Keysight Models 664xA, 665xA, 667xA, 668xA, and 669xA GPIB DC Power Supplies

Programming Guide
NOTICE: This document contains references to Agilent Technologies. Agilent's former Test and Measurement business has become Keysight Technologies. For more information, go to www.keysight.com.
Safety Guidelines

The beginning of the power supply Operating Manual has a Safety Summary page. Be sure you are familiar with the information on that page before programming the power supply for operation from a controller.

**WARNING.** Energy Hazard. Power supplies with high output currents (such as the Series 668xA/669xA) can provide more than 240 VA at more than 2 V. If the output connections touch, severe arcing may occur resulting in burns, ignition or welding of parts. Take proper precautions before remotely programming the output circuits.

Printing History

The edition and current revision of this guide are indicated below. Reprints of this guide containing minor corrections and updates may have the same printing date. Revised editions are identified by a new printing date. A revised edition incorporates all new or corrected material since the previous printing. Changes to the guide occurring between revisions are covered by change sheets shipped with the guide.

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DISP:MODE
DISP:TEXT

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INIT
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OUTP:REL
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Status Operation Registers
STAT:OPER?
STAT:OPER:COND?
STAT:OPER:ENAB
STAT:OPER NTR
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Status Questionable Registers
STAT:OUES?
STAT:QUES:COND?
STAT:QUES:ENAB
STAT:QUES NTR
STAT:QUES PTR

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General Information

About this Guide

This guide provides remote programming information for the following series of GPIB programmable power supplies:
- KEYSIGHT Series 664xA, 665xA, 667xA, 668xA, and 669xA

You will find the following information in the rest of this guide:
Chapter 2 Introduction to SCPI messages structure, syntax, and data formats. Examples of SCPI programs.
Chapter 3 Dictionary of SCPI commands. Table of programming parameters.
Chapter 4 Description of the status registers.
Chapter 5 Error messages.
Appendix A SCPI conformance information.
Appendix B Use of the alternate Compatibility programming language.

Documentation Summary

User’s Guide

The Operating Guide, shipped with the power supply, has information helpful to programming the power supply and explains the SCPI commands used for remote calibration. Sample calibration and verification programs are included.

External Documents

SCPI References
The following documents will assist you with programming in SCPI:
- Standard Commands for Programmable Instruments Volume 1, Syntax and Style
- Standard Commands for Programmable Instruments Volume 2, Command References
- Standard Commands for Programmable Instruments Volume 3, Data Interchange Format
- Standard Commands for Programmable Instruments Volume 4, Instrument Classes

To obtain a copy of the above documents, contact: Fred Bode, Executive Director, SCPI Consortium, 8380 Hercules Drive, Suite P3, La Mesa, CA 91942, USA

GPIB References
The most important GPIB documents are your controller programming manuals - Keysight BASIC, GPIB Command Library for MS DOS, etc. Refer to these for all non-SCPI commands (for example: Local Lockout).
The following are two formal documents concerning the GPIB interface:
- ANSI/IEEE Std. 488.1-1987 IEEE Standard Digital Interface for Programmable Instrumentation. Defines the technical details of the GPIB interface. While much of the information is beyond the need of most programmers, it can serve to clarify terms used in this guide and in related documents.
- ANSI/IEEE Std. 488.2-1987 IEEE Standard Codes, Formats, Protocols, and Common Commands. Recommended as a reference only if you intend to do fairly sophisticated programming. Helpful for finding precise definitions of certain types of SCPI message formats, data types, or common commands.

The previous two documents are available from the IEEE (Institute of Electrical and Electronics Engineers), 345 East 47th Street, New York, NY 10017, USA. The WEB address is www.ieee.org.
Prerequisites for Using this Guide

This organization of this guide assumes that you know or can learn the following information:

1. How to program in your controller language (Keysight BASIC, QUICKBASIC, C, etc.).
2. The basics of the GPIB (IEEE 488).
3. How to program I/O statements for an IEEE 488 bus instrument. From a programming aspect, the power supply is simply a bus instrument.
4. How to format ASCII statements within your I/O programming statements. SCPI commands are nothing more than ASCII data strings incorporated within those I/O statements.
5. The basic operating principles of the power supply as explained in “Chapter 5 – Front Panel Operation” of the Operating Guide.
6. How to set the GPIB address of the power supply. This cannot be done remotely, but only from the supply’s front panel (see System Considerations in “Chapter 2 – Remote Programming”).

VXIplug&play Power Product Instrument Drivers

VXIplug&play instrument drivers for Microsoft Windows 95 and Windows NT are now available on the Web at http://www.keysight.com/find/drivers. These instrument drivers provide a high-level programming interface to your Keysight Technologies instrument. VXIplug&play instrument drivers are an alternative to programming your instrument with SCPI command strings. Because the instrument driver’s function calls work together on top of the VISA I/O library, a single instrument driver can be used with multiple application environments.

Supported Applications
- Keysight VEE
- Microsoft Visual BASIC
- Microsoft Visual C/C++
- Borland C/C++
- National Instruments LabVIEW
- National Instruments LabWindows/CVI

System Requirements
The VXIplug&play Power Products instrument driver complies with the following:
- Microsoft Windows 95
- Microsoft Windows NT
- HP VISA revision F.01.02
- National Instruments VISA 1.1

Downloading and Installing the Driver

NOTE: Before installing the VXIplug&play instrument driver, make sure that you have one of the supported applications installed and running on your computer.

2. Select the instrument for which you need the driver.
3. Click on the driver, either Windows 95 or Windows NT, and download the executable file to your pc.
4. Locate the file that you downloaded from the Web. From the Start menu select Run <path>:\agxxxx.exe - where <path> is the directory path where the file is located, and agxxxx is the instrument driver that you downloaded.
5. Follow the directions on the screen to install the software. The default installation selections will work in most cases. The readme.txt file contains product updates or corrections that are not documented in the on-line help. If you decide to install this file, use any text editor to open and read it.
6. To use the VXIplug&play instrument driver, follow the directions in the VXIplug&play online help under “Introduction to Programming”.

Accessing Online Help
A comprehensive online programming reference is provided with the driver. It describes how to get started using the instrument driver with Keysight VEE, LabVIEW, and LabWindows. It includes complete descriptions of all function calls as well as example programs in C/C++ and Visual BASIC.
- To access the online help when you have chosen the default Vxipnp start folder, click on the Start button and select Programs | Vxipnp | Agxxxx Help (32-bit).
- - where agxxxx is the instrument driver.
Remote Programming

GPIB Capabilities Of The Power Supply

All power supply functions except for setting the GPIB address are programmable over the IEEE 488 bus (also known as the General Purpose Interface Bus or “GPIB”). The IEEE 488.1 capabilities of the power supply are listed in the Supplemental Characteristics of the Operating Guide. The power supply operates from a GPIB address that is set from the front panel (see System Considerations at the end of this chapter).

Introduction To SCPI

Important Learn the basics of power supply operation (see "Chapter 5 - Front Panel Operation" in the power supply Operating Guide) before using SCPI.

SCPI (Standard Commands for Programmable Instruments) is a programming language for controlling instrument functions over the GPIB (IEEE 488) instrument bus. SCPI is intended to function with standard GPIB hardware and conforms to the IEEE Standard Digital Interface for Programmable Instrumentation. SCPI is layered on top of the hardware portion of IEEE 488.2. The same SCPI commands and parameters control the same functions in different classes of instruments. For example, you would use the same DISPlay command to control the power supply display state and the display state of a SCPI-compatible multimeter.

Note HPSL and TMSL (Test and Measurement System Language) were earlier versions of SCPI. If you have programmed in either, then you probably can go directly to "Chapter 3 - Language Dictionary".

Conventions

The following conventions are used throughout this chapter:

Angle brackets <> Items within angle brackets are parameter abbreviations. For example, <NR1> indicates a specific form of numerical data.

Vertical bar | Vertical bars separate one of two or more alternative parameters. For example, 0|OFF indicates that you may enter either "0" or "OFF" for the required parameter.

Square Brackets [ ] Items within square brackets are optional. The representation [SOURce]:CURRent means that SOURce may be omitted.

Braces {} Braces indicate parameters that may be repeated zero or more times. It is used especially for showing arrays. The notation<A>{<,B>} shows that "A" is a required parameter, while "B" may be omitted or may be entered one or more times.

Boldface font Boldface font is used to emphasize syntax in command definitions. TRIGger:DELay <NRf> shows a command syntax.

Computer font Computer font is used to show program text within normal text. TRIGger:DELay .5 represents program text.
SCPI Messages

There are two types of SCPI messages, program and response.

- A program message consists of one or more properly formatted SCPI commands sent from the controller to the power supply. The message, which may be sent at any time, requests the power supply to perform some action.
- A response message consists of data in a specific SCPI format sent from the power supply to the controller. The power supply sends the message only when commanded by a special program message called a "query."

Types of SCPI Commands

SCPI has two types of commands, common and subsystem.

Common Commands

Common commands (see Figure 3-1) generally are not related to specific operation but to controlling overall power supply functions, such as reset, status, and synchronization. All common commands consist of a three-letter mnemonic preceded by an asterisk:

   *RST   *IDN?   *SRE 8

Subsystem Commands

Subsystem commands (see Figure 3-2) perform specific power supply functions. They are organized into an inverted tree structure with the "root" at the top. Some are single commands while others are grouped under other subsystems.

Structure of a SCPI Message

SCPI messages consist of one or more message units ending in a message terminator. The terminator is not part of the syntax, but implicit in the way your programming language indicates the end of a line (such as a newline or end-of-line character).

The Message Unit

The simplest SCPI command is a single message unit consisting of a command header (or keyword) followed by a message terminator.

   ABOR
   VOLT?

The message unit may include a parameter after the header. The parameter usually is numeric, but it can be a string:

   VOLT 20
   VOLT MAX

Combining Message Units

The following command message (see Figure 2-1) is briefly described here, with more details in subsequent paragraphs.

   VOLT:LEV 4.5;PROT 4.8;;:CURR?<NL>
The basic parts of the message in Figure 2-1 are:

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<th>Example</th>
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</tr>
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<td>Header Separator</td>
<td>The colon in VOLT:LEV</td>
</tr>
<tr>
<td>Data</td>
<td>4.5 4.8</td>
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<tr>
<td>Data Separator</td>
<td>The space in VOLT 4.5 and PROT 4.8</td>
</tr>
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<td>Message Unit Separator</td>
<td>The semicolons in VOLT: LEV 4.5; and PROT 4.8;</td>
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<tr>
<td>Root Specifier</td>
<td>The colon in PROT 4.8; CURR?</td>
</tr>
<tr>
<td>Query Indicator</td>
<td>The question mark in CURR?</td>
</tr>
<tr>
<td>Message Terminator</td>
<td>The &lt;NL&gt; (newline) indicator. Terminators are not part of the SCPI syntax.</td>
</tr>
</tbody>
</table>

**Parts of a SCPI Message**

**Headers**

*Headers* (which are sometimes known as "keywords") are instructions recognized by the power supply interface. Headers may be either in the long form or the short form.

**Long Form** The header is completely spelled out, such as VOLTAGE STATUS DELAY.

**Short Form** The header has only the first three or four letters, such as VOLT STAT DEL.

Short form headers are constructed according to the following rules:

- If the header consists of *four or fewer* letters, use all the letters. *(DFI DATA)*
- If the header consists of *five or more* letters and the fourth letter is not a vowel (a,e,i,o,u), use the first four letters. *(VOLTage STATus)*
- If the header consists of *five or more* letters and the fourth letter is a vowel (a,e,i,o,u), use the first three letters. *(DELay CLEar)*

You must follow the above rules when entering headers. Creating an arbitrary form, such as QUEST for QUESTIONABLE, will result in an error. The SCPI interface is not sensitive to case. It will recognize any case mixture, such as VOLTAGE, Voltage, Volt, volt.

**Note** Shortform headers result in faster program execution.
Header Convention. In this manual, headers are emphasized with **boldface** type. The proper short form is shown in upper-case letters, such as `DELay`.

Header Separator. If a command has more than one header, you must separate them with a colon. `(VOLT:PROT OUTPut:PROTection:CLEar)`

Optional Headers. The use of some headers is optional. Optional headers are shown in brackets, such as `OUTPut[:STATe] ON`. However, if you combine two or more message units into a compound message, you may need to enter the optional header. This is explained under "Traversing the Command Tree."

Query Indicator
Following a header with a question mark turns it into a query `(VOLT? VOLT:PROT?)`. If a query contains a parameter, place the query indicator at the end of the last header `(VOLT:PROT? MAX)`.

Message Unit Separator
When two or more message units are combined into a compound message, separate the units with a semicolon `(STATus:OPERation?;QUEStionable?)`.

---

**Important**
You can combine message units only at the current path of the command tree (see "Traversing the Command Tree").

---

Root Specifier
When it precedes the first header of a message unit, the colon becomes a "root specifier". This indicates that the command path is at the root or top node of the command tree. Note the difference between root specifiers and header separators in the following examples:

```
OUTP:PROT:DEL .1  All colons are header separators
OUTP:PROT:DEL .1  The first colon is a root specifier
OUTP:PROT:DEL .1;:VOLT 12.5  The third colon is a root specifier
```

Message Terminator
A terminator informs SCPI that it has reached the end of a message. Three permitted messages terminators are:

- Newline (`<NL>`), which is ASCII decimal 10 or hex 0A.
- End or identify (`<END>`).
- Both of the above (`<NL><END>`).

In the examples of this manual, there is an assumed message terminator at the end of each message. If the terminator needs to be shown, it is indicated as `<NL>` regardless of the actual terminator character.

Traversing the Command Tree
Figure 2-2 shows a portion of the subsystem command tree (you can see the complete tree in Figure 3-2). Note the location of the ROOT node at the top of the tree. The SCPI interface is at this location when:

- The power supply is powered on.
- A device clear (DCL) is sent to the power supply.
- The interface encounters a message terminator.
- The interface encounters a root specifier.
Figure 2-2. Partial Command Tree

Active Header Path
In order to properly traverse the command tree, you must understand the concept of the active header path. When the power supply is turned on (or under any of the other conditions listed above), the active path is at the root. That means the interface is ready to accept any command at the root level, such as TRIGger or STATus in Figure 2-2. Note that you do not have to precede either command with a colon; there is an implied colon in front of every root-level command.

If you enter STATUS, the active header path moves one colon to the right. The interface is now ready to accept : OPERATION, : PRESET, or : QUESTIONABLE as the next header. Note that you must include the colon, because it is required between headers.

If you next enter : OPERATION, the active path again moves one colon to the right. The interface is now ready to accept : EVENT?, : CONDITION?, : ENABLE, : NTRANSITION, or : PTRANSITION as the next header.

If you now enter : ENABLE, you have reached the end of the command string. The active header path remains at : ENABLE. If you wished, you could have entered : ENABLE 18; PTRANSITION 18 and it would be accepted. The entire message would be STATUS: OPERATION: ENABLE 18; PTRANSITION 18. The message terminator after PTRANSITION 18 returns the path to the root.

The Effect of Optional Headers
If a command includes optional headers, the interface assumes they are there. For example, if you enter STATUS: OPERATION?, the interface recognizes it as STATUS: OPERATION: EVENT? (see Figure 2-2). This returns the active path to the root (: STATUS). But if you enter STATUS: OPERATION: EVENT?, then the active path remains at : EVENT. This allows you to send STATUS: OPERATION: EVENT?: CONDITION? in one message. If you tried to send STATUS: OPERATION?: CONDITION? the command path would send STATUS: OPERATION: EVENT? and then return to : STATUS instead of to : CONDITION.

The optional header SOURCE precedes the current, digital, and voltage subsystems (see Figure 3-2). This effectively makes : CURRENT, : DIGITAL, and : VOLTAGE root-level commands.

Moving Among Subsystems
In order to combine commands from different subsystems, you need to be able to restore the active path to the root. You do this with the root specifier (:). For example, you could clear the output protection and check the status of the Operation Condition register as follows (see Figure 3-2):

```
OUTPUT: PROTECTION: CLEAR
STATUS: OPERATION: CONDITION?
```

By using the root specifier, you could do the same thing in one message:

```
OUTPUT: PROTECTION: CLEAR; : STATUS: OPERATION: CONDITION?
```
The SCPI parser traverses the command tree as described in Appendix A of the IEEE 488.2 standard. The “Enhanced Tree Walking Implementation” given in that appendix is not implemented in the power supply.

The following message shows how to combine commands from different subsystems as well as within the same subsystem (see Figure 3-2):

```
VOLTAGE:LEVEL 7;PROTECTION 8;;CURRENT:LEVEL 50;PROTECTION ON
```

Note the use of the optional header **LEVEL** to maintain the correct path within the voltage and current subsystems and the use of the root specifier to move between sub-systems.

### Including Common Commands

You can combine common commands with system commands in the same message. Treat the common command as a message unit by separating it with the message unit separator. Common commands do not affect the active header path; you may insert them anywhere in the message.

```
VOLT:TRIG 7.5;INIT;*TRG
OUTP OFF;*RCL 2;OUTP ON
```

### SCPI Queries

Observe the following precautions with queries:

- Remember to set up the proper number of variables for the returned data.
- Set the program to read back all the results of a query before sending another command to the power supply. Otherwise, a *Query Interrupted* error will occur and the unreturned data will be lost.

### Value Coupling

Value coupling results when a command directed to send one parameter also changes the value of a second parameter. There is no direct coupling among any power supply SCPI commands. However, be aware that until they are programmed, uninitialized trigger levels will assume their corresponding immediate levels. For example, if a power supply is powered up and **VOLT:LEV** is programmed to 6, then **VOLT:LEV:TRIG** will also be 6 until you program it to another value. Once you program **VOLT:LEV:TRIG** to another value, it will remain at that value regardless of how you subsequently reprogram **VOLT:LEVEL**.

### SCPI Data Formats

All data programmed to or returned from the power supply is ASCII. The data may be numerical or character string.

#### Numerical Data

Table 2-1 and Table 2-2 summarize the numerical formats.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Data Form</th>
<th>Talking Formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;NR1&gt;</td>
<td>Digits with an implied decimal point assumed at the right of the least-significant digit. Examples: 273 0273</td>
<td></td>
</tr>
<tr>
<td>&lt;NR2&gt;</td>
<td>Digits with an explicit decimal point. Example: 273. .0273</td>
<td></td>
</tr>
<tr>
<td>&lt;NR3&gt;</td>
<td>Digits with an explicit decimal point and an exponent. Example: 2.73E+2 273.0E-2</td>
<td></td>
</tr>
</tbody>
</table>
Listening Formats

- **<NRf>** Extended format that includes <NR1>, <NR2> and <NR3>. Examples: 273.2 273.
- **<NRf+>** Expanded decimal format that includes <NRf>, MIN and MAX. Examples: 273 273.2 273E2 MAX. MIN and MAX are the minimum and maximum limit values that are implicit in the range specification for the parameter.

Table 2-2. Suffixes and Multipliers

<table>
<thead>
<tr>
<th>Class</th>
<th>Suffix</th>
<th>Unit</th>
<th>Unit with Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>A</td>
<td>Ampere</td>
<td>MA (milliampere)</td>
</tr>
<tr>
<td>Amplitude</td>
<td>V</td>
<td>Volt</td>
<td>MV (millivolt)</td>
</tr>
<tr>
<td>Time</td>
<td>S</td>
<td>second</td>
<td>MS (millisecond)</td>
</tr>
</tbody>
</table>

**Common Multipliers**

- 1E3  K  kilo
- 1E-3  M  milli
- 1E-6  U  micro

Boolean Data

Either form [1|0] or [ON|OFF] may be sent with commands. Queries always return 1 or 0.

```
OUTPut OFF
CURRent:PROTection 1
```

Character Data

For query statements, character strings may be returned in either of the forms shown in Table 2-3, depending on the length of the returned string.

Table 2-3. Character Data Formats

- **<CRD>** Character Response Data. Permits the return of character strings.
- **<AARD>** Arbitrary ASCII Response Data. Permits the return of undelimited 7-bit ASCII. This data type has an implied message terminator.

**Note:** The IEEE 488.2 format for a string parameter requires that the string be enclosed within either single (’) or double (“ ”) quotes. Be certain that your program statements comply with this requirement.

Examples

The examples given here are generic, without regard to the programming language or type of GPIB interface. Because SCPI commands are sent as ASCII output strings within the programming language statements, the SCPI syntax is independent of both programming language and interface.

**Note:** The examples are followed by sample program code written for three popular types of BASIC-controlled GPIB interfaces.
Controlling the Output

**Important**
The power supply responds simultaneously to both digital and analog programming inputs. If it is receiving an input over the GPIB and a corresponding input from the front panel (and/or from the analog programming port), the power supply output will be the algebraic sum of the inputs.

**Programming Voltage and Current**
The following statements program both voltage and current and return the actual output from the sense terminals:

- `OUTP OFF`  
  Disable the output.
- `VOLT 4.5;CURR 255`  
  Program the voltage and current.
- `VOLT?;CURR?`  
  Read back the programmed levels.
- `OUTP ON`  
  Enable the output.
- `MEAS:VOLT?;MEAS:CURR?`  
  Read back the outputs from the sense terminals.

**Programming Protection Circuits**
This example programs the voltage and current, programs an overvoltage protection value, and turns on the overcurrent protection. It then reads back all the programmed values.

- `VOLT:LEV 4.5;PROT 4.75`  
  Program the voltage and overvoltage protection.
- `CURR:LEV 255;PROT:STAT ON`  
  Program the current and overcurrent protection.
- `VOLT:LEV?;PROT?;CURR:LEV?;PROT:STAT?`  
  Read back the programmed values.

Note the required use of the optional **LEVel** header in the above example (see "The Effect of Optional Headers", given previously).

**Changing Outputs by Trigger**
If you do not program pending triggered levels, they default to the programmed (immediate) output levels. The following statements shows some basic trigger commands.

- `OUTP OFF`  
  Disable the output.
- `VOLT:LEV:IMM 2.2;TRIG 2.5`  
  Program the (immediate) voltage level to 2.2V and the pending triggered level to 2.5 V.
- `CURR:LEV:IMM 150;TRIG 250`  
  Program the (immediate) current level to 150 A and the pending triggered level to 250 A.
- `VOLT:LEV?;TRIG?;CURR:LEV?;TRIG?`  
  Check all the programmed values.
- `OUTP ON`  
  Enable the output.
- `MEAS:VOLT?;CURR?`  
  Read back the immediate levels from the sense terminals.
- `INTIT;TRIG`  
  Arm the trigger circuit and send a single trigger.
- `INIT;*TRG`  
  Same as above, except using a common command.
- `MEAS:VOLT?;CURR?`  
  Read back the triggered levels from the sense terminals.

If you need to send two or more triggers, program the trigger circuit for continuous arming.

- `OUTP OFF`  
  Disable the output.
- `VOLT:LEV:IMM 5.0;TRIG 2.5`  
  Program the (immediate) voltage level to 5 V and the pending triggered level to 2.5 V.
- `INTIT:CONT ON`  
  Program the trigger circuit for continuous arming.
- `OUTP ON`  
  Enable the output to 5 V.
- `TRIG`  
  Trigger the output voltage to 2.5 V.
- `VOLT:TRIG 5;TRIG`  
  Set the pending trigger level to 5 V and trigger the output voltage back to 5 V.
- `INTIT:CONT OFF`  
  Remove the continuous trigger arming.
Saving and Recalling States
You can remotely save and recall operating states. See *SAV and *RCL in "Chapter 3 - Language Dictionary" for the parameters that are saved and recalled.

Note When you turn the power supply on, it automatically retrieves the state stored in location 0. When a power supply is delivered, this location contains the factory defaults (see *RST in "Chapter 3 - Language Dictionary").

OUTP OFF;VOLT:LEV 6.5;PROT 6.8
CURR:LEV 335;PROT:STAT ON
*SAV 2
*RCL 2

Writing to the Display
You can include messages to the front panel LCD in your programs. The description of DISP:TEXT in "Chapter 3 - Language Dictionary" shows the number and types of permitted display characters. In order to write to the display, you must first change it to text mode as shown in the following example:

DISP:MODE TEXT Switch display to text mode.
RECALLED 2 Write “Recalled 2” to the display.
DISP:MODE NORM Return display to its normal mode.

Programming Status
You can use status programming to make your program react to events within the power supply. "Chapter 4 - Status Reporting" explains the functions and bit configurations of all status registers. Refer to Figure 4-1 in that chapter while examining the examples given here.

Detecting Events via SRO
Usually you will want the power supply to generate interrupts (assert SRQ) upon particular events. For this you must selectively enable the appropriate status register bits. The following examples allow the power supply to assert SRQ under selected conditions.

1. STAT:OPER:ENAB 1280;PTR 1280;*SRE 128 Assert SRQ when the supply switches between CV and CC modes.
2. STAT:OPER:ENAB 1;PTR 1;NTR 1;*SRE 128 Assert SRQ when the supply enters or leaves calibration mode.
3. STAT:QUES 3;PTR 3;*SRE 128 Assert SRQ when the supply goes into overvoltage or overcurrent condition.
4. STAT:OPER:ENAB 1280;PTR 1280;
   STAT:QUES 3;PTR 3;*SRE 136 Assert SRQ under any event occurring in 1. or 3., above.

Reading Specific Registers
You can exercise program control without interrupts by reading specific registers.

STAT:OPER:1280;EVEN? Enable only the CV and CC events and read their status.
STAT:OPER:ENAB 1313;PTR 1313;EVEN? Enable all conditions of the Operation Status register and read any events.
STAT:OPER:ENAB?;EVENT?;::STAT:QUES:ENAB?;EVEN?;:*ESE?;*ESR? Read which events are active and which events are enabled in the Operation, Questionable, and Standard Event status registers.

Remote Programming 17
Note  The last query string can be handled without difficulty. However, should you request too many queries, the system may return a “Query DEADLOCKED” error (-430). In that case, break the long string into smaller parts.

Programming the Digital I/O Port
Digital control ports 1 and 2 are TTL outputs that can be programmed either high or low. Control port 3 can be programmed to be either a TTL input or a TTL output. Send a decimal parameter that translates into the desired straight binary code for these ports. (See DIG:DATA[:VAL] in “Chapter 3 - Language Dictionary” for the port bit configurations.)

DIG:DATA 3  Set ports 1 and 2 high and make 3 another output port.
DIG:DATA 7  Set ports 1 and 2 high and make 3 an input port.
DIG:DATA?  Read back the present port configuration.

System Considerations

The remainder of this chapter addresses some system issues concerning programming. These are power supply addressing and the use of the following types of GPIB system interfaces:

1. HP Vectra PC controller with Keysight 82335A GPIB Interface Command Library.
2. IBM PC controller with National Instruments GPIB-PCII Interface/Handler.

The GPIB Address
The power supply address cannot be set remotely; it must be set from the front panel. Once the address is set, you can assign it inside programs.

Setting the GPIB Address
Figure 4-6 in the power supply Operating Guide shows the ways the power supply can be connected to the GPIB bus. You can set up the GPIB address in one of three ways:

1. As a stand-alone supply (the only supply at the address). It has a primary address in the range of 0 to 30. For example: 5 or 7
2. As the direct supply in a serial link. It is the only supply connected directly to the GPIB bus. The primary address is unique and can be from 0 to 30. It is entered as an integer followed by a decimal separator. The secondary address always is 0, which may be added after the primary address. If the secondary address is omitted, it is assumed to be 0. For example: 5.0 or 7.
3. As a linked supply in serial link. It gets its primary address from the direct supply. It has a unique secondary address that can be from 1 to 15. It is entered as an integer preceded by a decimal separator. For example: .1 or .12

When you enter a secondary address, leading zeros between the decimal separator and the first digit are ignored. For example, .1, .01, and .001 are accepted as secondary address 1 and displayed as 0.01. Zeros following a digit are not ignored. Thus, .10 and .010 are both accepted as secondary address 10 and displayed as 0.10.

Changing the Power Supply GPIB Address
Use the Address key and numerical keypad for entering addresses. The power supply is shipped with a 5 stand-alone address as the default. The general procedure for setting an address is:
**Action**  | **Display Shows**  
--- | ---  
Press **Address** | Current address  
Press new address keys | New address replaces numbers on the display  
Press **Enter** | Display returns to meter mode  

If you try to enter a forbidden number, **ADDR ERROR** is displayed.  
The following examples show how to set addresses:  
To set stand-alone primary address **6**, press **Address 6 Enter**  
To set direct supply primary address **6**, press **Address 6 Enter**  
To set linked secondary address **1**, press **Address 1 Enter**  
To set linked secondary address **12**, press **Address 1 2 Enter**

---  

**Note**  
The power supply display will reset (recall the state in location 0) whenever you change between the following types of GPIB addresses:  
- A stand-alone primary address and a direct primary address.  
- A direct primary address and a secondary address.

---  

**Assigning the GPIB Address In Programs**  
The following examples assume that the GPIB select code is **7**, the the power supply is **6**, and that the power supply address will be assigned to the variable **@PS**.

1000 !Stand-alone address. The power supply will respond if it is set to **6**  
1010 **PS=706**  
1010 **ASSIGN @PS TO 706**  
1020 !Direct address. The power supply will respond if it is set to **6** or **6.0**  
1030 **PS-70600**  
1030 **ASSIGN @PS TO 70600**  
1040 !Linked address **1**. The power supply will respond if it is set to address **1** and is serially connected to a supply at direct address **6.0**  
1050 **PS=706.01**  
1090 **ASSIGN @PS TO 706.01**

For systems using the National Instruments DOS driver, the address is specified in the software configuration program (IBCONFIG.EXE) and assigned a symbolic name. The address then is referenced only by this name within the application program (see the National Instruments GP-IB documentation).
DOS Drivers

Types of Drivers
The Keysight 82335A and National Instruments GP-IB are two popular DOS drivers. Each is briefly described here. See the software documentation supplied with the driver for more details.

Keysight 82335A Driver. For GW-BASIC programming, the GPIB library is implemented as a series of subroutine calls. To access these subroutines, your application program must include the header file SETUP.BAS, which is part of the DOS driver software.

SETUP.BAS starts at program line 5 and can run up to line 999. Your application programs must begin at line 1000. SETUP.BAS has built-in error checking routines that provide a method to check for GPIB errors during program execution. You can use the error-trapping code in these routines or write your own code using the same variables as used by SETUP.BAS.

National Instruments GP-IB Driver. Your program must include the National Instruments header file DECL.BAS. This contains the initialization code for the interface. Prior to running any applications programs, you must set up the interface with the configuration program (IBCONF.EXE).

Your application program will not include the power supply symbolic name and GPIB address. These must be specified during configuration (when you run IBCONF.EXE). Note that the primary address range is from 0 to 30 but any secondary address must be specified in the address range of 96 to 126. The power supply expects a message termination on EOI or line feed, so set EOI w/last byte of Write. It is also recommended that you set Disable Auto Serial Polling.

All function calls return the status word IBSTA%, which contains a bit (ERR) that is set if the call results in an error. When ERR is set, an appropriate code is placed in variable IBERR%. Be sure to check IBSTA% after every function call. If it is not equal to zero, branch to an error handler that reads IBERR% to extract the specific error.

Error Handling
If there is no error-handling code in your program, undetected errors can cause unpredictable results. This includes "hanging up" the controller and forcing you to reset the system. Both of the above DOS drivers have routines for detecting program execution errors.

Important Use error detection after every call to a subroutine.

Keysight BASIC Controllers
The Keysight BASIC Programming Language provides access to GPIB functions at the operating system level. This makes it unnecessary to have the header files required in front of DOS applications programs. Also, you do not have to be concerned about controller "hangups" as long as your program includes a timeout statement. Because the power supply can be programmed to generate SRQ on errors, your program can use an SRQ service routine for decoding detected errors. The detectable errors are listed in Table 5-1 of “Chapter 5 - Error Messages”.

Sample Program Code
The following programs are intended only to show how some of the same power supply functions can be programmed to each of the three previously mentioned GPIB interfaces. The first two are for the DOS interfaces and the third for the Keysight BASIC interface.
Programming Some Power Supply Functions

SAMPLE FOR POWER SUPPLY AT STAND-ALONE ADDRESS 6. SEQUENCE SETS UP CV MODE OPERATION, FORCES SUPPLY TO SWITCH TO CC MODE, AND DETECTS AND REPORTS MODE CHANGE.

Controller Using Keysight 82335A Interface

5  ' < ----------------- Merge SETUP.BAS here ----------------- >
1000 MAX_ELEMENTS=2 : ACTUAL_ELEMENTS=0 : MAX.LENGTH=80 : ACT.LENGTH=0
1005 DIM OUTPUTS(2) : CDDES$=SPACE$(40)
1010 ISC=7 : PS=706

1020 'Set up the Power Supply Interface for DOS driver
1025 CALL IORESET (ISC) 'Reset the interface
1030 IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1035 TIMEOUT=3
1040 CALL IOTIMEOUT (ISC, TIMEOUT) 'Set timeout to 3 seconds
1045 IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1050 CALL IOCLEAR (ISC) 'Clear the interface
1055 IF PCIB.ERR <> NOERR THEN ERROR PCIB.BASERR
1060 CALL IOREMOTE (ISC) 'Set Power Supply to remote mode

1070 'Program power supply to CV mode with following voltage and current
1080 CODES$ = "VOLTAGE 7.8;CURRENT 480" : GOSUB 2000
1085 '
1090 'Query power supply outputs & print to screen
1095 CODES$ = "MEASURE:VOLTAGE?;CURRENT?" : GOSUB 2000 : GOSUB 3000
1100 VOUT = OUTPUTS(I)
1105 IOUT = OUTPUTS(2)
1110 PRINT "The output levels are "VOUT" Volts and "IOUT" Amps"

1120 'Program triggered current level to value insufficient to maintain
1125 'supply within its CV operating characteristic
1130 CODES$ = "CURR:TRIG 50" : GOSUB 2000
1135 '
1140 'Set operation status mask to detect mode change from CV to CC
1145 CODES$ = "STAT:OPER:ENAB 1024;PTR 1024" : GOSUB 2000
1150 '
1155 'Enable Status Byte OPER summary bit
1160 CODES$ = "**SRE 128" : GOSUB 2000
1165 '
1170 'Arm trigger circuit and send trigger to power supply
1175 CODES$ = "INITIATE;TRIGGER" : GOSUB 2000
1180 '
1185 'Wait for supply to respond to trigger
1190 FOR I= 1 to 100 : NEXT I
1195 '
1200 'Poll for interrupt caused by change to CC mode and print to screen
1205 CALL IOSPOLL (PS, RESPONSE)
1210 IF (RESPONSE AND 128)<>128 THEN GOTO 1240 'No OPER event to report
1215 CODES$ = "STATUS:OPER:EVEN?" : GOSUB 2000 'Query status oper register
Programming Some Power Supply Functions (continued)

```plaintext
1220 CALL IOENTER (PS,OEVENT) 'Read back event bit
1225 IF PCIB.ERR < > NOERR THEN ERROR PCIB.BASERR
1230 IF (OEVENT AND 1024) = 1024 THEN PRINT "Supply switched to CC mode."
1240 'Clear the status circuit
1245 CODES$ = "*CLS" :GOSUB 2000
1260 FOR I = 1 TO 100 :NEXT I 'Wait for supply to clear
1265 'Disable output and save present state in location 2
1265 CODES$ = "OUTPUT OFF;*SAV 2" :GOSUB 2000
1270 END
1275
2000 'Send command to power supply
2005 LENGTH = LEN(CODES$)
2010 CALL IOOUTPUTS (PS,CODES$,LENGTH) 'Send command to interface
2015 IF PCIB.ERR < > NOERR THEN ERROR PCIB.BASERR ISETUP.BAS error trap
2020 RETURN
2025
3000 'Get data from power supply
3005 CALL IOENTERA (PS,OUTPUTS(1),MAX.ELEMENTS,ACTUAL.ELEMENTS)
3010 IF PCIB.ERR < > NOERR THEN ERROR PCIB.BASERR
3015 RETURN
```

---

IBM Controller Using National Interface

```plaintext
990 '--------------------- Merge DECL.BAS here ------------------------
1000 'Power Supply Variable = PS% ; Stand-Alone Address = 706
1005 CODES$ = SPACE$(50):MODE$ = SPACE$(5):OEVENT$ = SPACE$(20)
1010 D$ = SPACE$(60):OUTPUT$ = SPACE$(40):BDNAME$ = "PS%"
1015 DIM OUTPUT(2)
1020 'Set up power supply interface for DOS driver
1030 CALL IBFIND(BDNAME$,PS%)
1035 IF PS% < O THEN PRINT "IBFIND Failed."
1040 CALL IBCLR(PS%)
1045 'Program power supply to CV mode with following voltage and current
1050 CODES = "VOLTAGE 7.8;CURRENT 480" :GOSUB 2000
1055 'Query power supply outputs and print to screen
1070 CODES = "MEASURE;VOLTAGE?,CURRENT?" :GOSUB 2000 :GOSUB 3000
1075 VOUT = OUTPUT(1)
1080 IOUT = OUTPUT(2)
1085 PRINT "The programmed levels are "VOUT" Volts and "IOUT" Amps"
1090 'Program triggered current level to value insufficient to maintain
1095 'supply within its CV operating characteristic
1100 'Set operation status mask to detect mode change from CV to CC
1105 CODES = "CURR:TRIG 50" :GOSUB 200
1110 'Set operation status mask to detect mode change from CV to CC
1120 CODES = "STAT:OPER:ENAB 1024;PTR 1024" :GOSUB 200
1125 'Set operation status mask to detect mode change from CV to CC
```
Programming Some Power Supply Functions (continued)

1130  'Enable Status Byte OPER summary bit
1135  CODES$ = "SRE 128" :GOSUB 2000
1140  'Arm trigger circuit and send trigger to power supply
1150  CODES$ = "INITIATE;TRIGGER" :GOSUB 2000
1160  'Wait for supply to respond to trigger
1165  FOR I=1 to 100 :NEXT I
1170  'Poll for interrupt caused by change to CC mode and print to screen
1175  SPOL% = 0
1180  CALL IBRSP(PS%, SPOL%)
1190  IF (SPOL% AND 128) = 128 THEN POLL = 1 'Set interrupt flag on OPER bit
1195  IF POLL <> 1 THEN GOTO 1230 'No interrupt to service
1200  'Query status oper register
1205  CALL IBRD(PS%, OEVENT$)
1210  IF IBSTA% < 0 THEN GOTO 2100 'Error detected
1215  OEVENT = VAL(OEVENT$)
1220  IF (OEVENT AND 1024) = 1024 THEN PRINT "Supply switched to CC mode."
1225  'Clear status circuit
1230  CODES$ = "CLS" :GOSUB 2000
1235  FOR I=1 TO 50 :NEXT I 'Wait for supply to clear
1240  'Disable output and save present state to location 2
1245  CODES$ = "OUTPUT OFF; SAV 2" :GOSUB 2000
1250  END
1255 'Send command to power supply
1260  CALL IBWR(PS%, CODES$)
1265  RETURN
1270 'Error detected
1275 CODES$ = "OUTPUT OFF; SAV 2" :GOSUB 2000
1280 IF IBSTAT% < 0 THEN GOTO 2100 'Parse data string
1285 END
1290 'Send command to power supply
1295 CALL IBWR(PS%, CODES$)
1300 IF IBSTAT% < 0 THEN GOTO 2100 'Error detected
1305 RETURN
1310 'Error detection routine
1315 PRINT "GPIB error. IBSTAT% = &H"; HEX$(IBSTAT%)
1320 PRINT "IBERR% = " ; IBERR%" in line " ; ERL
1325 STOP
1330 'Get data from power supply
1335 CALL IBRD(PS%, OUTPUT$)
1340 IF IBSTA% < 0 THEN GOTO 2100 'Print data string
1345 I=1
1350 C=INSTR(I, OUTPUT$, ";")
Programming Some Power Supply Functions (continued)

```plaintext
3030    WHILE C< >O
3035        D$=MID$(OUTPUT$,I,C-I)
3040        OUTPUT(X)=VAL(D$)  'Get values
3045        I=C+1
3050        C=INSTR(I,OUTPUT$,";")
3055        X=X+1
3060    WEND
3065        D$=RIGHT$(OUTPUT$,LEN(OUTPUT$)-(I-1))
3070        OUTPUT(X)=VAL(D$)
3076        OUTPUT$=SPACE$(40)  'Clear string
3080    RETURN
```

Controller Using Keysight BASIC

```plaintext
1000 !Power supply at stand-alone address = 706
1005 OPTION BASE 1
1010 DIM Codes$[80],Response$[80],Mode$[32]
1015!
1020 !Program power supply to CV mode with following voltage and current
1026 OUTPUT 706;"VOLTAGE 7.8;CURRENT 480"
1030!
1035 !Query power supply outputs and print to screen
1040 OUTPUT 706;"MEASURE:VOLTAGE?;CURRENT?"  !Query output levels
1045 ENTER 706;Vout, Iout
1050 PRINT "The output levels are ";Vout," Volts and ";Iout" Amps"
1055!
1060 !Program current triggered level to a value insufficient to maintain
1065 !supply within its CV operating characteristic
1070 OUTPUT 706;"CURR:TRIG 50"
1075!
1080 !Set operation status mask to detect mode change from CV to CC
1085 OUTPUT 706;"STAT:OPER:ENAB 1280;PTR 1280"
1090!
1095 !Enable Status Byte OPER summary bit
1100 OUTPUT 706;"SRE 128"
1105!
1110 !Arm trigger circuit and send trigger to power supply
1115 OUTPUT 706;"INITIATE;TRIGGER"
1130 !Poll for interrupt caused by change to CC mode and print to screen
1135 Response=SPOLL(706)
1140 IF NOT BIT (Response,7) THEN GOTO 1130  !No OPER event to report
1145 OUTPUT 706;"STAT:OPER:EVEN?"
1160 ENTER 706;Oevent
1156 IF BIT(Oevent,10) THEN PRINT "Supply switched to CC mode."
1160!
1165 !Clear status
1170 OUTPUT 706;"CLS"
1176!
1180 !Disable output and save present state in location 2
1185 OUTPUT 706;"OUTPUT OFF;"SAV 2"
1190 END
```
Language Dictionary

Introduction

This section gives the syntax and parameters for all the IEEE 488.2 SCPI commands and the Common commands used by the power supply. It is assumed that you are familiar with the material in "Chapter 2 - Remote Programming". That chapter explains the terms, symbols, and syntactical structures used here and gives an introduction to programming. You should also be familiar with "Chapter 5 - Front Panel Operation" (in the Operating Guide) in order to understand how the power supply functions.

The programming examples are simple applications of SCPI commands. Since SCPI syntax remains the same for all programming languages, the examples are generic.

Parameters

Most commands require a parameter and all queries will return a parameter. The range for a parameter may vary according to the model of power supply. Parameters for all current models are listed in Table 3-1 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

The dictionary is organized as follows:

- IEEE 488.2 common commands, in alphabetical order.
- Subsystem commands.

Common Commands

Common commands begin with an * and consist of three letters (command) or three letters and a ? (query). Common commands are defined by the IEEE 488.2 standard to perform some common interface functions. The power supply responds to the 13 required common commands that control status reporting, synchronization, and internal operations. The power supply also responds to five optional common commands controlling triggers, power-on conditions, and stored operating parameters.

Subsystem Commands

Subsystem commands are specific to power supply functions. They can be a single command or a group of commands. The groups are comprised of commands that extend one or more levels below the root. The description of subsystem commands follows the listing of the common commands.
Description Of Common Commands

Figure 3-1 shows the common commands and queries. These commands are listed alphabetically in the dictionary. 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. The description of each common command or query specifies any status registers affected. In order to make use of this information, you must refer to "Chapter 4 - Status Reporting", which explains how to read specific register bits and use the information that they return.

Figure 3-1. Common Commands Syntax Diagram
**CLS**

**Meaning and Type**
*Clear Status*  Device Status

**Description**
This command causes the following actions (see "Chapter 4 - Status Reporting" for descriptions of all registers):

- Clears the following registers:
  - Standard Event Status.
  - Operation Status Event.
  - Questionable Status Event.
  - Status Byte.
- Clears the Error Queue.
- 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)

**Query Syntax**  (None)

**ESE**

**Meaning and Type**
*Event Status Enable*  Device Status

**Description**
This command programs the Standard Event Status Enable register bits. The programming 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 Event Summary Bit (ESB) of the Status Byte register to be set. See "Chapter 4 - Status Reporting” for descriptions of all three registers.

**Bit Configuration of Standard Event Status Enable Register**

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>Bit Name</th>
<th>Bit Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>PON</td>
<td>128</td>
</tr>
<tr>
<td>6</td>
<td>CME</td>
<td>64</td>
</tr>
<tr>
<td>5</td>
<td>EXE</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>DDE</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>QYE</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>OPC</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

CME = Command error; DDE = Device-dependent error; EXE = Execution error; OPC = Operation complete; PON Power-on; QYE = Query error.

**Command Syntax**  *ESE <NRf>*

**Parameters**  0 to 255

**Suffix**  (None)

**Example**  *ESE 129*

**Query Syntax**  *ESE?*

**Returned Parameters**  <NR1>  (Register value)

**Related Commands**  *ESR?  *PSC  *STB?*

**CAUTION**
If PSC is programmed to 0, then the *ESE* command causes a write cycle to nonvolatile memory. The nonvolatile memory has a finite maximum number of write cycles (see Supplemental Characteristics in Chapter 1 of the power supply Operating Guide). Programs that repeatedly cause write cycles to nonvolatile memory can eventually exceed the maximum number of write cycles and may cause the memory to fail.
**ESR?**

**Meaning and Type**  
*Event Status Register*  
*Device Status*

**Description**  
This query reads the Standard Event Status Event register. Reading the register clears it. The bit configuration of this register is the same as the Standard Event Status Enable register (*ESE*). See "Chapter 4 - Status Reporting" for a detailed explanation of this register.

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>Parameters</th>
<th>Returned Parameters</th>
<th>Related Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>ESR?</em></td>
<td>(None)</td>
<td>&lt;NR1&gt;</td>
<td>*CLS *ESE *ESE? *OPC</td>
</tr>
</tbody>
</table>

**IDN?**

**Meaning and Type**  
*Identification*  
*System Interface*

**Description**  
This query requests the power supply to identify itself. It returns a string composed of four fields separated by commas.

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>Parameters</th>
<th>Returned Parameters</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>IDN?</em></td>
<td></td>
<td>&lt;AARD&gt;</td>
<td>Field</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hewlett-Packard</td>
<td>Manufacturer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>xxxxA</td>
<td>4-digit model number followed by a letter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nnnnA-nnnnn</td>
<td>10-character serial number or 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;R&gt;.xx.xx</td>
<td>Revision levels of firmware</td>
</tr>
</tbody>
</table>

**Example**  
Hewlett-Packard,6681,0,A.00.01

**Related Commands**  
(None)

**OPC**

**Meaning and Type**  
*Operation Complete*  
*Device Status*

**Description**  
This command causes the interface to set the OPC bit (bit 0) of the Standard Event Status register when the power supply has completed all pending operations. (See *ESE* for the bit configuration of the Standard Event Status register.) Pending operations are complete when:

- All commands sent before *OPC* have been executed. This includes overlapped commands. Most commands are sequential and are completed before the next command is executed. Overlapped commands are executed in parallel with other commands. Commands that affect output voltage, current or state, relays, and trigger actions are overlapped with subsequent commands sent to the power supply. The *OPC* command provides notification that all overlapped commands have been completed.
- Any change in the output level caused by previous commands has been completed (completion of settling time, relay bounce, etc.)
- All triggered actions are completed

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

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>Parameters</th>
<th>Related Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>OPC</em></td>
<td>(None)</td>
<td>*OPC? *WAI</td>
</tr>
</tbody>
</table>
**OPC**?

**Meaning and Type**

*Operation Complete*  
Device Status

**Description**

This query causes the interface to place an ASCII "1" in the Output Queue when all pending operations are completed. *Pending operations* are as defined for the *OPC* command. Unlike *OPC*, *OPC?* prevents processing of all subsequent commands. *OPC?* is intended to be used at the end of a command line so that the application program can then monitor the bus for data until it receives the "1" from the power module Output Queue.

---

**CAUTION**

Do not follow *OPC?* with *TRG* or GPIB bus triggers. Such triggers sent after *OPC?* will be prevented from executing and will prevent the power supply from accepting further commands. If this occurs, the only programmable way to restore operation is by sending the power supply a GPIB DCL (Device Clear) command.

---

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>Returned Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>OPC?</em></td>
<td>&lt;NR1&gt;</td>
</tr>
</tbody>
</table>

ASCII 1 is placed in the Output Queue when the power supply has completed operations.

**Related Commands**

*OPC  TRIG  WAI

---

**OPT?**

**Meaning and Type**

*Option Identification Query*

**Description**

This query requests the power supply to identify any options that are installed. Options are identified by number A. 0 indicates no options are installed.

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>Returned Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>OPT?</em></td>
<td>&lt;AARD&gt;</td>
</tr>
</tbody>
</table>

---

**PSC**

**Meaning and Type**

*Power-on Status Clear*  
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 = 1, then the above registers are cleared at power turn-on. If the command parameter = 0, then the above registers are not cleared at power turn-on but are programmed to their last state prior to power turn on. This is the most common application for *PSC* and enables the power module to generate an SRQ (Service Request) at power on.

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>Parameters</th>
<th>Example</th>
<th>Query Syntax</th>
<th>Returned Parameters</th>
<th>Related Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>PSC</em></td>
<td>&lt;bool&gt;</td>
<td>*PSC 0  *PSC 1</td>
<td><em>PSC?</em></td>
<td>&lt;NR1&gt; 0 1</td>
<td>ESE  SRE</td>
</tr>
</tbody>
</table>

---
*PSC causes a write cycle to nonvolatile memory. If *PSC is programmed to 0, then the *ESE and *SRE commands also cause a write cycle to nonvolatile memory. The nonvolatile memory has a finite number of write cycles (see “Table 1-2, Supplementary Characteristics”). Programs that repeatedly write to nonvolatile memory can eventually exceed the maximum number of write cycles and may cause the memory to fail.

*RCL

Meaning and Type
Recall Device State

Recalling a previously stored state may place hazardous voltage at the power supply output.

Description
This command restores the power supply to a state that was previously stored in memory with a *SAV command to the specified location. The following states are recalled:

- CURR[:LEV][:IMM]
- OUTP[:STAT]
- OUTP:REL:POL
- CURR:PROT:STAT
- OUTP:PROT:DEL
- VOLT[:LEV][:IMM]
- DIG:DATA[:VAL]
- OUTP:REL[:STAT]
- VOLT:PROT[:LEV]

Sending *RCL also does the following:

- Forces an ABORt command before resetting any parameters (this cancels any uncompleted trigger actions).
- Disables the calibration function by setting CAL:STATe to OFF.
- Sets display functions as follows:
  - DISP[:WIND][:STATe] to ON.
  - DISP[:WIND]:MODE to NORMal.
  - DISP[:WIND]:TEXT to ''. 
- Sets INIT:CONT to OFF.
- Sets TRIG:SOUR to BUS.

At power turn-on, the power supply normally is returned to the factory defined turn-on state (see *RST). However, it also may turn on to the state stored in location 0 (see Turn-On Condition under "Chapter 5 - Front Panel Operation" of the power supply Operating Guide).

Command Syntax  *RCL <NRf>
Parameters  0 | 1 | 2 | 3
Example  *RCL 3
Query Syntax  (None)
Related Commands  *PSC  *RST  *SAV
*RST

Meaning and Type
Reset   Device State

Description
This command resets the power supply to a factory-defined state as defined below. *RST also forces an ABORt command.

<table>
<thead>
<tr>
<th>Command</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAL:STAT OFF</td>
<td>OUTP[:STAT] OFF</td>
</tr>
<tr>
<td>CURR[:LEV][:IMM]</td>
<td>OUTP:PROT:DEL *</td>
</tr>
<tr>
<td>CURR[:LEV]:TRIG</td>
<td>OUTP:REL[:STAT] OFF</td>
</tr>
<tr>
<td>CURR:PROT:STAT</td>
<td>OUTP:REL:POL NORM</td>
</tr>
<tr>
<td>DIG:DATA 0</td>
<td>TRIG:SOUR BUS</td>
</tr>
<tr>
<td>DISP[:WIND]:STAT</td>
<td>VOLT[:LEV][:IMM] *</td>
</tr>
<tr>
<td>DISP[:WIND]:MODE</td>
<td>VOLT[:LEV][:TRIG] *</td>
</tr>
<tr>
<td>DISP[:WIND]:TEXT</td>
<td>VOLT:PROT[:LEV] *</td>
</tr>
<tr>
<td>INIT:CONT OFF</td>
<td></td>
</tr>
</tbody>
</table>

* Model-dependent value. See Table 3-1.

Command Syntax    *RST
Parameters          (None)
Query Syntax        (None)
Related Commands    *PSC   *SAV

*SAV

Meaning and Type
SAVE   Device State

Description
This command stores the present state of the power supply to the specified location in memory. Up to four states can be stored. Under certain conditions (see "Turn-On Conditions" in "Chapter 5 - Front Panel Operation" of the Operating Guide), location 0 may hold the device state that is automatically recalled at power turn-on.

The following power supply parameters are stored by *SAV:

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURR[:LEV][:IMM]</td>
<td>0</td>
</tr>
<tr>
<td>CURR:PROT:STAT</td>
<td>0</td>
</tr>
<tr>
<td>DIG:DATA[:VAL]</td>
<td>SAV 3</td>
</tr>
</tbody>
</table>

Example

Query Syntax    (None)
Related Commands   *RCL   *RST

CAUTION

The power supply uses nonvolatile memory for recording register states. Programs that repeatedly use *SAV for recalling states cause frequent write cycles to the memory and can eventually exceed the maximum number of write cycles for the memory (see in the power supply Operating Guide).
**SRE**

**Meaning and Type**

*Service Request Enable*  
Device Interface

**Description**

This command sets the condition of the Service Request Enable Register. This register determines which bits from the Status Byte Register (see *STB* for its bit configuration) are allowed to set the Master Status Summary (MSS) bit and the Request for Service (RQS) summary bit. A 1 in any Service Request Enable Register bit position enables the corresponding Status Byte Register bit and all such enabled bits then are logically ORed to cause Bit 6 of the Status Byte Register to be set. See "Chapter 4 - Status Reporting" for more details concerning this process.

When the controller conducts a serial poll in response to SRQ, the RQS bit is cleared, but the MSS bit is not. When *SRE* is cleared (by programming it with 0), the power supply cannot generate an SRQ to the controller.

**Command Syntax**

*SRE* <NRf>

**Parameters**

0-to 255

**Default Value**

(See *PSC*)

**Example**

*SRE 20*

**Query Syntax**

*SRE?*

**Returned Parameters**

<NR1> (Register binary value)

**Related Commands**

*ESE  *ESR  *PSC

---

If *PSC* is programmed to 0, then the *SRE* command causes a write cycle to nonvolatile memory. The nonvolatile memory has a finite number of write cycles (see Supplemental Characteristics in the power supply Operating Guide). Programs that repeatedly write to nonvolatile memory can eventually exceed the maximum number of write cycles and may cause the memory to fail.

---

**STB?**

**Meaning and Type**

*Status Byte*  
Device Status

**Description**

This query reads the Status Byte register, which contains the status summary bits and the Output Queue MAV bit. Reading the Status Byte register does not clear it. The input summary bits are cleared when the appropriate event registers are read (see "Chapter 4 - Status Reporting" for more information). The MAV bit is cleared at power on or by *CLS*.

A serial poll also returns the value of the Status Byte register, except that bit 6 returns. Request for Service (RQS) instead of Master Status Summary (MSS). A serial poll clears RQS, but not MSS. When MSS is set, it indicates that the power supply has one or more reasons for requesting service.

**Bit Configuration of Status Byte Register**

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

ESB = Event status byte summary; MAV = Message available; MSS = Master status summary; OPER = Operation status summary; QUES = Questionable status summary; RQS = Request for service.

1 Also represents RQS. 2 These bits are always zero.

**Query Syntax**

*STB?*

**Returned Parameters**

<NR1> (Register binary value)

**Related Commands**

(None)
**TRG**

Meaning and Type
*Trigger  Device Trigger*

Description
This command generates a trigger when the trigger subsystem has BUS selected as its source. The command has the same affect as the Group Execute Trigger (<GET>) command.

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>*TRG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>(None)</td>
</tr>
<tr>
<td>Query Syntax</td>
<td>(None)</td>
</tr>
</tbody>
</table>

Related Commands
ABOR  CURR:TRIG  INIT  TRIG[:IMM]  VOLT:TRIG  <GET>

**TST?**

Meaning and Type
*Test  Device Test*

Description
This query causes the power supply to do a self-test and report any errors (see "Selftest Error Messages" in "Chapter 3 - Turn-On Checkout" of the power supply Operating Guide).

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>*TST?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Returned Parameters</td>
<td>&lt;NR1&gt;</td>
</tr>
<tr>
<td>0</td>
<td>Indicates power supply passed self-test.</td>
</tr>
<tr>
<td>Nonzero</td>
<td>Indicates an error code.</td>
</tr>
</tbody>
</table>

Related Commands
(None)

**WAI**

Meaning and Type
*Wait to Continue  Device Status*

Description
This command instructs the power supply 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 power supply a GPIB DCL (Device Clear) command.

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>*WAI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>(None)</td>
</tr>
<tr>
<td>Query Syntax</td>
<td>(None)</td>
</tr>
</tbody>
</table>

Related Commands
*OPC  *OPC?
Description of Subsystem Commands

Figure 3-2 is a tree diagram of the subsystem commands. Commands followed by a question mark (?) take only the query form. Except as noted in the syntax descriptions, all other commands take both the command and query form. The commands are listed in alphabetical order and the commands within each subsystem are grouped alphabetically under the subsystem.

![Figure 3-2. Subsystem Commands Tree Diagram](image)

**ABOR**

This command cancels any trigger actions presently in process. Pending trigger levels are reset equal to their corresponding immediate values. ABOR also resets the WTG bit in the Operation Condition Status register (see "Chapter 4 - Status Reporting"). If INIT:CONT ON has been programmed, the trigger subsystem initiates itself immediately after ABORT, thereby setting WTG. **ABOR** is executed at power turn on and upon execution of *RCL or RST.

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>Parameters</th>
<th>Examples</th>
<th>Query Syntax</th>
<th>Related Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABORt</td>
<td>(None)</td>
<td>ABOR</td>
<td>(None)</td>
<td>INIT *RST *TRG TRIG</td>
</tr>
</tbody>
</table>

Calibration Commands

See Appendix A in the power supply Operating Guide.
Current Subsystem

This subsystem programs the output current of the power supply.

**CURR CURR:TRIG**

These commands set the immediate current level or the pending triggered current level of the power supply. The immediate level is the current programmed for the output terminals. The pending triggered level is a stored current value that is transferred to the output terminals when a trigger occurs. A pending triggered level is unaffected by subsequent CURR commands and remains in effect until the trigger subsystem receives a trigger or an ABORt command is given. If there is no pending CURR:TRIG level, then the query form returns the CURR level. In order for CURR:TRIG to be executed, the trigger subsystem must be initiated (see INITiate).

**Command Syntax**

[SOURce]:CURRent[:LEVel][:IMMediate][:AMPLitude] <NRf+>
[SOURce]:CURRent[:LEVel]:TRIGgered [:AMPLitude] <NRf+>

**Parameters**

Table 3-1

**Default Suffix**

A

**Examples**

CURR 200 MA  CURRENT:LEVEL 200 MA  
CURRENT:LEVEL:IMMediate:AMPLitude 2.5  
CURR:TRIG 20  CURRENT:LEVEL:TRIGgered 20

**Query Syntax**

[SOURce]:CURRent[:LEVel][:IMMediate][:AMPLitude]?  
[SOURce]:CURRent[:LEVel]:TRIGgered [:AMPLitude]?

**Returned Parameters**

<NRI> CURR? and CURR:TRIG? return presently programmed immediate and triggered levels. If not triggered level is programmed, both returned values are the same. CURR? MAX and CURR? MIN return the maximum and minimum programmable immediate current levels. CURR:TRIG? MAX and CURR:TRIG? MIN return the maximum and minimum programmable triggered current levels.

**Related Commands**

For CURR  *SAV  *RCL  *RST  
For CURR:TRIG  ABOR  CURR  *RST

**CURR:PROT:STAT**

This command enables or disables the power supply overcurrent protection (OCP) function. If the overcurrent protection function is enabled and the power supply goes into constant-current operation, then the output is disabled and the Questionable Condition status register OC bit is set (see "Chapter 4 - Status Reporting"). An overcurrent condition can be cleared with the OUTP:PROT:CLE command after the cause of the condition is removed.

**Command Syntax**

[SOURce]:CURRent:PROTection:STATE <bool>

**Parameters**

0 | 1 | OFF | ON

**RST Value**

OFF

**Examples**

CURR:PROT:STAT 0  CURRENT:PROTECTION:STATE OFF  
CURR:PROT:STAT 1  CURRENT:PROTECTION:STATE ON

**Query Syntax**

[SOURce]:CURRent:PROTection:STATE?

**Returned Parameters**

<NRI> 0 or 1

**Related Commands**

OUTP:PROT:CLE *RST
DIG:DATA

This command sets and reads the power supply digital control port when that port is configured for Digital I/O operation. Configuring of the port is done via an internal jumper (see Appendix D in the Operating Guide). The port has three signal pins and a digital ground pin. Pins 1 and 2 are output pins controlled by bits 0 and 1. Pin 3 is controlled by bit 3 and can be programmed to serve either as an input or an output. Pin 4 is the digital ground.

Bit position 2 normally serves as an output. To change it to an input, it must first be programmed high. The DIG:DATA? query returns the last programmed value in bits 0 and 1 and the value read at pin 3 in bit 2. The bits are turned on and off in straight binary code as follows:

<table>
<thead>
<tr>
<th>Digital I/O Port Programming Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit Configuration</td>
</tr>
<tr>
<td>Value</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

1 Pins 1 and 2 are always outputs

Command Syntax [SOURce]:DIGital:DATA[:VALuel <NRf>
Parameters 0 to 7
Suffix (None)
*RST Value 0
Examples DIG:DATA 7 DIGITAL:DATA:VALUE 7
Query Syntax [SOURce]:DIGital:DATA?
Returned Parameters <NR1> Values from 0 to 7
Related Commands *RST *RCL *SAV

Display Subsystem

This subsystem controls the state and output of the alphanumeric portion of the display.

DISP

Enables or disables the display. When disabled, the display characters are blank. The annunciators are not affected by this command.

Command Syntax DISP[:WINDow][:STATe] <bool>
Parameters 0 | 1 | OFF | ON
Suffix (None)
*RST Value ON
Examples DISP ON DISP:STATE ON
Query Syntax DISP[:WINDow][:STATe]?
Returned Parameters <NR1> 0 or 1
Related Commands DISP:MODE DISP:TEXT *RST
**DISP:MODE**

Switches the display between its normal metering mode and a mode in which it displays text sent by the user. The command uses the character data `<CRD>` format.

**Command Syntax**

```
DISPlay[:WINDow]:MODE NORMalITEXT
```

**Parameters**

- `<CRD>`
- NORMal | TEXT

**Examples**

```
DISP:MODE NORM
DISPLAY:MODE NORMAL
DISPLAY:WINDOW:MODE TEXT
```

**Query Syntax**

```
DISPlay[:WINDow]:MODE?
```

**Returned Parameters**

- `<CRD>`
- NORM | TEXT

**Related Commands**

DISP DISP:TEXT *RST

---

**DISP:TEXT**

Allows character strings to be sent to display. The characters will be displayed when the display mode is TEXT. The LCD has the following character set:

<table>
<thead>
<tr>
<th>Character Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>uppercase letters</td>
<td>A through Z (Case-sensitive entry)</td>
</tr>
<tr>
<td>digits</td>
<td>0 through 9</td>
</tr>
<tr>
<td>punctuation</td>
<td>_</td>
</tr>
<tr>
<td>blank space</td>
<td></td>
</tr>
</tbody>
</table>

A display is capable of showing up to 12 characters. However, the three punctuation characters do not count toward the 12-character limit when they are preceded by an alphanumeric character. When punctuation characters are included, then the maximum number of characters (alphanumeric + punctuation) that can be displayed is 15. If it exceeds the display capacity, a message will be truncated to fit and no error message will be generated. If any character in the message is not a member of the above character set, the character will not be rejected but will be displayed as a "starburst" (all 16 segments of the character will light).

**Command Syntax**

```
DISPlay[:WINDow]:TEXT [:DATA] <STR>
```

(See LCD character set)

**Parameters**

- `<STR>`

**Examples**

```
DISP:TEXT "DEFAULT_MODE"
DISPLAY:WINDOW:TEXT:DATA '533.2E-1VOLTS'
```

**Query Syntax**

```
DISPlay[:WINDow]:TEXT?
```

**Returned Parameters**

- `<STR>`
- (Last programmed text string)

**Related Commands**

DISP DISP:MODE *RST

---

**Note**

*IEEE Standard Digital Interface* for Programmable Instrumentation requires that a string be enclosed in either single (‘) or double (") quotes.
Initiate Subsystem

**INIT**
**INIT:CONT**

This subsystem enables the trigger system. When a trigger is enabled, an event on a selected trigger source causes the specified trigging action to occur. If the trigger subsystem is not enabled, all trigger commands are ignored. If **INIT:CONT** is OFF, then INIT enables the trigger subsystem only for a single trigger action. The subsystem must be enabled prior to each subsequent trigger action. If **INIT:CONT** is ON, then the trigger subsystem is continuously enabled and INIT is redundant.

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>INITiate[:IMMediate]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>For INIT[:IMM] (None)</td>
</tr>
<tr>
<td></td>
<td>For INIT:CONT 0</td>
</tr>
<tr>
<td>*RST Value</td>
<td>OFF</td>
</tr>
<tr>
<td>Examples</td>
<td>INIT INITiate:IMMediate</td>
</tr>
<tr>
<td></td>
<td>INIT:CONT 1 INITiate:CONTINUous 1</td>
</tr>
</tbody>
</table>

**Query Syntax**

**MEAS:CURR?**
**MEAS:VOLT?**

This query subsystem returns the voltage and current measured at the power supply's sense terminals.

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>MEASure:CURRent[:DC]? MEASure:VOLTage[:DC]?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>(None)</td>
</tr>
<tr>
<td>Default Suffix</td>
<td>A for MEAS:CURR? V for MEAS:VOLT?</td>
</tr>
<tr>
<td>Returned Parameters</td>
<td>&lt;NR3&gt;</td>
</tr>
</tbody>
</table>
Output Subsystem

This subsystem controls the power supply's voltage and current outputs and an optional output relay.

CAUTION: Do not install or program the Keysight Relay Accessories if the power supply maximum output current rating (see Table 3-1) exceeds the contact ratings of the relay.

OUTP

This command enables or disables the power supply output. The state of a disabled output is a condition of zero output voltage and a model-dependent minimum source current (see Table 3-1). The query form returns the output state.

Command Syntax

OUTPut[:STATe] <bool>

Parameters

0 | OFF | 1 | ON

Suffix

(None)

*RST Value

0

Examples

OUTP 1
OUTPUT:STATE ON

Query Syntax

OUTPut[:STATe]? OUTPut(:STATe)?

Returned Parameters

<NR1> 0 or 1

Related Commands

*RST  *RCL  *SAV

OUTP:PROT:CLE

Clears any OV (overvoltage), OC (overcurrent, unless set via external voltage control), OT (overtemperature), or RI (remote inhibit) protection features. After this command, the output is restored to the state it was in before the protection feature occurred.

OUTP:PROT:DEL

Sets the time between the programming of an output change that produces a CV, CC, or UNREG condition and the recording of that condition by the Status Operation Condition register. The delay prevents the momentary changes in power supply status that can occur during reprogramming from being registered as events by the status subsystem. Since the delay applies to CC status, it also delays the OCP (overcurrent protection) feature. The OVP (overvoltage protection) feature is not affected by this delay.

Examples

OUTP:PROT:CLE
OUTPUT:PROTECTION:CLEAR
OUTPUT:PROTECTION:DELAY 75E-1
OUTP:PROT:DEL MIN  OUTPUT:PROT:DELAY MAX

Query Syntax

OUTPut:PROTection:DELay? MAX

Returned Parameters

<NR3> OUTP:PROT:DEL? returns value of programmed delay.


Related Commands

OUTP:PROT:CLE
OUTP:PROT:DEL  *RST  *RCL  *SAV
OUTP:REL

Do not install or program the Keysight Relay Accessories if the power supply maximum output current rating (see Table 3-1) exceeds the contact ratings of the relay.

This command is valid only if the power supply is configured for the optional relay connector. Programming ON closes the relay contacts; programming OFF opens them. The relay is controlled independently of the output state. If the power supply is supplying power to a load, that power will appear at the relay contacts during switching. If the power supply is not configured for the relay option, sending either relay command generates an error.

Command Syntax

OUTPut:RELay[:STATe] <bool>

Parameters
0 | 1 | OFF | ON

*RST Value
0

Examples
OUTP:REL 1 OUTP:REL OFF

Query Syntax
OUTPput:RELay?

Returned Parameters
0 | 1

Related Commands
OUTP[:STAT] *RCL *SAV

OUTP:REL:POL

Do not install or program the Keysight Relay Accessories if the power supply maximum output current rating (see Table 3-1) exceeds the contact ratings of the relay.

This command is valid only if the power supply is configured for the optional relay connector. Programming NORMAL causes the relay output polarity to be the same as the power supply output. Programming REVerse causes the relay output polarity to be opposite to that of the power supply output. If OUTP[:STAT] = ON when either relay command is sent, the power supply output voltage is set to 0 during the time that the relays are changing polarity.

If the power supply is not configured for the relay option, sending either relay command generates an error.

Command Syntax

OUTPut:RELay:POLarity <CRD>

Parameters
NORMAL | REVerse

*RST Value
NORMAL

Examples
OUTP:REL:POL NORMAL

Query Syntax
OUTPput:RELay:POLarity?

Returned Parameters
NORMAL | REV

Related Commands
OUTP[:STAT] *RCL *SAV
**Status Subsystem**

This subsystem programs the power supply status registers. The power supply has three groups of status registers: **Operation**, **Questionable**, and **Standard Event**. The Standard Event group is programmed with Common commands as described in "Chapter 4 - Status Reporting". The Operation and Questionable status groups each consist of the Condition, Enable, and Event registers and the NTR and PTR filters.

**STAT:PRES**

This command sets all defined bits in the Status Subsystem PTR registers and clears all bits in the subsystem NTR and Enable registers. STAT:OPER:PTR is set to 1313 and STAT:QUES:PTR is set to 1555.

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>Status:Preset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>(None)</td>
</tr>
<tr>
<td>Examples</td>
<td>STAT:PRES</td>
</tr>
<tr>
<td>Query Syntax</td>
<td>STATUS:PRESET</td>
</tr>
<tr>
<td>Related Commands</td>
<td>(None)</td>
</tr>
</tbody>
</table>

**Status Operation Registers**

The bit configuration of all Status Operation registers is shown in the following table:

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>15-12</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>Bit Name</td>
<td>NU</td>
<td>NU</td>
<td>CC</td>
<td>NU</td>
<td>CV</td>
<td>NU</td>
<td>NU</td>
<td>WTG</td>
<td>NU</td>
<td>NU</td>
<td>NU</td>
<td>NU</td>
<td>CAL</td>
</tr>
<tr>
<td>Bit Weight</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>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

CAL = Interface is computing new calibration constants; CC = The power module is in constant current mode. CV = The power module is in constant voltage mode; NU = (Not used); WTG = Interface is waiting for a trigger.

**Note**

See "Chapter 4 - Status Reporting" for more explanation of these registers.

**STAT:OPER?**

This query returns the value of the Operation Event register. The Event register is a read-only register which holds (latches) all events that are passed by the Operation NTR and/or PTR filter. Reading the Operation Event register clears it.

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>Status:OPERation[:EVENT]?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>(None)</td>
</tr>
<tr>
<td>Returned Parameters</td>
<td>&lt;NR1&gt; (Register Value)</td>
</tr>
<tr>
<td>Examples</td>
<td>STATUS:OPERATION:EVENT?</td>
</tr>
<tr>
<td>Related Commands</td>
<td>*CLS STAT:OPER:NTR STAT:OPER:PTR</td>
</tr>
</tbody>
</table>

**STAT:OPER:COND?**

This query returns the value of the Operation Condition register. That is a read-only register which holds the real-time (unlatched) operational status of the power supply.

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>Status:OPERation:CONDITION?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>(None)</td>
</tr>
<tr>
<td>Returned Parameters</td>
<td>&lt;NR1&gt; (Register value)</td>
</tr>
<tr>
<td>Related Commands</td>
<td>(None)</td>
</tr>
</tbody>
</table>
STAT:OPER:ENAB

This command and its query set and read the value of the Operational Enable register. This register is a mask for enabling specific bits from the Operation Event register to set the operation summary bit (OPER) of the Status Byte register. This bit (bit 7) is the logical OR of all the Operational Event register bits that are enabled by the Status Operation Enable register.

Command Syntax  STATus:OPERation:ENABle <NRf>
Parameters  0 to 32727
Suffix  (None)
Default Value  0
Examples  STAT:OPER:ENAB 1312  STAT:OPER:ENAB 1
Query Syntax  STATus:OPERation:ENABle?
Returned Parameters  <NR1>  (Register value)
Related Commands  STAT:OPER:EVEN

STAT:OPER NTR
STAT:OPER PTR

These commands set or read the value of the Operation NTR (Negative-Transition) and PTR (Positive-Transition) registers. These registers serve as polarity filters between the Operation Enable and Operation Event registers to cause the following actions:

- When a bit in the Operation NTR register is set to 1, then a 1-to-0 transition of the corresponding bit in the Operation Condition register causes that bit in the Operation Event register to be set.
- When a bit of the Operation PTR register is set to 1, then a 0-to-1 transition of the corresponding bit in the Operation Condition register causes that bit in the Operation Event register to be set.
- If the same bits in both NTR and PTR registers are set to 1, then any transition of that bit at the Operation Condition register sets the corresponding bit in the Operation Event register.
- If the same bits in both NTR and PTR registers are set to 0, then no transition of that bit at the Operation Condition register can set the corresponding bit in the Operation Event register.

Note  Setting a bit in the value of the PTR or NTR filter can of itself generate positive or negative events in the corresponding Operation Event register.

Command Syntax  STATus:OPERtion:NTRansition <NRf>
STATus:OPERtion:PTRansition <NRf>
Parameters  0 to 32727
Suffix  (None)
Default Value  0
Examples  STAT:OPER:NTR 32  STAT:OPER:PTR 1312
Query Syntax  STAT:OPER:NTR?  STAT:OPER:PTR?
Returned Parameters  <NR1>  (Register value)
Related Commands  STAT:OPER:ENAB
Status Questionable Registers

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>15-11</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>Condition</td>
<td>NU</td>
<td>UNR</td>
<td>RI</td>
<td>NU</td>
<td>NU</td>
<td>NU</td>
<td>NU</td>
<td>OT</td>
<td>NU</td>
<td>NU</td>
<td>OC</td>
<td>OV</td>
</tr>
<tr>
<td>Bit Weight</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>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
| NU = (Not used); OC = Overcurrent protection circuit has tripped.  
OT = Overtemperature status condition exists; OV = Overvoltage protection circuit has tripped.  
RI = Remote inhibit is active; UNR = Power supply output is unregulated.  

Note: See "Chapter 4 - Status Reporting" for more explanation of these registers.

**STAT:QUES?**

This query returns the value of the Questionable Event register. The Event register is a read-only register which holds (latches) all events that are passed by the Questionable NTR and/or PTR filter. Reading the Questionable Event register clears it.

- **Query Syntax**: STAT:QUESTIONABLE[:EVENT]?
- **Parameters**: (None)
- **Returned Parameters**: <NR1> (Register Value)
- **Examples**: STAT:QUES?  STAT:QUESTIONABLE:EVENT?

**STAT:QUES:COND?**

This query returns the value of the Questionable Condition register. That is a read-only register which holds the real-time (unlatched) questionable status of the power supply.

- **Query Syntax**: STAT:QUESTIONABLE:CONDITION?
- **Parameters**: (None)
- **Returned Parameters**: <NR1> (Register Value)
- **Examples**: STAT:QUES:COND?  STAT:QUESTIONABLE:CONDITION?
- **Related Commands**: (None)

**STAT:QUES:ENAB**

This command and its query set and read the value of the Questionable Enable register. This register is a mask for enabling specific bits from the Questionable Event register to set the questionable summary bit (QUES) of the Status Byte register. This bit (bit 3) is the logical OR of all the Questionable Event register bits that are enabled by the Questionable Status Enable register.

- **Command Syntax**: STAT:QUESTIONABLE:ENAB <NRf>
- **Parameters**: 0 to 32727
- **Suffix**: (None)
- **Default Value**: 0
- **Examples**: STAT:QUES:ENAB 20  STAT:QUES:ENAB 16
- **Query Syntax**: STAT:QUESTIONABLE:ENAB?
- **Returned Parameters**: <NR1> (Register Value)
- **Related Commands**: STAT:QUES?
STAT:QUES NTR
STAT:QUES PTR

These commands allow you to set or read the value of the Questionable NTR (Negative-Transition) and PTR (Positive-Transition) registers. These registers serve as polarity filters between the Questionable Enable and Questionable Event registers to cause the following actions:

- When a bit of the Questionable NTR register is set to 1, then a 1-to-0 transition of the corresponding bit in the Questionable Condition register causes that bit in the Questionable Event register to be set.
- When a bit of the Questionable PTR register is set to 1, then a 0-to-1 transition of the corresponding bit in the Questionable Condition register causes that bit in the Questionable Event register to be set.
- If the same bits in both NTR and PTR registers are set to 1, then any transition of that bit at the Questionable Condition register sets the corresponding bit in the Questionable Event register.
- If the same bits in both NTR and PTR registers are set to 0, then no transition of that bit at the Questionable Condition register can set the corresponding bit in the Questionable Event register.

Note

Setting a bit in the PTR or NTR filter can of itself generate positive or negative events in the corresponding Questionable Event register.

<table>
<thead>
<tr>
<th>Command Syntax</th>
<th>STATtatus:QUEStionable:NTRansition &lt;NRf&gt;</th>
<th>STATtatus:QUEStionable:PTRansition &lt;NRf&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>0 to 32727</td>
<td></td>
</tr>
<tr>
<td>Suffix</td>
<td>(None)</td>
<td></td>
</tr>
<tr>
<td>Default Value</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Examples</td>
<td>STAT:QUES:NTR 16  STATUS:QUESTIONABLE:PTR 512</td>
<td></td>
</tr>
<tr>
<td>Query Syntax</td>
<td>STAT:QUES:NTR?  STAT:QUES:PTR?</td>
<td></td>
</tr>
<tr>
<td>Returned Parameters</td>
<td>&lt;NR1&gt; (Register value)</td>
<td></td>
</tr>
<tr>
<td>Related Commands</td>
<td>STAT:QUES:ENAB</td>
<td></td>
</tr>
</tbody>
</table>

System Commands

SYST:ERR?

This query returns the next error number followed by its corresponding error message string from the remote programming error queue. The queue is a FIFO (first-in, first-out) buffer that stores errors as they occur. As it is read, each error is removed from the queue. When all errors have been read, the query returns 0, NO ERROR. If more errors are accumulated than the queue can hold, the last error in the queue will be -350, TOO MANY ERRORS (see Table 5-1 in "Chapter 5 - Error Messages" for other error codes).

You can use the power supply front panel [Error] key to read errors from the queue. Errors generated at the front panel are not put into the queue but appear immediately on the display.

<table>
<thead>
<tr>
<th>Query Syntax</th>
<th>SYSTem:ERRor?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
<td>(None)</td>
</tr>
<tr>
<td>Returned Parameters</td>
<td>&lt;NR1&gt;,&lt;SRD&gt;</td>
</tr>
<tr>
<td>Examples</td>
<td>SYST:ERR?</td>
</tr>
<tr>
<td>Related Commands</td>
<td>(None)</td>
</tr>
</tbody>
</table>
**SYST:LANG**

This command switches the interface between its SCPI (TMSL) command language and its compatibility language. The compatability language is provided for emulation of older power supply systems and is described in Appendix B. Sending the command causes:

- The alternate language to become active and to be stored in nonvolatile memory.
- The power supply to reset to the state stored in Location 0.

If the power supply is shut off, it will resume operation in the last-selected language when power is restored.

**Command Syntax**

```
SYSTem:LANGuage <string>
```

**Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMSL</td>
<td>COMPatibility</td>
</tr>
</tbody>
</table>

**Default Value**

TMSL or last selected language.

**Note:** Parameter TMSL must be used in place of SCPI.

**Examples**

```
SYST:LANG TMSL
SYSTEM:LANGUAGE COMPATIBILITY
```

**Query Syntax**

```
SYSTem:LANGuage?
```

**Returned Parameters**

<CRD>

TMSL | COMP

**Related Commands**

None

---

**SYST:VERS?**

This query returns the SCPI version number to which the power supply complies. The returned value is of the form YYYY.V, where YYYY represents the year and V is the revision number for that year.

**Query Syntax**

```
SYSTem:VERSion?
```

**Parameters**

None

**Returned Parameters**

<NR2>

```
SYS:TVER?  SYSTem:VERSion?
```

**Related Commands**

None

---

**Trigger Subsystem**

This subsystem controls remote triggering of the power supply.

**TRIG**

When the trigger subsystem is enabled, TRIG generates a trigger signal. The trigger will then:

1. Initiate a pending level change as specified by CURR[:LEV]:TRIG or VOLT[:LEV]:TRIG.
2. Clear the WTG bit in the Status Operation Condition register.
3. If INIT:CONT has been given, the trigger subsystem is immediately re-enabled for subsequent triggers. As soon as it is cleared, the WTG bit is again set to 1.

**Command Syntax**

```
TRIGger[:IMMediate]
```

**Parameters**

None

**Examples**

```
TRIG TRIGGER:IMMEDIATE
```

**Query Syntax**

None

**Related Commands**

ABOR CURR:TRIG INIT *TRG VOLT:TRIG
**TRIG:SOUR**

This command selects the trigger source. Since the power supply has no other trigger source than the GPIB bus, this command need not be used. It is included in the command set to provide programming compatibility with other instruments (such as the Keysight Electronic Load family) that may have more than one trigger source.

**Command Syntax**

```
TRIGer:SOURce <CRD>
```

**Parameters**

- BUS
- *RST Value: BUS

**Examples**

```
TRIG:SOUR BUS
TRIGGER:SOURCE BUS
```

**Query Syntax**

```
TRIGger:SOURce?
```

**Returned Parameters**

- BUS

**Related Commands**

- *RST *TRG TRIG[:IMM]

---

**Voltage Subsystem**

This subsystem programs the output voltage of the power supply.

**VOLT**

**VOLT:TRIG**

These commands set the immediate voltage level or the pending triggered voltage level of the power supply. The immediate level is the voltage programmed for the output terminals. The pending triggered level is a stored voltage value that is transferred to the output terminals when a trigger occurs. A pending triggered level is unaffected by subsequent VOLT commands and remains in effect until the trigger subsystem receives a trigger or an ABORt command is given. If there is no pending VOLT:TRIG level, then the query form returns the VOLT level. In order for VOLT:TRIG to be executed, the trigger subsystem must be initiated (see INITiate).

**Command Syntax**

```
[SOURce]:VOLTage[LEVel]:IMMediate[:AMPLitude] <NRf+>
[SOURce]:VOLTage[LEVel]:TRIGgered[:AMPLitude] <NRf+>
```

**Parameters**

Table 3-1

**Default Suffix**

- V

**Examples**

```
VOLT 200 MV
VOLTAGE:LEVEL 200 MV
VOLTAGE:LEVEL:IMMEDIATE:AMPLITUDE 2.5
VOLT:TRIG 20
VOLTAGE:LEVEL:TRIGGERED 20
```

**Query Syntax**

```
[SOURce]:VOLTage[LEVel]:IMMediate[:AMPLitude]?
[SOURce]:VOLTage[LEVel]:TRIGgered[:AMPLitude]?
```

**Returned Parameters**

<NR3> VOLT? and VOLT:TRIG? return presently programmed immediate and triggered levels. If not triggered level is programmed, both returned values are the same.

```
VOLT? MAX and VOLT? MIN return the maximum and minimum programmable immediate voltage levels.
VOLT:TRIG? MAX and VOLT:TRIG? MIN return the maximum and minimum programmable triggered voltage levels.
```

**Related Commands**

- For VOLT *SAV *RCL *RST
- Related Commands For VOLT:TRIG ABOR VOLT *RST
**VOLT:PROT**

This command sets the overvoltage protection (OVP) level of the power supply. If the output voltage exceeds the OVP level, then the power supply output is disabled and the Questionable Condition status register OV bit is set (see "Chapter 4 - Status Reporting"). An overvoltage condition can be cleared with the OUTP:PROT:CLE command after the condition that caused the OVP trip is removed. The OVP always trips with zero delay and is unaffected by the OUTP:PROT:DEL command.

**Command Syntax**

[SOURce]:VOLTage:PROTection[:LEVel] <NRf+>

*Alternate Syntax*

[SOURce]:VOLTage:PROTection:AMPLitude <NRf+>

**Parameters**

Table 3-1

**Default Suffix**

V

**RST Value**

MAX

**Examples**

VOLT:PROT 21.5  VOLT:PROT:LEV MAX

**Query Syntax**

[SOURce]:VOLTage:PROTection[:LEVel]?

[SOURce]:VOLTage:PROTection?  MIN

[SOURce]:VOLTage:PROTection?  MAX

**Returned Parameters**

<NR3>  VOLT:PROT? returns presently programmed OVP level.

VOLT:PROT?  MAX and VOLT:PROT?  MIN return the maximum and minimum programmable OVP levels.

**Related Commands**

OUTP:PROT:CLE  *RST  *SAV  *RCL

* Available to accommodate earlier power supply programs.

---

**Command Summary**

This summary lists all power supply subsystem commands in alphabetical order, followed by all common commands in alphabetical order. See Table 3-1 for the command parameters accepted by each power supply model.

<table>
<thead>
<tr>
<th>Command</th>
<th>Subsystem Commands</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABOR</td>
<td>(none)</td>
<td></td>
</tr>
<tr>
<td>CAL</td>
<td>(See Appendix A in the Operating Manual)</td>
<td></td>
</tr>
<tr>
<td>[SOUR]:CURR[:LEV]:IMM[:AMPL]</td>
<td>&lt;NRf+&gt;[suffix]</td>
<td></td>
</tr>
<tr>
<td>[SOUR]:CURR[:LEV]:IMM[:AMPL]?</td>
<td>(none) [MIN][MAX]</td>
<td></td>
</tr>
<tr>
<td>[SOUR]:CURR[:LEV]:TRIG[:AMPL]</td>
<td>&lt;NRf+&gt;[suffix]</td>
<td></td>
</tr>
<tr>
<td>[SOUR]:CURR[:LEV]:TRIG[:AMPL]?</td>
<td>(none) [MIN][MAX]</td>
<td></td>
</tr>
<tr>
<td>[SOUR]:CURR:PROT:STAT</td>
<td>0</td>
<td>ON</td>
</tr>
<tr>
<td>(SOUR):CURR:PROT:STAT?</td>
<td>(none)</td>
<td></td>
</tr>
<tr>
<td>[SOUR]:DIG:DATA[:VAL]</td>
<td>&lt;NRf&gt;</td>
<td></td>
</tr>
<tr>
<td>[SOUR]:DIG:DATA[:VAL]?</td>
<td>(none)</td>
<td></td>
</tr>
<tr>
<td>DISP[WIN]:MODE</td>
<td>NORM</td>
<td>TEXT</td>
</tr>
<tr>
<td>DISP(WIND):MODE?</td>
<td>(none)</td>
<td></td>
</tr>
<tr>
<td>DISP[:WIN]D[:STAT]</td>
<td>0</td>
<td>OFF</td>
</tr>
<tr>
<td>DISP[:WIN][STAT]?</td>
<td>(none)</td>
<td></td>
</tr>
<tr>
<td>DISP[:WIN]:TEXT[:DATA]</td>
<td>&lt;STR&gt;</td>
<td></td>
</tr>
<tr>
<td>DISP[:WIN]:TEXT[:DATA]?</td>
<td>(none)</td>
<td></td>
</tr>
<tr>
<td>INIT[:IMM]</td>
<td>(none)</td>
<td></td>
</tr>
<tr>
<td>INIT:CONT</td>
<td>0</td>
<td>OFF</td>
</tr>
<tr>
<td>INIT:CONT?</td>
<td>(none)</td>
<td></td>
</tr>
</tbody>
</table>
## Command Summary

<table>
<thead>
<tr>
<th>Command</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEAS:CURR[:DC]?</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>MEAS:VOLT[:DC]?</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>OUTP[:STAT]</strong></td>
<td>OFF</td>
</tr>
<tr>
<td><strong>OUTP[:STAT]?”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>OUTP:PROT:DEL</strong></td>
<td>0 to 32.767</td>
</tr>
<tr>
<td><strong>OUTP:PROT:DEL?”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>STAT:OPER:COND?”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>STAT:OPER:ENAB?”</strong></td>
<td>&lt;NRf&gt;</td>
</tr>
<tr>
<td><strong>STAT:OPER[:EVEN]?”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>STAT:OPER:NTR”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>STAT:OPER:PTR”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>STAT:PRES”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>STAT:QUES:COND?”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>STAT:QUES:ENAB?”</strong></td>
<td>&lt;NRf&gt;</td>
</tr>
<tr>
<td><strong>STAT:QUES[:EVEN]?”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>SYST:LANG”</strong></td>
<td>TM</td>
</tr>
<tr>
<td><strong>SYST:LANG?””</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>SYST:VERS?””</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>TRIG[:IMM]”</strong></td>
<td>(none)</td>
</tr>
<tr>
<td><strong>TRIG:SOUR”””</strong></td>
<td>BUS</td>
</tr>
<tr>
<td><strong>[SOUR]:VOLT[:LEV]:TRIG[:AMPL]”””</strong></td>
<td>&lt;NRf+&gt;[suffix]</td>
</tr>
<tr>
<td><strong>[SOUR]:VOLT:PROT[:LEV]”””</strong></td>
<td>&lt;NRf+&gt;[suffix]</td>
</tr>
</tbody>
</table>
| **[SOUR]:VOLT:PROT[:LEV]?”””** | <NRf+>[suffix] 

## Common Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>*CLS</td>
<td>(None)</td>
</tr>
<tr>
<td>*ESE</td>
<td>&lt;NRf&gt;</td>
</tr>
<tr>
<td>*ESE?</td>
<td>(None)</td>
</tr>
<tr>
<td>*ESR?</td>
<td>(None)</td>
</tr>
<tr>
<td>*IDN?</td>
<td>(None)</td>
</tr>
<tr>
<td>*OPC?</td>
<td>(None)</td>
</tr>
<tr>
<td>*OPC</td>
<td>(None)</td>
</tr>
<tr>
<td>*SRE?</td>
<td>(None)</td>
</tr>
<tr>
<td>*SRE</td>
<td>&lt;NRf&gt;</td>
</tr>
<tr>
<td>*STB?</td>
<td>(None)</td>
</tr>
<tr>
<td>*TRG</td>
<td>(None)</td>
</tr>
<tr>
<td>*TST?</td>
<td>(None)</td>
</tr>
<tr>
<td>*WAI</td>
<td>(None)</td>
</tr>
</tbody>
</table>
## Programming Parameters

Table 3-1 list the programming parameters for each of the models.

### Table 3-1. Power Supply Programming Parameters (see note)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Keysight Model and Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURR[:LEV] MAX and CURR[:LEV]:TRIG MAX (Programming range is 0 to MAX)</td>
<td>6641A</td>
</tr>
<tr>
<td></td>
<td>6651A</td>
</tr>
<tr>
<td></td>
<td>51.188 A</td>
</tr>
<tr>
<td></td>
<td>6671A</td>
</tr>
<tr>
<td></td>
<td>225.23 A</td>
</tr>
<tr>
<td></td>
<td>6680A</td>
</tr>
<tr>
<td></td>
<td>895 A</td>
</tr>
<tr>
<td></td>
<td>6690A</td>
</tr>
<tr>
<td></td>
<td>450 A</td>
</tr>
<tr>
<td>RST Current Value</td>
<td>6641A</td>
</tr>
<tr>
<td></td>
<td>0.08 A</td>
</tr>
<tr>
<td></td>
<td>6651A</td>
</tr>
<tr>
<td></td>
<td>0.205 A</td>
</tr>
<tr>
<td></td>
<td>6671A</td>
</tr>
<tr>
<td></td>
<td>2.65 A</td>
</tr>
<tr>
<td></td>
<td>6680A</td>
</tr>
<tr>
<td></td>
<td>73.71 A</td>
</tr>
<tr>
<td></td>
<td>6690A</td>
</tr>
<tr>
<td></td>
<td>37.06 A</td>
</tr>
<tr>
<td>OUTP:PROT:DEL RST Value</td>
<td>0 to 32.727 s (MAX) for all models</td>
</tr>
<tr>
<td>VOLT[:LEV] MAX and VOLT[:LEV]:TRIG MAX (Programming range is 0 to MAX)</td>
<td>6641A</td>
</tr>
<tr>
<td></td>
<td>8.190 V</td>
</tr>
<tr>
<td></td>
<td>6680A</td>
</tr>
<tr>
<td></td>
<td>5.125 V</td>
</tr>
<tr>
<td></td>
<td>6690A</td>
</tr>
<tr>
<td>RST Voltage Value</td>
<td>0 V for all models</td>
</tr>
<tr>
<td>VOLT:PROT MAX (Programming range is 0 to MAX)</td>
<td>6641A</td>
</tr>
<tr>
<td></td>
<td>8.8 V</td>
</tr>
<tr>
<td></td>
<td>6671A</td>
</tr>
<tr>
<td></td>
<td>10.0 V</td>
</tr>
<tr>
<td></td>
<td>6680A</td>
</tr>
<tr>
<td></td>
<td>6.25 V</td>
</tr>
<tr>
<td></td>
<td>6690A</td>
</tr>
<tr>
<td></td>
<td>18 V</td>
</tr>
<tr>
<td>RST OVP value</td>
<td>MAX for all models</td>
</tr>
</tbody>
</table>

**Note**

For programming accuracy and resolution, see the Specifications and Supplemental Characteristics in the Operating Guide.
Status Reporting

Power Supply Status Structure

Figure 4-1 shows the status register structure of the power supply. The Standard Event, Status Byte, and Service RequestEnable registers and the Output Queue perform standard GPIB functions as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The Operation Status and Questionable Status registers implement status functions specific to the power supply. Table 4-2 and Figure 4-1 show the bit configuration of each status register.

Operation Status Group

Register Functions

The Operation Status registers record signals that occur during normal operation. The group consists of the following registers:

- A Condition register that holds real-time status of the circuits being monitored. It is a read-only register.
- A PTR/NTR (positive transition/negative transition) Filter that functions as described under STAT:OPER:NTR|PTR COMMANDS in "Chapter 3 - Language Dictionary". This is a read/write register.
- An Event register that latches any condition that is passed through the PTR or NTR filters. Reading the Event register clears it.
- An Enable register that functions as described under STAT:OPER:ENAB in "Chapter 3 - Language Dictionary". This is a read/write register.

The outputs of the Operation Status group are logically-ORed into the OPER(ation) summary bit (7) of the Status Byte register.

Register Commands

Commands that access this group are derived from the STAT:OPER commands described in "Chapter 3 - Language Dictionary" and summarized in Table 4-1.

<table>
<thead>
<tr>
<th>Register</th>
<th>Command</th>
<th>Query</th>
<th>Cleared By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition</td>
<td>(None)</td>
<td>STAT:OPER:COND?</td>
<td>Cannot be cleared</td>
</tr>
<tr>
<td>PTR Filter</td>
<td>STAT:OPER:PTR &lt;NRf&gt;</td>
<td>STAT:OPER:PTR?</td>
<td>Programming 0</td>
</tr>
<tr>
<td>NTR Filter</td>
<td>STAT:OPER:NTR &lt;NRf&gt;</td>
<td>STAT:OPER:NTR?</td>
<td>Programming 0 or STAT:PRES</td>
</tr>
<tr>
<td>Event</td>
<td>(None)</td>
<td>STAT:OPER:EVEN?</td>
<td>Reading or *CLS</td>
</tr>
</tbody>
</table>
Table 4-2. Bit Configurations of Status Registers

<table>
<thead>
<tr>
<th>Bit</th>
<th>Signal</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>CAL</td>
<td>The interface is computing new calibration constants.</td>
</tr>
<tr>
<td>5</td>
<td>WTG</td>
<td>The interface is waiting for a trigger.</td>
</tr>
<tr>
<td>8</td>
<td>CV</td>
<td>The power module is in constant voltage mode.</td>
</tr>
<tr>
<td>10</td>
<td>CC</td>
<td>The power module is in constant current mode.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Operation Status Group</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bit</th>
<th>Signal</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>OPC</td>
<td>Operation complete.</td>
</tr>
<tr>
<td>2</td>
<td>QYE</td>
<td>Query error.</td>
</tr>
<tr>
<td>3</td>
<td>DDE</td>
<td>Device-dependent error.</td>
</tr>
<tr>
<td>4</td>
<td>EXE</td>
<td>Execution error.</td>
</tr>
<tr>
<td>5</td>
<td>CME</td>
<td>Command error.</td>
</tr>
<tr>
<td>7</td>
<td>PON</td>
<td>Power on.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Standard Event Status Group</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bit</th>
<th>Signal</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>QUES</td>
<td>Questionable status summary bit.</td>
</tr>
<tr>
<td>4</td>
<td>MAV</td>
<td>Message Available summary bit.</td>
</tr>
<tr>
<td>5</td>
<td>ESB</td>
<td>Event Status summary bit.</td>
</tr>
<tr>
<td>6</td>
<td>MSS</td>
<td>Master Status summary bit.</td>
</tr>
<tr>
<td>7</td>
<td>RQS</td>
<td>Request Service bit.</td>
</tr>
<tr>
<td>7</td>
<td>OPER</td>
<td>Operation status summary bit.</td>
</tr>
</tbody>
</table>

**Questionable Status Group**

<table>
<thead>
<tr>
<th>Bit</th>
<th>Signal</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>OV</td>
<td>The power module overvoltage protection circuit has tripped.</td>
</tr>
<tr>
<td>1</td>
<td>OC</td>
<td>The power module overcurrent protection circuit has tripped.</td>
</tr>
<tr>
<td>4</td>
<td>OT</td>
<td>The power module has an overtemperature condition.</td>
</tr>
<tr>
<td>9</td>
<td>RI</td>
<td>The power module remote inhibit state is active.</td>
</tr>
<tr>
<td>10</td>
<td>UNR</td>
<td>The power module output is unregulated.</td>
</tr>
</tbody>
</table>

**Figure 4-1. Power Supply Status Model**
Questionable Status Group

Register Functions

The Questionable Status registers record signals that indicate abnormal operation of the power supply. As shown in Figure 4-1, the group consists of the same type of registers as the Status Operation group. The outputs of the Questionable Status group are logically-ORed into the QUES(tionable) summary bit (3) of the Status Byte register.

Register Commands

Programming for this group is derived from the STAT:QUES commands described in "Chapter 3 - Language Dictionary" and summarized in Table 4-3.

<table>
<thead>
<tr>
<th>Register Condition</th>
<th>Command</th>
<th>Query</th>
<th>Cleared By</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTR Filter</td>
<td>STAT:QUES:PTR &lt;NRf&gt;</td>
<td>STAT:QUES:PTR?</td>
<td>Programming 0</td>
</tr>
<tr>
<td>NTR Filter</td>
<td>STAT:QUES:NTR &lt;NRf&gt;</td>
<td>STAT:QUES:NTR?</td>
<td>Programming 0 or STAT:PRES</td>
</tr>
<tr>
<td>Event</td>
<td>(None)</td>
<td>STAT:QUES:EVEN?</td>
<td>Reading or *CLS</td>
</tr>
</tbody>
</table>

Standard Event Status Group

Register Functions

This group consists of an Event register and an Enable register that are programmed by common commands. The Standard Event Status Event register latches events relating to interface communication status (see Table 4-1). It is a read-only register that is cleared when read.

Read query  *ESR!
Clear by    *CLS  *ESR?

The Standard Event Status Enable register functions similarly to the enable registers of the Operation and Questionable status groups.

Register Commands

The common *ESE command programs specific bits in the Standard Event Status Enable register. Because the power supply implements *PSC, the register is cleared at power on if *PSC = 1. *ESR? reads the Standard Event Status Event register and reading the register clears it.

Programmed by  *ESE <NRf>
Read query    *ESE?
Clear         *ESE 0
Status Byte Register

This register summarizes the information from all other status groups as defined in the "IEEE 488.2 Standard Digital Interface for Programmable Instrumentation" standard. The bit configuration is shown in Table 4-1. The register can be read either by a serial poll or by *STB?. Both methods return the same data, except for bit 6. Sending *STB? returns MSS in bit 6, while poring the register returns RQS in bit 6.

The RQS Bit

Whenever the power supply requests service, it sets the SRQ interrupt line true and latches RQS into bit 6 of the Status Byte register. When the controller services the interrupt, RQS is cleared inside the register and returned in bit position 6 of the response. The remaining bits of the Status Byte register are not disturbed.

The MSS Bit

This is a real-time (unlatched) summary of all Status Byte register bits that are enabled by the Service Request Enable register. MSS is set whenever the power supply has at least one reason (and possibly more) for requesting service. Sending *STB? reads the MSS in bit position 6 of the response. No bits of the Status Byte register are cleared by reading it.

Determining the Cause of a Service Interrupt

You can determine the reason for an SRQ by the following actions:

- Use a serial poll or the *STB? query to determine which summary bits are active.
- Read the corresponding Event register for each summary bit to determine which events caused the summary bit to be set. When an Event register is read, it is cleared. This also clears the corresponding summary bit.
- The interrupt will recur until the specific condition that caused each event is removed. If this is not possible, the event may be disabled by programming the corresponding bit of the status group Enable register or NTR|PTR filter. A faster way to prevent the interrupt is to disable the service request by programming the appropriate bit of the Service Request Enable register.

Service Request Enable Register

This register is a mask that determines which bits from the Status Byte register will be ORed to generate a service request (SRQ). The register is programmed with the *SRE common command. When the register is cleared, no service requests can be generated to the controller.

Output Queue

The Output Queue is a first-in, first-out (FIFO) data register that stores power supply-to-controller messages until the controller reads them. Whenever the queue holds one or more bytes, it sets the MAV bit (4) of the Status Byte register. If too many unread error messages are accumulated in the queue, a system error message is generated (see Table 5-1 in "Chapter 5 - Error Messages"). The Output Queue is cleared at power on and by *CLS.

Initial Conditions At Power On

Status Registers

When the power supply is turned on, a sequence of commands initializes the status registers. For the factory-default *RST power-on state, Table 4-4 shows the register states and corresponding power-on commands.
<table>
<thead>
<tr>
<th>Register</th>
<th>Condition</th>
<th>Caused By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation PTR; Questionable PTR</td>
<td>All bits = 1</td>
<td>STAT:PRE</td>
</tr>
<tr>
<td>Operation NTR; Questionable NTR</td>
<td>All bits = 0</td>
<td>STAT:PRE</td>
</tr>
<tr>
<td>Operation Event; Questionable Event</td>
<td>All bits = 0</td>
<td>*CLS</td>
</tr>
<tr>
<td>Operation Enable; Questionable Enable</td>
<td>All bits = 0</td>
<td>STAT:PRE</td>
</tr>
<tr>
<td>Standard Event Status Enable</td>
<td>All bits = 0</td>
<td>*ESE 0</td>
</tr>
<tr>
<td>Status Byte</td>
<td>All bits = 0</td>
<td>*CLS</td>
</tr>
<tr>
<td>Status Request Enable</td>
<td>All bits = 0</td>
<td>*SRE 0</td>
</tr>
<tr>
<td>Output Queue</td>
<td>Cleared</td>
<td>*CLS</td>
</tr>
</tbody>
</table>

1If PSC=1. If PSC = 0, then the last previous state before turn on is recalled. The value of PSC is stored in nonvolatile memory.

The PON (Power-On) Bit

The PON bit in the Standard Event register is set whenever the power supply is turned on. The most common use for PON is to generate an SRQ at power on following an unexpected loss of power. To do this, bit 7 of the Standard Event Enable register must be set so that a power-on event registers in the ESB (Standard Event Summary Bit). Also, bit 5 of the Service Request Enable register must be set to permit an SRQ to be generated. The commands to accomplish these two conditions are:

*ESE 128
*SRE 32

If *PSC is programmed to 0, the contents of the Standard Event Enable and Service RequestEnable registers are saved in nonvolatile memory and recalled at power on. This allows a PON event to generate SRQ at power on. Programming *PSC to 1 prevents these registers from being saved and they are cleared at power on. This prevents a PON event from generating SRQ at power on.

Examples

Note
These examples are generic SCPI commands. See "Chapter 2 - Remote Programming" for information about encoding the commands as language strings.

Servicing an Operation Status Mode Event

This example assumes you want a service request generated whenever the power supply switches to the CC (constant current) mode. From Figure 4-1, note that the required path is for a condition at bit 10 (CC) of the Operation Status register to set bit 6 (RQS) of the Status Byte register. The required register programming is shown in Table 4-5.
Table 4-5. Generating RQS from the CC Event

<table>
<thead>
<tr>
<th>Register</th>
<th>Command</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation PTR</td>
<td>STAT:OPER:PTR 1024</td>
<td>Allows a positive transition at the CC input (bit 10) to be latched into the Status Event register.¹</td>
</tr>
<tr>
<td>Operation Enable</td>
<td>STAT:OPER:ENAB 1024</td>
<td>Allows the latched CC event to be summed into the OPER summary bit.</td>
</tr>
<tr>
<td>Service Request Enable</td>
<td>*SRE 128</td>
<td>Enables the OPER summary bit from the Status Byte register to generate RQS.</td>
</tr>
<tr>
<td>Operation Condition</td>
<td>STAT:OPER:EVEN?</td>
<td>When you service the request, read the event register to determine that bit 10 (CC) is set and to clear the register for the next event.</td>
</tr>
</tbody>
</table>

¹ All bits of the PTR registers bits are set to 1 at power on or in response to STAT:PRES.

Adding More Operation Events

To add the CV (constant voltage) event to this example, it is only necessary to add the decimal values for bit 8 (value 64) to the programming commands of the Operation Status group. The commands to do this are:

```
STAT:OPER:PTR 1280;ENAB 1280
```

It is not necessary to change any other registers, since the programming for the operation summary bit (OPER) path has already been done.

Servicing Questionable Status Events

To add OC (overcurrent) and OT (overtemperature) events to this example, program Questionable Status group bits 1 and 4.

```
STAT:QUES:PTR 18;ENAB 18
```

Next, you must program the Service Request Enable register to recognize both the questionable (QUES) and the operational (OPER) summary bits.

```
*SRE 136
```

Now when there is a service request, read back both the operational and the questionable event registers.

```
STAT:OPER:EVEN?;QUES:EVEN?
```

Monitoring Both Phases of a Status Transition

You can monitor a status signal for both its positive and negative transitions. For example, to generate RQS when the power supply either enters the CC (constant current) condition or leaves that condition, program the Operational Status PTR/NTR filter as follows:

```
STAT:OPER:PTR 1024;NTR 1024
STAT:OPER:ENAB 1024;*SRE 128
```

The PTR filter will cause the OPER summary bit to set RQS when CC occurs. When the controller subsequently reads the event register (STAT: OPER: EVEN?), the register is cleared. When CC subsequently goes false, the NTR filter causes the OPER summary bit to again set RQS.
SCPI Command Completion

SCPI commands sent to the power supply are processed either sequentially or in parallel. Sequential commands finish execution before a subsequent command begins. A parallel command can begin execution while a preexisting command is still executing (overlapping commands). Commands that affect trigger actions are among the parallel commands.

The *WAI, *OPC, and *OPC? common commands provide different ways of indicating when all transmitted commands, including any parallel ones, have completed their operations. The syntax and parameters for these commands are described in "Chapter 3 - Language Dictionary". Some practical considerations for using these commands are as follows:

*WAI  This prevents the power supply from processing subsequent commands until all pending operations are completed. If something prevents completion of an existing operation, *WAI can place the power supply and the controller in a "hang-up" condition.

*OPC?  This places a 1 in the Output Queue when all pending operations have completed. Because it requires your program to read the returned value from the queue before executing the next program statement, *OPC? could prevent subsequent commands from being executed.

*OPC  This sets the OPC status bit when all pending operations have completed. Since your program can read this status bit on an interrupt basis, *OPC allows subsequent commands to be executed.

The trigger subsystem must be in the Idle state in order for the status OPC bit to be true. Therefore, as far as triggers are concerned, OPC is false whenever the trigger subsystem is in the Initiated state. However, OPC is also false if there are any commands still pending.

Note  For a detailed discussion of *WAI, *OPC and *OPC?, see "Device/Controller Synchronization Techniques" in ANSI/IEEE Std 488.2.

DFI (Discrete Fault Indicator)

Whenever a fault is detected in the power supply, it is capable of generating a FLT signal at the digital port (see "Appendix D - Digital Port Functions" in the power supply Operating Guide). The source for the DFI signal can be any Questionable, Operation, or Standard Event status event (see Figure 4-1).

RI (Remote Inhibit)

Whenever a remote inhibit signal is received at the digital port (see “Appendix D - Digital Port Functions” in the power supply Operating Guide), the power supply will receive an RI event at the Questionable Status register. By programming the status subsystem, you may use RI to generate a service request (SRQ) to the controller and/or to create a DFI output at the digital port. By using RI/DFI in this way, you can chain the power supplies to create a serial shutdown in response to the INH input.
Error Messages

Power Supply Hardware Error Messages

Front panel error messages resulting from selftest errors or runtime failures are described in “Chapter 3 - Turn-On Checkout” of the power supply Operating Guide.

Calibration Error Messages

Front panel error messages resulting from calibration errors are described in Appendix A of the power supply Operating Guide.

System Error Messages

System error messages are obtained remotely with the SYST:ERR? query or by pressing the front panel key. The error number is the value placed in the error queue. SYST:ERR? returns the error number into a variable and combines the number and the error message into a string. Table 5-1 lists the system errors that are associated with SCPI syntax errors and with interface problems. Information inside the brackets is not part of the standard error message, but is included for clarification. When system errors occur, the Standard Event Status register (see "Chapter 4 - Status Reporting") records them as follows:

<table>
<thead>
<tr>
<th>Bit Set</th>
<th>Error Code</th>
<th>Error Type</th>
<th>Bit Set</th>
<th>Error Code</th>
<th>Error Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>-100 thru -199</td>
<td>Command</td>
<td>3</td>
<td>-300 thru -399</td>
<td>Device-dependent</td>
</tr>
<tr>
<td>4</td>
<td>-200 thru -299</td>
<td>Execution</td>
<td>2</td>
<td>-400 thru -499</td>
<td>Query</td>
</tr>
</tbody>
</table>

Table 5-1. Summary of System Error Messages

<table>
<thead>
<tr>
<th>Error Number</th>
<th>Error String [Description/Explanation/Examples]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-100</td>
<td>Command error [generic command error]</td>
</tr>
<tr>
<td>-101</td>
<td>Invalid character</td>
</tr>
<tr>
<td>-102</td>
<td>Syntax error [unrecognized command or data type]</td>
</tr>
<tr>
<td>-103</td>
<td>Invalid separator [illegal character encountered in place of separator]</td>
</tr>
<tr>
<td>-104</td>
<td>Data type error [e.g., “numeric or string expected, got block date”]</td>
</tr>
<tr>
<td>-105</td>
<td>GET not allowed [ &lt;GET&gt; inside a program message]</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 [syntactical correct but not defined for this device]</td>
</tr>
<tr>
<td>-121</td>
<td>Invalid character in number [e.g. alpha in decimal data, etc.]</td>
</tr>
<tr>
<td>-123</td>
<td>Exponent too large [ numeric overflow; exponent magnitude &gt;32000]</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 [numeric data not accepted where positioned]</td>
</tr>
<tr>
<td>-131</td>
<td>Invalid suffix [unrecognized suffix, or suffix not appropriate]</td>
</tr>
<tr>
<td>-138</td>
<td>Suffix not allowed [numeric element does not allow suffixes]</td>
</tr>
<tr>
<td>Error Number</td>
<td>Error String [Description/Explanation/Examples]</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>141</td>
<td>Invalid character data [bad character, or unrecognized]</td>
</tr>
<tr>
<td>144</td>
<td>Character data too long [maximum length is 12 characters]</td>
</tr>
<tr>
<td>148</td>
<td>Character data not allowed [character data not accepted where positioned]</td>
</tr>
<tr>
<td>150</td>
<td>String data error [generic string error]</td>
</tr>
<tr>
<td>151</td>
<td>Invalid string data [e.g., END received before close quote]</td>
</tr>
<tr>
<td>158</td>
<td>String data not allowed [string data not accepted where positioned]</td>
</tr>
<tr>
<td>160</td>
<td>Block data error [generic data block error]</td>
</tr>
<tr>
<td>161</td>
<td>Invalid block data [e.g., END received before length satisfied]</td>
</tr>
<tr>
<td>168</td>
<td>Block data not allowed [block data not accepted where positioned]</td>
</tr>
<tr>
<td>220</td>
<td>Parameter error</td>
</tr>
<tr>
<td>221</td>
<td>Settings conflict [uncoupled parameters]</td>
</tr>
<tr>
<td>222</td>
<td>Data out of range [e.g., outside the range of this device]</td>
</tr>
<tr>
<td>223</td>
<td>Too much data [out of memory; block, string, or expression too long]</td>
</tr>
<tr>
<td>240</td>
<td>Hardware error [device-dependent]</td>
</tr>
<tr>
<td>241</td>
<td>Hardware missing [device-dependent]</td>
</tr>
<tr>
<td>310</td>
<td>System error [device-dependent]</td>
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<tr>
<td>313</td>
<td>Calibration memory lost [out of calibration due to memory failure]</td>
</tr>
<tr>
<td>330</td>
<td>Self-test failed [more specific data after “;”]</td>
</tr>
<tr>
<td>350</td>
<td>Queue overflow [errors lost due to too many errors in queue]</td>
</tr>
<tr>
<td>400</td>
<td>Query error [generic query error]</td>
</tr>
<tr>
<td>410</td>
<td>Query INTERRUPTED [query followed by DAB or GET before response complete]</td>
</tr>
<tr>
<td>420</td>
<td>Query UNTERMINATED [addressed to talk, incomplete programming message received]</td>
</tr>
<tr>
<td>430</td>
<td>Query DEADLOCKED [too many queries in command string]</td>
</tr>
<tr>
<td>440</td>
<td>Query UNTERMINATED [query received after query for indefinite response]</td>
</tr>
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</table>
SCPI Conformance Information

Note See Chapter 3 - Language Dictionary for command syntax.

SCPI Version

This power supply conforms to Version 1990.0.

SCPI Confirmed Commands

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<th>Command</th>
<th>Command</th>
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<td>TRIG[:STAR]: DEL</td>
</tr>
<tr>
<td>CAL[:STAT]</td>
<td>OUTP: PROT: DEL?</td>
<td>TRIG[:STAR]: DEL?</td>
</tr>
<tr>
<td>[SOUR]: CURR[:LEV][:IMM][:AMPL]</td>
<td>STAT: OPER[:EVEN]?</td>
<td>TRIG[:STAR]: SOUR</td>
</tr>
<tr>
<td>[SOUR]: CURR[:LEV][:IMMI][:AMPL]?</td>
<td>STAT: OPER: COND?</td>
<td>TRIG[:STAR]: SOUR</td>
</tr>
<tr>
<td>(SOUR): CURR[:LEV]: TRIG[:AMPL]?</td>
<td>STAT: OPER: ENAB?</td>
<td>[SOUR]: VOLT[:LEV][:IMMI][:AMPL]?</td>
</tr>
<tr>
<td>[SOUR]: CURR[: PROT]: STAT</td>
<td>STAT: OPER: NTR</td>
<td>[SOUR]: VOLT[:LEV][:TRIG][:AMPL]</td>
</tr>
<tr>
<td>[SOUR]: CURR[: PROT]: STAT?</td>
<td>STAT: OPER: NTR?</td>
<td>[SOUR]: VOLT[:LEV][:TRIG][:AMPL]?</td>
</tr>
<tr>
<td>DISP[: WIND][:STAT]</td>
<td>STAT: OPER: PTR</td>
<td>[SOUR]: VOLT[: PROT][:LEV]</td>
</tr>
<tr>
<td>DISP[: WIND][: STAT]?</td>
<td>STAT: OPER: PTR?</td>
<td>[SOUR]: VOLT[: PROT][:LEV]?</td>
</tr>
<tr>
<td>DISP[: WIND]: TEXT[:DATA]</td>
<td>STAT: PRES</td>
<td>*CLS *RCL</td>
</tr>
<tr>
<td>DISP[: WIND]: TEXT[:DATA]?</td>
<td>STAT: QUES[:EVEN]?</td>
<td>*ESE *RST</td>
</tr>
<tr>
<td>INIT: CONT</td>
<td>STAT: QUES: ENAB</td>
<td>*ESR? *SRE</td>
</tr>
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<td>MEAS: CURR[: DC]?</td>
<td>SYST: ERR?</td>
<td>*OPC *STB?</td>
</tr>
<tr>
<td>MEAS: VOLT[: DC]?</td>
<td>SYST: LANG</td>
<td>*OPC? *TRG</td>
</tr>
<tr>
<td>OUTP[: STAT]</td>
<td>SYST: LANG?</td>
<td>*PSC *TST?</td>
</tr>
<tr>
<td>OUTP[: STAT]?</td>
<td>SYST: VERS?</td>
<td>*PSC? *WAI</td>
</tr>
<tr>
<td>OUTP: PROT: CLE</td>
<td>TRIG[:STAR][: IMM]</td>
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¹See Appendix A - Calibration in the Operating Guide for CAL commands.

SCPI Approved Commands

(None)
## NON-SCPI Commands

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<th>Command</th>
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<td>CAL:VOLT:PROT</td>
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<td>CAL:PASS</td>
<td>[SOUR]:DIG:DATA[:VAL]?</td>
<td>OUTP:REL[:STAT]?</td>
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<td>CAL:SAV</td>
<td>DISP[:WIND]:MODE</td>
<td>[SOUR]:VOLT:PROT[:AMPL]</td>
</tr>
<tr>
<td>CAL:VOLT[:DATA]</td>
<td>DISP[:WIND]:MODE?</td>
<td>[SOUR]:VOLT:PROT[:AMPL]?</td>
</tr>
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1See Appendix A - Calibration in the Operating Guide for CAL commands.
Compatibility Language

The Keysight Series 664xA, 665xA, 667xA, 668xA, and 669xA Power Supplies are programatically compatible with the Keysight 603xA Series AutoRanging Power Supplies (ARPS). This means that you can program the Keysight 664xA, 665xA, 667xA, 668xA, and 669xA supplies over the GPIB using the ARPS commands. Software that you have written for the autoranging power supplies can also be adapted to program the above supplies.

Note: The Keysight 664xA, 665xA, 667xA, 668xA, and 669xA serial link is not supported by ARPS commands. You can use only a GPIB primary address for the power supply.

To switch from SCPI commands to ARPS commands (and vice versa), use the SYST:LANG command. This command is documented in "Chapter 3 - Language Dictionary".

Table B-1 summarizes the ARPS commands that program the supplies. You will need to refer to the Series 603xA power supply manual[1] for complete information on the ARPS commands. Some of the ARPS commands are similar to SCPI commands, but others are unique to ARPS. For example, the ARPS FOLD commands have no function with the Series 664xA, 665xA, 667xA, 668xA, and 669xA supplies. Similarly, there are some SCPI commands that have no ARPS function.

Note: Parallel Polling:
When programmed for parallel polling and Compatibility Language, power supplies operating under the Keysight BASIC system can "hang up" the GPIB when the system is turned on. This can occur under the following conditions:

- The controller uses CS80 Protocol for an external disk drive (for example, the Keysight 9133D).
- The external disk drive and the power supply have the same select code and that code is 7 or less.
- The external disk drive and power supply addresses are binary complements of each other (e.g., 0 & 7, 1 & 6, etc.).

When the system is turned on, the power supply accesses the GPIB before the controller and prevents it from accessing the external disk drive. The solution is to change one of the GPIB addresses, or to ensure that the power supply is not turned on until after the controller has completed its selftest and has control of the GPIB.

---

1 This manual is listed in the Chapter 1 "Replaceable Parts" table of the power supply Operating Guide.
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<thead>
<tr>
<th>ARPS Command</th>
<th>Description</th>
<th>Similar SCPI Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSET x</td>
<td>These commands program output voltage. See Table 3-1 for the programming ranges of these commands. Initial condition: 0 V</td>
<td>VOLT</td>
</tr>
<tr>
<td>VSET xV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSET xMV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISET x</td>
<td>These commands program output current. See Table 3-1 for the programming ranges for these commands. Initial condition: 0 A</td>
<td>CURR</td>
</tr>
<tr>
<td>ISET xA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISET xMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSET?</td>
<td>These commands read voltage or current settings.</td>
<td>VOLT?</td>
</tr>
<tr>
<td>ISET?</td>
<td></td>
<td>CURR?</td>
</tr>
<tr>
<td>VOUT?</td>
<td>These commands measure and read output voltage or current.</td>
<td>MEAS:VOLT?</td>
</tr>
<tr>
<td>IOUT?</td>
<td></td>
<td>MEAS:CURR?</td>
</tr>
<tr>
<td>OVP x</td>
<td>NOTE: OVP commands do not work with Keysight 603xA supplies. These commands program the overvoltage protection. The OVP setting is programmed in either volts or millivolts. See Table 3-1 for the programming ranges of these commands. Initial condition: 10% above rated output.</td>
<td>VOLT:PROT</td>
</tr>
<tr>
<td>OVP xV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVP xMV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OVP?</td>
<td>This command reads the OVP setting.</td>
<td>VOLT:PROT?</td>
</tr>
<tr>
<td>VMAX x</td>
<td>These commands program an upper limit (soft limit) to the voltage programming value that the power supply will accept. The programming ranges are the same as those used for VSET.</td>
<td>(None)</td>
</tr>
<tr>
<td>VMAX xV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMAX xMV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMAX x</td>
<td>These commands program an upper limit (soft limit) to the current programming value that the power supply will accept. The programming ranges are the same as those used for ISET.</td>
<td>(None)</td>
</tr>
<tr>
<td>IMAX xA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IMAX xMA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMAX?</td>
<td>These commands read the soft voltage or current limits.</td>
<td>(None)</td>
</tr>
<tr>
<td>IMAX?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DLY x</td>
<td>These commands program the delay time before a new output voltage or current is implemented or an RST, OUT ON, or CLR command is received. During the delay the CV, CC, and CR conditions cannot be reported as faults, and foldback protection is disabled.</td>
<td>OUTP:PROT:DEL</td>
</tr>
<tr>
<td>DLY xS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DLY xMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DLY?</td>
<td>This command reads the delay time setting.</td>
<td>OUTP:PROT:DEL?</td>
</tr>
<tr>
<td>OUT OFF</td>
<td>These commands enable or disable the power supply output. The disabled state programs the output to relatively low voltage and current values. The supply will be able to implement commands even while the output is disabled. Initial condition: OUT ON</td>
<td>OUTP:STAT OFF</td>
</tr>
<tr>
<td>OUT 0</td>
<td></td>
<td>OUTP:STAT 0</td>
</tr>
<tr>
<td>OUT ON</td>
<td></td>
<td>OUTP:STAT ON</td>
</tr>
<tr>
<td>OUT 1</td>
<td></td>
<td>OUTP:STAT 1</td>
</tr>
<tr>
<td>FOLD OFF</td>
<td>These commands enable or disable Foldback protection. Foldback protection disables the power supply output if the power supply switches to whichever mode (CV or CC) is defined as the fold (error) condition. Note that foldback protection is disabled during the DELAY period. Initial condition: FOLD OFF</td>
<td>(None)</td>
</tr>
<tr>
<td>FOLD CC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLD 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLD 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLD CV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLD 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLD CC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLD 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FOLD?</td>
<td>This command reads the Foldback setting.</td>
<td>(None)</td>
</tr>
</tbody>
</table>

\(^1\) x = any digit (within range) \ MA = milliampere \ MV = millivolt \ MS = millisecond
### Table B-1. ARPS Commands (continued)

<table>
<thead>
<tr>
<th>ARPS Command</th>
<th>Description</th>
<th>Similar SCPI Command</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RST</strong></td>
<td>This command resets the power supply if the output is disabled by the overvoltage, remote inhibit, or foldback protection circuits. The power supply resets to the parameters stored for the power on state. Note that the settings can be changed while the supply is disabled.</td>
<td>OUTP:PROT:CLE</td>
</tr>
<tr>
<td><strong>HOLD OFF</strong></td>
<td>These commands determine if certain newly received commands are immediately acted on by the power supply or are acted on later while the supply continues to operate with previously received values. <strong>HOLD ON</strong> can be used to synchronize power supply actions with the actions of other GPIB devices. (See the TRG command.) Initial condition: <strong>HOLD OFF</strong></td>
<td>VOLT:TRIG CURR:TRIG</td>
</tr>
<tr>
<td><strong>HOLD?</strong></td>
<td>This command reads the HOLD setting.</td>
<td>VOLT:TRIG? CURR:TRIG?</td>
</tr>
<tr>
<td><strong>TRG</strong></td>
<td>These commands cause the power supply to act on commands that have been previously sent, but are being held (pending). The supply continues to operate with previously received values until a trigger command is received (see HOLD command.) The device trigger interface message performs the same function.</td>
<td>INIT ON;TRIG INIT ON;*TRG</td>
</tr>
<tr>
<td><strong>STO RCL</strong></td>
<td>These commands cause the power supply to store and recall power supply states, except for output on/off. Each state includes: voltage (1st and 2nd rank), current (1st and 2nd rank), soft voltage and current limit, delay time, service request on/off, foldback (1st and 2nd rank), and hold. Initial condition: Each register is initiated to the turn-on values.</td>
<td>*SAV *RCL</td>
</tr>
<tr>
<td><strong>STS?</strong></td>
<td>This command reads the contents of the status register, which maintains the present status of the power supply.</td>
<td>STAT:OPER:COND? STAT:QUES:COND? *ESE?</td>
</tr>
<tr>
<td><strong>ASTS?</strong></td>
<td>This command reads the contents of the accumulated status register, which stores any bit condition entered in the status register since the accumulated status register was last read, regardless of whether the condition still exists.</td>
<td>STAT:OPER? STAT:QUES? *ESE?</td>
</tr>
<tr>
<td><strong>UNMASK</strong></td>
<td>These commands determine the conditions that will set bits in the fault register, allowing the operator to define the conditions that will be reported as faults. Fault conditions can be enabled by sending a string of status register mnemonics after the <strong>UNMASK</strong> command. The mnemonics must be separated by commas, and may be sent in any order, but must correspond to the condition that will be enabled. Fault conditions can also be enabled by sending the decimal equivalent of the total bit weight of all conditions to be enabled. <strong>UNMASK NONE</strong> disables all conditions from setting bits in the fault register. Initial condition: <strong>UNMASK NONE</strong></td>
<td>STAT:OPER:ENAB STAT:QUES:ENAB *ESE</td>
</tr>
</tbody>
</table>

**mnemonics**

XXX
<table>
<thead>
<tr>
<th>ARPS Command</th>
<th>Description</th>
<th>Similar SCPI Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNMASK?</td>
<td>This command reads which bits in the status register have been enabled as fault conditions. The decimal equivalent of the total bit weight of all enabled bits is returned.</td>
<td>STAT:OPER:ENAB? STAT:QUES:ENAB? ESE</td>
</tr>
<tr>
<td>FAULT?</td>
<td>This command reads which bits have been set in the fault register. A bit is set in the fault register when the corresponding bit in the status register changes from inactive to active AND the corresponding bit in the mask register has been enabled. The fault register is reset only after it has been read. The decimal equivalent of the total bit weight of all enabled bits is returned.</td>
<td>STAT:OPER? STAT:QUES? *ESE</td>
</tr>
<tr>
<td>SRQ OFF</td>
<td>These commands enable or disable the power supply's ability to request service from the controller for fault conditions. UNMASK defines which conditions are defined as faults. Initial condition: SRQ OFF</td>
<td>*SRE</td>
</tr>
<tr>
<td>SRQ OFF</td>
<td>SRQ 0</td>
<td>SR*Q ON</td>
</tr>
<tr>
<td>SRQ 1</td>
<td>SRQ 1</td>
<td>*RST</td>
</tr>
<tr>
<td>SRQ?</td>
<td>This command reads the SRQ setting.</td>
<td>*SRE?</td>
</tr>
<tr>
<td>CLR</td>
<td>This command initializes the power supply to the power-on state. It also resets the PON bit in the serial poll register. The command performs the same function as the Device Clear (DCL) interface message.</td>
<td>*RST</td>
</tr>
<tr>
<td>ERR?</td>
<td>This command determines the type of programming error detected by the supply. A remote programming error sets the ERR bit in the status register, which can be enabled by UNMASK to request service.</td>
<td>SYST:ERR?</td>
</tr>
<tr>
<td>TEST?</td>
<td>This command causes the power supply to run selftest and report any detected failures.</td>
<td>*TST?</td>
</tr>
<tr>
<td>ID?</td>
<td>This command causes the power supply to report its model number and any options that affect the supply's output.</td>
<td>*IDN?</td>
</tr>
<tr>
<td>SYST:LANG</td>
<td>This command causes the alternate language to become active and to be stored in nonvolatile memory. In this case, the commands are equivalent. After being shut off, the power supply will resume in the last-selected language when power is restored. The parameter must be either COMP or TMSL, not SCPI.</td>
<td>SYST:LANG</td>
</tr>
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Measurement Assistance Center
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Tokyo 192-8510, Japan
(tel) (81) 426 56 7832
(fax) (81) 426 56 7840

**Latin America:**
Keysight Technologies
Latin American Region Headquarters
5200 Blue Lagoon Drive, Suite #950
Miami, Florida 33126
U.S.A.
(tel) (305) 267 4245
(fax) (305) 267 4286

**Australia/New Zealand:**
Keysight Technologies Australia Pty Ltd
347 Burwood Highway
Forest Hill, Victoria 3131
(tel) 1-800 629 485 (Australia)
(fax) (61 3) 9272 0749
(tel) 0 800 738 378 (New Zealand)
(fax) (64 4) 802 6881

**Asia Pacific:**
Keysight Technologies
24/F, Cityplaza One, 1111 King's Road,
Taikoo Shing, Hong Kong
tel: (852)-3197-7777
fax: (852)-2506-9284

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