

***XITRON TECHNOLOGIES***

**IEEE488 COMMAND GUIDE**

**2551/2551E**

**Single-Phase**

**Power Analyser**



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# Contents

<b>INTRODUCTION</b>	<b>11</b>
<b>GENERAL INTERFACE OPERATION</b>	<b>13</b>
<b>IEEE488 Bus Operation</b>	<b>13</b>
Local and Remote States	13
Device Clear and Bus Clear	14
Serial Poll	15
Group Execute Trigger	16
Talking and Listening to the 2551/ 2551E	16
Sending Commands to the 2551/ 2551E	16
Receiving Data from 2551/ 2551E	17
<b>SENDING COMMANDS TO THE 2551/ 2551E</b>	<b>19</b>
Sending Multiple Commands	19
Syntax Errors	19
Commands Defining Current	20
Commands Requiring No Data	20
Reset Commands	21
Clearing Captured Waveforms	21
Clearing Measurement Results	22
Resetting the DC Current Offset	23
Setting Default Measurement Configuration	23
Commands That Require Data	23
General Syntax	24
Configuring Measurements	24
Controlling the Front Panel	31
Initiating a Printout	34
Controlling SRQ Activity	37

<b>READING STATUS &amp; SETTINGS FROM THE 2551/ 2551E</b>	<b>39</b>
<b>Interrogative Command Syntax</b>	<b>39</b>
Interrogating Calibration Status	39
Interrogating Printer Status	40
Identifying the Product	41
Interrogating the Serial Poll Response Byte	43
Interrogating the Measurement Configuration	44
Interrogating Date and Time	49
<b>READING MEASUREMENT RESULTS FROM THE 2551/ 2551E</b>	<b>51</b>
General	51
Format of Measurement Results	51
Floating-Point Measurement Results	52
Other Measurement Result Formats	53
Selecting the Bank to Be Read	53
Setting the Time Interval Between Bank Updates	54
Selecting the Measurement Result(s) to Be Read	54
General Syntax of a Measurement Result Definition	55
Defining Current Measurement Results	57
Defining Voltage Measurement Results	61
Defining Power Measurement Results	64
Defining Frequency Measurement Results	67
Defining Load Measurement Results	67
Defining Integrated Measurement Results	68
Defining Waveform Results	71
Defining Historical Measurement Results	75
Defining Date and Time	77
<b>APPLICATION EXAMPLES</b>	<b>79</b>
Simple Interfacing	79
Sequence of Interfacing	80
Place the 2551/ 2551E into a "Known State"	80
Check the Product, Version and Option Content	81
Configure the 2551/ 2551E for Measurements	81
Configure the 2551/ 2551E to Provide the Desired Measurement Results	82
Decide How Often to Read the Measurement Results	84
Reading the Measurement Results	84

<b>Changing the Configuration of the 2551/ 2551E</b>	<b>87</b>
<b>Synchronization of Results to Input Changes</b>	<b>87</b>
<b>Commanding the 2551/ 2551E to Produce Printouts</b>	<b>89</b>
<b>Controlling the Front Panel</b>	<b>90</b>
<b>Debugging the Application</b>	<b>90</b>
<b>FREQUENTLY ASKED QUESTIONS</b>	<b>93</b>
<b>SUMMARY OF COMMANDS</b>	<b>103</b>
<b>SUMMARY OF RESULT DEFINITIONS</b>	<b>105</b>





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# Tables

Table 1 – Serial Poll Response Byte and Mask Definition _____	16
Table 2 – Data for the AC-ONLY command _____	24
Table 3 – Data for the AVERAGE command _____	25
Table 4 – Data for the BANDWIDTH command _____	26
Table 5 – Data for the HISTORY command _____	26
Table 6 – Data for the HISTORY-SCALE command _____	28
Table 7 – Data for the INTEGRATE command _____	29
Table 8 – Data for the MEASURE command _____	30
Table 9 – Data for the SYNC command _____	31
Table 10 – Data for the DISPLAY command, Basic results format _____	32
Table 11 – Data for the DISPLAY command, Harmonics listing format _____	32
Table 12 – Data for the DISPLAY command, Harmonics barchart format _____	32
Table 13 – Data for the DISPLAY command, Waveforms format _____	33
Table 14 – Data for the DISPLAY command, History format _____	33
Table 15 – Data for the DISPLAY command, Settings format _____	33
Table 16 – Data for the DISPLAY command, Blank format _____	33
Table 17 – Data for the PRINT command, Basic format _____	35
Table 18 – Data for the PRINT command, Harmonics listing format _____	35
Table 19 – Data for the PRINT command, Harmonics barchart format _____	35
Table 20 – Data for the PRINT command, Waveforms format _____	35
Table 21 – Data for the PRINT command, History format _____	36
Table 22 – Data returned due to PRINT-STATUS? command _____	40
Table 23 – Data returned due to *OPT? command _____	41

Table 24 – Data returned due to PRODUCT? command	42
Table 25 – Data returned due to AVERAGE? command	45
Table 26 – Data returned due to BANDWIDTH? command	46
Table 27 – Data returned due to HISTORY-SCALE? command	47
Table 28 – Data returned due to SYNC? command	48
Table 29 – Type for full bandwidth result definitions	56

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# Introduction

This guide describes the operation and control of both the Xitron 2551 and 2551E General Purpose Power Analysers using the built in IEEE488 interface. It is assumed that the user has knowledge of the manual operation of either product and is conversant with the terminology used in power analysis instruments.

Where this guide describes an IEEE488.1 command, the user should consult the documentation for the particular controller and software being used for details regarding the method by which the specific IEEE488.1 bus command may be issued. Similarly, the methods by which the user controls sending commands or data to the 2551/ 2551E, or reading data from the 2551/ 2551E is dependent on the specific controller and its software.

Within Xitron Technologies Inc. the National Instruments controller PCBs are used. These are mounted in IBM compatible PC computers (desktops and portables), ISA, PCI and PCIMCA interfaces have been tested, with Microsoft Visual C++, National Instruments IBIC and National Instruments LabView softwares, under Microsoft Windows 95 and Microsoft Windows NT 4.0 operating systems.

Throughout this guide <SP> is used to designate the single ASCII space character (decimal 32). <NL> is used to designate the single new line character (decimal 10).

This guide contains the following sections –

- **General 2551/ 2551E Interface Operation**  
Describes the general interfacing of a 2551/ 2551E to a controller, with details regarding the implementation of the IEEE488.1 bus commands. Plus general information regarding sending commands to and reading data from the 2551/ 2551E.
- **Sending Commands to the 2551/ 2551E.**  
Describes in detail, with examples, the commands that may be sent to the 2551/ 2551E, and the actions taken to these commands.
- **Reading Status & Settings from the 2551/ 2551E**  
Describes in detail, with examples, commands that allow the user to read status and settings information from the 2551/ 2551E.

- **Reading Measurement Results from the 2551/ 2551E**  
Describes in detail, with examples, the commands that allow the user to read measurement results from the 2551/ 2551E.
- **Application Examples**  
The previous sections describe each command individually, in detail. This section describes several example applications and the combinations of commands that may be used to achieve the best results.
- **Frequently Asked Questions**  
Gives the answers to many of the commonly asked questions regarding interfacing the 2551/ 2551E to the IEEE488 bus.

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# General Interface Operation

This section describes the general interfacing of a 2551/ 2551E to a controller, with details regarding the implementation of the IEEE488.1 bus commands, and general information regarding sending commands to and reading data from the 2551/ 2551E.

## IEEE488 Bus Operation

All commands to, and data from, the 2551/ 2551E use the standard 7-bit ASCII character set, and are transferred using the IEEE488.1 data handshake protocol. The interface has been built for high speed operation, using 3-state buffers, thus the T1 delay defined by the IEEE488.1 standard has been set to 350ns. The user should check the IEEE488.1 and IEEE488.2 standards for requirements placed on the cabling and mixing of instruments having different capabilities in this regard.

Generally the detailed usage of the IEEE488.1 interface is virtually transparent to the user. There are certain details that the user should be aware of when using the 2551/ 2551E on an IEEE488 bus.

## Local and Remote States

The 2551/ 2551E implements all of the IEEE488.1 defined local and remote states for talker and listener type devices.

### Local Without Local Lockout

In this state the 2551/ 2551E front panel operation is unaffected by the IEEE488 interface. Commands received from the IEEE488 interface are executed as received, and data may be read from the 2551/ 2551E as required from the interface.

### Local With Local Lockout

Other than the state that is entered when the 2551/ 2551E is commanded into the Remote state, this state is identical to the Local Without Local Lockout state.

## Remote Without Local Lockout

In this state the 2551/ 2551E displays REMOTE above the rightmost soft key and pressing this key commands the 2551/ 2551E to return to the Local state. The NEXT key is the only other active front panel key, allowing the user to switch between display screens, but not actually alter any configuration details. Commands received from the IEEE488 interface are executed as received, and data may be read from the 2551/ 2551E as required from the interface.

## Remote With Local Lockout

The state is the same as the Remote Without Local Lockout state, with the exception that the rightmost soft key is inoperative.

## Remote/Local State Transitions

- The 2551/ 2551E enters either of the Remote states when it becomes addressed while the IEEE488.1 interface REN line is asserted by the controller.
- The 2551/ 2551E enters either of the Local states when the IEEE488.1 interface REN line is unasserted by the controller.
- The 2551/ 2551E enters either of the Local states when the IEEE488.1 Interface command GTL is received from the controller.
- The 2551/ 2551E enters the Local Without Local Lockout state when initially powered, or when following an action of a \*RST command, or following receiving a DCL or SDC IEEE488.1 interface command from the controller.
- The enters either the Local With Local Lockout or the Remote With Local Lockout state when the LLO IEEE488.1 interface command is received.

## Device Clear and Bus Clear

The 2551/ 2551E uses the IEEE488.2 recommendation of a three level bus and device clear strategy.

## IEEE488.1 IFC Command

The IEEE488.1 Defined Bus Clear command (normally named IFC) performs the following operations.

- All pending data read or write operations via the interface are aborted.
- The data receive and transmit buffers are cleared. Note that any definition of the data to be read from the 2551/ 2551E is not cleared.
- The status byte (as returned by a serial poll) is cleared.

## IEEE488.1 DCL and SDC Commands

The IEEE488.1 defined Device Clear or Selective Device Clear commands (normally called DCL and SDC respectively) perform the following operations.

- The physical IEEE488.1 interface is initialized into a passive state.
- The data receive and transmit buffers are cleared.
- Any definition of the data to be read from the 2551/ 2551E is cleared.
- Any measurements being performed by the 2551/ 2551E are aborted and restarted.
- Any printout in progress using the Parallel Printer interface is aborted.
- Any code upgrade or calibration procedures in progress are aborted.

When initially controlling the 2551/ 2551E using the IEEE488 interface it is highly recommended that the user issue a Device Clear (either DCL or SDC) command prior to performing any other tasks. This ensures that there is no pending activities, which may otherwise modify the actions taken by the 2551/ 2551E.

## IEEE488.2 “\*RST” Command

The IEEE488.2 defined \*RST command acts as if the 2551/ 2551E had its power cycled off and back on. See *page 21* for further details regarding this command.

## Serial Poll

The 2551/ 2551E responds to a serial poll with a single 8-bit byte of data as defined by IEEE488.1. Bit 6 of this response is defined in this standard, and is set if the 2551/ 2551E is actively asserting SRQ at that time. Bit 6 is only present in the response to a Serial Poll, in all other uses of this status it is ignored. The act of performing a serial poll, forces the 2551/ 2551E to release the SRQ line (if it was previously asserting it) until such a time that an allowed cause for assertion occurs, and clears the contents of the serial poll response byte.

A Serial Poll Response Byte Mask is provided in the 2551/ 2551E, allowing the user to choose individual bits of the Serial Poll Response Byte, which will cause the 2551/ 2551E to assert the IEEE488 SRQ line.

Bit #	Decimal Value	Meaning if Set
0	1	2551/ 2551E has failed a self-test operation
1	2	2551/ 2551E has received a command with a syntax error
2	4	2551/ 2551E has new data available to be read
3	8	Not used
4	16	2551/ 2551E if voltage input is overloaded
5	32	2551/ 2551E if current input is overloaded
6	64	2551/ 2551E is actively asserting the IEEE488 SRQ line
7	128	Not used

Table 1 – Serial Poll Response Byte and Mask Definition

## Group Execute Trigger

This is defined by the IEEE488.1 standard (normally called GET). The 2551/ 2551E also responds in the same manner to the addressed form of this command used by Hewlett-Packard in its HPIB implementation. The action of this command is to force the 2551/ 2551E to action all received commands immediately.

## Talking and Listening to the 2551/ 2551E

All data transfers require that the 2551/ 2551E is either addressed to “TALK” (to send data from the 2551/ 2551E to the controller) or “LISTEN” (send commands from the controller to the 2551/ 2551E) as applicable. The 2551/ 2551E uses primary addressing only, there is no requirement on the user for secondary addresses. The primary address of the 2551/ 2551E for both TALK and LISTEN addressing is set manually by the user by using the front panel in the manner described in the 2551/2551E User Guide.

## Sending Commands to the 2551/ 2551E

All commands to the 2551/ 2551E use the standard 7-bit ASCII character set and utilize a common syntax for all commands.

- See the section on *Sending Commands to the 2551/ 2551E*, for details regarding commanding changes in the 2551/ 2551E operation.
- See the section on *Reading Status & Settings from the 2551/ 2551E*, for details regarding commanding responses indicating the present status and settings of the 2551/ 2551E.
- See the section on *Reading Status & Settings from the 2551/ 2551E*, for details regarding commanding responses indicating measurement results from the 2551/ 2551E.



---

Data received by the 2551/ 2551E from the IEEE488 interface is placed into a buffer, the contents of this buffer being acted on when any of the following events occur.

- The reception of the <NL> character.
- The reception of any character with the bus EOI line asserted by the controller.
- The reception of the GET IEEE488.1 bus command.

All whitespace and non-printable characters are discarded prior to being placed into the buffer, the user may freely use these to improve the readability of commands as desired.

Any lower case characters (the letters a through z) are converted to uppercase prior to being placed into the buffer, commands and data may be written in either form, or a mixture of upper- and lowercase, as desired.

The reception of an empty command, i.e. receiving one of the action events when the "receive" buffer is empty, neither causes an error, nor causes any other action.

Multiple commands may be sent at the same time, as a set of commands, by separating them with the semicolon character, prior to sending one of the action events shown above. The receive buffer is 512 characters in length. Note that any whitespace characters are not placed into this buffer, thus are not included in the given length.

## Receiving Data from 2551/ 2551E

The 2551/ 2551E and the 2551/ 2551E have many thousands of results available to the user, thus it is required that the user define which of these results is to be read from the 2551/ 2551E prior to performing a read operation. All data read from the 2551/ 2551E uses the standard 7-bit ASCII character set. Additionally the data always starts with a <SP> character and terminates with a <NL> character whenever the IEEE488 bus EOI line is asserted.

To allow the user to predefine several differing sets of data which may be required at varying times, the 2551/ 2551E uses a "bank" technique of transmit data buffers. These banks each have a different transmit buffer and take two forms.

### Interrogative Bank

The 2551/ 2551E has one interrogative transmit data buffer. The data placed into this buffer is defined by specific commands detailed later in this guide. The contents of the buffer are destroyed when read. If this buffer has data contained within it, then the transmittal of this buffer's contents takes priority over any other buffer. In this manner several status type data may be read from the 2551/ 2551E on the fly without having to interrupt the normal usage of the "transmit" buffer banks. This transmit buffer is 256 characters in length, multiple data is separated by the comma character. See the section on *Reading Status & Settings from the 2551/ 2551E*, for details regarding how to use the transmit buffer.

## Transmit Buffer Banks

The 2551/2551E and the 2551/2551E have five standard transmit buffer banks. Only one buffer at a time may be defined as "readable." The user defines a set of data for each bank, which the 2551/2551E formats into the respective bank. Each bank is updated with new information at a user defined rate, unless the specific bank is being read at that moment in time (the update is then delayed until the bank has been read and is updated prior to be read again). The commands by which the user defines each bank, and defines which bank is to be read, are detailed later in this guide. Each transmit buffer bank is 6000 characters in length, multiple data is separated by the comma character. An undefined bank (a bank for which no data has been defined) yields only the <SP> and <NL> characters when read. See the section on *Reading Measurement Results from the 2551/2551E*, for details regarding how to use these buffers.

# Sending Commands to the 2551/ 2551E

This section describes in detail, with examples, the commands that may be sent to the 2551/ 2551E to change its' configuration, and the actions taken by the 2551/ 2551E to these commands. Command syntax that defines data to be read from the 2551/ 2551E is described in later sections.

The commands that are described in this section are grouped as follows –

- Commands that require no data. These are simple commands, which always perform the same action.
- Commands that require data. These are commands where the action taken by the 2551/ 2551E is dependent on data sent following the command.

## Sending Multiple Commands

Multiple commands may be sent as a single set of commands. This is achieved by separating the commands with the semi-colon character prior to sending the action event (<NL>, assertion of EOI, or GET).

An example of two commands sent as a set is –

```
CLR-INTEGRATE;INTEGRATE=START<NL>
```

Commands are executed in the order received, thus care should be taken when sending multiple commands as a single set. Most commands do not interact with each other, if there is doubt regarding the order in which commands should be given, the user is strongly recommended to send each command separately and check that the desired action is taken in each case.

## Syntax Errors

All commands to the 2551/ 2551E use the exact syntax shown. If a command is received which has invalid syntax–

- The entire set of commands is discarded and an error is flagged. None of the commands included in the set are actually executed.
- An error message is shown in the lowermost portion of the display.

- A bit is set in the serial poll response status byte (see *Table 1*).
- May optionally cause the assertion of the IEEE488 bus SRQ line.

## Commands Defining Current

### CURRENT=n

This command sets the current input to be used. CURRENT=0 selects the internal current measurement, CURRENT=1 selects an external current:current transducer, CURRENT=2 selects an external current:voltage transducer.

### CURRENT?

This command is an interrogative command, returning a single digit (0, 1 or 2) describing the presently selected current input. The number is the same as described for the CURRENT=n command.

### CURRENT-SCALE=numeric

This command sets the current input scaling for the presently selected current input. This command should not be used in the same set of commands as the CURRENT=n command. The numeric may be of any floating point numeric format and may be of any polarity, and sets the overall multiplicative scale factor for the current input.

### CURRENT-SCALE?

This command is an interrogative command, returning a floating point number indicating the overall multiplicative scale factor for the presently selected current input.

### **Notes –**

- Harmonic number definitions may now be up to 50 (was previously 40).
- The “TEXT” and “PCL” portions of the various PRINT commands override the configured printer type selection for the purposes of that command only.

## Commands Requiring No Data

These are individual commands performing a single function that is apparent from the command itself.

---

## Reset Commands

### \*CLS

The action of this command follows the recommendations of the IEEE488.2 standard, clearing the serial poll response byte and all Transmit Buffer Banks and the definitions of their contents.

Do not include any commands that define responses from the 2551/ 2551E in the same set of commands as contains a \*CLS command.

### \*RST

The action of this command follows the recommendations of the IEEE488.2 standard, acting as if the 2551/ 2551E had its power cycled off and back on.

Do not include other commands in the same set of commands as contains a \*RST command.

Follow the \*RST command with a delay of at least 350ms before any other activity on the IEEE488 bus involving the 2551/ 2551E.

During operation of this command, the 2551/ 2551E will become totally disconnected from the IEEE488.1 bus for a short period of time. If the 2551/ 2551E is the only non-controller device on the bus, this may cause the IEEE488.1 controller to issue an error concerning the lack of IEEE488 devices on the bus. Ignore the error in the situation described here.

## Clearing Captured Waveforms

### CLR-A-CAPTURE

This command clears the peak current captured waveforms, these are immediately set to the presently available set of voltage, current and power waveforms.

No other measurement results are affected by this command.

This command is implied whenever measurements are started using the MEASURE command.

### CLR-A-GLITCH

This command clears the current glitch captured waveforms, these are immediately set to the presently available set of voltage, current and power waveforms.

No other measurement results are affected by this command.

This command is implied whenever measurements are started using the MEASURE command.

### CLR-V-CAPTURE

This command clears the peak voltage captured waveforms, these are immediately set to the presently available set of voltage, current and power waveforms.

No other measurement results are affected by this command.

This command is implied whenever measurements are started using the MEASURE command.

### CLR-V-GLITCH

This command clears the voltage glitch captured waveforms, these are immediately set to the presently available set of voltage, current and power waveforms.

No other measurement results are affected by this command.

This command is implied whenever measurements are started using the MEASURE command.

## Clearing Measurement Results

### CLR-INRUSH

This command clears all inrush measurements, each inrush measurement result is flagged to be set to the next available applicable measurement.

No other measurement results are affected by this command.

Sending this command while measurement results are frozen has no affect.

This command is implied whenever measurements are started using the MEASURE command.

### CLR-INTEGRATE

This command clears all integrated measurements to zero.

No other measurement results are affected by this command.

This command is implied whenever measurements are started using the MEASURE command.

---

## Resetting the DC Current Offset

### SET-DC-ZERO

This command sets the DC current zero offsets to the presently measured values.

Both the DC and RMS values of the measured current must be less than 2% of the full-scale value for the 2551/ 2551E, otherwise a command error is generated.

Only in rare situations will this command be used when the 2551/ 2551E has frozen measurement results.

This command may be issued when the 2551/ 2551E is configured for AC only with no apparent effect since only the DC offsets will be updated.

## Setting Default Measurement Configuration

### SETDEFAULTS

This command sets the measurement configuration to factory default values. Use this command to ensure that a 2551/ 2551E is placed into an exactly known state. The action of this command is equivalent to the following commands.

- BANDWIDTH=1. Measurement bandwidth is set to 20Hz to 5KHz
- AC-ONLY=0. Measurements include both AC and DC content
- AVERAGE=1. Measurements are averaged over 250ms
- SYNC=0. Measurements are synchronized to the voltage signal
- MEASURE=1. Normal measurements are enabled
- INTEGRATE=0. Integrated measurements are stopped, and their results are cleared
- HISTORY=1. Historical results storage is enabled, and any stored results are cleared
- CLR-INRUSH. Inrush results are cleared
- CLR-INTEGRATE. Integrated results are cleared.
- CLR-A-CAPTURE, CLR-V-CAPTURE, CLR-A-GLITCH and CLR-V-GLITCH. All captured Waveforms are cleared

It is not recommended to issue other commands in the same set as this command.

## Commands That Require Data

These are commands performing functions that are dependent on data passed with the commands. Each of these commands has the same general syntax, described below.

## General Syntax

Each command contains three fields as shown in the general example below—

keyword = data

*keyword.* This is a single ASCII word, defining the general command.

The = (decimal 61) character. This is mandatory, and immediately follows the command word.

*data.* Each command has its own syntax for the data it requires. Generally, when more than one data is required, each data element is separated from the previous by the / (decimal 47) character.

If the same command is included more than once in the same set of commands (e.g., HISTORY=STOP ; HISTORY=START<NL>), then only the last data is used. This is not recommended and may yield unreliable results in some circumstances.

## Configuring Measurements

### AC-ONLY

This command selects whether measurement results will be made available with only the AC content or with both the DC and AC content included.

This command takes a single ASCII character as data.

Character	Selection
0	Both DC and AC included
1	Only AC included

Table 2 – Data for the AC-ONLY command

### Notes –

- The AC-ONLY? Interrogative command returns the present state of the AC-ONLY command.
- If measurements are not frozen when this command is executed, then all measurements will be restarted as if the MEASURE=START command had also been executed at the same time.
- The SETDEFAULTS command implies AC-ONLY=0.

### Example –

- The user transmits: AC-ONLY=0<NL>

The 2551/ 2551E selects the measurement results that will include both DC and AC components. All measurements will restart if the 2551/ 2551E is presently making measurements.



## AVERAGE

This command sets the measurement-averaging period to be used for standard measurement results.

This command takes a single ASCII character as data.

Character	Averaging Period
0	50ms
1	250ms
2	1s
3	2.5s
4	5s
5	10s
6	20s
7	1 minute

*Table 3 – Data for the AVERAGE command*

### **Notes –**

- The AVERAGE? Interrogative command returns the present state of the AVERAGE command.
- If measurements are not frozen when this command is executed, then all measurements will be restarted as if the MEASURE=START command had also been executed at the same time.
- The SETDEFAULTS command implies AVERAGE=1.

### *Example –*

- The user transmits: AVERAGE=2<NL>

The 2551/ 2551E selects a 1 second averaging period for measurement results, and will restart all measurements if the 2551/ 2551E is presently making measurements.

## BANDWIDTH

This command sets the bandwidth to be used for standard measurement results.

This command takes a single ASCII character as data.

Character	Bandwidth
0	20Hz to 100KHz
1	20Hz to 5KHz
2	2Hz to 2KHz
3	0.2Hz to 200Hz
4	0.02Hz to 20Hz

Table 4 – Data for the BANDWIDTH command

### Notes –

- The BANDWIDTH? Interrogative command returns the present state of the BANDWIDTH command.
- If measurements are not frozen when this command is executed, then all measurements will be restarted as if the MEASURE=START command had also been executed at the same time.
- The SETDEFAULTS command implies BANDWIDTH=1.

### Example –

- The user transmits: BANDWIDTH=1<NL>  
The 2551/ 2551E selects a 20Hz to 5KHz bandwidth for measurement results, and will restart all measurements if the 2551/ 2551E is presently making measurements.

## HISTORY

This command is used to set whether the historical data is to be updated or frozen. This command takes a single data only, which may be any of the following ASCII data.

ASCII Data	Command Action
0	Historical data is frozen
STOP	Historical data is frozen
1	Historical data is updated at the commanded rate
START	Historical data is updated at the commanded rate

Table 5 – Data for the HISTORY command

### Notes –

- HISTORY=1 or HISTORY=START clears any presently stored historical data, even if historical data storage was already enabled.

- If all measurement results are frozen when the HISTORY=1 (or HISTORY=START) command is received, then both standard and historical measurements will be started.
- Any commands, which affect starting, stopping or restarting measurements, also affect historical data.
- Although there is a slight increase in product speed when the history data collection process is disabled, this would rarely yield any benefit thus would be rarely used. Normally the MEASURE command would be used to start and stop all measurements, including the historical results.
- The HISTORY? Interrogative command returns the present state of the HISTORY command.
- See the HISTORY-SCALE command for setting the rate at which the historical data is updated.

*Example –*

- The user transmits: HISTORY=STOP<NL>

The 2551/ 2551E will stop updating the historical results, leaving all results frozen with the present contents. If the historical results were already frozen, then this has no affect.

## HISTORY-SCALE

This command sets the rate at which historical data is stored by the 2551/ 2551E. Any presently stored historical data is cleared when this command is actioned. This command takes a single data only, which may be any of the following ASCII data.

See the HISTORY command for starting and stopping the update of historical data.

ASCII Data	History Update Rate
0	0.4 seconds per division
1	1 second per division
2	2 seconds per division
3	5 seconds per division
4	10 seconds per division
5	30 seconds per division
6	1 minute per division
7	3 minutes per division
8	10 minutes per division
9	30 minutes per division
10	1 hour per division
11	3 hours per division
12	6 hours per division
13	12 hours per division
14	1 day per division

Table 6 – Data for the HISTORY-SCALE command

### Notes –

- When enabled, all historical data is updated.
- Historical data is always cleared by this command.
- There are 20 equally spaced historical data points per division, thus the time between each stored data point is  $1/20^{\text{th}}$  of the times indicated above.
- All peak data are stored as the highest peak recorded between each data point.
- All other (non-peak) data are stored as the average value recorded between each data point. Historical data is unaffected by the selected measurement result averaging period.
- Any commands, which affect starting, stopping or restarting measurements, also affect historical data.
- The HISTORY-SCALE? Interrogative command returns the present state of the HISTORY-SCALE command.

### Example –

- The user transmits: HISTORY-SCALE=3<NL>

The 2551/ 2551E will update the historical results at a rate equivalent to 5 seconds per division (250ms per data point) if enabled. All presently stored historical data is cleared.

## INTEGRATE

This command is used to set whether the integrated data (e.g. Watt-Hour data) is to be updated or frozen. This command takes a single data only, which may be any of the following ASCII data.

ASCII Data	Command Action
0	Integrated data is frozen
STOP	Integrated data is frozen
1	Integrated data is updated
START	Integrated data is updated

*Table 7 – Data for the INTEGRATE command*

### Notes –

- This command does not affect any presently integrated data. See the CLR-INTEGRATE command for how to clear integrated data.
- Any command that affects integrated data also affects integrated average data.
- If all measurement results are frozen when the INTEGRATE=1 (or INTEGRATE=START) command is received, then both standard and integrated measurements will be started.
- Any command that starts, stops or restarts measurements also affects integrated data.
- The INTEGRATE? Interrogative command returns the present state of the INTEGRATE command.

### Examples –

- The user transmits: INTEGRATE=STOP<NL>

The 2551/ 2551E will stop updating the integrated results, leaving all results frozen with the present contents. If the integrated results were already frozen, then this has no affect.

- The user transmits: INTEGRATE=START<NL>

The 2551/ 2551E will start updating the integrated results. Any values presently in the integrated results will be added. If the integrated results were already being updated, then this has no affect.

- The user transmits: CLR-INTEGRATE;INTEGRATE=START<NL>

The 2551/ 2551E will start updating the integrated results after clearing any previously integrated values. Note that these commands may be issued in either order.

## MEASURE

This command is used to set whether the measurement results are to be updated or frozen. This command takes a single data only, which may be any of the following ASCII data.

ASCII Data	Command Action
0	All results are frozen
STOP	All results are frozen
1	Results are cleared and allowed to be updated
START	Results are cleared and allowed to be updated

*Table 8 – Data for the MEASURE command*

### Notes –

- MEASURE=1 or MEASURE=START always clears any presently stored historical, captured waveform, and integrated data.
- MEASURE=1 or MEASURE=START always disables update of integrated data, and enables update of historical, captured waveform, and standard measurement data.
- MEASURE=0 or MEASURE=STOP always disables update of all data, setting all results as frozen.
- The MEASURE? Interrogative command returns the present state of the MEASURE command.

### Example –

- The user transmits: MEASURE=STOP<NL>

The 2551/ 2551E will stop updating all results, leaving all results frozen with the present contents. If results were already frozen, then this has no affect.

## SYNC

This command selects the type of synchronization, which the 2551/ 2551E will use for all measurements' results.

This command takes a single ASCII character as detailed in the table below.

Character	Synchronization
0	Voltage Input
1	Current Input
2	Fixed 50Hz synchronization
3	Fixed 60Hz synchronization
4	Fixed 400Hz synchronization
5	None

*Table 9 – Data for the SYNC command*

### **Notes –**

- The SYNC? Interrogative command returns the present state of the SYNC command.
- Synchronization is assumed to be the fundamental frequency used for harmonics measurements. Selecting no synchronization (ASCII data 5) disables all harmonics and harmonics related results (including waveforms).
- If all measurement results are not frozen when this command is executed, then all measurements will be restarted as if the MEASURE=START command had also been executed at the same time.

### *Example –*

- The user transmits: SYNC=0<NL>

The 2551/ 2551E selects synchronizing measurements to the voltage waveform, and restarts all measurements if the 2551/ 2551E is presently making measurements.

## **Controlling the Front Panel**

### **DISPLAY**

This command selects which display format is to be presented at the front panel. This command only affects the display format, there is no affect on measurement results of any kind.

This command takes one of several different data, in multiple fields. Each syntax reflects the set of soft menu choices shown on the front panel for each selection, in order from left to right.

BASIC / RMS / MEASURED
BASIC / RMS / INRUSH
BASIC / RMS / INTEGRATED
BASIC / RMS / INTEGRATED-AVERAGE
BASIC / DC / MEASURED
BASIC / DC / INRUSH
BASIC / DC / INTEGRATED
BASIC / DC / INTEGRATED-AVERAGE
BASIC / DC / LOAD
BASIC / RECTIFIED / MEASURED
BASIC / RECTIFIED / INRUSH
BASIC / FUNDAMENTAL / MEASURED
BASIC / FUNDAMENTAL / LOAD
BASIC / HARMONICS / MEASURED

*Table 10 – Data for the DISPLAY command, Basic results format*

HARMONIC-LIST / ABSOLUTE / <i>nn</i>
HARMONIC-LIST / PERCENT / <i>nn</i>
HARMONIC-LIST / PHASE / <i>nn</i>
<i>nn is the first harmonic to display, expressed as one or two ASCII digits, 1 = fundamental</i>

*Table 11 – Data for the DISPLAY command, Harmonics listing format*

HARMONIC-BARCHART / ABS-LINEAR / VOLTAGE
HARMONIC-BARCHART / ABS-LINEAR / CURRENT
HARMONIC-BARCHART / ABS-LOG / VOLTAGE
HARMONIC-BARCHART / ABS-LOG / CURRENT
HARMONIC-BARCHART / PCT-LINEAR / VOLTAGE
HARMONIC-BARCHART / PCT-LINEAR / CURRENT
HARMONIC-BARCHART / PCT-LOG / VOLTAGE
HARMONIC-BARCHART / PCT-LOG / CURRENT

*Table 12 – Data for the DISPLAY command, Harmonics barchart format*



WAVEFORMS / CONT-VA / <i>xx</i>
WAVEFORMS / CONT-VW / <i>xx</i>
WAVEFORMS / DIST-VA / <i>xx</i>
WAVEFORMS / V-PEAK / <i>xx</i>
WAVEFORMS / A-PEAK / <i>xx</i>
WAVEFORMS / V-GLITCH / <i>xx</i>
WAVEFORMS / A-GLITCH / <i>xx</i>
<i>xx = the display zoom factor, one of the following ASCII strings : x0.5 x1 x2 x5</i>

*Table 13 – Data for the DISPLAY command, Waveforms format*

HISTORY / V-RMS
HISTORY / V-PEAK
HISTORY / V-PKPK
HISTORY / V-THD
HISTORY / A-RMS
HISTORY / A-PEAK
HISTORY / A-PKPK
HISTORY / A-THD
HISTORY / WATTS
HISTORY / VAR
HISTORY / PF

*Table 14 – Data for the DISPLAY command, History format*

SETTINGS
----------

*Table 15 – Data for the DISPLAY command, Settings format*

BLANK
-------

*Table 16 – Data for the DISPLAY command, Blank format*

### *Examples –*

- The user transmits: DISPLAY=BASIC/RMS/MEASURED<NL>  
The 2551/ 2551E front panel displays full bandwidth (RMS) measured results.
- The user transmits: DISPLAY=HARMONIC-LIST/PERCENT/1<NL>  
The 2551/ 2551E front panel displays a listing of the harmonics results, expressed as a percentage of the fundamental, starting at the fundamental.
- The user transmits:  
DISPLAY=HARMONIC-BARCHART/ABS-LOG/VOLTAGE<NL>  
The 2551/ 2551E front panel displays a barchart of the voltage harmonics results, expressed in voltage units, using a logarithmic scale.

- The user transmits: `DISPLAY=WAVEFORMS/V-PEAK/x1<NL>`  
The 2551/ 2551E front panel displays the voltage and current waveforms, captured at the highest voltage peak, using a x1 zoom.
- The user transmits: `DISPLAY=HISTORY/A-RMS<NL>`  
The 2551/ 2551E front panel displays the RMS current historical data.
- The user transmits: `DISPLAY=HISTORY/A-PKPK<NL>`  
The 2551/ 2551E front panel displays the current “envelope” (i.e. both positive and negative peaks) historical data.
- The user transmits: `DISPLAY=SETTINGS<NL>`  
The 2551/ 2551E front panel displays the configuration settings (including the present date and time of day).
- The user transmits: `DISPLAY=BLANK<NL>`  
The 2551/ 2551E front panel displays a fixed message indicating that the display has been blanked. This yields the fastest product speed as the display is not updated in this situation.

## KEY

This command is used to simulate a front panel key being pressed, as if the 2551/ 2551E were operating in the LOCAL state under manual control.

This capability should be used with caution, as it is possible to switch to the SETTINGS display and change the IEEE Address using this command, which will yield undesired results under most circumstances.

The data for this command consists of a single ASCII character between 0 and 5 inclusive, corresponding to the front panel keys, in order from left to right, as viewed from the front panel.

## Initiating a Printout

### PRINT

This command initiates a printout having the format specified in the data portion of this command. Prior to issuing this command the user should ensure that the response to the `PRINT-STATUS?` command (see *page 40*) indicates that no printer activity is present, otherwise the print in progress will be aborted and the newly specified printout will be started, this may result in a badly formatted printout, similarly there should only be one of these commands in a single command set.

This command takes several different data, in multiple fields, each valid syntax is shown below.

## BASIC

*Table 17 – Data for the PRINT command, Basic format*

## HARMONIC-LIST

*Table 18 – Data for the PRINT command, Harmonics listing format*

HARMONIC-BARCHART / ABS-LINEAR / VOLTAGE / <i>tt</i>
HARMONIC-BARCHART / ABS-LINEAR / CURRENT / <i>tt</i>
HARMONIC-BARCHART / ABS-LOG / VOLTAGE / <i>tt</i>
HARMONIC-BARCHART / ABS-LOG / CURRENT / <i>tt</i>
HARMONIC-BARCHART / PCT-LINEAR / VOLTAGE / <i>tt</i>
HARMONIC-BARCHART / PCT-LINEAR / CURRENT / <i>tt</i>
HARMONIC-BARCHART / PCT-LOG / VOLTAGE / <i>tt</i>
HARMONIC-BARCHART / PCT-LOG / CURRENT / <i>tt</i>
<i>tt = the characters TEXT or PCL dependant on the printout format desired</i>

*Table 19 – Data for the PRINT command, Harmonics barchart format*

WAVEFORMS / CONT-VA / <i>xx</i> / <i>tt</i>
WAVEFORMS / CONT-VW / <i>xx</i> / <i>tt</i>
WAVEFORMS / DIST / <i>xx</i> / <i>tt</i>
WAVEFORMS / V-PEAK / <i>xx</i> / <i>tt</i>
WAVEFORMS / A-PEAK / <i>xx</i> / <i>tt</i>
WAVEFORMS / V-GLITCH / <i>xx</i> / <i>tt</i>
WAVEFORMS / A-GLITCH / <i>xx</i> / <i>tt</i>
<i>xx = the desired zoom factor, one of the following ASCII strings : x0.5 x1 x2 x5</i>
<i>tt = the characters TEXT or PCL dependant on the printout format desired</i>

*Table 20 – Data for the PRINT command, Waveforms format*

HISTORY / V-RMS / <i>tt</i>
HISTORY / V-PEAK / <i>tt</i>
HISTORY / V-PKPK / <i>tt</i>
HISTORY / V-THD / <i>tt</i>
HISTORY / A-RMS / <i>tt</i>
HISTORY / A-PEAK / <i>tt</i>
HISTORY / A-PKPK / <i>tt</i>
HISTORY / A-THD / <i>tt</i>
HISTORY / WATTS / <i>tt</i>
HISTORY / VAR / <i>tt</i>
HISTORY / PF / <i>tt</i>
<i>tt = the characters TEXT or PCL dependant on the printout format desired</i>

Table 21 – Data for the PRINT command, History format

*Examples –*

- The user transmits: PRINT=BASIC<NL>  
The 2551/ 2551E initiates printing of a single-page tabulation of measured inrush, integrated and integrated average results.
- The user transmits: PRINT=HARMONIC-LIST<NL>  
The 2551/ 2551E initiates printing of a single-page tabulation of measured voltage and current harmonics, giving results in absolute units, percentage of fundamental, and phase relative to voltage fundamental.
- The user transmits:  
PRINT=HARMONIC-BARCHART/ABS-LOG/VOLTAGE/PCL<NL>  
The 2551/ 2551E initiates printing of a single-page graphical representation of a voltage harmonic barchart, using absolute units with a logarithmic scale. Assumption: The printer supports PCL level 2 graphics with a minimum of 75dpi raster graphics capability.
- The user transmits: PRINT=WAVEFORMS/CONT-VA/x1/PCL<NL>  
The 2551/ 2551E initiates printing of a single-page graphical representation of the voltage, current and power waveforms, using a x1 zoom. Assumption: The printer supports PCL level 2 graphics with a minimum of 75dpi raster graphics capability. For the PCL format only, the CONT-VA and CONT-VW formats yield the same printout, as all three waveforms are printed in each case.

- The user transmits: `PRINT=WAVEFORMS/V-PEAK/x1/PCL<NL>`  
The 2551/ 2551E initiates printing of a single-page graphical representation of the voltage and current waveforms, as captured at the highest voltage peak, using a x1 zoom. The printer is assumed to support PCL level 2 graphics with a minimum of 75dpi raster graphics capability.
- The user transmits: `PRINT=HISTORY/A-RMS/PCL<NL>`  
The 2551/ 2551E initiates printing of a single-page graphical representation of the RMS current historical data. The printout includes the time of day for each division.

## Controlling SRQ Activity

### STATUS

This command sets the Serial Poll Response Byte Mask. The STATUS command filters which events in the Serial Poll Response Byte will cause the IEEE488.1 interface SRQ line to be asserted by the 2551/ 2551E. The data portion of this command is formed by the addition of the codes, which the user selects, to cause the SRQ line to become asserted.

Table 1 contains the bit definitions for both the Serial Poll Response Byte and the Serial Poll Response Byte Mask.

### Notes –

- If the command is sent with zero data (i.e., `STATUS=0`) then the 2551/ 2551E will release the IEEE488.1 interface SRQ line and clear the Serial Poll Response Byte.
- This command does not affect the byte read by the controller as a result of any of the methods by which it may read the Serial Poll Response Byte, only whether the 2551/ 2551E asserts the SRQ line (or not).
- If the specified code is already asserted, then the SRQ line will be immediately asserted.
- If the 2551/ 2551E is asserting the SRQ line due to a status bit being set that was previously included, but is no longer, and the STATUS command does not have the data 0, then the 2551/ 2551E will continue asserting the SRQ line. This is due to the causative event, allowed at the time it occurred, that is yet to be recognized by the controller.

*Examples –*

- The user transmits: STATUS=0<NL>

The 2551/ 2551E clears the Serial Poll Response Byte Mask and releases the SRQ line.

- The user transmits: STATUS=52<NL>

Then the 2551/ 2551E sets the Serial Poll Response Byte Mask to decimal 52. This command selects if voltage overload, current overload, or new data being available will cause the 2551/ 2551E to assert the IEEE488.1 interface SRQ line. If any of these are presently asserted then the SRQ line is immediately asserted.

---

# Reading Status & Settings from the 2551/ 2551E

Successful reception of these commands cause the 2551/ 2551E to place data into the Interrogative Bank transmit buffer and a subsequent read of the 2551/ 2551E will return the requested data. In this document these are called Interrogative Commands.

If multiple Interrogative Commands are sent in a single set of commands, then the buffer will contain the response to each of these, in the order requested, separated by the comma character.

If several Interrogative Commands are issued in separate sets of commands, without the intervening results being read, then only the last result will be read from the 2551/ 2551E.

After reading the Interrogative Bank transmit buffer, this buffer's contents are automatically destroyed and the 2551/ 2551E reverts to allowing the previously requested Transmit Buffer Bank to be read.

Interrogative commands return the value of the interrogated status or setting, which prevailed prior to the decode of the set of commands being executed, thus do not report any changes made due to other commands in the same set.

## Interrogative Command Syntax

### Interrogating Calibration Status

**\*CAL?**

The 2551/ 2551E places an ASCII string describing the status of the last external calibration into the Interrogative Bank following the recommendations of the IEEE488.2 standard for this command. The character 1 (decimal 49) is placed if the 2551/ 2551E has not been successfully calibrated, or the previously stored calibration has become corrupted, otherwise the character 0 (decimal 48) is placed.

*Example –*

- The user transmits: \*CAL?<NL>  
The user reads the 2551/ 2551E and receives the characters: <SP>0<NL>  
This indicates that the 2551/ 2551E was successfully calibrated.

**CAL-DATE?**

The 2551/ 2551E places an ASCII string indicating the date on which the 2551/ 2551E was last successfully calibrated against external standards. The string NOT CALIBRATED is returned if the 2551/ 2551E has not been successfully calibrated, or the previously stored calibration has become corrupted.

*Example –*

- The user transmits: CAL-DATE?<NL>  
The user reads the 2551/ 2551E and receives the characters:  
<SP>Apr<SP>28<SP>1998<NL>  
This indicates that the 2551/ 2551E was last successfully calibrated on the 28th of April, 1998.

**Interrogating Printer Status****PRINT-STATUS?**

The 2551/ 2551E places a single ASCII character indicating the status of the parallel printer port of the 2551/ 2551E. Note that the user may only command a printout (either manually or by means of the PRINT command) when the printer port is presently idle. If multiple printouts are required, then the user must poll this interrogative until the port is idle prior to transmitting another PRINT command. The character returned is one of the following.

Character	Printer Status
0	Printer Interface is idle
1	Printer Interface is active, with no errors
2	Printer Interface is active, with a paper out indication
3	Printer Interface is active, with an offline indication
4	Printer Interface is active, with a printer error indication

*Table 22 – Data returned due to PRINT-STATUS? command*



*Example –*

- The user transmits: PRINT-STATUS?<NL>  
The user reads the 2551/ 2551E and receives the characters: <SP>0<NL>  
This indicates that the 2551/ 2551E is not presently printing.

## Identifying the Product

### \*IDN?

The 2551/ 2551E places an ASCII string describing the product into the Interrogative Bank following the recommendations of the IEEE488.2 standard for this command.

*Example –*

- The user transmits: \*IDN?<NL>  
The user reads the 2551/ 2551E and receives the characters:  
<SP>XITRON,2551,0,1.0<NL>

or

<SP>XITRON,2551E,0,1.0<NL>

This indicates that the product is manufactured by XITRON, is a 2551/ 2551E, that the serial number is not available, and that the firmware version is 1.0.

### \*OPT?

The 2551/ 2551E places an ASCII string describing the product option content into the Interrogative Bank following the recommendations of the IEEE488.2 standard for this command.

This string contains one of the following ASCII strings, dependent on the option content of the 2551/ 2551E.

40A,950V
8A,950V
40A,1500V
8A,1500V
40A,400V
8A,400V

*Table 23 – Data returned due to \*OPT? command*

*Examples –*

- The user transmits: \*OPT?<NL>  
The user reads the 2551/ 2551E and receives the characters: <SP>40A,1500V<NL>  
This indicates that the 2551/ 2551E contains options 40A and 1500V.
- The user transmits: \*IDN?;\*OPT?<NL>  
The user reads the 2551/ 2551E and receives the characters:  
<SP>XITRON,2551,0,1.0,40A,1500V<NL>  
or  
<SP>XITRON,2551E,0,1.0,40A,1500V<NL>  
This indicates that the product is manufactured by XITRON, is a 2551/ 2551E, the firmware version is 1.0, and it contains options 40A and 1500V.

**PRODUCT?**

The 2551/ 2551E places an ASCII string describing the product into the Interrogative Bank. This string contains one of the following ASCII strings, dependent on the option content of the 2551/ 2551E.

2551/40A/950V	2551E/40A/950V
2551/8A/950V	2551E/8A/950V
2551/40A/1500V	2551E/40A/1500V
2551/8A/1500V	2551E/8A/1500V
2551/40A/400V	2551E/40A/400V
2551/8A/400V	2551E/8A/400V

*Table 24 – Data returned due to PRODUCT? command*

*Example –*

- The user transmits: PRODUCT?<NL>  
The user reads the 2551/ 2551E and receives the characters:  
<SP>2551/40A/1500V<NL>  
or  
<SP>2551E/40A/1500V<NL>

This indicates that the product is a 2551/ 2551E, Option 40A option is fitted, and Option 1500V is fitted. Note that the current and voltages contained in this data are the nominal full-scale peak measurement abilities for the option content of this 2551/ 2551E.

## VER?

The 2551/ 2551E places an ASCII string describing the version of firmware into the Interrogative Bank. This string contains four digits, the first two digits describe the major version, and the last two digits describe the minor version.

### *Example –*

- The user transmits: VER?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>0100<NL>

This indicates that the major firmware version is 01, and the minor firmware version is 00.

## Interrogating the Serial Poll Response Byte

### \*SRE?

The 2551/ 2551E places an ASCII string describing the serial poll response byte mask into the Interrogative Bank following the recommendations of the IEEE488.2 standard for this command. The ASCII string represents, using the numeric characters, an integer corresponding to the present value of the serial poll response byte mask. See *Table 1* for details regarding the content of this mask.

### *Example –*

- The user transmits: \*SRE?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP><SP>52<NL>

This indicates that the 2551/ 2551E will assert the IEEE488 SRQ line if new data is available to be read, the voltage input is overloaded, or the current input is overloaded.

### \*STB?

The 2551/ 2551E places an ASCII string which represents, using the characters 0 through 9, an integer corresponding to the present value of the serial poll response byte following the recommendations of the IEEE488.2 standard for this command. Note that, unlike actually performing a serial poll operation, the contents of the serial poll response byte are unaffected by this action. The ASCII string always contains three characters, using leading zero suppression. See *Table 1* for details regarding the content of this byte.

*Example –*

- The user transmits: \*STB?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP><SP>20<NL>

This indicates that the 2551/ 2551E has new data available to be read (always the case for this command), and that the voltage input has been overloaded at some time since the status byte was last cleared.

**STATUS?**

The 2551/ 2551E places an ASCII string representing, using the characters 0 through 9, an integer corresponding to the present value of the serial poll response byte. Note that, unlike actually performing a serial poll operation, the contents of the serial poll response byte are unaffected by this action. The ASCII string always contains three characters, using leading zero suppression. See *Table 1* for details regarding the content of this byte.

*Example –*

- The user transmits: STATUS?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP><SP>20<NL>

This indicates that the 2551/ 2551E has new data available to be read (always the case for this command), and that the voltage input has been overloaded at some time since the status byte was last cleared.

**Interrogating the Measurement Configuration****AC-ONLY?**

The 2551/ 2551E places the ASCII character 1 (decimal 49) if it is presently making measurements without the DC content, or the ASCII character 0 (decimal 48) if the measurements include the DC content. The AC-ONLY command controls this configuration.

*Example –*

- The user transmits: AC-ONLY?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>0<NL>

This indicates that the 2551/ 2551E is making measurements which include the DC content of the signals.

## AVERAGE?

The 2551/ 2551E places a single ASCII character representing the presently selected averaging period for measurement results. The AVERAGE command controls this configuration. The characters returned are as follows.

Character	Averaging Period
0	50ms
1	250ms
2	1s
3	2.5s
4	5s
5	10s
6	20s
7	1 minute

*Table 25 – Data returned due to AVERAGE? command*

### *Example –*

- The user transmits: AVERAGE?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>1<NL>

This indicates that the 2551/ 2551E is making measurements averaged over a period of 250ms.

## BANDWIDTH?

The 2551/ 2551E places a single ASCII character representing the presently selected bandwidth for measurement results. The BANDWIDTH command controls this configuration. The characters returned are as follows.

Character	Bandwidth
0	20Hz to 100KHz
1	20Hz to 5KHz
2	2Hz to 2KHz
3	0.2Hz to 200Hz
4	0.02Hz to 20Hz

Table 26 – Data returned due to BANDWIDTH? command

### Example –

- The user transmits: BANDWIDTH?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>1<NL>

This indicates that the 2551/ 2551E is making measurements using a bandwidth of 20Hz to 5KHz.

## HISTORY?

The 2551/ 2551E places the ASCII character 1 (decimal 49) if it is presently storing historical measurements, or the ASCII character 0 (decimal 48) if not. Note that the 2551/ 2551E is not updating historical results whenever measurements are frozen (see the HISTORY and MEASURE commands).

### Example –

- The user transmits: HISTORY?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>1<NL>

This indicates that the 2551/ 2551E is storing historical measurement results.

## HISTORY-SCALE?

The 2551/ 2551E places a pair of ASCII characters representing the presently selected timescale for historical measurement results. The HISTORY-SCALE command controls this configuration.

The characters returned are as follows—

Characters	History Timescale
<SP>0	0.4 seconds per division
<SP>1	1 second per division
<SP>2	2 seconds per division
<SP>3	5 seconds per division
<SP>4	10 seconds per division
<SP>5	30 seconds per division
<SP>6	1 minute per division
<SP>7	3 minutes per division
<SP>8	10 minutes per division
<SP>9	30 minutes per division
10	1 hour per division
11	3 hours per division
12	6 hours per division
13	12 hours per division
14	1 day per division

*Table 27 – Data returned due to HISTORY-SCALE? command*

### *Example –*

- The user transmits: HISTORY-SCALE?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP><SP>1<NL>

This indicates that the 2551/ 2551E is storing historical measurement results at the rate of 1 second per division.

## INTEGRATE?

The 2551/ 2551E places the ASCII character 1 (decimal 49) if it is presently integrating measurements, or the ASCII character 0 (decimal 48) if not. Note that the 2551/ 2551E is not updating integrated results whenever measurements are frozen (see the INTEGRATE and MEASURE commands).

### *Example –*

- The user transmits: INTEGRATE?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>1<NL>

This indicates that the 2551/ 2551E is integrating results (i.e. Watt-Hour and related results are being updated).

## MEASURE?

The 2551/ 2551E places the ASCII character 1 (decimal 49) if it is presently performing measurements, or the ASCII character 0 (decimal 48) if measurements are presently frozen by the user. The MEASURE command controls this configuration.

### *Example –*

- The user transmits: MEASURE?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>0<NL>

This indicates that the 2551/ 2551E has frozen all measurement results.

## SYNC?

The 2551/ 2551E places a single ASCII character representing the presently selected source of synchronization for measurement results. The SYNC command controls this configuration. The characters returned are as follows.

Character	Synchronization
0	Voltage Input
1	Current Input
2	Fixed 50Hz synchronization
3	Fixed 60Hz synchronization
4	Fixed 400Hz synchronization
5	None

*Table 28 – Data returned due to SYNC? command*



*Example –*

- The user transmits: SYNC?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>0<NL>

This indicates that the 2551/ 2551E is making measurements synchronized to the Voltage Input signal.

## Interrogating Date and Time

### DATE?

The 2551/ 2551E places an ASCII string indicating the present date. Note that the returned format is fully year 2000 compliant.

*Example –*

- The user transmits: DATE?<NL>

The user reads the 2551/ 2551E and receives the characters:

<SP>Apr<SP>28<SP>1998<NL>

This indicates that the date is the 28<sup>th</sup> of April, 1998.

### TIME?

The 2551/ 2551E places an ASCII string indicating the present time of day using 24 hour format.

*Examples –*

- The user transmits: TIME?<NL>

The user reads the 2551/ 2551E and receives the characters: <SP>13:28:51<NL>

This indicates that the time of day is 13 hours, 28 minutes and 51 seconds.

- The user transmits: TIME?;DATE?<NL>

The user reads the 2551/ 2551E and receives the characters:

<SP>13:28:51,Apr<SP>28<SP>1998<NL>

This indicates that the time of day is 13 hours, 28 minutes and 51 seconds, and the date is the 28th of April, 1998.



# Reading Measurement Results from the 2551/ 2551E

This section describes the methods by which the user may obtain measurement results from the 2551/ 2551E.

## General

The 2551/ 2551E uses Transmit Buffer Banks to transfer measurement results to the controller. Each of these, there are five in the 2551/ 2551E, contains the following functionality.

- Each can contain up to 6000 characters of formatted measurement results.
- Each is individually programmed by the user regarding the measurement results to be formatted in the bank.
- Each is individually programmed by the user regarding how often the formatted measurement results are to be updated.
- Each bank may be non-destructively read any number of times between updates.
- The bank selected to be read can cause the assertion of the IEEE488.1 interface SRQ line when updated with formatted measurement results, this assertion can be used for controller data read purposes, or controller timing duties, or both.

After defining which measurement results are to be placed into each bank, and how often each bank is to be updated, the user has simply to set which bank is to be read prior to reading the data contained within it. In this manner, the user can rapidly, on an “as required” basis, switch between several (up to five) different sets of measurement results without having to send long and complex commands each time.

Each bank is controlled by a pair of commands, one to set the time interval between updates, the other to set the content of the bank. A further command is provided to select which bank will be read by the controller.

## Format of Measurement Results

Data read from any bank always has a <SP> character (decimal 20) as the first character, and <NL> (with the IEEE488.1 interface EOI line asserted) as the last character.

If more than one measurement result is included in the data transmitted from the 2551/2551E bank, then the comma character separates them.

In this manner the user can easily synchronize parsing and terminating the set of measurement results using any of the standard methods. Using an exact character count to terminate reading the measurement results is strongly discouraged as this can lead to serious synchronization problems, particularly in the presence of noise signals. The user is recommended to use either the <NL> character (i.e., the EOS method) or the EOI line of the IEEE488.1 interface as the terminator for the set of measurement results.

Similarly, the user is discouraged from using character count within the string to identify the position of individual measurement results, but is recommended to parse the "receive data" string using the comma characters to delimit between individual measurement results. In this manner the parsing function is immune to noise interference, and any future changes in the exact syntax of the data returned from the 2551/2551E shall be accommodated automatically, without the user being forced to rewrite software for the controller.

It should also be noted that this method of formatting the data from the 2551/2551E is identical in nature (but not in detail) to all other Xitron Technologies Inc. products, and following the recommended method will accommodate all products.

Once the user has started to read the contents of a buffer, i.e., after the initial <SP> character has been fully transmitted from the 2551/2551E, updates of that bank are blocked until the entire contents have been transmitted from the 2551/2551E. If the user only reads a portion of a buffer, then this bank becomes "frozen" until the remainder is subsequently read by the controller. If it is desired to abort reading measurement results from a buffer during a transfer, then the IFC IEEE488.1 Interface command should be used to clear this. The banks do not require reprogramming after the IFC command. Some interface controller software use the name CLI rather than IFC.

Each measurement result read from a bank takes one of the following formats, dependant on the type of data for the specified measurement result.

Several result definitions yield multiple formatted results, in this case it is possible that the 6000 character limit on the total formatted data may be reached before the limit of 50 definitions is reached. During decode this is detected and a command error is raised if this occurs.

## **Floating-Point Measurement Results**

Most measurement results are "floating point" and are formatted as an ASCII string floating-point value, which always uses seven ASCII characters. The value is always expressed in decimals, which may or may not contain a decimal point. Leading zero suppression is used, with the polarity indicating character (either the <SP> or minus character) always positioned immediately prior to the leftmost non-space character. At least one digit character is always used, even if zero. Some examples are shown below.

Common ASCII string to binary floating-point functions (in the software used in the controller) can usually correctly convert this format without any special software by the user. Although presently the 2551/ 2551E does not use exponent format, most other Xitron Technologies Inc. products do, and possible future extensions to the capabilities of the 2551/ 2551E may use the exponent format. The user is recommended to allow for conversion of a general floating-point format (including decimal format shown here, and exponent format used in other products) for both inter-product and future compatibility, most conversion routines in high level language libraries provide this flexibility.

#### *Examples—*

- <SP><SP><SP><SP><SP><SP>0 (the floating-point value zero)
- <SP><SP><SP><SP><SP><SP>1 (the floating-point value one)
- <SP><SP><SP><SP><SP><SP>-1 (the floating-point value negative one)
- <SP>1000.1 (the floating-point value positive one thousand and one tenth)
- -1000.1 (the floating-point value negative one thousand and one tenth)

## **Other Measurement Result Formats**

A few measurement results do not use floating point numbers (e.g., date, time, depth of valid historical data etc.). The formats used for these are detailed later in this section, along with the details regarding the definitions of these measurement results.

## **Selecting the Bank to Be Read**

This is achieved by the READBANK command. Following reset, Bank #0 is selected by default. In simple interface duties, this command need not be used, as a single bank will suffice.

### **READBANK**

This command should be followed by an = character (decimal 61) and a single digit character in the range 0 (decimal 48) through 4 (decimal 52). The bank from which the data sent to the controller will be obtained when the 2551/ 2551E is next addressed to talk is selected by the digit character.

#### *Example —*

- The user transmits: READBANK=0<NL>

The 2551/ 2551E selects that the contents of bank #0 will be sent to the controller when it is next addressed to talk.

## Setting the Time Interval Between Bank Updates

This is achieved by the UPDATE<sub>n</sub> set of commands (n is a digit character between 0 and 4 inclusive, defining which bank is to have its update interval changed). Following reset, all banks have an update interval of 250ms. In most applications this will suffice, thus these commands are rarely used.

### UPDATE0, UPDATE1, UPDATE2, UPDATE3 and UPDATE4

This command should be followed by an = character (decimal 61) and one or more digit characters. The update interval for the bank controlled by the command is set to the integer data number of 10ms intervals. Although allowed, setting the update rate to less than 2 is not recommended.

#### *Examples –*

- The user transmits: UPDATE0=25<NL>  
The 2551/ 2551E sets the update interval for bank #0 to 250ms (25 x 10ms).
- The user transmits: UPDATE1=1000<NL>  
The 2551/ 2551E sets the update interval for bank #1 to 10 seconds (1000 x 10ms).
- The user transmits: UPDATE0=25;UPDATE1=1000<NL>  
The 2551/ 2551E sets the update interval for bank #0 to 250ms and sets the update interval for bank #1 to 10 seconds.

## Selecting the Measurement Result(s) to Be Read

There are many thousands of possible measurement results which may be formatted into a bank, thus the user needs to determine measurement results are desired and the order in which they should be presented, for each bank the user will use.

This is achieved by the BANK<sub>n</sub> set of commands (n is a digit character between 0 and 4 inclusive, defining which bank is to have its definition changed). Following reset, all banks are set to not be updated with any measurement results.

### BANK0, BANK1, BANK2, BANK3 and BANK4

This command should be followed by an = character (decimal 61) and one or many (up to 50) measurement result definitions. If many measurement result definitions are to be given, then each should be separated by the / character (decimal 47). Alternatively, this command may be followed by no data, in which case no measurement results will be formatted into the specified bank.

The following paragraphs detail each available measurement result definition and their allowable formats. A separate booklet is available from Xitron Technologies Inc. that contains the exact method used to compute each of these measurement results.

The same measurement result may be placed into more than one bank, and may be placed more than once in the same bank, if desired.

### *Examples –*

- The user transmits: BANK0<NL>

The 2551/ 2551E sets that no measurement results will be formatted into bank #0. This bank will remain empty.

- The user transmits: BANK0=VOLTS[RMS]<NL>

- The 2551/ 2551E sets that the single measurement result of RMS voltage shall be formatted into bank #0. Note that both AC and DC components are included in the RMS voltage results if the 2551/ 2551E is configured using the AC-ONLY command.

- The user transmits: BANK1=VOLTS[RMS]/AMPS[RMS]<NL>

The 2551/ 2551E sets that the measurement result of RMS voltage (both AC and DC components included) followed by RMS current (both AC and DC components included) shall be formatted into bank #1.

The comma character in the data transmitted from the 2551/ 2551E separates multiple measurement results.

- The user transmits:

BANK0;BANK1=VAR[RMS];BANK2=VOLTS[RMS]/AMPS[RMS]<NL>

The 2551/ 2551E sets that bank #0 shall yield no measurement results, bank #1 shall yield the measurement result of VAR (Imaginary Power), and bank #2 shall yield the measurement results of RMS voltage and RMS current respectively. Particularly note the difference in use between the / character (separates each data for a command) and the semi-colon character (separates commands) in this example.

## **General Syntax of a Measurement Result Definition**

The exact format for each definition syntax is shown later in this guide, however, knowledge of the underlying general format will assist the user in quickly generating measurement result definitions for banks.

### *keyword*

A few measurement result definitions require no further definition other than the *keyword* defining the result.

### *keyword [ type ]*

Most measurement result definitions allow for this format. The general result is defined by the *keyword*. The *type* portion may be any of the following strings (not all results use all the available type formats).

This format is generally used when a full bandwidth measurement result is required (e.g., RMS Voltage or Current, Total Power etc.).

ASCII characters	Type of result defined
RMS	True RMS
DC	DC only
MAX	Highest valued peak or value
MIN	Lowest valued peak or value
PEAK	Highest valued absolute peak
PKPK	Difference between the MAX and MIN results
CF	Crest Factor
RECT	Average Rectified
FF	Form Factor
THD	% of fundamental, using all harmonics
FUND	Fundamental amplitude
ACDC	Same as RMS
HIGHEST	Same as MAX
LOWEST	Same as MIN
WORST	Same as PEAK

Table 29 – Type for full bandwidth result definitions

### ***keyword [ harmonic ]***

Many measurement result definitions allow for this format. The general result is defined by the *keyword*. The *harmonic* is one or two ASCII digits defining the integer harmonic number (the fundamental is 1) at which the result is to be evaluated. The maximum harmonic available is 40 in all cases, if a harmonic is requested but the harmonic is not available because of bandwidth limitations, the result is returned as 0.

This format is generally used where the result is only required at a particular harmonic (usually the fundamental), note that the FUND *type* shown above, and a *harmonic* value of 1 in this format yield the same result.

When many harmonic results are required for the same general result, use the harmonic array format shown later.

### ***keyword [ harmonic - harmonic ]***

This is similar to the single harmonic number format shown above, but evaluates the requested result over the inclusive range of harmonics defined by the pair of integers separated by the minus character. The order of the harmonics is unimportant. The maximum harmonic available is 40, results for harmonics that are not available due to bandwidth limitations are assumed to be 0.



Note that certain results do not use all of the inclusive range of harmonics (e.g., TRIPLENS only uses harmonics divisible by three).

This format is generally used when one or more harmonics are to be excluded from the evaluation of the result, typically this would be the fundamental (e.g., VOLTS[2-40] yields the total distortion voltage).

While all results are correctly evaluated as defined by the users harmonic range, this may not always be the result intended, e.g., K-factor should not exclude the fundamental.

### *keyword [ harmonic : harmonic ]*

This is similar to the single harmonic number format shown above, but evaluates the requested result at each harmonic in the inclusive range of harmonics defined by the pair of integers separated by the colon character. The maximum harmonic available is 40, if a harmonic less than 40 is requested but the harmonic is not available because of bandwidth limitations, the result is returned as 0.

This format yields many results from a single definition. The first result given is always for the lowest harmonic in the defined range independent of the order in which the harmonic range is defined.

This format provides the user with an efficient method of obtaining a harmonic listing for a particular result (e.g., VOLTS[1:40] yields a listing of the first 40 voltage harmonics).

## **Defining Current Measurement Results**

### **AMPS[CF]**

The Crest Factor of the current input signal, using either AC or DC coupling (see the AC-ONLY command). The result format is floating point, unitless, and is always positive.

### **AMPS[DC]**

The mean amplitude of the current input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Amps.

### **AMPS[FF]**

The Form Factor of the current input signal, using either AC or DC coupling (see the AC-ONLY command). The result format is floating point, unitless, and is always positive.

### **AMPS[FUND]**

The RMS current amplitude measurement result evaluated for the fundamental component only. The result format is floating point, in Amps, and is always positive.

**AMPS[MAX]**

The highest peak measured instantaneous current amplitude. The result format is floating point, in Amps.

**AMPS[MIN]**

The lowest peak measured instantaneous current amplitude. The result format is floating point, in Amps.

**AMPS[PEAK]**

The highest absolute peak measured instantaneous current amplitude. The result format is floating point, in Amps, and is always positive.

**AMPS[PKPK]**

The difference between the highest and lowest peak measured instantaneous current amplitude. The result format is floating point, in Amps, and is always positive.

**AMPS[RECT]**

The average rectified current amplitude. The result format is floating point, in Amps, and is always positive.

**AMPS[RMS]**

The RMS current amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Amps, and is always positive.

**AMPS[THD]**

The ratio of the harmonic current amplitude of all harmonics except the fundamental, to the current fundamental. The result format is floating point, in percent, and is always positive.

**AMPS[ *harmonic* ]**

The RMS current amplitude measurement result evaluated at the specified harmonic. The result format is floating point, in Amps, and is always positive.

**AMPS[ *harmonic* : *harmonic* ]**

The RMS current amplitude measurement result evaluated for each harmonic. Each result format is floating point, in Amps, and is always positive.

**AMPS[ *harmonic* - *harmonic* ]**

The RMS current amplitude measurement result evaluated for a range of harmonics. The result format is floating point, in Amps, and is always positive.

**A-INRUSH[DC]**

The highest inrush mean amplitude of the current input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Amps.

**A-INRUSH[MAX]**

The highest inrush highest peak measured instantaneous current amplitude. The result format is floating point, in Amps.

**A-INRUSH[MIN]**

The lowest inrush lowest peak measured instantaneous current amplitude. The result format is floating point, in Amps.

**A-INRUSH[PEAK]**

The highest inrush highest modulus peak measured instantaneous current amplitude. The result format is floating point, in Amps, and is always positive.

**A-INRUSH[RECT]**

The highest inrush average rectified current amplitude. The result format is floating point, in Amps, and is always positive.

**A-INRUSH[RMS]**

The highest inrush RMS current amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Amps, and is always positive.

**A-PHASE[ *harmonic* : *harmonic* ]**

The RMS current phase measurement result evaluated for each harmonic, relative to the fundamental voltage waveform. Each result format is floating point, in degrees, and is in the range  $\pm 180^\circ$ .

**A-RELHARM[ *harmonic* ]**

The RMS current amplitude measurement result evaluated at the specified harmonic, relative to the fundamental current amplitude measurement. The result format is floating point, in percent, and is always positive.

**A-RELHARM[ *harmonic : harmonic* ]**

The RMS current amplitude measurement result evaluated for each harmonic, relative to the fundamental current amplitude measurement. Each result format is floating point, in percent, and is always positive.

**A-RELHARM[ *harmonic - harmonic* ]**

The RMS current amplitude measurement result evaluated for a range of harmonics, relative to the fundamental current amplitude measurement. The result format is floating point, in percent, and is always positive. This is typically used to obtain the %THD, relative to fundamental, over a specified range of harmonics.

**EVEN-TRIPLENS[ *harmonic - harmonic* ]**

The RMS current amplitude measurement result evaluated for a range of harmonics, using only those harmonics, which are divisible by 3 with an even result (e.g., 6, 12, 18 etc.). The result format is floating point, in Amps, and is always positive.

**IEC-CLASS-D**

The percent of the current waveform which is outside of the envelope for IEC61000-3-2 Class D analysis, expressed as a floating point value.

**K-FACTOR[ *harmonic - harmonic* ]**

The current K-factor measurement result evaluated for a range of harmonics. The result format is floating point, unitless, and is always positive. Note that the harmonic range should always include the fundamental (i.e. 1).

**ODD-TRIPLENS[ *harmonic - harmonic* ]**

The RMS current amplitude measurement result evaluated for a range of harmonics, using only those harmonics, which are divisible by 3 with an odd result (e.g., 3, 9, 15 etc.). The result format is floating point, in Amps, and is always positive.

**TRIPLENS[ *harmonic - harmonic* ]**

The RMS current amplitude measurement result evaluated for a range of harmonics, using only those harmonics, which are divisible by 3. The result format is floating point, in Amps, and is always positive.

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## Defining Voltage Measurement Results

### VOLTS[CF]

The Crest Factor of the voltage input signal, using either AC or DC coupling (see the AC-ONLY command). The result format is floating point, unitless, and is always positive.

### VOLTS[DC]

The mean amplitude of the voltage input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Volts.

### VOLTS[FF]

The Form Factor of the voltage input signal, using either AC or DC coupling (see the AC-ONLY command). The result format is floating point, unitless, and is always positive.

### VOLTS[FUND]

The RMS voltage amplitude measurement result evaluated for the fundamental component only. The result format is floating point, in Volts, and is always positive.

### VOLTS[MAX]

The highest peak measured instantaneous voltage amplitude. The result format is floating point, in Volts.

### VOLTS[MIN]

The lowest peak measured instantaneous voltage amplitude. The result format is floating point, in Volts.

### VOLTS[PEAK]

The highest modulus peak measured instantaneous voltage amplitude. The result format is floating point, in Volts, and is always positive.

### VOLTS[PKPK]

The difference between the highest and lowest peak measured instantaneous voltage amplitude. The result format is floating point, in Volts, and is always positive.

**VOLTS[RECT]**

The average rectified voltage amplitude. The result format is floating point, in Volts, and is always positive.

**VOLTS[RMS]**

The RMS voltage amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Volts, and is always positive.

**VOLTS[THD]**

The ratio of the harmonic voltage amplitude of all harmonics except the fundamental, to the voltage fundamental. The result format is floating point, in percent, and is always positive.

**VOLTS[ *harmonic* ]**

The RMS voltage amplitude measurement result evaluated at the specified harmonic. The result format is floating point, in Volts, and is always positive.

**VOLTS[ *harmonic* : *harmonic* ]**

The RMS voltage amplitude measurement result evaluated for each harmonic. Each result format is floating point, in Volts, and is always positive.

**VOLTS[ *harmonic* - *harmonic* ]**

The RMS voltage amplitude measurement result evaluated for a range of harmonics. The result format is floating point, in Volts, and is always positive.

**V-INRUSH[DC]**

The highest inrush mean amplitude of the voltage input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Volts.

**V-INRUSH[MAX]**

The highest inrush highest peak measured instantaneous voltage amplitude. The result format is floating point, in Volts.

### V-INRUSH[MIN]

The lowest inrush lowest peak measured instantaneous voltage amplitude. The result format is floating point, in Volts.

### V-INRUSH[PEAK]

The highest inrush highest modulus peak measured instantaneous voltage amplitude. The result format is floating point, in Volts, and is always positive.

### V-INRUSH[RECT]

The highest inrush average rectified voltage amplitude. The result format is floating point, in Volts, and is always positive.

### V-INRUSH[RMS]

The highest inrush RMS voltage amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Volts, and is always positive.

### V-PHASE[ *harmonic* : *harmonic* ]

The RMS voltage phase measurement result evaluated for each harmonic, relative to the fundamental voltage waveform. Each result format is floating point, in degrees, and is in the range  $\pm 180^\circ$ .

### V-RELHARM[ *harmonic* ]

The RMS voltage amplitude measurement result evaluated at the specified harmonic, relative to the fundamental voltage amplitude measurement. The result format is floating point, in percent, and is always positive.

### V-RELHARM[ *harmonic* : *harmonic* ]

The RMS voltage amplitude measurement result evaluated for each harmonic, relative to the fundamental voltage amplitude measurement. Each result format is floating point, in percent, and is always positive.

### V-RELHARM[ *harmonic* - *harmonic* ]

The RMS voltage amplitude measurement result evaluated for a range of harmonics, relative to the fundamental voltage amplitude measurement. The result format is floating point, in percent, and is always positive. This is typically used to obtain the %THD, relative to fundamental, over a specified range of harmonics.

## Defining Power Measurement Results

### PF[FUND]

The power factor measurement result evaluated for the fundamental component only. The result format is floating point, unitless.

### PF[RMS]

The power factor measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, unitless.

### PF[ *harmonic* ]

The power factor measurement result evaluated at the specified harmonic. The result format is floating point, unitless.

### PF[ *harmonic - harmonic* ]

The power factor measurement result evaluated for a range of harmonics. The result format is floating point, unitless.

### VA[DC]

The apparent power measurement result evaluated from the DC components only. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in VA, and is always positive.

### VA[FUND]

The real power measurement result evaluated for the fundamental component only. The result format is floating point, in VA, and is always positive.

### VA[RMS]

The apparent power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in VA, and is always positive.

### VA[ *harmonic* ]

The real power measurement result evaluated at the specified harmonic. The result format is floating point, in VA, and is always positive.



**VA[ *harmonic* : *harmonic* ]**

The real power measurement result evaluated for each harmonic. Each result format is floating point, in VA, and is always positive.

**VA[ *harmonic* - *harmonic* ]**

The real power measurement result evaluated for a range of harmonics. The result format is floating point, in VA, and is always positive.

**VAR[FUND]**

The imaginary power measurement result evaluated for the fundamental component only. The result format is floating point, in VAR.

**VAR[RMS]**

The imaginary power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in VAR.

**VAR[ *harmonic* ]**

The imaginary power measurement result evaluated at the specified harmonic. The result format is floating point, in VAR.

**VAR[ *harmonic* : *harmonic* ]**

The imaginary power measurement result evaluated for each harmonic. Each result format is floating point, in VAR.

**VAR[ *harmonic* - *harmonic* ]**

The imaginary power measurement result evaluated for a range of harmonics. The result format is floating point, in VAR.

**VAR-INRUSH[RMS]**

The highest inrush imaginary power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in VAR. VAR-INRUSH[RMS] may also be used for this definition.

### WATTS[DC]

The same as VA[DC]. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Watts.

### WATTS[FUND]

The real power measurement result evaluated for the fundamental component only. The result format is floating point, in Watts.

### WATTS[RMS]

The real power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Watts.

### WATTS[ *harmonic* ]

The real power measurement result evaluated at the specified harmonic. The result format is floating point, in Watts.

### WATTS[ *harmonic* : *harmonic* ]

The real power measurement result evaluated for each harmonic. Each result format is floating point, in Watts.

### WATTS[ *harmonic* - *harmonic* ]

The real power measurement result evaluated for a range of harmonics. The result format is floating point, in Watts.

### W-INRUSH[DC]

The highest inrush real power using only the DC components. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Watts.

### W-INRUSH[RMS]

The highest inrush real power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Watts.

---

## Defining Frequency Measurement Results

### FREQ

The measured frequency of the voltage input unless SYNC=1 command is prevailing, in which case it is the measured frequency of the current input. The result format is floating point, in Hz, and is always positive. A zero result indicates that the input has too low of an AC amplitude for frequency measurement (approx. 5% full-scale for the option fitted), or that the frequency lies outside of the configured bandwidth (see the BANDWIDTH command).

## Defining Load Measurement Results

### LOAD-R[FUND]

The calculated load resistance, evaluated from the fundamental voltage and current amplitudes, expressed as the real part of series real and imaginary components. The result format is floating point, in Ohms.

### LOAD-X[FUND]

The calculated load reactance, evaluated from the fundamental voltage and current amplitudes, expressed as the imaginary part of series real and imaginary components. The result format is floating point, in Ohms.

### LOAD-Z[DC]

The calculated load impedance, evaluated from the DC voltage and current amplitudes. The result format is floating point, in Ohms.

### LOAD-Z[FUND]

The calculated load impedance, evaluated from the fundamental voltage and current amplitudes. The result format is floating point, in Ohms, and is always positive.

### PARALLEL-C

The calculated load capacitance, evaluated from the fundamental voltage and current amplitudes, expressed as the imaginary part of parallel real and imaginary components. The result format is floating point, in micro-farads.

### PARALLEL-R

The calculated load resistance, evaluated from the fundamental voltage and current amplitudes, expressed as the real part of parallel real and imaginary components. The result format is floating point, in Ohms.

## SERIES-L

The calculated load inductance, evaluated from the fundamental voltage and current amplitudes, expressed as the imaginary part of series real and imaginary components. The result format is floating point, in milli-henries.

## Defining Integrated Measurement Results

### A-HR[DC]

The integrated mean amplitude of the current input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Amp-Hours.

### A-HR[RMS]

The integrated RMS current amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Amp-Hours, and is always positive.

### A-INTEG-AVG[RMS]

The average integrated RMS current amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Amps, and is always positive.

### A-INTEG-AVG[DC]

The average integrated mean amplitude of the current input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Amps.

## INTEGRATED-TIME

The total length of time over which all present integrated results have been integrated. The result format is floating point, in Hours, and is always positive.

### PF-INTEG-AVG[RMS]

The average integrated power factor measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, unitless.

### VA-HR[DC]

The integrated apparent power measurement result using only the DC components. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in VA-Hours, and is always positive.

### VA-HR[RMS]

The integrated apparent power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in VA-Hours, and is always positive.

### VA-INTEG-AVG[DC]

The average integrated apparent power measurement result using only the DC components. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in VA, and is always positive.

### VA-INTEG-AVG[RMS]

The average integrated apparent power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in VA, and is always positive.

### VAR-HR[RMS]

The integrated imaginary power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in VAR-Hours. VAR-HR[RMS] may also be used for this definition.

### VAR-INTEG-AVG[RMS]

The average integrated imaginary power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in VARs. VAR-INTEG-AVG[RMS] may also be used for this definition.

### V-HR[DC]

The integrated mean amplitude of the voltage input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Volt-Hours.

### V-HR[RMS]

The integrated RMS voltage amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Volt-Hours, and is always positive.

### V-INTEG-AVG[DC]

The average integrated mean amplitude of the voltage input signal. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Volts.

### V-INTEG-AVG[RMS]

The average integrated RMS voltage amplitude measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Volts, and is always positive.

### W-HR[DC]

The integrated real power measurement result using only the DC components. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Watt-Hours.

### W-HR[RMS]

The integrated real power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Watt-Hours.

### W-INTEG-AVG[DC]

The average integrated real power measurement result using only the DC components. If configured as AC only then this result is always zero (see the AC-ONLY command). The result format is floating point, in Watts.

### W-INTEG-AVG[RMS]

The average integrated real power measurement result, including DC if configured (see the AC-ONLY command), over the full configured bandwidth (see the BANDWIDTH command), including any non-harmonic content. The result format is floating point, in Watts.

---

## Defining Waveform Results

With the exceptions noted, each of these returns a set of 200 results. The first result is that at 0 phase of the voltage waveform, each successive result being at  $\pi/100$  radians increased delay from the previous.

### A-CAPTURED-A

The set of current waveform amplitudes building the current waveform that was captured when the highest instantaneous current peak was detected. Each result is floating point, in Amps. Note that this yields 1600 characters in total.

### A-CAPTURED-V

The set of voltage waveform amplitudes building the voltage waveform that was captured when the highest instantaneous current peak was detected. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

### A-CAPTURED-W

The set of power waveform amplitudes building the power waveform that was captured when the highest instantaneous current peak was detected. Each result is floating point, in Watts. Note that this yields 1600 characters in total.

### A-CAPTURE-DATE

The date when waveforms were captured because the highest instantaneous current peak was detected. This is formatted as an ASCII string of format *mmm dd yyyy* (*mmm* is the three letter month, *dd* is the numeric date, *yyyy* is the four digit year).

### A-CAPTURE-PEAK

The highest instantaneous current peak detected, causing the capture of waveforms. The result format is floating point, in Amps.

### A-CAPTURE-PHASE

The phase delay of the highest instantaneous current peak detected, causing the capture of waveforms. The result format is floating point, in degrees, and is in the range  $\pm 180^\circ$ .

### A-CAPTURE-TIME

The time of day when waveforms were captured because the highest instantaneous current peak was detected. This is formatted as an ASCII string of format *hh:mm:ss* (*hh* is the two digit hour of the day, *mm* is the minute, *ss* is the second).

## A-DISTORTION

The set of current waveform amplitudes building the current distortion waveform. This is effectively the A-WAVEFORM data with the fundamental current component removed. Each result is floating point, in Amps. Note that this yields 1600 characters in total.

## A-GLITCHED-A

The set of current waveform amplitudes building the current waveform that was captured when the highest instantaneous current glitch was detected. Each result is floating point, in Amps. Note that this yields 1600 characters in total.

## A-GLITCHED-V

The set of voltage waveform amplitudes building the voltage waveform that was captured when the highest instantaneous current glitch was detected. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

## A-GLITCH-DATE

The date when waveforms were captured because the highest instantaneous current glitch was detected. This is formatted as an ASCII string of format *mmm dd yyyy* (*mmm* is the three letter month, *dd* is the numeric date, *yyyy* is the four digit year).

## A-GLITCH-PEAK

The highest instantaneous current glitch that was detected, causing the capture of waveforms. The result format is floating point, in Amps.

## A-GLITCH-PHASE

The phase delay of the highest instantaneous current glitch detected, causing the capture of waveforms. The result format is floating point, in degrees, and is in the range  $\pm 180^\circ$ .

## A-GLITCH-TIME

The time of day when waveforms were captured because the highest instantaneous current glitch was detected. This is formatted as an ASCII string of format *hh:mm:ss* (*hh* is the two digit hour of the day, *mm* is the minute, *ss* is the second).

## A-WAVEFORM

The set of current waveform amplitudes building the actual current waveform. Each result is floating point, in Amps. Note that this yields 1600 characters in total.



## V-CAPTURED-A

The set of current waveform amplitudes building the current waveform that was captured when the highest instantaneous voltage peak was detected. Each result is floating point, in Amps. Note that this yields 1600 characters in total.

## V-CAPTURED-V

The set of voltage waveform amplitudes building the voltage waveform that was captured when the highest instantaneous voltage peak was detected. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

## V-CAPTURED-W

The set of power waveform amplitudes building the power waveform that was captured when the highest instantaneous voltage peak was detected. Each result is floating point, in Watts. Note that this yields 1600 characters in total.

## V-CAPTURE-DATE

The date when waveforms were captured because the highest instantaneous voltage peak was detected. The result is formatted as an ASCII string of format *mmm dd yyyy* (*mmm* is the three letter month, *dd* is the numeric date, *yyyy* is the four digit year).

## V-CAPTURE-PEAK

The highest instantaneous voltage peak detected, causing the capture of waveforms. The result format is floating point, in Volts.

## V-CAPTURE-PHASE

The phase delay of the highest instantaneous voltage peak detected, causing the capture of waveforms. The result format is floating point, in degrees, and is in the range  $\pm 180^\circ$ .

## V-CAPTURE-TIME

The time of day when waveforms were captured because the highest instantaneous voltage peak was detected. This is formatted as an ASCII string of format *hh:mm:ss* (*hh* is the two digit hour of the day, *mm* is the minute, *ss* is the second).

## V-DISTORTION

The set of voltage waveform amplitudes building the voltage distortion waveform. This is effectively the V-WAVEFORM data with the fundamental voltage component removed. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

### V-GLITCHED-A

The set of current waveform amplitudes building the current waveform that was captured when the highest instantaneous voltage glitch was detected. Each result is floating point, in Amps. Note that this yields 1600 characters in total.

### V-GLITCHED-V

The set of voltage waveform amplitudes building the voltage waveform that was captured when the highest instantaneous voltage glitch was detected. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

### V-GLITCH-DATE

The date when waveforms were captured because the highest instantaneous voltage glitch was detected. This is formatted as an ASCII string of format *mmm dd yyyy* (*mmm* is the three letter month, *dd* is the numeric date, *yyyy* is the four digit year).

### V-GLITCH-PEAK

The highest instantaneous voltage glitch detected, causing the capture of waveforms. The result format is floating point, in Volts.

### V-GLITCH-PHASE

The phase of the highest instantaneous voltage glitch detected, causing the capture of waveforms. The result format is floating point, in degrees, and is in the range  $\pm 180^\circ$ .

### V-GLITCH-TIME

The time of day when waveforms were captured because the highest instantaneous voltage glitch was detected. This is formatted as an ASCII string of format *hh:mm:ss* (*hh* is the two digit hour of the day, *mm* is the minute, *ss* is the second).

### V-WAVEFORM

The set of voltage waveform amplitudes building the actual voltage waveform. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

### W-WAVEFORM

The set of power waveform amplitudes building the actual power waveform. Each result is floating point, in Watts. Note that this yields 1600 characters in total.

---

## Defining Historical Measurement Results

With the exception of HISTORY-SIZE, all of these return a 200 result set of results. The first result formatted is the earliest point, the last is the latest. Results which have not been placed into historical storage (i.e., at a time prior to starting the storage of historical data) is returned as a zero or blank value (use HISTORY-SIZE to obtain the number of valid data).

### A-HISTORY[MAX]

The set of highest instantaneous current amplitudes that have been stored historically. Each result is floating point, in Amps. Note that this yields 1600 characters in total.

### A-HISTORY[MIN]

The set of lowest instantaneous current amplitudes that have been stored historically. Each result is floating point, in Amps. Note that this yields 1600 characters in total.

### A-HISTORY[PEAK]

The set of highest instantaneous absolute current amplitudes that have been stored historically. Each result is floating point, in Amps, and is always positive. Note that this yields 1600 characters in total.

### A-HISTORY[PKPK]

The set of current amplitude ranges (MAX minus MIN results) that have been stored historically. Each result is floating point, in Amps, and is always positive. Note that this yields 1600 characters in total.

### A-HISTORY[RMS]

The set of RMS current amplitudes that have been stored historically. Each result is floating point, in Amps, and is always positive. Note that this yields 1600 characters in total.

### A-HISTORY[THD]

The set of evaluated current distortion results that have been stored historically. Each result is floating point, in percent relative to fundamental, and is always positive. Note that this yields 1600 characters in total.

## HISTORY-DATE

The set of dates, which correspond to each measurement result, that has been stored historically. Results that have not been placed into historical storage (i.e., at a time prior to starting the storage of historical data) are returned as a string containing 11 <SP> characters. Otherwise, each result is an ASCII string of format *mmm dd yyyy* (*mmm* is the three letter month, *dd* is the numeric date, *yyyy* is the four digit year). Note that this yields 2400 characters in total.

## HISTORY-SIZE

The number of valid, historically-stored sets of results that have presently been stored. The number is formatted as a three-digit integer. This number can be in the range 0 (indicating that no result sets have been stored yet) to 200 (indicating that all historical results are valid). Note that this number of results will be found at the end of the set of results obtained by any of the individual historically-stored data definitions.

## HISTORY-TIME

The set of time of day results, which correspond to each measurement result that has been stored historically. Results that have not been placed into historical storage (i.e., at a time prior to starting the storage of historical data) are returned as a string containing 8 <SP> characters. Otherwise, each result is an ASCII string of format *hh:mm:ss* (*hh* is the two digit hour of the day, *mm* is the minute, *ss* is the second). Note that this yields 1800 characters in total.

## PF-HISTORY

The set of power factor measurements that have been stored historically. Each result is floating point, unitless. Note that this yields 1600 characters in total.

## VAR-HISTORY

The set of imaginary power amplitudes that have been stored historically. Each result is floating point, in VAR. Note that this yields 1600 characters in total.

## V-HISTORY[MAX]

The set of highest instantaneous voltage amplitudes that have been stored historically. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

## V-HISTORY[MIN]

The set of lowest instantaneous voltage amplitudes that have been stored historically. Each result is floating point, in Volts. Note that this yields 1600 characters in total.

### V-HISTORY[PEAK]

The set of highest instantaneous absolute voltage amplitudes that have been stored historically. Each result is floating point, in Volts, and is always positive. Note that this yields 1600 characters in total.

### V-HISTORY[PKPK]

The set of voltage amplitude ranges (highest minus lowest) that have been stored historically. Each result is floating point, in Volts, and is always positive. Note that this yields 1600 characters in total.

### V-HISTORY[RMS]

The set of RMS voltage amplitudes that have been stored historically. Each result is floating point, in Volts, and is always positive. Note that this yields 1600 characters in total.

### V-HISTORY[THD]

The set of evaluated voltage distortion results that have been stored historically. Each result is floating point, in percent relative to fundamental, and is always positive. Note that this yields 1600 characters in total.

### W-HISTORY

The set of real power amplitudes that have been stored historically. Each result is floating point, in Watts. Note that this yields 1600 characters in total.

## Defining Date and Time

This data is also available as interrogative results.

### DATE

The present date is formatted as an ASCII string of format *mmm dd yyyy* (*mmm* is the three letter month, *dd* is the numeric date, *yyyy* is the four digit year).

The 2551/ 2551E places an ASCII string indicating the present date.

### TIME

The time of day is formatted as an ASCII string of format *hh:mm:ss* (*hh* is the two digit hour of the day, *mm* is the minute, *ss* is the second).



# Application Examples

This section shows the general outline of how to initialize, configure, control and obtain measurement results from the 2551/ 2551E. It specifically lists the commands, whether IEEE488.1 or data, to send to the 2551/ 2551E and the format of measurement results obtained from the 2551/ 2551E. This is not specific to a particular method by which these operations can be performed, nor is it specific to a particular language or manufacturer of IEEE488 interface. The user should consult the manuals on these to obtain information regarding how to send commands or data to the 2551/ 2551E, and how to read data from the 2551/ 2551E.

## Simple Interfacing

For many applications, the interfacing of the 2551/ 2551E follows the example given below. The user should check whether a different configuration is required (the default configuration is used in this example), and whether different measurement results are required.

1. Send the IEEE488.1 interface DCL (Device Clear) command. This ensures that the 2551/ 2551E IEEE488.1 physical interface is in a known condition.
2. Wait 500ms.
3. Send the command SETDEFAULTS<NL> to the 2551/ 2551E. This ensures that the 2551/ 2551E measurement configuration is in a known condition.
4. Send the command BANK0=VOLTS[RMS]/AMPS[RMS]/WATTS[RMS]<NL> to the 2551/ 2551E. This configures the 2551/ 2551E to return the RMS values for voltage, current and real power.
5. Read the 2551/ 2551E and save the response string. The response string contains three decimal floating-point numbers, with separating comma characters, terminated by the <NL> character (with EOI asserted). The first returned data is the RMS voltage (in Volts), the second is the RMS current (in Amps), the last is the real power (in Watts). An example response is shown below, indicating 115.03Vrms, 1.2345Arms and 123.45W.  
<SP><SP>115.03,<SP>1.2345, <SP>123.45<NL>
6. Parse the response into the required format in the controller.

7. Manipulate, store and/or display the results on the controller as required.
8. Repeat from line 5.

The example shown above, modified to produce the required measurement results, will suffice for most applications. The remainder of this section details the various methods that may be used for interfacing to the 2551/ 2551E and discusses possible reasons for each method to be used, or not.

## Sequence of Interfacing

Generally there will be other devices than the 2551/ 2551E on the bus, which also require control and possibly have measurement or status data read from them. The methods by which other devices are operated cannot be covered here, but the general outline of their interface will normally integrate with the outline shown below.

### Place the 2551/ 2551E into a "Known State"

Whenever the controller is first activated with the 2551/ 2551E attached to it via the IEEE488 interface, it is important that the user have knowledge of its state, such that all operations will yield the desired result. Of particular importance is to ensure that any bus handshake errors are eliminated which may have been caused by the connection of the IEEE488 cable, or by starting the IEEE488 controller.

To achieve a known state it is strongly recommended that the user always command a DCL IEEE488.1 command (or SDC) when the controller is first started with the 2551/ 2551E active on the bus.

After waiting a minimum of 350ms the user should then place the 2551/ 2551E into either of the REMOTE states by commanding the controller to assert the REN line of the IEEE488.1 interface, and then addressing the 2551/ 2551E to listen. This limits the front panel manual use of the 2551/ 2551E to display changes only. While the 2551/ 2551E is executing the DCL or SDC command, it releases itself from the IEEE488.1 bus momentarily. This may cause the bus controller to detect no IEEE488 devices present and cause it to report an error. Ignore the "No device present" error message, if present.

The 2551/ 2551E configuration should then be set to default values by sending the following data. If the REN line was asserted in the previous step without sending the 2551/ 2551E listen address, then this operation will achieve this and place the 2551/ 2551E into the REMOTE state.

```
SETDEFAULTS<NL>
```

This sets the factory default measurement configuration into the 2551/ 2551E by means of a single command. In this manner the user only needs to reconfigure those items required, rather than configuring all items.



## Check the Product, Version and Option Content

In many cases it may be desired to ensure that the product being controlled is actually a 2551/ 2551E (rather than another product in the 2551/ 2551E family), and to check that it has the correct option content for the application. Although there are none at this time, it may be possible that compatibility issues occur between different versions of firmware in the 2551/ 2551E. This is of particular importance if a future version adds a new feature that is not currently available. If the user software is reliant on this new feature then it is important that the version of 2551/ 2551E firmware is checked for compatibility. This can be checked by sending the any of the following interrogative commands and reading the responses to them from the 2551/ 2551E.

VER?	To obtain the firmware version from the 2551/ 2551E.
PRODUCT?	To obtain information regarding the product and option content of the 2551/ 2551E.

Alternatively the \*IDN? And \*OPT? commands may be used.

As an example of this –

1. Send PRODUCT? ; VER? <NL> to the 2551/ 2551E.
2. Read the 2551/ 2551E. No delay is required after sending an interrogative command and reading the 2551/ 2551E. The 2551/ 2551E automatically holds sending data to the controller until the previously requested data is ready to be sent. An example of the data read by the controller from the 2551/ 2551E is –

```
<SP>2551/40A/950V,0100<NL>.
```

or

```
<SP>2551E/40A/950V,0100<NL>.
```

The user can program string comparisons to check for product, option content, and firmware revision using this data string.

## Configure the 2551/ 2551E for Measurements

In many cases the factory default measurement configuration set above will suffice. If the application has specific demands then the user should check whether any of the following commands should be sent to the 2551/ 2551E to configure it for measurements. These commands should not be sent with the SETDEFAULTS commands shown above, but should be sent individually to ensure that the action of any command does not interfere with the actions required by another command. Refer to the relevant section of this guide for details on each configuration command, none of which interact with any other.

- **HISTORY-SCALE–**

If the storage of historical measurement results is desired, and these should be stored with a time scaling of other than the default of 5 sec/division.

- **INTEGRATE**–  
If the user needs to obtain integrated measurement results, e.g., Watt-Hours etc. If the user requires exact timing, this command may be used in other places in this sequence.
- **AVERAGE**–  
If measurement results are to be averaged over a period other than 250ms.
- **BANDWIDTH**–  
If measurements are to be made over a bandwidth of other than 20Hz to 5KHz.
- **AC-ONLY**–  
If measurements are to be made without the inclusion of any DC signal content.
- **SYNC**–  
If the measurement of the fundamental frequency is to be made on the current signal rather than the voltage signal, or if the 2551/ 2551E is to use a fixed fundamental frequency, or the user wishes to disable harmonics measurements entirely.

## **Configure the 2551/ 2551E to Provide the Desired Measurement Results**

The section of this booklet entitled *Reading Measurement Results from the 2551/ 2551E* should be read prior to programming the controller for this section.

The user should decide what measurement results will be required from the 2551/ 2551E, and whether there will be a requirement for different sets of measurement results under different conditions. If status information from the 2551/ 2551E is going to be needed, then this can be achieved by issuing interrogative commands during the execution of the main portion of the application, these will not be needed to be programmed into a Transmit Buffer Bank.

In many applications there is only a requirement for one set of measurement results, and these are not usually very extensive in size. In these cases, the user may program a single Transmit Buffer Bank to provide the required information. It is recommended that the user choose to use Bank #0 in this situation since this is the default bank.

Each bank has a 6000-character maximum data size and a 50-definition limit. Use multiple banks if–

- The amount of data required from the 2551/ 2551E is extensive,
- The user requires different data dependant on the stage of the application,
- The user requires different data dependant on other events which may occur.

In the rare situation where more than 5 banks are required then these will have to be programmed during the main execution of the application, rather than being programmed during the initialization as shown here.

After deciding on the data which will be required from the 2551/ 2551E, and possibly which data will be required from which bank, then the user should program the respective banks using the BANK0, BANK1, BANK2, BANK3, and BANK4 commands. To ensure that an unused bank does not contain a definition which would take the 2551/ 2551E time to format, it is recommended that unused banks be cleared by sending the respective BANKn command with no = character and no subsequent data. For readability of code, and to ensure that the 512-character command limit of the 2551/ 2551E is not exceeded, it is recommended that each BANKn command be sent individually, i.e., each terminated by the <NL> character. Some examples of bank measurement result definitions are given below.

## SINGLE BANK USAGE

Sending the command:

```
BANK0=VOLTS[RMS]/VOLTS[CF]/VOLTS[THD]/WATTS[RMS]<NL>
```

Configures the 2551/ 2551E to return the RMS Voltage, Voltage Crest Factor, Voltage Total Harmonic Distortion and Total Load Power respectively when bank #0 is read. In this application none of the other banks will be required, thus the following command will disable them.

```
BANK1;BANK2;BANK3;BANK4<NL>
```

## MULTIPLE BANK USAGE

In this example application the same measurement results as shown in the example above will normally be needed, however there will be times when the voltage waveform will be needed, and other occasions when historical RMS Voltage and Voltage THD data will be needed. In this case three banks will be programmed to provide this data, with the main execution portion of the application changing between these banks as required. In practice it is possible that the entire history data might not be full when the history data is read, thus the number of valid history data will also be read to determine the valid data points.

The following commands would be sent to the 2551/ 2551E to achieve programming of these banks—

```
BANK0=VOLTS[RMS]/VOLTS[CF]/VOLTS[THD]/WATTS[RMS]<NL>
```

```
BANK1=V-WAVEFORM<NL>
```

```
BANK2=HISTORY-SIZE/V-HISTORY[RMS]/V-HISTORY[THD]<NL>
```

```
BANK3;BANK4<NL>
```

When bank #0 is read, the RMS Voltage, Voltage Crest Factor, Voltage Total Harmonic Distortion and Total Load Power measurement results will be obtained, all in floating point format, comma delimited.

When bank #1 is read, a 200 point, comma delimited, set of floating point voltage waveform amplitudes will be read. This may be plotted within the user application by parsing the data into an array and then plotting the array, or the actual response may be written as a file and the file imported at a later date into a spreadsheet program for analysis or plotting.

When bank #2 is read, the number of valid data points (comma delimited), followed by a 200 point, comma delimited set of RMS Voltage historical results, followed by a 200 point, comma delimited set of Voltage THD historical results, will be read. The valid historical data points within each set of 200 will reside in the end of the set. It is guaranteed that both historical data sets (since they are obtained in the same bank) are consistent with each other. If historical data is read from different banks then consistency between data sets cannot be guaranteed unless the storing of historical data is frozen using the HISTORY or MEASURE commands. Similar to the waveform data, this may be plotted within the user application by parsing the data into arrays and then plotting the arrays, or the actual response may be written as a file and the file imported at a later date into a spreadsheet program for analysis or plotting.

## **Decide How Often to Read the Measurement Results**

In most applications, measurement results will be read from the 2551/ 2551E at slow rates (e.g., once a second or slower) and merely reading the 2551/ 2551E whenever required is the best method. In these cases the UPDATEn commands are not needed, as the default bank update rate of the 2551/ 2551E (250ms) is sufficient for this purpose.

In some applications it is required to obtain measurement results at high speeds, in these cases the UPDATEn command should be used for each bank that will be required to be read at high speed to ensure that the contents are maintained at this speed.

There is little gain in setting an update interval of more than 500ms. Setting an update interval of less than 20ms is not recommended.

As an example, sending the following command configures bank #1 for a 50ms update rate that would be suitable to maintain recent data for reading at intervals down to 100ms.

```
UPDATE1=5<NL>
```

## **Reading the Measurement Results**

With regard to the rate that measurement data will be needed, and the type of data that will be read, the user should decide which (or combination) of the following techniques will be used to read the data from the 2551/ 2551E.

## Asynchronously Reading Measurement Results from One Bank

This method allows the user to read up to 750 measurement results whenever it is desired. This accommodates the requirements for most applications. In this case there is no special programming of either the 2551/ 2551E or the controller, thus this is the simplest of all methods. The 2551/ 2551E always maintains the contents of the bank at the rate defined by the UPDATEn command. The user need not be concerned with maintaining synchronism with the 2551/ 2551E, or be concerned about the 2551/ 2551E forcing the controller to wait for new measurement results, as they are always available to be read. Since the default after application of power is to use bank #0, this should be the bank chosen. The UPDATE and READBANK commands need not be used.

## Asynchronously Reading Measurement Results from Many Banks

If needed, several banks may be read asynchronously. The READBANK command should be issued prior to each read operation to define the bank which will be read, there is no requirement for any delay between issuing the READBANK command and reading the data from this bank. There are no requirements on the order in which banks are read, or that the banks are read at the same rate. An example of the command to send to the 2551/ 2551E to request that results be returned from bank #1 is as follows.

```
READBANK=1<NL>
```

In some situations, the controller may actually be performing several tasks, some of which may require different information from the 2551/ 2551E. This is another case where different banks of measurement results can be used. Each application should program separate banks and use the READBANK command immediately prior to reading the required results. Dependent on the operating system being used, care may be needed to ensure that another application cannot execute between the READBANK command being issued and the read of the measurement results.

## Polling before Reading Measurement Results

In some situations it may be desired to only read some of the measurement results when a certain event occurs. In this case the application simply polls for the event and then reads the 2551/ 2551E when required. In its simplest form this is simply the previously described *Asynchronously Reading Measurement Results from One Bank* technique. The examples below give details for applications where the trigger event is detected within the 2551/ 2551E.

Example 1. Reading a captured waveform only when the waveform is updated.

A bank is used to obtain the date and time at which the voltage peak captured waveforms were last updated. A second bank is used to obtain the voltage waveform captured.

```
BANK0=V-CAPTURE-DATE/V-CAPTURE-TIME<NL>
```

```
BANK1=V-CAPTURED-V<NL>
```

At each poll operation the controller sends the READBANK=0<NL> command to the 2551/ 2551E and reads the 2551/ 2551E. The entire returned string is then compared to that which was last returned from the 2551/ 2551E. If the strings differ then the controller sends the READBANK=1<NL> command and reads the newly updated captured voltage waveform data array.

Example 2. Reading a bank only after it has been updated.

A bank is used to obtain many measurement results, in this example the bank is programmed to return all 40 harmonics of the voltage and current signals (i.e., 80 results in total).

```
BANK0=VOLTS[1:40]/AMPS[1:40];READBANK=0<NL>
```

The user only wishes to read this information every 500ms, but this is difficult to program at the controller due to other timing issues.

Sending the UPDATE0=50<NL> command to the 2551/ 2551E programs bank #0 to be updated every 500ms.

At intervals (usually less than 500ms) the controller sends the STATUS?<NL> interrogative command to the 2551/ 2551E, and then reads the present SRQ Response Byte Status. The application then converts the returned integer into binary and checks if bit 2 (see *Table 1*) is set.

If bit 2 is set then the controller reads the 2551/ 2551E again, this time the contents of bank #0 will be returned because the response to the interrogative has been cleared by reading it. The controller should then send the command STATUS=0<NL> to clear the SRQ Response Byte status.

If bit 2 is clear then no action is required and the poll operation may be repeated at any time following this.

## Using SRQ to Force Reading Measurement Results

In example 2 of the section on *Polling before Reading Measurement Results* above, the SRQ Response byte was used to poll for determining if a bank had been updated. The technique discussed in this section provides an alternative, interrupt driven method of achieving this.

Before using this technique, it is recommended that the user be fully conversant with the methods of programming interrupt driven IEEE488 activities with the particular controller and software being used. Interrupt driven techniques are often the most complex to program, and usually are the most complex to debug.

Assuming that the same requirements in example 2 above are present, the following commands should be sent to the 2551/ 2551E to program the bank for the required data.

```
BANK0=VOLTS[1:40]/AMPS[1:40];READBANK=0<NL>
```

```
UPDATE0=50<NL>
```

The user should then program the 2551/ 2551E to assert the IEEE488.1 interface SRQ line whenever the bank is updated by sending the following command.

```
STATUS=4<NL>
```

The application should be programmed to detect the assertion of the SRQ line and perform a serial poll of the 2551/ 2551E to determine if it is the cause. Since the 2551/ 2551E has only been programmed to assert this line when the bank is updated, there is no need to actually check the response byte, in more typical applications this would be performed since there would be other allowed causes (e.g., overload detection). When the interrupt occurs the application simply reads the newly updated set of measurement results (voltage and current harmonics in this example) from the 2551/ 2551E. No command to the 2551/ 2551E is needed to perform this. The SRQ Status Byte is automatically cleared when the serial poll takes place, in some cases it may be required to program the application to perform the serial poll. The user should check the documentation for the particular controller and software being used. Some packages automatically perform the serial poll.

## Changing the Configuration of the 2551/ 2551E

In rare circumstances, it may be required to reconfigure measurements in the 2551/ 2551E after the initial configuration that was performed when the application was started.

Following any change to the measurement configuration of the 2551/ 2551E, or sending the MEASURE=START<NL> or MEASURE=1<NL> commands, the 2551/ 2551E will stop all measurements momentarily, clear all previous measurement results, and then restart measurements using the new configuration. Prior to the completion of the first internal measurement cycle, measurement results are not available and will be returned as exactly zero. Typically this is a period of approximately 4 cycles of the applied voltage waveform or 10ms (whichever is longer), this may be longer for harmonics and frequency data, and shorter for peak measurements.

The user may wish to detect exactly zero measurement results and discard them following reconfiguring measurements, or starting measurements using the MEASURE command.

## Synchronization of Results to Input Changes

To achieve the fastest possible measurement of a changed input signal level, it may be beneficial to synchronize the 2551/ 2551E when it is known that a change in input has occurred. An example of this is when line input is first applied to the load under the control of the application.

The action of the MEASURE=START<NL> or MEASURE=1<NL> command is the same, whether the 2551/ 2551E was already taking measurements, or not. This command (either form produces the same actions) the 2551/ 2551E will stop all measurements momentarily, clear all previous measurement results, and then restart measurements. This process takes a very short period of time (less than 1ms). The first measured results available do not use any programmed measurement result averaging, thus are available as soon as possible with full accuracy. By sending this command at the same time as the change in input signals, the user can ensure that the fastest possible response is taken by the 2551/ 2551E.

For the fastest possible response, the UPDATEn command for the bank(s) used should be set to the shortest update interval. The response is not the same for all measurement result types. These are discussed below –

### Peak and Peak Inrush Results

Although cleared by the MEASURE command, these data are updated almost immediately following starting measurements.

In most cases there would be no requirement to use the MEASURE command to synchronize for these measurement results alone, since they are always updated at the fastest possible rate (virtually in real time).

### Full Bandwidth Amplitude Measurements

RMS, DC and similar measurements follow the time scales discussed previously. It is often advantageous to synchronize using the MEASURE command if these measurement results are desired at the fastest possible rate. There is some improvement in speed if the user maintains the voltage signal to the 2551/ 2551E when switching power to the load, as the 2551/ 2551E can maintain the frequency measurement in that situation. Thus switching the load power in the wiring between the 2551/ 2551E and the load offers the fastest approach.

### Frequency Measurements

Internally, frequency measurements (usually configured to measure the voltage signal) are unaffected by any configuration changes or by the MEASURE command. The frequency measurement available to the interface is a “latched” version of this internal frequency measurement. In this manner the user readable frequency measurement becomes available after approximately 4 cycles (or 50ms, whichever is longer) of the applied voltage waveform. If the voltage waveform is removed, or significantly altered, then the frequency result can take considerably longer to settle (up to 10 times longer or more), particularly if the DC content of the voltage signal is significantly altered. If possible, the user should consider maintaining the voltage signal at all times.



## Harmonics Measurements

Harmonics measurement results require that the fundamental frequency be exactly known before any accuracy can be achieved. These results become available 4 cycles + 25ms after the acquisition of an accurate frequency measurement. In this manner the issues affecting the frequency measurement response time are even more significant when the user requires harmonic measurements.

## Waveforms

These are similar to harmonics measurements.

## Historical Measurement Results

These are automatically updated at the correct rate, with data resolution equal to  $1/20^{\text{th}}$  of the division time period specified by the HISTORY-SCALE command. No special attention is required to maintain correct timing of these data.

If the fastest time scaling is selected, i.e. 400ms/division (20ms per data point), then the entire data depth is the equivalent of 4 seconds. Generally the controller is able to correctly stop the history updates if it is required to ensure that an event is contained in the history file. The user should check that the controller and software can accommodate any requirements on this, with particular regard to any other activities which the controller may be performing.

# Commanding the 2551/ 2551E to Produce Printouts

It is often advantageous to program the controller to command the 2551/ 2551E to perform printouts. This ensures that the correct printouts are obtained in a consistent manner. The various formats of the PRINT command are detailed on page 34.

Prior to commanding a printout, the user should ensure that the printer is ready to perform the desired printout, i.e. has completed any previous printout, has paper, is on line, and is operational. This can be achieved by using the PRINT-STATUS? interrogative command. It is recommended that all PRINT commands be preceded by a loop as detailed below.

1. Send the PRINT-STATUS?<NL> command to the 2551/ 2551E.
2. Read the 2551/ 2551E. The response will be ASCII integer characters forming an integer status of the printer. See *page 40* for details.
3. If the status indicates that the printer is not ready (indicated by a non-zero reply) then the application might inform the operator and/or wait for the problem to clear by repeating from step 1 above.

## Controlling the Front Panel

In some applications it may be advantageous to use the 2551/ 2551E display panel to relate information to the operator. In these situations it is often desirable to ensure that the user is viewing the desired display data, rather than relying on the user selecting which data to display.

The various formats of the DISPLAY command, detailed on page 31, allow the controller to enforce the display of the desired information. When using this facility, the 2551/ 2551E should be placed into the REMOTE state (preferably the REMOTE WITH LOCAL LOCKOUT state) to ensure that the operator cannot override the controller.

Under some circumstances it may be desired to duplicate the front panel of the 2551/ 2551E on the display panel of the controller. All data presented on the front panel is also available as measurement results and configuration interrogative commands via the IEEE488 interface, thus this may be achieved by the user in the normal manner.

Although not documented in this guide, there are alternative methods for achieving this by accessing the actual pixel data for the graphics display on the 2551/ 2551E front panel and using the KEY command documented in this guide. The method of performing this using National Instruments LabView™ is available on request, the user should contact Xitron Technologies Inc. for assistance in this regard if required.

## Debugging the Application

When debugging IEEE488 control applications the following points should be considered.

- Initially send all commands as single commands, i.e., do not send multiple commands with a single terminator. In this manner, by single stepping through the commands, the user can establish which command is causing a syntax error should this occur. Since there is little benefit, in the 2551/ 2551E, to sending multiple commands, the user should consider not using them.
- The user should consider testing all measurement result definitions, and checking their responses, by using an interactive manual utility such as the IBIC program provided with the National Instrument controllers. In this manner the user is not debugging both the software and the 2551/ 2551E interface at the same time.
- By viewing the **Setup** display while controlling the 2551/ 2551E, the user may check that the correct IEEE488 activities are taking place. To the immediate right of the IEEE address selection in this display may be the words TALK, LISTEN and SRQ. These are displayed when each of these bus activities takes place. Under some circumstances the user may need to slow down the response of the IEEE488 bus to ensure that changes in these are visible.





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# Frequently Asked Questions

This section provides some answers to the most commonly asked questions regarding interfacing the 2551/ 2551E to an IEEE488 controller. Xitron Technologies Inc. is continually updating its knowledge of the answers to questions asked by customers. If your question is not listed here or the answers given do not apply to your particular situation, please contact Xitron Technologies Inc.

## The controller issues a message that there is no listeners, but the 2551/ 2551E is connected. What is wrong?

This can be caused by a great many problems. The most common issues are –

1. A faulty IEEE488 cable, or the cable is not correctly mounted on the controller and/or the 2551/ 2551E. Carefully visually check the contacts on the connectors of the cable, the controller and the 2551/ 2551E.
2. Check the address setting for both the controller and the 2551/ 2551E. These must not be the same address.
3. Check if there are multiple applications using the same IEEE488 controller. In some circumstances, and under some operating systems, this cannot be performed due to controller or software limitations.
4. Attempt to communicate with (i.e. send commands to) the 2551/ 2551E. Use a simple command like MEASURE=STOP. Under some circumstances, when the 2551/ 2551E is first plugged into the IEEE488 cable, it has been found that some controllers do not clear this error automatically when the error does not exist anymore. This can occur when the 2551/ 2551E is first plugged into the bus, or after a device clear bus command.
5. Reboot the controller and the 2551/ 2551E with the IEEE488 cable attached. Under some circumstances it has been found the certain controllers can achieve an illegal handshake condition which cannot be recovered from when the cable is first attached.
6. Check that the controller has not been configured to perform any “special” handshake techniques. The 2551/ 2551E does not utilize “special” high speed handshaking, such as the National Instruments HS488 technique.

7. Check that any device drivers for your controller and operating system are correctly configured to support the selected 2551/ 2551E address.

### I send a Device Clear but it doesn't seem to do anything. What is wrong?

Some instruments perform operations similar to a power cycle when they receive a device clear. This activity is immediately visible on the front panel of the product. The 2551/ 2551E fully implements a device clear in less than 350ms, and does not perform a full power cycle reset. There is little visible activity on the front panel when the IEEE488 bus receives a device clear. This is normal.

### The 2551/ 2551E sometimes does not go into REMOTE. What is wrong?

Some controllers have a configuration to not re-address devices that were previously addressed. In order for a device to go from LOCAL into REMOTE both the REN line must be asserted and the device listen address must be received.

This situation arises if the device enters the LOCAL state when it was previously addressed to listen, and no other bus address has been used since that time (this could have been days, or even weeks ago). The controller will not place the 2551/ 2551E (or other device) back into REMOTE because it will not re-address it, when configured in the LOCAL state.

In this case, any data apparently sent to the 2551/ 2551E will not actually arrive there and be acted upon, although the controller acts as if it had been correctly sent. Thus, any commands sent to the 2551/ 2551E are ignored, as well as the 2551/ 2551E not entering the REMOTE state.

Some common causes of the 2551/ 2551E entering the LOCAL state are –

- Executing a device clear bus command
- Executing a \*RST IEEE488.2 command
- Power cycling the 2551/ 2551E
- Removing the IEEE488 cable from the 2551/ 2551E and then replacing it
- Pressing the F4 soft menu key of the front panel of the 2551/ 2551E (marked REMOTE while in remote). This can be disabled by entering the REMOTE WITH LOCAL LOCKOUT state.

If these circumstances could occur, then reconfigure the IEEE488 controller to always readdress a listener.

Another consideration is the controllers use of the REN interface line. In some configurations this line is totally under the control of software, in others it is always asserted whenever the controller is active. If this line is under the control of software, and more than one application is using the IEEE488 bus, then it is possible for this line be in the wrong state.

### When I read the 2551/ 2551E, all I receive is a space and a new line. What is wrong?

This indicates that the 2551/ 2551E has not been “told” what to talk about. Check the following.

1. A bank was configured to format at least one measurement result. This uses one of the BANKn commands. E.g., BANK0=VOLTS[RMS]
2. The bank configured by the command noted in 1 has been set to transmit its results. This uses the READBANK=n command. E.g., if BANK1 command was used, then READBANK=1 will select that bank.
3. The commands noted in 1 and 2 were correctly terminated. All commands must be terminated by a new line character, with the last character having the EOI line asserted, or by the bus GET command. Check the documentation for your particular controller and the software that you are using for details regarding how to do this.
4. The front panel displayed COMMAND ERROR when the commands noted in 1 or 2 were transmitted. If this was the case then the 2551/ 2551E ignored the command. The user should check the syntax of the command carefully.
5. The commands noted in 1 and 2 were sent to the correct address.
6. A device clear, \*RST or \*CLS command was not sent to the 2551/ 2551E after the commands in 1 and 2 were transmitted. If this occurred then this would have cleared the response definitions.
7. Try sending a device clear and then repeat the test. Under some circumstances the IEEE488 bus can become “locked” in an unusual handshake condition.
8. Check that the controller software did not report “No Listeners” when either of the commands noted in 1 and 2 above were transmitted. Certain controllers do not automatically clear the flag reporting this condition when it ceases to exist, under this circumstance, the command is not actually transmitted to the 2551/ 2551E, but the error flag does become cleared and subsequent commands are correctly sent by the controller.
9. Try sending the commands and receiving the data using a manually interactive utility, if one is available, for your particular controller and operating system. If this performs correctly, then there are problems with the software that you were previously using.

**I sent the command CLR-INRUSH:MEASURE=START, but I get a COMMAND ERROR message.**

The correct separator between commands is the semi-colon, not the colon character. Whenever a command error is reported by the 2551/ 2551E, the user should carefully check the syntax of the commands sent to the 2551/ 2551E. Common problems are –

1. Using the colon character instead of the semi-colon character between commands.
2. Using an incorrect character between data (e.g. for the DISPLAY command) or between measurement result definitions for the BANKn= command. In these cases the separator should be the / character (not the \ character).
3. Using a space character as a command separator. All whitespace characters are ignored by the 2551/ 2551E, thus these cannot be used as separators.

**I have carefully checked my command syntax, but I still get a command error.**

1. Check for a colon character (incorrect) that “looks like” a semi-colon character (correct). Some controller displays make it difficult to tell the difference.
2. Some (mostly very old) controllers and/or controller software used an ASCII only format on the bus and allowed the use of the most significant bit as a parity bit. Although the 2551/ 2551E only uses the 7-bit ASCII command set, it does check the entire set of 8 bits of the IEEE488 data bus. Check if the use of the most significant bit for parity can be disabled.

**After a READBANK or BANKn command, how long do I have to delay before the new data is available?**

The 2551/ 2551E automatically switches to the new bank or results after a READBANK command is received, and automatically changes the results in a bank when the BANKn command is received. In both of these cases the user does not need any delay after sending the command. Of interest, the reception of either of these commands forces an update of the affected bank of results and can be used to ensure that the latest data is returned.

**When I plot Waveform (or History) data received over the IEEE488 bus, it looks different than on the 2551/ 2551E display.**

The waveform and history data transmitted over the IEEE488 bus has 200 point horizontal resolution and virtually infinite vertical resolution. The display of the 2551/ 2551E has substantially reduced resolution over these and thus can look different. This is particularly the case for captured waveforms, where the display has substantially reduced resolution in both time and amplitude thus cannot accurately display fast or small glitches.



I send the interrogative for AVERAGE, but the reply does not seem correct.

Replies to interrogative commands are formulated when first executed. Any subsequent changes to the status (that's been replied to) will not be visible unless the interrogative is requested again. This will include any changes made in the same command set. This applies to all commands in the same set of commands, independent of their relative position. Generally it is not advisable to send commands with interrogatives in the same set of commands, nor is it advisable to send commands between the interrogative and reading the reply.

In the following sequence –

1. The 2551/ 2551E is using an AVERAGE value of 1.
2. AVERAGE?<NL> is sent to the 2551/ 2551E.
3. AVERAGE=2<NL> is sent to the 2551/ 2551E.
4. The 2551/ 2551E is read. The data indicates that the AVERAGE setting is 1.

Similarly –

1. The 2551/ 2551E is using an AVERAGE value of 1.
2. AVERAGE=2;AVERAGE?<NL> is sent to the 2551/ 2551E.
3. The 2551/ 2551E is read. The data indicates that the AVERAGE setting is 1.

I want to calibrate my 2551/ 2551E using the IEEE488 bus, but I cannot find the commands to do so. How do I do this?

Calibration is dependent on the option content of the 2551/ 2551E product. All 2551/ 2551E product options require specialized calibration equipment that can (if misused) seriously affect the performance of the 2551/ 2551E. For these reasons the commands for IEEE488 controlled calibration to external standards are not included in this guide. They are available, along with specific assistance if needed, from Xitron Technologies Inc. on request.

How do I parse the floating-point data I receive from the 2551/ 2551E?

The answer to this is very dependent on the particular software language being used. Most languages include standard “libraries” which include a general purpose ASCII string to the floating-point conversion utility. These generally support the syntax used in the 2551/ 2551E. In the C (or C++) language the standard “atof” or “strtod” library functions can be used. The following requirements are needed –

- Ignore leading spaces
- Terminate on the first invalid character

- Use the . character (period or full stop) as the decimal point. Note that some languages use the , character (comma). The comma cannot be used with the 2551/ 2551E without some form of character conversion.

If multiple data are being read from the 2551/ 2551E, then the location of each data should be determined by the position of the comma separating character, rather than using exact character position. In this manner any future changes to returned data syntax will be automatically accommodated by the users software.

### How fast can I get data from the 2551/ 2551E? What affects the speed?

The 2551/ 2551E can transmit data over the IEEE488 bus at over 300,000 bytes per second, and can receive commands at over 100,000 bytes per second. The command decode time varies greatly between commands, but is typically between 50us and 3ms, with an average latency of less than a few milliseconds for most applications.

The 2551/ 2551E command set has been optimized to provide the most speed possible when transmitting characters. The user should attempt to reduce the number of commands needed when operating at high speeds. Note that there are 5 banks of measurement results available, thus the user rarely needs to reconfigure the data that will be read from the 2551/ 2551E.

The most significant affects on IEEE488 speed are the following, listed in the order of importance, with the most significant first –

1. Using a high speed controller, which has been correctly configured. The 2551/ 2551E is capable of operating with handshake delays down to 350ns, the default configuration for many controllers is set to either 500ns (common) or even 1 $\mu$ s (older controllers). If there are no open collector type bus devices on the IEEE488 bus, then this handshake setting can be changed to 350ns for the controller (if available).
2. The IEEE488 bus handshakes at the speed of the slowest device on the bus. If speed is a premium then ensure that all connected devices are capable of high speed operation or consider using more than one bus. One bus for the high speed devices and one for the slower devices.
3. Maximize the amount of data read from a measurement result response bank. Although this has little affect on the 2551/ 2551E, it has been found that many controllers have significant software overhead when the terminator is received at the end of each data set. This can be several milliseconds and is very dependent on the particular controller and software used. Avoid displaying every measurement received, this can significantly slow down the maximum available transfer rate.

4. Avoid using the 20Hz to 100KHz bandwidth configuration.  
This should only be used when required. Although this bandwidth includes the standard line frequencies, the IEEE488 bus performance is lower when used. The use of this bandwidth setting reduces the maximum IEEE488 speed by approximately 25%.
5. Consider selecting “No Harmonics” synchronization.  
The maximum bus speed quoted for the 2551/ 2551E includes the calculation of up to 40 harmonics for all signals. If these are disabled by using this synchronization selection then a significant increase in speed can be achieved. The actual increase is very dependent on many issues. Note that harmonics results and waveforms are not available in this configuration.
6. Select either a graphical front panel display, or the blank display for the 2551/ 2551E.  
These displays offer the highest display update rates, which has an impact on the time available for IEEE488 bus transfers. The slowest displays are the textual ones, e.g., **Basics**, **Harmonics** (Listings) and **Setup** displays. The fastest display is the blank display. This can yield up to 10% improvement.

### I'm using the 2551/ 2551E with an IEEE488 Bus Isolator and getting unreliable data transfers from the 2551/ 2551E to the controller, what is wrong?

This is a known issue with certain National Instruments Optically Isolated IEEE488 Bus Isolators. The symptom is that the leading space character, which the 2551/ 2551E always issues when read, is sometimes missing at the controller. The user should contact National Instruments regarding upgrading the isolator.

Other isolators and controllers may also have this problem. Many IEEE488 bus instruments only format a response when addressed to talk, thus there is usually some delay between the device being addressed to talk, and the device starting to place data onto the bus. The 2551/ 2551E always has pre-formatted responses available, thus there is virtually no delay before the 2551/ 2551E is ready to place data onto the bus. During the manufacturers' testing of the bus isolator or controller this possibility may not have been foreseen and may cause problems that appear specific to the 2551/ 2551E.

This can also cause problems with the users' controller software when configuring for DMA activity. The user should ensure that the correct DMA channel has been configured and enabled prior to addressing the 2551/ 2551E to talk.

### I have configured the 2551/ 2551E to assert the SRQ line but it never gets asserted.

This is often caused by one or more of the following –

- The configured reason for the 2551/ 2551E to assert the SRQ line has never occurred.

- The driver for the controller has been configured for automatic serial poll. When this has been configured the driver will immediately serial poll the 2551/ 2551E, causing it to release the SRQ line.
- Another application is running on the controller that is performing a serial poll, releasing the SRQ line.

### How should I configure my controller to terminate when reading data from the 2551/ 2551E?

The controller may terminate reading data from the 2551/ 2551E when either the <NL> (decimal 10) character is received by the controller, or any character is received from the 2551/ 2551E with the EOI line asserted. Most controllers can be configured to automatically terminate on one (or both) of these.

### The IEEE488 Bus Keeps “Hanging”.

This is usually caused by severe interference on the IEEE488 cable. Check all of the following –

- High Quality cables are used. The lower priced cables often use inferior shielding and wire gauges.
- All Cable connectors are firmly secured using the integral screws.
- All devices on the bus are well grounded to the same grounding point. The IEEE488 bus has little common mode interference rejection and all signals are chassis ground referenced at both ends. Thus care must be taken when connecting between devices at different ground potentials.
- Ensure that the 2551/ 2551E (and any other power device) has the chassis well grounded.  
Any high-speed common mode interference on the measurement signals will cause common mode interference on the chassis of the 2551/ 2551E, grounding significantly reduces this. If necessary, use the rear panel chassis ground binding post to securely ground the chassis (use heavy gauge wire or braid for good high frequency grounding).
- Check the maximum length of any IEEE488 cable and the overall maximum. When using 350ns timing for handshake these limits are reduced from the standard bus. 15m cables should NOT be used. If necessary, limit the controller bus handshake speed to 500ns or slower.
- If the controller is a PC card in a PC compatible computer, check for PC card conflicts in the computer. Particularly DMA and IRQ conflicts. Older 8-bit ISA interfaced cards suffer greatly from problems of this type. Because the 2551/ 2551E can burst transfer data to the computer at maximum speed (>1Mb/sec), often these types of problems only become evident when using the 2551/ 2551E and not with other (slower) devices.

## How do I access the envelope History data from the IEEE488 bus?

The voltage and current displayed envelope data is available from the IEEE488 bus by reading the positive and negative graphs separately.

The definitions V-HISTORY[MAX] and V-HISTORY[MIN] give the positive and negative graphs for voltage.

The definitions A-HISTORY[MAX] and A-HISTORY[MIN] give the positive and negative graphs for current.

By plotting the MAX and MIN data on the same graph, the envelope graph is obtained.



# Summary of Commands

The table below lists a summary of all of the commands available for the 2551/ 2551E. Where a command requires data to define the actual action taken, the designation =*data* follows the keyword in this table. The user should refer to the relevant section of this guide for details regarding each command.

The commands are listed in alphabetical order.

*CAL?	Interrogates the calibration status
*CLS	Clears the 2551/ 2551E responses
*IDN?	Interrogates a product description
*OPT?	Interrogates the 2551/ 2551E option content
*RST	Power resets the 2551/ 2551E
*SRE?	Interrogates the enabled causes of 2551/ 2551E SRQ activity
*STB?	Interrogates the 2551/ 2551E serial poll response byte
AC-ONLY?	Interrogates the setting for the AC-ONLY command
AC-ONLY= <i>data</i>	Sets measurement results to be AC only, or AC & DC
AVERAGE?	Interrogates the setting for the AVERAGE command
AVERAGE= <i>data</i>	Sets the measurement result averaging period
BANDWIDTH?	Interrogates the setting for the BANDWIDTH command
BANDWIDTH= <i>data</i>	Sets the measurement bandwidth
BANK0 BANK1 BANK2 BANK3 BANK4	Clears the definitions for each transmit buffer bank
BANK0= <i>data</i> BANK1= <i>data</i> BANK2= <i>data</i> BANK3= <i>data</i> BANK4= <i>data</i>	Sets the measurement results to be placed into each transmit buffer bank
CAL-DATE?	Interrogates the date of the last calibration
CLR-A-CAPTURE	Clears the peak current captured waveforms

CLR-A-GLITCH	Clears the current glitch captured waveforms
CLR-INRUSH	Clears the inrush measurement results
CLR-INTEGRATE	Clears the integrated measurement results
CLR-V-CAPTURE	Clears the peak voltage captured waveforms
CLR-V-GLITCH	Clears the voltage glitch captured waveforms
DATE?	Interrogates the present date
DISPLAY= <i>data</i>	Selects the display format
HISTORY?	Interrogates the setting for the HISTORY command
HISTORY= <i>data</i>	Enables or disables historical result storage
HISTORY-SCALE?	Interrogates the setting for the HISTORY-SCALE command
HISTORY-SCALE= <i>data</i>	Sets the time scaling for historical result storage
INTEGRATE?	Interrogates the setting for the INTEGRATE command
INTEGRATE= <i>data</i>	Enables or disables update of integrated results
KEY= <i>data</i>	Simulates a front panel keypress
MEASURE?	Interrogates the setting for the MEASURE command
MEASURE= <i>data</i>	Enables or disables update of all measurement results
PRINT= <i>data</i>	Selects and initiates a printout
PRINT-STATUS?	Interrogates the status of the parallel printer port
PRODUCT?	Interrogates the product and option content
READBANK= <i>data</i>	Sets the transmit buffer bank to be used
SET-DC-ZERO	Sets the DC current input offset
SETDEFAULTS	Sets the 2551/ 2551E to a default configuration
STATUS?	Interrogates the 2551/ 2551E serial poll response byte
STATUS= <i>data</i>	Controls 2551/ 2551E SRQ activity
SYNC?	Interrogates the setting for the SYNC command
SYNC= <i>data</i>	Selects the measurement synchronization method
TIME?	Interrogates the present time of day
UPDATE0= <i>data</i> UPDATE1= <i>data</i> UPDATE2= <i>data</i> UPDATE3= <i>data</i> UPDATE4= <i>data</i>	Sets the update interval for each transmit buffer bank
VER?	Interrogates the firmware revision



## Summary of Result Definitions

This section provides a summary of the result definitions that may be used with the BANK0, BANK1, BANK2, BANK3 and BANK4 commands to define the set of measurement results that will be formatted into each bank of measurement results.

The *keyword[type]* format uses one of the following *type* definitions. Not all definitions are valid for all keywords.

ACDC	Same as RMS
CF	Crest Factor
DC	DC only
FF	Form Factor
FUND	Fundamental amplitude
HIGHEST	Same as MAX
LOWEST	Same as MIN
MAX	Highest valued peak or value
MIN	Lowest valued peak or value
PEAK	Highest valued absolute peak
PKPK	Difference between the MAX and MIN results
RECT	Average Rectified
RMS	True RMS
THD	% of fundamental, using all harmonics
WORST	Same as PEAK

The summary of the result definitions is listed in alphabetical order.

A-CAPTURED-A	Peak current captured current waveform
A-CAPTURE-DATE	Date of peak current captured waveforms
A-CAPTURED-V	Peak current captured voltage waveform
A-CAPTURED-W	Peak current captured power waveform
A-CAPTURE-PEAK	Peak current in the peak current captured waveform

A-CAPTURE-PHASE	Phase delay of the peak current in the peak current captured waveform
A-CAPTURE-TIME	Time of peak current captured waveforms
A-DISTORTION	Current distortion waveform
A-GLITCH-DATE	Date of current glitch captured waveforms
A-GLITCHED-A	Current glitch captured current waveform
A-GLITCHED-V	Current glitch captured voltage waveform
A-GLITCH-PEAK	Current glitch size in the current glitch captured waveform
A-GLITCH-PHASE	Phase delay of the current glitch in the current glitch captured waveform
A-GLITCH-TIME	Time of current glitch captured waveforms
A-HISTORY[type]	Historical current results
A-HR[type]	Integrated Current
A-INRUSH[type]	Inrush Current
A-INTEG-AVG[type]	Integrated Average Current
AMPS[type] AMPS[harmonic] AMPS[harmonic-harmonic] AMPS[harmonic:harmonic]	Current
A-PHASE[harmonic:harmonic]	Current Phase (relative to voltage fundamental)
A-RELHARM[harmonic] A-RELHARM[harmonic-harmonic] A-RELHARM[harmonic:harmonic]	Current, percentage of fundamental
A-WAVEFORM	Current waveform
DATE	Present date
EVEN-TRIPLENS[harmonic-harmonic]	Even triplens current
FREQ	Frequency
HISTORY-DATE	Dates of historical results
HISTORY-SIZE	Number of historical results
HISTORY-TIME	Times of historical results
IEC-CLASS-D	Percentage outside IEC61000-3-2 Class D envelope
INTEGRATED-TIME	Total Integration Time (hours)
K-FACTOR[harmonic-harmonic]	Current K-factor
LOAD-R[type]	Series Load Resistance
LOAD-X[type]	Series Load Reactance
LOAD-Z[type]	Load Impedance
ODD-TRIPLENS[harmonic-harmonic]	Odd triplens current
PARALLEL-C	Parallel Load Capacitance (uF)
PARALLEL-R	Parallel Load Resistance

PF[type] PF[harmonic] PF[harmonic-harmonic]	Power Factor
PF-HISTORY	Historical power factor results
PF-INTEG-AVG[type]	Integrated Average Power Factor
SERIES-L	Series Load Inductance
TIME	Present time
TRIPLENS[harmonic-harmonic]	Triplens current
VA[type] VA[harmonic] VA[harmonic-harmonic] VA[harmonic:harmonic]	Apparent Power (VA)
VA-HR[type]	Integrated Apparent Power (VA)
VA-INTEG-AVG[type]	Integrated Average Apparent Power (VA)
VAR[type] VAR[harmonic] VAR[harmonic-harmonic] VAR[harmonic:harmonic]	Imaginary Power (VAR)
VAR-HISTORY	Historical imaginary power results
VAR-HR[type]	Integrated Imaginary Power (VAR)
VAR-INRUSH[type]	Inrush Imaginary Power (VAR)
VAR-INTEG-AVG[type]	Integrated Average Imaginary Power (VAR)
V-CAPTURED-A	Peak voltage captured current waveform
V-CAPTURE-DATE	Date of peak voltage captured waveforms
V-CAPTURED-V	Peak voltage captured voltage waveform
V-CAPTURED-W	Peak voltage captured power waveform
V-CAPTURE-PEAK	Peak voltage in the peak voltage captured waveform
V-CAPTURE-PHASE	Phase delay of the peak voltage in the peak voltage captured waveform
V-CAPTURE-TIME	Time of peak voltage captured waveforms
V-DISTORTION	Voltage distortion waveform
V-GLITCH-DATE	Date of voltage glitch captured waveforms
V-GLITCHED-A	Voltage glitch captured current waveform
V-GLITCHED-V	Voltage glitch captured voltage waveform
V-GLITCH-PEAK	Voltage glitch size in the voltage glitch captured waveform
V-GLITCH-PHASE	Phase delay of the voltage glitch in the voltage glitch captured waveform
V-GLITCH-TIME	Time of voltage glitch captured waveforms
V-HISTORY[type]	Historical voltage results
V-HR[type]	Integrated Voltage

V-INRUSH[type]	Inrush voltage
V-INTEG-AVG[type]	Integrated Average Voltage
VOLTS[type] VOLTS[harmonic] VOLTS[harmonic-harmonic] VOLTS[harmonic:harmonic]	Voltage
V-PHASE[harmonic-harmonic]	Voltage phase (relative to fundamental)
V-RELHARM[harmonic] V-RELHARM[harmonic-harmonic] V-RELHARM[harmonic:harmonic]	Voltage, percentage of fundamental
V-WAVEFORM	Voltage waveform
WATTS[type] WATTS[harmonic] WATTS[harmonic-harmonic] WATTS[harmonic:harmonic]	Real Power (Watts)
W-HISTORY	Historical real power results
W-HR[type]	Integrated Real Power (Watts)
W-INRUSH[type]	Inrush Real Power (Watts)
W-INTEG-AVG[type]	Integrated Average Real Power (Watts)
W-WAVEFORM	Power waveform