3/96

Spectrometer Control

INTERFACING & PROGRAMMING MANUAL
For
SpectrAcq, DataLink, DataScan,
JY232, JY488, SPEX232, & SPEX488

SPEX

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Instruments SA, Inc.

Part Number 80123

About the Manuals...

You may have more than one manual, depending on your system configuration. To find the manual that has the information you need, these guidelines may help.

- Each manual generally covers a product and the features and accessories peculiar to and/or contained within that product.
- Accessories that can be applied to various products are usually covered by separate documentation.
- Software that is exclusively used with one instrument or system is normally covered in the manual for that product.
- Software that is also used with other products is covered in its own manual.
- If you are reading about a product that interacts with other products, you will be referred to other documentation as necessary.

Important Firmware Version Notice

This manual has been extensively rewritten to correspond to changes made in the firmware. These changes simplify the use of the hand-held terminal.

Programs written for Flash version 2.4 or earlier of DataScan / DataLink need to be changed. When you update to Flash version 3.0 or later, if you use the intelligent commands "p","t", or"s".
The"p" command has an additional input; parameter #19.
The"p" command now returns an error code.
The"t" command now returns cycle# in addition to point#.
The"s" command sets scan cycle to read.

For details, refer to Section 10, Command Descriptions.

If you have a KeyLink or HandScan, to determine the firmware version present in the supporting spectrometer controller, install your hand-held terminal according to the procedure outlined in the Getting Started section of the manual that came with it. Then press the <STAT> key. if you have the current version, the display will show the version numbers for BOOT and FLASH. The FLASH number is the important one in this instance. If your hand-held terminal is connected to a DataLink / DataScan Controller- Photometer, the flash version should be 3.0 or higher. If your hand-held terminal is connected to a JY232 or SPEX232 Spectrometer Control Interface, the flash version should be 2.0 or higher. If your KeyLink or HandScan does not respond to the <STAT> key as described above, refer to the Service Policy in Section 12 for information about contacting us to arrange an upgrade of your firmware.

If you are communicating from a computer, and do not have a KeyLink or HandScan, establish communications via either RS-232 (as instructed in Section 4), or IEEE 488 (as instructed in Section 5). Once communicating, send the UTIL GET VERSION commands for boot and main as described in Section 10.1.
If your computer is connected to a DataLink / DataScan Controller- Photometer, the Main version should be 3.0 or higher. If your computer is connected to a JY232 or SPEX232 Spectrometer Control Interface, the main version should be 2.0 or higher. If your spectrometer controller does not respond as described, refer to the Service Policy in Section 12 for information about contacting us to arrange an upgrade of your firmware.

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1 Overview:

The JY232, SPEX232, JY488, and SPEX488 are a family of products shared by the two spectrometer product lines of Instruments SA. For the Jobin-Yvon line, the JY- prefix is used for the control interfaces, for Spex systems, the SPEX prefix is used. Although the computer interface and commands are the same in the two product lines, the physical location of the connectors and boards varies.

There are controller- photometers for both product lines that use an expanded version of the same command set. There are additional commands for data acquisition and control of the optional high voltage power supplies. DataLink is the name of the controller-photometer for J-Y. For the Spex line it's DataScan.

WARNING: *The stepper motor drive electronics are not compatible* between the Spex and J-Y brands. If a DataLink is connected to a Spex monochromator control input, *damage will result*. If a DataScan is connected to a J-Y monochromator motor, *nothing will happen.*

In terms of the interfacing protocol and commands, there is no difference between the two brands. System configuration details, however, do vary depending on the different spectrometer types within either brand. This manual covers both versions of spectrometer interfaces, and generally refers to any of them as the "spectrometer controller".

Some of the commands are relevant only to particular options or components and, therefore, may or may not be used by all systems. In these cases, the command descriptions in this manual advise you of appropriate use.

The spectrometer controller interface supports the Keylink / HandScan hand-held terminal, providing the capability to control spectral scanning as well as several optional automated devices in the spectrometer and spectrometer controller (including shutters, slits, mirrors, turrets, and high voltages).

2 Getting Started:

There are several features of this interface that provide unusual flexibility to command your system. The sections 3 through 6 outline the various methods to start communications, depending on what you are interfacing to. Please select the section that is appropriate for the method you will use to command your system.

2.1 Command Set Structure:

The spectrometer controller family supported by this command set has been designed with a multi-purpose interface. This interface will communicate with a simple ASCII "terminal" or an "intelligent" computer program.

The command set's "terminal" communications mode accommodates the limited capabilities of the HandScan / KeyLink hand-held terminals. This mode accepts commands limited to one ASCII character, and sends back ANSI format character strings to be displayed on the terminal. The spectrometer controller's internal program *bootstraps into the terminal communications mode* in order support these terminals.

When you will be sending commands from a computer program, a command can be issued to change to the "intelligent" communications mode. This stops the character strings intended for the terminal display, and enables more useful responses from the spectrometer controller.

The single character commands used by the terminal are also used in the intelligent communications mode. There are additional single and multiple character commands that are available only in the intelligent communications mode.

3 RS-232 Communication with a Hand-held Terminal:

The KeyLink / HandScan hand-held terminals are shipped with a cable (#36406) to connect to the spectrometer controller's RS-232 port or the SPEX232 / JY232 interface connector on your spectrometer or stepper motor driver. The connector on the spectrometer or spectrometer controller is a male 25 pin D-type. Depending on the instrument you have, this connector may be labeled " RS-232," "Control Input," "SPEX232," or "JY232".

Please refer to the Getting Started section of your KeyLink / HandScan manual for further instructions.

4 RS-232 Communication with a Computer:

The SPEX232 / JY232 or DataScan / DataLink spectrometer control interfaces are designed to connect to a computer equipped with an RS-232 serial communications port.

4.1 Cable Connection:

A 25 pin standard RS-232 null modem cable (our part # 97133) should be used to connect the spectrometer controller to the computer. If you are using an IBM compatible computer, for example, you may use any available COM port. In the null modem cable, connections are wired as shown. If the COM port you intend to use on your PC is a 9 pin (IBM PC/AT type), use a 9 to 25 pin adapter (our part 97134).

If you have a HandScan or KeyLink, be careful not to use the #36406 cable provided with it to connect to your computer's COM port. That is not wired as a null modem cable.

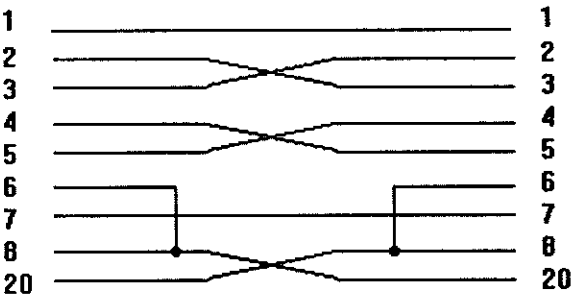


Figure 3: Null modem cable pin connections

4.2 Data Bit and Handshaking Requirements:

The Spectrometer Controller communicates serially using 8 bit data bytes with 1 stop bit. There is no parity checking. Your PC should assert DTR when unable to accept data from the spectrometer controller. refer to Appendix 2 for connector pin assignments.

4.3 Testing Communications:

To set up to control your spectrometer over the RS-232 interface, we strongly recommend the following tests be performed with the sample programs provided, using an IBM compatible PC. Especially if you intend to use a different type of computer, we stress it is important to borrow a PC and complete these tests. For peace of mind, it is better to build on a solid foundation. Please assure yourself

first that the hardware and example programs are functional. In this way, you can be sure that all is well before starting to translate and modify the sample programs for your own application.

We provide a support diskette with these spectrometer controllers which includes program examples to communicate with a DOS PC. Insert the support diskette into your floppy drive, and at the DOS prompt, type"A:<Enter>" to access the floppy. (Or use"B:<Enter>" if appropriate for the floppy drive that you are using.)

The first program you should run to verify communication to the spectrometer controller is in the UTILITY directory. Type "cd\utility" followed by "<Enter>". to access the directory. The program name is HWCFG232. This is a working program that has been in routine use for configuration at the factory. To run this program: the COM port to be used, and the baud rate should be set. You should use COM 1 or COM 2 , as the program requires interupts. Type "hwcfg232" followed by "<Enter>" to start the configuration program. A screen will appear showing the communications port and baud rate settings. If these are correct, press "<Enter>" otherwise change the settings as needed and then press <Enter>. (When shipped from the factory, the default settings are for COM port 1, at 19200 baud). If the interface is properly installed and functional, the program will establish communications and read back the present configuration from the spectrometer controller. If communication fails, an error message with appropriate advice to correct the problem will be displayed.

Review the configuration on the screen. At the factory, this was set up to match your system. A record of the configuration was printed by using the <F8> function. This page was included with the documentation shipped with the spectrometer controller. Normally, there will be no further need to use this program, unless you replace gratings or need to change the maximum high voltage limit, if you have that option. You may want to familiarize yourself with some of the parameters and options on the screen, such as grating g/mm, and HV limit. Press <F10> to exit the program

4.4 Automatic Baud Rate Selection:

Serial communications with the spectrometer controller can be started without concern about baud rate in most cases. When the spectrometer controller is powered on, it bootstraps itself into an idle condition, ready to "Autobaud" or match the baud rate that the terminal or host computer is communicating with. This can be accomplished by sending a space character (ASCII char 32 in DECIMAL, 20 in HEX) to the spectrometer controller. (HandScan / KeyLink users

please note that the Decimal Point key will send a "<Space>".) The spectrometer controller automatically selects the baud rate to match the device or computer that is communicating with it. The compatible baud rates are: 1200, 2400, 4800, 9600, and 19200. Because of this feature, most computers and terminals can be simply plugged in and used. The necessity of setting baud rate switches has been eliminated. The first character received is compared with stored data to determine its baud rate. However, due to allowances in the EIA RS-232C standard, it is not always possible to make a proper baud match on the first attempt. You may have to send the space character more than once. When this is done, and the autobaud has been successful, the spectrometer controller will send the asterisk character "*" back. Under some conditions, the "*" may be followed by more characters. If the spectrometer controller is already running, sending "<Space>" will get an F, B, or string response. If the spectrometer controller is already running and autobauded, it will not re-autobaud. It is important to remember this when switching programs on the host computer. For example: After running HWCFG232 at 9600 baud, you want to run the example program SCAN_232.BAS. But the Basic program runs at 4800 baud. It will not communicate unless the spectrometer controller is powered off, then back on. This is the only way to set the baud rate.

4.5 Preparing to program via RS-232.

To help you get started writing routines with the Programmer's Command Set, we provide example programs on the Support Diskette. Excerpts of these examples can be used as building blocks for your programs. In particular, when opening communications, careful attention should be paid to insure that the procedure used in the example is followed. The example GWBASIC programs SCAN_232.BAS and 232_SCAN.BAS are also provided in the \USERPROG directory of the support diskette. GWBASIC or QBASIC must be available on your computer to run these programs. There is a READ.ME ASCII text file on the support diskette that may contain further, updated information.

Run these programs and use them to control your spectrometer. Get a feel for how the system responds to commands ... watch the drive move on your spectrometer.

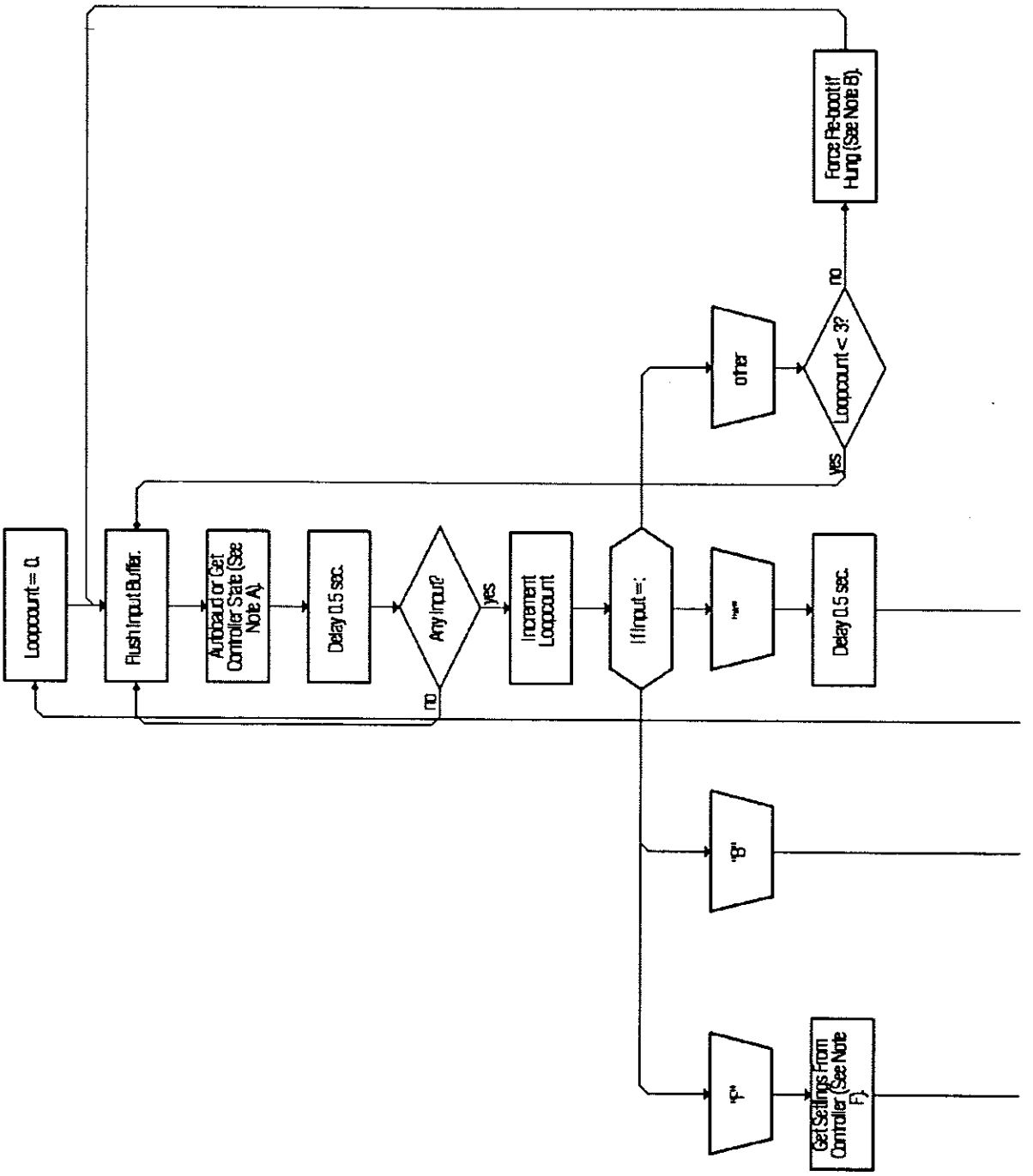
4.6 RS-232 Communications Startup:

The part of your program that will establish communications must follow the steps outlined in the "RS-232 Start Up Procedure" flow chart. The example BASIC programs provided on the support diskette and listed in Appendix 3 include working examples of the startup procedure.

It is important to understand that the command set's internal program bootstraps into the terminal communications mode to allow the spectrometer controller to be used with a "dumb terminal", such as the HandScan / KeyLink. In this mode, the spectrometer controller accepts single ASCII character commands, and returns strings of ASCII characters preceded by the ANSI <Escape> X, Y sequence for character positioning on the terminal screen.

When starting RS-232 communications with the spectrometer controller, your program should follow the example outlined in the flowchatr on the following pages. You must determine if a baud rate has been previously established, and if so which program and communication mode is active. "Flush buffer" instructions are needed to clear characters from a previous run or to clear out the terminal communications mode display prompts. These prompts will be sent by the spectrometer controller until you establish yourself as a computer program by switching to the intelligent communications mode.

RS-232 Start Up Procedure



Notes on RS-232 Start Up Procedure

A: Send Autobaud character "<Space>"; response will be"*" if this is first time power up or after a re-boot.
OR
WHERE AM I command "<Space>", valid if the spectrometer controller has already been started; response will be "B" (for BOOT) or "F" (for MAIN), depending on the previous state of the spectrometer controller.

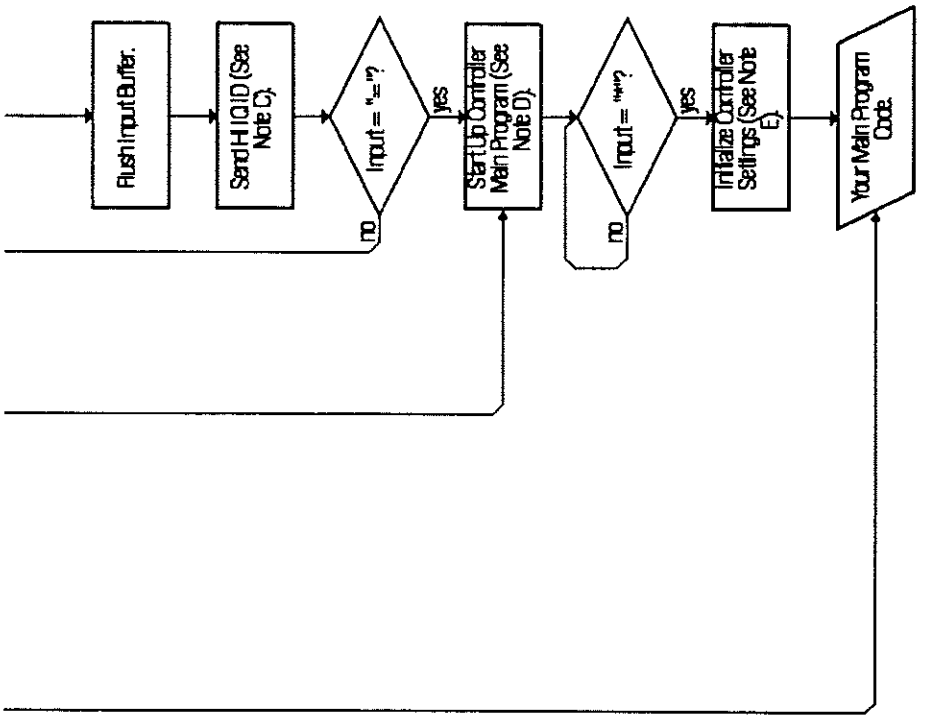
B: Force a re-boot if hung from previous incomplete command: Send decimal value "<248>", followed by decimal value "<222>".

C: Send decimal value "<247>"

D: Send "O2000<Null>". To transfer control from the BOOT to the MAIN program. You must send the "<Null>". Wait 0.5 second.

E: Initialize mono (see command "A" and SET commands) and get initial settings from the user eg. spectral position.

F: You can read your last position etc. from the spectrometer controller. You do not have to re-initialize the spectrometer



To Autobaud (establish the communications baud rate), follow this procedure:

1 Send the autobaud character "<Space>"

2 If you receive "*", go to step 3.
If you receive "B", go to step 5
If you receive "F", go to step 6
If you receive "<Escape>", go to step 8
If you receive any other character or nothing, try again.

3 If this is the first communication after its power-up or bootstrap, the spectrometer controller will respond with "*" when it recognizes your baud rate. Due to allowances in the RS-232 standard, it may be necessary to send the "<Space>" more than once before receiving the "*". A string of characters intended for the hand-held terminal display will also be sent following the "*". Flush these extra characters. If you receive some character other than "*", skip to step 4.

Once the "*" is received, communications is established. Send "<247>" as one byte. This is acknowledged by the character "=". This switches the spectrometer controller to the intelligent communications mode, and turns off the strings of response characters intended for the hand-held terminal. The <247> command is only recognized at this point during the start-up sequence. If any other character is received at this point in the sequence, the spectrometer controller assumes that it is connected to a terminal, and will respond accordingly. Follow this by sending "<Space>".You should receive a "B": If so, go to step 5. If not, go to step 7.

4 If the spectrometer controller has completed the autobaud sequence at some previous time, it will respond to receiving the <Space> differently from the above, sending back a character which tells you which internal program is running in the spectrometer controller. If you receive "B" for boot, go to step 5, if you receive "F" for main, go to step 6. If you receive <Escape> plus a string of characters, go to step 8. If you do not receive any of these responses, go to step 7.

5 If you receive "B", you are talking to the BOOT program. Send "O2000<Null>" to transfer to the spectrometer controller's MAIN program. Then wait 0.5 second to be sure that the main program is ready to accept additional commands before proceeding. Follow this with "<Space>".You should receive an "F". If so, go to step 6. If you receive <Escape> plus a string of characters, go to step 8. If you do not receive either of these

responses, go to step 7.

6 If you receive the "F" character, you are talking in intelligent communications mode to the MAIN program. The spectrometer controller is ready to accept commands. Receipt of this character also implies that the spectrometer controller has previously been run by a program. In this case you may not have to send the INIT and SET commands described later. Instead, you may wish to read back the previous positions from the spectrometer controller into your program.

7 If the spectrometer controller program is not responding for any reason, you may force a re-boot by sending "<248>" followed by "<222>", both as single bytes. The <248> sets the spectrometer controller in Intelligent communications mode, in case it was not in that mode. The <222> re-boots the spectrometer controller program from most, but not all hung conditions. However, if you wish to change baud rates, you must turn the spectrometer controller power off, then on again, and go to step 1.

8 If you receive <Escape> plus a string of characters, communications has been previously established in hand-held terminal communications mode. Send "<248>", pause, and then send "<Space>". You should receive an "F". If so, go to step 6. If not, go to step 7.

If you wish to alternate control between the computer and a KeyLink / HandScan terminal, this can be accommodated. The computer will have to communicate at the same baud rate as the hand-held terminal (19,200 baud). A commercial RS-232 A/B switch box can be connected with the common connection to the spectrometer controller. Connect the hand-held terminal and computer to the A and B connections. Start up the spectrometer controller connected to the hand-held terminal, following the instruction manual for the hand-held terminal. Switch the cable connection to the computer, then change to the intelligent communuications mode by sending the pseudo-command <248> from the computer at any time after you are in the main program. The spectrometer controller sends no response character for a pseudo-command.

To change back to the hand-held terminal, your computer should issue the "Y" command "go to terminal communications mode" and receive the "o" response before you physically switch the connection back to the hand-held terminal.

More detailed information on alternating control between the hand-held terminal and your computer can be found in the UTIL command descriptions in Section 10.

Information on switching between IEEE 488 and RS-232 is also in the UTIL commands section.

4.7 Re-booting a Spectrometer Controller

If your program exits before you complete a command, the spectrometer controller will hang. It will wait for the rest of the command input. This condition can be cleared by re-powering the spectrometer controller.

Assuming that you are communicating in the intelligent mode, you may send the pseudo-command "<222>" as a single byte to re-boot the spectrometer controller. The <222> is ignored if the spectrometer controller is not hung waiting for additional parameters. Pseudo-commands do not cause the spectrometer controller to send back any response character.

If you are in the terminal communications mode, you may force a re-boot by sending the pseudo-commands "<248>" and "<222>", in that sequence, both as single bytes. The "<248>" first insures that the spectrometer controller is in the intelligent communications mode to accept the <222>.

You may want to re-boot the spectrometer controller at some time, without manually turning it off and back on. To do this, intentionally send it an incomplete command. For example, send "G", MOTOR SET POSITION without specifying the position. Follow with the pseudo-command "<222>". This will put you at the beginning of the start-up sequence.

5 IEEE 488 Communication with a Computer:

If you have a JY488 / SPEX488 interface for your spectrometer, or a DL488 / DS488 option in your controller- photometer you may communicate with the spectrometer controller via the General Purpose Interface Bus (GPIB).

Please refer to the documentation provided with your computer's IEEE 488 interface for information about how to send the various characters.

IEEE 488 can take command of the spectrometer controller at any time by asserting the REM line. If IEEE 488 is initializing the system, the entire auto-baud sequence used for serial communication (as described on page 9, 14) is skipped. The system is automatically forced into the intelligent communications mode, where the spectrometer controller expects to receive the commands as outlined later in the Command Descriptions in Section 10. You must also send "O2000<Null>", to transfer control to the main program that resides in the spectrometer controller. Then wait 0.5 second to be sure that the main program is ready to accept additional commands before proceeding.

If you desire to change the IEEE 488 address, the command to do so must be issued instead of the "O2000<Null>" command (i.e. the CHANGE IEEE 488 ADDRESS command, described later, is valid when the spectrometer controller is in the system initialization portion of its boot program, not in the main program). The new address will be saved by the spectrometer controller in non-volatile memory. When you change the address, you should POWER OFF the spectrometer controller and make the necessary changes to your program to reflect this address change. Then when you POWER ON the spectrometer controller and restart your program, access the spectrometer controller at the new address.

The optional 488 interface is designed as an IEEE 488 Talker/Listener. The primary IEEE 488 address is set at the factory to 1, however, it can be reconfigured with a command to set the address from 1 to 31 (see the UTIL CHANGE 488 ADDRESS command on page 47).

Note that the IEEE address can also be changed via RS-232, if your spectrometer controller is so equipped. Use the HWCFG232.EXE program on the support diskette if you are using a DOS computer, or, after establishing RS-232 communications, send the UTIL CHANGE IEEE 488 ADDRESS command from your own program.

The support diskette provided with each DataLink / DataScan, JY488 or SPEX488 includes utility programs and BASIC program examples to communicate with a

DOS PC.

5.1 Supported IEEE 488 Computer Interface Boards:

The IEEE 488 example programs work with several of the National Instruments PC interface boards.

- GPIB-PCII/PCIIA 488.2 Interface board: The driver supplied by National should be version 1.2 or newer, and their BASIC support disk should be version 2.Ø or newer.
- Older GPIB-PCIIA boards require National's revision C13 or newer software.
- AT-GPIB 488 boards require National's revision E7 or newer software.
- AT-GPIB 488.2 board: Must be version 2.1.1 software, and their BASIC support disk version 2.2 or newer.
- GPIB-PCIII board: this model must be replaced with one of the above. Contact your local National Instruments dealer with regard to their current replacement program.

There are other boards by National and other suppliers for IBM compatible and MacIntosh computers. Many of these boards can function in *SIMILAR* fashion, and these instructions *MAY* be helpful in setting them up. As we canno: support or guarantee reliable communications with other boards and software, we strongly recommend that you use the National Instruments products as described above.

5.2 Establishing GPIB Communications:

The IEEE board and it's associated software driver must be installed in your computer as per National Instruments' instructions. The driver must be installed via your computer's CONFIG.SYS file.

This set up assumes that the National Instruments software driver has the PCII board name as GPIB0 and the first device name as DEV1. Run the IBCONF program and set the configuration as follows:

GPIB0

Primary GPIB Address	0
Secondary GPIB Address	None
Timeout Setting	T3s
EOS byte	00H
Terminate read on EOS	no
Set EOI with EOS on write	no
Type of compare on EOS	7-bit
Set EOI w/ last byte of write	yes
System controller	yes
Assert REN when SC	no
Enable auto serial polling	yes
Timing	500 nanoseconds
Enable 488.2 protocols	yes
CIC protocols	no
Handler Type	PC2
Interrupt Setting	none
Base I/O address	02B8H
DMA channel	1

DEV1

Primary GPIB address	1
Secondary GPIB address	None
Timeout Setting	T10s
EOS byte	0Dh
Terminate read on EOS	yes
Set EOI with EOS on write	no
Type of compare on EOS	7-bit
Set EOI w/ last byte of write	yes
Repeat addressing	no

The above are default settings. Refer to the example program listings of 488_SCAN.BAS and SCAN_488.BAS for details.

The part of your program that will establish communications must follow the steps outlined in the "IEEE 488 Start Up Procedure" flow chart. The example BASIC programs provided on the support diskette and listed in Appendix 142 include working examples of the startup procedure.

Note that timeout settings vary by command. In most cases 300 milliseconds is sufficient. Longer timeout recommendations are given, for the commands that need them, in Section 10: Command Descriptions.

Note that single byte reads rely on an explicit byte count of 1 to terminate, rather than EOI. Multi-byte reads assume that the EOS character is <CR>. See the 488SCAN.BAS listing in Appendix 3. You will find this near the variable declarations at the beginning of the program.

- ICH$ and ACK$ are 1 byte program variables
- RBUF$ is set to 132 characters to handle the largest expected string
- The spectrometer controller does not assert EOI

For examples of low level IEEE 488 bus signals to use and expect when issuing commands, refer to Appendix 5 on page 176

5.3 To test GPIB communications:

This test assumes that you have correctly completed the GPIB set-up above.

Connect your GPIB cable between the National Instruments board in your computer and the SPEX488 or DS488. If other devices are to be used on the same bus, it is recommended that they be disconnected temporarily, to reduce the possible sources of problems while establishing communications for the first time.

From the directory where the National Instruments programs reside, Run IBIC, and issue the following commands at the : prompt.

IBFIND GPIBØ	Finds the PCII board in the PC
IBFIND DEV1	Finds the DS488 or SPEX 488 at address 1
IBWRT " "	Send one space character (must be enclosed in Quotation marks)
IBRD 1	Read 1 character.

If you have successfully communicated, you should receive a B or an F. If you have an error message displayed, refer to the National Instruments documentation to interpret it.

To gain further assurance of communication to the spectrometer controller, the following test will read the configuration from the nonvolatile memory in the DS488 or SPEX488.

Insert the DataScan \SPEX232\ SPEX488 support diskette into your Floppy Drive, and at the DOS prompt, type "A:<Enter>" to access the floppy. (Use "B:<Enter>", if appropriate for your computer.)

Type "cd\utility\ieee488" followed by "<Enter>". Then type "hwcfg488 1" followed by"<Enter>". You should see the HW CONFIGURATION screen on your computer's monitor.

> **CAUTION:** *Do not press the <F3> key, as this will change the configuration in your spectrometer controller.*

Press the <F2> key to read the hardware configuration from the non-volatile memory in the DataScan or SPEX232. If the GPIB interface is properly installed and functional, the program will read and display the settings from your system. If communication fails, refer to the National Instruments documentation for further troubleshooting information. It is important to keep in mind that this is a working program that has been in routine use for configuration at the factory, and will access the DS488 or SPEX488 if the National Instruments board is properly installed and functional.

Review the configuration on the screen. At the factory, this was set up to match your system. A record of the configuration was printed by using the <F8> function. This was included with the documentation shipped with the spectrometer controller. Normally, there will be no further need to use this program, unless you replace gratings or need to limit the maximum high voltage if you have a DataScan / DataLink. You may want to familiarize yourself with some of the parameters and options on the screen, such as grating g/mm, and HV limit. Press <F10> to exit the program.

5.4 To change the GPIB address:

The J-Y and Spex spectrometer controllers are each shipped from the factory with a default device address of 1. To change the address, insert the DataLink / JY232 / JY488 or DataScan / SPEX232 / SPEX488 support diskette into your Floppy Drive, and at the DOS prompt, type "A:<Enter>" to access the floppy. (Use "B:<Enter>", if appropriate for your computer.)

Type "cd\utility\ieee488" followed by "<Enter>". Then type "hwcfg488 1" followed by "<Enter>".

You should see the HW CONFIGURATION screen on your computer's monitor. Press <F2> to read the hardware configuration from the address shown in the lower right corner of the screen.

If you wish to change the address, move the cursor to that field and enter the new number. Any address from 1 to 31 is valid. However, depending on the configuration of your PC interface board you may be limited to 1 to 15. To write the new address into non-volatile memory in the SPEX488 or DS488, press <F3>. To verify that it was accepted, press <F2>, and see the address that is returned on the screen. When the spectrometer controller is powered off, then on again, the new address will become active. Subsequent communication must be to the new address.

An alternative method of changing the GPIB address is possible for DataScan and the SPEX232/488 interface. You may write the new address over your computer's serial COM port via RS-232. A null modem cable (Spex p/n 97133) should be used.

To use the serial port, a similar program is provided on the support disk, in the UTILITY directory. The program name is HWCFG232. To run this program, the COM port to be used, and the baud rate should be specified.

On the support diskette, access the subdirectory A:\UTILITY and execute the program by typing "hwcfg232" A screen will appear showing the communications port and baud rate settings. If these are correct, press, otherwise change the settings as needed. and press <Enter>. (When shipped from the factory, the default settings are for COM port 1, at 19200 baud). The program will establish communications and read back the present configuration from the spectrometer controller. This configuration will then be displayed in the HW CONFIGURATION screen on your computer's monitor. You can now change the address as in the above IEEE488 example.

5.5 Preparing to program via IEEE 488:

After success in communicating using the National Instruments hardware and software you may proceed to command the spectrometer controller using the Programmer's Command Set.

Due to National Instruments' licensing restrictions, we cannot distribute ready to run source code example programs for the SPEX488 and DS488 interface. The GWBASIC programs SCAN_488.BAS and 488_SCAN.BAS provided on the support diskette must be merged with DECL.BAS from National Instruments, and National's BIB.M must be in the same directory as the SCAN_488 and 488_SCAN programs. GWBASIC must be available on your computer as well. If you are using a compiler other than GWBASIC, check the National Instruments support disk for the appropriate files.

There is a READ.ME file on the DataScan support diskette that may contain further, updated information.

When these programs are executed, you will be prompted to enter the GPIB address. Unless you have changed the address as described earlier, the address will be 1, as shipped from the factory.

SCAN_488.BAS is a simple program intended to demonstrate proper usage of the various commands by example. It includes usage of DataScan acquisition and high voltage commands in the Intelligent communications mode. You will see how to set and read motor speeds, read the firmware version number from the FLASH RAM, as well as other commands.

488_SCAN.BAS is a spectrometer control program that has been used at the factory to test systems like yours. It offers a formatted input screen to enter parameters and execute a scan routine. Conversions from working spectral units to motor steps are performed by the program. Data acquisition commands are not included, but you may easily add them.

Please understand that these are rudimentary example programs provided free of charge. They have been tested within reason. They are intended as references for programmers to excerpt from. We do not guarantee or support these in the same way as our complete software packages. They are intended as examples only. If you construct programs based on these Command Set examples, we strongly recommend that you add prudent error trapping and protection features to your program to protect your system and enhance ease-of-use. Much aggravation can be avoided by such things as limits on stepper motor travel and speed, as well as other variables, and validity checking on commands.

5.6 IEEE 488 Communications Startup:

The part of your program that will establish communications must follow the steps outlined in the IEEE 488 Start Up Procedure flow chart on page 26.

It is important to understand that the command set's internal program bootstraps into the RS-232 terminal communications mode. In this mode, the spectrometer controller accepts single ASCII character commands, and responds sending ASCII characters preceded by the ANSI <Escape> X, Y sequence for character positioning on the terminal screen.

When the spectrometer controller is addressed on the IEEE 488 bus, it automatically sets itself in the intelligent communications mode and you need only establish whether you are talking to the BOOT or the MAIN internal spectrometer controller program.

Send the 'where am I' command, "<Space>", and the spectrometer controller will respond with "B" for boot, or "F" for main. This tells you which internal program is running in the spectrometer controller.

If you receive "B", you are talking to the BOOT program. Send "O2000" plus the "<Null>" character to transfer to the spectrometer controller's MAIN program. Wait 0.5 second to be sure that the main program is ready to accept additional commands before proceeding.

If you receive the "F" character, you are talking to the MAIN program. This means that the spectrometer controller has previously been run by a program. In this case you may not have to send the INIT and SET commands described later. Instead, you may wish to read back the previous positions into your program.

In intelligent communications mode, the terminal prompts are turned off. Commands are acknowledged with single characters.

The flush buffer commands clear characters from a previous run or clear out the ASCII terminal communications mode prompts that are sent by the spectrometer controller until you establish yourself as a computer program by switching to the intelligent communications mode.

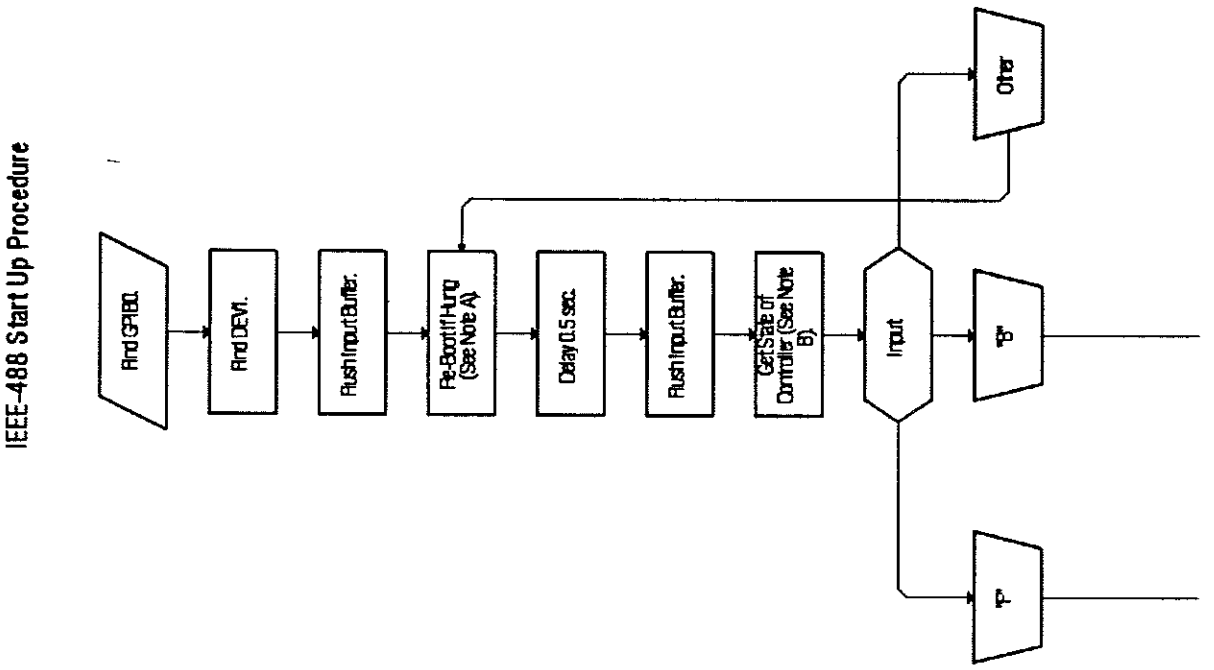
5.7 Re-booting a Spectrometer Controller

If your program exits before you complete a command, the spectrometer controller will hang. It will wait for the rest of the command input. This condition can be cleared by re-powering the spectrometer controller.

Assuming that you are communicating in the intelligent mode, you may send the pseudo-command "<222>" as a single byte to re-boot the spectrometer controller. The <222> is ignored if the spectrometer controller is not hung waiting for additional parameters. Pseudo-commands do not cause the spectrometer controller to send back any response character.

If you are in the terminal communications mode, you may force a re-boot by sending the pseudo-commands "<248>" and "<222>", in that sequence, both as single bytes. This first insures that the spectrometer controller is in the intelligent communications mode to accept the <222>.

You may want to re-boot the spectrometer controller at some time, without manually turning it off and back on. To do this, intentionally send it an incomplete command. For example, send "G", MOTOR SET POSITION without specifying the position. Follow with the pseudo-command "<222>". This will put you at the beginning of the start-up sequence.


IEEE-488 Start Up Procedure
Find GPIB0
Find DEVI
Flush Input Buffer
Re-Boot If Hung (See Note A)
Delay 0.5 sec
Flush Input Buffer
Get State of Controller (See Note B)
Input
Other
"p"
"p-"

Notes on IEEE-488 Start Up Procedure

A: Send decimal value "<222>". This will force a re-boot if hung from an incomplete command.

B: Send WHERE AM I command "<Space>"; response will be "B" (for BOOT) or "F" (for MAIN) depending on the previous state of the spectrometer controller.

C: Send "O2ØØØ<Null>". To transfer control from the BOOT to the MAIN program. You must send the "<Null>". Wait 0.5 second.

D: You can read your last position etc. from the spectrometer controller. You do not have to re-initialize the spectrometer controller.

E: Initialize mono (see command "A" and SET commands) and get initial settings from the user, eg. spectral position.

6 Using Both RS-232 and IEEE 488:

On a spectrometer controller that is equipped with both the RS-232 and IEEE 488 interfaces, if the IEEE 488 is the first method of communications used, then RS-232 will be disabled since the autobaud process has been bypassed.

However, if RS-232 is the first method of communications used, once autobauding is performed, and communications is established in terminal communications mode (e.g. using HandScan / KeyLink or other "dumb terminal") at initialization time, IEEE 488 may take control by the REN action of the IEEE 488 BUS. If you want to return to RS-232 in terminal communications mode, from IEEE 488, you must issue the "UTIL SET TERMINAL COMMUNICATIONS MODE" command (see the command descriptions in Section 10) and wait for confirm before you set the IEEE 488 to LOCAL to allow the RS-232 interface to take control.

7 Configuration for Instruments and Options:

Normally the monochromator type and configuration are loaded in the non-volatile memory of your spectrometer controller. If, for any reason, this configuration does not match your present system, you may use the HWCFG program to modify it. There are two versions of the program. If you are using a GPIB interface, access the subdirectory A:\UTILITY\IEEE488 and execute the program by typing "hwcfg488 1" (where 1 is the current device address). If you are using a serial interface, access the subdirectory A:\UTILITY and execute the program by typing "hwcfg232" A screen will appear showing the communications port and baud rate settings. If these are correct, press, otherwise change the settings as needed. and press <Enter>. (When shipped from the factory, the default settings are for COM port 1, at 19200 baud). The program will establish communications and read back the present configuration from the spectrometer controller. This configuration will then be displayed in the HW CONFIGURATION screen on your computer's monitor.

CAUTION: DO NOT PRESS THE <F3> KEY, AS THIS WILL CHANGE THE CONFIGURATION IN YOUR SPECTROMETER CONTROLLER.

Press the <F2> key to read the hardware configuration from the non-volatile memory in the spectrometer controller. If the interface is properly installed and functional, the program will read and display the settings from your system. If communication fails, an error message will be displayed. If you are using an RS-232 interface, check the possible faults advised by the message. If you are using the GPIB, Refer to National Instruments' documentation to decode the message.

Always print the current configuration using <F8> before making modifications.

Review the configuration on the screen. At the factory, this was set up to match your system. A record of the configuration was printed by using the <F8> function. This was included with the documentation shipped with the spectrometer controller. The most common use of this program is to change settings when you replace gratings or if you need to limit the maximum high voltage if you have a DataScan. You may want to familiarize yourself with some of the parameters and options on the screen, such as grating g/mm, and HV limit.

For example: If you have other monochromators to be operated through this spectrometer controller, put the cursor on MONO TYPE then press <F1>. A help screen will appear showing all valid type numbers. (The Monochromator type for a 270M is "13").

```
V2.01 RS-232                HW CONFIGURATION PROGRAM                    Verify: OFF
/=========================================================================================\
||MONO SYSTEM          1  2  | MONO SYSTEM          1  2  | MONO SYSTEM          1  2||
||-----------------------------------------------------------------------------------||
||Mono  Drive. . . . N  N  | Front Entr Shut. . N  N  | Filter Wheel. . . N  N||
||Front Entr Slit. . N  N  | Side  Entr Shut. . N  N  | Accessory 1 . . . N  N||
||Side  Entr Slit. . N  N  | Swing Entr Mirror. N  N  | Accessory 2 . . . N  N||
||Front Exit Slit. . N  N  | Swing Exit Mirror. N  N  | Accessory 3 . . . N  N||
||Side  Exit Slit. . N  N  | Turret . . . . . . N  N  | Accessory 4 . . . N  N||
||===================================================================================||
||MONO SYSTEM                1       2   | MONO SYSTEM                 1       2||
||-----------------------------------------------------------------------------------||
||Mono  Type . . . . .       0       0   | Front Entr Slit Type.       0       0||
||Actual Grating 1 . .       0       0   | Side  Entr Slit Type.       0       0||
||Actual Grating 2 . .       0       0   | Front Exit Slit Type.       0       0||
||Auto Calibr Offset .       0       0   | Side  Exit Slit Type.       0       0||
||===================================================================================||
||                              SYSTEM WIDE PARAMETERS                               ||
||===================================================================================||
||High Voltage 1. . . . N  | Accessory 1 . . . . . N  | H V 1 Limit . .       0||
||High Voltage 2. . . . N  | Accessory 2 . . . . . N  | H V 2 Limit . .       0||
||Data Acq Module . . . N  | Accessory 3 . . . . . N  | 488 Address . .       1||
\=========================================================================================/
Copyright Park Scientific, Inc.  1991                          COM1:  9600 Baud
```

To write a new configuration to be permanently stored in the spectrometer controller, press <F3>. To verify that it was accepted, press <F2> and see the new configuration is returned on the screen. Press <F10> to quit when finished. When the spectrometer controller is powered off, then on again, the new configuration will become active.

8 Communications Conventions:

This is a definition of the communications that should occur when a computer interfaces with the spectrometer controllers.

1. Whenever you see <CR>, it means to use ASCII Carriage Return. (13 in DECIMAL).

2. The parameter "Mono System #" is used to select which of the spectrometer controller's monochromator drive ports you are addressing. This can be either 0 or 1 for a DataScan / DataLink. For a SPEX232 / JY232 or SPEX488 / JY488 it is always 0, as these interfaces are individually dedicated to spectrometers

3. The parameter "Channel #" selects which data acquisition channel you are addressing. The first channel is 0, the second is channel 1. (This differs from controller labeling that starts with 1 as the first channel.) Channel # = 2, where appropriate, means select BOTH the first and second channels. An example of this is the command "ACQ START," which can accept 2 for the Channel # to start the data acquisition on both input channels simultaneously.

4. Any string that is placed inside of a pair of double quotes, i.e. "abcd" means that you should send all characters exactly as shown inside the double quotes. You should include spaces, But do not include the double quote characters. Also if you see a character symbolized using < > in a string, you send the character only, not the symbols. For example: if you see"1,0,<Null>", you should send only 5 ASCII characters: the 1, the comma, the 0, another comma, and the Null character (decimal 0).

5. Anything placed inside of a pair of square brackets, i.e. [0..1] indicates the valid range of the parameter associated with it.

9 Command Syntax and Confirmation :

This section outlines the rules of syntax required to successfully send commands and recognize confirmation responses that will inform you that the spectrometer controller has or has not received a valid command string.

9.1 Standard Commands:

As a prerequisite to sending operational commands to your spectrometer controller, you must establish communications first. Refer to Section 4 for RS-232, or Section 5 for IEEE 488. Only after communications have been successfully established can other commands can be sent to it.

All commands are ASCII text, unless specifically noted otherwise. The "Standard Commands" are only 1 character and are detailed in the command descriptions in Section 10. For commands requiring additional input, the command is sent, immediately followed by the relevant parameter(s). The command parameters form a string of characters representing the data that is sent or received.

For example, if you wished to send 1000 as a parameter for the command MOTOR SET POSITION, you should send the character string "1000". The general format for sending commands and/or parameters is the following:

1. Send the command (e.g. MOTOR INIT). This is a single character with no termination.

2a. If there is only one parameter, send the parameter, then the PARAMETER BLOCK END character "<CR>" (13 in DECIMAL, 0d in HEX).

2b. If there are multiple parameters, send the PARAMETER DELIMITER character "," between parameters, then send the PARAMETER BLOCK END "<CR>" character after the last parameter.

3. When all the parameters have been received by the spectrometer controller, it will respond with a single CONFIRMATION character indicating whether or not it has received all the expected parameters. A CONFIRMATION character of "o" indicates that the parameters were OK; "b" indicates that the parameters were BAD. Your program must read the confirmation, if it is ignored, the system will hang.

4a. If the spectrometer controller has been issued a command that would require it to send back information (e.g. MOTOR READ POSITION), then that information will be sent immediately after the CONFIRMATION character "o". If there is only one parameter for the spectrometer controller to send back, then that parameter will be sent followed by the PARAMETER BLOCK END character "<CR>".

4b. If there are multiple parameters to be sent back to the host, the CONFIRMATION character "o" is sent first, followed immediately (without delimiter) by the first parameter. The PARAMETER DELIMITER character "," will be sent between parameters; and the PARAMETER BLOCK END character "<CR>" will be sent after the last parameter. For example, a typical response to MOTOR READ SPEED might be: "o400,800,2000" followed by "<CR>".

9.2 Extended Commands:

The command set is not limited by the number of characters in the English alphabet.

The character "Z" has been assigned for access to extended commands. The first parameter following this command is recognized as the number representing the extended command you wish to execute. Depending on the command number you send, you may be required to send more parameters following the command.

Otherwise, extended commands are handled in the same way as the standard commands above.

For an example, see the description of the command Z11: TTL AUTOMATIC OUTPUTS on page 88.

9.3 Pseudo-Commands:

These commands perform some special utility functions. The syntax is the same as standard single byte commands, except that the bytes sent as commands are not text. They are values such as <222>. In this document, they are expressed as decimal values, between the < and > symbols. The pseudo-command to re-boot the spectrometer controller is expressed as <222>. Another difference is that pseudo commands do not generate a response character from the spectrometer controller.

10 Command Descriptions:

This section details the usage of the Programmer's Command Set.

The commands are sorted into functional groups, each command within a group has a common prefix. The groups are as follows.

- UTIL: the utility commands facilitate startup and communications related functions.
- MOTOR: the motor commands control the spectrometer grating drive.
- SLIT: the slit commands provide control of the automated slits in spectrometers so equipped.
- ACC: the accessory commands control automated grating turrets, entrance / exit port selection mirrors, and blocking shutters.
- ACQ: the acquisition commands control the data collection through spectrometer controllers that include signal channels.
- TTL: the TTL commands read and control the setting of logic lines that are available on a connector on the spectrometer controller. These logic signals can be used to interface to your process.
- THRESHOLD: the threshold commands are used to establish the signal levels at which TTL lines will be asserted to highs or lows.
- SCAN: the scan commands provide semi- autonomous operation of the spectrometer controller. Complete scan definitions can be loaded in advance and then be executed with a simple start scan command.

Individual commands can be located with the Index at the end of this manual. They are listed by their Characters and by their Command names. Certain key words are also listed in the Index to help you locate the command you are looking for.

There are two distinct methods of programming to perform scanning experiments with data acquisition: elementary and independent.

In the elementary command method of running an experiment, your program has absolute control over every step of the experiment. Your program also has absolute responsibility to perform all the required steps according to the protocol outlined in

this manual. For instance, a program may issue the following series of commands in order to set up and acquire one data point:

1. HIGH VOLTAGE SET to turn on the high voltage.
2. MOTOR MOVE RELATIVE to set the spectral position
3. MOTOR BUSY (loop) to verify completion of the positioning move.
4. INTEGRATION TIME SET to set the signal integration time
5. GAIN SET to set the gain level for the desired channels.
6. ACQ START to start the acquisition.
7 ACQ BUSY (loop) to verify completion of the signal integration.
8. READ DATA to read back the acquired data and overrange status.

Please note that the above routine is far from complete. It is Intended to illustrate the level of elementary steps that would be involved in running an experiment.

Some commands provide independent operation. All the parameters needed to perform a routine are sent at one time. These parameters include the positions, integration time, and gains, comparable to the above example. In this independent command method, a setup command loads a string of operating parameters:

1 SCAN SET PARAMETERS sets all the operating parameters
2 SCAN START begins the routine.
3. SCAN GET DATA reads back the complete scan of data.

With this independent method, the host program is free to perform other tasks while the scan is in process. If desired, data can be read "on the fly" as the scan is progressing, or after the scan is completed. See the other commands having the SCAN- prefix in Section 10.8 for additional capabilities of the independent commands.

10.1 Utility Commands:

The commands in this section provide the means to properly start up communications with the spectrometer controller, as well as other, related commands.

This section includes commands used to switch communications modes between "intelligent" communications mode for computer control and "terminal" communications mode for hand-held terminal control.

Also described here are the commands used to determine the spectrometer controller's internal program version numbers, which is useful to know whencontacting us for service. There is also a command to determine out which part of the spectrometer controller internal program you are talking to.

There is a command to allow you to change the spectrometer controller's IEEE address, as well.

UTIL WHERE AM I "<Space>"

When communicating over an RS-232 link, this character is first used for automatic baud rate selection. Refer to the discussion on Autobauding on pages 9, 14 for a complete explanation of this process. If Autobauding has not been established, you will receive no response. (No response can also indicate that the program is hung). It may be necessary to send the "<Space>" character more than once, before the spectrometer controller responds with "<*>". After Autobauding, while the spectrometer controller is still in the terminal communications mode, the response to the "<Space>" character will be "<Escape>" followed by a string of characters intended for the terminal's display. If you are in the intelligent communications mode, the response to the "<Space>" character will identify which part of the spectrometer controller's internal program you are talking to; the BOOT program will respond "<B>", the MAIN program will respond "<F>"

When communicating over the IEEE 488 bus, the intelligent communications mode is set automatically, so the response to the "<Space>" character will identify which part of the spectrometer controller's internal program you are talking to; the BOOT program will respond "<B>", the MAIN program will respond "<F>". No response indicates that the program is hung.

If you receive an "F" in response to sending "<Space>", you also know that the spectrometer controller has been previously accessed.

For more detail on the startup sequence, refer to the flowchart for your communications interface: RS-232 on page 12 or IEEE 488 on page 26.

The spectrometer controller will respond to this command differently than it does to the standard commands. The normal "o" confirmation character will not be sent back. There will be no "<CR>"after the response, either.

Normally, if you receive the "B" response, indicating that you are talking to the BOOT program, you will want to send the string "O2000<Null> to start the spectrometer controller's MAIN program.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Program status
Example: Send "<Space>"	Receive Nothing if not yet successful in autobauding, or the system is hung or; Receive "*" if autobauding is successful for the first time or; Receive "<Escape>" followed by a string of characters if communicating in the Terminal mode or; Receive "B" if communicating in Intelligent mode with the BOOT program or; Receive "F" if communicating in Intelligent mode with the MAIN program

UTIL STARTUP INTELLIGENT MODE "<247>"

This command is used during the startup sequence for RS-232 communications only. It puts the spectrometer controller in intelligent communications mode.

If you start communications to the spectrometer controller via IEEE 488, the intelligent communications mode is set automatically. In that case there is no need for this command.

The only valid time to send this command is during the RS-232 startup sequence, immediately following receipt of the "*" that confirms that the autobaud selection was successful. To be sure you use this command at the correct point in the startup sequence, please refer to the startup flowchart for RS-232 communications on page 12.

Also see the UTIL SET INTELLIGENT MODE command which performs a similar function at times other than during the startup sequence.

The spectrometer controller will respond to this command differently than it does to the standard commands. No confirmation character will be sent back. only the "=" will be sent back to advise you that the spectrometer controller has switched to the intelligent communications mode. There will be no "<CR>" termination on this response.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Acknowledgement
Example: Send "<247>"	Receive "="

UTIL SET INTELLIGENT MODE "<248>"

This command is used to put the spectrometer controller into Intelligent Communications mode.

This command's intended use is to take control away from the hand-held controller, and give control to your program. To use the spectrometer controller in this way, the first communication after power on must be from the hand-held terminal. In this way, the baud rate selection is established with the hand-held terminal while the BOOT sequence is in the proper state to autobaud.

Also see the UTIL STARTUP INTELLIGENT MODE command which performs a similar function during the RS-232 startup sequence.

The spectrometer controller will not send any response characters upon receipt of this pseudo command. No confirmation character will be sent back. There will be no "<CR>" termination either.

You should wait 200 milliseconds after sending this command before issuing other commands.

After sending the "<248>" command, you may verify its effect by sending the UTIL WHERE AM I "<Space>" command.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. No response at all.
Example: Send "<248>"	Receive nothing

UTIL SET TERMINAL MODE "<Y>"

This command is used to put the spectrometer controller into Terminal Communications mode.

This command's intended use is to switch control to the hand-held controller, and away from your program. To enable you to use the spectrometer controller in this way, the first communication after power on must have been from the hand-held controller. That way, the autobaud rate selection was established while the BOOT sequence was in the proper state to autobaud.

Also see the UTIL SET INTELLIGENT MODE command, which performs the opposite function.

The spectrometer controller will respond to this command in the normal way, sending back the "o" character to confirm receipt of the command.

Note: After you receive the confirmation, press the <.> key on the hand-held terminal twice to re-establish communications.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends: 1. Confirmation
Example: Send "<Y>"	Receive "o"

UTIL START MAIN PROGRAM "O2000<Null>"

This "command" is actually a string of characters that is sent to the spectrometer controller as part of the start up sequence. The command is valid only when the spectrometer controller's BOOT program is running and the spectrometer controller is in the intelligent communications mode. It is used to jump from the BOOT to the MAIN program in the spectrometer controller.

If you are communicating over an RS-232 link, you may need to send the UTIL SET INTELLIGENT MODE "<248>" command (see page 41) to switch the spectrometer controller from the terminal communications mode to the intelligent communications mode. If you are using IEEE 488, this is not necessary.

The spectrometer controller will respond to this command differently than it does to the standard commands. The "<*>" character will be sent back to confirm that the MAIN program is running.

Wait 500 milliseconds after issuing the "O2000<Null>" command to be sure that the spectrometer controller has had sufficient time to establish itself in the MAIN program and send back the "<*>".

See the UTIL WHERE AM I "<Space>" command on page 38 which offers an easy way to verify that you are in the MAIN program.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "O2000<Null>"	Receive: "<*>"

UTIL RE-BOOT IF HUNG "<222>"

This pseudo command is used to restart the program in the spectrometer controller if it becomes hung. Note that depending on the condition that causes the spectrometer controller to hang, this command may not necessarily always un-hang and re-boot it.

The "<222>" command is helpful if you want to force the spectrometer controller to a known state. In this case, deliberately hang it by sending an incomplete command, such as MOTOR SET POSITION without any position parameter. Then you may issue the "<222>" command to re-bootstrap the spectrometer controller.

The "<222>" will be ignored if the Spectrometer controller is not hung.

The spectrometer controller will respond to this command differently than it does to the standard commands. No confirmation character will be sent back.

Wait 200 milliseconds after issuing this command to be sure that the spectrometer controller has had sufficient time to bootstrap before issuing other commands.

To proceed from this point, see the UTIL WHERE AM I "<Space>" command on page 38 which offers an easy way to determine if the re-boot was successful.

If you are communicating over an RS-232 link, see the UTIL SET INTELLIGENT MODE "<248>" command on page 41 to switch the spectrometer controller from terminal communications to intelligent communications mode. If you are using IEEE 488, this is not necessary.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Nothing
Example: Send "<222>"	Receive Nothing

UTIL READ MAIN VERSION "<z>"

This command is used to read the firmware revision number of the spectrometer controller's MAIN program.

This command is also helpful when contacting us for service assistance. If you can advise us of the firmware version you are using, we can respond more effectively to your needs.

The spectrometer controller will respond to this command in the normal way, by sending back the "o" character to confirm receipt of the command, and following that with a string such as "V3.3<CR>" to advise you of the version of the MAIN program firmware in the spectrometer controller. The length of the string could, conceivably, vary. The "<CR>" denotes the end of the string.

A similar command, UTIL READ BOOT VERSION, provides you the means to read the other firmware revision number.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends: 1. Confirmation 2. MAIN version number
Example: Send "<z>"	Receive "o" Receive "V3.3<CR>" or similar response

UTIL READ BOOT VERSION "<y>"

This command is used to read the firmware revision number of the spectrometer controller's BOOT program.

This command is also helpful when contacting us for service assistance. If you can advise us of the firmware version you are using, we can respond more effectively to your needs.

The spectrometer controller will respond to this command in the normal way, by sending back the "o" character to confirm receipt of the command, and following that with a string such as "V2.3<CR>" to advise you of the version of the BOOT program firmware in the spectrometer controller. The length of the string could, conceivably, vary. The "<CR>" denotes the end of the string.

A similar command, UTIL READ MAIN VERSION, provides you the means to read the other firmware revision number.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends: 1. Confirmation 2. BOOT version number
Example: Send "<y>"	 Receive "o" Receive "V2.3<CR>" or similar response

UTIL CHANGE IEEE 488 ADDRESS "<E>"

This command provides a means to change the IEEE 488 address of the spectrometer controller on the GPIB bus.

This command is only valid at one point in the startup sequence. While in the BOOT portion of the spectrometer controller's internal program, instead of sending the "O2000<Null>" string to transfer to the MAIN program, send the "<E>" command.

Please do not confuse this "<E>", which is a BOOT command, with the MAIN command "<E>" that will return the motor busy status.

To be sure you use this command at the correct point in the startup sequence, please refer to the startup flowchart for RS-232 communications on page 12 or the IEEE 488 startup flowchart on page 26.

Note that the value of the new address sent to the spectrometer controller should be sent in ASCII characters to be read directly as a hexidecimal address. For example, to set the IEEE address to (decimal) 11, you send "EB<Null>"

The spectrometer controller will respond to this command differently than it does to the standard commands. The standard "<o>" confirmation character will not be sent back. Instead, the character with the binary value of "<2>" will be sent back to acknowledge that the spectrometer controller has received a new address. The "<2>" response is the same, regardless of the address sent. There will be no "<CR>" termination on this response.

At this point, the new address has only been stored in the spectrometer controller's non-volatile memory.

To enable GPIB communication using the new address, you must turn the spectrometer controller off, then on again.

Unless you use this command again, the new address will remain in effect each time you turn on the spectrometer controller.

HOST sends 1. Command 2. New address in ASCII HEX	SPECTROMETER CONTROLLER sends 1. Acknowledgement
Example: Send "E3<Null>"	Receive "<2>"

10.2 Grating Motor Commands:

These commands control the movement of the grating scan drive to change the spectral position of the instrument. In other words, this group of commands deal with control of the portion of the spectrum allowed to pass through the spectrometer to the sample or detector.

The movements are expressed in steps. Because of this, various spectrometers, regardless of scanning mechanism, can be controlled. This also provides you the opportunity to work in whatever spectral units you prefer. Simply write your program to convert your units to steps. In this way, a monochromator that has a mechanism for scanning directly in Angstrom units can be controlled by your program to step in electron volts, for example.

The base spectral unit and steps per unit factors for all currently supported spectrometers are listed in Appendix 1: Monochromator Setup Parameters.

If you are writing a routine for an autocalibrating monochromator (180D, 220M, 270M, or HR460), please note: If your program that moves the grating or slit drives will also require movement of a accessory, it is best to send the slit, turret, and shutter commands first. These are positioned by DC motors that can complete their movements while you send other commands. Follow these with the slit and monochromator grating drive commands. These are positioned by stepper motors, and must be handled one at a time.

This group of elementary commands provides direct control over each motor movement. If you prefer to download a scan routine to have the controller automatically scan and acquire a series of datapoints, see the Independent Scan Commands starting on page 92.

MOTOR INIT "A"

This command is used to initialize the monochromator, and normally only needs to be called once when all the hardware is powered on and the software is started.

For autocalibrating monochromators like the 180M, 220M, 220M+, 270M, and the HR460, this command does quite a bit. The monochromator wavelength drive motor is initialized, and upon completion, ends up at a particular (phase sensed) step position associated with the upper limit switch. This is the only known position when the monochromator is first powered on and initialized.

The wavelength value that corresponds to this initial position can be found on a label on the back of the instrument. The value needed is the "switch position" or "DMD.INI" number. Do not use the "offset" number.

Typically the base grating is 1200 g/mm, see Appendix 1 for the actual base grating groove density for your monochromator. At the factory, the corresponding step position value for the base grating of your monochromator is stored in the non-volatile memory of the controller. At initialization, this value is used as the starting position. After initialization, any movements will cause the position value to be updated. The host can then determine the step position by using the MOTOR READ POSITION command.

Note that the "A" command is used to move the drive accurately to the initialization position. This is not the same as movement by any other command that results in hitting the switch. In all other cases the movement is halted in an uncontrolled way. Thereafter, an accurate step position can no longer be assumed.

The autocalibrating monochromators can also have motorized slits, a motorized turret, motorized mirrors, and automatic shutters. These accessories are also initialized to their known positions. Motorized slits are left nominally closed (step position 0), the turret is initialized to POSITION 0 (the same side that the turret goes to when the mono is powered on), the mirrors are initialized to the FRONT (or AXIAL) position, and the shutters are left closed.

The initialization of a fully optioned autocalibrating monochromator can take 1-2 minutes. The confirmation character is not sent until the entire initialization process is completed. It is important that the host program and interface driver do not time out before this process is completed.

If you are communicating with the spectrometer controller via IEEE 488, set the timeout to 100 seconds for this command. After initialization is complete, reduce the timeout to 300 ms for normal commands.

For all other (non-autocalibrating) monochromators, this command will simply attempt to move the monochromator drive off the limit switch if it detects that it is up against one.

HOST sends: 1. Command	SPECTROMETER CONTROLLER sends: 1. Confirmation
Example: Send "A"	Receive "o"

MOTOR SET SPEED "B"

This command is used to set the speeds (in hertz) that should be used to move the monochromator. The Min Frequency is the starting speed of the mono; the Max Frequency is the fastest speed that the motor can move reproducibly; and the Ramp Time is the time it should take for the motor to ramp up from the Min Frequency to the Max Frequency. The Monochromator Setup Parameters table in Appendix 1 specifies the optimum speeds for each type of monochromator that is supported.

The values for Min Frequency and Max Frequency should be within the range of 100 - 80,000. Ramp Time should be within the range of 100 - 65,535.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Mono System #[0..1] 3. Min FrequencySteps/Sec. 4. Max FrequencySteps/Sec. 5. Ramp TimeMilliseconds (ms)	1.Confirmation
Example: Send "B0,400,800,2000<CR>"	Receive "o"

MOTOR READ SPEED "C"

This command is used to read back the speeds that were set using the previous command (MOTOR SET SPEED). If the MOTOR SET SPEED command was never issued, the default speed parameters for the monochromator will be returned. These parameters are specified by using either the HWCFG232 or the HWCFG488 program provided on the support diskette.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Mono System #[0..1]	1. Confirmation 2. Min FrequencySteps/Sec 3. Max FrequencySteps/Sec 4. Ramp TimeMilliseconds (ms)
Example: Send "C0<CR>"	Receive "o" Receive "400,800,2000<CR>"

MOTOR BUSY CHECK "E"

This command is also used with SLIT MOTORS.

This command is used to poll the Spectrometer controller after the command MOTOR MOVE RELATIVE or SLIT MOVE RELATIVE is issued in order to check to see if the motor has completed its move. The "Busy Status" that is returned is not terminated by a <CR> character. The values that may be returned are "q" and "z" (FUNCTION BUSY and FUNCTION NOT BUSY, respectively).

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Busy Status["q" or "z"]
Example: Send "E"	 Receive "o" Receive "q"

MOTOR MOVE RELATIVE "F"

This command is used to move a monochromator a relative number of steps from its current position. When this command is issued, the monochromator will start moving at the Min Frequency set with the MOTOR SET SPEED command, and ramp up to the Max Frequency.

The host computer regains control as soon as the move is initiated, not after the entire move has completed. Therefore, it is necessary to poll the spectrometer controller, after instructing it to move the spectrometer, to see if the move has completed; this is accomplished using the MOTOR BUSY command.

Only 1 stepper motor can be moved at a time. This means that if a slit or the wavelength drive of a monochromator is currently being moved (even if it is connected to the other monochromator drive port), you cannot send the MOTOR MOVE RELATIVE command. You must test the MOTOR BUSY status or otherwise be sure that no other motors are moving.

If a stepper motor is busy, you may not move an accessory (DC) motor, such as a mirror, shutter, or turret. You may, however, start an accessory (DC) motor moving and then send other commands before it has reached its destination.

Using a positive number of steps as the parameter for "Steps to Move" will change the spectral position to a greater step position (move forward); a negative number will change the spectral position to a lesser step position (move backwards). Please note that the host computer is responsible for performing backlash correction on negative moves; it is not performed automatically with this command. For each of the supported monochromators, the recommended number of steps for wavelength drive backlash correction is listed in the Monochromator Setup Parameters Table in Appendix 1.

The only limit to the value that the "Steps to Move" parameter can have is the total number of possible steps for the installed monochromator.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Mono System #[0..1] 3. Steps to Move	1. Confirmation
Example: Send "F0,1000<CR>"	Receive "o"

MOTOR SET POSITION "G"

This command is only used to correct the stored value of the actual current step position of the monochromator. For non-autocalibrating monochromators, a first pass calibration should be done when the instrument is powered on. Take the position reading from the monochromator's mechanical counter and convert it to steps. Use the appropriate steps/unit factor from the Monochromator Setup Parameters table in Appendix 1. Enter the result using this command.

Afterwards, if higher precision is needed, search to a known calibration position in your region of spectral interest, and update the value. Such a fine calibration is typically made using a known spectral emission peak or a transition edge from absorption to transmission of a filter. Keep backlash error to a minimum by making your final pass to the calibration position from the same direction you will use for your measurements. The required backlash overshoot is given in Appendix 1: Monochromator Setup Parameters.

After the positioning precisely on a known spectral feature, and having taken backlash into account, use this command to enter the step position that corresponds to the spectral line you use.

With autocalibrating spectrometers (220M, 220M+, 270M, HR460); the instrument self-calibrates to a precise phase sensitive step position associated with the upper limit switch after the MOTOR INIT command has been executed. This factory calibrated switch position is included with your calibration documentation shipped with the instrument from the factory. It is also marked on a label on the rear of the spectrometer. Don't confuse this position with the offset value, also labeled on the spectrometer. This autocalibration is significantly more accurate than the first pass manual calibration described above. If your work requires the ultimate in calibration accuracy at your particular region of spectral interest, you may prefer to do the fine calibration mentioned above.

Keep in mind also that the monochromators give most reproducible results when scanning in the direction they were designed for:

- For wavelength drives; scan in the direction of increasing wavelength
- For wavenumber drives; scan in the direction of decreasing wavenumbers

HOST sends 1. Command 2. Mono System #[0..1] 3. Mono Step Position	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: – Send "G0,1000000<CR>"	Receive "o"

MOTOR READ POSITION "H"

This command is used to read back the current monochromator step position. Whenever the monochromator is moved, the step position continuously updates itself to reflect the current position. This command can be issued after the MOTOR MOVE RELATIVE command, while polling the Busy Status. The sequence of commands might be as follows:

1. Issue the MOTOR MOVE RELATIVE command to initiate a spectral position move.

2. Issue the MOTOR BUSY command to test the Busy Status.

3. If the motor is still busy, issue the MOTOR READ POSITION command to retrieve its current position.

4. Repeat 2 and 3 until the MOTOR BUSY command returns a status of not busy.

5. Issue the MOTOR READ POSITION command to verify the new step position.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Motor Step Position
Example: Send "H0<CR>"	Receive "o" Receive "1000000<CR>"

MOTOR LIMIT STATUS "K"

This command is used to check the limit status of all installed monochromators. The grating scan motor of each spectrometer has an allowable operating range, if this range is exceeded in either direction, the drive will mechanically trip a limit switch. The value returned in response to the limit status command is the ASCII representation of the Binary limit status of each monochromator. If there are no monochromators connected (but there are connectors for them), then a limit condition may be set for each missing monochromator. Therefore, when checking limit conditions, you should only check those valid for the monochromator you are interested in. Do not automatically check for limits on both monos if only one is really connected.

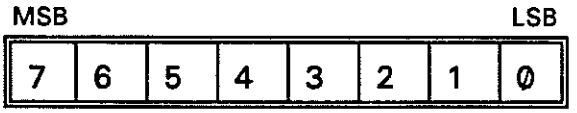
This command does not return limit status fro auticalibrating monochromators.

The ASCII string returned must be converted into a 1 Byte (8 bit) Binary number. To do this in C, you could first read the ASCII string (into variable ascii_stat), then use the following code segment:

```
unsigned char    binary_stat;
binary_stat = (unsigned char)atoi( ascii_stat );
```

Once the string is converted properly, each bit can be decoded in the following manner to determine if there is a limit condition:

In this diagram, bit #Ø is the Least Significant Bit, and bit #7 is the Most Significant Bit.



Example 1
If bit #Ø has the value of 1, while all the rest of the bits have the value of Ø, the binary value of the entire byte is 1.

Example 2
If bit #7 has the value of 1 while all the rest of the bits have the value of Ø, the binary value of the entire byte is 128.

If you are programming in BASIC, to decode the limit bits, make successive tests comparing and subtracting binary place values from the number.

- First determine if the returned byte is greater or equal to 128. If so, bit 7 is set; subtract 128. If not, bit 7 is not set, do not subtract 128.
- Next, repeat the procedure using 64 in place of 128. This will test for the state of bit 6.
- Next, repeat the procedure using 32 in place of 128. This will test for the state of bit 5.

Continue decreasing the comparison value by powers of 2 until all bits have been tested.

Limit Condition Assignments to Bits in Motor Limit Status Byte:

For MONO TYPES #1 through #13:

BIT#	Limit Condition
Ø	Lower limit on first monochromator.
1	Upper limit on first monochromator.
2	Lower limit on second monochromator.
3	Upper limit on second monochromator.
4	UNUSED.
5	UNUSED.
6	UNUSED.
7	UNUSED.

For MONO TYPES #14 through #19:

BIT#	Limit Condition
Ø	UNUSED.
1	UNUSED.
2	UNUSED.
3	UNUSED.
4	Either limit on first monochromator.
5	Either limit on second monochromator.
6	UNUSED.
7	UNUSED.

When bit #4 or bit #5 has a value of 1, the determination of whether the LOWER or UPPER limit has been reached must be made by checking the direction of the last monochromator drive movement.

For ALL MONO TYPES:
A binary value of zero (Ø) means that no limits are hit.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Motor Limit Status
Example: Send "K"	Receive "o" Receive "Ø<CR>"

MOTOR STOP "L"

This command is also used with SLIT MOTORS.

This command is used to stop the monochromator or slits if they are moving. If the monochromator has ramped up to a frequency higher than its Min Frequency, this command will initiate a ramp down. Since the motor may not stop immediately, the MOTOR BUSY command should subsequently be called until it returns a Busy Status of not busy.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "L"	Receive "o"

10.3 Slit Commands

This series of commands controls automated slits. These commands only apply if you have motorized slits installed on your monochromator system.

These values are to be used to designate the slit to be controlled:

Slit #0	Front (Axial) Entrance Slit
Slit #1	Side (Lateral) Entrance Slit
Slit #2	Front (Axial) Exit Slit
Slit #3	Side (Lateral) Exit Slit

SLIT SET SPEED "g"

This command is used to set the speed that should be used to move slits. The Frequency parameter is used to specify the speed in hertz. Note that although slits are motors, they do not ramp as the monochromator motor does.

The Frequency parameter should be within the range of 10 - 10,000.

Refer to Appendix 1 for recommended settings to for your spectrometer's slits.

HOST sends 1. Command 2. Mono System #[0..1] 3. Slit #[0..3] 4. FrequencySteps/Sec.	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "g0,0,400<CR>"	Receive "o"

SLIT READ SPEED "h"

This command is used to read back the speed that was set using the previous command (SLIT SET SPEED). If the SLIT SET SPEED command was never issued, the default speed parameter for the specified slit will be returned.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Mono System #[0..1] 3. Slit #[0..3]	1. Confirmation 2. FrequencySteps/Sec.
Example: Send "h0,0<CR>"	Receive "o" Receive "400<CR>"

SLIT SET POSITION "i"

This command is used to set (calibrate) the current step position of the specified slit. Motorized slits are normally initialized during the execution of the MOTOR INIT command, and they are initialized to the 0 step position.

The SLIT SET POSITION command should only be called with 0 as the Slit Step Position parameter, and it should only be called after the MOTOR INIT command has been executed.

Attempting to calibrate a slit by manually measuring the width of the opening will not yield accurate results.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Mono System #[0..1] 3. Slit #[0..3] 4. Slit Step Position	1. Confirmation
Example: Send "i0,0,0<CR>"	Receive "o"

SLIT READ POSITION "j"

This command is used to read back the current position of the specified slit. Whenever the slit is moved, the step position continuously updates itself to reflect the current position. This command can be issued after the SLIT MOVE RELATIVE command, while polling the Busy Status with the MOTOR BUSY command to get a continuously updated reading of the slit's current position.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Mono System #[0..1] 3. Slit #[0..3]	1. Confirmation 2. Slit Step Position
Example: Send "j0,0<CR>"	Receive "o" Receive "100<CR>"

SLIT MOVE RELATIVE "k"

This command is nearly identical to the MOTOR MOVE RELATIVE command.

This command is used to move the specified slit a relative number of steps from its current position. When this command is issued, the slit will start moving immediately.

The host computer regains control as soon as the move is initiated, not after the entire move has completed. Therefore, it is necessary to poll the spectrometer controller, after instructing it to move the slit, to see if the move has completed; this is accomplished using the MOTOR BUSY command (described earlier in this document).

Using a positive number of steps as the parameter for "Steps to Move" will move the slit motor to a greater step position (wider opening); a negative number will move the slit motor to a lesser step position (narrower opening). Please note that backlash correction is not performed automatically with this command. The host computer program is responsible for performing backlash on negative moves. The recommended number of steps for backlash for slits is given in the Monochromator setup parameters table in Appendix 1.

Only 1 slit can be moved at a time. You cannot move a slit if the monochromator motor or any other slit is moving (even if it is connected to a different monochromator drive port if the spectrometer controller is so equipped). You must test the MOTOR BUSY status or be sure that no other motors are moving before you send a SLIT MOVE RELATIVE command.

The only limit to the value that the "Steps to Move" parameter can have is the total number of possible steps for the installed slit.

HOST sends 1. Command 2. Mono System #[0..1] 3. Slit #[0..3] 4. Steps to Move	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "k0,0,500<CR>"	Receive "o"

10.4 Monochromator Accessory Commands:

These commands actuate the automated mechanical accessories that are interfaced to the spectrometer controller.

Each controllable "accessory" is operated by a DC motor or solenoid. As such, each has only two positions. The shutters reach their new positions in a matter of milliseconds, but turrets and side or lateral mirror assemblies may need several seconds to come to their new positions.

When writing your program, it is important to allow for these delays. Once an accessory command is accepted by the spectrometer controller, you are free to send other commands immediately. However, some commands depend on the positioning of accessories. Before using those commands, you should first test using the ACC BUSY CHECK command to be sure that all accessories have reached their destinations.

If you are writing a routine for an autocalibrating monochromator (180D, 220M, 220M+, 270M, or HR460), please note: If your program that moves an accessory will also require movement of the grating or slit drives, it is best to send the slit, turret, and shutter commands first. These are positioned by DC motors that can complete their movements while you send other commands. Follow these with the slit and monochromator grating drive commands. These are positioned by stepper motors, and must be handled one at a time.

ACC SHUTTER OPEN "W"

This command is used to open the "Active" shutter. It is possible to have 2 entrance shutters installed on a monochromator (Front/Axial and Side/Lateral), but only one can be "Active" at any given time. The "Active" shutter is the one that is in the light path.

If the Entrance Mirror is in the Front (Axial) position, or if there is no Entrance Mirror, then the Front (Axial) Entrance Shutter is "Active".

If the Entrance Mirror is in the Side (Lateral) position, then the Side (Lateral) Entrance Shutter is "Active".

If this command is used with the ACC BUSY CHECK command, it has a Delay of 100 ms.

Note that the shutter commands described here do not control the exposure shutters associated with multichannel detectors which are operated by the electronics of the multichannel detection system.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "W0<CR>"	Receive "o"

ACC SHUTTER CLOSE "X"

This command is used to close the "Active" shutter. Refer to the SHUTTER OPEN command above for more information.

If this command is used with the ACC BUSY CHECK command, it has a Delay of 100 ms.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "X0<CR>"	Receive "o"

ACC TURRET POSITION 1 "a"

This command is used to rotate the turret to the "Other" grating. In this context, "Other" refers to the grating that is not in use after the system is initialized using the MONO INIT command.

If this command is used with the ACC BUSY CHECK command, it has a Delay of 10000 ms.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "a0<CR>"	Receive "o"

ACC TURRET POSITION 0 "b"

This command is used to rotate the turret to the "Default" grating. In this context, "Default" refers to the grating that is in use after the system is initialized using the MONO INIT command.

If this command is used with the ACC BUSY CHECK command, it has a Delay of 10000 ms.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "b0<CR>"	Receive "o"

ACC ENTR MIRROR SIDE "c"

This command is used to move the entrance mirror to the Side (Lateral) position.

If this command is used with the ACC BUSY CHECK command, it has a Delay of 15000 ms.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "c0<CR>"	Receive "o"

ACC ENTR MIRROR FRONT "d"

This command is used to move the entrance mirror to the Front (Axial) position.

If this command is used with the ACC BUSY CHECK command, it has a Delay of 15000 ms.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "d0<CR>"	Receive "o"

ACC EXIT MIRROR SIDE "e"

This command is used to move the exit mirror to the Side (Lateral) position.

If this command is used with the ACC BUSY CHECK command, it has a Delay of 15000 m

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "e0<CR>"	Receive "o"

ACC EXIT MIRROR FRONT "f"

This command is used to move the exit mirror to the Front (Axial) position.

If this command is used with the ACC BUSY CHECK command, it has a Delay of 15000 ms.

HOST sends 1. Command 2. Mono System #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "f0<CR>"	Receive "o"

ACC BUSY CHECK "l"

This command is used to test if one of the monochromator accessories described above is still moving. Be careful not to confuse this l (lowercase L) with a number 1 or an uppercase i). This test simply counts down the delay, and returns not busy when the timer runs down. This command has the same format as the MOTOR BUSY command, and it returns the same Busy Status characters ("q" for FUNCTION BUSY and "z" for FUNCTION NOT BUSY). The Busy Status is not terminated by a <CR> character.

It is very useful to test for accessory busy before beginning an acquisition. This will ensure that all of the accessories are in their proper positions before integration begins.

It is not necessary, however, to make this test each time an accessory is moved. Unlike the monochromator and slit motors, it is perfectly fine to initiate multiple accessory moves in succession, without waiting for each to complete. For example, if you wanted to rotate the turret and move the entrance mirror, you could send the appropriate commands without waiting in between; then, before you start your data acquisition, you should make the ACC BUSY CHECK. When multiple accessories are moved in succession, only the longest Delay will be counted down; Delays are not added together.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Busy Status["q" or "z"]
Example: Send "l"	 Receive "o" Receive "q"

10.5 Data Acquisition Commands:

The data acquisition commands relate only to the DataScan / DataLink controller-photometers, and to SpectrAcq spectrometer controllers that include SAQ-CTI signal input channels.

These commands facilitate the setup and integration of signals from Photomultipliers or solid state monochannel detectors through the signal input channels of the above controllers.

Generally, these commands apply to all three controller types. When a command is specific to one or two controller types, this is noted in the description.

This group of elementary commands provides direct control over the acquisition of each datapoint. If you prefer to download a scan routine to have the controller automatically acquire a series of datapoints, see the Independent Scan Commands starting on page 92.

Data Acquisition Guidelines (for DataLink / DataScan Only):

Before performing any type of data acquisition using the AUTOGAIN option, the amplifier offsets must first be computed or set to obtain accurate measurements. In any of the FIXED GAINS, offsets are not subtracted. This applies to BOTH operating methods described below, with version 3.Ø or higher of Flash.

This is accomplished by issuing the command MEASURE ACQUISITION OFFSETS or SET ACQUISITION OFFSETS. These offsets are automatically computed into the final datapoint result that is read by the host while acquiring with AUTOGAIN.

If you are running in any of the fixed gains, the offset is NOT automatically factored into the resulting data. If desired, offset subtraction must be performed after the data is read back by your controlling program.

The command set is designed to allow maximum flexibility for the controlling program. Therefore, whenever possible, the data that is returned is in its "rawest" form; this is why, in fixed gains, there is no offset processing performed. However, with AUTOGAINing, any or all of the different gains can be used during a given integration period (depending on the fluctuation of the signal being measured); and since each gain can have a different offset value associated with it, it is most convenient to handle that processing in the firmware.

A few operating parameters must be set before the data acquisition can take place:

1. The integration time must be set.
2. The gain must be set for the channel being used.
3. If using a photomultiplier, the high voltage must be turned on.

ACQ MEASURE OFFSETS "W"

This command relates only to the DataScan / DataLink controller- photometers. It is used to compute the offsets associated with each gain setting. The offsets are to be factored into the final data as it is acquired in AUTOGAIN. Since there are 4 gains in this data acquisition system, 4 separate offsets will be computed.

Before issuing this command, you should ensure that all hardware are in their desired states. This depends largely on the type of detector you are using, the type of experiment you are performing, and your personal preference. For example, in some cases it may be necessary to turn off the high voltage and open the shutters before measuring the offsets. In other cases, you may want to close the shutters and leave the high voltage on (to do a background subtraction, for example). But whatever method you choose, you must have all devices in their proper states before sending this command.

The spectrometer controller will take an average of 100 reads per channel to allow an accurate computation of the offsets. As a result, the response to this command will be delayed longer than most.

> If you are communicating with the spectrometer controller via IEEE 488, set the timeout to 2 seconds for this command.

After offset computation is complete, reduce the timeout to 300 ms for normal commands.

The 4 values that are returned are the actual offsets that were measured (in counts per ADC read, where 1 ADC read takes 2 ms). Each value will be within the range of a signed integer (2 bytes).

We recommend that you save the measured offset values to disk storage. See ACQ SET OFFSETS to save time on subsequent power up sequences for the spectrometer controller. For many applications where environmental conditions are stable, weekly or monthly calculation of offsets may be sufficient.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Channel #[0..1]	1. Confirmation 2. Offset Gain 1 3. Offset Gain 10 4. Offset Gain 100 5. Offset Gain 1000
Example: Send "w0<CR>"	 Receive "o" Receive "2,21,-19,22<CR>"

ACQ SET OFFSETS "x"

This command relates only to the DataScan / DataLink controller- photometers. Because offset measurement is normally not required each time the spectrometer controller is powered on, the ACQ SET OFFSETS command is provided to load offsets that were measured and computed previously. If you intend to use the acquisition channels in more than one gain range the offsets are important. Therefore you should at least SET the offsets, if not MEASURE them, each time the spectrometer controller is powered on.

This command is used to explicitly set the acquisition offsets to some desired values. This command has the same effect and implications as the end result of the previous command ACQ MEASURE OFFSETS. The difference is that ACQ SET OFFSETS is user-determined while ACQ MEASURE OFFSETS is instrument-determined.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Channel #[0..1] 3. Offset Gain 1 4. Offset Gain 10 5. Offset Gain 100 6. Offset Gain 1000	1. Confirmation
Example: Send "x0,2,21,-19,22<CR>"	Receive "o"

ACQ CHANNEL GAIN SET "R"

This command is used to set the gain to use with the specified data acquisition channel. The valid values for the Gain parameter are from Ø to 4, with Ø to 3 specifying different amplifications, and 4 specifying AUTOGAIN. The following table shows the meaning of each number:

Parameter	Amplification
Ø	x 1
1	x 1Ø
2	x 1ØØ
3	x 1ØØØ
4	AUTOGAIN

If AUTOGAIN is specified, then the gain with the highest amplification that is not overranged will be selected for each reading of the Analog to Digital Converter (ADC) for the duration of the integration time. Data is scaled to the lowest gain that was actually used during the integration; the gain that the data was scaled to is returned. For example, if you use an integration of 1ØØ ms and are measuring a source with a 6Ø Hz intensity fluctuation, gains Ø and 1 may be used during the integration; the data that was read on gain 1 will be divided by 1Ø and added to the data that was read on gain Ø. Hence, the data that is read back using ACQ READ DATA may have been acquired over multiple gains.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Channel #[Ø..1] 3. Gain Level[Ø..4]	1. Confirmation
Example: Send "RØ,4<CR>"	Receive "o"

ACQ GAIN READ "S"

This command is used to read back the gain level for the specified channel that was set using the previous command ACQ GAIN SET.

HOST sends 1. Command 2. Channel #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Gain Level[0..4]
Example: Send "S0<CR>"	Receive "o" Receive "4<CR>"

ACQ INTEGRATION TIME SET "O"

This command is used to set the integration time that will be used when the command ACQ START is sent. The integration time is in milliseconds and should be a factor of 2, with 2 ms being the shortest time. If the time is not set to a factor of two, the time will be rounded up by 1 ms (e.g. 5 ms will become 6 ms). The value returned when you issue the command ACQ INTEGRATION TIME READ will be the 6 ms (not 5). The maximum integration on any gain level (including AUTOGAIN) is 300,000 ms (5 minutes).

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Channel #[0..1] 3. Time Milliseconds (ms)	1. Confirmation
Example: Send "O0,50<CR>"	Receive "o"

ACQ INTEGRATION TIME READ "P"

This command is used to read back the integration that was set using the previous command ACQ INTEGRATION TIME SET. DataLink / Datascan systems take an ADC reading once every 2 ms. The value read back for these will always be a multiple of 2 .

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Channel #[0..1]	1. Confirmation 2. Time Milliseconds (ms)
Example: Send "P0<CR>"	Receive "o" Receive "50<CR>"

ACQ START "M"

The integration time and gain must be set prior to sending this command.

This command is used to start integrating data on the chosen channel. When data acquisition is started, the spectrometer controller will read data from the Analog to Digital Converter (ADC) once every 2 milliseconds (ms). Therefore, the integration time that is used by the system will always be a factor of two, with 2 ms being the shortest time. If the integration time is set to an odd number (e.g. 5 ms), it will be rounded up by 1 ms (e.g. 6 ms). The data that is returned by the ACQ DATA READ command will always be normalized to represent 1 ADC reading every 1 ms.

The channel parameter sets the input channel. Channel Ø is the firs input, channel 1 is the second. This differs from the labelling on the spectrometer controller which is marked 1 and 2. The command allows the number 2 as a parameter for Channels 1 and 2 to integrate signal on both channels simultaneously. The 2 ms rule still applies. In this case, you must send the command ACQ DATA READ twice in order to get the back the data from each channel.

For a 2 channel simultaneous data acquisition, the integration times for both channels must be the same. If the times are not the same, the integration time for the first channel will be used.

HOST sends 1. Command 2. Channel #[Ø..2]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "MØ<CR>"	Receive "o"

ACQ STOP "N"

This command is used to stop the integration of data that was initiated with the ACQ START command. Integrations in process on all channels will be stopped.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "N"	Receive "o"

ACQ BUSY "Q"

This command is used to poll the spectrometer controller after the command ACQ START is issued in order to check to see if the data acquisition has completed. The Busy Status that is returned is not terminated with a <CR> character (as is the case with all busy tests). The values that may be returned are "q" for FUNCTION BUSY and "z" for FUNCTION NOT BUSY.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Busy Status["q" or "z"]
Example: Send "Q"	 Receive "o" Receive "q"

ACQ READ DATA "T"

This command is used to read back the acquired data. Before issuing this command, the ACQ BUSY command should be sent to make sure that the integration is complete. If the ACQ START command was issued as a 2 channel data acquisition, the READ ACQ DATA command must be issued twice to retrieve data from both channels.

Along with the acquisition data, an overrange status and gain level are also returned. If running AUTOGAIN, the acquisition data will already have offsets accounted for, and the data is scaled according to the amplification of the gain level. The overrange status can be either a Ø or a 1, with Ø indicating that the data is not overranged. A status of 1 means that the signal is too strong for the gain that was used. (In AUTOGAIN, it means that the least sensitive gain was overranged). The gain level that is returned for fixed gains is the same value that was set with the GAIN SET command. When using AUTOGAIN the returned gain level is the one that the acquired data was scaled to.

The value for ACQ DATA will be within the range of ± 2 $X10^9$.

HOST sends 1. Command 2. Channel #[Ø..1]	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Acq Data 3. Overrange Status[Ø..1] 4. Gain Level[Ø..4]
Example: Send "TØ<CR>"	 Receive "o" Receive "135000,Ø,3<CR>"

10.6 High Voltage Commands:

HIGH VOLTAGE SET "U"

This command is used to set the specified high voltage module to a specified voltage. The maximum voltage for the installed module must not be exceeded in the HV Level parameter of this command.

For safety, we strongly recommend that you set HV to 0 when exiting your program.

Note also that when HV is turned on, you should allow some settling time for your detector to become stable before acquiring data. Four seconds is sufficient for many detectors. However, you should be aware that some photomultiplier tubes may take several minutes to settle when high voltage is applied. Cooled photomultipliers may take hours to stabilize to the extent necessary to measure the low light levels they ar intended for. You may wish to experiment with your system to arrive at an optimal delay.

HOST sends 1. Command 2. HV Module #[0..1] 3. HV LevelVolts	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "U0,800<CR>"	Receive "o"

HIGH VOLTAGE READ "V"

This command is used to read back the present high voltage setting for the specified module that was established using HIGH VOLTAGE SET.

HOST sends 1. Command 2. HV Module #[0..1]	SPECTROMETER CONTROLLER sends 1. Confirmation 2. HV LevelVolts
Example: Send "V0<CR>"	Receive "o" Receive "800<CR>"

10.7 TTL I/O Port Commands:

These commands assert and read the TTL I/O lines on the SPECTROMETER CONTROLLER. Note that the SPEX232, SPEX488, JY232, and JY488 do not support these commands. The TTL lines generally are used to interface to ancillary devices that relate to the process that the spectrometer controller is associated with.

TTL WRITE OUTPUT "m"

This command is used to "toggle" the lines of the output port of the spectrometer controller. Each line of the output port is represented as 1 bit out of a total of 8 (or 1 byte).

The Binary value that results from setting the desired bits to 1 should be converted into an ASCII string.

In this diagram, bit #Ø is the Least Significant Bit, and bit #7 is the Most Significant Bit.

7	6	5	4	3	2	1	Ø

Example 1
To raise only the first line of the output port high, we would set bit #Ø to the value of 1, while all the rest of the bits would have the value of Ø. The binary value of the entire byte would be 1, therefore, the string to send would be "1".

Example 2
If we wanted to raise all of the lines of the output port high, we would set all 8 bits to have the value of 1. The binary value of the entire byte would be 255, therefore, the resulting string would be "255".

HOST sends 1. Command 2. Input Port Value[Ø..255]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "m255<CR>"	Receive "o"

TTL READ OUTPUT "n"

This command is used to read back the current value of the output port that was set either by issuing the previous command TTL WRITE OUTPUT or by enabling TTL AUTOMATIC OUTPUTS. The value is read back as a number which should be converted to its binary equivalent, then examined 1 bit at a time to determine which lines of the output port are raised high.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Input Port Value[0..255]
Example: Send "n"	Receive "o" Receive "255<CR>"

TTL READ INPUT "o"

This command is used to read back the current value of the input port. The value is read back as a number which should be converted to its binary equivalent, then examined 1 bit at a time to determine which lines of the input port are raised high.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Input Port Value[0..255]
Example: Send "o"	Receive "o" Receive "255<CR>"

TTL AUTOMATIC OUTPUTS "Z11"

This is an "extended" command. The Z character serves as a prefix for all extended commands. The first parameter (11, in this case) is read by the spectrometer controller as part of the command designation.

This command is used to enable or disable the automatic updating of the lines of the output port on the spectrometer controller when using the independent method scan commands. These lines can be used to provide a TTL signal to an external device that can then monitor some of the activities in the instrument or trigger some external event based on the states of the output port lines. If you are using the command TTL WRITE OUTPUT to control some of these port lines, you may want to disable TTL AUTOMATIC OUTPUTS for those lines.

For this command, 8 parameters corresponding to the 8 output port lines are necessary. Each parameter should either be a 1 (Enable) or a Ø (Disable).

7	6	5	4	3	2	1	Ø

Line States		Description
Ø	Hi--Start of scan / Lo--End of scan.	This line is raised high when a scan is started using the SCAN START command, and it is lowered when the scan completes.
1	Hi--Start of integ. Lo--End of integ.	This line is raised high when each data integration begins, and it is lowered when each data integration completes.
2	Hi--Ch #1 data > = THRESHOLD.	A threshold is a user defined value (see next command, THRESHOLD WRITE VALUES). This line goes high when the data acquired on channel 1 (after full integration) equals or exceeds the threshold High Value set for channel 1.

3	Hi--Ch #1 data < = THRESHOLD.	This line goes high when the data acquired on channel 1 (after full integration) equals or falls below the threshold Low Value set for channel 1.
4	Hi--Ch #2 data > = THRESHOLD.	This line goes high when the data acquired on channel 2 (after full integration) equals or exceeds the threshold High Value set for channel 2.
5	Hi--Ch #2 data < = THRESHOLD.	This line goes high when the data acquired on channel 2 (after full integration) equals or falls below the threshold Low Value set for channel 2.
6	Hi--Wait for input trigger.	This line is raised high when the INDEPENDENT SCAN is waiting for a trigger input.
7	Not used	Reserved for future use.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Line 0[0..1] 3. Line 1[0..1] 4. Line 2[0..1] 5. Line 3[0..1] 6. Line 4[0..1] 7. Line 5[0..1] 8. Line 6[0..1] 9. Line 7[0..1]	1. Confirmation
Example: Send "Z11,1,1,0,0,0,0,1,0<CR>"	Receive "o"

THRESHOLD WRITE VALUES "I"

Be careful not to confuse this I (uppercase i) with a number 1or a lower case L. This command is used to write the User Defined Threshold values for the acquisition data.

This command is used with the "Independent" Scan Commands to specify the High and Low boundaries for data acquired on both channels, so that when data that falls outside that range is acquired, a line on the TTL output port can be set high or low.

To benefit from this feature, you must enable the output port lines that correspond to the data you want to monitor using the command TTL AUTOMATIC OUTPUTS.

For the High Value of channels 1 and 2, output port lines 2 and 4 (respectively) will be raised high if the acquired data on those channels equal or exceed those values. The output port lines will be lowered again when the data falls below the specified high values.

For the Low Value of channels 1 and 2, output port lines 3 and 5 (respectively) will be raised high if the acquired data on those channels equal or fall below those values. The output port lines will be lowered again when the data rises above the specified low values.

All 4 parameters must be within the range of $\pm$ 2 X10^9.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command 2. Channel 1 High Value 3. Channel 1 Low Value 4. Channel 2 High Value 5. Channel 2 Low Value	1. Confirmation
Example: Send "I000,200,1000,200<CR>"	Receive "o"

THRESHOLD READ VALUES "J"

This command is used to read back the User Defined Threshold values that were set using the WRITE THRESHOLD VALUES command.

HOST sends	SPECTROMETER CONTROLLER sends
1. Command	1. Confirmation 2. Channel 1 High Value 3. Channel 1 Low Value 4. Channel 2 High Value 5. Channel 2 Low Value
Example: Send "J"	Receive "o" Receive "1000,200,1000,200<CR>"

10.8 Independent Scan Commands:

These commands refer to a complete scan and acquisition routine definition for systems with SpectrAcq, or DataScan / DataLink spectrometer controllers. Once started, the spectrometer controller can perform the routine unattended. The data will be stored in memory and can be accessed at the end of the scan or "on the fly."

Data Memory Allocation:

The maximum number of total data points that can be stored is 5001. Total, in this case, means the amount of memory required to store all data points, taking into account the number of cycles and channels in the scan experiment, as well as the Data Storage mode.

For Example, if your routine will acquire 500 datapoints in each of two channels, and it will run for three cycles, the total memory needed is 500 X 2 X 3 = 3000 datapoints.

Data Acquisition Guidelines (for DataLink / DataScan Only):

Before performing any type of data acquisition using the AUTOGAIN option, the amplifier offsets must first be computed or set to obtain accurate measurements. In any of the FIXED GAINS, offsets are not subtracted. This applies to BOTH operating methods described below, with version 3.0 or higher of Flash.

This is accomplished by issuing the command MEASURE ACQUISITION OFFSETS or SET ACQUISITION OFFSETS. These offsets are automatically computed into the final datapoint result that is read by the host while acquiring with AUTOGAIN.

If you are running in any of the fixed gains, the offset is NOT automatically factored into the resulting data. If desired, offset subtraction must be performed after the data is read back by your controlling program.

The command set is designed to allow maximum flexibility for the controlling program. Therefore, whenever possible, the data that is returned is in its "rawest" form; this is why, in fixed gains, there is no offset processing performed. However, with AUTOGAINing, any or all of the different gains can be used during a given integration period (depending on the fluctuation of the signal being measured); and since each gain can have a different offset value associated with it, it is most

convenient to handle that processing in the firmware.

A few operating parameters must be set before the data acquisition can take place:

1. The integration time must be set.
2. The gain must be set for the channel being used.
3. If using a photomultiplier, the high voltage must be turned on.

SCAN SET PARAMETERS "p"

This command is used to specify all of the parameters that the SpectrAcq or DataScan / DataLink spectrometer controller will need in order to perform a complete scan independently.

Keep in mind also that the monochromators give the most reproducible results when scanning in the direction they were designed for:

- For wavelength drives; scan in the direction of increasing wavelength
- For wavenumber drives; scan in the direction of decreasing wavenumbers

The following list shows all the parameters that must sent with this command.

1. Scan Type - This is the first parameter, it will determine the usage of the other parameters. A value from 0 to 3 sets the scan type.
   - 0 Mono 1 Scan - monochromator connected to Mono Port 1 is scanned.
   - 1 Mono 2 Scan - monochromator connected to Mono Port 2 is scanned.
   - 2 Synchronous Scan - both monochromators scan synchronized, with the second separated by an offset.
   - 3 Time Base Scan - data acquired over time, with the monochromator parked at one position.

2. Start Position - a value in steps[1] that defines the starting position for all types of scans except Time Base Scan. If running Time Base Scan, this parameter is ignored. For Mono 1 or Synchronous scans, this parameter sets the start position for mono 1. For a Mono 2 scan, it sets the start position for mono 2.

3. End Position - a value in steps[1] that defines the ending position of a scan for all types except Time Base Scan. If running Time Base SCAN, this parameter is ignored. For a Mono 1 or Synchronous scan this is the end position for Mono 1. For a Mono 2 scan, it sets the end position for Mono 2.

4. Increment - a value in steps[1] that defines the scan drive increment between acquisition points of a scan. This number must be positive and less than or equal to the total travel of the monochromator you are scanning. If running a Time Base scan, this parameter is ignored.

5. Integration Time - period of time in milliseconds over which the data will be acquired at each point. For all scan types except Time Base Scan, the effective limit for this parameter is 300,000 ms (5 minutes), and this number should be an even number. See the ACQ INTEGRATION TIME SET command on page 81 for a further explanation.

   Because the Time Base Scans use a different scaling technique, in this case the limit on this parameter depends on the intensity of the signal as well as the gain that is being used. If we always read the maximum signal possible, then the following table indicates the maximum integration times:

GAIN	INTEGRATION TIME
1 / AUTOGAIN	520 ms
10	5200 ms
100	52000 ms
1000	520000 ms

6. Scan Cycles - the number of times (255 max) you wish to repeat the same scan over the same defined region.

7. Dwell Time - the period of time that the system waits after moving the monochromator, before starting the integration, in milliseconds. This number must be positive and can be as large as 2,147,483,648 ms. of (the maximum value for a signed long integer). If no Dwell Time is desired, send "<0>" for this parameter.

8. Delay Time - the period of time that the system waits after completing each cycle, in milliseconds. Same as above, this number must be positive and can be as big as the maximum value for a signed long integer. If no Delay Time is desired a value of 0 may be used.

9. Mono 2 Start Position - for a Mono 2 scan or a Synchronous scan, this is the starting position in steps[1] for monochromator 2. For a Mono 1 Scan or Time Base Scan, the position in steps[1] where you wish to park your second monochromator. If a second monochromator does not exist in the spectrometer controller's configuration, this parameter will be ignored.

10. There are two different meanings for this parameter, depending on the scan type used:

    - Mono 1 Park Position - for a Mono 2 Scan or Time Base Scan, the position in steps[1] where you wish to park your first monochromator.

    - Sync Direction Indicator - for a Synchronous Scan, this parameter should be a position for in steps[1] for monochromator 2 that indicates the direction that mono 2 will move from its start position. If the position entered is greater than the start position, the second monochromator will scan towards higher step positions. If a smaller position is used, the scan direction is reversed.

11. Mono 2 Increment - for a Synchronous Scan only, the increment in steps[1] between acquisition points for the second monochromator. This number must be positive and less than or equal to the total travel of monochromator 2. If a second monochromator does not exist in the spectrometer controller's configuration, this parameter will be ignored.

12. Time Increment - for a Time Base Scan, the total amount of time in milliseconds between integration starts. If Time Increment is zero, then the Integration Time becomes the effective Time Increment. This number must be positive and can be as big as 2,147,483,648 ms. It must also be less than or equal to the Total Time. If not running a Time Base Scan this parameter will be ignored.

13. Total Time - for a Time Base Scan, the total time length of the scan in milliseconds. This number must be positive and can be as big as 2,147,483,648 ms. If not running a Time Base Scan this parameter will be ignored.

14. Channel Select - this indicates the data acquisition channel to be used for this experiment. Ø for channel 1; 1 for channel 2; and 2 to use both channels simultaneously.

15. Gain Channel 1 - if running the experiment with Ø or 2 in the above parameter (Channel), the gain set here will be active. Ø for gain 1; 1 for gain 1Ø; 2 for gain 1ØØ; 3 for gain 1ØØØ; 4 for AUTOGAIN.

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[1] When calculating the value for offset, the Steps / Base unit and ratio of actual grating grooves per mm to base grating grooves per mm must be taken into account. Refer to Appendix 1 for the values needed to calculate the step positions and offsets for your monochromators.

16. Gain Channel 2 - if running the experiment with 1 as the Channel parameter this gain will be used.

17. Shutter Mode - use Ø for AUTO shutter mode; 1 for MANUAL shutter mode. In AUTO mode, the active shutter will automatically be opened (if controllable) at the start of each cycle and closed at the end of each cycle.

18. Trigger Mode - use Ø for NO TRIGGER; 1 to wait for a trigger at the start of the EXPERIMENT; 2 to wait for a trigger at the start of each CYCLE; 3 to wait for a trigger at the start of each DATA POINT. The trigger can be in form of a hardware trigger on the I/O port or a software trigger (character "@").

19. Data Mode - use Ø to STACK the acquired scans of data separately in memory. Use 1 to SUM the acquired scans of data in memory. The Data mode is used when there is more than 1 cycle in the experiment. STACKed mode will put each data point for each cycle into a unique memory location; SUMmed mode will put each data point for the first cycle into a unique memory location, then sum the data of each subsequent cycle into the same memory location.

If the spectrometer controller receives faulty parameters, it will return one of the following error codes.

Ø NO ERROR - This is good.

1 SCAN TYPE ERROR - The Scan Type parameter was not set within its valid range.

2 LOW INTEGRATION TIME ERROR - The Integration Time parameter was set to less than 1 ms.

3 LOW CYCLES ERROR - The Cycles parameter was set to Ø. There must be at least 1 cycle.

4 CHANNEL NUMBER ERROR - The Channel parameter was not set within its valid range.

5 GAIN ERROR - The Gain Channel 1 or Gain Channel 2 parameter was not set within its valid range.

6 SHUTTER MODE ERROR - The Shutter Mode parameter was not set within its valid range.

7 TRIGGER MODE ERROR - The Trigger Mode parameter was not set within its valid range.

8 DATA ERROR - The Data Mode parameter was not set within its valid range.

9 LOW TOTAL TIME ERROR - The Total Time parameter was set to less than 1 ms for the TIME BASE SCAN. This error will not appear if running a scan type other than TIME BASE.

1Ø LOW STEP INCREMENT ERROR - The Step Position Increment parameter was set to Ø for the MONO 1 SCAN, MONO 2 SCAN, or SYNCHRONOUS SCAN. This error will not appear if running a TIME BASE SCAN.

11 SIZE ERROR - The defined experiment will produce more than the allowable 5ØØ1 data points.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Error Code
Example: Send "p0,9600,17600,32,50,2,0,0,0,0,0,0,0,0,0,4,0,0,0,0<CR>"	Receive "o" Receive "0<CR>"

SCAN START "q"

This command is used to start the experiment defined using the SCAN SET PARAMETERS command. The previous command must have been executed with NO ERROR (Ø) returned; otherwise the experiment will not start.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "q"	Receive "o"

SCAN STOP "v"

This command is used to stop the running routine initiated by SCAN START.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "v"	Receive "o"

SCAN CURRENT STATUS "r"

This command is used to inquire the hardware status from the SpectrAcq or DataScan / DataLink spectrometer controller. It will return the following statuses:

- 0 The scan is idle and waiting to be started.
- 1 A monochromator is currently moving.
- 2 The spectrometer controller is performing the data acquisition.
- 3 The spectrometer controller is in the "DWELL" phase; or for Time Base Scan, it is pausing in between data acquisitions.
- 4 The spectrometer controller is in the "DELAY" phase.
- 5 NOT USED.
- 6 The spectrometer controller is waiting for a trigger.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Scan Status
Example: Send "r"	 Receive "o" Receive "1<CR>"

SCAN CYCLE TO READ "s"

This command is used to set the cycle number to read stored data from the SpectrAcq or DataScan / DataLink spectrometer controller. The cycle number to read always defaults to 1 at the start of a new scan. When issuing the SCAN GET DATA command, the data value will be read from the cycles number that has been set with this command. If you are running a multi-cycle experiment and the Data Mode parameter is set to STACKED, you will need to use this command.

HOST sends 1. Command 2. Cycle #[1 ...]	SPECTROMETER CONTROLLER sends 1. Confirmation
Example: Send "s2<CR>"	Receive "o"

SCAN GET DATA POINT NUMBER "t"

This command is used to get the number of the last data point that was acquired by the SpectrAcq or DataScan / DataLink spectrometer controller. The cycle number will also be returned.

HOST sends 1. Command	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Data Pt. # 3. Cycle #
Example: Send "t"	Receive "o" Receive "30,1<CR>"

SCAN GET DATA "U"

This command is used to read back the acquired data from the SpectrAcq or DataScan / DataLink spectrometer controller. The cycle number must first be set using the SCAN SET CYCLE TO READ and the Data Index must be specified, for the spectrometer controller to send back the desired data point. Note that the first data point is numbered 1, not 0. If only 1 channel is specified in the Channel parameter when setting up the experiment, then the data for that channel along with it's overrange and gain information will be returned. If 2 channels were specified, the data, overrange, and gain will be returned for channel 1; then for channel 2.

If you may possibly be reading data before a scan is completed, be sure to check the SCAN STATUS to see if the scan is completed. If you want to read the data during a scan in process, use SCAN GET DATA POINT NUMBER to determine the range of valid data points to be read.

In all scan types other than Time Base Scan, if AUTOGAIN is used, the data is automatically scaled to the lowest gain that was used during the acquisition (see ACQ READ DATA for further explanation).

In Time Base Scans the data is scaled to the highest gain (1000) then returned.

For TIME BASE scans, the results will be more accurate if the data is read only after completion of the scan. This removes the uncertainty associated with host communication time from the interval between datapoints. For less time critical experiments, however, data can easily be read as soon as it is acquired in hardware.

The data is normalized to reflect 1 read of the ADC per 1 ms. In other than Time Base Scan, the ADC is actually read once every 2 ms; in Time Base Scan the ADC is read every 5 ms.

The second of the two values that are returned, "Overrange & Gain," is a number that has two items of information encoded in it. If any of the ADC reads reached maximum, overrange will be indicated by adding 8 to the gain level.

If you set any of the fixed gains, the gain level number will be as it was set.

If you set AUTOGAIN, the data will be scaled to one of the 4 gain levels. To determine the gain that was used for scaling, simply subtract 8 from the value returned. If the value is 8 or greater, an overrange occurred. If the value is less

than 8, then it is not overranged, and the remaining value is the gain used for scaling.

HOST sends 1. Command 2. Data Index # [1...]	SPECTROMETER CONTROLLER sends 1. Confirmation 2. Data 3. Overrange & Gain 4. *Data 5. *Overrange & Gain
Example: Send "u30<CR>"	Receive "o" Receive "1025,0<CR>"

* If 2 channel acquisition.

11 In Case of Difficulty ...

Your instrument is designed to provide years of reliable service. If you are experiencing a problem, reviewing this section before contacting us will save time and help you eliminate some simple errors that can be easily corrected.

11.1 Troubleshooting:

Some of the more common difficulties that may be encountered are listed below. With each, some suggestions are given that will help correct the problem for most cases.

The Handscan / KeyLink terminal does not perform the self-test of its display upon power-on of the supporting spectrometer controller or spectrometer.

- Check cabling according to the Getting Started section.
- Check the supporting spectrometer controller's power connections and fuses.
- Check the supporting spectrometer controller's internal cable connections.

No communications with the HandScan / KeyLink. (No version number displayed after pressing **Decimal Point**.)

- Check cable connections for partially dislodged connectors.
- Try pressing **Decimal Point** a few more times.
- Refer to The HandScan / Keylink manual Appendix to check and/or correct the terminal configuration parameters.
- Refer to the Service Policy section to contact us for further information, or possible exchange of the terminal.

System not responding to any commands:

- Check external cable connections. See the Getting Started section for proper connection.
- Review the instructions pertaining to the interface type (IEEE 488 or RS-232) referred to in the Getting Started section to check for proper set-up and communications. Be sure to read the footnotes.
- Refer to the manuals provided with the instrument(s) in your system, for further troubleshooting relating to the spectrometer controller.
- Check system configuration with the HWCFG program on the support diskette to see that it matches the actual hardware.
- If you are running your own software along with the Handscan / KeyLink, stop your program and try starting over and accessing the system with the hand-held terminal only. See Getting Started to check for proper set-up and communications. Be sure to read the footnotes. Next load the example programs on the support software diskette provided with the system to see if

the system can be accessed from an IBM compatible PC.

- Try using the re-boot command "<222>"

System responds to some commands, but not all.

- Check to be sure that the failing command is valid under the present conditions.
- Check all required parameters and make certain that they are within software and hardware limits for that function.
- Check to see that the configuration matches the actual hardware by running the HWCFG program on the support diskette. In particular, check that the device you are having difficulty with is configured properly.
- If you are running your own software along with the Handscan / KeyLink, stop your program and try starting over and accessing the problematic functions with the hand-held terminal only. See Getting Started to check for proper set-up and communications. Be sure to read the footnotes. Next load the example programs on the support software diskette provided with the system to see if the device in question can be accessed from an IBM compatible PC.