is no need to reprogram the sequence itself unless changes are needed.

If the user needs to synchronize the execution of the sequence to external events, the HOLD type step can be used to cause the 981/3i to suspend execution of the sequence until the **CONT** command is received from the computer. As an example, if the computer is controlling switching which needs to be altered during execution the user would program the following during execution –

- Detect that the HOLD step is being performed by the response to the polled **STEP?** command.
- If the HOLD step is being performed, then program the required change(s) to switches and send the command **CONT** to the 981/3i 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 981/3i 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.