360 VECTOR NETWORK ANALYZER

GPIB PROGRAMMING MANUAL

Software Version 3.07

Wiltron

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SECTION I
GENERAL GPIB INFORMATION

1-1 INTRODUCTION

This manual describes remote operation of the WILTRON 360 Vector Network Analyzer using IEEE-488 Interface Function Messages and 360 GPIB Commands (i.e., Product Specific Commands). The software version supported by this manual is Version 3.07.

Included is a description of the IEEE-488 General Purpose Interface Bus (GPIB) hardware and the bus data transfer and control functions. Also included is a brief introduction to GPIB programming, including considerations for preparing GPIB programs for the 360 Vector Network Analyzer (VNA). All 360 VNA GPIB commands currently used are listed and described.

The information about the IEEE-488 interface bus presented in this manual is general in nature. For complete and specific information, refer to the ANSI/IEEE Std 488-1978 document entitled "IEEE Standard Digital Interface for Programmable Instrumentation". This document precisely defines the set of dedicated hardware signal lines, interface functions, protocols, and messages for the interface bus.

1-1.1 Relationship of This Manual to Other 360 VNA Manuals

This manual is intended to be used in conjunction with the 360 Vector Network Analyzer System Operation Manual. Refer to that manual for general information about the 360 VNA, including equipment set up and manual mode operating instructions. Section I of that manual lists and describes all 360 VNA documentation set manuals, including test set and software manuals.

1-1.2 How to Use This Manual

Only information pertinent to 360 VNA GPIB programming is provided in this manual. Familiarity with manual (front panel) operation of the 360 VNA is assumed. System operating details are given in this manual only if they are unique to the GPIB operating mode, or are different than when operated in the normal manual mode.

This section of the manual describes the manual and contains a brief description of the GPIB hardware and the GPIB data transfer and control functions. If you are already familiar with this material, this section may be skipped. The remainder of the manual is organized as follows:

- Section II — Introduction to GPIB Programming for the 360 VNA — contains a brief introduction to GPIB programming techniques and describes procedures to be used when preparing GPIB programs for the 360 VNA. If you are already familiar with this material, this section may be skipped.

- Sections III, IV and V — describe the 360 GPIB commands used for Basic Front Panel Functions, Calibration Functions and Advanced Programming/GPIB Unique Functions, respectively. The programming information and tables containing the command descriptions are grouped *by function* in these sections. Use this information as a tutorial and for reference when preparing programs.

- The Functional Index Of Commands — lists the 360 GPIB commands by function and references the paragraph, table and page number where the descriptions for that group of commands are located in Sections III thru V.

- 360 GPIB Quick Reference Guide — This separately bound document is located behind the last section tab of this manual. It lists the 360 GPIB commands *alphabetically* and references the location in Sections III thru V of this manual where information for each command is located. The listing in this guide for each command includes a brief description of the command function and associated parameters. Use this guide as a quick reference when preparing programs.

1-1.3 Command Categories Used in This Manual

The 360 VNA GPIB interface responds to more than 400 commands to implement the set of 360 network analyzer functions. For descriptive purposes, these commands are organized into the following functional classifications:

a. Basic Front Panel Functions

These commands produce basic 360 VNA measurement operations identical to those produced by the corresponding key functions on the 360 front panel. These commands are described in Section III.

b. Calibration Functions

The set of calibration commands can be used to set up the calibration parameters under program control and to guide an operator through the 360 VNA calibration process. These commands are described in Section IV.

c. GPIB Unique Functions

These commands produce 360 VNA operations that are unique to the GPIB mode of operation or are operations that are best done using computer control of the system. They are described in Section V.

1-2 DESCRIPTION OF THE IEEE-488 (IEC-625) INTERFACE BUS

The IEEE-488 General Purpose Interface Bus (GPIB) is an instrumentation interface for integrating instruments, computers, and other controllers into systems. The bus uses 16 signal lines to effect transfer of data and commands to all instruments connected on the bus.

No more than 15 instruments may be connected to the interface bus (however, a system may contain more than one interface bus). The maximum total accumulative cable length for one interface bus may not exceed twice the number of instruments connected (in meters) , or 20 meters—whichever is less.

The instruments on the bus are connected in parallel, as shown in Figure 1-1. Eight of the signal lines (DIO1 thru DIO8) are used for the transfer of data and other messages in a byte-serial, bit-parallel form. The remaining eight lines are used for communications timing (handshake), control, and status information. Data are transmitted on the eight GPIB data lines as a series of eight-bit characters, referred to as bytes.

Data transfer is by means of an interlocked handshake technique (Figure 1-2). This technique permits asynchronous communications over a wide range of data rates. The following paragraphs provide an overview of the data, and handshake buses, and describe how these buses interface with the 360 VNA.

1-2.1 IEEE-488 Hardware Interface

The IEEE-488 interface bus hardware implementation is made up of 16 signal lines that comprise three functional groups; see Figure 1-1.

- Data Bus (8 lines)
- Data Byte Transfer Control Bus (3 lines)
- General Interface Management Bus (5 lines)

The signal lines in each of the three groups are designated according to function. Table 1-1 lists these designations.

1-2.2 Data Byte Transfer Control Bus Description

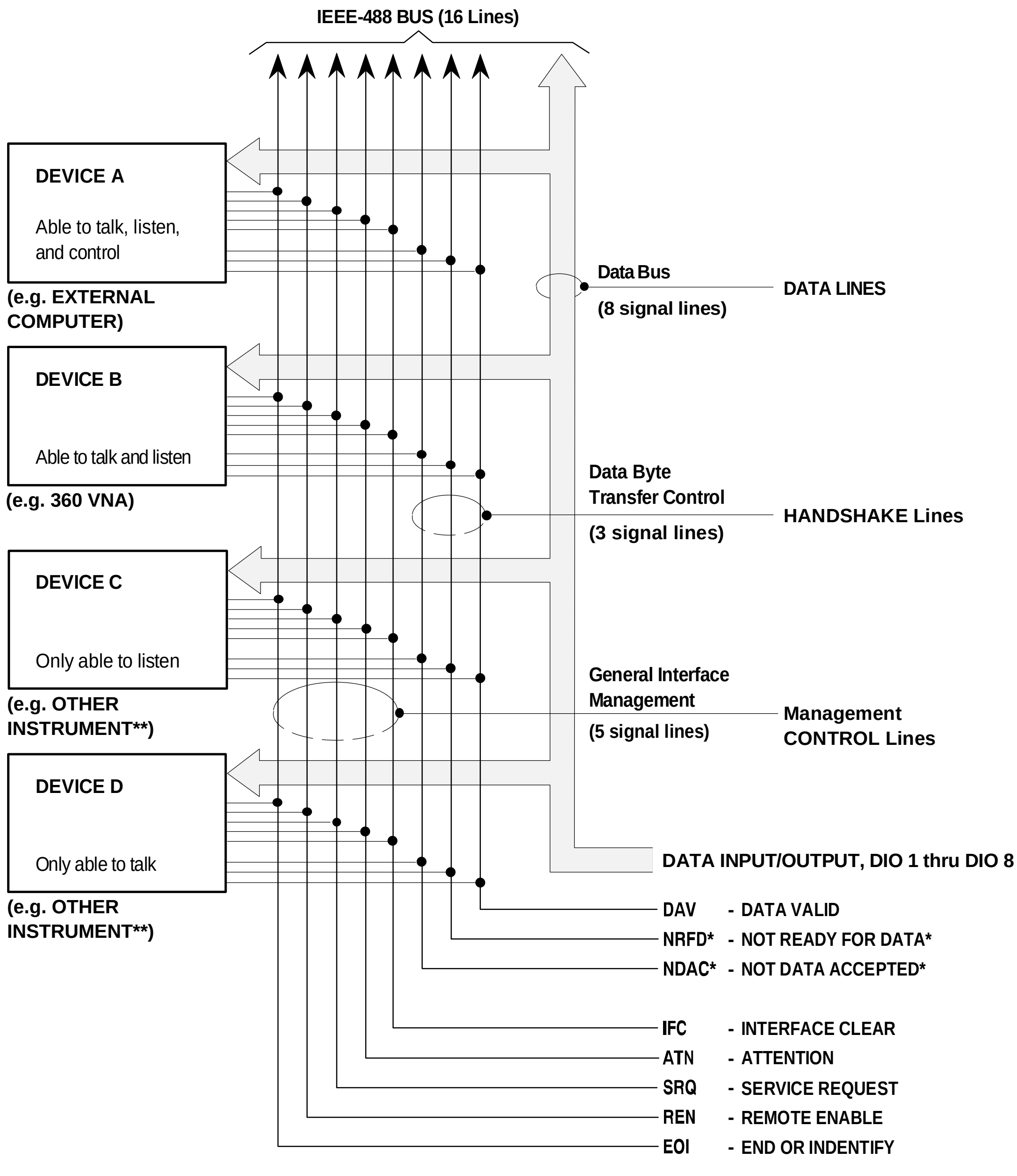
Control of information transfer on the GPIB data Bus is accomplished by a technique called the “three-wire handshake”, which involves the three signal lines of the Data Byte Transfer Control Bus. This technique is described briefly below and is depicted in Figure 1-2. For further information, refer to the ANSI/IEEE Std 488-1978 document.

a. DAV (Data Valid)

This line goes TRUE (arrow 1) when the talker has (1) sensed that NRFD is FALSE, (2) placed a byte of data on the bus, and (3) waited an appropriate length of time for the data to settle.

Table 1-1. Interface Bus Signal Line Designations

BUS TYPE	SIGNAL LINE	
	Name	**Function**
Data Bus	DIO1–DIO8	Data Input/Output, 1 thru 8
Data Byte Transfer and Control	DAV NRFD NDAC	Data Available Not Ready For Data Not Data Accepted
General Interface Control	ATN IFC SRQ REN EOI	Attention Interface Clear Service Request Remote Enable End Or Identify



Note: The configuration shown in this diagram depicts an external computer connected via GPIB to a 360 VNA and other microwave instruments. The second *dedicated* GPIB that is part of the 360 VNA is not shown (refer to Figure 2-1 in the next section).

* NEGATION IS REPRESENTED BY LOW STATE ON THESE TWO LINES
** IF USED

Figure 1-1. Interface Connections and Bus Structure

b. NRFD (Not Ready For Data)

This line goes TRUE (arrow 2) when a listener indicates that valid data has not yet been accepted. The time between the events shown by arrows 1 and 2 is variable and depends upon the speed with which a listener can accept the information.

c. NDAC (Not Data Accepted)

This line goes FALSE to indicate that a listener has accepted the current data byte for internal processing. When the data byte has been accepted, the listener releases its hold on NDAC and allows the line to go FALSE. However, since the GPIB is constructed in a wired-OR configuration, NDAC will not go FALSE until all listeners participating in the interchange have also released the line. As shown by arrow 3, when NDAC goes FALSE, DAV follows suit a short time later. The FALSE state of DAV indicates that valid data has been removed; consequently, NDAC goes LOW in preparation for the next data interchange (arrow 4).

Arrow 5 shows the next action in time: NRFD going FALSE after NDAC has returned TRUE. The FALSE state of NRFD indicates that all listeners are ready for the next information interchange. The time between these last two events is variable and depends on how long it takes a listener to process the data byte. In summation, the wired-OR construction forces a talker to wait for the slowest instrument to accept the current data byte before placing a new data byte on the bus.

1-2.3 IEEE-488 Interface Functions and Protocols

The IEEE-488 standard document describes a total of 11 different possible interface functions. Each of these interface functions acts in accordance with a specific protocol defined in the standard. This set of functions and protocols define every possible manner that information and control can be passed between devices connected to the GPIB.

Specific instruments, such as the 360 VNA, are implemented using only a portion, or subset, of the total set of interface functions defined by the standard. Table 1-2 lists the functional subset supported by the 360 VNA.

Table 1-2. 360 VNA GPIB Interface Function Subset Capability

Function Identifier	Function	360 Capability
AH1	Acceptor Handshake	Complete Capability
SH1	Source Handshake	Complete Capability
T6	Talker	No Talk Only (TON)
TE0	Talker With Address Only	No Capability
L4	Listener	No Listen Only (LON)
LE0	Listener With Address Only	No Capability
C0	Controller	No Capability
SR1	Service Request	Complete Capability
RL1	Remote/Local	Complete Capability
PP1	Parallel Poll	Complete Capability
DC1	Device Clear	Complete Capability
DT1	Device Trigger	Complete Capability
E1	Open Collector Driver Electronics	Complete Capability

1-2.4 IEEE-488 Message Types

There are three types of information transmitted over the GPIB:

- **IEEE Interface Function Messages —** These messages are sent on the data lines and interface management lines to control the state of the interface and the manner in which it responds to commands. These messages are used to maintain control of the interface. The user generally has control over these signals; however, the extent of user control is implementation-dependent and varies with the specific hardware and software used with the external controller.

- **Product-Specific Commands —** These commands are mnemonic codes sent by the external computer to the 360 VNA to control the setup and measurement operations of the 360 VNA. The function and contents of these commands are not specified by the IEEE-488 standard. They are unique and specific to the WILTRON 360 VNA and are described in Sections III, IV, and V of this manual.

These commands (also referred to as “360 GPIB commands”) are transmitted over the data bus of the GPIB interface to the 360 VNA in the form of ASCII strings containing one or more codes. They are decoded by the *internal 360 VNA controller* and cause the various measurement functions of the system to be performed. (The 360 VNA GPIB interface does not decode these commands; it only acts as the transmission channel to the internal controller.)

- **Data and Instrument Status Messages —** These messages are sent by the 360 VNA to the external computer via the GPIB. They contain measurement data, setup information, or system status information that the 360 VNA transmits over the data bus in response to specific commands from the external computer requesting the data. The contents of these messages are specific to the 360 VNA. They may be in the form of ASCII strings, or binary data.

  In some cases data messages will be transmitted from the external computer to the 360 VNA. For example, messages to load calibration data.

  An SRQ (service request) is an interface function message sent *from the 360 VNA* to the external computer to request service from the computer, usually due to some predetermined system condition or error. To send this message, the 360 VNA sets the SRQ bit of the General Interface Management Bus true and then sends a status byte on the data bus lines.

  An SRQ interface function message is also sent by the 360 VNA in response to a serial poll message from the computer, or upon receiving either an OEB or OPB command from the computer. The protocols associated with the SRQ functions are defined in the ANSI/IEEE Std 488-1978 document. The 360 GPIB commands for these functions along with the SRQ status byte format information is contained in Paragraph 5-6 — SRQ Status Bytes: Commands — in this manual.

The manner in which Interface Function Messages and Product-Specific Commands are invoked in programs is implementation specific for the GPIB interface used with the external computer. Even though both message types are represented by mnemonics, they are implemented and used in different ways.

The Interface Function Messages normally are sent automatically by the GPIB driver software in response to invocation of a software function. For example, to send the SDC interface function message, one would call the ibclr function of the National Instruments software driver. On the other hand, the 360 GPIB command RST is sent in a string message to the addressed device (e.g. 360 VNA). In the case of the National Instruments example, this would be done by using the ibwrt function call.

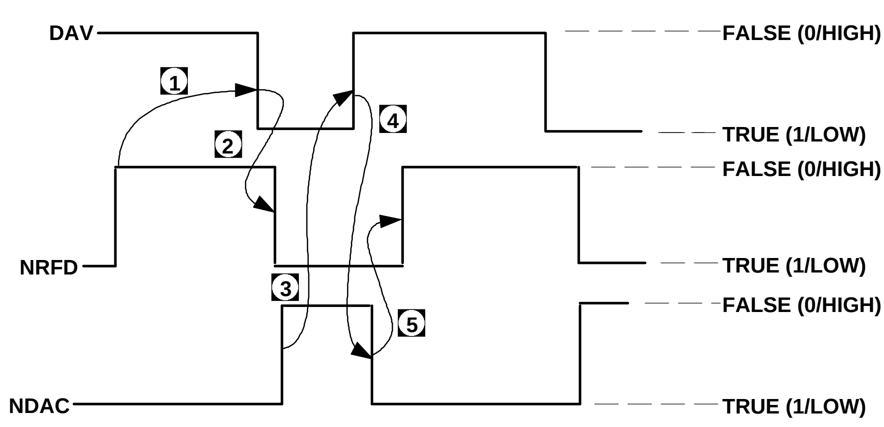


Figure 1-2. Typical GPIB Handshake Operation

1-3 360 VNA GPIB OPERATION

All of the front panel control functions of the 360 VNA, except for LINE ON/OFF, are controllable using 360 GPIB commands sent from the external computer. When in the GPIB operating mode, the 360 VNA functions as both a listener and a talker (Table 1-2).

1-3.1 Setting Default GPIB Operating Parameters

The 360 VNA GPIB address value is set to 6 at the factory. This value may be changed via the GPIB SETUP MENU (from the UTILITY MENU); refer to Index A1 of the 360 Vector Network Analyzer System Operation Manual. The data delimiting terminator is set as CR/CR-LF at the factory. This may also be changed via the GPIB SETUP MENU.

1-3.2 Response to GPIB Interface Function Messages

Table 1-3 lists the set of IEEE–488 Interface Function Messages that the 360 VNA will recognize. With the exception of the DCL and SDC messages, these messages affect only the operation of the 360 VNA GPIB interface. The response of the 360 VNA GPIB interface for each message is included in Table 1-3 (next page).

Interface function messages are transmitted on the GPIB data lines and interface management lines as either unaddressed or addressed commands. The manner in which these messages are invoked in programs is implementation dependent. For programming information, refer to the documentation included with the GPIB Interface for the external computer used.

1-3.3 360 VNA Response To GPIB Error Conditions

The following paragraphs describe how the 360 VNA responds to error conditions during the GPIB mode of operation

a. Syntax Error

The 360 beeps and sends a Service Request (SRQ) to the external computer (if SRQs are enabled). The 360 also ignores any further commands until it is programmed to talk or be unlistened.

b. Parameter Out Of Range Error

Upon detecting this condition, the 360 moves the cursor adjacent to the erroneous entry, beeps, and displays the entry in red. It also sends an SRQ (if enabled) to the external computer. The error is cleared upon execution of the next instruction.

c. Action Requested Not Possible

The 360 sends an SRQ (if enabled) to the external computer and ignores the command.

Table 1-3. 360 VNA Response to IEEE-488 Interface Function Messages

Interface Function Message	Message Function	Addressed Command	360 VNA Response
DCL SDC	Device Clear Selected Device Clear	No Yes	Resets the 360 to its default state. Equivalent to the RST command.
GTL	Go To Local	Yes	Returns the 360 to local (control panel) control.
GET	Group Execute Trigger	Yes	Executes a string of commands defined by the DEF...END mnemonics. **NOTE** The GET command is buffered and executed in-line with other commands.
IFC	Interface Clear	No	Stops the 360 GPIB from talking/listening.
LLO	Local Lockout	No	Disables the control panel RETURN TO LOCAL key
REN	Remote Enable	No	Places the 360 in remote when addressed to listen
SPE	Serial Poll Enable	No	Outputs the binary status byte
SPD	Serial Poll Disable	No	Disables the serial poll function
PPC	Parallel Poll Configure	Yes	Sets the assigned bus line to reflect its SRQ status
PPE	Parallel Poll Enable	Yes	Enables the 360 for parallel poll operation
PPU	Parallel Poll Unconfigure	No	Cancels any previous parallel poll configurations
PPD	Parallel Poll Disable	Yes	Disables the parallel polling function
Note:These are *not* Device Specific Commands. These messages are implementation dependent — refer to the documentation included with the GPIB Interface for the external computer used.			

SECTION II
INTRODUCTION TO GPIB PROGRAMMING
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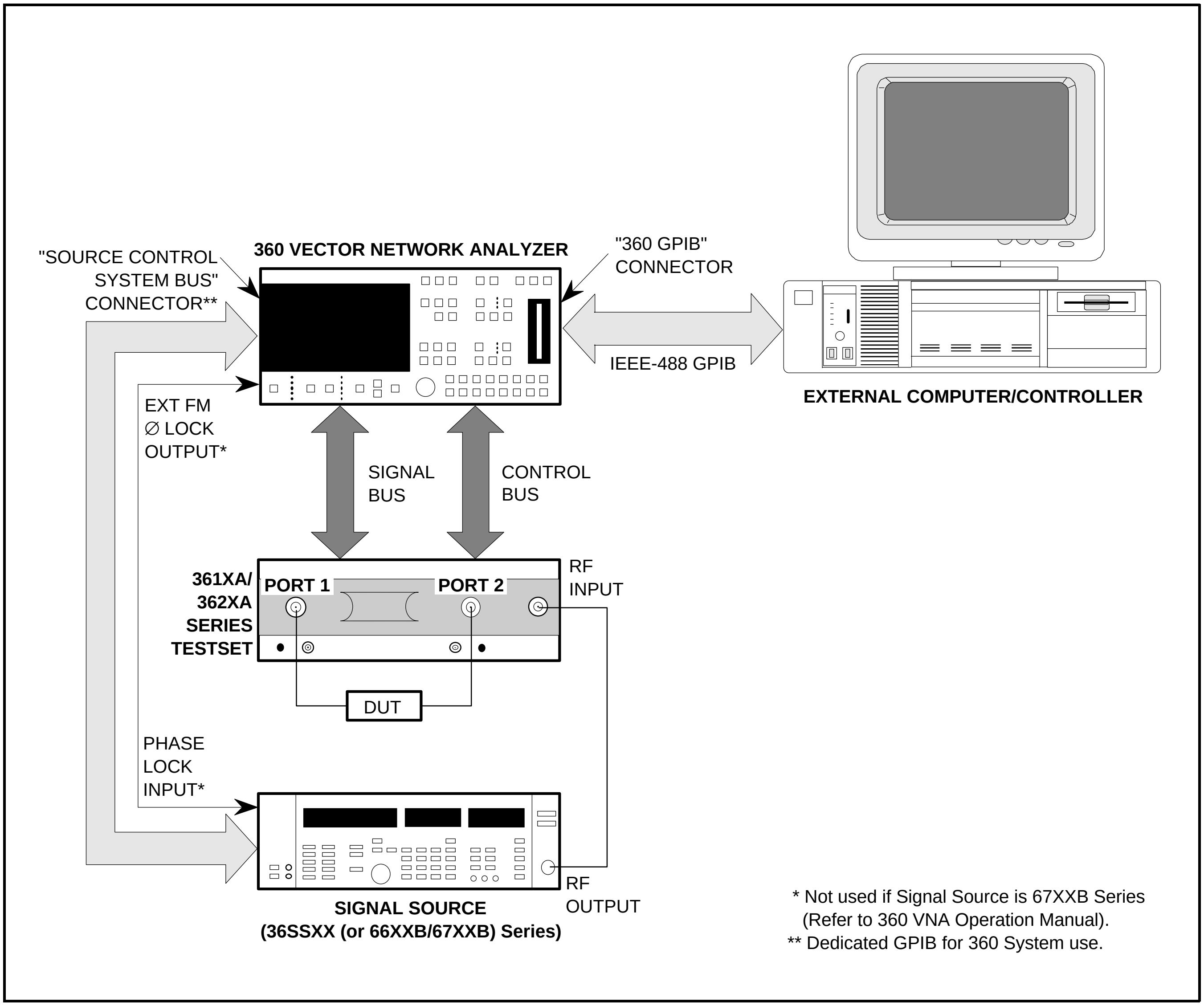

Figure 2-1. Minimum 360 VNA Configuration with GPIB Control

SECTION II
INTRODUCTION TO GPIB PROGRAMMING FOR THE 360 VNA

2-1 INTRODUCTION

This section contains a brief introduction to GPIB programming techniques and describes procedures to be used when preparing GPIB programs for the 360 VNA. It includes information about equipment requirements and configuration for GPIB control of the 360 VNA, 360 GPIB command syntax, and programming tips. Example programs are provided that familiarize the user with the most frequently used 360 GPIB commands.

Familiarity with manual (front panel) operation of the 360 is assumed. (Throughout this section, the 360 VNA is referred to simply as “360”.) A complete description of front panel operation is contained in the 360 Vector Network Analyzer System Operation Manual.

2-2 EQUIPMENT AND CONFIGURATION

The programming examples contained in this tutorial assume that the equipment listed below is present and configured as described.

2-2.1 Required Equipment

The following equipment represents a minimum GPIB controllable 360 VNA system:

1. A 360 Vector Network Analyzer consisting of:
   - A 360 Network Analyzer unit
   - A 3600A Series Test Set
   - A compatible WILTRON Signal Source (360SSXX, 66XXB, 67XXB, etc).
2. A computer/controller that supports the IEEE-488 GPIB standard. The examples in this section address the following two computer types:
   - IBM XT, AT, and PS/2 compatibles,
   - Hewlett Packard 9000 and Vectra series
3. An IEEE-488 GPIB interface (built in, or add-in peripheral card) with appropriate driver software. The National Instruments PC2 or PC2A IEEE-488 interface card is assumed for all IBM compatible computers.
4. Appropriate software:
   - Microsoft QuickBASIC, version 4.0 (or later);
   - Microsoft “C”, version 5.1 or later; or:
   - HP BASIC, version 5.0 or later (for HP computers).
   - Any other programming language that supports the National Instruments PC2 or PC2A IEEE-488 interface card (Pascal, Fortran, etc).
5. A GPIB cable (preferably 2 meters long).

2-2.2 Configuration

Configure the 360 as shown in Figure 2-1 (facing page). Apply power to the 360 and allow the system software to load from disk. Once the software has finished loading, the 360 is ready to be remotely controlled via the GPIB. It is important to note that *the 360 will not respond to GPIB commands until the 360 system software has been loaded.*

If not previously done, connect a GPIB cable from the computer/controller to the “360 GPIB” connector on the rear panel of the 360 Network Analyzer.

NOTE

The 360 Network Analyzer has two GPIB busses: the “360 GPIB” that connects the 360 Network Analyzer unit to the computer/controller and the “SYSTEM CONTROL” bus (which connects to the signal source(s) and a system plotter—if used).

Apply power to the computer/controller and load the appropriate programming language software (QuickBASIC, “C”, or HP BASIC). This tutorial contains programming examples written in each of these three languages, as explained in paragraph 2-4.

2-2.3 Default GPIB Operating Parameters

The default GPIB address for the 360 is 06, and the default data delimiting terminator is CR/CR-LF. The default values for these GPIB operating parameters may be changed via the GPIB SETUP MENU (from the UTILITY MENU); refer to Index A1 of the 360 Vector Network Analyzer System Operation Manual.

2-3 360 GPIB PROGRAMMING BASICS

In the "remote" mode of operation, the 360 is controlled using IEEE-488 Product Specific Commands and Interface Function Messages. The Product Specific Commands are a set of pre-defined mnemonics that are unique to the WILTRON model 360 Vector Network Analyzer. (Refer to paragraph 1-2.3 for further information.) In this manual, they are referred to as "360 GPIB commands" or simply "commands".

These commands may be issued one at a time or in a sequence (i.e., a command string). Commands, command strings, and IEEE-488 Interface Function Messages can be included as part of a program run on an external computer/controller to remotely stimulate the 360 to perform particular microwave measurement operations.

2-3.1 360 GPIB Command Set

There are approximately four hundred 360 GPIB commands. These commands allow the user to program every front panel and menu function of the 360. These many commands reflect the ability of the 360 to perform many specialized functions; however, typical programs written for ATE applications usually use a small subset of these.

The list of GPIB commands may seem intimidating at first glance; however, it can actually be broken down into a few, easy-to-remember categories that reflect the major functions and operations of the 360. The GPIB Command Function Index located behind its section tag at the rear of this manual provides and overview (and index to) these command group categories. A complete listing and description of all 360 GPIB commands is provided in Sections III, IV, and V.

2-3.2 Command Syntax

The 360 GPIB commands are nothing more than a shorthand method for representing instrument commands. Most 360 GPIB commands are three character contractions of their titles or descriptions; for example: RST (reset). Depending on function, some commands must be followed by a numeric value and terminator code; example: SRT 2 GHZ (start frequency = 2 GHz).

The commands for all numeric entry, such as frequency, scale, reference position, etc, include a data entry followed by a terminator code. All commands that require data *must* have a valid terminator code following the data entry.

The 360 will accept multiple commands in string format. Separator characters may be used to improve program readability, but are not required.

a. Terminator Codes

These terminators are codes which perform the same function as the termination keys located on the front panel of the 360. For example: to enter a start frequency using the 360 front panel keys, type "40"; then press the "MHz" terminator key. Likewise, a numeric entry in a GPIB program must be terminated by one of the terminator codes listed in Table 3-2.

b. Separator Characters

Separator characters may be used between commands and between data or other mnemonics to improve program readability. Their use is optional. The more common permitted separator characters are: space, comma, and semicolon.

2-3.3 Programming Tips

The 360 is a "channel-based" instrument, which means that most commands apply only to the current active channel. Therefore, to set up a desired state for multiple channels, a CH1 - CH4 command should precede the setup. For example:

"D14 CH1 S11 SMI CH2 S12 MPH CH3 S21 MAG CH4 S22 ISM"

This command string sets up a quad display (D14) and then sets the S-parameter and graph type desired for each Channel:

Channel 1: S11, Smith chart;
Channel 2: S12, log magnitude and phase;
Channel 3: S21, log magnitude;
Channel 4: S22, inverted Smith chart).

Other commands are "global" in their extent, meaning they apply to all channels. Examples of these commands: start/stop frequency (SRT,STP), averaging (AVG,AOF), and source power (PWR).

2-4 TYPICAL GPIB PROGRAM STRUCTURE

A typical GPIB program may be composed of the following basic functional program groups:

- Preliminary GPIB Control Establishment
- Calibration
- Front Panel Setup
- Measurement
- Data Transfer

Each of these topics will be covered in detail in order to provide the user with the basic tools needed to develop complete programs.

This tutorial contains programming examples written in three languages: QuickBASIC, Microsoft C, and HP BASIC. The language used is stated for each example.

2-4.1 Establishing GPIB Control

The first step in any GPIB program should be the initialization of the GPIB interface and any attached instruments. This step insures that:

1. Communication has been established between the computer/controller and the instrument(s), and,
2. The instrument(s) are restored to a "known" initial state.

The process used to initialize the 360 will differ, depending on the computer/controller used. Examples of initialization routines written in QuickBASIC and "C" for use with the National Instruments PC2/PC2A card and HP BASIC for the Hewlett-Packard GPIB interface are shown in Figure 2-2.

NOTE

In order for communication to take place over the GPIB, the controlling program must contain correct GPIB addresses for the 360 and any other controlled instruments. Also, the data delimiting terminator used must be correct for the GPIB interface used with the external computer/controller; refer to paragraph 2-2.3.

QuickBASIC example:

```
CALL IBFIND ("DEV6", vna%)
CALL IBCLR
```

Microsoft C example:

```
int vna;

vna = ibfind("DEV6");
ibclr(vna);
```

HP BASIC example:

```
100 ASSIGN @gpib TO 7
110 ASSIGN @vna TO 706
120 FORMAT OFF
130 REMOTE @gpib
140 ABORT @gpib
150 CLEAR @vna
```

Figure 2-2. Example Initialization Routines

2-4.2 Front Panel Setup

Front panel setup involves the configuration of the 360 for a particular measurement. In the "Setup" subroutine, the 360 is setup to display all four S-Parameters (D14). The graph type for all four channels is set to Log Magnitude and Phase (MPH). The S-parameters are displayed as follows:

Channel 1 (CH1): S11 (S11);
Channel 2 (CH2): S12 (S12);
Channel 3 (CH3): S21 (S21);
Channel 4 (CH4): S22 (S22).

The start frequency is set to 40.0 MHz (SRT 40.0 MHZ) and the stop frequency is set to 20.0 GHz (STP 20.0 GHZ). Examples of front panel setup routines are shown in Figure 2-3.

2-4.3 Calibration

Calibration, as it applies to network analysis, is a technique used to remove most measurement errors due to imperfections in the measurement system. The calibration process characterizes the systematic measurement errors. The resulting data is stored and subtracted from subsequent measurement data to yield the correct measurement data for the device-under-test.

As performed using the 360 front panel controls, the calibration process requires the user to define the characteristics of the test set test ports, perform the calibration steps, and then verify the quality of the calibration. (Refer to Paragraph 4-9 — Measurement Calibration — in the 360 Vector Network Analyzer System Operation Manual.)

As shown in the example programs contained in Section IV of this manual, it is possible to use the external computer to guide the system operator through the calibration process using a suitably written program. The various 360 GPIB commands that are used to perform the calibration process are described in the first portion of Section IV. Listings of example HP BASIC and "C" program segments for 360 calibration are presented in Section IV, paragraphs 4-2.4 through 4-2.6.

2-4.4 Measurement and Data Output

The commands that control the measurement functions of the 360VNA are listed and described in paragraph 3-4 — Measurement Control Commands. These commands mimic the measurement operations that are performed using the 360 front panel keys and menus.

An example of a main program and associated program functions written in "C" that initialize the 360 and perform calibration, measurement and data output functions is listed and described in Application Note AN360-8. A similar example of a main program and associated subprograms written in HP BASIC is presented in Application Note AN360-9. These application notes are included at the rear of this manual behind the tab labeled "Supplements".

2-4.5 Data Transfer Programming

The commands that control the transfer of data to/from the 360 are listed and described in paragraph 5-3 — Data Transfer Commands. The functions performed by many of these commands are unique—most do not have direct counterparts when operating from the front panel keys and menus.

Figures 2-4 through 2-7 contain listings of an example program written in "C". This example is a complete program that automates data transfer to/from the 360. The four parts of the program shown in the figures are described in paragraphs *b* through *e* below.

a. Programming Considerations

When writing a program for data transfer to/from the 360, the following items should be considered:

- **Data Transfer Sequence —** Data may be transferred *from the 360* to the external computer in any order. However, the 360 should be put in HOLD to prevent the data from being overwritten.

  Data should be transferred from the external computer *to the 360* in the following order:
  Front Panel Setup
  Measurement Frequencies
  Calibration Coefficients
  Measurement Data.

- **Front Panel Setup and Measurement Frequency Data —** Front panel setup data, including frequency information, is contained in the data transfers performed by the OFP and IFP commands. However, when Discrete Fill is used to enter frequency data, or when access to individual frequency values is important, the OFV and IFV commands must be used.

- **Data Transfer Formats —** Use of the FMA and FMB commands is the preferred method of data transfer for Binary floating point data. ASCII data transfer is significantly slower than for binary floating point data. Also, ASCII data must be converted to a numeric format using a suitable "C" program to be useful for most applications.

b. Example Program: Variable Declaration

The program segment shown in Figure 2-4 contains the variable declarations for the example program. These variable declarations define and initialize the variables common to the main program and program functions.

c. Example Main Program

The main program shown in Figure 2-5 performs the following operations:

1. The 360 and GPIB are initialized to a known state by the first two program functions so that the program starts under identical conditions each time it is run:
   - GPIB function ibfind() enables the GPIB to control the 360 (this assumes that the 360 address is set to 6.)
   - GPIB function ibclr() instructs the 360 to reset to the default state. It is used before 360 parameters are established by the program.
2. The program function xfr_from_360() is called to transfer data *from* the 360.
3. The program function xfr_to_360() is called to transfer data *to* the 360.
4. The last program function of the main program, ibloc(), instructs the external computer to return the 360 to local operation and end program execution.

d. Data Transfer from the 360 VNA to the External Computer

The program function xfr_from_360() shown in Figure 2-6 performs the following operations:

1. The GPIB function ibwrt() instructs the 360 to return to local operation (RTL).
2. The operator is instructed to perform a Reflection Only calibration, set up the front panel as desired and install the device to be measured. They are then instructed to press any key on the external computer keyboard to output data from the 360.
3. The next ibwrt() function sends instructions to the 360 to trigger a sweep (TRS), wait a full sweep(WFS) and hold (HLD).

QuickBASIC example:

```
SUB Setup

CALL IBWRT (vna%, “D14 CH1 S11 MPH CH2 S12 MPH”)
CALL IBWRT (vna%, “CH3 S21 MPH CH4 S22 MPH”)
CALL IBWRT (vna%, “SRT 40.O MHZ STP 20.0 GHZ”)
SUB END
```

Microsoft C example:

```
Setup (vna)
int vna;
{
ibwrt (vna, “D14 CH1 S11 MPH CH2 S12 MPH”, 27);
ibwrt (vna, “CH3 S21 MPH CH4 S22 MPH”, 23);
ibwrt (vna, “SRT 40.0 MHZ STP 20.0 GHZ”, 25);
}
```

HP BASIC example:

```
500 SUB Setup(@vna)
510 OUTPUT @vna;"D14 CH1 S11 MPH CH2 S12 MPH"
520 OUTPUT @vna;"CH3 S21 MPH CH4 S22 MPH"
530 OUTPUT @vna;"SRT 40.0 MHZ STP 20.0 GHZ"
```

Figure 2-3. Example Front Panel Setup Routines

```
/*********************************************************/
/*              Program to Transfer Data over the GPIB                */
/*          to/from a Wiltron 360 Vector Network Analyzer         */
/*   using an IBM AT Computer with National Instruments GPIB   */
/*                          Written in Microsoft C                          */
/*********************************************************/
#include <stdio.h>
/*——————————————————————————————
              Variable Declaration
  Define and Initialize variables common to all functions.
——————————————————————————————-*/
int ans, vna, count, points;
char freq[12800], setup[5000];
struct header
 {
  char preamble [2];
  int size;
 }
 cal_headr, data_headr;
struct cal
 {
  double real;
  double imag;
 }
 cal1[512], cal2[512], cal3[512];
struct data
 {   float real;
  float imag;
 }
data[512];
```

Figure 2-4. Variable Declaration for Example Data Transfer Program (Microsoft “C”)

```
/*——————————————————————————————
                              Main Program
          Initialize GPIB and put 360 under GPIB control,
              call program functions to transfer data,
                  and return 360 to local operation.
——————————————————————————————*/
main()
  {
  vna = ibfind(“DEV6"); /*enables GPIB to control 360*/
  ibclr(vna);              /*resets 360 to default parameters*/
     xfr_from_360(vna);  /*calls data output function*/
     xfr_to_360(vna);     /*calls data input function*/
  ibloc(vna);              /*returns 360 to_local control*/
  }                           /*ends program*/
```

Figure 2-5. Main Program for Example Data Transfer Program (Microsoft “C”)

4. The 360 is then instructed to output the data types listed below to the external computer. The external computer reads the data sent from the 360 using multiple ibrd() functions. The data types transferred are:
   - Front panel setup data in binary string format (OFP),
   - Measurement frequency values (OFV) in ASCII format (FMA),
   - Calibration coefficients (OC1, OC2, and OC3) in binary floating point - double precision (FMB) with the least significant byte first (LSB),
   - Corrected measurement data (OCD) from the active channel in binary floating point - single precision (FMC) with the least significant byte first (LSB).
5. When the data transfer is completed, the 360 is again returned to local operation.

```
/*——————————————————————————————————————
                    Data Output Function
        Setup, calibrate and measure a_device,
        transfer data from 360 to controller,
          and return 360 to local operation.
——————————————————————————————————————*/
xfr_from_360(vna)
 {
   ibwrt(vna,"RTL",3);
 printf("\n\t\t*                INSTRUCTIONS                *");
 printf("\n\t\t*   Perform a Reflection Only calibration,   *");
 printf("\n\t\t*       set up front panel as desired,       *");
 printf("\n\t\t*     and connect device to be measured._    *\n");
 printf("\n\t\t*   PRESS ANY KEY TO OUTPUT DATA FROM 360    *\n");
   ans = getch();
   ibwrt(vna,"TRS WFS HLD",11);

 printf("\n\t\tTransferring front panel setup to controller...");
   ibwrt(vna,"OFP",3);
   ibrd(vna,setup,sizeof(setup));

 printf("\n\t\tTransferring frequencies  to controller...");
   ibwrt(vna,"FMA OFV",7);
   ibrd(vna,freq,sizeof(freq));

 printf("\n\t\tTransferring cal coefficients to controller...");
   ibwrt(vna,"FMB LSB OC1 OC2 OC3",19);
   ibrd(vna,&cal_headr,4);
   ibrd(vna,&cal1[0],cal_headr.size);
   ibrd(vna,&cal_headr,4);
   ibrd(vna,&cal2[0],cal_headr.size);
   ibrd(vna,&cal_headr,4);
   ibrd(vna,&cal3[0],cal_headr.size);

 printf("\n\t\tTransferring measurement data to controller...");
   ibwrt(vna,"FMC LSB OCD",11);
   ibrd(vna,&data_headr,4);
   ibrd(vna,&data[0],data_headr.size);

 printf("\n\n\t\t    —- 360 returned to local operation.—-\n");
   ibwrt(vna,"RTL",3);
```

Figure 2-6. Output Data Transfer Program Function for Example Data Transfer Program (Microsoft "C")

e. *Data Transfer from the External Computer to the 360 VNA*

The program function xfr_to_360() shown in Figure 2-7 performs the following sequence of operations:

1. The operator is instructed to press any key on the external computer keyboard to output data to the 360.
2. The program function prn_data() (shown in Figure 2-7, sheet 2) then displays the measurement frequency data and calibration coefficients on the external computer monitor (Figure 2-8).
3. The 360 is then instructed to input the data types listed below from the external computer. The external computer sends the data to the 360 using multiple ibwrt() functions. The data types transferred are:

- Front panel setup (IFP) in binary string format,

```
/*————————————————————————————-
                    Data Input Function
              Reset 360 to default parameters,
            transfer data from controller to 360,
                   and turn on calibration.
————————————————————————————-*/
xfr_to_360(vna)
 {
 printf("\n\t\t*            PRESS ANY KEY            *");
 printf("\n\t\t* TO DISPLAY CAL DATA AND OUTPUT DATA TO 360*\n");
    ans = getch();
    ibwrt(vna,"RST",3);

 prn_data();

 points=data_headr.size/8;

 printf("\n\t\tTransferring front panel setup to 360...");
    ibwrt(vna,"IFP",3);
    ibwrt(vna,setup,sizeof(setup));

 printf("\n\t\tTransferring frequencies  to 360...");
    ibwrt(vna,"FMA IFV",7);
    ibwrt(vna,freq,points*25);

 printf("\n\t\tTransferring cal coefficients to 360...");
    ibwrt(vna,"ARF FMB LSB IC1 IC2 IC3",24);
    ibwrt(vna,&cal_headr,4);
    ibwrt(vna,&cal1[0],cal_headr.size);
    ibwrt(vna,&cal_headr,4);
    ibwrt(vna,&cal2[0],cal_headr.size);
    ibwrt(vna,&cal_headr,4);
    ibwrt(vna,&cal3[0],cal_headr.size);
    ibwrt(vna,"CON",3);

 printf("\n\t\tTransferring measurement data to 360...");
    ibwrt(vna,"FMC LSB ICD",11);
    ibwrt(vna,&data_headr,4);
    ibwrt(vna,&data[0],data_headr.size);

 printf("\n\n\t\t   —-  360 data transfer completed  —-");
 }
```

Figure 2-7. Input Data Transfer Program Function for Example Data Transfer Program (1 of 2)

- Frequency values (IFV) in ASCII format (FMA),
- Calibration coefficients (IC1, IC2 and IC3) in binary floating point - double precision (FMB) with the least significant byte first (LSB),
- Corrected measurement data (ICD) from the active channel in binary floating point - single precision (FMC) with the least significant byte first (LSB).

4. The 360 is instructed to simulate a Reflection Only calibration (AFR) before it is sent the calibration coefficients (IC1, IC2 and IC3). The calibration is then applied (CON), and the corrected data is displayed on the 360 monitor.

```
prn_data()
    {
    points=cal_headr.size/16;

    printf("\n\n\n\t\t          —-  CALIBRATION   COEFFICIENTS   —-");
    printf("\nFREQUENCY                   CAL1                                   CAL2");
    printf("                                    CAL3\n");
    printf("    (GHz)         (Real)          (Imag)            (Real)          (Imag)");
    printf("             (Real)          (Imag)\n");

    for   (count=0;count<points;count=count    +   1)
        printf("     %c.%c%c     %9.4f  %9.4f     %9.4f  %9.4f     %9.4f  %9.4f\n",
            freq[count*25+3],
            freq[count*25+5],freq[count*25+6],
            cal1[count].real,   cal1[count].imag,
            cal2[count].real,   cal2[count].imag,
            cal3[count].real,   cal3[count].imag);
    }
```

Figure 2-7. Input Data Transfer Program Function for Example Data Transfer Program (2 of 2)

—- CALIBRATION COEFFICIENTS —-

FREQUENCY	CAL1		CAL2		CAL3	
(GHz)	(Real)	(Imag)	(Real)	(I mag)	(Real)	(Imag)
1.00	-0.0092	0.0010	0.0332	-0.0096	-0.1188	-0.2103
1.10	-0.0062	-0.0079	-0.0334	-0.0221	-0.2540	-0.0176
1.20	0.0052	-0.0086	0.0280	0.0505	-0.1614	0.2134
1.30	0.0126	0.0019	-0.0032	-0.0661	0.8899	0.2584
1.40	0.0058	0.0132	-0.0149	0.0290	0.2714	0.0803
1.50	-0.0100	0.0113	0.0253	0.0245	0.2306	-0.1893
1.60	-0.0180	-0.0050	0.0019	-0.0472	-0.0326	-0.3096
1.70	-0.0068	-0.0201	-0.0318	0.0208	-0.2822	-0.1468
1.80	0.0143	-0.0170	0.0097	0.0396	-0.2833	0.1616
1.90	0.0240	0.0030	0.0482	-0-0528	-0.0120	0.3308
2.00	0.0098	0.0205	-0.0782	0.0045	0.2655	0.1846

Figure 2-8. Frequency and Calibration Data Displayed on External Computer Monitor by xfr_to_360()

SECTION III
COMMANDS FOR BASIC FRONT PANEL FUNCTIONS

Table of Contents

SECTION III
COMMANDS FOR BASIC FRONT PANEL FUNCTIONS

3-1 INTRODUCTION

This section describes the GPIB Product Specific Commands that control the basic test and measurement functions associated with the 360 VNA front panel controls and menus. In this section, these messages are refered to as “360 GPIB commands” or simply “commands”. The command information is grouped by control function; example: Data Entry Commands, Hard Copy Commands, etc., (see Table of Contents, page 3-1).

To find command information not in this section, refer to the GPIB Command Function Index for a listing of *all* 360 GPIB commands, grouped by function. Refer also to the 360 Quick Reference Guide, which lists all commands alphabetically and includes a brief description of the function of each command. (See section tabs at rear of manual.)

3-2 CHANNEL CONTROL COMMANDS

The commands listed in Table 3-1 set up the current display mode and active channel for the 360 VNA. Commands D13, D14, D24 and DSP select which channels are to be displayed. Commands CH1–CH4 select the active channel. The active channel is that channel to which any channel-based changes are applied.

Table 3-1. Channel Control Commands

360 GPIB Command	Description
DSP	Select single channel of active display
D13	Select dual channel display, channels 1 & 3
D14	Select quad display, all four channels
D24	Select dual channel display, chans 2 & 4
CH1	Select channel 1 as active channel
CH2	Select channel 2 as active channel
CH3	Select channel 3 as active channel
CH4	Select channel 4 as active channel

3-3 DATA ENTRY TERMINATOR CODES

The codes listed in table 3-2 are used as terminator statements in conjunction with commands that require numeric values. (Almost all commands that require numeric values *also* require the use of an appropriate terminator.) The appropriate terminators for commands requiring them are listed along with the description of the command in the tables throughout this section and in Sections IV and V.

Table 3-2. Data Entry Terminator Codes

Terminator Code	Description
CMT	Select centimeter as terminator
DBL	Select dB log as terminator
DBM	Select dBm as terminator
DEG	Select degrees as terminator
GHZ	Select gigahertz as terminator
IMU	Select imaginary units as terminator
KHZ	Select kilohertz as terminator
MHZ	Select megahertz as terminator
MMT	Select millimeter as terminator
MTR	Select meter as terminator
NSC	Select nanoseconds as terminator
PSC	Select picoseconds as terminator
REU	Select real units as terminator
USC	Select microseconds as terminator
VLT	Select volts as terminator
XM3	Select unitless terminator, x 10E-3
XX1	Select unitless terminator, x 1
XX3	Select unitless terminator, x 10E+3

3-4 MEASUREMENT CONTROL COMMANDS

The commands listed in Table 3-3 control the parameter being measured on the active channel (S11, S21, S22, and S12) and the basic measurement setup. All commands except S11, S21, S22, and S12 are global; that is, they apply to the entire instrument.

The SA1, SA2, and TA2 commands can only be used with the Models 3620, 3621 and 3622 Test Sets (i.e., test sets with attenuators). Note that the two source attenuators have ranges of 0 to 70 dB while the test attenuator has a range of 0 to 40 dB.

The HLD command holds the sweep *at* the current point; the CTN command continues sweeping *from* the current point. The TRS command either restarts the sweep (continuous sweep mode) or triggers a single sweep (in hold mode). The SWP command puts the 360 into continuous swept mode.

The WFS command causes the 360 to wait a full sweep so that any data on the display is valid. This is useful for scaling the display. It is *required* when outputting data from the 360, so as to ensure that the data being output is valid (see Section V, paragraph 5-3.1, Data Transfer Program Example and Program Notes).

Table 3-3. Measurement Control Commands (1 of 2)

360 GPIB Command	Description	Values	Terminators
BH0	Set bias off while in hold	N/A	N/A
BH1	Set bias on while in hold	N/A	N/A
CTN	Continue sweeping from current point	N/A	N/A
CWF (value)	CW turned on and CW frequency set to value	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
DA1	Select a1=Ra as denominator for parameter being defined	N/A	N/A
DA2	Select a2=Rb as denominator for parameter being defined	N/A	N/A
DB1	Select b1=Ta as denominator for parameter being defined	N/A	N/A
DB2	Select b2=Tb as denominator for parameter being defined	N/A	N/A
DE1	Select unity as denomitor for parameter being defined	N/A	N/A
FHI	Set data points to maximum	N/A	N/A
FLO	Set data points to minimum	N/A	N/A
FME	Set data points to normal	N/A	N/A
HLD	Hold instrument at current point	N/A	N/A
LA1	Select a1=Ra as phase lock for parameter being defined	N/A	N/A
LA2	Select a2=Rb as phase lock for parameter being defined	N/A	N/A
NA1	Select a1=Ra as numerator for parameter being defined	N/A	N/A

Table 3-3. Measurement Control Commands (2 of 2)

360 GPIB Command	Description	Values	Terminators
NA2	Select a2=Rb as numerator for parameter being defined	N/A	N/A
NB1	Select b1=Ta as numerator for parameter being defined	N/A	N/A
NB2	Select b2=Tb as numerator for parameter being defined	N/A	N/A
NU1	Select unity as numerator for parameter being defined	N/A	N/A
PW2 (value)	Set source 2 power level in dBm	Depends on power range of source	DBM, XX1, XX3, XM3
PWR (value)	Set source 1 power level in dBm	Depends on power range of source	DBM, XX1, XX3, XM3
RH0	Set RF off while in hold	N/A	N/A
RH1	Set RF on while in hold	N/A	N/A
S11	Measure S_{11} on active channel	N/A	N/A
S12	Measure S_{12} on active channel	N/A	N/A
S21	Measure S_{21} on active channel	N/A	N/A
S22	Measure S_{22} on active channel	N/A	N/A
SA1 (value)	Set source attenuator, port 1	0 dB to 70 dB	DBL, DBM, XX1, XX3, XM3
SA2 (value)	Set source attenuator, port 2	0 dB to 70 dB	DBL, DBM, XX1, XX3, XM3
SRT (value)	Set start frequency	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
STP (value)	Set stop frequency	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
SWP	Frequency sweep mode	N/A	N/A
TA1 (value)	Test set port 1 test attenuator	0 to 100 (Depends on test set)	DBL, DBM, XX1, XX3, XM3
TA2 (value)	Set test attenuator, port 2	0 to 100 (Depends on test set)	DBL, DBM, XX1, XX3, XM3
TRS	Trigger/restart sweep	N/A	N/A
US1-US4	Measure user parameter 1-4 on active channel	N/A	N/A
USL (string)	Enter user parameter label string	5 characters max	N/A
WFS	Wait full sweep until all display data is valid	N/A	N/A

3-5 DISPLAY CONTROL COMMANDS

The commands listed in Table 3-4 set up the graph type on the active channel. Most of these commands are straightforward with the exception of SME, ISE, SMC and ISC. Both the SME and ISE commands require values and terminators to be included with the command (see Table 3-4). The allowable values for these commands are 10, 20, and 30.

Example: **"SME 20 DBL"** This code selects a 20 dB expanded Smith chart on the active channel.

Commands SMC and ISC also require values and only allow the value 3.

Example: **"SMC 3 DBL"** This code selects a 3 dB compressed Smith chart on the active channel. Additional considerations for commands SCL and REF are as follows:

a. SCL Command

The SCL command sets the scaling-per-division of the graph on the active channel. Notice that for graph types with two types of information, the unitless terminators always apply to the *first* type of information. The first type of information is always displayed on the top graph

Example: **"MPH SCL 10 XX1"** This code will select a log magnitude and phase display on the active channel and set the magnitude scaling to 10 dB/div. The only way to scale the degrees part of the graph is by explicit use of the DEG terminator.

Example: **"MPH SCL 45 DEG"** This code selects a log magnitude and phase display on the active channel and sets the phase scaling to 45 degrees/div.

NOTE

Smith charts and inverted Smith charts can not be scaled using the SCL command—the different charts are selected using the SME, ISE, SMC, and ISC commands.

b. REF Command

The REF command selects which graticule line will be considered the "reference." Notice that for graphs with one type of information—such as MAG or PHA—the allowable reference line values are 0 to 8, while for graphs with two types of information the reference line value can only be 0 to 4. As described for the SCL command, for graphs having two types of information present, the unitless terminators apply to the first type of information. There is no reference line defined for Smith charts, inverted Smith charts, linear polar, or log polar displays.

Table 3-4. Display Control Commands (1 of 2)

360 GPIB Command	Description	Values	Terminators
APR (value)	Set group delay aperture for display on active channel	0 to 20	XX1, XX3, XM3
ASC	Autoscale display on active channel	N/A	N/A
ASP (value)	Set polar stop sweep position angle	0 to 360 (–360 to +360)	DEG
AST (value)	Set polar start sweep position angle	0 to 360 (–360 to +360)	DEG
DLA	Select group delay display for active channel	N/A	N/A
IMG	Select imaginary display for active channel	N/A	N/A
ISC (value)	Select inverted compressed Smith chart for active channel	3	DBL, XX1
ISE (value)	Select inverted expanded Smith chart for active channel	10, 20, 30	DBL, XX1
ISM	Select normal inverted Smith chart for active channel	N/A	N/A

Table 3-4. Display Control Commands (2 of 2)

360 GPIB Command	Description	Values	Terminators
LIN	Select linear magnitude display for active channel	N/A	N/A
LPH	Select linear magnitude and phase display for active channel	N/A	N/A
MAG	Select log magnitude display for active channel	N/A	N/A
MPH	Select log magnitude and phase display for active channel	N/A	N/A
OFF (value)	Set offset for display on active channel	Mag offset: –999.99 – 999.99 Phase offset: –360 to e360 Polar offset: 0 – 999.99 Lin polar offset: 5E^{-9} – 1000.0	Depends on graph type
PCP	Select measurement phase polar chart mode	N/A	N/A
PCS	Select sweep position polar chart mode	N/A	N/A
PHA	Select phase display for active channel	N/A	N/A
PHO (value)	Set phase offset for display on active channel	0 to 360 (–360 to +360)	Depends on graph type
PLG	Select log polar display for active channel	N/A	N/A
PLR	Select linear polar display for active channel	N/A	N/A
REF (value)	Set reference line for display on active channel	If single graph: 1–8 If two graphs: 1–4	Depends on graph type
REL	Select real display for active channel	N/A	N/A
RIM	Select real and imaginary display for active channel	N/A	N/A
SCL (value)	Set resolution for display on active channel	Mag resolution: 0.001 – 50 Phase resolution: 0.01 – 90 Polar resolution: 1E^{-9} – 999.99 Lin polar resolution: 200 max	Depends on graph type
SMC (value)	Select compressed Smith chart for active channel	3	DBL, XX1
SME (value)	Select expanded Smith chart for active channel	10, 20, 30	DBL, XX1
SMI	Select normal Smith chart for active channel	N/A	N/A
SWR	Select SWR display for active channel	N/A	N/A

3-6 ENHANCEMENT COMMANDS

The commands listed in Table 3-5 control the data enhancement functions of the 360 VNA. These include IF bandwidth, averaging, and smoothing. Note that for the averaging function the maximum averaging number is 4095. For the smoothing function, the maximum smoothing number is 20 (%).

Table 3-5. Enchancement Commands

360 GPIB Command	Description	Values	Terminators
AOF	Turn off averaging	N/A	N/A
AVG (value)	Turn on averaging and set to value	1 to 4095	XX1, XX3, XM3
IFM	Select minimum I.F. bandwidth	N/A	N/A
IFN	Select normal I.F. bandwidth	N/A	N/A
IFR	Select reduced I.F. bandwidth	N/A	N/A
SOF	Turn off smoothing	N/A	N/A
SON (value)	Turn on smoothing and set to value (%)	0 to 20	XX1, XX3, XM3

3-7 REFERENCE DELAY COMMANDS

The commands listed in Table 3-6 are used to set up both the reference delay applied to a channel and the relative dielectric constant of the system. Note that commands RDD, RDT, and RDA change the active channel reference delay while commands DIA, DIT, DIP, DIM, and DIE change the system dielectric constant—which is a global change. The command RDA should only be used if at least one valid sweep has been previously completed.

Table 3-6. Reference Delay Commands

360 GPIB Command	Description	Values	Terminators
DIA	Select air as active dielectric	N/A	N/A
DIE (value)	Set active dielectric to value	1 to 999.999	XX1, XX3, XM3
DIM	Select microporous teflon as active dielectric (1.69)	N/A	N/A
DIP	Select polyethylene as active dielectric (2.26)	N/A	N/A
DIT	Select teflon as active dielectric (2.1)	N/A	N/A
RDA	Set automatic reference delay calculation	N/A	N/A
RDD (value)	Set reference delay in distance for active channel	–999.999 to 999.999	MMT, CMT, MTR
RDT (value)	Set reference delay in time for active channel	–999.999 to 999.999 μs	PSC, NSC, USC

3-8 TRACE MEMORY COMMANDS

The commands listed in Table 3-7 control the trace memory function on the active channel and the trace math that can be applied to it. Before using the commands MEM, DTM or DNM to view a display that involves trace memory, or to store trace memory to disk, the data from the selected channel must first be stored to memory using the STD command.

Example: **“WFS STD DIV DNM”**

This example code causes the 360 to:

- Wait a full sweep until data is valid (WFS).
- Store data to memory (STD).
- Select complex division as the trace math (DIV).
- Display the data normalized to memory using this trace math (DNM).

NOTE

The SDK and RCK commands that are used to store and retrieve the active channel trace memory to and from the disk are described in Section V, paragraph 5-5, Disk Functions Commands.

Table 3-7. Trace Memory Commands

360 GPIB Command	Description
ADD	Select addition as trace math for active channel
DAT	Display measurement data on active channel
DIV	Select division as trace math for active channel
DNM	Display data normalized to trace memory on active channel
DTM	Display measurement data and trace memory on active channel
MEM	Display trace memory on active channel
MIN	Select subtraction as trace math for active channel
MUL	Select multiplication as trace math for active channel
STD	Store trace to memory

3-9 MARKER COMMANDS

The commands listed in Table 3-8 control the location and display of the markers and the functions related to the markers. The MK1–MK6 commands are used to set a marker to a desired frequency, time, or distance. The terminator mnemonics used must match the active channel domain (frequency point, time, or distance)—Otherwise, an action-not-possible error will result.

Example: **"MK1 1.0000 NSC"** trying to use this code for a frequency domain channel will generate an action-not-possible error.

Markers can be individually turned *off* using the MO1–MO6 commands. These commands remove the specified marker *and the readout* from the screen display.

All markers can be *disabled* using the MOF command. This command removes the marker from the display, but the marker readout remains.

A marker is turned on whenever any of the following conditions occur:

- When the marker is set to a value, for example: **"MK2 4.5632 GHZ".**
- When the marker is selected for readout, for example: **"MR2"**
- When the marker is selected as the delta reference marker, for example : **"DR2"**

The MMN and MMX commands move the active marker to the minimum and maximum trace values on the active channel, respectively. There must be an active marker selected for these command to execute.The M1S–M6S, M1E–M6E and M1C–M6C command are used to define a marker sweep using the specified marker for either the start, stop, or CW frequency.

Example: **"WFS MR1 MMX M1S"**

This code sequence causes the 360 to:

- Wait for a full sweep of data to be present (WFS).
- Turn on marker 1 and select it for readout (MR1).
- Move marker 1 to the maximum value of the trace on the active channel (MMX).
- Set the start frequency equal to the marker frequency (M1S).

Table 3-8. Marker Commands

360 GPIB Command	Description	Values
DR1-DR6	Select marker 1 - 6 as delta reference marker	N/A
DRF	Turn delta reference mode on	N/A
DRO	Turn delta reference mode off	N/A
M1C-M6C	Set marker 1-6 sweep CW frequency	N/A
M1E-M6E	Set marker 1-6 sweep/zoom end freq, time or distance	N/A
M1S-M6S	Set marker 1-6 sweep/zoom start freq, time or distance	N/A
MK1 (value) – MK6 (value)	Turn on marker 1-6 and set to value	Limited to current sweep/zoom range
MMN	Set active marker to minimum trace value	N/A
MMX	Set active marker to maximum trace value	N/A
MO1-MO6	Turn off marker 1-6	N/A
MOF	Marker display off	N/A
MON	Marker display on	N/A
MR1-MR6	Read-out frequency at marker 1-6 (through GPIB)	N/A

3-10 LIMITS COMMANDS

The Limits Commands listed in Table 3-9:

- Set up the upper and lower limit values for the active channel.
- Set the limit delta for the limit frequency readout function. The range of values and allowable terminator mnemonics are dependent on the graph type of the active channel, much like the SCL and REF commands described in paragraph 3-5.

For graph types that have two types of information, the unitless terminators always apply to the *first* type of information. The first type of information is always displayed on the top graph. The second type of limit line value is accessed by explicit use of the appropriate data terminator mnemonic.

Examples:

1. **"LUP 20 XX1"** for a log magnitude and phase display: sets the upper limit on the magnitude display to 20 dB.
2. **"LUP 45 DEG"** must be used to set the upper limit on the phase graph.

NOTE

The LFR, LFP, and LFD commands that deal with limit frequency readouts, are only available on the following graph types: log magnitude (MAG), log magnitude and phase (MPH), phase (PHA), linear magnitude (LIN), linear magnitude and phase (LPH), standing wave ratio (SWR), and group delay (DLA). The active channel must be a frequency domain channel.

The LFP command can be used to select phase limit frequency readouts on log magnitude and phase and linear magnitude and phase graph types. If the LFR command is used for either of these graph types, the magnitude limit frequency readout menu for the channel is displayed.

Table 3-9. Limits Commands

360 GPIB Command	Description	Values	Terminators
LFD (value)	Set limit frequency read-out delta value	Depends on graph type	Depends on graph type
LFP	Select limit frequency read-out for phase displays	N/A	N/A
LFR	Select limit frequency read-out for active channel	N/A	N/A
LLO (value)	Turn on lower limit and set to value	Depends on graph type	Depends on graph type
LOF	Turn limits display off	N/A	N/A
LON	Turn limits display on	N/A	N/A
LUP (value)	Turn on upper limit and set to value	Depends on graph type	Depends on graph type

3-11 HARD COPY COMMANDS

The commands concerned with hard copy output are listed in Tables 3-10 and 3-11. These commands are straightforward with the exception of commands PT0–PT9. The PT0–PT9 commands are used to:

(1) Specify the density of tabular data points output to the printer when using the PTB and PMT commands, and

(2) Specify the number of data points included in the output file used with the TDD command.

The value used with the PT0–PT9 commands specifies the number of points that are *skipped* during printing. Therefore, PT0 selects the *densest* printing mode while PT9 gives the *fewest* number of data points. The HD0 command disables headers and page formatting for tabular printouts. The HD1 command enables headers and page formatting.

The hard copy output commands consist of two categories: *setup* and *action:*

Setup commands are those that specify the desired size and location of the plot and the pen numbers for each element of the plot. These commands are described in Table 3-10.

Action commands actually initiate a plot for the subset of the display specified by the setup commands. These commands are described in Table 3-11.

The LMS, LID, LDT, and LNM commands require a string of characters to be sent over the GPIB along with the command. A string input to the 360 *must* have the quote characters (“ ”) surrounding the desired characters for the string and *cannot* exceed the maximum number of characters specified for the command. An example of embedding quote characters in a string sent to the 360 is shown in Figure 3-1. This example is in HP 85 BASIC:

The TDD and TTB commands enable the user to store tabular data to the disc and recall it for output to the printer with the tabular printout points controlled by commands PT0–PT9. These commands are described in Section V, paragraph 5-5, Disk Function Commands.

Table 3-10. Setup Commands for Hard Copy Output (1 of 2)

360 GPIB Command	Description	Values	Terminators
DPN (value)	Enter pen number for data	1 to 8	XX1
FFD	Form feed to printer/stop print/plot	N/A	N/A
GPN (value)	Enter pen number for graticule	1 to 8	XX1
HD0	Turn off tabular data headers and page formatting	N/A	N/A
HD1	Turn on tabular data headers and page formatting	N/A	N/A
HPN (value)	Enter pen number for header	1 to 8	XX1
LDT (string)	Enter label string for operator’s name	String of characters up to 12 characters long	N/A
LID (string)	Enter label string for device I.D.	String of characters up to 12 characters long	N/A
LMS (string)	Enter label string for model/serial number	String of characters up to 12 characters long	N/A
LNM (string)	Enter label string for operator’s name	String of characters up to 12 characters long	N/A
MPN (value)	Enter pen number for markers and limits	1 to 8	XX1
PBL	Select quarter-size plot, bottom left corner	N/A	N/A
PBR	Select quarter-size plot, bottom right corner	N/A	N/A
PFL	Select full-size plot	N/A	N/A

Table 3-10. Setup Commands for Hard Copy Output (2 of 2)

360 GPIB Command	Description	Values	Terminators
PT0-PT9	Select tabular printout points skipped, 0-9	N/A	N/A
PTL	Select quarter-size plot, top left corner	N/A	N/A
PTR	Select quarter-size plot, top right corner	N/A	N/A
SPD (value)	Enter pen speed percentage	10 to 100	XX1, XX3, XM3

Table 3-11. Action Commands for Hard Copy Output

360 GPIB Command	Description	Values	Terminators
PFS	Print full screen image	N/A	N/A
PGR	Print graph area screen image	N/A	N/A
PGT	Plot graticule	N/A	N/A
PLD	Plot data area only	N/A	N/A
PLH	Plot header	N/A	N/A
PLM	Plot markers and limits	N/A	N/A
PLS	Plot entire screen	N/A	N/A
PLT	Plot data traces only	N/A	N/A
PMK	Print tabular data for markers	N/A	N/A
PMN	Plot menu	N/A	N/A
PMT	Print tabular data for traces and markers	N/A	N/A
PST	Stop print/plot	N/A	N/A
PTB	Print tabular data for traces	N/A	N/A

```
10  ! EXAMPLE ON USE OF STRINGS
20 Q$=CHR$(34) ! QUOTE SYMBOL
30 M$="4_TO_8_FILTR" ! MODEL
40 I$="456789" ! I.D.
50 D$="8/25/87" ! DATE
60 O$="GPIB_WHIZ" ! OPERATOR
70 OUTPUT 706 “LMS”Q$&M$&Q$
80 OUTPUT 706 “LID”&Q$&I$&Q$
90 OUTPUT 706 “LDT”&Q$&D$&Q$
100 OUTPUT 706 “LNM”&Q$&O$&Q$
110 END
```

Figure 3-1. An Example of Hard Copy Code Using Embedded Quotes

3-12 SYSTEM STATE COMMANDS

Table 3-12 lists the system state commands. These commands are used to specify CRT display parameters, information display format, and other parameters that control the operation of the system. The function of approximately half of these commands is to display test set connector type information on the system screen.

Table 3-12. System State Commands (1 of 2)

360 GPIB Command	Definition	Notes
ACF	Accept 360 system configuration	N/A
BC0	Set CRT blanking on (screen blanked)	Allows for the ultimate in security — a totally blank screen. In this mode, the 360 is fully operational over the GPIB but nothing appears on display.
BC1	Set CRT blanking off (screen active)	Screen blanking is turned off.
BLU	Select blue as third color	Allows selection of the third color used by the 360 for markers, limits, and some menu annotation
CYN	Select cyan as third color	Allows selection of the third color used by the 360 for markers, limits, and some menu annotation.
DC1	Display channel 1 and 2 operating parameters	Displays channels 1 and 2 operating parameters in the data area of the screen.
DC3	Display channel 3 and 4 operating parameters	Displays channels 1 and 2 operating parameters in the data area of the screen.
DCP	Display calibration parameters	Displays calibration parameters in the data area of the screen.
DF2	Display 2.4 mm female connector information	N/A
DF3	Display GPC-3.5 female connector information	N/A
DFK	Display K female connector information	N/A
DFN	Display TYPE N female connector information	N/A
DFP	Display front panel instrument state	Displays global operating parameters in the data area of the screen.
DFS	Display SMA female connector information	N/A
DFT	Display TNC female connector information	N/A
DFV	Display V female connector information	N/A
DG7	Display GPC-7 male connector information	N/A
DGS	Display GPIB status information	DIsplays the GPIB system parameters in the data area of the screen.
DM2	Display 2.4 mm male connector information	N/A
DM3	Display GPC-3.5 male connector information.	N/A
DMK	Display K male connector information	N/A
DMN	Display TYPE N male connector information	N/A
DMS	Display SMA male connector information	N/A

Table 3-12. System State Commands (2 of 2)

360 GPIB Command	Definition	Notes
DMT	Display TNC male connector information	N/A
DMV	Display V male connector information	N/A
DWG	Display waveguide parameters	N/A
FOF	Frequency information blanked	Instructs the 360 to blank any frequency information from the screen and any hard copy output. This code is useful for security reasons.
FON	Frequency information displayed	Frequency blanking can be turned off using this code.
INT	Initialize (format) data-only disk in drive	See Paragraph 5-5
RST	Reset instrument to default parameters	Similiar to pressing the “DEFAULT PROGRAM” key
RTL	Return to local (front panel) control	Performs the same function as the control panel RETURN TO LOCAL key. This code has no effect if the 360 is in local lockout.
TST	Perform self test	Performs the same self-test function as the SELF TEST menu selection from the TESTS menu. Returns a string of 20 zeros if self test passes. Returns up to 20 error numbers if fail. For a listing of error messages that correspond to the error numbers, refer to the ERROR AND STATUS MESSAGES information contained in Section IV of the 360 Vector Network Analyzer Operation Manual.

3-13 TEST SET MULTIPLEXER CONTROL COMMANDS

Table 3-13 list the test set multiplexer commands. These commands control the 360 Test Set Multiplexer during remote (GPIB) system operation.

Command ACF—Accept 360 System Configuration—is normally used in conjunction with these commands (refer to paragraph 3-12—System State Commands). Commands SFA and SFB are used to control an external A/B RF switch (if used).

NOTE

The 360 Test Set Multiplexer is an option to the 360 VNA. The external A/B RF switch is customer supplied.

Table 3-13. Test Set Multiplexer Control Commands

360 GPIB Command	Definition
MP0	Set non-selected test set standby power off
MP1	Set non-selected test set standby power on
RFA	Set RF switch to A position
RFB	Set RF switch to B position
SRA	Set signal source to A
SRB	Set signal source to B
TSA	Set test set to A
TSB	Set test set to B

3-14 VIDEO SWITCH CONTROL COMMANDS

Table 3-14 list the video output control commands that control the internal 360 video switching paths. These switching paths are shown in Figure 3-2.

The video output control commands perform the same functions as the U7 menu selections. (The U7 menu is invoked from the VIDEO CONFIGURATION selection of the U1 Utility Menu; refer to the 360 Vector Network Analyzer Operation Manual.)

Table 3-14. Video Output Redirection Control Codes

360 GPIB Command	Definition
VEE	Video – External signal to external monitor
VEI	Video – External signal to internal screen
VIE	Video – Internal signal to external monitor
VII	Video – Internal signal to internal screen

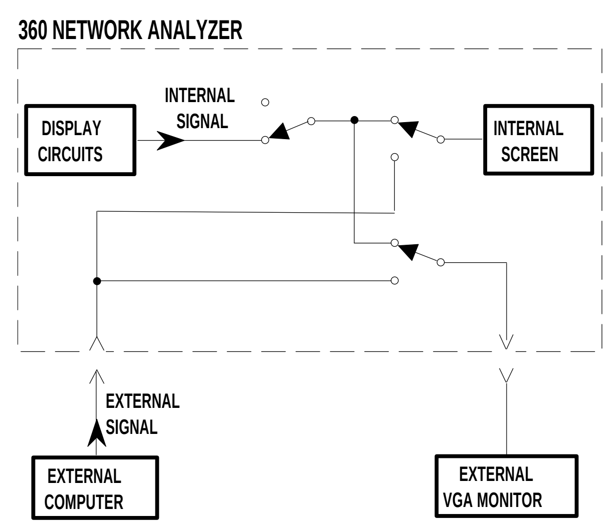

Figure 3-2. 360 VNA Video Signal Paths

3-15 PULSE SYSTEM COMMAND

The PMC mnemonic is the only command used with the 360PS20A Pulsed VNA system. This command provides control of the 3636A Pulsed/CW Test Set pulse modulators by writing a control byte image to the modulator control register of the test set (via the 360 VNA). Refer to the 360PS20A Pulsed/CW Vector Network Analyzer Operation Manual for further information about operation of the 360PS20A Pulsed VNA system and system components.

The bit assignment of the register byte image is shown in Figure 3-3; note that only the upper nibble (i.e, four most significant bits) are used. If bit = 1, the corresponding modulator will be turned on full to override the profile pulse. If bit = 0, the profile pulse will control the modulator. The example code shown below is a program function to turn on all four modulators. Note that byte is shown in hexadecimal format (example is written in "C".)

Example:

```
unsigned char control_byte;
ibwrt(pna, "PMC", 3);           /* send mnemonic
                                   to 360 VNA */
control_byte = 0xF0;            /* all modulators
                                   Ta, Ra, Tb, and
                                   Rb full on */
ibwrt(pna, &control_byte, 3);  /* send
                                   byte to 360 */
```

Rb	Tb	Ra	Ta	0	0	0	0
7	6	5	4	3	2	1	0
Upper Nibble				Lower Nibble			

Figure 3-3. Pulse System Control Byte Bit Structure

3-16 NOISE FIGURE SYSTEM COMMANDS

The commands listed in Table 3-15 are used to control the functions of the 3642A Noise Figure Module and to read the status byte from that module. The 3642A Noise Figure Module is part of the 360NF20A Noise Figure Vector Network Analyzer System. Refer to the 360NF20A Noise Figure/Vector Network Analyzer Operation Manual for information about the bit structure and bit functions of the control registers affected by these commands.

Table 3-15. Noise Figure System Commands

360 GPIB Command	Description	Values
MC1 (value)	Write control byte to 3642A Noise Figure Module Primary Control Register	Binary, 8 bit
MC2 (value)	Write control byte to 3642A Noise Figure Module Secondary Control Register	Binary, 8 bit
RSB (value)	Read Status Register (ID byte)	Binary, 8 bit

3-17 MILLIMETER-WAVE TEST SET COMMANDS

The commands listed in Table 3-16 control the functions of the 3635A Millimeter Wave Test Set when operated in the GPIB mode.

Table 3-16. Millimeter-Wave Test Set Commands

360 GPIB Command	Description
LDM	Load new modules (must be specified for the band and head changes that are to take place). The mnemonic "LDM" must be specified after band.
P2A	Select model number 3640 "A" for port 2
P2B	Select model number 3641 "B" for port 2
Q22	Select Q band (33-50 GHz) with WR-22
U19	Select U band (40-60 GHz) with WR-19
V15	Select V band (50-75 GHz) with WR-15
W10	Select W band (75-110 GHz) with WR-10

SECTION IV
COMMANDS FOR
CALIBRATION FUNCTIONS

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SECTION IV
COMMANDS FOR
CALIBRATION FUNCTIONS

4-1 INTRODUCTION

This section describes the GPIB Product Specific Commands used to perform system calibration functions. In this section, these messages are referred to as "360 GPIB commands" or simply "commands". These commands perform the following functions.

- Specify the calibration method desired.
- Specify the type of calibration desired.
- Specify the calibration standards to be used.
- Specify the transmission line type and associated characteristics.
- Control the calibration data-taking process.

4-2 DESCRIPTION OF CALIBRATION COMMANDS

Table 4-2 located at the rear of this section lists all GPIB commands that are used to perform the 360 VNA calibration function under remote control. This table provides a brief description of the function for each command and lists permissible values and terminators, if required. Programming examples showing typical usage of these commands are provided in paragraphs following the table.

NOTE

The 360 VNA calibration function requires operator intervention. However, it is possible to use the external controller to guide the operator through the calibration process using a suitable program containing the calibration commands described in this section.

4-2.1 Major Calibration Commands

The following paragraphs provide detailed descriptions of the major GPIB commands used for calibration. They also provide programming information and techniques for the use of these commands.

a. Specify Normal 501 Point Calibration (NOC)

This command sets up a normal frequency range calibration.

b. Enter Start Frequency for Normal Calibration (SRT)

This command sets the *lower limit* of the range of frequencies used for the calibration process.

c. Enter Stop Frequency for Normal Calibration (STP)

This command sets the *upper limit* of the range of frequencies used for the calibration process.

d. Specify Discrete Frequency Calibration (DFC)

This command sets up a calibration at discrete frequencies only.

1. Only the points entered using the DFQ, IFV, FRS, FRI, FRP, or FIL commands are used in calibration ($2 \leq$ number of points ≤ 501) .

2. The IFV command allows for a frequency list input of calibration frequencies. Refer to paragraph 5-3, Data Transfer Commands, for more details.

3. The DFQ, FRS, FRI, FRP, FIL, and DFO commands can also be used to specify frequencies outside of calibration.In this application, any calibration data is lost.

e. Specify CW Calibration (CWC)

This command sets up a *continuous wave* (CW) calibration.

f. Set up to Specify Port One Calibration Standards (P1C)

This command specifies port one as the port to which subsequent connector-related commands will apply.

g. Set up to Specify Port Two Standards (P2C)

This command specifies port two as the port to which subsequent connector-related commands will apply.

Example:

"P1C CFK P2C CMK"

This sequence of commands sets up a female K connector for port 1 (P1C CFK) and a male K connector for port 2 (P2C CMK).

h. Other Connector Specification (CND)

This command allows a non-standard connector to be specified. This is the same as selecting OTHER from the control panel menu. When specifying the CND command, the connector offset for the open and/or short device and the capacitance coefficients for the open device are entered to characterize the connector.

i. Specify Sliding Load for Calibration (SLD)

This command specifies a sliding load. If specifying the SLD command, the data-taking process for the load includes six slide positions. If any frequencies are below 2 GHz, you *must* use a broadband load.

4-2.2 Required Calibration Command Sequence

A program to control the calibration process *must* use a specific order for the GPIB calibration commands. Table 4-1 lists this acceptable order.

4-2.3 Other Calibration Related Commands

The following commands are used for special types of calibrations and to simulate a calibration process.

a. A12, A8T, ARF, AFR, AFT, and ARL

These commands simulate the completion of a calibration. When used in this manner, commands associated with calibration coefficients (IC1–IC9, ICA–ICC, OC1–OC9, OCA–OCC) are matched with the corresponding error terms. For additional information, refer to Section V, paragraph 5-3, Data Transfer Commands.

Table 4-1. Calibration Command Ordering

Order	Item	Typical Commands Used	Required / Optional
1	Calibration Method	SCM, OCM, LCM	O
2	Line Type	LTC, LTW, LTU	O
3	Waveguide Parameters	WK1, WKD, WCO, SH1, SH2	O
3	Calibration Type	C12, C8T, CRF, CFR, CFT, CFL	R
4	Isolation Usage	ISN, ISF	O
5	Data Points	NOC, DFC, TDC, CWG	O
6	Frequency: Range Discrete * CW	 SRT, STP DFQ, DFD, IFV, FRS, FRI, FRP, FIL, FRC CWF	 O R O
7	Connector Type , and Offset Short Values	P1C, P2C, CMS, CFS, CMK, CFK, CMV, CFV, CMC, CFC, CM2, CF2, CMN, CFN, CM3, CF3, CNG, CND, COO, COS, CC0, CC1, CC2, CC3, SH1, SH2	O
8	Load Type	SLD, BBL	O
9	Through Parameters	TOL, TDL, TFL, TFE	O
11	LRL Band	LR2, LR3	O
12	LRL Parameters	RM1, RRP, LL1, LL2, LL3, LM2, LM3, BPF	O
13	Microstrip Parameters	U10, U15, U25, USW, SBT, SBD, USE, USZ	O
14	Begin Calibration (Data Collection)	BEG	R

∗ Required commands if DEC command previously issued. Command CND must be issued before sending CCO–CC3, and COS.

NOTE

The A8T, A12, ARF, AFR, AFT, and ARL commands match up with corresponding calibration type commands. These commands can be used for advanced applications that input calibration coefficients into the 360 (refer to Section V, paragraph 5-3).

b. CON and COF

These commands are not used during calibration. They are used during normal measurements to apply the current calibration (CON) or to turn off any applied calibration (COF).

c. LM2 and LM3

These commands are used to select a match for the second or the third device respectively during a LRM type calibration. Example:

```
ibwrt(pna, "LM2", 3);        /* match as second
                                device */
```

d. U10, U15, and U25

These commands are used to select 10, 15, or 25 mil UTF calibration kits respectively. These calibration kits are used to perform a 360 calibration for microstrip device measurements. Example:

```
ibwrt(pna, "U10", 3);        /* select 10 mil
                                calibration */
```

4-2.4 A Simple Example Calibration Program

The following is an example program to set up a typical calibration sequence for the 360 VNA:

"SCM LTC C12 DFC FRS 1.0 GHZ FRI 100MHZ FRP 41 XX1 FIL DFD P1C CFK P2C CMK BBL BEG"

This example code sets up a calibration using standard calibration mode (SCM), coax cable media (LTC), and 12-term calibration type (C12). A discrete set of points is defined for frequency operation starting at 1 GHz (FRS 1.0 GHZ), spaced 100 MHz apart (FRI 100MHZ), at 41 consecutive points (FRP 41 XX1). This range is confirmed or "filled" (FIL), then completed (DFD).

The Port 1 test port connector is defined as a female type K connector (P1C CFK) and the Port 2 test port connector is defined as a male K type connector (P2C CMK). Broadband loads are selected as the default load type (BBL). The BEG command instructs the 360 to begin the calibration-data-taking-process.

The calibration control program should contain commands to control the data-collection portion of the calibration process. Typical commands used for this process are:

- Take Calibration Data for Current Standard (TCD)
- Go on to the Next Calibration Step (NCS)
- Averaging On and Set to Value (AVG)
- Averaging Off (AOF)
- Set IF Bandwith to Normal (IFN)
- Set IF Bandwith to Reduced (IFR)
- Set IF Bandwith to Minimum (IFM)
- Any Graph Type Specification or Scaling Change
- Active Channel Specification (CH1–CH4)

The TCD and NCS commands control the data-taking process. Commands AVG, AOF, IFN, IFR, and IFM control the data-enhancement function used for a particular measurement (refer to Section III, paragraph 3-6, Enhancement Commands).

Before the TCD and NCS commands are invoked in the program, the system operator must be instructed to perform the *exact* steps necessary to setup the calibration sequence for the type of 360 calibration to be used. An example program segment to continue the 12-term calibration started in the previous example is shown in Figure 4-1. This example program segment is in written in HP-BASIC.

The calibration control program should determine if the 360 is ready for the next step of the calibration sequence before prompting the system operator to connect new calibration standards to the test ports. This can be done by monitoring the status of the 360 or by requesting "dummy" data output from the 360 after executing the NCS command.

For example, the command in the example below instructs the 360 to take calibration data (TCD), go to the next calibration step (NCS), and output the number of points it is measuring (ONP). When the controller is able to read the points string from the 360, the calibration step is complete.

```
260 OUTPUT 706;"TCD NCS ONP"
270 ENTER 706; N$     ! READ #POINTS WHEN STEP IS COMPLETE
280 DISP "CALIBRATION STEP COMPLETE"
```

4-2.5 An Example HP-BASIC Subprogram

A listing of an example calibration subprogram is shown in Figure 4-1. This program guides the 360 system operator through a 12 term calibration sequence. The calibration is performed at 41 discrete frequencies with 100 MHz spacing from 1 to 5 GHz (see explanation of line 330 in preceding paragraph).

In this example, the same technique is used as described in paragraph 4-2.4 to determine if the 360 is ready for the next calibration step.

An example of a main program that calls this and other subprograms is described in application note, AN360-9, which is included behind the Supplements tab in this manual.

```
290   !                          —-CALIBRATION SUBPROGRAM—-
300   !
310   SUB Cal_12_term(@vna)
320   PRINT TABXY(35,1);"CALIBRATION"
330   OUTPUT @vna; “LTC SCM C12 DFC FRS 1 GHZ FRI 100 MHZ FRP 41 XX1 FIL
      DFD P1C CFK P2C CMK BBL BEG ONP”
340   ENTER @vna;N$
350   DISP “CONNECT BROADBAND LOADS TO PORT 1 AND PORT 2"
360   GOSUB Continue
370   DISP “CONNECT OPEN TO PORT 1 AND SHORT TO PORT 2"
380   GOSUB Continue
390   DISP “CONNECT SHORT TO PORT 1 AND OPEN TO PORT 2"
400   GOSUB Continue
410   DISP “CONNECT PORT 1 TO PORT 2"
420   GOSUB Continue
430   DISP “12 TERM CALIBRATION COMPLETE”
440   SUBEXIT
450 Continue: BEEP
460   LOOP
470   ON KEY 5 LABEL “TAKE CAL DATA” GOTO 490
480   END LOOP
490   DISP “TAKING CALIBRATION DATA...”
500   OUTPUT @vna;"TCD NCS ONP"
510   ENTER @vna;N$
520   RETURN
530   SUBEND
540   !
```

Figure 4-1. Example Program Segment to Control Calibration Data Collection (HP BASIC)

4-2.6 An Example "C" Program Function

An example "C" program function, "cal_12_term()", is shown in Figure 4-2. This program function performs the same calibration sequence described in paragraphs 4-2.4 and 4-2.5. In this example, the program function "cal_data()" instructs the 360 to take calibration data (TCD) and advance to the next step (NCS) after determining if the 360 is ready.

An example of a main program that calls this and other subprograms is described in the application note, AN360-8, which is included behind the Supplements tab in this manual.

```
/*——————————————————————————————————-
                    Calibration Function
   Setup for a 12-Term Calibration and prompt the operator
              to install cal devices as required.
 ——————————————————————————————————-*/
cal_12_term(vna)
  int vna;
  {
  static char
    a[]="LTC SCM C12 DFC FRS 1 GHZ FRI 100 MHZ FRP 41 XX1",
    b[]="FIL DFD P1C CFK P2C CMK BBL BEG ONP",
    point_str[40];

  printf("\n\t\t\t\tCALIBRATION\n");
  ibwrt(vna,a,sizeof(a));
  ibwrt(vna,b,sizeof(b));
  ibrd(vna,point_str,40);
  printf("\nConnect BROADBAND LOADS to Port 1 and Port 2:\n");
  cal_data(vna);
  printf("\nConnect OPEN to Port 1 and SHORT to Port 2:\n");
  cal_data(vna);
  printf("\nConnect SHORT to Port 1 and OPEN to Port 2:\n");
  cal_data(vna);
  printf("\nConnect Port 1 to Port 2:\n");
  cal_data(vna);
  printf("\n\t\t        12-Term Calibration Complete\n");
  }

  cal_data(vna)        /* function to take cal data */
    int vna;
    {
    static char
      key,
      c[]="TCD NCS ONP",
      point_str[40];

    printf("\tPress ENTER key to Take Cal Data\n");
    while((key = getch())!='\r');
    printf("Taking Calibration Data...\n");
    ibwrt(vna,c,sizeof(c));
    ibrd(vna,point_str,40);
    }
```

Figure 4-2. Example "C" Program Function to Perform a 12 Term Calibration

Table 4-2. Calibration Commands (1 of 4)

360 GPIB Command	Description	Values	Terminators
A8T	Simulate 8-term (1-path) calibration	N/A	N/A
A12	Simulate 12-term calibration	N/A	N/A
AFR	Simulate frequency response calibration	N/A	N/A
AFT	Simulate transmission-only frequency response calibration	N/A	N/A
ARF	Simulate reflection only calibration	N/A	N/A
ARL	Simulate reflection-only frequency response calibration	N/A	N/A
BBL	Select broadband load for calibration	N/A	N/A
BEG	Begin calibration data-collection steps	N/A	N/A
BPF (value)	Break point frequency for 3 line LRL only	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
C8T	Select 8-term (1-path) calibration	N/A	N/A
C12	Select 12-term calibration	N/A	N/A
CC0 (value) CC3 (value)	Enter capacitance coefficients 0-3 for open for user-specified connector	–9999.99 to +9999.99	XX1
CF2	Select female 2.4 mm connector for current port	N/A	N/A
CF3	Select female GPC-3.5 connector for current port	N/A	N/A
CFC	Select female TNC connector for current port	N/A	N/A
CFK	Select female K connector for current port	N/A	N/A
CFN	Select female Type N connector for current port	N/A	N/A
CFR	Select transmission and reflection frequency response calibration	N/A	N/A
CFS	Select female SMA connector for current port	N/A	N/A
CFT	Select transmission-only frequency response calibration	N/A	N/A
CFV	Select female V connector for current port	N/A	N/A
CM2	Select male 2.4 mm connector for current port	N/A	N/A
CM3	Select male GPC-3.5 connector for current port	N/A	N/A
CMC	Select male TNC connector for current port	N/A	N/A
CMK	Select male K connector for current port	N/A	N/A

Table 4-2. Calibration Commands (2 of 4)

360 GPIB Command	Description	Values	Terminators
CMN	Select male Type N connector for current port	N/A	N/A
CMS	Select male SMA connector for current port	N/A	N/A
CMV	Select male V connector for current port	N/A	N/A
CND	Select user-specified connector for current port	N/A	N/A
CNG	Select GPC-7 connector for current port	N/A	N/A
COF	Turn off vector error correction	N/A	N/A
CON	Turn on vector error correction	N/A	N/A
COO (value)	Enter offset for open for user-specified connector	–999.9999 to +999.9999	MMT, CMT, MTR
COS (value)	Enter offset for short for user-specified connector	–999.999 m to 999.999 m	MMT, CMT, MTR
CRF	Select reflection only calibration	N/A	N/A
CRL	Select reflection-only frequency response calibration	N/A	N/A
CWC	Select CW frequency calibration data points	N/A	N/A
DFC	Select discrete frequency calibration data points	N/A	N/A
DFD	Done specifying discrete frequency ranges	N/A	N/A
DFQ (value)	Enter single discrete frequency	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
FIL	Fill defined discrete frequency range	N/A	N/A
FRC	Clear all defined discrete frequency ranges	N/A	N/A
FRI (value)	Set discrete frequency fill range increment frequency	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
FRP (value)	Set discrete frequency fill range number of points	1 to (501 — current number of points)	XX1, XX3, XM3
FRS (value)	Set discrete frequency fill range start frequency	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
ISF	Exclude isolation	N/A	N/A
ISN	Include isolation	N/A	N/A
KEC	Keep existing calibration data	N/A	N/A
LCM	Select LRL calibration method	N/A	N/A
LL1 (value)	Enter length of line 1 for LRL calibration	0 to +999.9999	MMT, CMT, MTR
LL2 (value)	Enter length of line 2 for LRL calibration	0 to +999.9999	MMT, CMT, MTR

Table 4-2. Calibration Commands (3 of 4)

360 GPIB Command	Description	Values	Terminators
LL3 (value)	Enter length of line 3 for 3 line LRL calibration	0 to +999.9999	MMT, CMT, MTR
LLZ (value)	Enter line impedance for LRL calibration	0.001 to 1x10E+3	XX1, XX3, XM3
LM2	Select a match for the second device during a LRM type calibration	N/A	N/A
LM3	Select a match for the third device during a LRM type calibration	N/A	N/A
LR2	Specify 2 line LRL	N/A	N/A
LR3	Specify 3 line LRL	N/A	N/A
LTC	Select coaxial transmission line for calibration	N/A	N/A
LTU	Select microstrip transmission line for calibration	N/A	N/A
LTW	Select waveguide transmission line for calibration	N/A	N/A
NCS	Go on to next calibration step	N/A	N/A
NOC	Select normal calibration data points This code	N/A	N/A
OCM	Select offset short calibration method	N/A	N/A
P1C	Select port 1 for connector specification	N/A	N/A
P2C	Select port 2 for connector specification	N/A	N/A
RGZ	Select reflective device greater than Z0 (LRL)	N/A	N/A
RLZ	Select reflective device less than Z0 (LRL)	N/A	N/A
RM1	Select reference plane at line 1 midpoint (LRL)	N/A	N/A
ROL (value)	Enter reflective device offset length for LRL calibration	–999.999 to +999.999	MMT, CMT, MTR
RPC	Repeat previous calibration	N/A	N/A
RRP	Select reference plane at reflection plane (LRL)	N/A	N/A
SBD (value)	Enter substrate dielectric for microstrip calibration	1.0 to 9999.99	XX1, XX3, XM3
SBT (value)	Enter substrate thickness for microstrip calibration	0.001 mm to 1.0 m	MMT, CMT, MTR
SCM	Select standard calibration method	N/A	N/A

Table 4-2. Calibration Commands (4 of 4)

360 GPIB Command	Description	Values	Terminators
SH1 (value)	Set offset short 1 offset length	–999.999 to +999.999	MMT, CMT, MTR
SH2 (value)	Set offset short 2 offset length	–999.999 to +999.999	MMT, CMT, MTR
SLD	Select sliding load for calibration	N/A	N/A
TCD	Take calibration data for current standard	N/A	N/A
TDC	Select time domain harmonic frequency calibration data points	N/A	N/A
TDL (value)	Through DC coefficient for loss	–999.999 to +999.999	XX1
TFE (value)	Through frequency exponent for loss	–9.999 to +9.999	XX1
TFL (value)	Through frequency coefficient for loss	–999.999 to +999.999	XX1
TOL (value)	Through offset length	–999.9999 to +999.9999	MMT, CMT, MTR
U10	Select 10 mil UTF calibration kit for calibration for microstrip device measurements	N/A	N/A
U15	Select 15 mil UTF calibration kit for calibration for microstrip device measurements	N/A	N/A
U25	Select 25 mil UTF calibration kit for calibration for microstrip device measurements	N/A	N/A
USE (value)	Enter effective dielectric for microstrip calibration	1.0 to 9999.99	XX1, XX3, XM3
USW (value)	Enter microstrip width for microstrip calibration	0.001 mm to 1.0 m	MMT, CMT, MTR
USZ (value)	Enter microstrip impedance for microstrip calibration	1.0 to 9999.99	XX1, XX3, XM3
WCO (value)	Set waveguide cutoff frequency for user-defined kit	0 to current start frequency	GHZ, MHZ, KHZ
WKD	Select user-defined waveguide calibration kit	N/A	N/A
WKI	Select installed waveguide calibration kit	N/A	N/A

SECTION V
ADVANCED GPIB PROGRAMMING AND GPIB UNIQUE FUNCTIONS

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SECTION V
ADVANCED GPIB PROGRAMMING AND GPIB UNIQUE FUNCTIONS

5-1 INTRODUCTION

This section describes the GPIB Product Specific Commands that produce operations that are unique to the GPIB mode of operation. Example commands included in this group are: Data Transfer commands, Group Execute commands, etc. (see Table of Contents, page 5-1). In this section, these messages are referred to as “360 GPIB commands” or simply “commands”.

5-2 SAVE/RECALL COMMANDS

The Save/Recall commands listed in Table 5-1 allow the system user to save and recall:

- (1) front panel setup data to and from internal memory, and
- (2) calibration and front panel setup data to/from the disk. The syntax for entering a file name string to the 360 is the same as the syntax for the strings in the LMS, LID, LDT and LNM commands described in Section III, paragraph 3-11.

The double quote characters must enclose the string sent to the 360. The 360 accepts only MS-DOS compatible file name characters. Refer to paragraph 5-5, Disk Function Commands, for more information about file naming conventions.

Table 5-1. Save/Recall Commands

360 GPIB Command	Description	Values	Terminators
SV1-SV4	Save front panel setup to internal memory location 1-4	N/A	N/A
RC1-RC4	Recall front panel setup data from internal memory location 1-4	N/A	N/A

5-3 DATA TRANSFER COMMANDS

Table 5-2 describes the data transfer commands. The 360 transfers data to/from an external computer via the GPIB in two basic formats: binary and ASCII. All ASCII data values either output by the 360 or expected as input *must* have the following form:

Where:

S xxx . yyyyyyyyyyyyyyy E sz

S = sign, either blank or "–"

x = digits to the left of the decimal (3)

y = digits to the right of the decimal (15)

E = exponential notation indicator

s = exponent sign, either '+' or '–'

z = digits for exponent (2)

• = decimal point

Separate all ASCII transfers that involve data pairs (such as real and imaginary elements) by commas. For transfers involving more than one item of information, separate each item by a line feed.

For example, the 360 response to the commands **"FMA OCD"** would be:

(Repeated Number of Points) <LF>

<Real ASCII>, <Imaginary ASCII>

EOI on Last Byte

Binary data transfers involving numerical values use 32-bit or 64-bit floating point numbers in IEEE-754 format. The format of string data, such as that used for front panel setup data, is not user controllable. Binary data is always sent in the standard block format shown in Figures 5-1 and 5-2.

The data-format commands (FMA, FMB and FMC) and the byte-ordering commands (LSB and MSB) control the format of the data that is input or output by the 360 VNA under control of many of the data transfer commands (Table 5-2). However, the commands that transfer binary data strings and ASCII data are not affected by the data format and byte-ordering commands. (These commands always input/output binary data strings and ASCII data regardless of the currently selected data format.) Refer to Table 5-2 and Figure 5-2 for details.

LSB MODE:

		Byte Count		Byte Count Bytes
#	A	Least Significant Byte	Most Significant Byte	Binary Data Least Significant Byte First for All Elements

Standard Preamble Bytes

EOI Coincidental With The Last Byte

MSB MODE:

		Byte Count		Byte Count Bytes
#	A	Most Significant Byte	Least Significant Byte	Binary Data Least Significant Byte First for All Elements

Standard Preamble Bytes

EOI Coincidental With The Last Byte

Figure 5-1. Binary Data Transfer Message Format

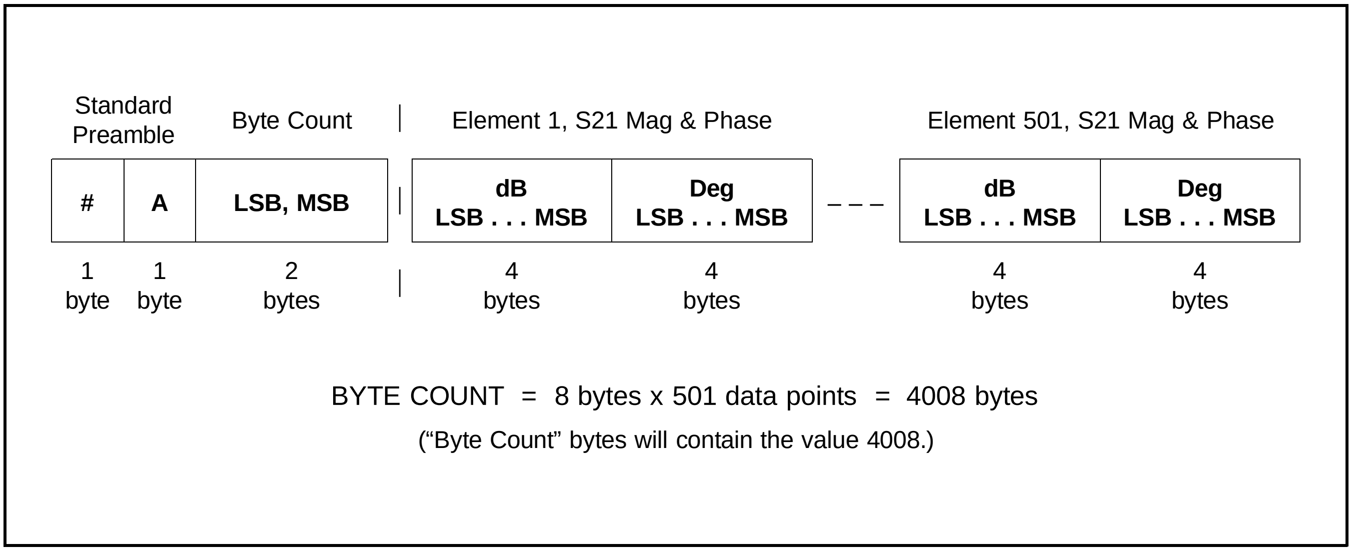

Figure 5-2. Example of Binary Data Transfer

Table 5-2. Data Transfer Commands (1 of 2)

360 GPIB Command	Brief Description	Descript. (Para.)	Data Formats
CCD	Collect corrected data for parameter of active channel	5-3 m.	N/A
CFD	Collect final (display format) data for parameter of active channel	5-3 m.	N/A
CRD	Collect raw data for parameter of active channel	5-3 m.	N/A
FMA	Select ASCII data transfer format	5-3 e.	N/A
FMB	Select IEEE-754 64-bit data transfer format	5-3 e.	N/A
FMC	Select IEEE-754 32-bit data transfer format	5-3 e.	N/A
IC1 (value) – IC9 (value)	Input calibration coefficient 1-9	5-3 g.	FMA, FMB, FMC
ICA (value), ICB (value), ICC (value)	Input calibration coefficient A, B, C	5-3 g.	FMA, FMB, FMC
ICD (value)	Input corrected data for parameter of active channel	5-3 l.	FMA, FMB, FMC
ICF (Binary string)	Input information for front panel setup *and* calibration in binary string format	5-3 n.	Binary string
ICL (Binary string)	Input all 12 calibration coefficients in binary string format	5-3 g.	Binary string
IFD (value)	Input final (display format) data for parameter of active channel	5-3 l.	FMA, FMB, FMC
IFP (Binary string)	Input information for current front panel setup in binary string format	5-3 i.	Binary string
IFV (value)	Input frequency list	5-3 h.	FMA, FMB, FMC
IS1 (Binary string) – IS4 (Binary string)	Input information for front panel setups in binary string format	5-3 i.	Binary string

Table 5-2. Data Transfer Commands (2 of 2)

360 GPIB Command	Brief Description	Descript. (Para.)	Data Formats
LSB	Select least significant byte first binary transfers	5-3 f.	N/A
MSB	Select most significant byte first binary transfers	5-3 f.	N/A
OAP (value)	Output active parameter value	5-3 b.	ASCII
OC1 (value) – OC9 (value)	Output calibration coefficient 1–9	5-3 g.	FMA, FMB, FMC
OCA (value), OCB (value), OCC (value)	Output calibration coefficient A, B, C	5-3 g.	FMA, FMB, FMC
OCD (value)	Output corrected data for parameter of active channel	5-3 l.	FMA, FMB, FMC
OCF (Binary string)	Output information for front panel setup *and* calibration in binary string format	5-3 o.	Binary string
OCL (Binary string)	Output all 12 calibration coefficients in string form	5-3 g.	Binary string
OCS	Output collected data	5-3 m.	N/A
ODR (Binary string)	Output disk directory	5-3 k.	Binary string
OFD (value)	Output final (disp. format) data for parameter of active channel	5-3 l.	FMA, FMB, FMC
OFP (Binary string)	Output information for current front panel setup in binary string format	5-3 j.	Binary string
OFV (value)	Output frequency values	5-3 h.	FMA, FMB, FMC
OID (value)	Output instrument identification string	5-3 d.	40 byte ASCII strg
OKP (value)	Output number of front panel key pressed	5-3 c.	ASCII
OM1 (value) – OM6 (value)	Output marker 1-6 value (display format)	5-3 a.	ASCII
ONP (value)	Output number of points currently being measured	5-3 p.	ASCII
ORD (value)	Output raw data for parameter of active channel	5-3 l.	FMA, FMB, FMC
OS1 (Binary string) – OS4 (Binary string)	Ouput information for front panel setups (1–4) in binary string format	5-3 j.	Binary string

The most important points to consider about data transfer are (1) the data format to use and (2) the byte ordering desired. When using the FMA data format, the byte ordering selected by the LSB or MSB commands is irrelevant.

ASCII data is not dependent on the active byte order. However, even if the 360 is using FMA format, some transfers (such as the OS1–OS4 commands) still use the binary transfer format, which is affected by the active byte ordering. Conversely, even if you select FMB or FMC data format, some transfers will always occur in ASCII and are unaffected by the LSB or MSB commands.

NOTE

The byte ordering mode (LSB or MSB) also affects the order of the two bytes that comprise the byte count portion of the standard preamble (Figure 5-1.)

Table 5-3. Output Values Vs Various Graph Types

Display Type	Output Values
Log magnitude	dB, degrees
Phase	dB, degrees
Log mag & phase	dB, degrees
Linear magnitude	Lin Mag (Rho or Tau), degrees
Linear mag & phase	Lin Mag (Rho or Tau), degrees
Smith chart	Ohms, Ohms (r + jx)
Inverted Smith	Siemens, Siemens (g + jb)
Group delay	Seconds, degrees
Log polar	dB, degrees
Linear polar	Lin Mag (Rho or Tau), degrees
Real	Real, imag
Imaginary	Real, imag
Real & Imaginary	Real, imag
SWR	SWR, Degrees

5-3.1 Descriptions of Data Transfer Commands

A detailed description of each of the data transfer commands follows:

a. OM1 - OM6

These commands output the value of the trace on the active channel at marker 1–6. The output is always a pair of ASCII values and is dependent upon the graph type used for the active channel (See Table 5-3).

b. OAP

This command outputs the value of the active parameter as a single ASCII value. If there is no active parameter, a zero value is output.

c. OKP

This command outputs a single ASCII value representing the number of the key pressed on the front panel of the 360 VNA.

d. OID

This command outputs a 40-byte ASCII string defining the current 360 VNA system configuration. The format of the OID string is shown in Table 5-4.

Table 5-4. OID Response String

Number of Bytes					
4	9	9	6	6	6
xxxx Model No.	xx.xxxxxx Low Freq. GHZ	xx.xxxxxx High Freq. GHZ	Sxx.x Low Pwr dBM	Sxx.x High Pwr dBM	xxx.xx S.W. Rev.

e. FMA, FMB, FMC

These commands set up the current active data transfer format.When the current transfer format is unknown, it is a good practice to precede any data transfer commands which depend on these formats with the desired format command.

f. LSB, MSB

These two commands control the ordering of bytes for floating point data transfers. They also control the ordering of the two bytes that comprise the byte count in the standard block header for binary data transfers. LSB specifies that transfers are to be least significant byte first while MSB specifies most significant byte first.

g. IC1-IC9, ICA, ICB, ICC, OCL, ICL, OC1–OC9, OCA, OCB, OCC

These commands provide for calibration coefficient transfers. Table 5-5 shows the ordering of the calibration coefficients for various calibration types. For example, if you desire the ETF error term from an 8-term calibration, you would use the OC4 or IC4 commands.

NOTE

Calibration coefficients are output, or expected as input, only for the currently defined set of sweep frequencies. If data points are not at maximum and/or the frequency range has been zoomed-in (with error correction turned on), not all calibration coefficients will be output or used as input.

If a request is made for an unavailable calibration coefficient array, the 360 VNA treats it as an impossible request and ignores the command.

h. *OFV, IFV*

The OFV command outputs the current 360 VNA measurement frequencies.

The IFV command can be used to input an arbitrary list of frequencies into the 360 VNA (2 ≤ number of frequencies ≤ 501). This code can be used to specify a set of frequencies to used for calibration (after a calibration type has been specified). Command IFV can also be used in the normal measurement mode to input frequencies for a special application. In this usage, any existing calibration data is lost.

i. *IFP, IS1–IS4*

These commands input a binary string of data as information for stored setups (IS1– IS4), or as information for the current front panel setup (IFP). The data string must be exactly the length of the string output by the OFP or OS1–OS4 commands and is checked for validity before the operation is performed. If either the number of bytes, or the contents of the string are invalid, a *parameter out of range error* is generated.

For the IFP command, if the setup data is valid the 360 VNA will change its setup based on the new front panel setup information.

j. *OFP, OS1–OS4*

These commands output a binary string of data from either one of the four stored setups (OS1–OS4) or from the current front panel setup (OFP). The size of a front panel setup is 3 kBytes (3072 bytes).

k. *ODR*

This command outputs a binary string that is an image of the directory table of the current disk mounted in the floppy disk drive of the 360 VNA. If a disk error occurs, the 360 does a disk-error-status-update and transfers no data. The data string for the directory is exactly 3.5 kBytes (3584 bytes) long.

l. *ICD, IFD, ORD, OCD, OFD*

These commands transfer data for the S-parameter on the active channel. Only the *current* measurement points will be output (ORD, OCD, OFD) or expected as input (ICD, IFD).

1. The ORD and OCD commands both output data for the parameter on the active channel in (real, imaginary) pairs (real, imaginary). Similarly, ICD expects corrected data for the parameter on the active channel in pairs.
2. The OFD command outputs data values for the parameter on the active channel that depend on the current graph type being used (see Table 5-3). The IFD command expects the data being input to match the graph type on the active channel in the same way.
3. When parameter data input to the 360 VNA is complete (ICD and IFD) the 360 redraws the parameter on the active channel using this data. To prevent the newly drawn data from being overwritten by new measurement data the instrument should be in hold prior to inputting the data.

m. *CRD, CCD, CFD, OCS*

The CRD, CCD, and CFD commands collect data in the current data format for the parameter on the active channel until either another command is received or data buffer space has been exhausted. The OCS command outputs the collected data.

NOTE

> Any command after the CRD, CCD, or CFD commands will terminate the collection mode. This includes Group Execute Triggers (GETs) defined using the DEF...END commands. Measurement trigger GETs set up by the TIB command are permitted. Error correction must be turned off before executing CRD.

Upon receipt of the CRD, CCD, or CFD command the 360 VNA will:

1. Clear bit 7 of the main status register.
2. Abort any current sweep.
3. Set up for the collection sweep.

When the system is ready to begin a new sweep, bit 7 of the main status register is set. If the instrument is in CW mode, it will phase lock at that frequency before bit 7 of the main status register is set. The number of data points that can be collected is determined by the data format shown in Table 5-6.

n. *ICF*

This command inputs a binary string of data as information for the current front panel setup and calibration.

o. OCF

This command outputs the current front panel setup and calibration information in binary string data format.

p. ONP

This command outputs the number of data points currently being measured by the 360 VNA as a single ASCII value.

Table 5-6. Maximum Data Points vs Data Format

Data Format	Maximum Number of Collected Points
FMC (32-bit)	6137
FMB (64-bit)	3068
FMA (ASCII)	983

Table 5-5. Calibration Coefficient Ordering

	Calibration Type						
Coefficient #	**12-Term C12**	**8-Term C8T**	**Reflection Only CRF**	**Frequency Response CFR**	**Transmission Freq. Response CFT**	**Reflection Freq. Response CRL**	**None**
1	EDF	EDF	EDF	ERF	ETF	ERF	–
2	ESF	ESF	ESF	ETF	–	–	–
3	ERF	ERF	ERF	–	–	–	–
4	EXF	ETF	–	–	–	–	–
5	ELF	–	–	–	–	–	–
6	ETF	–	–	–	–	–	–
7	EDR	–	–	–	–	–	–
8	ESR	–	–	–	–	–	–
9	ERR	–	–	–	–	–	–
A	EXR	–	–	–	–	–	–
B	ELR	–	–	–	–	–	–
C	ETR	–	–	–	–	–	–

5-3.2 Data Transfer Program Example and Program Notes

a. Data Transfer Example

Figure 5-3 is a listing of an example program written in Microsoft "C". It uses a number of data transfer commands as well as various commands from Section III. The program is written to run on an IBM-PC or compatible computer with a National Instruments GPIB-PCIIA board and "C" language interface drivers. The functions performed by the program are:

- Reset the 360 to its default state.
- Read a full array of frequencies from the 360.
- Input a subset of these frequencies into the 360.
- Take S21 transmission data.
- Loop this data back into the 360 as error term ETF for a transmission frequency response calibration.
- Turn on correction in the 360 and read in a full corrected sweep of data using this as the error term.
- Print the results on the computer screen.

b. Data Transfer Program Notes:

- This program uses a large time-out value (100 seconds). This prevents the controller from quitting while the 360 is busy. For example, after sending **"TRS WFS FMC LSB ORD"**, enough time must be allocated to allow the 360 to complete a new sweep and format the data for output.
- A structure was defined (**struct std_header**) for manipulating the standard block header so that message byte counts are easily accessed.

.

- All transfers use LSB mode to be compatible with INTEL microprocessors.
- FMB is equivalent to **"double"** in "C", FMC is equivalent to **"float"**.
- Before measurement data is read from the 360, the controller sends a "WFS" command to ensure the data is valid.
- Reads can be terminated by (1) reading the header and then using the byte count value or (2) by specifying a maximum value for the transfer count and letting the transfer terminate when the 360 sets the EOI line signaling the end of information.
- The program defines a structure for the S21 (mag, phase) data pairs output by the 360 for the OFD command. This allows for easy access to each frequency point's two data values using array indexing.
- The AFT command *must* be sent before the IC1 command so that the 360 can discern what calibration coefficient #1 corresponds to **(ETF** in this example).
- It is good practice to preface a data transfer command with a format and byte-order command (ie., **"FMB LSB OFV"**), although both the format and the byte-order carry on to the next transfer.
- A section of a string may be read (such as the header) followed by the remainder of the string. *However the entire data stream must be read before any subsequent data will be available.*

```
#include "stdio.h"
#include "decl.h"
int pna_360, etf_bytes;
unsigned char ans[10];
/* Array for frequencies in 64-bit form */
double freqs[512];
/* Array to hold the raw S21 data to be used as ETF */
unsigned char etfbufr[512*2*4];
/* Structure template to use for manipulating the block header */
struct std_header
{
char preambl_1;
char preambl_2;
unsigned int msg_count;};
struct std_header hedr;
/* Structure template for the (mag,phase) data pairs for S21 */
struct data_pair
 {
   float dB;
   float degrees;
 };
struct data_pair s21[512];
main()
 {
   int i, num_pts;
   /* Find the 360 on the bus, assuming it's set for address 6 */
   pna_360 = ibfind("DEV6");
   if(pna_360  0)    /* problem finding a device at address 6 */
      printf("ERROR FINDING DEVICE 6");
else
 {
      ibtmo(pna_360,T100s);   /* set the timeout at 100 seconds */
      /* reset to default state, go to high frequency resol. */
      ibwrt(pna_360,"RST FHI",7);
      /* Request frequencies in 64-bit floating point format (LSB) */
      ibwrt(pna_360,"FMB LSB OFV",11);
      /* Read in 1st 4 bytes = header: #A <LSB> <MSB>*/
      ibrd(pna_360,&hedr.preambl_1,4);
      /* Read in rest of data as frequencies */
      /* Byte count in header tells us how much to read */
      ibrd(pna_360,freqs,hedr.msg_count);
      /* Input the first 401 frequencies into the 360 */
      ibwrt(pna_360,"FMB LSB IFV",11);
      hedr.msg_count = (401 * 8);   /* each frequency is 8 bytes long */
      ibwrt(pna_360,&hedr.preambl_1,4); /*output 1st 4 bytes = header*/
      /* Output 401 points of frequency information */
      ibwrt(pna_360,freqs,hedr.msg_count);
      /* 360 is measuring at the inputted frequencies - set up */
      /* for S21 measurement */
      ibwrt(pna_360,"CH1 DSP S21 MPH FHI",19);
      printf("CONNECT THROUGH LINE BETWEEN PORTS.  HIT ENTER WHEN READY\n");
      scanf("%1c",ans);
```

Figure 5-3. A “C” Language Example Program for Data Transfer Using the 360 (1 of 2)

```
    /* Get a full sweep of data and then input raw data */
    /* in 32-bit form into etfbufr[] */
    ibwrt(pna_360,"TRS WFS FMC LSB ORD",19);
    /* Read entire string, INCLUDING HEADER.  Will terminate on EOI */
    ibrd(pna_360,etfbufr,512*4*2);
    etf_bytes = ibcnt;    /* save #bytes read into buffer */
    /* Now we have a full sweep of raw transmission data.  This */
    /* can be used directly as error coefficient ETF for a      */
    /* transmission frequency response calibration.             */
    ibwrt(pna_360,"AFT FMC LSB IC1",15);
    /* "AFT" is used to "fool" the 360 into thinking it has  */
    /* done a trans. frequency response calibration so       */
    /* that cal. coefficient 1 = ETF. Send 360 the IC1 data. */
    ibwrt(pna_360,etfbufr,etf_bytes);
    /* The 360 now has a valid cal. coefficient array - turn */
    /* correction on & get a full error corrected sweep of data */
    ibwrt(pna_360,"CON WFS FMC LSB OFD",19);
    ibrd(pna_360,&hedr.preambl_1,4);    /* read header, then S21 data */
    /* read in S21 data, let read terminate on EOI */
    ibrd(pna_360,&s21[0].dB,(512*4*2));
    /* Print out frequencies and S21 corrected (dB,degrees) data */
    printf("CORRECTED S21 DATA:\n");
    printf("\n");
     printf("  FREQUENCY          MAGNITUDE        PHASE\n");
    printf("    (Hz)               (dB)          (degrees)\n");
    num_pts = (ibcnt / 8); /* each point is (dB,deg) @ 4 bytes each */
    for(i=0; i  num_pts; i++)
       printf("%13e:  %13.6f   %13.6f\n",
       freqs[i], s21[i].dB, s21[i].degrees);
}
```

Figure 3-4. A “C” Language Example Program for Data Transfer Using the 360 (2 of 2)

5-4 GROUP EXECUTE TRIGGER COMMANDS

The 360 is extremely flexible in its implementation of group execute trigger (GET) functions. The two 360 GPIB commands specifically designated for implementing the *normal* group execute trigger functions are DEF and END (Table 5-7). However, almost all 360 GPIB commands—in any combination—can be set up as part of the DEF—END response to the receipt of a GET (IEEE-488 interface function message) from the external computer.

NOTE

The DEF—END response to the receipt of a GET interface function message is turned-off by the receipt of the TIB command earlier in the program. (The TIB command provides a sweep trigger upon receipt of a GET interface function message—refer to paragraph 5-9.)

The response to the GET interface function message is set up by issuing the DEF command followed by a sequence of commands terminated with the END command. The sequence may be comprised of any sequence of 360 GPIB commands that does not include a data input command. If a data input command is included, the 360 reads the data as additional commands. This usually causes a syntax error to be issued. The entire DEF—END string is preparsed and compacted. The maximum compacted string size is 255 characters.

An example of the use of the DEF and END commands is shown in the following command string:

“DEF CFT NOC SRT 1 GHZ STP 18 GHZ BEG TCD NCS MR1 WFS MMX OM1 MMN OM1 END”

When this sequence of commands is sent to the 360, it is stored as the response to the group execute trigger. The commands between the DEF and END commands will not be executed as part of the normal program flow. The DEF—END sequence will be executed every time the 360 receives a GET interface function message from the external computer *provided* that a TIB command has not been issued earlier in the program. For the example shown above, the 360 will perform the following sequence every time it is triggered by a GET interface function message:

- Perform a transmission frequency response calibration from 1 to 18 GHz (CFT NOC SRT 1 GHZ STP 18 GHZ BEG TCD NCS).
- Turn on marker (MR1).
- Wait for a full sweep of data (WFS).
- Move marker 1 to the maximum value on the trace (MMX).
- Output the maximum value (OM1).
- Move marker 1 to the minimum value on the trace (MMN).
- Output the minimum value (OM1).

Thus, every time the 360 receives a GET interface function message , it outputs the maximum and minimum values for the new calibration just performed.

NOTE

1. When the 360 VNA is triggered via the GPIB, the 360 puts the trigger command (GET) into the command buffer behind any preceding instructions. The commands in the DEF ... END string are executed upon completion of the commands issued prior to the GET command.

2. When the TIB = GPIB coding method is used for measurement triggering, group execute triggers will not execute the commands in the DEF... END string. The group execute trigger will initiate a measurement. See paragraph 5-9, Sweep Control Commands, for more details.

Table 5-7. Group Execute Trigger Commands

360 GPIB Command	Description	Data Formats
DEF	Begin definition of group execute trigger action	N/A
END	End definition of group execute trigger action	N/A

5-5 DISK FUNCTION COMMANDS

The Disk Function commands listed in table 5-6 are used for the following:

- Reading files from the disk.
- Writing files to the disk.
- Deleting files.
- Formatting a data-only disk.
- Loading calibration kit information from the disk.

All of the Disk Function commands, except the INT and LKT commands, require a file name string. File name strings can be up to 8 characters long and *must* be enclosed by double quote characters ("); see the descriptions of the LMS, LDT, LID, and LNM commands in Section III, paragraph 3-11. Examples of the disk function commands usage are shown in Figure 5-4.

The TDD and TTB commands enable the user to store tabular data to the disc and recall it for output to the printer with the tabular printout points controlled by commands PT0–PT9 (Commands PT0–PT9 are described in Section III, paragraph 3-11).

CAUTION

The INT command immediately formats the disk loaded in the 360 floppy drive. *Any data on the disk will be destroyed.* Use this command carefully.

NOTE

The maximum file size that can be handled with the RTB command is 58 kbytes.

Only file name characters accepted by MS-DOS are valid for use with these commands. Characters that are *not* acceptable as file names are:

. — Period/Decimal Point
" — Quotation Marks
/ — Slash
\ — Back slash
[ ] — Brackets
: — Colon
| — Pipe
> — Greater Than
< — Less Than
+ — Plus sign
= — Equal Sign
; — Semicolon
, — Comma
And: All ASCII characters with a value lower than the value of the space character (32 decimal).

NOTE

Spaces are acceptable before and after the characters of a command, value or terminator. They are *not* acceptable *between* the characters of these program items.

Table 5-8. Disk Functions Commands (1 of 2)

360 GPIB Command	Description	Values
DEC(filename)	Delete calibration and front panel setup file from disk	String up to 8 characters long for file name
DED(filename)	Delete tabular printout data file from disk	String up to 8 characters long for file name
DEN(filename)	Delete trace memory file from disk	String up to 8 characters long for file name
INT	Initialize (format) disk in drive as a data-only disk	N/A
LKT	Load calibration kit information from disk	N/A
RCK(filename)	Recall active channel's trace memory from disk file	String up to 8 characters long for file name
RLD(filename)	Recall calibration data and front panel setup information from disk file	String up to 8 characters long for file name
RTB(filename)	Recall tabular data file from disk for output to printer	String up to 8 characters long for file name

Table 5-8. Disk Functions Commands (2 of 2)

360 GPIB Command	Description	Values
SDK(filename)	Store active channel's trace memory to disk file	String up to 8 characters long for file name
STO(filename)	Store calibration data and front panel setup information to disk file	String up to 8 characters long for file name
TDD(filename)	Store tabular printout data to ASCII disk file	String up to 8 characters long for file name

```
! EXAMPLE 1 - SAVE CAL AND FRONT
! PANEL SETUP TO DISK
Q$ = CHR$(34)     ! DOUBLE QUOTE SYMBOL(“)
C$ = “12_TERM”    ! FILE NAME FOR CAL DATA
! STORE TO DISK FILE “12_TERM.CAL”
OUTPUT 706;"STO"&Q$&C$&Q$
! EXAMPLE 2 - SAVE TABULAR DATA
! TO DISK FILE
Q$ = CHR$(34)     ! DOUBLE QUOTE SYMBOL(“)
T$ = “S21_THRU”   ! FILE NAME FOR TAB DATA
! STORE TO DISK FILE “S21_THRU.DAT”
OUTPUT 706;"TDD"&Q$&T$&Q$
! EXAMPLE 3 - SAVE TRACE MEMORY
! TO DISK, RECALL IT ON A DIFFERENT
! CHANNEL AND THEN DELETE FILE
OUTPUT 706;"CH1 D13 S11 CH3 S21 FHI WFS"
OUTPUT 706;"CH1 STD" ! STORE TRACE TO MEMORY
Q$ = CHR$(34)     ! DOUBLE QUOTE SYMBOL(“)
N$ = “S11TRACE”   ! FILE NAME FOR TRACE DATA
! STORE TO DISK FILE “S11TRACE.NRM”
OUTPUT 706;"SDK"&Q$&N$&Q$
! RECALL SAME DATA ON CHANNEL 3
OUTPUT 706;"CH3 RCK"&Q$&N$&Q$
! DELETE THE TRACE MEMORY FILE
OUTPUT 706;"DEN"&Q$&N$&Q$
```

Figure 5-4. Disk Function Commands Example

5-6 SRQ STATUS BYTE STRUCTURE AND COMMANDS

The status of the 360 is defined by primary and secondary status bytes. The structure and contents of these status bytes are described in the following paragraphs.

5-6.1 Primary Status Byte

The bit structure of the primary status byte is shown in Table 5-9. The function of each bit is described below. All bits of the primary status byte are reset whenever a CSB command is received.

- **Cal. Sweep Complete**. This bit is set when a calibration sweep is completed after the TCD command has been received.
- **Sweep Complete In Hold.** This bit is set when a full sweep is completed in hold after the TRS command has been received.
- **Syntax Error.** This bit is set is set when a syntax error occurs
- **Parameter Out Of Range.** This bit is set when data values are out of the allowable range or the data was found to be invalid.
- **Action Not Possible.** This bit is set when a command can not execute in the current instrument state.
- **2nd Byte Has Status.** This bit is set when a condition represented by a set bit in the Secondary Status Byte is true.
- **SRQ.** The Service Request bit is set during the serial poll response when the 360 is requesting service.
- **Ready for Measurement.** This bit is cleared at the start of both the GPIB measurement trigger command (TIB) and by the data collection commands (CRD, CCD, CFD). The bit is set after a point has been measured subsequent to a GET in the GPIB measurement trigger mode when the instrument is ready for data collection.

5-6.2 Secondary Status Byte

The bit structure of the Secondary Status Byte is shown in Table 5-10. The function of each bit is described below. All bits of the secondary status byte are reset whenever a CSB command is received.

- **Disk Error.** This bit is set when a disk error occurs.
- **Self Test Failed.** This bit is set true if any portion of the self test fails.
- **Hardware Error.** This bit is set when there is a problem with the system hardware.
- **Key Pressed.** This bit is set when a key on the front panel is pressed.
- **Power On.** This bit is set when the system is first powered on.

Table 5-11 lists the status byte commands. These commands are used to:

- Output the status of the 360 to the external computer.
- Input service request enable masks.
- Clear the primary and secondary status bytes.

In order for the 360 to generate a service request for a particular condition, both the condition bit and the SRQ bit in the Primary Status Byte Mask must be enabled. The binary value of each bit in the byte sent will be:

Bit Value = 1 – Status Condition Enabled.

When the 360 requests service, the serial poll response byte will show only one *enabled* bit set. The controller can then always tell which enabled condition generated the Service Request (SRQ). This also implies that the primary status byte and the serial

Table 5-9. Primary Status Byte Bit Structure

Bit Number							
7	6	5	4	3	2	1	0
Ready for Meas.	SRQ	2nd Byte Has Status	Action Not Possible	Out of Range	Syntax Error	Complete in Hold	Sweep Complete

Table 5-10. Secondary Status Byte Bit Structure

Bit Number							
7	6	5	4	3	2	1	0
Power On	Key Pressed	X*	X	X	Hardware Error	Self Test Fail	Disk Error

poll response byte will not necessarily be equal. Any true bits for conditions not enabled will show up in the serial poll response byte. Figure 5-5 shows a listing of an example program that performs status-byte-enable mask setup for the primary status byte and service request handling operations.

NOTE

Data transfers for the OPB, OEB, IPM and IEM commands involve a single binary data byte. The condition mask byte for the IPM and IEM commands must immediately follow the command.

Table 5-11. Status Byte Commands

360 GPIB Command	Description	Values
CSB	Clear primary and secondary status bytes	N/A
IEM<byte>	Input extended (secondary) status mask	One binary byte
IPM<byte>	Input primary status mask	One binary byte
OEB	Output extended (secondary) status byte	One binary byte
OPB	Output primary status byte	One binary byte
SQ0	Disable service requests	N/A
SQ1	Enable any unmarked service requests	N/A

```
! SET UP SERVICE REQUEST SUBROUTINE ADDRESS
ON INTR 7 GOSUB 1000
! ENABLE SRQ CONDITION AS AN INTERRUPT
ENABLE INTR 7;8
REMOTE 706
! ENABLE SRQ, SYNTAX, PARAM,
! OUT OF RANGE AND ACTION
! NOT POSSIBLE ERRORS = BITS
! 2,3,4 & 6
! MASK = 4+8+16+64 = 92
OUTPUT 706 USING “#,AAA,B”;"IPM",92
1000  ! SRQ SERVICE ROUTINE
1010  STATUS 7,1;A     ! READ INTERRUPT CAUSE REGISTER
1020  R=SPOLL(706)     ! POLL THE 360
1030  IF BIT(R,2)  1 THEN GOTO 1050
1040  DISP “SYNTAX ERROR”
1050  IF BIT(R,3)  1 THEN GOTO 1070
1060  DISP “PARAMETER OUT OF RANGE”
1070  IF BIT(R,4)  1 THEN GOTO 1090
1080  DISP “ACTION NOT POSSIBLE”
1090  ! READ THE PRIMARY STATUS BYTE
1100  OUTPUT 706;"OPB"
1110  ENTER 706 USING “#,B”;B
1120  DISP “PRIMARY STATUS = ”,B
1130  ! RE-ENABLE INTERRUPT AND RETURN
1140  ENABLE INTR 7;8 @ RETURN
```

Figure 5-5. Example of Status-Byte-Enable-Mask Setup and Service Request Handling

5-7 TIME DOMAIN COMMANDS

The time domain commands for the 360 VNA are listed below in Table 5-12. Option 2A (High-Speed Time Domain [Distance] Software option) adds these commands to the 360 VNA software.

The time domain commands are used to:

1. Specify the domain of a channel.
2. Set up operating modes and parameters for the selected processing type of the channel.

Table 5-12. Time Domain Commands (1 of 2)

360 GPIB Command	Description	Values	Terminators
DBP	Select distance bandpass mode for active channel	N/A	N/A
DCA	Select automatic D.C. term calculation for lowpass	N/A	N/A
DCO	Select open for D.C. term for lowpass	N/A	N/A
DCS	Select short for D.C. term for lowpass	N/A	N/A
DCV (value) *	Enter value for D.C. term for lowpass	-1000 MΩ to 1000 MΩ	XX1, XX3, XM3
DCZ	Select line impedance for D.C. term for lowpass	N/A	N/A
DLP	Select distance lowpass mode for active channel	N/A	N/A
DPI	Select distance phasor impulse mode for active channel	N/A	N/A
FGT	Select frequency with time gate for active channel	N/A	N/A
FQD	Select frequency domain for active channel	N/A	N/A
GCT (value)	Set gate center value	0.0000 to 999.999 µs 0.0000 to 999.999 m	PSC, NSC, USC, MMT, CMT, MTR
GDS	Display gate symbols on active channel	N/A	N/A
GLS	Select low sidelobe gate shape	N/A	N/A
GMS	Select minimum sidelobe gate shape	N/A	N/A
GNM	Select nominal gate shape	N/A	N/A
GOF	Turn off gating on active channel	N/A	N/A
GON	Turn on gating on active channel	N/A	N/A
GRT	Select rectangular gate shape	N/A	N/A
GSN (value)	Set gate span value	0.0000 to 999.999 µs 0.0000 to 999.999 m	PSC, NSC, USC, MMT, CMT, MTR
GSP (value)	Set gate stop value	–999.9999 to +999.9999	PSC, NSC, USC,
GST (value)	Set gate start value	–999.9999 to +999.9999	PSC, NSC, USC,

* Certain time domain codes can only be used with particular processing types or instrument states. For example, “DCV 25 XX1" sets the d.c. term for low pass to 25 ohms. The 360 can only execute this command string if the active channel is in the time domain low pass mode (TLP or DLP) or if a valid lowpass set of frequencies exist for frequency domain (FQD) or frequency gated by time (FGT).

Table 5-12. Time Domain Commands (2 of 2)

360 GPIB Command	Description	Values	Terminators
LPI	Select lowpass impulse response	N/A	N/A
LPS	Select lowpass step response	N/A	N/A
MRR	Restore original marker range	N/A	N/A
TBP	Select time bandpass mode for active channel	N/A	N/A
TLP	Select time lowpass mode for active channel	N/A	N/A
TPI	Select time phasor impulse mode for active channel	N/A	N/A
WLS	Select low sidelobe window shape	N/A	N/A
WMS	Select minimum sidelobe window shape	N/A	N/A
WNM	Select nominal window shape	N/A	N/A
WRT	Select rectangular window shape	N/A	N/A
ZCT (value)	Set zoom range center value	–999.999 to 999.999 µs –999.999 to 999.999 m	PSC, NSC, USC MMT, CMT, MTR
ZSN (value)	Set zoom range span value	0 to 999.999 µs 0 to 999.999 m	PSC, NSC, USC MMT, CMT, MTR
ZSP (value)	Set zoom range stop value	–999.999 to 999.999 µs –999.999 to 999.999 m	PSC, NSC, USC MMT, CMT, MTR
ZST (value)	Set zoom range stop value	–999.999 to 999.999 µs –999.999 to 999.999 m	PSC, NSC, USC MMT, CMT, MTR

5-8 MULTIPLE SOURCE CONTROL COMMANDS

Table 5-13 lists the multiple source control commands. These commands are used to define up to five different "multiple source control bands". In each, the device under test (DUT), source 1, source 2, and receiver frequency ranges may be different. The DUT frequency range is entered using any of the frequency entry commands. The MSD command puts the 360 in the DEFINE mode, which allows entry of arbitrary frequencies for the DUT. Band equations for source 1, source 2, and the receiver are then set up using the ED1, ED2, EDR, etc, commands. The band equations used are shown below. In these equations, "F" is the DUT frequency range.

For swept operation:

F = (multiplier/divisor) x (F + offset),

or, for CW operation: .

F = (multiplier/divisor) x (offset).

For a frequency band to be saved, the band equations must produce frequencies within the operating range of the respective system component.

Figure 5-6 shows an example program using multiple source control commands. This program is for a fixed LO, swept IF mixer measurement. The frequency values used are:

DUT range = 2 – 6 GHz
Source 1 = 2 – 6 GHz = (1/1) X (F + 0)
Source 2 = 500 MHz CW = (1/1) X (500 MHz)
Receiver = 1.5 – 5.5 GHz = (1/1) X (F – 500 MHz)

```
10 ! Multiple Source Control Example
20 OUTPUT 706; "MSD SRT 2 GHZ STP 6 GHZ"
30 OUTPUT 706; "BD1 BSP 6 GHZ"
40 OUTPUT 706; "ED1 ESW EML 1 XX1"
50 OUTPUT 706; "EDV 1 XX1 EOS 0 GHZ"
60 OUTPUT 706; "ED2 ECW EOS 500 MHZ"
70 OUTPUT 706; "EDR ESW EML 1 XX1"
80 OUTPUT 706; "EDV 1 XX1 EOS -500 MHZ"
90 OUTPUT 706; "SVB MS1"
100 END
```

Figure 5-6. Multiple Source Control Example

Table 5-13. Multiple Source Control Commands

360 GPIB Command	Description	Values	Terminators
BD1 - BD5	Select multiple source control band 1-5	(Limited to current DUT range)	N/A
BSP (value)	Enter band stop frequency for multiple source control	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
BST (value)	Enter band 1 startup frequency for multiple source control	Start sweep frequency to stop sweep frequency	GHZ, MHZ, KHZ
CLB	Clear all multiple source control band definitions	N/A	N/A
ECW	Multiple source control equation in CW mode	N/A	N/A
ED1	Edit source 1 multiple source control equation	N/A	N/A
ED2	Edit source 2 multiple source control equation	N/A	N/A
EDR	Edit receiver multiple source control equation	N/A	N/A
EDV (value)	Set multiple source control equation divisor	–199 to –1, 1 to 199	XX1, XX3, XM3
EML (value)	Set multiple source control equation multiplier	–199 to 199	XX1, XX3, XM3
EOS (value)	Set multiple source control equation offset frequency	–999.9999 to 999.9999	GHZ, MHZ, KHZ
ESW	Multiple source control equation in sweep mode	N/A	N/A
MS0	Multiple source control off	N/A	N/A
MS1	Multiple source control on	N/A	N/A
MSD	Multiple source control define model	N/A	N/A
SVB	Save multiple source control band definition	N/A	N/A

5-9 SWEEP CONTROL COMMANDS

Table 5-14 lists the 360 GPIB commands that allow control of sweep triggering. The TIN, TEX and TIB commands select the measurement trigger source, as follows:

- Command TIN selects internal triggering;
- Command TEX selects triggering via the rear-panel input connector;
- Command TIB selects triggering via the group execute trigger, GET, which is an IEEE-488 interface function message that is issued by the external computer.

NOTE

The use of the TIB command turns-off the normal DEF—END response to the GET interface function message; refer to paragraph 5-4.

The HC0 command should be used to disable the internal I.F. calibration when external or GPIB triggering is used (so that triggers are not missed while the instrument performs an I.F. calibration). The HC1 command can then be used to enable and initiate an immediate I.F. calibration, when desired.

Table 5-14. Sweep Control Commands

360 GPIB Command	Description
HC0	Disable Internal I.F. Calibration
HC1	Enable and Trigger Internal I.F. Calibration
TEX	Select External Measurement Triggering
TIB	Select Measurement Triggering Via Group Execute Trigger
TIN	Select Internal Measurement Triggering

5-10 REAR PANEL OUTPUT CONTROL COMMANDS

Table 5-15 lists the commands for controlling the rear-panel voltage output of the 360 VNA. The RV1 command enables the output and command RV0 disables it. The orientation of the output can be set to either horizontal (RVH), vertical (RVV), or lock direction (RVL).

In the horizontal mode, the voltage output is a digital ramp starting at the voltage start value set by command VST and ending at the voltage stop value set by command VSP. The start value corresponds to the first point of the sweep and the stop value corresponds to last point of the sweep. In the vertical mode, the output voltage is a measure of the instantaneous data point value. The output voltage is related to the scaling of the graph for channel 1. The reference line corresponds to the zero volt value and each graticle line is equal to a ±1 volt value span. The values set by the VST and VSP commands have no effect in the vertical mode.

In the lock direction mode, the start voltage value is output for forward sweeps (lock to Ra). The stop voltage value is output for reverse sweeps (lock to Rb).

The RP0 command is used to set an intermediate voltage value that is output at the rear panel connector. This command can be executed only if the normal rear panel output voltage is disabled.

Table 5-15. Rear Panel Output Control Commands

360 GPIB Command	Description	Values	Terminators
RPO (value)	Set value for direct rear panel voltage	–10 to 9.96 volts	VLT
RV0	Disable rear panel output voltage	N/A	N/A
RV1	Enable rear panel output voltage	N/A	N/A
RVH	Select horizontal rear output voltage mode	N/A	N/A
RVL	Select lock direction output voltage mode	N/A	N/A
RVV	Select verticle rear output voltage mode	N/A	N/A
VSP (value)	Set stop value for rear panel output voltage	–10 to 9.96 volts	VLT
VST (value)	Set start value for rear panel output voltage	–10 to 9.96 volts	VLT

5-11 SCREEN DRAW COMMANDS

The commands listed in Table 5-16 control the screen drawn functions of the 360 VNA in the GPIB mode of operation.

Table 5-16. Screen Draw Commands

360 GPIB Command	Description	Values	Termin-ators
CWP (value)	Enter number of points drawn in CW	1 – 501	XX1
DD0	Turn off data drawing	N/A	N/A
DD1	Turn on data drawing	N/A	N/A

5-12 RECEIVER MODE COMMANDS

The commands listed in Table 5-17 control the 360 VNA receiver mode functions in the GPIB mode of operation.

Table 5-17. Receiver Mode Control Commands

360 GPIB Command	Description
SDR	Select standard receiver mode
SL0	Select source lock mode with GPIB source control off
SL1	Select source lock mode with GPIB source control on
ST0	Select set on mode with GPIB source control off
ST1	Select set on mode with GPIB source control on
TK0	Select tracking mode with GBIB source control off
TK1	Select tracking mode with GBIB source control on