PRINTER HISTORY

The manual printing date and part number indicate the current edition. Reprints between editions will have the same printing date and may include change pages with corrections or additions to be made to the manual by the user.

New editions of this manual will have a new printing date and, in some cases, may have a new part number. The new edition will include all changes and corrections made since the previous edition.

Edition 2 - August, 1989
Edition 1 - December, 1988

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SAFETY GUIDELINES

The beginning of the Electronic Load Operating Manual has a Safety Summary Page. Be sure that you are familiar with the information on that page before programming the electronic load for operation from a controller.

THREE YEAR WARRANTY

The HP Electronic Load Family products have a three year warranty. Please replace the first paragraph of the warranty statement on the inside front cover with the following:

This Hewlett-Packard hardware product is warranted against defects in material and workmanship for a period of three years from date of delivery. HP software and firmware products, which are designated by HP for use with a hardware product and when properly installed on that hardware product, are warranted not to fail to execute their programming instructions due to defects in material and workmanship. If HP receives notice of such defects during the warranty period, HP shall repair or replace software media and firmware which do not execute their programming instructions due to such defects. HP does not warrant that the operation for the software, firmware or hardware shall be uninterrupted or error free.
# CONTENTS (continued)

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INTRODUCTION

PURPOSE

The purpose of this guide is to enable you to use HPSL commands to remotely control your Hewlett-Packard electronic load from a controller using HPSL programming language. It is assumed that the following has been done:

■ The electronic load has been installed and is operating normally from its front panel.
■ The controller has been connected to the electronic load and the electronic load’s HP-IB address has been set.

NOTE

The electronic load HP-IB address cannot be set by program. It must be set from the front panel of the electronic load (refer to the Installation chapter of your electronic load Operating Manual).

DOCUMENTATION

IMPORTANT!

Read your electronic load Operating Manual before using this guide.

Supplied

Every Electronic Load comes with the following documentation:

Operating Manual

Installation and Basic Operating Instructions, including local front-panel operation. Be sure to read that document first.

Programming Reference Guide

This guide. For remote operation from a controller.

Recommended

The following reference documents are recommended:

■ 1Tutorial Description of the Hewlett-Packard Interface Bus
  □ Highly recommended for those not experienced with IEEE 488.1 and 488.2
■ 2ANSI/IEEE Standard 488.2-1987
  □ The source document for programming via IEEE 488.1 and IEEE 488.2

1Contact your local HP Sales Office
2Contact Institute of Electrical and Electronics Engineers, 345 E. 47 Street, New York, NY 10017, USA

HOW TO USE THIS GUIDE

Chapter   Synopsis
2 - Introduction to HPSL     The basics of HPSL to help you understand the terminology and diagrams in Chapter 4
3 - Introduction to Programming     How to understand the command tree diagram and construct typical operating programs
4 - Language Dictionary     An alphabetically ordered description of all electronic load HP-IB commands
5 - Status Reporting     An explanation of how the electronic load status registers are affected by the HP-IB programming statements.

WHAT YOU SHOULD ALREADY KNOW

This guide does not assume that you know anything about HPSL or are a programmer. It is assumed that you do know:

■ the basics of the Hewlett-Packard Interface Bus (HP-IB)
■ how to send and receive ASCII data to and from an HP-IB instrument (or where, in your computer and HP-IB interface documentation, to find instructions for doing this).
■ how to incorporate the HPSL statements as ASCII strings within output and input statements of the programming language you are using.
■ the basic operating principles of the electronic load as explained in Chapters 2 and 5 of your electronic load Operating Manual.

HP-IB CAPABILITIES OF THE ELECTRONIC LOAD

The HP-IB capabilities of a typical electronic load are listed in Table 1-1.

NOTE

Refer to the General Information chapter of your electronic load Operating Manual for its exact capabilities.
<table>
<thead>
<tr>
<th>HP-IB Capability</th>
<th>Response</th>
<th>Interface Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talker/Listener</td>
<td>All electronic load functions except for setting the HP-IB address are programmable over the HP-IB. The electronic load can send and receive messages over the HP-IB. Status information is sent using a serial poll. Front panel annunciators indicate the present HP-IB state of the electronic load.</td>
<td>AH1, SH1, T6, L4</td>
</tr>
<tr>
<td>Service Request</td>
<td>The electronic load sets the SRQ line true if there is an enabled service request condition. Refer to Chapter 5—Status Reporting for more information.</td>
<td>SR1</td>
</tr>
<tr>
<td>Remote/Local</td>
<td>In local mode, the electronic load is controlled from the front panel but will also execute commands sent over the HP-IB. The electronic load powers up in local mode and remains in local mode until it receives a command over the HP-IB. Once the electronic load is in remote mode, the front panel RMT annunciator is on, all front panel keys (except [Local] ) are disabled, and the display is in normal metering mode. Pressing [Local] on the front panel returns the electronic load to local mode. [Local] can be disabled using local lockout so that only the controller or the power switch can return the electronic load to local mode.</td>
<td>RL1</td>
</tr>
<tr>
<td>Device Trigger</td>
<td>The electronic load will respond to device trigger function.</td>
<td>DT1</td>
</tr>
<tr>
<td>Device Clear</td>
<td>The electronic load responds to the Device Clear (DCL) and Selected Device Clear (SDC) interface commands. These cause the electronic load to clear any activity that would prevent it from receiving and executing a new command (including *WAI and *OPC?). DCL and SDC do not change any programmed settings.</td>
<td>DCL, SDC</td>
</tr>
</tbody>
</table>
Chapter 2
INTRODUCTION TO HPSL

WHAT IS HPSL?

HPSL stands for Hewlett-Packard Systems Language. It is a programming language developed by Hewlett-Packard for controlling instrument functions. HPSL is intended to function with standard HP-IB hardware. HPSL conforms to the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. This standard provides codes, formats, protocols, and common commands not defined in the original IEEE 488.1 standards. Unless you intend to do some very intricate programming, you need not be expert in the IEEE 488.2 standard, although it is a good reference document to have available.

NOTE

TMSL (Test and Measurement Systems Language) is a later version of HPSL that has been made available outside of Hewlett-Packard for industry use. Although it is very similar, the HPSL used in the electronic loads may not be totally compatible with TMSL.

HPSL STATEMENTS

HPSL statements are instrument control commands and queries. A command statement sends an instruction to the electronic load and a command query requests information from the electronic load.

Simple Command Statements

The simplest command statement consists of a command, or keyword, usually followed by a parameter or data:

VOLT:25
CURR:50
TRIG

Simple command statements

Compound Command Statements

When two or more keywords are connected by colons (2:), it creates a compound command statement. The last keyword usually is followed by a parameter or data.

VOLT:SLEW 1000
CURR:RANG 6
TRIG:SOUR BUS

Compound command statements

Simple Command Queries

The simplest command query consists of a keyword followed by a question mark:

VOLT?
CURR? CHAN?

Simple command queries

Compound Command Queries

When two or more keywords are connected by colons and followed by a question mark, it creates a compound query statement.

VOLT:TRIG?
CURR:PROT? MEAS:POW?

HPSL Keywords

Keywords (also known as "Instrument Control Headers") are recognized by the electronic load's decoder, or "parser". Each keyword is intended to be descriptive of the statement function. Refer to Figure 4-2 in 'Chapter 4—Language Dictionary' for a quick look at all the electronic load keywords.

Forms of Keywords

Every keyword has two forms:

Long Form    The word is spelled out completely to identify its function. STATUS, RESISTANCE, and TRIGGER are long-form keywords.

Short Form   The word contains only the first three or four letters of the long form. STAT, RES, and TRIG are short-form keywords.

Short forms are constructed according to the following rules:

- If the keyword consists of four or fewer letters -
  - then all the letters are used

- If the keyword consists of five or more letters -
  - and the fourth letter is IS NOT a vowel (a,e,i,o,u)
  - then the first four letters are used
  - and the fourth letter is a vowel
  - then only the first three letters are used

NOTE

The short form provides the fastest program execution.

Keyword Conventions

In keyword definitions and diagrams in this guide, the short-form part of each keyword is emphasized in boldface UPPERCASE letters to help you remember it.

- TRIGger
- IMMEDIATE
- RESistance
- SHORt
The HPSL parser (decoder) is not sensitive to case. It will accept Trig, trig, trigger, TRIGGER, triGgER, etc. Regardless of which form you use, you must spell out all the letters. For example, RESI or TRI will not be recognized.

**Keyword Parameters**

Parameters are data values that the parser expects to find after certain keywords. All data programmed to or returned from the electronic load is ASCII. The data may be numerical data or character strings. HPSL uses the parameter forms in Section 7 of IEEE 488.2 Standard Digital Interface for Programmable Instrumentation with the additions described here.

**Numerical Data Formats.** HPSL accepts the first four numerical data types listed in Table 2-1 and described in Section 7 of IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. In addition, HPSL recognizes an expanded form of decimal numeric value known as <NRf>. This allows the characters MIN and MAX to be entered for the minimum and maximum values that the parameter can be set to under the existing operating conditions.

**Table 2-1. Numerical Data Formats**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Data Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR1</td>
<td>Digits with no decimal point. The decimal point is assumed to be to the right of the least-significant digit. For example, 273, 0273</td>
</tr>
<tr>
<td>NR2</td>
<td>Digits with a decimal point. E.g., 273.3, 27.3, .0273</td>
</tr>
<tr>
<td>NR3</td>
<td>Digits with a decimal point and an exponent. E.g., 2.73E+2, 2.73E-2</td>
</tr>
<tr>
<td>NRf</td>
<td>Flexible decimal form that includes NR1 or NR2 or NR3. E.g., 273, 27.3, 2.73E+2</td>
</tr>
<tr>
<td>NRf+</td>
<td>Expanded decimal form that includes NRf and MIN, MAX. E.g., 273, 27.3, 2.73E-2, MIN, MAX. MIN and MAX are the minimum and maximum limit values for the parameter and are implicit in the range specification for the parameter.</td>
</tr>
</tbody>
</table>

**Numerical Data Suffixes and Multipliers.** Numeric data may be followed by a suffix that dimensions the data. A suffix may be preceded by a multiplier. Section 7 of IEEE 488.2 Standard Digital Interface for Programmable Instrumentation describes the approved data suffixes and multipliers. Where no suffix is entered, the dimension is implied by the syntax of the command. The electronic loads make use of the suffixes and multipliers listed in Table 2-2 and Table 2-3. Note the special consideration given to the multiplier for Mega. In most cases, mega is represented by MA. However, there are exceptions made for megahertz (MHZ) and megohm (MOHM). In only these two cases, M is understood to be 1E+6. Do not confuse the mega multiplier MA with the combination suffix and multiplier MA, which represents milliamperes (1E-3).

**Table 2-2. Suffix Elements**

<table>
<thead>
<tr>
<th>Class</th>
<th>Preferred Suffix</th>
<th>Secondary Suffix</th>
<th>Referenced Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>A</td>
<td></td>
<td>Ampere</td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td></td>
<td>Hertz</td>
</tr>
<tr>
<td>Resistance</td>
<td>OHM</td>
<td>MOHM</td>
<td>Megahertz</td>
</tr>
<tr>
<td>Time</td>
<td>s</td>
<td></td>
<td>Ohm</td>
</tr>
<tr>
<td>Amplitude</td>
<td>V</td>
<td></td>
<td>Megohm</td>
</tr>
<tr>
<td>Power</td>
<td>W</td>
<td></td>
<td>Second</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>A/s</td>
<td></td>
<td>Volt</td>
</tr>
<tr>
<td></td>
<td>V/s</td>
<td></td>
<td>Watt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Amperes/Second</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Volts/Second</td>
</tr>
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**Table 2-3. Most-Used Suffix Multipliers**

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<th>Multiplier</th>
<th>Mnemonic</th>
<th>Definition</th>
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<td>1E6</td>
<td>MA</td>
<td>mega</td>
</tr>
<tr>
<td>1E3</td>
<td>K</td>
<td>kilo</td>
</tr>
<tr>
<td>1E-3</td>
<td>M</td>
<td>milli</td>
</tr>
<tr>
<td>1E-6</td>
<td>U</td>
<td>micro</td>
</tr>
<tr>
<td>1E-9</td>
<td>N</td>
<td>nano</td>
</tr>
</tbody>
</table>

**NOTE**

You may construct compound suffixes of multipliers and elements. For example: 1 KHz for 1000 Hz; 1 A/μs for 1000000 A/s

**Numerical Data Conventions.** In this guide, numerical data types are shown in emphasized text within angle brackets, such as <NR1> or <NRf>. On drawings, numerical data appears within boxes <NRf>.

Data suffixes are shown inside brackets within boxes <suffix>. The brackets around the suffix indicate that the entry is optional. That is because there is a default suffix for the data that accompanies each command.

**Character Data Formats.** For command statements, the <NRf > data format permits entry of required characters. For query statements, character strings may be entered in either of the forms shown in Table 2-4, depending on the length of the returned string.

**Table 2-4. Query Character String Formats**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Character Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>crd</td>
<td>Character Response Data. Permits the return of up to 12 characters</td>
</tr>
<tr>
<td>aard</td>
<td>Arbitrary ASCII Response Data. Permits the return of undefined 7-bit ASCII. This data type is an implied message terminator (refer to &quot;Separators and Terminators&quot;).</td>
</tr>
</tbody>
</table>
Character Data Conventions. In this guide, character string parameters are emphasized similarly to keywords, such as ON, OFF, and CONTinuous. This applies both to text and drawings.

Separators and Terminators

In addition to keywords and parameters, HPSL program statements require the following:

Data Separators. Data must be separated from the previous command keyword by a space. This is shown in examples as a space (VOLT 25) and on diagrams by the letters SP inside a circle.

Keyword Separators. Keywords (or headers) are separated by a colon (:) or a semicolon (;), or both. For example:

- \texttt{INP:SHOR}
- \texttt{MEAS:CURR;VOLT?}
- \texttt{CURR 25;VOLT 50}

**IMPORTANT**

Proper use of the (:) and the (;) is very important to the construction of command messages. This is explained in "Chapter 3—Introduction to Programming".

Program Line Terminators. A terminator informs HPSL that it has reached the end of a statement. Normally, this is sent automatically by your HP-I B programming statements. The termination also occurs with other terminator codes, such as E01. In this guide, the terminator is assumed at the end of each example line of code. If it needs to be indicated, it is shown by the symbol `<nl>`, which stands for "new line" and represents the ASCII coded byte 0A hexadecimal (or 10 decimal).

**COMMON COMMANDS**

Common statements are not derived from HPSL but are generic commands and queries defined by the IEEE 488.2 standard. The following examples are common statements:

- \texttt{*RST}
- \texttt{*IDN?}
- \texttt{*TRG}

Common statements are executed independently of HPSL statements. Their relationship to HPSL statements is described more fully in "Chapter 3". The function of each common statement is summarized in "Chapter 4—Language Dictionary" and fully described in Section 10 of IEEE 488.2 Standard Digital Interface for Programmable Instrumentation.
Chapter 3
INTRODUCTION TO PROGRAMMING

TYPES OF COMMANDS AND QUERIES

The electronic load responds to two types of commands and queries, Common and Root. Common commands were introduced in Chapter 2—Introduction to HP41CL and are relatively simple to use. The root commands are organized in a hierarchy that is best shown via a command tree diagram.

UNDERSTANDING THE COMMAND TREE

Figure 4-2 in Chapter 4—Language Dictionary is a tree diagram of all the root commands for the electronic load. Notice the following:

■ The originating point of the diagram is at the root. In this case, the diagram resembles an inverted tree. “Root” is not a command, but the origin for all commands.
■ The root divides into two major branches—Channel-Specific commands and Channel-Independent commands. Both types are accepted by all electronic loads.
■ Each major branch divides into several branches. The CURRent commands are a branch. The VOLTage commands are another branch. So are the TRIGger commands.
■ Some keywords are within brackets [ ]. These are implied keywords. Implied keywords are optional, but you may want to use them in certain situations (see Implied Keywords, later in this chapter)

NOTE
For fastest program execution, omit implied keywords.

■ Commands followed by ? are queries. They cause the electronic load to store information in its output buffer from where it can be read by the controller over the HP-IB.

UNDERSTANDING A TYPICAL BRANCH

Here are the keywords for the RESistance branch as they appear in Chapter 4—Language Dictionary:

Command and Function
RESistance[:LEVel][:IMMediate]
Specify input resistance for RESistance mode
RESistance[:LEVel]:TRIGgered
Preset input resistance level pending trigger occurrence
RESistance:RANGE
Specify full-scale resistance input range
RESistance:TLEVel
Specify resistance level for TRANsient function

NOTE
Ignore the meanings of these commands for now. All keywords are defined in the Language Dictionary and command functions are explained in the electronic load Operating Manual

Figure 3-1 shows the RESistance commands, which form a typical branch that forms a “subtree” of its own. You can see that the RESistance branch has three subbranches: LEVel, RANGE, and TLEVel. When it reaches the end of a branch, the parser expects a parameter, a question mark (that identifies the keyword as a query), a semicolon or semicolon-colon combination, or an end-of-line terminator.

Figure 3-1. RESistance Branch Subtree

Figure 3-2 is the syntax diagram for the RESistance branch. You can still identify the tree structure, although it runs from left-to-right instead of from top-to-bottom. Note the following symbols that were discussed in Chapter 2—Introduction to HP41CL.

■ Keywords with the short form shown in bold-faced capital letters. Implied keywords are not within brackets in diagrams.
■ Spaces shown as "SP" within circles.
■ Boxes showing the form (NRI+) of the parameter.
■ Boxes showing optional suffixes. Multipliers are not shown.
■ Question marks that convert a command into a query
■ Colons (:) that precede each keyword. They are important and are discussed later in more detail.
Traversing the RESistance Branch

From Figure 3-2 note that there are two implied keywords that you can usually ignore. This makes two of the commands very simple. If you enter:

RES 1.5

you will send the electronic load an immediate resistance level command. The command actually is:

RES:LEV:IMM 1.5

but the parser assumes that the two implied keywords are there. For the same reason, you can query the immediate resistance value with:

RES?

NOTE

When sending a query, do not enter a space between the keyword and the question mark.

The newline character <nl> or EOI terminator sends the parser back to the root level. Many controllers automatically send this character at the end of each program output string. To program the resistance range and the TLEVel value, you could send:

RES:RANG 1000 <nl>
RES:TLEV 5000 <nl>

NOTE

MAX and MIN are the maximum and minimum values allowed in the present operating mode of the electronic load. For the electronic load this generally means the limits within the present range.

MAX and MIN may also be used with queries to find the maximum and minimum permitted settings of the present mode. For example:

RES? MAX Returns the maximum permitted value of the present range

Using the NRf+ Format

Referring to Figure 3-2, note that all parameters are of the <NRf+> type. This allows you to easily set a numeric parameter to its maximum or minimum value. If you wanted to increase the immediate resistance of the presently selected range to its maximum value, you could send:

RES MAX <nl>
TRVERSING THE COMMAND TREE

NOTE
The HPSL parser traverses the command tree as described in Appendix A of IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The Enhanced Tree Walking Implementation given in that appendix is not implemented in HPSL. The simplified explanation given here is sufficient for using the electronic load command set in most applications.

Use of the Colon
When you examined the RESistance branch, you noticed the colon (:) that separated keywords from each other. A colon represents a change in branch level. ROOT is the highest level. Whenever you enter a (:), the parser expects it to be followed by a command of the next lower level. For example:

INP:PROT:CLE
CURR:LEV:TRIG

INP and CURR are root-level commands. PROT and LEV are first branches, and CLE and TRIG are second branches. Each (:) instructs the parser to move down to the next branch.

NOTE
A colon after a keyword always moves the parser down, never up the command tree.

If you enter INP:PROT:CLE:, you will get an error because the parser expects to find another keyword after the last (:). In this example, you will also get an error if you enter INP:PROT because another keyword is required after PROT. However, a command like MODE:RES is o.k. because no keyword or parameter is expected after RES. You will know what is required in each case by referring to the Language Dictionary.

Use of the Semicolon

The semicolon (;) is a "back-up" command. It instructs the parser to return to the previous colon. Figure 3-3 illustrates how the semicolon moves the parser backwards.

NOTE
The semicolon by itself can back the parser up to a colon only within the same branch.

The semicolon allows you to combine command statements on one line to create command messages.

VOLT:SLEW 5000 <nl> Statements are on separate lines
VOLT:TELV 55 <nl>
VOLT:SLEW 5000;TELV 55 <nl> Combined statements form a message

Figure 3-3. What the Semicolon Does

NOTE
There is no single command to move the parser back two colons. In example a above, backing up from Level 2 to Level 1 requires a return to the root.

Getting Back to the Root

To go from a command in one branch to a command in another branch, you must first return to the root. You can do this by:

- entering a new-line character. This is symbolized by (<nl>) and can be any control character that starts a new line, such as:
  - linefeed (LF)
  - an end-of-line (EOI)
- entering a semicolon followed by a colon (;). This instructs the parser to return to the root.

Looking at Figure 4-2 in the "Language Dictionary", suppose you wanted to set two trigger levels; the CURRent level to 15.5 and the VOLTage level to 25.5. Either of the following commands would do this.

CURR:TRIG 15.5 <nl>
VOLT:TRIG 25.5 <nl>

or

CURR:TRIG 15.5;VOLT:TRIG 25.5 <nl>

Similarly, the following query would return the present values of current, power, and voltage and the state of the output port.

MEAS:CURR?:POW?:VOLT?:PORT? <nl>
NOTE

The \(<\text{nl}\)> notation is assumed and will be omitted in later programming examples.

![Diagram](image.png)

Figure 3-4. Returning the Parser to the Root

**Implied Keywords**

Keywords shown within brackets, such as \text{CURR[:LEV]}\text{el}\], are implied keywords. If they are omitted, the parser will execute them automatically.

**How to Use Implied Keywords.** Because \text{[LEV]el} is an implied keyword, the parser regards the following two commands as the same:

\text{CURR[:LEV]el 30}
\text{CURR 30}

Under most circumstances, implied keywords are optional and you may omit them as in the above example. Sometimes you may choose to use them in order to make the semicolon move the parser in the desired way. Returning to our previous keyword diagram under Figure 3-2, note that you can set the immediate resistance value with:

\text{RES .5}

The parser automatically assumes that you want to program \text{LEV}el. If you wanted to program both \text{LEV} and \text{TLEV}el in one program line and sent:

\text{RES .5;TLEV 1 Incorrect parser positioning}

the parser would end up back at the root and you would get an error because there is no \text{TLEV}el command at the root. The correct statement would be:

\text{RES[:LEV]el .5;TLEV 1 Correct parser positioning}

or

\text{RES .5;RES[:TLEV]el 1}

By inserting the implied keyword in \text{RES[:LEV]el .5}; you allowed the parser to interpret the \text{.} as a command to move back to the branch containing \text{RANG}e and \text{TLEV}el. Without \text{LEV}el in the command, the parser would "find" only \text{RES}, \text{CURR}, \text{STAT}, or other root-level commands.

**HPSL Queries**

You can program more than one query in a single line, such as:

\text{CURR[:LEV]el [:VOLT] Returns present values of programmed current, resistance, and voltage}

However, observe the following precautions:

- You must read back the results of the queries before sending another command line to the electronic load. Otherwise, a \text{Query Interrupted} error will occur and the returned data will be lost.
- Multiple queries must be separated by semicolons and some controllers may have problems interpreting this format. In this case, you must enter each query and its corresponding readback on a separate line.

**HPSL COMPATABILITY**

**The SOURce Implied Keyword**

Referring to Figure 4-2 in the Language Dictionary, note that several of the Channel-Specific branches include the implied keyword \text{[SOUR]ce}. It is there to make electronic load programs compatible with other HPSL devices. Although the electronic load will accept it, you can omit \text{[SOUR]ce} and consider the Channel-Specific branch as connected directly to the root.

**Aliases**

Looking at Figure 4-2 you will notice that some electronic load commands will accept two keywords that perform the identical function. For example:

\text{MODe[:FUNCTION] Examples of two commands that do the same thing}
\text{INPut[:OUTPut]}
\text{CHANnel[:INSTRument]}

These alternate keywords are called "aliases" and are supported by the electronic load in order to make it compatible with other HPSL instruments.

**VALUE COUPLING**

When you program, you must be aware of the effect known as value coupling. Value coupling results when a command directed toward one parameter changes the value of another parameter. For example, the \text{CURR}ent branch includes the following keywords:

\text{Command}
\text{CURR}ent[:LEV]el[:IMMediate]
\text{CURR}ent[:RANG]e
\text{CURR}ent[:TLEV]el

3-4 Introduction to Programming
There is value coupling among the RANge, LEVel, and TLEVel commands. If a previously programmed LEVel value is outside a particular range, then changing to that range will affect the value of LEVel. There are several instances of value coupling among the electronic load commands and you should always check a command’s description in the Language Dictionary to determine if it is value coupled to another command.

**Common Commands**

Common commands, while not part of the command tree, can be mixed in with regular commands. The electronic load responds to the Common commands and queries listed in Figure 4-1 of the "Language Dictionary. You can mix Common commands in with regular programming statements; the Common command will be executed without affecting the position of the parser.

**Programming Examples**

The following programming examples are practical applications of the electronic load. Although they are in HP Series 300 Basic, the principles can be applied to any other version of BASIC or even to another language.

**Battery Testing**

The principal measurement of a battery’s performance is its rated capacity. The capacity of a fully charged battery, at a fixed temperature, is defined as the product of the rated discharge current in amperes and the discharge time in hours, to a specified minimum termination voltage in volts (see Figure 3-5). A battery is considered completely discharged when it reaches the specified minimum voltage called the "end of discharge voltage" (EODV).

In this example, the electronic load discharges three nickel-cadmium batteries to determine their discharge rates at a fixed temperature (see Figure 3-6). The batteries are connected in series so that when the EODV is reached, it is still above the minimum operating voltage of the electronic load. The EODV for nickel-cadmium batteries is typically 1.0 volts.

**Figure 3-6. Batteries in Series**

**Power Supply Testing**

A typical use for electronic loads when testing power supplies involves power supply burn-in. One of the problems associated with burn-in is what to do if the power supply fails before the test is over. One solution involves continuously monitoring the supply and removing the load if the supply fails during the test (see Figure 3-7).

In this example, the Electronic Load is used to burn-in a power supply at its rated output current. Because the Electronic Load is operating in CC mode, if the power supply's output current drops below the rated output current during the test, the UNR (unregulated) condition will be set on the Electronic Load. This can be used to indicate that a failure has occurred on the power supply. If the unregulated condition persists for a specified time, the inputs of the Electronic Load are turned off.

The purpose of this example is not to illustrate power supply to testing, but to explain how to program and use the status registers on the Electronic Load. The part of the program that runs the test simply monitors the supply at the rated output current for one hour and stops the test. You can replace this portion of the program with your own routine to test the power supply. Although SRQ (service request) is enabled to interrupt only on the UNR bit in this example, you can modify the program to interrupt on other conditions.

**Figure 3-5. Typical Discharge Curve**

**Figure 3-7. Typical Burn-In Test**
Battery Test Example Program

10 ! Battery Test Example Program
20 !
30 Eodv=1.0 ! End of discharge voltage for single cell
40 Number_of_cells=3 ! Number of cells to be discharged in series
50 Discharge_at=.05 ! Constant current discharge rate in amperes
60 !
70 OUTPUT 705;"INPUT OFF" ! Disables the inputs
80 OUTPUT 705;"MODE:CURRENT" ! Sets CC mode
90 OUTPUT 705;"CURRENT:LEVEL";Discharge_at ! Sets the CC level
100 OUTPUT 705;"INPUT ON" ! Enables the inputs
110 !
120 Start_time=TIMEDATE ! Records test start time
130 !
140 Start_test: ! Starts test routine that
150 OUTPUT 705;"MEASURE:VOLTAGE?" ! continuously measures and reads
160 ENTER 705;Sum_of_volts ! back the voltage and current
170 OUTPUT 705;"MEASURE:CURRENT?" ! until batteries are completely
180 ENTER 705;Actual_current ! discharged
190 !
200 PRINT "Total cell voltage: ";Sum_of_volts
210 PRINT "Actual current: ";Actual_current
220 PRINT "Elapsed time in seconds: ";TIMEDATE-Start_time
230 !
240 IF Sum_of_volts>(Number_of_cells*Eodv) THEN GOTO Start_test
250 ! Checks if the total voltage is less than the
260 ! sum of the minimum cell voltages of all cells
270 !
280 OUTPUT 705;"INPUT OFF" ! Disables the inputs
290 !
300 END
Power Supply Test Example Program

10 ! Power Supply Test Example Program
20 !
30 Current=10 ! Load current in amperes
40 Burn_in_time=36000 ! One hour burn-in time
50 !
60 ON INTR 7 GOSUB Srq_service ! Set up interrupt linkage
70 ENABLE INTR 7;2 ! Enable interrupts for SRQs
80 !
90 OUTPUT 705;"INPUT OFF" ! Disables the inputs
100 OUTPUT 705;"*SRE 4" ! Enable SRQ (SRQ enable)
110 OUTPUT 705;"STAT:CSUM:ENAB 2" ! Enable Chan 1 (channel summary)
120 OUTPUT 705;"STAT:CHAN:ENAB 1024" ! Enable UNR bit (channel status)
130 OUTPUT 705;"MODE:CURRENT" ! Sets CC mode
140 OUTPUT 705;"CURRENT:LEVEL";Current ! Sets the CC level
150 OUTPUT 705;"INPUT ON" ! Enables the inputs
160 !
170 PRINT "Burn-in test started at ";TIME$(TIMEDATE)
180 !
190 FOR I=1 TO Burn_in_time ! Loop on wait. You can write your
200 WAIT .1 ! own power supply test routine and
210 NEXT I ! insert it in this section.
220 !
230 OUTPUT 705;"INPUT OFF" ! Disables the inputs at end of test
240 PRINT "Burn-in test complete at ";TIME$(TIMEDATE)
250 STOP
260 !
270 Srq_service: ! Service request subroutine
280 Load_status=SPOLL(705) ! Conduct serial poll
290 IF BIT(Load_status,6) THEN ! Check if SRQ bit is set
300 GOSUB Check_unr
310 ELSE
320 PRINT "A condition other than UNR generated SRQ at ";TIME$(TIMEDATE)
330 END IF ! You can also check the other bits
340 ENABLE INTR 7 ! Reenable interrupts before return
350 RETURN
360 !
370 Check_unr: ! Check if UNR bit still set
380 WAIT 1 ! Wait 1 s before reading UNR bit
390 OUTPUT 705;"STAT:CHAN:COND?" ! Read channel condition register
400 ENTER 705;Value !
410 IF Bit(Value,10)=0 THEN ! Return value for UNR bit only
420 OUTPUT 705;"*CLS" ! If 0, clear channel event register
430 PRINT "UNR was momentarily asserted at ";TIME$(TIMEDATE)
440 ELSE
450 OUTPUT 705;"INPUT OFF" ! Disables the inputs
460 PRINT "UNR is asserted at ";TIME$(TIMEDATE);" Inputs are turned off"
470 STOP
480 END IF
490 RETURN
500 END
Chapter 4
LANGUAGE DICTIONARY

INTRODUCTION

This section gives the syntax and parameters for all the IEEE 488.2 common commands and HPSL commands used by the electronic loads. It is assumed that you are familiar with the material in Chapters 2 and 3, which explain the terms, symbols, and syntactical structures used here and provide an introduction to programming. You should also be familiar with the Operation Overview and Remote Operation chapters in the electronic load Operating Manual that was shipped with the electronic load. Those chapters explain how the electronic load functions and how to write simple programs to perform basic functions from a controller.

Because the versatility of HPSL allows such freedom in programming, the programming examples show just simple applications of the commands. With experience, you will find ways of combining simple statements into more complex compound ones, or forming iterations within compound statements. Because HPSL functions are the same in all electronic loads, the examples in this chapter are generic. If you send a command or query in a manner consistent with the syntax of your programming language, then the statement or query will always perform the specified function.

Keywords

Keyword explanations use the “long form” of the word, but the short form is used in the examples. If you have any concern that the meaning of a keyword in your program listing will not be obvious at some later time, then use the long form to help make your program self-documenting.

Parameters

Most commands require a parameter and most queries will return a parameter. The range for a parameter may vary according to the model of electronic load. For consistency, the examples and explanations use parameters for the Model HP 6060A Electronic Load. However, these examples and explanations are valid for any electronic load. Parameters for all current models can be found in Table 4-1 at the end of this chapter.

Related Commands

Where appropriate, related commands or queries are included. These are listed either because they are directly related by function or because reading about them will clarify or enhance your understanding of the original command or query.

ORDER OF PRESENTATION

All the electronic loads commands and queries are included in this dictionary. The dictionary is organized as follows:

- IEEE 488.2 common commands, in alphabetical order
- Root level commands, in alphabetical order. These consist of:
  - Single commands.
  - Subsystems. The individual commands for a subsystem are listed in alphabetical order under the subsystem.

COMMON COMMANDS

Introduction

Common commands are defined by the IEEE 488.2 standard to perform some of the basic instrument functions, such as identification, reset, determining how status is read and cleared, and how commands and queries are processed. Common commands are accepted and processed when they are sent as separate commands and also when they are included within program messages. Execution of a common command does not change the position of the parser in the program tree but leaves it in the same place it was before the common command was executed (refer to Chapter 2 - Introduction to HPSL). This does not mean that a common command has no effect on the rest of a programming message.

The electronic loads respond to the 13 required common commands that control internal operation, synchronization, status and event registers, and system data. Because they have full trigger capability, the electronic loads also respond to *TRG. In addition, the electronic loads accept six optional common commands. The description for each common command or query specifies if it affects status registers. In order to make use of this information, you must refer to Chapter 5 - Status Reporting, which explains how to read the status registers and use the information that they return.

Order of Presentation

Figure 4-1 shows the common commands and queries, which are presented in alphabetical order. If a command has a corresponding query that simply returns the data or status specified by the command, then both command and query are included under the explanation for the command. If a query does not have a corresponding command or is functionally different from the command, then the query is listed separately.
Figure 4-1. Common Commands Syntax Diagram
**CLS**

*Clear Status Command*

**Type**
Device Status

**Description**
This command causes the following actions (see *Chapter 5 - Status Reporting* for descriptions of all registers):

- Clears the following registers without affecting any corresponding Enable Registers or Transition Filters:
  - Channel Status Event Registers for all channels
  - Channel Summary Event Register
  - Questionable Status Event Register
  - Standard Event Status Event Register
  - Operation Status Event Register

- Clears the Error Queue

- Forces a previously executed *OPC* command to appear as if it had been completed. It does not do this with the *OPC?* command (see *OPC?* for more details).

- If *CLS* immediately follows a program message terminator (<nl>), then the output queue and the MAV bit are also cleared.

**Command Syntax**
*CLS*

**Parameters**
None

**Related Commands**
*OPC* *OPC?*

---

**ESE**

*Standard Event Status Enable Command/Query*

**Type**
Device Status

**Description**
This command sets the condition of the Standard Event Status Enable Register, which determines which events of the Standard Event Status Event Register (see *ESR?*) are allowed to set the ESB (Event Summary Bit) of the Status Byte Register. A “1” in the bit position enables the corresponding event. All of the enabled events of the Standard Event Status Event Register are logically ORed to cause the ESB (bit 5) of the Status Byte Register to be set. See *Chapter 5 - Status Reporting* for descriptions of all three registers.

**Command Syntax**
*ESE <NRF>
*ESE

Parameters 0 to 255

Suffix None

Example *ESE 129 Enables the OPC and PON events of the Standard Event Status Event Register

Query Syntax *ESE?

Returned Parameters <NR1> Value: 0 to 255

Suffix None

Related Commands *PSC *STB?

---

*ESR?

Standard Event Status Register Query

Type Device Status

Description This query reads the Standard Event Status Event Register. Reading the register clears it. See Chapter 5 - Status Reporting for a detailed explanation of this register.

<table>
<thead>
<tr>
<th>Standard Event Status Event Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit Position 7</td>
</tr>
<tr>
<td>Condition</td>
</tr>
<tr>
<td>Bit Weight</td>
</tr>
</tbody>
</table>

Query Syntax *ESR?

Returned Parameters <NR1> Value: 0 to 255

Suffix None

Related Commands *OPC *CLS
*IDN?  

Identification Query

Type  
System Interface

Description  
This query requests the electronic load to identify itself.

Query Syntax  
*IDN?

Returned Parameters  
<aaard> form consisting of four strings separated by commas. The content of each string is:

<table>
<thead>
<tr>
<th>String</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hewlett-Packard</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>xxxxxA</td>
<td>Four-digit model number followed by a letter suffix</td>
</tr>
<tr>
<td>0</td>
<td>Always returns zero</td>
</tr>
<tr>
<td>a.xx.xx</td>
<td>Revision level of the primary interface firmware</td>
</tr>
</tbody>
</table>

Example  
HEWLETT-PACKARD,6060A,0,A.01.02

This identifies a HP Model 6060A Electronic Load; with primary interface firmware revision A.01.02

Related Commands  
*OPT?  *RDT?

*OPC  

Operation Complete Event Bit Command

Type  
Device Status

Description  
This command causes Bit 0 of the Standard Event Status Event Register to be set when the electronic load has completed all pending operations (see *ESR? for the bit configuration of this register). Pending operations are complete when:

- all previous commands have been executed
- any change in the input level caused by previous commands has been completed (effects of slew rate have been accounted for)
**OPC**

- no pending trigger level operations are set for the single electronic load or for any channel of the multiple electronic load

**OPC** does not prevent processing of subsequent commands but Bit 0 will not be set until all pending operations are completed.

### Command Syntax

*OPC*

### Parameters

None

### Related Commands

*WAI  *OPC?

---

**OPC?**

*Operation Complete Output Query*

#### Type

Device Status

#### Description

This query causes the electronic load to place an ASCII “1” in the Output Queue when all pending operations are completed. *Pending operations* are complete when:

- all commands that were issued before an *OPC? command have been executed
- any change in the input level caused by these previous commands has been completed (effects of slew rate have been accounted for)
- no pending trigger level operations are set for the single electronic load or for any channel of the multiple electronic load

Unlike *OPC, *OPC? prevents processing of all subsequent commands. When all pending operations are completed, an ASCII “1” is placed in the Output Queue. *OPC? is intended to be used at the end of a command line so that the program can then monitor the bus for data until it receives the “1” from the Output Queue.

#### Caution

Do not follow a :LEV:TRIG command (CURR:TRIG, VOLT:TRIG or RES:TRIG) with *OPC? unless TRIG:SOUR has been previously set to EXTernal, LINE, or TIMer. These are the only triggers that can be processed after OPC?. TRIG:IMM, *TRG, and HP-IB bus triggers sent after *OPC? will be prevented from executing, stopping system operation. If this occurs, the only programmable way to restore operation is by sending the electronic load a HP-IB DCL (Device Clear) command.

### Command Syntax

*OPC?
*OPC?

Returned Parameters: <NR1>

ASCII 1 is placed in the Output Queue when the electronic load has completed all pending operations.

Suffix: None

Related Commands: *OPC *TRIG:SOUR *WAI

*OPT?

Type: Device Options

Description: This query specifies options installed in the multiple electronic load. The query presently is not supported and returns a zero for all electronic loads.

Query Syntax: *OPT?

Returned Parameters: 0

Suffix: None

Related Commands: *IDN? *RDT?

*PSC

Type: Device Initialization

Description: This command controls the automatic clearing at power turn-on of:

- the Service Request Enable Register
- the Standard Event Status Enable Register

If the command parameter = 0, then the electronic load can be programmed to request service at turn on. Any non-zero parameter causes both registers to be cleared at turn on, preventing the electronic load from being capable of requesting service at that time. See “Chapter 5 - Status Reporting” for details of these registers.
**PSC**

Command Syntax  *PSC <NR1>*

Parameters  0 or not zero

Suffix  None

Query Syntax  *PSC?*

Returned Parameters  <NR1>  
  0 = power-on clear flag is false; affected registers not cleared at turn on.
  1 = power-on clear flag is true; affected registers cleared at turn on.

Suffix  None

Related Commands  None

---

**RCL**

Recall Instrument State Command

Type  Device State

Description  This command restores the electronic load to a state that was previously stored in memory with the *SAV command to the specified location (see *SAV). *RCL also does the following:

- forces an ABORt command before resetting any parameters (this removes all pending trigger levels)
- after all parameters have been recalled, executes an INP:PROT:CLE to clear the electronic load's protection circuits
- sets CAL:MODE to OFF (see the electronic load Operating Manual for the calibration commands)
- sets CHAN to 1 in the multiple electronic load

At power turnon, the equivalent of an *RCL 0 is executed to restore the electronic load to the state stored in location 0. This same state is also set if the *RCL command is directed to a location where no state was stored since the last time power was cycled.

Note  *RCL does not affect any Status Enable Registers or Transition Filters.
**RCL**

**Command Syntax**  
*RCL* <NRef>

**Parameters**  
0 through 6 where:
- States 1-6  Volatile states previously stored by *SAV*
- State 0  Nonvolatile state previously stored by *SAV 0*

**Suffix**  
None

**Related Commands**  
*RST  *SAV

---

**RD*T**

*Resource Description Transfer Query*

**Type**  
Device Specification

**Description**  
This query returns the model number of a single electronic load or the model number of the module installed in each channel of a multiple electronic load. For multiple electronic loads, a semicolon (;) separates each module and the string is terminated with a LF (line feed).

**Query Syntax**  
*RD*T?

**Returned Parameters**  
<aaar> String value as follows:
- single  
  *CHAN1:nnnnL*; where "nnnnL" = model number electronic load
- multiple  
  *CHAN<c>:nnnnnL*; where "c" = channel number and electronic "nnnnnL" = number and suffix letter of the module in that channel

**Related Commands**  
*IDN?  *OPT?
**RST**

Reset Command

**Type**
Device State

**Description**
This command sets the electronic load to its factory-defined state (see Table 4-1 at the end of this chapter). There are no parameters with this command; it sets all channels of the multiple electronic load to the same state.

*RST* also does the following:

- forces an ABORt command before resetting any parameters
- after all parameters have been reset, executes an IN:PROT:CLE to clear the electronic load's protection circuits

**Note**
*RST* does not affect any Status Enable Registers or Transition Filters.

**Command Syntax**
*RST*

**Parameters**
None

**Related Commands**
*RCL, *SAV

---

**SAV**

Save Command

**Type**
Device State

**Description**
This command stores the present state of the single electronic load and the states of all channels of the multiple electronic load in a specified location in memory. Locations 0 through 6 may be used. Location 0 is in nonvolatile memory and retains its state throughout power cycling. The electronic load will be set to the state in location 0 at power turn-on. If no state has been saved to location 0, then it will still contain the factory-default state (see Table 4-1 at the end of this chapter). States stored in locations 1 through 6 are lost whenever power is cycled.

**Note**
To restore the factory-default state to Location 0, execute:
*RST,*SAV 0
The parameters stored by *SAV are identical to those affected by *RST (See Table 4-1 at the end of this chapter) except that the following states are not stored:

- CAL:MODE ON|OFF (Refer to the Electronic Load; Operating Manual)
- CHAN

Note

*SAV also does not store the states of Status Enable Registers or Transition Filters.

Command Syntax

*SAV <NRf>

Parameters

0 to 6

Suffix

None

Example

*SAV 2  Save the present state of the electronic load to location 2

Related Commands

*RCL  *RST

*SRE

Service Request Enable Command/Query

Type

Device Interface

Description

This command sets the condition of the Service Request Enable Register, which determines which events of the Status Byte Register (see *STB) are allowed to set the MSS (Master Status Summary) bit. A “1” in the bit position enables the corresponding Status Byte bit to set the MSS bit. All the enabled bits are logically ORed to cause Bit 6 (the Master Summary Status Bit) of the Status Byte Register to be set. See “Chapter 5 - Status Reporting” for more details concerning the Status Byte Register.

Command Syntax

*SRE <NRf>

Parameters

0 to 255

Suffix

None

Example

*SRE 20 Enables either the CSUM or MAV condition to cause a service request

Common Commands
**SRE**

**Query Syntax**  
*SRE?

**Returned Parameters**  
<NR1> Value: 0 to 255

**Suffix**  
None

**Related Commands**  
*PSC

---

**STB?**

**Read Status Byte Query**

**Type**  
Device Status

**Description**  
This query reads the Status Byte Register. Note that the MSS (Master Summary Status) bit and not the RQS bit is returned in Bit 6. This bit indicates whether or not the electronic load has at least one reason for requesting service. **STB?** does not clear the Status Byte Register, which is cleared only when subsequent action has cleared all its set bits. Refer to “Chapter 5 - Status Reporting” for more information about this register.

**Status Byte Register**

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>OPER</td>
<td>MSS</td>
<td>ESB</td>
<td>MAV</td>
<td>QUES</td>
<td>CSUM</td>
<td>^10</td>
<td>^10</td>
</tr>
<tr>
<td>Bit Weight</td>
<td>128</td>
<td>64</td>
<td>32</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

^1 Always zero

**Parameters**  
None

**Returned Parameters**  
<NR1> Value: 0 to 255

**Suffix**  
None

**Related Commands**  
None
**TRG**

Immediate *Trigger* Command

**Type**

Device Trigger

**Description**

This command, which is essentially the same as the Group Execute Trigger (GET), generates a trigger to the electronic load only if TRIG:SOUR is set to BUS (refer to the TRIGger Subsystem Root commands).

**Command Syntax**

*TRG

**Parameters**

None

**Related Commands**

<GET> TRIG:SOUR

---

**TST?**

Self *Test* Query

**Type**

Device Test

**Description**

This query causes the electronic load to go through a limited self test (a more complete one is done at power turn on). The testing does not alter the mode or parameter settings of the electronic load.

**Query Syntax**

*TST?

**Returned Parameters**

<NR1> 0 = test passed

Nonzero indicates a self-test failure. For single electronic loads, the returned value is of concern only to service personnel. For multiple electronic loads, the returned values indicate failures in the following modules:

- **multiple electronic load Failure Bit Map**

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed Channel</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>Mainframe</td>
</tr>
<tr>
<td>Bit Weight</td>
<td>64</td>
<td>32</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

**Suffix**

None

**Related Commands**

None

---

Common Commands Language Dictionary 4-13
**WAI**

*Wait-to-Continue Command*

<table>
<thead>
<tr>
<th><strong>Type</strong></th>
<th>Device Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>This command instructs the electronic load not to process any further commands until all pending operations are completed. “Pending operations” are as defined under the *OPC command. *WAI can be aborted only by sending the electronic load an HP-IB DCL (Device Clear) command.</td>
</tr>
<tr>
<td><strong>Command Syntax</strong></td>
<td>*WAI</td>
</tr>
<tr>
<td><strong>Parameters</strong></td>
<td>None</td>
</tr>
<tr>
<td><strong>Related Commands</strong></td>
<td>*OPC  *OPC?</td>
</tr>
</tbody>
</table>
Root-Level Commands

Introduction

Root-level commands are those that are specific to the family of Electronic Loads. The commands are grouped as either channel-specific or channel-independent commands. In the Multiple Electronic Load, channel-specific commands are directed (via the CHANnel command) to specific modules in the mainframe.

Tree Diagram

Figure 4-2 is a tree diagram of the root-level commands. Commands starting at the root directory are listed as either single commands or command subsystems. Command subsystems may consist of a single command, but usually are comprised of a set of commands that extend two or more levels below the root. Refer to Chapter 3 - Introduction to Programming for rules for traversing the command tree and for examples.

Figure 4-2. Electronic Loads Tree Diagram
**ABORt**

Channel-Independent Termination Command

**Description**
This command applies only to trigger functions. It cancels all pending [:LEVel]:TRIG operations (such as CURR:TRIG) in all operating modes and on all channels. As a result, subsequent triggers have no effect on the input level. This command resets the WTG bit of the Operation Condition Register (refer to “Chapter 5 - Status Reporting”) and has the same effect on status as the receipt of a trigger. **ABORt** has no affect on the Transient Subsystem.

**Command Syntax**
**ABORt**

**Parameters**
None

**Examples**
**ABOR**  
Aborts all pending trigger level operations in the Current, Resistance, or Voltage Subsystems

**CURR 10;CURR:TRIG 20;:ABOR;:TRIG**  
Cancels the programmed trigger level so that the triggered input remains at 10 amps

**Query**
None

**Related Commands**
CURR[:LEV]:TRIG  VOLT[:LEV]:TRIG  STAT:OPER:COND?

**CHANnel**

Channel-Independent Command/Query

**Note**
This command is for the multiple electronic load but is supported in single electronic loads for compatibility.

**Description**
**CHANnel** selects the multiple electronic load channel to which all subsequent channel-specific commands will be directed. If the specified channel number does not exist or is outside the MIN/MAX range, an error code is generated (see Table 4-2 at the end of this chapter). When used with the single electronic load the only valid parameter is 1.

**Note**
This command and **INSTRument** are the only channel commands for electronic loads. No other methods of channel selection are supported.
Command Syntax

CHANnel[:LOAD] <NRf+>

Parameters

(See Table 4-1 at the end of this chapter)

Examples

CHANNEL:LOAD 5  Select Channel 5
CHAN 5

CHAN MAX  Select highest existing channel in a multiple electronic load.

Query Syntax

CHAN?  CHAN? MAX  CHAN? MIN

Returned Parameters

<NR1>  CHAN? returns number of channel presently selected.
CHAN? MAX returns the number of channels installed in the multiple electronic load. If none are installed, 0 is returned. For single electronic loads CHAN? MAX returns 1. CHAN? MIN always returns 1 for either single or multiple loads.

Suffix

None

Related Commands

None

Alternate Syntax

INSTRument can be used as an alias for CHANnel
**CURRent Subsystem**  Channel-Specific Current Programming Function

**Description**
This subsystem programs the CC (constant-current mode) function of a single electronic load or a single channel of a multiple electronic load.

**Keywords**

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRent[:LEVel][:IMMediate]</td>
<td>Specify the input current level for the CURRent mode</td>
</tr>
<tr>
<td>CURRent[:LEVel]:TRIGgered</td>
<td>Preset a new input current level to be valid when a trigger occurs</td>
</tr>
<tr>
<td>CURRent:PROTection[:LEVel]</td>
<td>Set current limit at which protection occurs</td>
</tr>
<tr>
<td>CURRent:PROTection:DElay</td>
<td>Set time for which protection current limit may be exceeded</td>
</tr>
<tr>
<td>CURRent:PROTection:STATe OFF</td>
<td>0</td>
</tr>
<tr>
<td>CURRent:PROTection:STATe ON</td>
<td>1</td>
</tr>
<tr>
<td>CURRent:RANGE</td>
<td>Specify full-scale input current range</td>
</tr>
<tr>
<td>CURRent:SLEW</td>
<td>Specify the current level rate of change for all current ranges and for the middle and maximum resistance ranges</td>
</tr>
<tr>
<td>CURRent:TLEVel</td>
<td>Specify input current level used with the TRANsient Subsystem</td>
</tr>
</tbody>
</table>

**Related Subsystems**  RESistance  VOLTage
**Description**

This is an implied keyword that specifies the value of the programmed current level and whether that level is to be applied immediately or on occurrence of a trigger. If the specified channel is in the CC (constant-current) Mode, an IMMediate current level is transferred to the input as soon as the command is executed. A TRIGgered level is stored and then transferred to the electronic load input when a trigger occurs. At that time, the change to the input level occurs at the slew rate presently in effect. Following the trigger event, subsequent triggers will not affect the input level unless the electronic load has been sent another TRIGgered level command.

If the electronic load is not in the CC (Constant-Current) Mode when an IMMediate or TRIGgered level command is sent, the programmed levels are saved for the time the electronic load is placed in the CC mode. Triggered levels are processed by the Current Subsystem even when the electronic load is not in the CC Mode. In this case, the TRIGgered level becomes a stored IMMediate level that takes effect when the electronic load is again in the CC Mode.

**Note**

Setting an IMMediate current level to the same value as the most recent TRIG current level will not deactivate a pending TRIG level. You must use **ABORt** to deactivate it.

The present current level changes to the pending level on any of the following conditions:

- On a TRIG[:IMM] command (always)
- On receipt of an external trigger signal (if TRIG:SOUR is set to EXT)
- On the next line voltage cycle (if TRIG:SOUR is set to LINE)
- On receipt of *TRG (unless TRIG:SOUR is set to HOLD)
- On receipt of an HP-IB <GET> (if TRIG:SOUR is set to BUS)
- On the next trigger timer pulse (if multiple electronic load is set to TRIG:SOUR TIM)

The programmed current level (whether IMMediate or TRIGgered can be implicitly changed with a RANGe command (see “Chapter 3 - Introduction to Programming” for information concerning value coupling).

**Command Syntax**

```
CURR[:LEVel][:IMMediate] <NRf+>
CURR[:LEVel]:TRIGgered <NRf+>
```
Parameters
See Table 4-1

Status and Errors
TRIGgered level commands affect the WTG bit in the Operation Condition register and the OPC bit of the Standard Event Status Event register (see Chapter 5 - Status Reporting). Programmed current levels outside the value range generate an error (see Table 4-2 at the end of this chapter). The correct current range must be programmed before the current level is programmed.

Value Coupling
If CURR:RANGE is set to a range that is below either type of LEVEL, then that LEVEL will assume the MAX value of that range.

Examples
CURR 25
CURRENT:LEVEL 25

CURR:TRIG 25MA
CURRENT:LEVEL:TRIGGERED 25E-3

CURR 30;:CURR:TRIG MIN
Set input to 30 Amps now and minimum current when trigger occurs

Query Syntax
CURR? CURR? MAX CURR? MIN

Returned Parameters
<NR3>
CURR? and CURR:TRIG? return the presently programmed current levels. After a trigger or ABORT, CURR:TRIG? returns the same value as CURR?.


Related Commands
ABORT CURR:RANG see also TRANSient Subsystem

Current Subsystem
Description
This command sets a limit to the input current that the electronic load will sink. A current limit may be specified for the single electronic load or for a channel of the multiple electronic load. When the input current reaches the current limit for the specified delay period, the input of the electronic load or channel is shut off and draws no current. This, in effect, provides a “soft circuit breaker” for the input current. The INPut:PROTection:CLEAR command (or front panel key) re-enables the input current. The trigger-activated current functions (CURR:LEV:TRIG and CURR:TLEV) automatically keep track of incoming triggers while the input is shut down and will respond to the trigger as soon as the protection fault is cleared.

The :PROTection:DElay command specifies the time that the input current may equal or exceed [:LEVEL] before the soft circuit breaker is actuated. The PROTection:STATe command enables or disables the soft circuit breaker function.

Note
If the soft circuit breaker function causes the input to shut down, it will not affect INP[:STATe]. If INP:STAT is programmed ON, it will remain so even after the CURR:PROT has turned the electronic load off.

Command Syntax

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRent:PROTection[:LEVEL]&lt;NRf+&gt;</td>
<td>Set immediate current limit</td>
</tr>
<tr>
<td>CURRent:PROTection:DElay &lt;NRf+&gt;</td>
<td>Set time that current may be at or above :LEVEL before input is turned off</td>
</tr>
<tr>
<td>CURRent:PROTection:STATe OFF/0</td>
<td>Disable protection function</td>
</tr>
<tr>
<td>CURRent:PROTection:STATe ON/1</td>
<td>Enable protection function</td>
</tr>
</tbody>
</table>

Parameters
See Table 4-1 at the end of this chapter

Examples

CURR:PROT:LEVEL 35  Set input current limit to 35 amperes
CURR:PROT:STAT ON

CURR:PROT 35;DELAY .025  Set input current limit to 35 amperes and allow it to be exceeded for 25 milliseconds
CURR:PROT 35;DEL 25MS
**Query Syntax**

- CURR:PROT?
- CURR:PROT? MIN
- CURR:PROT:DEL?
- CURR:PROT:DEL? MIN
- CURR:PROT:DEL? MAX
- CURR:PROT:STAT?

**Returned Parameters**
- <NR3>
  - CURR:PROT? returns the value of existing current limit.
  - CURR:PROT? MAX and CURR:PROT? MIN return the maximum and minimum programmable values for the current limit.
- <NR3>
  - CURR:PROT:DEL? returns the value of existing delay.
- <NR1>
  - CURR:PROT:STAT? returns the state of the protection circuit where 1 is ON and 0 is OFF.

**Related Commands**
- CURR:RANG
- INP:PROT:CLE

---

**CURR:RANGe**

*Channel-Specific Current Command/Query*

**Description**

This command selects the full-scale current range of the electronic load. Programming any value within the low range automatically selects the low range and programming any value within the high range automatically selects that range. In the HP 6060A for example, programming a value from 6 to 60 amperes automatically selects the 60-ampere range.

**Important**

Whenever the electronic load changes range, it momentarily goes into the OFF (minimum current) state.

When CURR:RANG is executed, the values of the current levels (IMMediate, TRIGgered and TLEVel) are adjusted as follows:

<table>
<thead>
<tr>
<th>If</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td>The existing current setting is within the new range</td>
<td>the current level does not change</td>
</tr>
<tr>
<td>The existing current setting is not within the new range</td>
<td>the current level is set to the maximum of the new range</td>
</tr>
</tbody>
</table>
CURR:RANGe

For example, assume the electronic load is in the 60 A range and the main current level (CURR:LEV) is 30 A. Switching to the 6 A range will reduce the current to the maximum of that range, or 6 A. However, if another parameter (such as CURR:TRIG) was already within the new range (e.g., 4 A), then it will remain at that level in the new range. Of course, there is no change in value when switching from the lower range to the higher range. However, the accuracy of the programmed value may be compromised because of the reduced resolution of the higher range.

**Command Syntax**

CURRent:RANGe <NRf+>

**Parameters**

See Table 4-1 at the end of this chapter

**Value Coupling**

This command affects the following parameters:

CURR:LEVel  CURR:TELevel

**Examples**

CURR:RANG 60;LEV 25.25  *Set current to 25.25 A on 60-ampere range*

CURR:RANG 6;:TRIG 4.5  *In previous example, change range to 6 A and set Triggered level to 4.5 A. Due to coupling, the main level will drop to 6 A and remain there until a trigger occurs*

**Query Syntax**

CURR:RANG?
CURR:RANG? MAX
CURR:RANG? MIN

**Returned Parameters**

<NR3>  CURR:RANG? returns the present current range in amperes.
CURR:RANG? MAX and CURR:RANG? MIN return the maximum and minimum programmable ranges for the electronic load.

**Related Commands**

CURR:[LEV]  CURR:TRIG  CURR:TELeV

4-24  Language Dictionary  Current Subsystem
CURR:SLEW

Channel-Specific Current Command/Query

Description
This command sets the current programming slew rate for both CC mode ranges and the resistance programming slew rate for the middle and high CR mode ranges. The programmed slew rate is used for all programmed current changes except INPut ON or OFF. The hardware implements discrete slew rates (refer to the Electronic Load Operating Manual) and automatically selects the one that is closest to the programmed value. To determine the actual rate, use the query (CURR:SLEW?).

Command Syntax
CURRent:SLEW <NRF+>

Parameters
See Table 4-1 at the end of this chapter

Examples
CURRENT:SLEW MAX  *Set slew rate for maximum of present current range*

CURR:RANGE MAX;SLEW 4E5  *Set range to 60 A and slew rate to 400,000 A/s (400 mA/µs)*

Note
Programming a slew rate value greater than MAX sets the slew rate to maximum without generating an error message.

Query Syntax
CURR:SLEW?
CURR:SLEW? MAX
CURR:SLEW? MIN

Note
This query is not applicable to CR mode when it is operating in the low-resistance range

Returned Parameters
<NRF3>  CURR:SLEW? returns the internally selected slew rate (in A/S) that was chosen as closest to the programmed value within the permissible range. CURR:SLEW? MAX and CURR:SLEW? MIN return the maximum and minimum programmable slew rates for the present range.

Related Commands
None
**CURR:TEVel**

*Channel-Specific Current Command/Query*

**Description**
This command specifies the value of the programmed current level for the TRANSient input when the electronic load is in the CC Mode. When the Transient Subsystem is on, the electronic load input current will switch (under control of the Transient Subsystem) between the main level and TEVel at a rate determined by the present value of SLEW. In order for the input current level to switch, TEVel must be set to a value greater than the main level. If TEVel is set to a value below the main level, no error is generated but switching will not occur until the main level is subsequently below the value of TEVel. If TEVel is programmed outside the specified range, an error is generated (see Table 4-2 at the end of this chapter).

**Command Syntax**
`CURR:TEVel <NR3>`

**Parameters**
See Table 4-1 at the end of this chapter

**Value Coupling**
If CURR:RANGe is set to a range that is below TEVel, then TEVel will assume the MAX value of that range.

**Examples**
- `CURR:TEV MAX`  *Set transient level to maximum current for the range*
- `CURR:RANG 6;TEV 5.5`  *Set range to 6 A and Transient level to 5.5 A*

**Query Syntax**
- `CURR:TEV?`
- `CURR:TEV? MAX`
- `CURR:TEV? MIN`

**Returned Parameters**
- `<NR3>`
  - `CURR:TEV?` returns the transient current level for present current range. If the electronic load is not in CC Mode, the level will still be set, even if it is less than the presently programmed input level.
  - `CURR:TEV? MAX` and `CURR:TEV? MIN` return the maximum and minimum programmable values for the present range.

**Related Commands**
- `CURR:RANG`  also see TRANSient Subsystem

---

4-28  Language Dictionary
Current Subsystem
INPut Subsystem

Channel-Specific Input Programming Functions

Description

This subsystem has commands for:

- Turning the electronic load input on or off
- Placing a short across the electronic load input
- Clearing any input software protection circuits that have been set

For multiple electronic loads these commands function only on the presently specified channel.

Keywords

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPut[:STATE] ON</td>
<td>1</td>
</tr>
<tr>
<td>INPut[:STATE] OFF</td>
<td>0</td>
</tr>
<tr>
<td>INPut:PROTection:CLEar</td>
<td>Reset input protection circuits</td>
</tr>
<tr>
<td>INPut:SHORT[:STATE]:ON</td>
<td>1</td>
</tr>
<tr>
<td>INPut:SHORT[:STATE]:OFF</td>
<td>0</td>
</tr>
</tbody>
</table>

Alternate Syntax

OUTPut can be used as an alias for INPut.

Related Subsystems

CURRent  RESistance  VOLTage

Syntax Diagram

Input Subsystem Syntax Diagram
**INP:PROT:CLEar**  

*Channel-Specific Input Command*

**Description**  
This command resets the electronic load latched protective features (such as overvoltage, overcurrent, overpower, etc.). If an electronic load protective circuit has shut down the input and no **INPut:OFF** command has been sent, **INPut:CLEar** will restore the input to the **ON** state and restore the previously existing operating mode and its parameters. Of course, if the cause of a shutdown condition is not corrected, it will reoccur.

If a trigger is received during the time a protection circuit has shut down the input, any triggered levels (**CURR:TRIG, RES:TRIG**, etc) are stored and will be transferred to the main level after the protection is cleared. Triggers received during protective shutdown are also applied to the Transient Subsystem. This ensures that after the shutdown is cleared, the transients on the restored channel will still be synchronized with those of other channels.

**Command Syntax**  
**INPut:PROTection:CLEar**

**Parameters**  
None

**Query Syntax**  
None

**Related Commands**  
**CURR:PROT[:LEV]**  
**CURR:PROT:DEL**  
**CURR:PROT:STAT**

---

**INP:SHORT**  

*Channel-Specific Input Command/Query*

**Description**  
This command applies the equivalent of an electronic short across the input of the electronic load. The actual condition of the electronic load under a short condition depends on its operating mode as follows:

<table>
<thead>
<tr>
<th>Mode of Operation</th>
<th>Shorted Condition¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-Range CC Mode</td>
<td>MAX current</td>
</tr>
<tr>
<td>Low-Range CC Mode</td>
<td>MAX current</td>
</tr>
<tr>
<td>Low-Range CR Mode</td>
<td>MIN resistance</td>
</tr>
<tr>
<td>Middle-Range CR Mode</td>
<td>MIN resistance</td>
</tr>
<tr>
<td>High-Range CR Mode</td>
<td>MIN resistance</td>
</tr>
<tr>
<td>CV Mode</td>
<td>MIN voltage</td>
</tr>
</tbody>
</table>

¹See Table 4-1 for specific values.
If a mode or current or resistance range is changed, the short will be reapplied to the new mode or range. If a trigger is received while SHORT is ON, any triggered levels (CURR:TRIG, RES:TRIG, etc.) are stored and will be transferred to the main level after SHORT is programmed OFF. Triggers received during SHORT:ON are also applied to the Transient Subsystem. This ensures that after the short is programmed off, the transients on the shorted channel will still be synchronized with those of channels that had remained unshorted.

Executing INPut:SHORT does not affect any programmed settings and the electronic load will return to them when the short is removed. This command is subordinate to INPut[:STATe]. If INPut[:STATe] is programmed OFF, then the effect of INPut:SHORT:ON will not be observed until INPut[:STATe]:ON is sent to the electronic load.

Command Syntax

\[
\text{INPut:SHORT[:STATe]} <\text{NRf+}>
\]

Parameters

<table>
<thead>
<tr>
<th>Value Range</th>
<th>Units</th>
<th>*RST Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF or 0</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>ON or 1</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

Examples

\[
\text{INP:SHOR ON} \quad \text{Set shorted input condition}
\]
\[
\text{INP:SHOR 1}
\]

\[
\text{CHAN 2;INP:SHOR 1;CHAN 1;INP:SHOR 0}
\]

On multiple electronic load, short Channel 1 and unshort Channel 2

Query Syntax

\[
\text{INP:SHOR?}
\]

Returned Parameters

\[
<\text{NR1}>
\]

Value; 0 for unshorted, 1 for shorted

Related Commands

\[
\text{INP[:STAT]}
\]
**INP[:STATe]**

*Channel-Specific Input Command/Query*

**Description**
This implied keyword turns the electronic load input ON and OFF. When INPut is OFF, the electronic load will draw minimal current at its input. INP[STATe]:OFF overrides INP[put]:SHORT:ON. The presently programmed slew rate setting is not used when turning the input on or off; the current and voltage change at their maximum rates.

**Command Syntax**
INPut [:STATe] <NRf+>

**Parameters**

<table>
<thead>
<tr>
<th>Value Range</th>
<th>Units</th>
<th>*RST Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF or 0</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>ON or 1</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

**Examples**

INP[:STAT OFF   *Turn electronic load input off*
INP 0

INP[:STAT OFF;SHOR ON;:INP ON  *Turn input off, short the input, and turn input on*

**Query Syntax**
INP?

**Returned Parameters**

<NR1> Value; 0 for OFF, 1 for ON

**Related Commands**
CURR:PROT INP:SHOR

---

**MEASure**

*Channel-Specific Measurement Query*

**Description**
This function consists of queries that return the current, voltage, and power at the input of the electronic load.

**Query Syntax**

<table>
<thead>
<tr>
<th>Query</th>
<th>Value Returned</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEASure:CURRent[:DC]?</td>
<td>electronic load input current</td>
</tr>
<tr>
<td>MEASure:POWer[:DC]?</td>
<td>Computed electronic load input power</td>
</tr>
<tr>
<td>MEASure:VOLTage[:DC]</td>
<td>electronic load input voltage</td>
</tr>
</tbody>
</table>

4-30 Language Dictionary  Root-Level Commands
MEASure

Returned Parameters

<NR3> Value representing amperes, watts, or volts

Note

If the input voltage or current exceeds the maximum measurement capability of the electronic load, an 9.9E+37 out-of-range indication will be returned in place of the normal measurement reading.

Examples

MEAS:VOLT? Return input voltage

MEAS:CURR?;VOLT?;POW? Return input current, voltage and power

CHAN 1;:MEAS CURR?;CHAN 2;:MEAS POW? Return Channel 1 current & Channel 2 power

Related Commands

None

Syntax Diagram

Measure Query Syntax Diagram

MODE

Channel-Specific Command/Query

Description

This command selects the operating mode of the electronic load, which can be:

CURRent Constant-current (CC) input
RESSistance Constant-resistance (CR) input
VOLTage Constant-voltage (CV) input
If the mode is changed while the input is on, the input is momentarily turned off as if INPut:STATE OFF were executed. However, changing modes does not change the state of the input nor does it turn off the TRANsient function. For multiple electronic loads, the mode of each channel is programmed independently.

Command Syntax

\begin{itemize}
  \item \texttt{MODE:CURRent[:DC]} \quad \text{Sets electronic load to constant-current mode}
  \item \texttt{MODE:RESistance} \quad \text{Sets electronic load to constant-resistance mode}
  \item \texttt{MODE:VOLTage[:DC]} \quad \text{Sets electronic load to constant-voltage mode}
\end{itemize}

Parameters

Enter the desired mode as a string variable in either the full or abbreviated format. There are no units. The *RST Default is \textit{CURR}ent.

Examples

\begin{itemize}
  \item \texttt{MODE:CURR} \quad \text{Set electronic load input to CC mode}
  \item \texttt{CHAN 1; :MODE:CURR; :CHAN 2; :MODE:RES} \quad \text{Set Channel 1 input to CC mode and Channel 2 input to CR mode}
\end{itemize}

Query Syntax \texttt{MODE?}

Returned Parameters \texttt{<aard>} \quad \text{String value: CURR, RES, or VOLT}

Alternate Syntax \texttt{FUNCTION} can be used as an alias for \texttt{MODE}.

Syntax Diagram

\begin{center}
\begin{tikzpicture}
  \node (MODE) {MODE};
  \node (CURRent) [right of=MODE] {CURRent};
  \node (DC) [right of=CURRent] {DC};
  \node (RESistance) [below of=CURRent] {RESistance};
  \node (VOLTage) [below of=RESistance] {VOLTage};
  \node (question mark) [below of=VOLTage] {?};

  \draw[->] (MODE) -- (CURRent);
  \draw[->] (CURRent) -- (DC);
  \draw[->] (MODE) -- (RESistance);
  \draw[->] (RESistance) -- (DC);
  \draw[->] (MODE) -- (VOLTage);
  \draw[->] (VOLTage) -- (DC);
\end{tikzpicture}
\end{center}
PORT0

Channel-Specific Output Command/Query

Description
This command controls the general-purpose digital port on the rear of each electronic load or each channel of the multiple electronic load. The state of the port is with respect to the common side of the electronic load input. Setting a port to the OFF or 0 state connects it to the common; setting a port to the ON or 1 state disconnects it from common and sets it to a TTL logical high.

The command is the same for both single and multiple electronic loads. To control a port in a multiple electronic load you must first select the channel and then use PORT0 on that channel.

Command Syntax
PORT0[:STATE] <NRf+>

Note
This command does not have a four-character short form. You must always include the fifth character (zero).

Parameters

<table>
<thead>
<tr>
<th>Value Range</th>
<th>Units</th>
<th>*RST Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF or 0</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>ON or 1</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>

Examples
PORT0 ON    Set the port output high (logical 1)

CHAN 1:: PORT0 ON::CHAN 2:: PORT0 OFF    Set Channel 1 port high and Channel 2 port low

Query Syntax
PORT0?

Returned Parameters
<NR1>  1 for ON or 0 for OFF

Related Commands
None
RESistance Subsystem

Channel-Specific Resistance Programming Function

Description
This subsystem programs the constant-resistance (CR) mode function of a single electronic load or a single channel of a multiple electronic load. There is no SLEW command in this subsystem. In the lowest resistance range the level changes in Volts/sec at the rate specified by the present VOLT:SLEW command. The middle and high ranges change level in Amps/sec at the rate specified by the present CURR:SLEW command.

Keywords

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESistance[:LEVEL][:IMMediate]</td>
<td>Specify input resistance for CR mode</td>
</tr>
<tr>
<td>RESistance[:LEVEL][:TRIGgered]</td>
<td>Preset a new input resistance to be valid when a trigger occurs</td>
</tr>
<tr>
<td>RESistance:RANGE</td>
<td>Specify full-scale input resistance range</td>
</tr>
<tr>
<td>RESistance:TELEVEL</td>
<td>Specify input resistance used with TRANSient Subsystem</td>
</tr>
</tbody>
</table>

Syntax Diagram

Resistance Subsystem Syntax Diagram

Related Subsystems  CURRent  VOLTage
**Channel-Specific Resistance Command/Query**

**Description**

This is an implied keyword that specifies the value of the programmed input resistance and whether that value is to be applied immediately or on occurrence of a trigger. If the specified channel is in the CR (constant-resistance) Mode, an IMMediate resistance level is transferred to the input as soon as the command is executed. A TRIGgered level is stored and transferred to the electronic load input when the trigger occurs. At that time, the change to the input level occurs at the presently active voltage slew rate (for the lowest resistance range) or presently active current slew rate (for the middle and highest ranges). Following the trigger event, subsequent triggers will not affect the input level unless the electronic load has been sent another TRIGgered level command.

If the electronic load is not in the CR Mode when an IMMediate or TRIGgered level command is sent, the programmed levels are saved for the next time the electronic load is placed in the CR Mode. Triggered levels are processed by the Resistance Subsystem even when the electronic load is not in the CR Mode. Thus, the TRIGgered level becomes a stored IMMediate level that takes effect when the electronic load is again in the CR mode.

**Note**

Setting an IM resistance level to the same value as the most recent TRIG resistance level will not deactivate a pending TRIG level. You must use ABORT to deactivate it.

The present resistance level of each channel changes from the present level to the pending level on any of the following:

- On a TRIG[:IMM] command (always)
- On receipt of an external trigger signal (if TRIG:SOUR is set to EXT)
- On the next line voltage cycle (if TRIG:SOUR is set to LINE)
- On receipt of *TRG (unless TRIG:SOUR is set to HOLD)
- On receipt of an HP-IB <GET> (if TRIG:SOUR is set to BUS)
- On the next trigger timer pulse (if multiple electronic load is set to TRIG:SOUR TIM)

The programmed resistance level (whether IMMediate or TRIGgered) can be implicitly changed with a RANGE command (refer to “Chapter 3 - Introduction to Programming” for information concerning value coupling).

**Command Syntax**

- `RESistance[:LEVEL][:IMMediate] <NRF+>`
- `RESistance[:LEVEL]:TRIGgered <NRF+>`

**Parameters**

See Table 4-1 at the end of this chapter
Note
The higher values of resistance levels have less resolution. Programmed levels are set to the nearest value obtainable by the hardware.

Status and Errors
TRIGgered level commands affect bits in the STATus OPERating CONDition and STATus CHANnel CONDition registers (see Chapter 5 - Status Reporting). Programmed resistance values outside the value range generate an error (see Table 4-2 at the end of this chapter). The correct resistance range must be programmed before the resistance level is programmed. Note from the parameters (see Table 4-1) that there is considerable overlap between the middle and high ranges, but no overlap between the low and middle ranges.

Value Coupling
If RES:RANGE is set to a range that is below either type of LEVEL, then that LEVEL will assume the MAX value of that range.

Examples
RES 25
RESISTANCE:LEVEL 25

RES:TRIG: .025
RESISTANCE:LEVEL:TRIGGERED 25E-3

RES:IMM .1;TRIG 1
Set input to 100 milliohms now and to 1 ohm when trigger occurs

Query Syntax
RES? RES? MAX RES? MIN

Returned Parameters
<NR3> RES? and RES:TRIG? return the presently programmed input resistance levels. After a trigger or ABORt, RES:TRIG? returns the same value as RES?.

Related Commands
ABOR RES:RANG TRANsient Subsystem
RES:RANGe

Channel-Specific Resistance Command/Query

Description

This command selects the full-scale resistance range of the electronic load. See Table 4-1 for the ranges of each model. Programming any value equal to or greater than zero (\( \geq 0 \)) and less than or equal to (\( \leq \)) the maximum value of the lowest range automatically selects that range. Programming any value greater than the minimum range and less than or equal to (\( \leq \)) the maximum value of the middle range automatically selects that range. There is no overlap between the low and middle ranges. Programming a value greater than the maximum value of the middle range automatically selects the highest range.

Note

Whenever the electronic load changes resistance range, the input momentarily goes into the OFF (minimum current) state.

The values of the input resistance (IMMediate, TRIGgered and TLEVel) are adjusted as follows:

\[
\begin{align*}
\text{If} & \quad \text{Then} \\
\text{The existing resistance setting is} & \quad \text{the resistance value does not} \\
\text{within the new range} & \quad \text{change} \\
\text{The existing resistance value is} & \quad \text{the resistance is set to the closest} \\
\text{not within the new range} & \quad \text{limit of the new range}
\end{align*}
\]

For example, assume the HP 6060A Electronic Load; is in the 10000-ohm range and the input resistance (RES:LEV) is 2000 ohms. Switching to the 1000-ohm range will reduce the resistance to the closest limit of that range, or 1000 ohms. However, if another parameter (such as RES:TRIG) was already within the new range (e.g., 500 ohm), then it will remain at that level in the new range. When switching between two ranges that overlap, the accuracy of the programmed value may be compromised because of reduced resolution when going from a lower to a higher range.

Command Syntax

\[
\text{RESistance:RANGe <NRf+>}
\]

Parameters

See Table 4-1 at the end of this chapter

Value Coupling

This command affects the following parameters:

\[
\text{RES:LEV} \quad \text{RES:TLEV}
\]
Examples
RES:50  Set resistance 50 ohms

RES:RANG 1;:TRIG 45E-3  Change range to 1 ohm and set Triggered resistance to 45 milliohms. The main resistance will drop to 1 ohm and remain there until a trigger occurs.

Query Syntax
RES:RANG?
RES:RANG? MAX  RES:RANG? MIN

Returned Parameters
<NR3>  RES:RANG? returns the present resistance range in ohms.
RES:RANG? MAX and RES:RANG? MIN return the maximum and minimum programmable ranges for the electronic load.

Related Commands
RES:[LEV]  RES:TRIG  RES:TLEV

---

RES:TLEV

*Channel-Specific Resistance Command/Query*

Description
This command specifies the value of the programmed resistance level for the TRANSient input when the electronic load is in the CR (constant-resistance) Mode. When the Transient Subsystem is on, the electronic load input resistance will switch (under control of the Transient Subsystem) between the main resistance and TLEV at a rate determined by the present value of VOLT:SLEW (lowest resistance range) or by CURR:SLEW (middle and high resistance ranges). In order for input resistance level switching to occur, TLEV must be programmed as follows:

- Lowest range  TLEV > LEV
- Middle and highest ranges  TLEV < LEV

If the above rules are not followed, no error is generated but transient switching will not occur. If the main resistance is subsequently programmed to the proper level with respect to TLEV, switching will begin provided the TRANSient subsystem is on. If TLEV is programmed outside the specified range, an error is generated (see Table 4-2 at the end of this chapter).
Command Syntax  
RESistance:TLEVel <NRf>

Parameters  
See Table 4-1 at the end of this chapter

Value Coupling  
The higher values of resistance levels have less resolution. Programmed levels are set to the nearest value obtainable by the hardware.

Examples  
RES:TLEV MAX  * Set transient level to maximum resistance for the range

RES;RANG 1000  
RES 200;RES:TLEV 400;TRAN ON  * Since TLEV > LEV on the 1k range, no transient switching occurs

RES:TLEV 100  * Now TLEV < LEV and input switches from 100 to 200 ohms

Query Syntax  
RES:TLEV?

Returned Parameters  
<NR3>  * Transient resistance value for present range. If the electronic load is not in Resistance Mode, the value will still be set, even if it is less than the presently programmed input resistance.

Related Commands  
See TRANsient Subsystem
STATus Subsystem

Channel-Specific & Channel-Independent Status Commands/Queries

Description

The electronic load has the following four groups of device-dependent status registers:

<table>
<thead>
<tr>
<th>Register Group</th>
<th>Registers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Status</td>
<td>Condition, Enable, Event</td>
</tr>
<tr>
<td>Channel Summary</td>
<td>Enable, Event</td>
</tr>
<tr>
<td>Questionable Status</td>
<td>Condition, Enable, Event</td>
</tr>
<tr>
<td>Operation Status</td>
<td>Condition, Enable, Event, Transition Filters</td>
</tr>
</tbody>
</table>

Note

See “Chapter 5 - Status Reporting” for details concerning the functions of these four groups of registers.

There are four groups of status command/queries corresponding to the above registers. The groups are placed in alphabetical order in the rest of this subsystem. The keywords for all groups are summarized below.

Keywords

STATus:CHANnel :CONDition?
STATus:CHANnel [:EVENT]?  
STATus:SUMmary :EVENT?  
STATus:OPERation :CONDition?  
STATus:OPERation [:EVENT]?  
STATus:QUESTionable :CONDition?  
STATus:QUESTionable [:EVENT]?  

Related Commands/Queries

*CLS *ESE *ESR? *SRE *STB
**Channel-Specific Channel Status Command/Queries**

**Description**

The Channel Status group consists of a set of registers for each channel. Each channel register set monitors all events for that channel and sums them into a corresponding summary bit in the Event register of the Channel Summary group.

The following Channel Status registers are associated with each channel:

- **Condition**: Real-time ("live") channel status
- **Event**: Records all channel events that occurred since the last time the register was read
- **Enable**: Mask for selecting which bits in the Event register are allowed to be summed into the corresponding channel bit of the Channel Summary Event register

**Bit Configuration of Channel Status Registers**

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>15,14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8-5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>2NU</td>
<td>PS</td>
<td>OV</td>
<td>RV</td>
<td>UNR</td>
<td>EPU</td>
<td>NU</td>
<td>OT</td>
<td>OP</td>
<td>NU</td>
<td>OC</td>
<td>VE</td>
</tr>
<tr>
<td>Bit Weight</td>
<td>8192</td>
<td>4096</td>
<td>2048</td>
<td>1024</td>
<td>512</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

1 See Chapter 5 - Status Reporting for explanations of the bit mnemonics. 2NU = Always zero

**Command/Query Syntax**

**STATus:CHA*Nnel:CONDITION?**

Returns the binary value of the Channel Status Condition register, which represents the present status. A condition exists if the corresponding bit = 1.

**STATus:CHA*Nnel[:EVEN*t]?**

Returns the binary value of the Channel Event register, which latches 0-to-1 transitions of the channel conditions the first time they occur. The Event bit remains 1 even if the condition has since disappeared. Reading this register resets it to zero.

**STATus:CHA*Nnel:ENABle**

A mask that specifies which bits of the Channel Status Event register will be allowed to be summed into the appropriate channel bit of the Channel Summary register. Set the bit to 1 to enable the condition. Program MAX to enable all allowable bits or MIN to disable them.

**STATus:CHA*Nnel:ENABle?**

Returns the binary mask value of the Channel Status Enable register.
The STAT:CHAN commands are channel specific. For the multiple electronic loads, always send a CHANnel command to select the desired channel.

**Examples**

**STAT:CHAN?** Returns the value of the Event register in a single electronic load, or of the presently addressed channel Event register in a multiple electronic load.

**STAT:CHAN:ENAB 18** Programs the Channel Enable register to allow the occurrence of either an OC or an OT condition to set the corresponding bit in the Channel Summary Event register for the present channel.

**STAT:CHAN:EVEN?;COND?** Returns the values of the Event and Condition registers for the present channel. The Condition value is the status as it existed at the moment the Condition register was read.

**CHAN 2;STAT:CHAN:ENAB 19** Programs the Channel Status Enable register to enable OV, OC, and OT conditions to set the Channel Summary Event bit for Channel 2.

**Related Commands/Queries**

- STAT:CSUM
- STAT:QUEs
- *CLS
- INP:PROT:CLE
- *CLS
- INP:PROT:CLE

**Channel-Independent Channel Summary Command/Queries**

**Description**

The Channel Summary group of registers provides a convenient way to determine if any enabled CHAN:STAT Events have occurred on a particular channel. The Channel Summary group is primarily intended for use with multiple electronic loads. However, all commands in this group are valid with single electronic loads. The following registers comprise the Channel Summary group:
STAT:CSUMmary

<table>
<thead>
<tr>
<th>Event</th>
<th>Indicates all channels on which an enabled STAT:CHAN Register Event has occurred since the last time the register was read.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable</td>
<td>Mask for selecting which bits in the Channel Event register are allowed to be summed into the CSUM (Channel Summary) bit of the Status Byte register.</td>
</tr>
</tbody>
</table>

The bit maps for these registers are:

### Bit Configuration of Channel Summary Registers

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>12</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>NU</td>
</tr>
<tr>
<td>Bit Weight</td>
<td>8192</td>
<td>4096</td>
<td>2048</td>
<td>1024</td>
<td>512</td>
<td>256</td>
<td>128</td>
<td>64</td>
<td>32</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

1Not all channel bits may be used. NU = always zero

The following command/queries are associated with this register group:

### Command/Query Syntax

<table>
<thead>
<tr>
<th>Command/Query</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATus:CSUMmary[:EVENt]?</td>
<td>Returns the binary value of the Channel Summary Event register. A 1 in the bit position indicates that there is an event from that channel. Reading this register resets it to zero.</td>
</tr>
<tr>
<td>STATus:CSUMmary:ENABle</td>
<td>A mask that specifies which bits of the Channel Summary Event register can be selected to set the Status Byte register CSUM bit. Set the bit to 1 to enable the bit. Program MAX to enable all allowable bits or MIN to disable them.</td>
</tr>
<tr>
<td>STATus:CSUMmary:ENABle?</td>
<td>Returns the binary mask value of the Channel Summary Enable register.</td>
</tr>
</tbody>
</table>

### Returned Parameters

<NR1> Register binary value

### Examples

<table>
<thead>
<tr>
<th>STAT:CSUM?</th>
<th>Returns the value of the CSUMmary EVENT register</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT:CSUM:ENAB 18</td>
<td>Programs the Channel Summary Enable register to allow the Channel Summary Event register to set the error summary bits for Channels 1 and 4</td>
</tr>
</tbody>
</table>
**STAT:OPERation**

*Channel-Independent Operation Status Command/Queries*

**Description**

The Operation Status registers provide information about the following operating conditions:

- **WTG**
  - A 1 indicates that at least one channel of the electronic load is waiting for a trigger to occur

- **CAL**
  - A 1 indicates that the calibration constants of the channel are presently being recalculated. Unless you are explicitly calibrating the electronic load, this bit is always 0

The WTG bit is used to detect if the electronic load is waiting to complete the transfer of a pending trigger level. When the bit is set, it means that the electronic load has processed a trigger level command (e.g., `CURR:TRIG 25`) but is waiting for a trigger in order to execute that command.

**Note**

Refer to the electronic load *Operating Manual* for information concerning Calibration commands.

The following registers are associated with Operation Status commands:

<table>
<thead>
<tr>
<th>Register</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>Real-time (&quot;live&quot;) operating status</td>
</tr>
<tr>
<td>PTR/NTR</td>
<td>Programmable filters that determine what type of transition (0-to-1 or 1-to-0) in the Condition register will set the corresponding bit in the Event register</td>
</tr>
<tr>
<td>Event</td>
<td>Records all channel conditions that occurred since the last time the register was read</td>
</tr>
<tr>
<td>Enable</td>
<td>Mask for selecting which bits in the Event register are allowed to be summed into the OPER (Operation Summary) bit of the Status Byte register</td>
</tr>
</tbody>
</table>

**Bit Configuration of Operation Status Registers**

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>11 - 6</th>
<th>5</th>
<th>4 - 1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>1NU</td>
<td>WTG</td>
<td>1NU</td>
<td>CAL</td>
</tr>
<tr>
<td>Bit Weight</td>
<td>32</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1NU = Not Used

---

**Status Subsystem**
The following command/queries are associated with this register group:

**Command/Query Syntax**

<table>
<thead>
<tr>
<th>Register</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATus:OPERation:CONDition?</td>
<td>Returns the binary value of the Operation Status Condition register, which represents the present status. The condition is occurring whenever the bit is 1</td>
</tr>
<tr>
<td>STATus:OPERation:PTRansition</td>
<td>A filter that specifies whether or not a 0-to-1 transition in the Condition register will set the corresponding bit in the Event register. Program the bit position to 1 to enable the transition requirement.</td>
</tr>
<tr>
<td>STATus:OPERation:PTRansition?</td>
<td>Returns the binary value of the PTRansition filter</td>
</tr>
<tr>
<td>STATus:OPERation:NTRansition</td>
<td>A filter that specifies whether or not a 1-to-0 transition in the Condition register will set the corresponding bit in the Event register. Program the bit position to 1 to enable the transition requirement.</td>
</tr>
<tr>
<td>STATus:OPERation:NTRansition?</td>
<td>Returns the binary value of the NTRansition filter</td>
</tr>
<tr>
<td>STATus:OPERation[:EVENt]?</td>
<td>Returns the binary value of the Operation Event register, which latches specified transitions in the Operation Condition register the first time they occur. The event bit remains 1 even if the condition has since disappeared. <em>Reading this register resets it to zero.</em></td>
</tr>
<tr>
<td>STATus:OPERation:ENABle</td>
<td>A mask that specifies which bits of the Operation Status Event register are allowed to be summed into the OPER (Operation) bit of the Status Byte register. Set the bit to 1 to enable the corresponding condition. Program MAX to enable all allowable bits or MIN to disable them.</td>
</tr>
</tbody>
</table>

**Note**

To specify a bit to be set on either a 0-to-1 or a 1-to-0 transition, program both filters (NTR and PTR) for that bit to 1. To prevent a bit from being sent under any conditions, program that bit in both filters to 0.

**Returned Parameters**

- `<NR1>` Register binary value

**Examples**

- `STAT:OPER? Returns the binary value of the Operation Status Event register`
- `STAT:OPER:COND? Returns the status of the Electronic Load as it existed the instant the register was read`
- `STAT:OPER:PTR 32;NTR 32 Program a recorded event on any transition of the WTG bit`

4-46 Language Dictionary Status Subsystem
ABORt can also cause a WTG bit event if the corresponding NTRansition bit is set to 1.

Related Commands/Queries

ABOR  *CLS  TRIG  *TRG

Channel-Independent Questionable Status Command/Queries

The Questionable Status register group provides information that some data or parameters may be unreliable. The Questionable Status registers monitor the same conditions as the Channel Status group. However, the Questionable status monitors a specified condition for all channels in the multiple electronic loads and sums them into the QUES (Questionable Summary) bit of the Status Byte register. This permits the controller to use a single command to determine if the specified condition exists on any of the channels. All commands associated with this group are valid with single electronic loads, but in that case the Questionable and Channel Status registers will hold the same information. The following three Channel Status registers are associated with each channel:

**Condition**: Real-time (“live”) recording of Questionable data.

**Event**: Records all Questionable conditions that occurred since the last time the register was read.

**Enable**: Mask for selecting which bits on the Event register are allowed to be summed into the QUES bit of the Status Byte register.

### Bit Configuration of Questionable Status Registers

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>15,14</th>
<th>13</th>
<th>12</th>
<th>11</th>
<th>10</th>
<th>9</th>
<th>8-5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>1NU</td>
<td>PS</td>
<td>OV</td>
<td>RV</td>
<td>UNR</td>
<td>EPU</td>
<td>NU</td>
<td>2TE</td>
<td>2PE</td>
<td>NU</td>
<td>2CE</td>
<td>2VE</td>
</tr>
<tr>
<td>Bit Weight</td>
<td>8192</td>
<td>4096</td>
<td>2048</td>
<td>1024</td>
<td>512</td>
<td>16</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1NU = Not Used.

2All signals are the same as the Channel Status Condition register.
Different mnemonics are required by the HP-SL standard.

---

**Note**: See “Chapter 5 - Status Reporting” for an explanation of the bit mnemonics.
**STAT:QUESTionable**

### Command/Query Syntax

<table>
<thead>
<tr>
<th>Query</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATus:QUESTionable:CONDition?</td>
<td>Returns the binary value of the Questionable Status Condition register, which represents real-time status of possible Electronic Load malfunctions. A condition exists if the corresponding bit = 1.</td>
</tr>
<tr>
<td>STAT:QUESTionable:EVENt?</td>
<td>Returns the binary value of the Questionable Status Event register, which latches each 0-to-1 transition of the condition of the Questionable Condition register the first time it occurs. The bit remains 1 even if the original condition has since disappeared. <em>Reading this register resets it to zero.</em></td>
</tr>
<tr>
<td>STATus:QUESTionable:ENABLE</td>
<td>A mask that specifies which bits of the Questionable Event register can be summed into the QUES bit of the Status Byte register. Set the bit to 1 to enable the corresponding event. Program MAX to enable all allowable bits or MIN to disable them.</td>
</tr>
<tr>
<td>STATus:QUESTionable:ENABLE?</td>
<td>Returns the binary mask value of the Questionable Status Enable register.</td>
</tr>
</tbody>
</table>

### Returned Parameters

| <NR1> | Register binary value |

### Examples

- **STAT:QUES?**  
  *Returns the binary value of the Questionable Status Event register and clears it*

- **STAT:QUES:EVEN?;ENAB?**  
  *Returns the binary values of the Questionable Status Event and Enable registers*

- **STAT:QUES:ENAB 19**  
  *Programs the Questionable Status Enable register to enable OV, OC, and OT conditions to set the Status Byte register QUES bit*

### Related Commands/Queries

*CLS  
:INP:PROT:CLE
SYST:ERRor?

*Channel-Independent Error Query*

**Description**
This query reads the remote programming error queue of the electronic load. The queue, which operates in a FIFO (first-in, first-out) mode, records only programming errors - not front panel errors. As it is read, each error is removed from the queue. When all errors have been read, a zero is returned.

Negatively numbered errors are generic HP-SL errors and positively numbered errors are specific to the electronic load. (see Table 4-2 at the end of this chapter) If the error queue should become full, error -350 will be returned.

**Query Syntax**
SYSTem:ERRor?

**Returned Parameters**
- `<aard or crd>` Gives the error number and a short description of the error
- **Error Number Range**
  - -32768 to 32767

**Note**
For an error summary list, see Table 4-2 at the end of this chapter.

**Examples**
SYST:ERR? *Returns the oldest (first) error currently in the system error queue*

**Related Queries**
None
**TRANsient Subsystem**

*Channel-Specific Transient Programming Function*

**Description**

The Transient Subsystem may be used with Constant-Current, Constant-Resistance, or Constant-Voltage load operation. The transient function provides an alternate input level (TLEVel) that occurs periodically under programmed control.

The three transient modes are:

- **CONTinuous**  
  A continuous pulse train that alternates between LEVel and TLEVel under control of an internal oscillator

- **PULSe**  
  A one-shot pulse that alternates between LEVel and TLEVel upon occurrence of an explicit trigger

- **TOGGLE**  
  Each explicit trigger causes the input to alternate between LEVel and TLEVel

The input levels (LEVel and TLEVel) are programmed from the Current, Resistance, or Voltage Subsystems. So is SLEW, which determines the rate at which the input changes from one level to the other.

**Note**

For a detailed description of transient subsystem operation, see *Operation Overview* in the Electronic Load *Operating Manual*.

**Keywords**

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANsient[:STATe] ON</td>
<td>Enable Transient function</td>
</tr>
<tr>
<td>TRANsient[:STATe] OFF</td>
<td>Disable Transient function</td>
</tr>
<tr>
<td>TRANsient:MODE CONTinuous</td>
<td>Select continuous pulse train varying between LEVel and TLEVel at FREquency</td>
</tr>
<tr>
<td>TRANsient:MODE PULSe</td>
<td>Select single triggered pulses of duration TWIDth</td>
</tr>
<tr>
<td>TRANsient:MODE TOGGLE</td>
<td>Select pulses that switch between LEVel and TLEVel on alternate triggers</td>
</tr>
<tr>
<td>TRANsient:DCYCLE</td>
<td>Set pulse duty cycle of CONTinuous mode</td>
</tr>
<tr>
<td>TRANsient:FREquency</td>
<td>Set pulse frequency of CONTinuous mode</td>
</tr>
<tr>
<td>TRANsient:TWIDth</td>
<td>Set pulse duration of PULSe mode</td>
</tr>
</tbody>
</table>

**Related Commands**

| LEVel | <GET> | *TRG | SLEW | TLEVel |

**Related Subsystem**

TRIGger Subsystem
Syntax Diagram

Transient Subsystem Syntax Diagram
**TRAN:DCYCle**  
*Channel-Specific Transient Command/Query*

**Description**  
DCYCle specifies the duty cycle of TLEV, as a percent of the total cycle, when the electronic load is in the CONTinuous mode. If programmed when the electronic load is in the PULSe or TOGGle mode, DCYCle is stored until the next time the electronic load is in CONTinuous mode. If a value is specified outside the parameter limits, an error is generated (see Table 4-2 at the end of this chapter).

**Command Syntax**  
TRANsient:DCYCle <NRf+>

**Parameters**  
See Table 4-1 at the end of this chapter

**Examples**  
TRAN:DCYC 10 *Set Continuous output to TLEVel for 10% of the cycle*

TRAN:MODE CONT;FREQ 500;DCYC 10;STAT 1 *Set Transient Generator to continuous mode, 500 Hz at 10% duty cycle and enable the generator*

**Query Syntax**  
TRAN:DCYC?  TRAN:DCYC? MAX  TRAN:DCYC? MIN

**Returned Parameters**  
<NR3>  
TRAN:DCYC? returns present value of Continuous Mode duty cycle in percent  
TRAN:DCYC? MAX and TRAN:DCYC? MIN return the maximum and minimum programmable duty cycle values

**Related Commands**  
TRAN:FREQ

**TRAN:FREQuency**  
*Channel-Specific Transient Command/Query*

**Description**  
FREQuency specifies the pulse frequency of the CONTinuous mode. If specified in a PULSe or TOGGle mode, FREQuency will be stored for the next time the electronic load is in the CONTinuous mode. If a value is specified outside the parameter limits, an error is generated (see Table 4-2 at the end of this chapter).

**Command Syntax**  
TRANsient:FREQuency <NRf+>

---

4-52 Language Dictionary  
Transient Subsystem
**Requests**

**Parameters**
See Table 4-1

**Examples**

**TRAN: FREQ 100**  Set Transient Generator frequency to 100 Hz

**TRAN: FREQ 10 KHZ**  Set Transient Generator frequency to 10 kHz

**TRAN: MODE CONT; FREQ 560; DCYC 50; STAT 1**  Set Transient Generator to continuous mode, frequency to 560 Hz, duty cycle to 50% and enable the generator

**TRAN: STAT OFF; FREQ 2E4; STAT ON**  Turn off Transient Generator, change frequency to 20 kHz, and turn generator on

**Query Syntax**


**Returned Parameters**

<NR3>  TRAN:FREQ? returns the value representing continuous mode FREQency in hz

TRAN:FREQ? MAX and TRAN:FREQ? MIN return the maximum and minimum programmable frequency values

**Related Commands**

TRAN: DCYC

---

**TRAN: MODE**

*Channel-Specific Transient Command/Query*

**Description**

Selects the type of operation provided by the transient generator for each channel.

- **CONTinuous mode** provides periodic pulses of programmable frequency and duty cycle, which are not related to TWIDth in any way. Each channel has its own oscillator that runs asynchronously with respect to oscillators of other channels.
- **PULSe** mode provides a triggered one-shot pulse with a programmable pulse duration. When a trigger occurs, the input goes to **TLEVel** for the duration of **TWIDth** (which is not related to **FREQency** or **DCYCLE** in any way) and then returns to **LEVel**. This mode is not retriggerable; triggers that occur while the input is at **TLEVel** are ignored. In multiple electronic loads, the trigger is applied to all channels simultaneously and **TRIG:SOUR TImer** can be used to produce synchronized load waveforms (see **TRIGger** Subsystem).

- **TOGGle** mode causes the input to switch between **LEVel** and **TLEVel** on alternate triggers. Odd triggers set **TLEV**; even triggers set **LEV**. **FREQ**, **DCYC**, and **TWID** have no effect on this mode. Triggers are applied to all channels simultaneously in the multiple electronic load.

---

**Note**

The Operation Status Condition register WTG bit (see “Chapter 5 - Status Reporting”) is not affected by setting either the **PULSe** or **TOGGle** modes.

---

**Command Syntax**

```
TRANsient:MODE <aard>
```

**Parameters**

<table>
<thead>
<tr>
<th>Value Range</th>
<th>*RST Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONT, PULS, TOGG</td>
<td>CONT</td>
</tr>
</tbody>
</table>

**Examples**

```
TRAN:MODE PULS  Set Transient Generator to pulse mode

TRAN:STAT 0;MODE CONT;STAT 1  Turn off Transient Generator, change mode to continuous, and turn generator on
```

**Query Syntax**

```
TRAN:MODE?
```

**Returned Parameters**

Character string **CONT**, **PULS**, or **TOGG**

**Related Commands**

See **TRIGger** Subsystem
**TRAN[:STATE]**

*Channel-Specific Transient Command/Query*

**Description**

STATe is an implied keyword that enables or disables the Transient Subsystem. When the subsystem is disabled, TLEVel inputs cannot occur. However, they may be programmed while the subsystem is disabled and will take effect when the subsystem is enabled. The enable or disable state may be programmed with either characters or equivalent numerics.

**Command Syntax**

\[ \text{TRANsient[:STATe]} \ <\text{NRf}+> \]

**Parameters**

<table>
<thead>
<tr>
<th>Value Range</th>
<th>*RST Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON or 1;OFF or 0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Examples**

\[ \text{TRAN ON} \quad \text{Enable Transient Generator function} \]

\[ \text{TRAN:STAT 1;MODE TOGG} \quad \text{Enable Transient Generator function and set to toggle mode} \]

\[ \text{TRAN:STAT 0;MODE PULS;TWID 10E-3;STAT ON} \quad \text{Disable Transient Generator function, set generator to Pulse Mode with a 10-millisecond pulse, and re-enable the generator function} \]

**Query Syntax**

\[ \text{TRAN:STAT?} \]

**Returned Parameters**

\[ <\text{NR1}> \quad \text{Value; 0 for OFF, 1 for ON} \]

**Related Commands**

None

---

**TRAN:TWIDth**

*Channel-Specific Transient Command/Query*

**Description**

TWIDth specifies the duration of TLEVel during the PULSe mode. If specified when the electronic load is in the CONTinuous or TOGGLE mode, TWIDth is stored until the next use of PULSe mode. If a value is entered outside the specified parameters, an error is generated (see Table 4-2 at the end of this chapter).

**Transient Subsystem**
**TRAN:TWIDth**

**Command Syntax**  
TRANsient:TWIDth <NRf>

**Parameters**  
See Table 4-1 at the end of this chapter

**Examples**  
TRAN:TWID 5E-5  Set Transient Generator pulse duration to 50 microseconds

TRAN:STAT 1;MODE PULS;TWID .500  Enable Transient Generator function, set mode to pulse, and program pulse width to 500 milliseconds

**Query Syntax**  

**Returned Parameters**  
<NR3>  
TRAN:TWID? returns value representing duration of TLEV in seconds  
TRAN:TWID? MAX and TRAN:TWID? MIN return the maximum and minimum programmable duration values

**Related Commands**  
None

---

**TRIGger Subsystem**  
*Channel-Independent Trigger Programming Function*

**Description**  
In a multiple electronic load triggering can be initiated from the controller, the a-c line, the external Trigger jack, or the mainframe timer. Single electronic loads may be triggered from their external Trigger jack, or from the controller. Any trigger signal generated by a single electronic load or multiple electronic load also exists at the Trigger output jack and may be used as a trigger source for any other electronic load.

**Note**  
For a detailed explanation of the effects of triggers, see Operation Overview in the electronic load Operating Manual.
Keywords

Command | Function
--- | ---
TRIGger[:IMMediate] | Trigger-true input from the controller
TRIGger:SOURce EXTernal | Selects trigger source at external Trigger jack
TRIGger:SOURce BUS | Selects HP-IB *TRG or <GET> as trigger source
TRIGger:SOURce HOLD | Disables all trigger inputs except the TRIG:IMM command
1TRIGger:SOURce LINE | Selects the internal a-c line frequency detector as the trigger source
1TRIGger:SOURce TIMer | Selects internal trigger oscillator as the trigger source

1 These commands apply only to multiple electronic loads

Related Commands | *TRG <GET>

Related Subsystems | TRANsient Subsystem

Syntax Diagram
**TRIG[:IMMediate] Implied Channel-Independent Trigger Command**

**Description**
This implied keyword generates a trigger signal to the electronic load, regardless of which trigger SOURce is currently in effect. This is the only command that overrides TRIG:SOUR HOLD. When TRIG:IMM is executed, all pending triggered levels are transferred to the electronic load’s input. The input also is affected if the Transient generator is enabled in either the PULSe or TOGGLE mode. In a multiple electronic load, a trigger is applied simultaneously to all channels.

**Note**
When TRIG:IMM is executed in a single electronic load there is brief period (≤100 μs) during which the electronic load can also respond to either an external trigger or a <GET> command. This situation does not occur with multiple electronic loads.

TRIG:IMM affects the WTG bit of the Operation Status Event register (see “Chapter 5 - Status Reporting”).

**Command Syntax**
TRIGger

**Parameters**
None

**Examples**

```
TRIG   Immediate trigger commands
TRIG:IMM
```

**Related Commands**
None

---

**TRIG:SOURce Channel-Independent Trigger Command/Query**

**Description**
TRIGger:SOURce selects the electronic load trigger source as follows:

- **BUS**
  
  Accepts a HP-IB <GET> signal or *TRG command as the trigger source. This mode guarantees that all previous commands will be completed before the trigger is executed.
EXTernal

Selects the electronic load's external Trigger jack as the trigger source. The EXTernal trigger is processed asynchronously with respect to other commands.

The user must ensure that the trigger occurs at a valid time with respect to commands that are already being processed or are pending.

Note

When TRIG:SOUR BUS is specified for a single electronic load there is brief period (100 μs) during which the electronic load can also respond to an external trigger. This situation does not occur with multiple electronic loads.

HOLD

Only the TRIGger:IMMediate command causes a trigger in this mode. All others, including *TRIG, are ignored.

1LINE

This generates triggers in synchronization with the a-c line frequency

1TIMER

Selects the multiple electronic load's internal trigger oscillator as the trigger source. The oscillator begins running as soon as this command is executed. The oscillator period is selected with the TRIG:TIM command. TRIG:SOUR TIM can be used with TRAN:MODE PULS to generate synchronous, continuous transient waveforms on multiple channels.

1These modes exist only in the multiple electronic load. Programming them in a single electronic load will generate an error.

Command Syntax

TRIGger:SOURce

Parameters

<table>
<thead>
<tr>
<th>1Value Range</th>
<th>Units</th>
<th>*RST Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS, EXTernal, HOLD,</td>
<td>None</td>
<td>HOLD</td>
</tr>
<tr>
<td>LINE, TIMer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1The long or short form may be used

Examples

TRIG

Send immediate bus trigger

TRIG: IMM

TRIG:SOUR HOLD; IMM

Disable all sources and send immediate bus trigger

Trigger Subsystem Language Dictionary 4-59
TRIG:SOURce

Query Syntax  TRIG:SOUR?

Returned Parameters  BUS  EXT  HOLD  LINE  TIM

Related Commands  &410 <GET>  *TRG

---

TRIG:TIMer

Channel-Independent Trigger Command/Query

Description
This command determines the period of the trigger pulses generated by the multiple electronic load’s internal trigger oscillator. The trigger oscillator begins running as soon as this command is executed. If the command is executed when the TRIG:SOUR is not TIMer, the programmed period will take effect when the next TRIG:SOUR:TIM statement is executed. If the TIM parameter is out of the specified limits, an error is generated (see Table 4-2 at the end of this chapter).

Note
Do not confuse this command with TRIG:SOUR TIM. In that command, TIM is a parameter for SOURce. This TIM is on the same tree level as SOURce and has its own parameter.

Command Syntax  TRIGger:TIMer <NRf+>

Parameters
See Table 4-1 at the end of this chapter

Examples
TRIG:SOUR TIM;TIM .001  Select timer mode with frequency = 1 kHz

TRIG:TIM 5E-5  Change trigger frequency to 20 kHz

Query Syntax  TRIG:TIM?

Returned Parameters  <NR3>  Value representing period in seconds

Related Commands  None
VOLTage Subsystem  

*Channel-Specific Voltage Programming Function*

**Description**  
This subsystem programs the voltage-mode function of a single electronic load or a single channel of a multiple electronic load.

**Keywords**

<table>
<thead>
<tr>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLTage[:LEVEL][:IMMediate]</td>
<td>Specify main level for CV Mode</td>
</tr>
<tr>
<td>VOLTage[:LEVEL]:TRIGgered</td>
<td>Preset voltage level pending trigger occurrence</td>
</tr>
<tr>
<td>VOLTage:SLEW</td>
<td>Specify voltage level rate of change</td>
</tr>
<tr>
<td>VOLTage:TLEVel</td>
<td>Specify input voltage level used by TRANSient subsystem</td>
</tr>
</tbody>
</table>

**Syntax Diagram**

Voltage Subsystem Syntax Diagram

**Related Subsystems**  
CURRent  RESistance
**VOLT[:LEVel]**

*Channel-Specific Voltage Command/Query*

**Description**
This implied keyword specifies the value of the programmed voltage level and whether that level is to be applied immediately or on occurrence of a trigger. If the specified channel is in the Voltage Mode, an IMMEDIATE voltage level is transferred to the input as soon as the command is executed. A TRIGGERed level is stored and transferred to the input when a trigger occurs. At that time, the change to the input level occurs at the slew rate presently in effect. Following the trigger event, subsequent triggers will not affect the input level unless the electronic load has been sent another TRIGGERed level command.

If the electronic load is not in the CV (Constant-Voltage) Mode when an IMMEDIATE or TRIGGERed level command is sent, the programmed levels are saved for the next time the electronic load is placed in the CV Mode. Triggered levels are processed by the Voltage Subsystem even when the electronic load is not in the CV Mode. Thus, the TRIGGERed level becomes a stored IMMEDIATE level that takes effect when the electronic load is again in the CV Mode.

**Note**
Setting an IMM voltage level to the same value as the most recent TRIG voltage level will not deactivate a pending TRIG level. You must use ABORT to deactivate it.

The present voltage level changes to the pending level on any of the following conditions:
- On a TRIG:IMM command (always)
- On receipt of an external trigger signal (if TRIG:SOUR is set to EXT)
- On the next line voltage cycle (if TRIG:SOUR is set to LINE)
- On receipt of *TRG (unless TRIG:SOUR is set to HOLD)
- On receipt of an HP-IB <GET> (if TRIG:SOUR is set to BUS)
- On the next trigger timer pulse (if multiple electronic load is set to TRIG:SOUR TIM)

**Command Syntax**

\[
\text{VOLTage[:LEVel][:IMMediate]} <\text{NRf}> \\
\text{VOLTage[:LEVel][:TRIGgered]} <\text{NRf}>
\]

**Parameters**
See Table 4-1 at the end of this chapter

**Status and Errors**
TRIGGERed level commands affect the WTG bit in the Operation Condition register and the OPC bit in the Standard Event Status Event register (refer to “Chapter 5 - Status Reporting”)
Examples

VOLT 25
VOLTAGE:LEVEL 25

VOLT:TRIG 25MV
VOLTAGE:LEVEL:TRIGGERED 25E-3

VOLT 12; VOLT:TRIG MIN
Set input to 12 Volts now and minimum voltage when trigger occurs

Query Syntax

VOLT? VOLT? MAX VOLT? MIN

Returned Parameters

<NR3> VOLT? and VOLT:TRIG? return the presently programmed voltage levels. After a trigger or ABORt, VOLT:TRIG? returns the same value as VOLT?.

VOLT? MAX, VOLT? MIN, VOLT:TRIG? MAX, and VOLT:TRIG? MIN return the maximum and minimum programmable LEVel and TLEVel values for the present range.

Related Commands

ABOR. See also TRANSient Subsystem

VOLT:SLEW

Channel-Specific Voltage Command/Query

Description

This command sets the voltage programming slew rate and the resistance programming slew rate for lowest CR range. The programmed slew rate remains in effect for all programmed voltage changes except INPut ON or OFF. The hardware implements discrete slew rates (refer to the Electronic Load Operating Manual) and automatically selects the one that is closest to the programmed value. To determine the actual value, use the query VOLT:SLEW?.

Command Syntax

VOLTage:SLEW <NRf+>

Parameters

See Table 4-1 at the end of this chapter
VOLT:SLEW

Examples

VOLT:SLEW 5E6 \hspace{1cm} \text{Set slew rate for 5,000,000 Volts/Sec}
VOLTAGE:SLEW MAX

VOLT:TRIG 60MV;:VOLT:SLEW 1E4 \hspace{1cm} \text{Triggered input of 60 mV to be}
\hspace{1cm} \text{slewed at 10000 volts/second}

Note

Programming the slew rate value greater than MAX sets the slew rate to maximum without generating an error message.

Query Syntax

VOLT:SLEW?
VOLT:SLEW? MAX
VOLT:SLEW? MIN

Returned Parameters

<NR3> \hspace{1cm} \text{VOLT:SLEW? returns the internally selected slew rate (in V/s) that was chosen as closest to the programmed value within the permissible range.}
\text{VOLT:SLEW? MAX and VOLT:SLEW? MIN return}
\text{the maximum and minimum programmable slew rates for the present range.}

Related Commands

None

---

VOLT:TLEVel

Channel-Specific Voltage Command/Query

Description

This command specifies the value of the programmed voltage level for the TRANsient input when the electronic load is in the CV (constant-voltage) Mode. When the Transient Subsystem is on, the electronic load input voltage will switch (under control of the Transient Subsystem) between the main level and TLEVel at a rate determined by the present value of SLEW. In order for input voltage level switching to occur, TLEVel must be greater than the main level. If TLEVel is set to a value below the main level, no error is generated but switching will not occur until the main level is subsequently programmed below the value of TLEVel. If TLEVel is programmed outside the specified range, an error is generated (see Table 4-2 at the end of this chapter).

Command Syntax

VOLTage:TLEVel <NRf>

Parameters

See Table 4-1 at the end of this chapter
Examples

VOLT:TLEV MAX  Set transient level to maximum voltage

VOLT 40;TLEV 60  Set main voltage level to 40 V and transient level to 60 V

Query Syntax

VOLT:TLEV?
VOLT:TLEV? MAX
VOLT:TLEV? MIN

Returned Parameters

<NR3>  VOLT:TLEV? returns the transient voltage level for present range. If the electronic load is not in CV Mode, the level will still be set, even if it is less than the presently programmed input level. VOLT:TLEV? MAX and VOLT:TLEV? MIN return the maximum and minimum programmable values for the present range.

Related Commands

TRANsient Subsystem
COMMAND PARAMETERS

Table 4-1 lists the programming parameters for all the electronic loads. The four-digit models (e.g., HP 6060A) are single electronic loads, while the five-digit models (e.g., HP 60502A) are modules within the mainframe of the multiple electronic load.

ERROR MESSAGES

Table 4-2 lists the error numbers and associated error messages that apply to the electronic load. The error number is the value that is placed in the electronic load’s error queue. This can be read back using the SYST:ERR? query, which returns the error number into a variable, and both the error number and error message into a string. Information inside the brackets is not part of the standard error message, but is included for clarification. Command errors (-100 through -199) set bit 5 in the Standard Event Status register. Execution errors (-200 through -299) set bit 4 in the Standard Event Status register. Device-dependent errors (-300 through -399) set bit 3 in the Standard Event Status register. Query errors (-400 through -499) set bit 2 in the Standard Event Status register. See ‘Chapter 5—Status Reporting’ for a complete description of the Standard Event Status register.

Hardware Errors During Turn-On Selftest

If an HP-IB failure occurs during selftest, the electronic load may or may not be able to communicate with the controller. If it can, error -330 (Self Test Error) is placed in the error queue. If an electronic load input error occurs during selftest, error -330 and error -240 (Hardware Error) are placed in the queue. If input errors occur, the electronic load will generate one or more -240 errors for each command it cannot process. Use the SYST:ERR? query to read the error queue after turn-on to ensure that no -330 or -240 errors are present. Any electronic load value returned by a query (such as CURR?) should be assumed to be invalid.

Hardware Errors During Operation

It an error does not occur during selftest but after the electronic load has been operating correctly for a time, error -240 is placed in the error queue. Most subsequent commands will not be executed and will also cause one or more -240 errors to be placed in the queue after each attempt. If your application requires the controller to be signalled if the electronic load fails, program the status registers to allow Execution errors or Device-dependent errors to generate an SRQ to the controller. See Chapter 5—Status Reporting for more details.
Table 4-1. Summary of Command Parameters

<table>
<thead>
<tr>
<th>Command</th>
<th>Value Range</th>
<th>Units</th>
<th>*RST Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAN</td>
<td>1 to maximum number of channels; MIN; MAX</td>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>JRR[:LEV]</td>
<td>0 to 6; MIN; MAX</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>JRR[:TRIG]</td>
<td>0 to 30; MIN; MAX</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>JRR[:PROT]</td>
<td>0 to 61.2; MIN; MAX &lt;sup&gt;1&lt;/sup&gt;</td>
<td>A</td>
<td>61.2</td>
</tr>
<tr>
<td>LEVI</td>
<td>0 to 6</td>
<td>s</td>
<td>15</td>
</tr>
<tr>
<td>TAT</td>
<td>OFF or ON</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>JRR[:RANG]</td>
<td>6; 60; MIN; MAX</td>
<td>A</td>
<td>60</td>
</tr>
<tr>
<td>JRR[:SLEW]</td>
<td>0.0001 to 5; MIN; MAX</td>
<td>A/µs</td>
<td>5</td>
</tr>
<tr>
<td>JRR[:TLEV]</td>
<td>0 to 6; MIN; MAX</td>
<td>A</td>
<td>0</td>
</tr>
<tr>
<td>P:SHOR</td>
<td>OFF or ON</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>P:[STAT]</td>
<td>OFF or ON</td>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>ODE</td>
<td>CURR; RES; VOLT</td>
<td>None</td>
<td>CURR</td>
</tr>
<tr>
<td>JRTD</td>
<td>OFF or ON</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>S[:LEV]</td>
<td>0 to 1; MIN; MAX</td>
<td>Ω</td>
<td>1000</td>
</tr>
<tr>
<td>S[:TRIG]</td>
<td>1 to 1000; MIN; MAX</td>
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</tr>
<tr>
<td>S[:RANGE]</td>
<td>1; 1000; 10000; MIN; MAX</td>
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</tr>
<tr>
<td>S[:LEV]</td>
<td>0 to 1; MIN; MAX</td>
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<td>1000</td>
</tr>
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<td>2000</td>
</tr>
<tr>
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<td>S[:NCYC]</td>
<td>3 to 97; MIN; MAX</td>
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<td>S[:FREQ]</td>
<td>0.25 to 10,000; MIN; MAX</td>
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<td>S[:MODE]</td>
<td>CONT; PULS; TOGG</td>
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<td>CONT</td>
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<td>S[:STAT]</td>
<td>OFF or ON</td>
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<td>1</td>
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<td>S[:TWID]</td>
<td>.00005 to 6; MIN; MAX</td>
<td>s</td>
<td>.0005</td>
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<tr>
<td>F:SOURE</td>
<td>BUS; EXT; HOLD; LINE; TIM&lt;sup&gt;2&lt;/sup&gt;</td>
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<td>F:TIM&lt;sup&gt;2&lt;/sup&gt;</td>
<td>.000008 to 4; MIN; MAX</td>
<td>s</td>
<td>.001</td>
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<td>TLT[:LEV]</td>
<td>0 to 60; MIN; MAX</td>
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<td>60</td>
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<tr>
<td>TLT[:TRIG]</td>
<td>0 to 5; MIN; MAX</td>
<td>V&lt;sub&gt;µs&lt;/sub&gt;</td>
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<tr>
<td>TLT[:RANGE]</td>
<td>0 to 60; MIN; MAX</td>
<td>V</td>
<td>60</td>
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</table>

<sup>1</sup> Protection level is 102% of normal maximum.

Available only with Multiple Electronic Loads.
<table>
<thead>
<tr>
<th>Error Number</th>
<th>Error String [Description/Explanation/Examples]</th>
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<tr>
<td>-100</td>
<td>Command error [generic]</td>
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<tr>
<td>-101</td>
<td>Invalid character</td>
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<tr>
<td>-102</td>
<td>Syntax error [unrecognized command or data type]</td>
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<tr>
<td>-103</td>
<td>Invalid separator</td>
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<tr>
<td>-104</td>
<td>Data type error [e.g., ‘numeric or string expected, got block data’]</td>
</tr>
<tr>
<td>-105</td>
<td>GET not allowed</td>
</tr>
<tr>
<td>-108</td>
<td>Parameter not allowed [too many parameters]</td>
</tr>
<tr>
<td>-109</td>
<td>Missing parameter [too few parameters]</td>
</tr>
<tr>
<td>-112</td>
<td>Program mnemonic too long [maximum 12 characters]</td>
</tr>
<tr>
<td>-113</td>
<td>undefined header [operation not allowed]</td>
</tr>
<tr>
<td>-121</td>
<td>Invalid character in number [includes ‘9’ in octal data ‘#q’, etc.]</td>
</tr>
<tr>
<td>-123</td>
<td>Exponent too large [numeric overflow; exponent magnitude &gt;32 k]</td>
</tr>
<tr>
<td>-124</td>
<td>Too many digits [number too long; more than 255 digits received]</td>
</tr>
<tr>
<td>-128</td>
<td>Numeric data not allowed</td>
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<tr>
<td>-131</td>
<td>Invalid suffix [unrecognized units, or units not appropriate]</td>
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<tr>
<td>-138</td>
<td>Suffix not allowed</td>
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<tr>
<td>-141</td>
<td>Invalid character data [bad character, or unrecognized]</td>
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<tr>
<td>-144</td>
<td>Character data too long [maximum length is 12 characters]</td>
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<tr>
<td>-148</td>
<td>Character data not allowed</td>
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<tr>
<td>-150</td>
<td>String data error</td>
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<td>-151</td>
<td>Invalid string data [e.g., END received before close quote]</td>
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<td>-158</td>
<td>String data not allowed</td>
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<td>-160</td>
<td>Block data error</td>
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<td>-161</td>
<td>Invalid block data [e.g., END received before length satisfied]</td>
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<td>-168</td>
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<tr>
<td>-170</td>
<td>Expression error</td>
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<td>-171</td>
<td>Invalid expression [e.g., illegal character in expression]</td>
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<tr>
<td>-178</td>
<td>Expression data not allowed</td>
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<td>-180</td>
<td>Macro error</td>
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<tr>
<td>-181</td>
<td>Invalid outside macro definition [e.g., ‘$1’ outside macro definition.]</td>
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<tr>
<td>-183</td>
<td>Invalid inside macro definition</td>
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<td>-200</td>
<td>Execution error [generic]</td>
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<tr>
<td>-220</td>
<td>Parameter error</td>
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<td>-221</td>
<td>Settings conflict [uncoupled parameters]</td>
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<td>-222</td>
<td>Data out of range [e.g., frequency too high for this instrument]</td>
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<tr>
<td>-223</td>
<td>Too much data [out of memory; block, string, or expression too long]</td>
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<td>-240</td>
<td>Hardware error</td>
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<tr>
<td>-310</td>
<td>System error</td>
</tr>
<tr>
<td>-313</td>
<td>Calibration memory lost [out of cal due to memory failure]</td>
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<tr>
<td>-330</td>
<td>Self-test failed [more specific data after ‘,,,’]</td>
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<td>-350</td>
<td>Too many errors [error queue overflow]</td>
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<tr>
<td>-400</td>
<td>Query error</td>
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<tr>
<td>-410</td>
<td>Query INTERRUPTED [query followed by DAB or GET before response complete]</td>
</tr>
<tr>
<td>-420</td>
<td>Query UTERMINATED [addressed to talk, incomplete program message received]</td>
</tr>
<tr>
<td>-430</td>
<td>Query DEADLOCKED [input buffer and output buffer full; can’t continue]</td>
</tr>
<tr>
<td>-440</td>
<td>Query UTERMINATED after indefinite response [indefinite response request not the last request in message unit]</td>
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</table>
### COMMAND SUMMARY

This summary lists all electronic load common commands in alphabetical order, followed by all root-level commands in alphabetical order. See Table 4-1 for numerical parameters for each model of electronic load. See Chapter 2 if you are not familiar with the representations used for data types.

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<th>Command</th>
<th>Parameters</th>
<th>Type</th>
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<td>(none)</td>
<td>CI</td>
</tr>
<tr>
<td>*<strong>ESE</strong></td>
<td>(space)&lt;NRF&gt;</td>
<td>CI</td>
</tr>
<tr>
<td>*<strong>ESE?</strong></td>
<td>(none)</td>
<td>CI</td>
</tr>
<tr>
<td>*<strong>ESR?</strong></td>
<td>(space)&lt;NRF&gt;</td>
<td>CI</td>
</tr>
<tr>
<td>*<strong>IDN?</strong></td>
<td>(none)</td>
<td>CI</td>
</tr>
<tr>
<td>*<strong>OPC</strong></td>
<td>(none)</td>
<td>CI</td>
</tr>
<tr>
<td>*<strong>OPC?</strong></td>
<td>(none)</td>
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</tr>
<tr>
<td>*<strong>PSC</strong></td>
<td>(space)&lt;NRF&gt;</td>
<td>CI</td>
</tr>
<tr>
<td>*<strong>PSC?</strong></td>
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<td>CI</td>
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<tr>
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</tr>
<tr>
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<tr>
<td>*<strong>STB</strong></td>
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</tr>
<tr>
<td>*<strong>TRG</strong></td>
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<tr>
<td>*<strong>WA1</strong></td>
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<td>(space)&lt;NRF&gt;</td>
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Chapter 5
STATUS REPORTING

This chapter discusses the status data structure of the electronic loads as shown in Figure 5-1. The Standard Event Status register group, the Output Queue, and the Status Byte and Service Request Enable registers perform standard HP-IB functions and are defined in IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. Other status register groups implement the status reporting requirements of the electronic load. The Channel Status and Channel Summary groups are primarily used by multiple electronic loads. This is because each channel in a multiple electronic load has its own Status register to provide status information for that channel.

GENERAL REGISTER MODEL

The Condition register represents the present or “live” state of various electronic load signals. Reading the Condition register does not change the state of its bits. Only changes in electronic load conditions change the contents of this register. Not all status register groups have a Condition register. In some cases, such as the Standard Event Status registers, conditions are directly input into an Event register. In other cases, such as the Channel Summary registers, summary information from other registers is directly input into an Event register.

The Event register captures changes in conditions. Each bit in an Event register either corresponds to a condition bit in a Condition register, or to a specific condition in the electronic load. An event becomes true when the associated condition makes one of the following electronic load-defined transitions:

- Positive Transition (0-to-1)
- Negative Transition (1-to-0)
- Positive or Negative Transition (1-to-0 or 0-to-1)

The PTR/NTR filters determine what type of condition transitions set the bits in the Event register. Only the Operation Status registers allow transitions to be programmed. All other register groups use an implied 0-to-1 condition transition to set bits in the Event register. Reading an Event register clears the register (all bits set to zero). When the electronic load is turned on, Event registers are set to zero, and the PTR/NTR filters are set to their firmware-assigned states.

The Enable register selects which bits in the corresponding Event register are logically-ORed into the Summary bit. At turn-on, Enable registers are set to zero. However, the Standard Event Enable register and the Service Request Enable register are not set to zero if the *PSC command is programmed. These registers are set to the most recent values saved in non-volatile memory before the Electronic Load was last turned off.

CHANNEL STATUS

The Channel Status registers inform you that one or more channel status conditions, which indicate the presence of certain errors or faults, have occurred on a specific channel. Table 5-1 describes the channel status conditions that apply to the electronic load.

The Channel Status Condition register represents the present status of a channel; the bits are set when the indicated condition is true.

The Channel Status Event register records all of the channel conditions that have occurred since the last time this register was read. A condition transition from 0-to-1 on a bit in the Channel Status Condition register will set the corresponding bit in the Channel Status Event register. Reading the Channel Status Event register resets it to zero.

The Channel Status Enable register can be programmed to specify which channel status event bits are logically-ORed to become the corresponding channel bit in the Channel Summary Event register.

CHANNEL SUMMARY

The Channel Summary registers can summarize the channel status conditions of up to six channels. The channel/bit assignments in the Channel Summary registers are as follows:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Bit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel 1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Channel 2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Channel 3</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Channel 4</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Channel 5</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>Channel 6</td>
<td>6</td>
<td>64</td>
</tr>
</tbody>
</table>

When an enabled bit in the Channel Status Event register is set, it causes the corresponding channel bit in the Channel Summary Event register to be set. Reading the Channel Summary Event register resets it to zero.

The Channel Summary Enable register can be programmed to specify which channel summary event bits from the existing channels are logically-ORed to become Bit 2 (CSUM bit) in the Status Byte register. For single electronic loads, only Channel 1 exists.
Figure 5-1. Electronic Load Status Registers

5-2 Status Reporting
<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Bit&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>VF</td>
<td>0</td>
<td>1</td>
<td><strong>Voltage Fault.</strong> Either an overvoltage or a reverse voltage condition has occurred on a channel. When either of these conditions occur, Bit 0 is set and remains set until INP:PROT:CLE is programmed. Note that this bit reflects the active state of the Flt pin on the back of the unit.</td>
</tr>
<tr>
<td>OC</td>
<td>1</td>
<td>2</td>
<td><strong>Overcurrent.</strong> An overcurrent condition has occurred on a channel. This condition sets Bit 1 if the current exceeds 102% of the rated current, or if the current exceeds the user-programmed current protection level. If the overcurrent condition is removed, Bit 1 is cleared.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>However, if the user-programmed overcurrent condition persists beyond the user-programmed current protection delay time, Bit 13 is also set and the channel is turned off. In this case, Bits 1 and 13 remain set until the overcurrent condition is removed and INP:PROT:CLE is programmed.</strong></td>
</tr>
<tr>
<td>OP</td>
<td>3</td>
<td>8</td>
<td><strong>Overpower.</strong> An overpower condition has occurred on a channel. This condition sets Bit 3 when the internal overpower protection circuit is limiting the input power. This occurs if the unit exceeds the rated power of a channel when extended power is unavailable (see EPU). At low operating temperatures, the overpower limits are raised so that the unit can operate beyond the rated power (see EPU). If the overpower condition is removed, Bit 3 is cleared.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>However, if an overpower condition occurs and persists for more than 3 seconds, Bit 13 (PS bit) is also set and the channel is turned off. In this case, Bits 3 and 13 remain set until the overpower condition is removed and INP:PROT:CLE is programmed.</strong></td>
</tr>
<tr>
<td>OT</td>
<td>4</td>
<td>16</td>
<td><strong>Overtemperature.</strong> An overtemperature condition has occurred on a channel. When this occurs, both Bit 4 and Bit 13 (PS bit) are set and the channel is turned off. Bits 4 and 13 remain set until the channel (or unit) has cooled down well below the overtemperature trip point and INP:PROT:CLE is programmed.</td>
</tr>
<tr>
<td>EPU</td>
<td>9</td>
<td>512</td>
<td><strong>Extended Power Unavailable.</strong> At high operating temperatures, the unit cannot be operated beyond the rated power of a channel. This condition sets Bit 9. At low operating temperatures, Bit 9 is cleared and extended power is available. This allows up to 33% greater power dissipation than the rated power of a channel for a period of time. The overtemperature limits are adjusted accordingly (see OP).</td>
</tr>
<tr>
<td>UNR</td>
<td>10</td>
<td>1024</td>
<td><strong>Unregulated input.</strong> A channel is unregulated. This condition sets Bit 10. When the load becomes regulated, Bit 10 is cleared. Unregulated input does not occur in CV mode or in the 1 ohm range of CR mode.</td>
</tr>
<tr>
<td>RV</td>
<td>11</td>
<td>2048</td>
<td><strong>Reverse Voltage on input.</strong> A channel has a reverse voltage applied to it. When this occurs, both Bit 11 and Bit 0 (VF bit) are set. When the reverse voltage is removed, Bit 11 is cleared. However, Bit 0 remains set until INP:PROT:CLE is programmed.</td>
</tr>
<tr>
<td>OV</td>
<td>12</td>
<td>4096</td>
<td><strong>Overvoltage.</strong> An overvoltage condition has occurred on a channel. When this occurs, both Bit 12 and Bit 0 (VF bit) are set and the FETs are turned on as hard as possible to lower the voltage. Bits 12 and 0 remain set until the overvoltage condition is removed and INP:PROT:CLE is programmed.</td>
</tr>
<tr>
<td>PS</td>
<td>13</td>
<td>8192</td>
<td><strong>Protection Shutdown.</strong> A channel has turned off because of an overcurrent, overvoltage, or overtemperature condition. When any of these three conditions occur, Bit 13 is set and remains set until INP:PROT:CLE is programmed.</td>
</tr>
</tbody>
</table>

<sup>1</sup> Bits 2, 5-8, 14, and 15 are not used by the electronic load.
QUESTIONABLE STATUS

The Questionable Status registers inform you that one or more questionable status conditions, which indicate the presence of certain errors or faults, have occurred on at least one channel. This lets you check for specific errors or faults that have occurred without having to poll each channel individually. Table 5-2 lists the questionable status conditions that apply to the electronic load. These conditions are the same as the channel status conditions. Refer to Table 5-1 for a complete description.

The Questionable Status Condition register represents the present status of all channel conditions; the bits are set when the indicated condition is true.

The Questionable Status Event register represents all of the conditions that have occurred since the last time this register was read. A condition transition from 0-to-1 on a bit in the Questionable Status Condition register will set the corresponding bit in the Questionable Status Event register. Reading the Questionable Status Event register resets it to zero.

The Questionable Status Enable register can be programmed to specify which questionable status event bits are logically-ORed to become Bit 3 (QUES bit) in the Status Byte register.

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Bit1</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>VE/VF</td>
<td>0</td>
<td>1</td>
<td>Voltage Error (Voltage Fault)</td>
</tr>
<tr>
<td>CE/OC</td>
<td>1</td>
<td>2</td>
<td>Current Error (Overcurrent)</td>
</tr>
<tr>
<td>PE/OP</td>
<td>3</td>
<td>8</td>
<td>Power Error (Overpower)</td>
</tr>
<tr>
<td>TE/OT</td>
<td>4</td>
<td>16</td>
<td>Temperature Error (Overtemperature)</td>
</tr>
<tr>
<td>EPU</td>
<td>9</td>
<td>512</td>
<td>Extended Power Unavailable</td>
</tr>
<tr>
<td>UNR</td>
<td>10</td>
<td>1024</td>
<td>Unregulated input</td>
</tr>
<tr>
<td>RV</td>
<td>11</td>
<td>2048</td>
<td>Reverse Voltage on input</td>
</tr>
<tr>
<td>OV</td>
<td>12</td>
<td>4096</td>
<td>Overvoltage</td>
</tr>
<tr>
<td>PS</td>
<td>13</td>
<td>8192</td>
<td>Protection Shutdown</td>
</tr>
</tbody>
</table>

1 Bits 2, 5-8, 14, and 15 are not used.

OUTPUT QUEUE

The Output Queue is a data structure that stores output messages until they are read from the electronic load. The Output Queue stores messages sequentially on a FIFO (first-in, first-out) basis. When there is data in the queue, it sets Bit 4 (MAV bit) in the Status Byte register.

STANDARD EVENT STATUS

The function of the Standard Event Status register is standard on all IEEE 488.2 devices. Table 5-3 describes the standard events that apply to the electronic load. Note that all programming errors that have occurred will set one or more of the error bits in the Standard Event Status register. Programming errors are listed in Table 4-2.

The Standard Event Status register represents all of the standard events that have occurred since the last time this register was read. Reading the Standard Event Status register resets it to zero.

The Standard Event Enable register can be programmed to specify which standard event bits are logically-ORed to become Bit 5 (ESB bit) in the Status Byte register.

NOTE

The present settings of the Standard Event Enable register can be saved in non-volatile memory if *PSC is programmed to zero. The next time the unit is turned on, the Standard Event Enable register will be programmed according to the saved settings.

Table 5-3. Standard Event Status Bit Description

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Bit1</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPC</td>
<td>0</td>
<td>1</td>
<td>Operation Complete. The electronic load has completed all pending operations. Programming *OPC causes this bit to be set when the electronic load completes all pending operations.</td>
</tr>
<tr>
<td>QYE</td>
<td>2</td>
<td></td>
<td>Query Error. The output queue was read when no data was present or the data in the queue was lost. Errors in the range of -499 thru -400 can set this bit.</td>
</tr>
<tr>
<td>DDE</td>
<td>3</td>
<td>8</td>
<td>Device Dependent Error. Memory was lost, or self-test failed. Errors in the range of -399 thru -300 can set this bit.</td>
</tr>
<tr>
<td>EXE</td>
<td>4</td>
<td>16</td>
<td>Execution Error. A command parameter was outside the legal range or inconsistent with the electronic load's operation, or the command could not be executed due to some operating condition. Errors in the range of -299 thru -200 can set this bit.</td>
</tr>
<tr>
<td>CME</td>
<td>5</td>
<td>32</td>
<td>Command Error. A syntax or semantic error has occurred or the electronic load received a &lt; GET &gt; within a program message. Errors in the range of -199 thru -100 can set this bit.</td>
</tr>
<tr>
<td>PON</td>
<td>7</td>
<td>128</td>
<td>Power On. The electronic load has been turned on or off since the last time this register was read. This bit is always set when the electronic load is turned on.</td>
</tr>
</tbody>
</table>

1 Bits 1 and 7 are not used by the electronic load.

5-4 Status Reporting
OPERATION STATUS

The Operation Status registers let you determine whether either of the operation conditions described in Table 5-4 presently exist on the electronic load.

The Operation Condition register represents the present status of the electronic load; the bits are set when the indicated condition is true.

The PTR/NTR filter determines what type of transition in the Operation Condition register will set the bit in the corresponding Operation Event register.
- Programming a bit in the PTR filter causes a 0-to-1 transition in the Operation Condition register to set the corresponding bit in the Operation Event register.
- Programming the NTR filter causes a 1-to-0 transition to set the bit.
- Programming both filters causes either transition to set the bit.

If the transition filters are not programmed, the bit is disabled.

NOTE

When the unit is turned on, the PTR filter is programmed on for the CAL bit, and the NTR filter is programmed on for the WTG bit.

The Operation Event register represents all of the filtered operation conditions that have occurred since the last time this register was read. Reading the register resets it to zero.

The Operation Enable register can be programmed to specify which operation event bits are logically-ORed to become Bit 7 (OPER bit) in the Status Byte register.

NOTE

Refer to the Electronic Load Operating Manual for information about calibration.

STATUS BYTE REGISTER

The Status Byte register summarizes all of the status events from all status registers. Table 5-5 describes the status events that apply to the electronic load.

The Status Byte register can be read with a serial poll or *STB? query. When a serial poll is sent in response to a service request, Bit 6 of the Status Byte register will contain the RQS bit. The RQS bit is the only bit that is automatically cleared after a serial poll. The other bits in the Status Byte register (including the MSS bit) are unaffected by a serial poll.

When the Status Byte register is read with a *STB? query, Bit 6 of the Status Byte register will contain the MSS bit. The MSS bit indicates that the load has at least one reason for requesting service. It is the inclusive-OR of the enabled bits (excluding bit 6) of the Status Byte Register. *STB? does not affect the status byte. The Status Byte register is cleared when a *CLS command clears all of the associated status registers.

SERVICE REQUEST ENABLE REGISTER

The Service Request Enable register can be programmed to specify which bits in the Status Byte register will generate service requests. All bits except Bit 6 (RQS/MSS) can be enabled to generate service requests. In addition to generating a service request, the enabled bits in the Service Request Enable register are logically-ORed to become the MSS bit in the Status Byte register.

NOTE

The present settings of the Service Request Enable register can be saved in non-volatile memory if *PSC is programmed to zero. The next time the unit is turned on, the Service Request Enable register will be programmed according to the saved settings.

Table 6-4. Operation Status Bit Description

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Bit</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL</td>
<td>0</td>
<td>1</td>
<td>Calibrating. A calibration calculation is in progress. (Refer to the Operating Manual for details of calibration commands.)</td>
</tr>
<tr>
<td>WTG</td>
<td>5</td>
<td>32</td>
<td>Waiting for trigger. At least one channel is waiting for a trigger to occur. Any TRIG command for any mode on any channel sets this bit. When a trigger is received, the bit is reset. ABO&lt;sub&gt;r&lt;/sub&gt; also resets this bit.</td>
</tr>
</tbody>
</table>

1 Bits 1-4, and 6-15 are not used by the electronic load.
<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>Bit&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSUM</td>
<td>2</td>
<td>4</td>
<td><em>Channel Summary</em>. Indicates if an enabled channel event has occurred. Affected by Channel Condition, Channel Event, and Channel Summary Event registers.</td>
</tr>
<tr>
<td>QUES</td>
<td>3</td>
<td>8</td>
<td><em>Questionable</em>. Indicates if an enabled questionable event has occurred. Affected by Questionable Condition and Questionable Event registers.</td>
</tr>
<tr>
<td>MAV</td>
<td>4</td>
<td>16</td>
<td><em>Message Available</em>. Indicates if the Output Queue contains data.</td>
</tr>
<tr>
<td>ESB</td>
<td>5</td>
<td>32</td>
<td><em>Event Status Bit</em>. Indicates if an enabled standard event has occurred. Affected by Standard Event register.</td>
</tr>
<tr>
<td>RQS/MSS</td>
<td>6</td>
<td>64</td>
<td>During a serial poll, RQS (<em>Request Service</em>) is returned and cleared. For an <em>STB?</em> query, MSS (<em>Master Summary Status</em>) is returned without being cleared.</td>
</tr>
<tr>
<td>OPER</td>
<td>7</td>
<td>128</td>
<td><em>Operation</em>. Indicates if an enabled operation event has occurred. Affected by Operation Condition and Operation Event registers.</td>
</tr>
</tbody>
</table>

<sup>1</sup> Bits 0 and 1 are not used by the electronic load. They will be read back as zeroes.
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