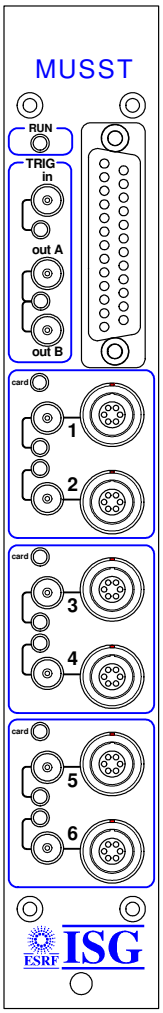


MUSST

Multipurpose Unit for
Synchronisation, Sequencing and Triggering

User Manual

DESCRIPTION

MUSST is an NIM module that produces trigger patterns synchronised with external events. A trigger pattern is a sequence of trigger output signals that can be adapted to the specific needs of a particular experiment and be used to synchronise the different beamline components involved. In addition, the built-in data storage capability makes possible to use the module as a data acquisition unit.

The detection of events is achieved by hardware comparators that guarantee the proper synchronisation of trigger patterns and minimum delays in the generation of output signals. Events can be chained in order to produce specific trigger sequences. A programmable sequencer is in charge of executing application specific programs that can be written by the user in a high-level language and transferred to MUSST through one of the available communication ports: GPIB or serial line.

The functionality of this module covers a wide range of the requirements found at the ESRF beamlines in what concerns synchronisation and triggering. Existing applications that could benefit from the features of the module are among others: continuous scans at constant or variable step, 2D mapping, synchronous operation of shutters or fast scans with special detectors like CCD sensors in kinetics mode.

Date	Version	Comments
31/05/2006	0.2	Current draft version.
28/05/2007	1.0	First complete version.
15/07/2009	1.1	Modified analogue input cabling, included new daughter card.

CONTENTS

MANUAL ORGANIZATION

Section 1 gives a brief overview of the MUSST functional aspects as well as its main functional blocks. The description is made in general terms and specific technical details are minimised.

Section 2 describes the MUSST hardware. The connectors and signals functions of both front and rear panels are detailed.

Section 3 is dedicated to the MUSST deployment in a *real world* setup.

Section 4 covers the available commands to communicate with MUSST.

1. FUNCTIONAL DESCRIPTION

One of the main goals in the development of MUSST was to produce a module that is independent of the particular driving electronics (motor controllers, piezo drives or sensors, etc) and the data acquisition system (counting chains, CCD cameras, detector electronics, ADC's, etc). In this way a large number of experiments that use very diverse hardware can be synchronised in a homogeneous way with minimum differences in software. A dedicated and flexible enough module for triggering and synchronisation presents in addition the advantage that can be used both with the existing control hardware and with new commercial or in-house developed modules in the future.

A MUSST module includes 6 signal input channels. These channels admit either incremental or sampled absolute signal values. In this way the module can operate with the diversity of signals used at the beamlines like positions from stepper motors, incremental encoders, frequency inputs, analogue sensors, absolute encoders, piezoelectric actuators, etc. The use of internal interchangeable input modules (daughter cards) allows dealing with the electrical particularities of each type of signal.

In addition to the signal input channels, MUSST includes a 32-bit timer, a module with 16 TTL I/O signals that is used to read and generate bit patterns and external trigger inputs and outputs.

A primary event happens either when an input signal reaches a target value, when an input bit pattern matches a predefined value, after a certain programmed time or when one of the external trigger input signals is received. Several primary event conditions can be combined to generate more complex events. At each event the unit can be programmed to take one or several actions. Possible actions are:

- Generation of trigger output signals.
- Update of the output signals of the TTL I/O module
- Storage of the input values and internal timers in RAM

Several units can be cascaded to produce more complex trigger sequences or operated synchronously in parallel to increase the number of effective input channels.

The next sub-sections give a general description of the main components of a MUSST module.

1.1. Signals and functional blocks

The figure below depicts a simplified functional block diagram and the associated signals of MUSST.

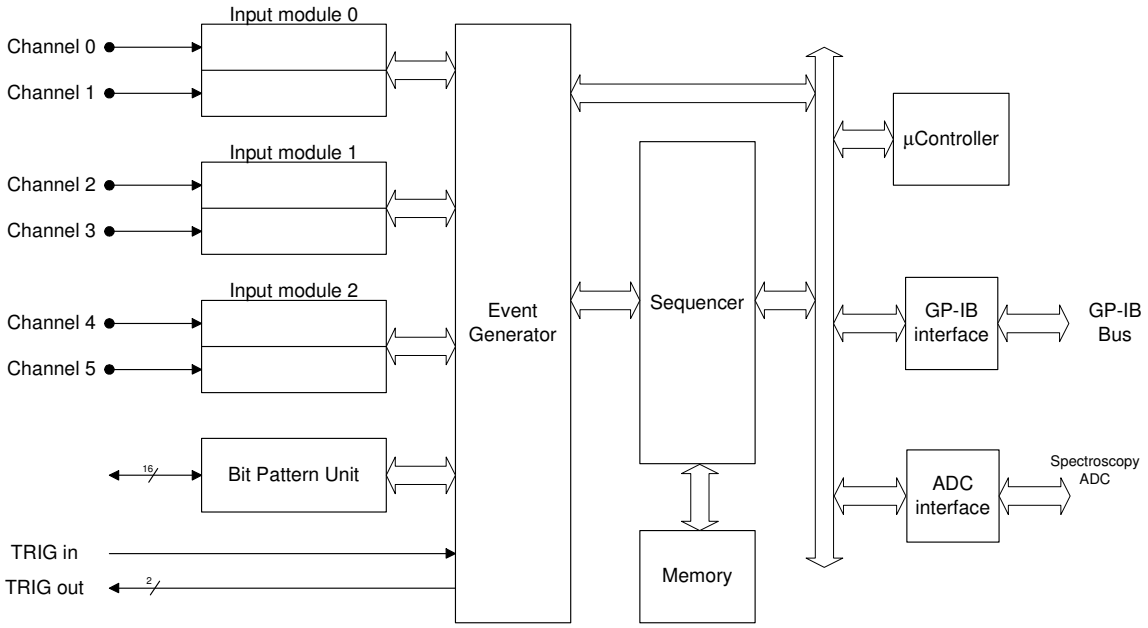


Figure 1: MUSST simplified block diagram

1.1.1. Input signals

MUSST includes three groups of two signal input channels. It is possible to install up to three internal daughter cards (one per group) adapted to a specific type of signal. The internal logic supports two types of signals: counting (incremental) and sampled (absolute).

Incremental signals (motor position, incremental encoders, frequency outputs) are integrated in time by using up/down counters. The maximum input frequency in this case is 25 MHz.

Sampled signals (like analogue values or absolute encoders) are sampled at a fixed rate and can be optionally processed by a digital IIR filter. The maximum sampling rate is dependent on the bit resolution. 16-bit sampling can be achieved up to 3 MHz. In practice the actual sampling rate depends on the design of each particular input module (daughter card).

The input signals are internally represented in 32 bit words. Those channels that are not used for external signals can be reconfigured internally as timers or event counters.

1.1.2. Bit pattern unit

This unit handles 16 TTL signals that are accessible from a front panel connector and can be independently configured as input or output lines.

Bit patterns can be extracted from this set of signals by using mask registers and decoded to generate trigger conditions. All 16 digital signals are sampled at each programmed event and can be optionally stored in memory. Input lines can be configured to latch fast pulses.

Output bit patterns can be set by software or automatically generated by the sequencer at each event. In this way it is possible to produce level-active signals like detector gates or shutter control lines.

1.1.3. Trigger signals

MUSST can be programmed to generate TTL output pulses at selected events. These pulses are accessible through two front-panel connectors.

An external TTL trigger signal can be used as an input to synchronise the module with external devices. A front panel connector is available for this use.

It is also possible to synchronise several MUSST modules between them by means of a dedicated signal accessible at the rear panel.

1.1.4. Sequencer

The combination of trigger conditions and events to produce more complicated trigger sequences is accomplished by a logic unit that is able to decode and execute a reduced set of microcoded instructions. Microcode is stored in a memory block and instructions are fetched and executed by the sequencer.
In addition to microcode, the memory can be also used to store the values of the input channels at selected events along with the internal time and the digital value of the bit pattern unit.

The sequencer runs at 50 MHz and most of the microcoded instructions are executed in one to three clock cycles (20 to 60 ns).

1.1.5. Computer control

All the different internal units of MUSST are initialised and operated by a microcontroller that also manages a standard GPIB interface for communication purposes.

The firmware running in the microcontroller implements a high-level command set that allows and simplifies the control of the module by an external computer. The microcontroller also compiles on-the-fly the sequencing program into microcoded instructions to be executed by the sequencer.

1.1.6. Spectroscopy ADC interface

MUSST can be used as a Multi-Channel Analyzer when associated with a commercial spectroscopy ADC. The ADC data transfer is done by means of a Canberra® based interface. In addition, MUSST can deal with the Canberra® Instrument Control Bus for configuration purposes.

2. HARDWARE DESCRIPTION

The MUSST hardware is composed by the front panel, the rear panel, the internal boards and the optional daughter cards. The following sub-sections detail each one of these components.

2.1. Front Panel

The MUSST front panel is depicted in the figure below. The front panel gives access to the input channels, the trigger signals, the digital I/Os and the visual indicators. The functionality of these components is described in the next paragraphs.

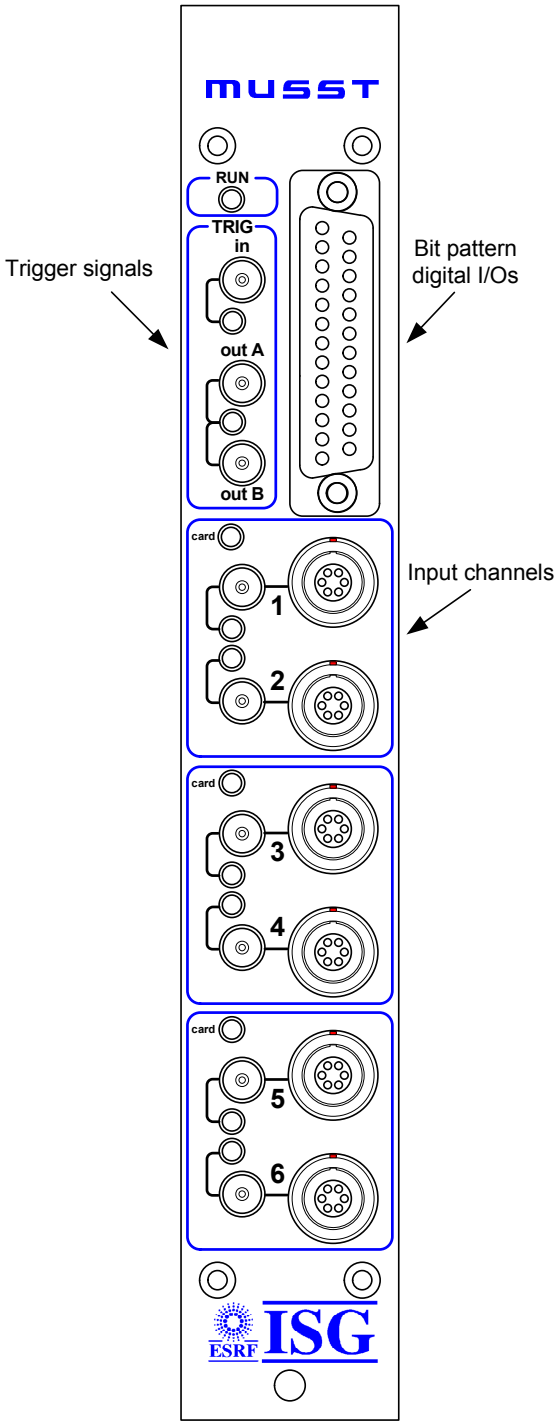


Figure 2: MUSST Front Panel

2.1.1. *RUN*

The front panel yellow *RUN* LED provides a visual indication of the states of the module in what concerns the sequencer program according to the following table.

Table 1: MUSST main states

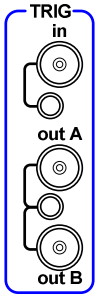
		
***RUN* LED**	**STATE**	**STATE DESCRIPTION**
off	IDLE NOPROG PROG ERROR	No sequencer program running
on	RUN	Sequencer program running
blinking	STOP BREAK	Sequencer program stopped

See the *?STATE* request in Section 4.1 for a detailed description of the complete set of states of the module.

2.1.2. *TRIG in*, *TRIG out A*, *TRIG out B*

The front panel trigger signals are available in 3 Lemo® 00-series connectors. The function and electrical characteristics of these signals are described in the table below.

Table 2: *MUSST trigger signals*

	Connector/ Indicator	**Function**	**Electrical Characteristics**
	*TRIG in*	Input trigger signal: allows synchronisation of MUSST with external devices or acts as an external gate for the MCA application	LOW level: 0,8V max HIGH level: 2,0V min
	TRIG out A	Output trigger signal A: 100ns positive pulse that can be generated at an event occurrence	LOW level: 0,44V max (no load) HIGH level: 3,76V min (no load) Output impedance: 50Ω
	TRIG out B	Output trigger signal B: its logic level can be toggled at each event occurrence or set to a desired level (by software or by the sequencer)	LOW level: 0,44V max (no load) HIGH level: 3,76V min (no load) Output impedance: 50Ω
	signal activity red LEDs	For merely visual control, the activity of these signals can be observed by the blinking of the correspondent LED (one for the input and another one for the two output trigger signals).	

The figure below illustrates how the output trigger signals can behave when a sequence of events is detected by the module.

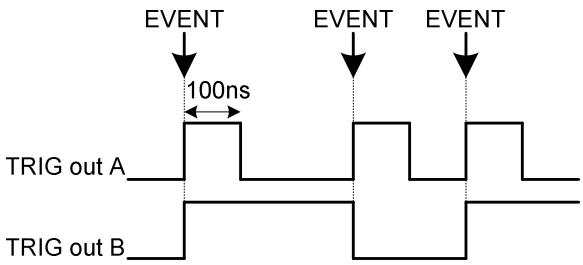


Figure 3: MUSST front panel trigger outputs

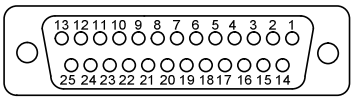
This example is valid only if both signals have been selected to take part of the list of actions the module must carry out at an event occurrence. For more details about the list of actions, see Section **Error! Reference source not found.**.

2.1.3. Digital I/Os

The 16-bit TTL input/output signals are available in the female 25-pin Sub D front panel connector.

The table below illustrates how these signals are distributed in the connector.

Table 3: MUSST Digital Inputs and Outputs

Digital Inputs/Outputs		
Front panel *25-pin female sub-D connector*  front view		
Pin	**Signal**	**Default Direction**
1	I/O 0	INPUT
2	I/O 1	
3	I/O 2	
4	I/O 3	
5	I/O 4	
6	I/O 5	
7	I/O 6	
8	I/O 7	
9	I/O 8	OUTPUT
10	I/O 9	
11	I/O 10	
12	I/O 11	
13	I/O 12	
15	I/O 13	
18	I/O 14	
21	I/O 15	
24, 25	+5V (200mA max.)	
14, 16, 17, 19, 20, 22 and 23	ground	

The 16 signals are grouped in four 4-bit blocks. Each block can be configured to work as 4-bit inputs or 4-bit outputs signals. However, by default, this configuration is not allowed and the direction of the signals is pre-defined (8 inputs and 8 outputs). A hardware intervention is needed in order to change the direction configuration.

For further information about the digital I/Os configuration, see the *IOCFG* command in Section 4.1.

An auxiliar +5V (200mA maximum) power supply is also available in this connector. This is intended to power interface circuits (e.g., level translators, optocouplers) that can be necessary in certain applications. A self-resetable internal fuse protects this auxiliar power supply from short-circuits and overcurrent.

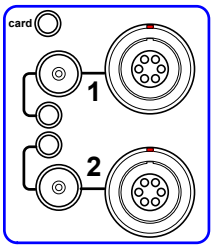
An accessory has been developed in order to simplify the cabling of these signals. *MUSST Extender* is a interconnection box that allows to access the digital I/O signals through standard BNC connectors. Refer to Appendix E for further information.

2.1.4. Input channels

MUSST has 6 input channels divided in 3 identical groups of 2 channels.

The table below summarises the function and behaviour of each connector and visual indicator of one 2-channel group.

Table 4: *MUSST input channels description*

	Connector/ Indicator	**Function/Behaviour**	**Electrical Characteristics**
	*card* green LED	Lit when a daughter card is present in the correspondent group of channels	
	signal activity red LEDs	Blinks to indicate that the correspondent input signal is of incremental nature and presents positive transitions. Turned off otherwise.	
	6-pin Lemo® ENG series connector	Main signal inputs. It is composed by 3 pairs of differential RS422 or single-ended TTL signals.	Differential RS422 or single-ended TTL (see Appendix C.2)
	coaxial Lemo® 00-series connector	Auxiliar input. Can be used to input one single-ended TTL signal. It allows cabling simplification since only a single coaxial cable is needed.	Single-ended TTL: LOW level: 0,8V max HIGH level: 2,0V min

The MUSST input channels can be independently configured to work in several different modes: up, down, up-and-down or quadrature counting. In addition, external preset and gate control signals can also be taken into account by the correspondent channel.

As mentioned in *Table 4*, the input signals can be electrically compatible to either single-ended TTL or differential RS422.

Specific signals (analogue, absolute encoder) can be also dealt provided a correspondent plug-in daughter card is installed. Refer to the documentation of the chosen daughter card to check its input characteristics.

Cabling of the input channels depends strongly on the chosen configuration. The next table describes the different possibilities of cabling and Appendix D.3 depicts the ESRF incremental encoder adapter cabling.

Refer to the *CHCFG* command in Section 4.1 for further information about channels configuration.

Table 5: MUSST input signals cabling

MUSST input signals cabling

plug for the front panel socket
LEMO®
FGG.1B.306.CLAD76

rear view

signal type / mode	single-ended signals		differential signals	
	signal	**plug pin**	**signal**	**plug pin**
up	counter up	1	counter up +	1
			counter up -	2
	gate	3	gate +	3
			gate -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
down	counter down	1	counter down +	1
			counter down -	2
	gate	3	gate +	3
			gate -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
up-down with direction	counter up-down	1	counter +	1
			counter -	2
	direction	3	direction +	3
			direction -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
up-down with two inputs	counter up	1	counter up +	1
			counter up -	2
	counter down	3	counter down +	3
			counter down -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
quadrature counter or encoder	counter 0°	1	counter 0°+	1
			counter 0°-	2
	counter 90°	3	counter 90°+	3
			counter 90°-	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
analogue signals (see daughter card manual)	signal	3	signal+	3
			signal-	4
	ground	4 + shield	ground	shield

2.2. Rear Panel

The MUSST rear panel is depicted in the following figure. The rear panel is composed by the communication ports (GPIB and serial line), the synchronisation signal, the spectroscopy ADC interface and the power connector. These components are described in the next sub-sections.

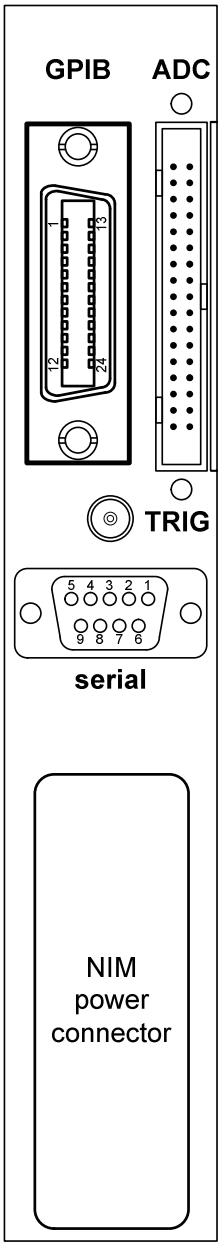


Figure 4: MUSST rear panel

2.2.1. GPIB

The main communication way with MUSST is the by GPIB port (General Purpose Interface Bus). GPIB presents both a reasonable data rate and latency time what makes it a well compromised solution for MUSST communication.

The MUSST GPIB port only becomes active if any cable is connected to the serial line ports (see Section 2.2.2). Whenever a connection is made to any of the serial ports, the GPIB is disabled

In addition to the ASCII based commands, GPIB communication provides support for binary data transfer.

For further information about communication see Appendix B.

2.2.2. Serial line ports

This connector includes two serial line ports, RS232 and RS422. Both ports have the same function and any of them can be used for communication purposes in the same way of the GPIB port (see Section 2.2.1). However, due to the limited data rate, serial port is not suitable for data transfer and should be used only for diagnostics or setting needs: setting of GPIB address, configuration of channels, etc.

It is important to note that the serial port is also used for firmware downloading purposes during either the manufacturing or a software updating.

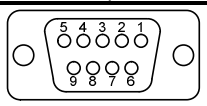
The serial port should be configured as follows:

Table 6: Serial port setting

Baudrate	9600
Parity	NO
Stop bits	1

The table below shows the pin-out of both RS232 and RS422 serial ports available in the rear panel female 9-pin Sub D connector. Note that the signal direction is related to MUSST side, i.e., “IN” means an input signal for MUSST.

Table 7: MUSST serial port connector pin-out



Female 9-pin Sub D

Pin	Port	Signal	Direction
2	RS232	TXD	OUT
3		RXD	IN
5	common	GND	-
8	RS422	TXD+	OUT
9		TXD-	OUT
6		RXD+	IN
7		RXD-	IN

2.2.3. *TRIG*

This is a bidirectional TTL signal aimed to mainly synchronise several MUSST modules working together. It is available through a Lemo® 00-series connector.

A positive 100ns pulse can be generated at each event occurrence in the same way of the front panel *TRIG out A* signal (see Section 2.1.2).

The electrical implementation of this signal is described in Appendix C.3.

2.2.4. *ADC*

This is the data and control connection to spectroscopy ADCs in order to use MUSST as a Multi-Channel Analyser.

The interface follows the specification of similar products designed by Canberra®. The connection between MUSST and the spectroscopy ADC is made by a 34-wire ribbon cable with a 34-pin HE10 connector in both ends.

In addition to the data interface, MUSST is capable to handle the Canberra® ICB - Instrument Control Bus – for the associated ADC configuration purposes. An auxiliar cable should be installed internally and made accessible by a rear panel cut-out in order to use this capability as illustrated in the figure below (see more details about this cable in Appendix D.5) .

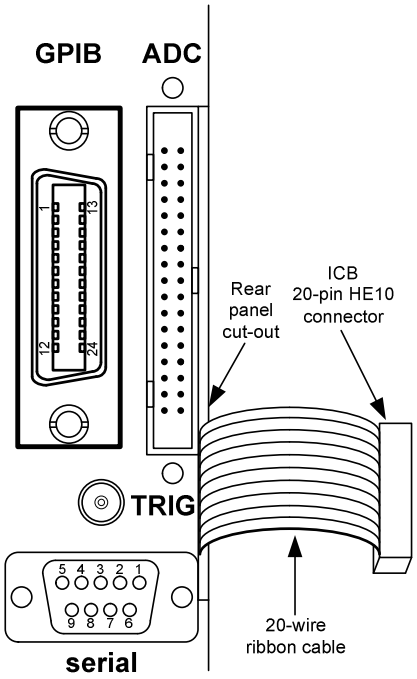


Figure 5: MUSST rear panel connection for ICB cable

The following table highlights the main differences between using the commercial solution (Canberra® AIM + ADC) and the MUSST solution (MUSST + commercial spectroscopy ADC).

Table 8: Comparison between commercial and MUSST solution for spectroscopy

	Canberra® solution	**MUSST solution**
Multi-Channel Analyser module	Canberra® Model 556A AIM Acquisition Interface Module	MUSST
Number of ADCs	up to 2	1
Acquisition Memory	128k x 16 bits	512k x 32 bits
Host communication	Ethernet	GPIB
Canberra® ICB - Instrument Control Bus interface	yes	yes
LFC - Loss Free Counting mode	yes	no

2.2.5. NIM power supply

The MUSST module uses the +6V, +12V, +24V and -24V power supplies of the NIM crate where it is installed.

The table below presents the MUSST power supply requirement without any daughter card installed.

Table 9: MUSST power supply requirement without daughter card

parameter	**pin**	**typical values**
+6V	10	650 mA
+12V	16	45 mA
+24V	28	10 mA
-24V	29	10 mA
GND	34	
module power		5.5 W

3. OPERATION INSTRUCTIONS

This section deals with the practical aspects of the deployment of MUSST in an experimental setup. Information about installation and main configurations of the module as well as some practical usage tips are given in the next sub-sections.

3.1. Installation and configuration

Installation of MUSST requires connection to a host by one of the communication ports, specification of the input, trigger and digital I/Os signals as well as specification of the sequencer program and data storage.

A number of configuration has also to be done by means of software commands. The configuration parameters are stored in an internal non-volatile memory that can be recovered after an off-on cycle.

The figure below gives an overview of a generic installation where host communication, input channels, daughter cards, digital I/Os, trigger signals and spectroscopy ADC are depicted. The next sub-sections describe each of these items.

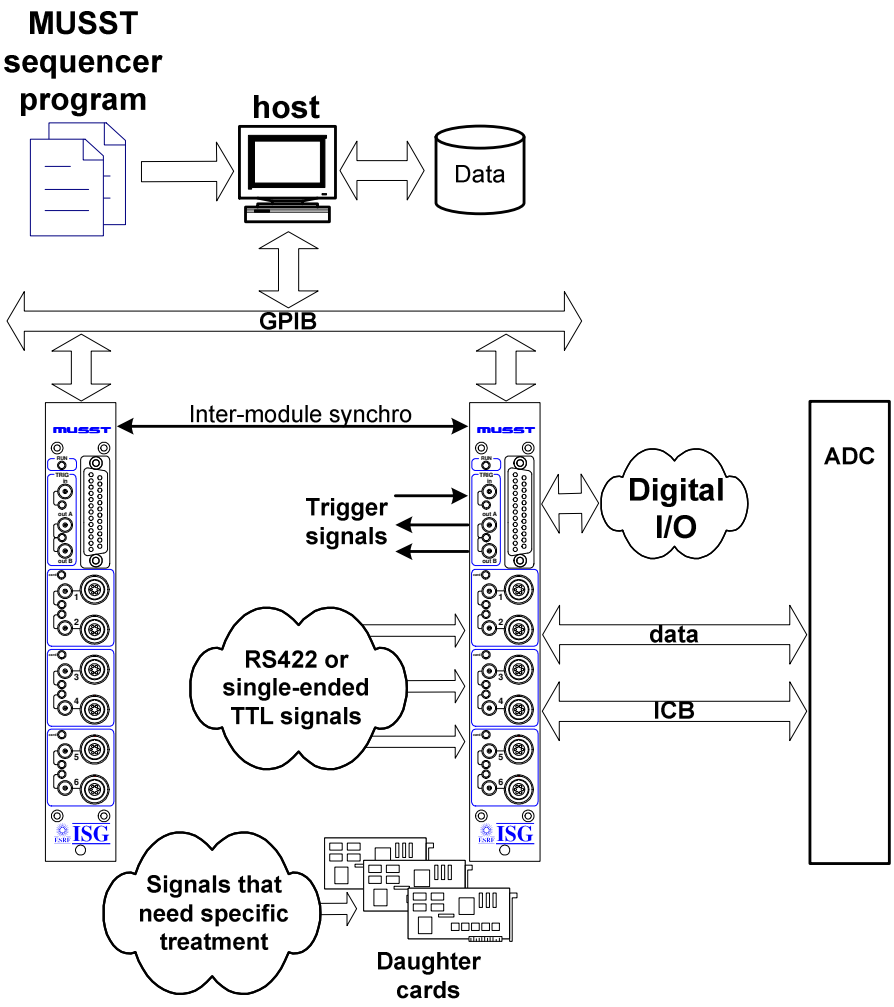


Figure 6: General overview of MUSST deployment

3.1.1. Communication: GPIB and serial ports

Due to the limited data rate of the serial ports, the preferred communication way with MUSST is the GPIB.

GPIB connection can be obtained by means of a PCI GPIB card or an Ethernet-to-GPIB controller and the cable can be as long as 20 meters provided the electrical load is correctly configured.

The MUSST modules should have an individual address ranging from 1 to 31 (default address is 13).

The GPIB address and electrical load can be set or checked by the *GPIB/?GPIB* command and request, respectively (see Section 4.1).

3.1.2. Input channels

No daughter card is necessary if the input signal observes both of the conditions below.

- the signal is electrically compatible to either single-ended TTL or differential RS422.
- the signal is to be treated as a source for an up, down, up-down or quadrature counter (or encoder)

In this case, the signal needs only to be cabled as indicated in Section 2.1.4 and the correspondent channel configured according to the desired mode.

The input channels can also be configured to count specific internal signals such as time, MCA data, software or sequencer increments and trigger signals actions. In the case of time counting, the internal timer timebase should be configured to match the desired time resolution.

A desired value can be loaded into the channels or the timer for the usage convenience. In the case of a counter, this value can be also preset by an external signal if the *PRESET* keyword is used in the channel configuration.

If the input signal does not observe the conditions above or it observes them but any of the available modes is not convenient for the usage, a specific daughter card is necessary. Most common daughter cards are those that are able to deal with absolute encoder interfaces and analogue signals (ADCs).

See the *CHCFG*, *TMRCFG*, *CH* and *TIMER* commands in Section 4.1 for a complete description of channel and timer configuration, and channel and timer values setting, respectively. See also the *?VAL* request in the same Section for value readings.

3.1.3. Digital I/Os

The digital I/Os can be used to control or to read two-state-logic devices (provided the necessary interfacing is realised): shutter controllers, pneumatics valves, relays, electromechanical switches.

The *IO/?IO* command allows setting and reading of individual or grouped bits, while the command *IOCFG* is used to configure the direction of these signals. The *?VAL* request can be also used to read the value of these signals. See Section 4.1 for further information.

3.1.4. Trigger signals

The front panel trigger signals (*TRIG in*, *TRIG out A* and *TRIG out B*) can be used to synchronise external instruments to MUSST and vice-versa.

The rear panel trigger signal (*TRIG*) is mainly used to synchronise several MUSST modules working together.

TRIG in signal can be taken into account both by a user sequencer program or by the *RUNCT* command.

TRIG out A and *TRIG* are controlled by the sequencer program while *TRIG out B* can be controlled by both the sequencer program and by software (see command *BTRIG*)

Both *TRIG out A* and *TRIG out B* signals are also activated by the *RUNCT* command.

Refer to Section 4.1 for the mentioned commands.

3.1.5. Sequencer program and data storage

For each specific application, a different program should be written for the sequencer. A high level programming language has been created in order to facilitate this task, as described in Section **Error! Reference source not found.**.

The written program should be uploaded into the module through one of the communication ports to be compiled on-the-fly by the internal compiler. An uploaded program can be listed and cleared by the *?LIST* and *CLEAR* commands, respectively.

Variables can be defined and used in the sequencer program and special commands are available to handle them: *VAR/?VAR* to define/query variables and *?VARINFO* to query variable information.

Once the program has been compiled, it can be run and aborted by the *RUN* and *ABORT* commands, respectively. The *STOP* command stops execution of the program, while the *CONT* command re-runs the program from where it has been stopped. The *?RETCODE* request queries the program return code, if any.

Furthermore, debugging functionalities for the sequencer program are also available by using breakpoints and step execution of the tested program. Breakpoints are managed by the *BREAK* command and stepping is done by the *STEP* command, while the *?INSTR* request allows checking the current instruction.

The MUSST internal memory for data storage is shared between event data and MCA histogram storing (see 3.1.6). Event data is the selected data stored by the sequencer program in the internal memory.

Management of the event data memory includes the *ESIZE* command to set the event data memory size, *EBUFF* to select the current memory buffer and *EPTR* to handle the memory position pointer.

The stored data can be transferred to the host through the GPIB ASCII or binary transfer mode (see the *?EDAT* and *?*EDAT* requests).

All the commands mentioned above are referenced in Section 4.1.

3.1.6. Spectroscopy ADC

Using MUSST as an MCA (Multi-Channel Analyser) requires a spectroscopy ADC connected through a Canberra® standard data and control interface. Configuration parameters of the ADC can be sent and received by means of the Canberra® ICB (Instrument Control Bus).

The MUSST internal storage memory for histogramming should be configured to the desired number of channels and buffers. The stored histograms can be transferred to the host in binary blocks through the GPIB port even during an acquisition. In addition, the buffers can be automatically emptied next to its reading. These features optimises acquisition and data transfer time.

See the *ICB*, *HSIZE*, *HBUFF*, *HMEMCLR* and ?*HDAT/?*HDAT* commands in Section 4.1 for further information about ICB configuration, histogramming memory size, setting of buffers, buffer clearing and histogram data transfer, respectively.

3.2. Usage tips

Refer to Section 4.1 for all the commands mentioned below.

- The *?INFO* request provides a summary of the configuration parameters. It is a quick and easy way to check the current configuration.

- It is always useful to check the endianess (big endian/ little endian) of the host processor if data transfer from MUSST is desired. The *DFORMAT* command allows changing the way MUSST formats the data.

- Use of alias for the channels and digital I/Os improves readability and gives the user a more significant name for these signals. Refer to the *ALIAS* command for more details.

- The *RUNCT* command runs the timer, the counters and the MCA for a defined time. It is an easy way to quickly check the good functioning of these elements.

- When using time related functionalities (*RUNCT* command or time-driven events), it is important to adapt the system timer timebase to the needed time resolution (see the *TMRCFG* command). For instance, launching a 1µs counter run with the system timer configured to 1MHz can lead to incorrect results since this value is in the limit of the time resolution. Changing system timer to a higher frequency (10MHz or 50MHz) can correct this problem.

- It is quite common to have a situation where one wants to change an incremental encoder direction sign. This can be done easily by using the *INV* keyword in the correspondent channel configuration. Moreover, the *INV* keyword can be also used to change the polarity of the input signals (see the *CHCFG* command).

- Communication with MUSST can be an issue if the module address is already used by another instrument in the same GPIB controller. The less disturbing solution for the existing experimental setup is to set a new GPIB address to MUSST through the serial line port by means of the *GPIB* command. Once the setting of the new address is done, it is important to disconnect the serial port connector in order to enable the GPIB. On the other hand, if there is no address conflict, the MUSST GPIB address can be changed through the GPIB port as well.

4. COMMAND SET

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4.1. Command reference

+

Add program code line

Syntax:

+(code line)

Description:

Adds a program source code line to the current program. The line includes all the ASCII characters after the '+' sign including any white space. Program source code lines are stored in the module internal memory and compiled on the fly.

The content of the program memory can be inspected at any time with the ?LIST query and deleted by means of the CLEAR command.

It is possible to clear the program memory and/or load new programs or program blocks while another program is already running in the sequencer. In this case the program lines are compiled and stored in a temporary buffer. Whenever the running program stops or exits, the new program is loaded into the sequencer. This feature can be used to speed up program changes.

Examples:

```
Command:  CLEAR
Command:  ?STATE
Answer:   NOPROG
Command:  +// This is a simple and useless program
Command:  +
Command:  +UNSIGNED A
Command:  +PROG
Command:  +  A = 1
Command:  +ENDPROG
Command:  ?STATE
Answer:   IDLE
Command:  ?LIST
Answer:   $
          // This is a simple and useless program

          UNSIGNED A
          PROG
            A = 1
          ENDPROG
          $
```

ABORT

Abort program execution

Syntax:

ABORT

Description:

If a program is loaded in the module, this command aborts the execution and resets the sequencer. The program remains loaded in the sequencer and can be started again either from the beginning of from one the valid entry points.

After an ABORT command, if a valid program is loaded in memory, the module goes into IDLE state. If there is no program, the module goes into NOPROG state. If the program is incomplete or contains errors, the state is set to BADPROG.

Examples:

Command:	`RUN`
Command:	`?STATE`
Answer:	`RUN`
Command:	`ABORT`
Command:	`?STATE`
Answer:	`IDLE`

ADDR / ?ADDR

Set/query serial line address

Syntax:

ADDR <slAddress>

Description:

Sets the serial line address to the <slAddress>. The address may be any alphanumerical character string. The maximum length is 9 characters. Any leading zeroes in the address are discarded.

When the serial line ports of different modules are daisy-chained for communication, a particular module can be accessed by preceding any command with a prefix formed by the module address followed by a colon character (:). If the first character of the address is non-numeric, a leading zero must be added.

The serial line address is not used in GPIB communication.

Syntax:

?ADDR

Answer:

<slAddress>

Description:

Returns the serial line address of the module.

Examples:

Command:	?ADDR
Answer:	<empty>
Command:	ADDR 3
Command:	?ADDR
Answer:	3
Command:	ADDR M2
Command:	?ADDR
Answer:	M2

ALIAS / ?ALIAS

Define/delete/query system aliases

Syntax:

ALIAS {CH*n* | IO*n* | <alias>} <newAlias>

ALIAS CLEAR {CH*n* | IO*n* | <alias>}

Description:

The ALIAS command sets the alias of any input channel or I/O line to the name <newAlias>. System aliases must be a valid symbol names with a maximum length of 12 characters.

If <newAlias> has already been used as system alias for a different channel or I/O line, the previous system alias definition is removed.

Only one system alias is allowed per input channel or I/O line. If the channel or I/O line has already an associated system alias, the old one is discarded and replaced by the new one.

System aliases can be deleted by means of the CLEAR keyword.

Syntax:

?ALIAS [{CH*n* | IO*n* | <alias>}]

Answer:

{CH*n* | IO*n*} [<alias>]

Description:

The ?ALIAS query returns the generic specifier and the system alias associated to an input channel or I/O line. The signal itself must be passed as parameter, either by its generic identifier (CH*n* or IO*n*) or by its associated system alias. If there is no system alias for the specified signal, the alias field is empty in the query answer.

If no signal is specified as parameter to the ?ALIAS query, it returns a multiline answer with one line per each signal that has a defined alias.

Examples:

```
Command:   ALIAS IO3 SHCMD
Command:   ?ALIAS IO3
Answer:    IO3 SHCMD
Command:   ALIAS CH1 PHI
Command:   ?ALIAS
Answer:    $
           CH1 PHI
           IO3 SHCMD
           $
```

BREAK / ?BREAK

Manage/list breakpoints

Syntax:

BREAK ADD [{<line> | -<ucAddr>}]

BREAK {CLEAR | ENABLE | DISABLE} [{<bkn> | ALL}]

Description:

With the ADD keyword, this command adds a program breakpoint at the program source code <line> or the at microcode instruction at address <ucAddr>. If no source code line number or microcode address is specified, the breakpoint is set at the current program address.

Every breakpoint is identified with incrementing numbers starting from 1. Breakpoints preserve their numbers even if other breakpoints with lower numbers are deleted. Breakpoints are enabled at creation time.

Breakpoints can be enabled, disabled or deleted by means of the ENABLE, DISABLE or CLEAR keywords. These action can apply either to a single breakpoint with number <bkn> or to all the defined breakpoints if the keyword ALL is used. Disabled breakpoints are not active but remain in the list and can be re-enabled at later time.

Syntax:

?BREAK [<bkn>] [ASM] [CODE]

Answer:

<bkn> {+ | -} <line> <ucAddr> [: (ucode_line)] [: (source_line)]

Description:

The ?BREAK query returns the source code line number and the microcode address at which the breakpoint with number <bkn> is placed. It also returns a character '+' or '-' depending on whether the breakpoint is enabled or not. The keywords ASM and CODE can optionally be used to make the query return the corresponding microcode disassembled line and the source code line respectively.

If the breakpoint number <bkn> is not specified, the query returns a multiline answer with one line per defined breakpoint.

Examples:

Command: `BREAK ADD 4`

Command: `BREAK ADD -34`

Command: `BREAK DISABLE 1`

Command: `?BREAK`

Answer:
```
$
1  -   4 0x00A
2  +  11 0x022
$
```

BTRIG / ?BTRIG

Set/query the level of the TRIG out B output signal

Syntax:

BTRIG {0 | 1}

Description:

Sets the logic level of the *TRIG out B* front panel output.

Syntax:

?BTRIG

Answer:

{0 | 1}

Description:

Returns the current logic level of the *TRIG out B* output signal.

Examples:

Command:	`BTRIG 1`
Command:	`?BTRIG`
Answer:	`1`

CH / ?CH

Set/query input channels

Syntax:

CH {CH*n* | <alias>} [<newVal>] [{RUN | STOP}]

Description:

Loads one of the input registers with the value <newVal>. The input channel may be specified either by the generic identifier CH*n* or by the corresponding system alias if defined.

In case of channels configured in counting mode, this command can also be used to start or stop the counter by means of the RUN and STOP keywords.

Channels configured in sampling mode (ADC's, encoders, …) are always active and cannot be started or stopped.

Syntax:

?CH {CHn | <alias>}

Answer:

<value> {RUN | STOP}

Description:

The ?CH query returns the current value of the input channel and its RUN/STOP state.

Example:

Command:	`CH CH2 34`
Command:	`?CH CH2`
Answer:	`34 STOP`
Command:	`CH CH2 RUN`
Command:	`?CH CH2`
Answer:	`1032 RUN`

?CHAIN

Query secondary serial port status

Syntax:

?CHAIN

Answer:

{YES | **NO} {RS232** | **RS422** | **NONE}**

Description:

Returns whether or not (“YES” or “NO”) there is another instrument connected to the secondary serial port as well as its electrical specification (“RS232” or “RS422”).

The secondary serial port is the port that is not used for communications with the host computer and that can be eventually used for daisy-chaining of modules. If no serial port is used, the module is accessed by GPIB, the query returns “NONE” as secondary port type.

Example:

Command: `?CHAIN`

Answer: `NO RS422`

CHCFG / ?CHCFG

Set/query input channel configuration

Syntax:

CHCFG {CHn | <alias>} [*channel_config*] [ALIAS <new_alias>]

with *channel_config* one of:

CNT {UP | DOWN} [INV] [GATE [INV]] [PRESET [INV]]

CNT UPDOWN {PULSE | DIR | QUAD {[X4] | X2 | X1}} [INV] [PRESET [INV]]

ENC {[QUAD] {[X4] | X2 | X1} | PULSE | DIR} [INV] [PRESET [INV]]

{1KHZ | 10KHZ | 100KHZ | 1MHZ | 10 MHZ | 50MHZ} [GATE [INV]] [PRESET [INV]]

{PROG | SOFT} [GATE [INV]] [PRESET [INV]]

{ITRIG | ATRIG | BTRIG | EVENT | EVSEEN | MCA} [GATE [INV]] [PRESET [INV]]

{MCALT | MCADT} [PRESET [INV]]

SSI [INV] [FILT [<n>]]

ADC {[+-10V] | +-5V | +10V} [FILT [<n>]]

Description:

Sets the configuration parameters for channel CH*n*. In addition to the configuration, the CHCFG command can also be used to set the system alias for the selected channel.

Input channels can be configured to use different types of signals and/or operation modes. Most of the possible configurations accept an external gate and preset signal. The external preset loads the correspondent channel with the last loaded value. These features need to be activated by means of the GATE and PRESET keywords. The optional keyword INV following GATE and PRESET can be used to invert the polarity of the corresponding external signal.

The available modes are:

- Generic counter (CNT). The input channel is configured as a generic counter. The counting source is an external signal applied to the corresponding front panel connector. The counter can be started and stopped and usually must be cleared at the beginning of each counting interval. Possible counting modes are UP, DOWN and UPDOWN.

  In case of upward or downward counting, the channel counts the signal applied to the IN0 line at the input connector. The polarity of the signal can be inverted by means of the INV keyword. By default the channel counts the rising edges of the input signal. When inverted, the falling edges are counted.

  A channel configured for UPDOWN counting uses the signals applied to the IN0 and IN1 lines of the input connector. The channel must be set in one of three possible modes, PULSE, DIR and QUAD, depending on the type of signal it accepts.

  In PULSE mode the pulses applied to the IN0 line increment the counter, while pulses applied to IN1 decrement it. In PULSE mode the INV keyword inverts the polarity of the input signals and not the direction (up/down) of the counter.

  Is DIR mode the channel counts the pulses of the line IN0 while logic level of the IN1 line selects the counting direction (0 = downwards, 1 = upwards).

  In QUAD mode the channel operates in phase counting mode. The channel counts the edges of the IN0 and IN1 signals and the counting direction is selected by the sign of the phase between both. The channel can be set to count 1, 2 or 4 edges per signal period (X1, X2 and X4 keywords). See also the ENC mode.

In DIR and QUAD modes, the INV keyword inverts the counting direction.

- Encoder mode (ENC). The input channel is configured as a updown counter but it is permanently active and cannot be stopped. In this way it can be used to track an external signal and follow its variations in time. This mode is intended primarily to be used with incremental position encoders. The encoder mode accepts the same options PULSE, DIR and QUAD than the updown generic counting mode (CNT UPDOWN).

  The INV keyword inverts the counting direction (up/down) of the channel.

- Timer mode (1KHZ, 10KHZ, 100KHZ, 1MHZ, 10MHZ, 50MHZ). The channel is set to operate as a timer by counting one among the six internal timebases. The selected timebase can be different from the one selected for the system timer (see TMRCFG command). Channels in timer mode can be gated and/or preset by external signals applied to the IN1 and IN2 lines respectively.

- MCA timer (MCALT, MCADT). The input channel is configured to measure the live time (MCALT) or dead time (MCADT) of the external spectroscopy ADC. The channel is internally set to the same timebase than the system timer and the time unit is therefore selected by the TMRCFG command.

- Special counters (PROG, SOFT, ITRIG, ATRIG, BTRIG, EVENT, EVSEEN, MCA). The input channel is configured to count special signals or internal conditions. Possible counting sources are the following:

  PROG – The channel counter is incremented under control of the sequencer by means of the #INC CHn program instruction.

  SOFT – The channel counter is incremented by INCR command issued from the host computer.

  ITRIG, ATRIG, BTRIG – The channel counts the input or output trigger signals.

  EVENT – The channel counts the event occurrences that have been produced but have not been treated yet by the sequencer.

  EVSEEN – The channel counts the event occurences that have already been treated by the sequencer.

  MCA – The channels counts all the events (MCA total counts) transferred from the spectroscopy ADC .

- ADC mode (ADC). The input channel is loaded with digital value of the analogue voltage applied to the input. This mode requires the installation of a specific daughter board. The sampling period and the bit resolution depends on the daughter board installed.

  With certain daughter boards, the input range can be selected between ±10V, ±5V or 0-10V.

  The analogue value is always represented as a signed 32 bit value. The positive full scale corresponds to the 0x7FFFFFFF digital value.

  It is possible to enable an internal first order low-pass digital filter with the FILT <n> option. The effective filter time constant is $2^{<n>}$·T where T is the sampling period. If the FILT keyword is used with no argument, the digital filter is disabled.

- SSI mode (SSI). The input channel receives the digital value from an external device, typically an absolute position encoder, through a SSI interface. This mode requires the installation of a specific daughter board.

  The digital value is aligned to the most significant bits of a signed 32 bit value

  The INV keyword inverts the sign of the channel. The configuration of the SSI interface are selected by means of the SSICFG command.

  It is possible to enable an internal first order low-pass digital filter with the FILT <n> option in the same way that in the ADC mode.

Syntax:

?CHCFG {CHn | <alias>}

Answer:

***channel_config* [ALIAS <alias>]**

where *channel_config* is one of the possible combinations presented above.

Description:

Returns the channel configuration and the corresponding system alias if defined. The channel can be specified either by a channel identifier CH*n* or by a valid system alias.

Examples:

Command:	`CHCFG CH1 ENC INV ALIAS PHI`
Command:	`?CHCFG PHI`
Answer:	`ENC INV ALIAS PHI`
Command:	`CHCFG PHI CNT UPDOWN DIR INV`
Command:	`?CHCFG PHI`
Answer:	`CNT UPDOWN DIR INV ALIAS PHI`
Command:	`CHCFG PHI 1MHZ ALIAS`
Command:	`?CHCFG PHI`
Answer:	`ERROR`
Command:	`?ERR`
Answer:	`Bla, bla, bla`
Command:	`?CHCFG CH1`
Answer:	`1MHZ`

CLEAR

Delete current program

Syntax:

CLEAR

Description:

Deletes the current program from the module memory. Source code and variable declaration are lost but the module keeps executing any microcode program that was already loaded and running in the sequencer. Program execution is aborted as soon as the sequencer stops, either by a program exit instruction, a STOP command, a breakpoint, etc. If in the mean time a new program has been loaded and compiled by the module, the corresponding microcode is loaded into the sequencer.

Examples:

Command:	`?STATE`
Answer:	`IDLE`
Command:	`CLEAR`
Command:	`?STATE`
Answer:	`NOPROG`

CONT

Continue program execution

Syntax:

CONT [<nBkpts>]

Description:

When the program is stopped (STOP or BREAK states) it can be continued by the CONT command.

Program execution will skip the first <nBkpts> breakpoints found if this argument is specified.

Examples:

Command:	`STOP`
Command:	`?STATE`
Answer:	`STOP`
Command:	`CONT`
Command:	`?STATE`
Answer:	`RUN`

DBCMD

Execute daughter board specific command

Syntax:

DBCMD {CHn | <alias>} [{RESET|SSIRAW|SSINORM | OUT {0|1} | REG <add> <val>}]

Description:

Executes an action in the daughter board associated to channel CH*n*. Possible commands and actions are:

Command	Action
`RESET`	Initialises the channel electronics in the daughter board
`SSIRAW`	In case of SSI inputs, get the status bits along with the data bits
`SSINORM`	In case of SSI inputs, get only data bits
`OUT {0|1}`	Sets the auxiliary channel digital output to 0 or 1
`REG` *`addr val`*	Sets the daughter board internal register at address *addr* to value *val*

Examples:

Command: `DBCMD CH3 RESET`

Command: `ALIAS CH1 PHI`

Command: `DBCMD PHI OUT 1`

Command: `DBCMD CH5 REG 1 0xF035`

Command: `DBCMD CH3 SSIRAW`

?DBINFO

Query the list of installed daughter boards

Syntax:

?DBINFO [*]

Description:

Returns the list of installed daughter boards. If the parameter '*' is used, the request returns in addition the current values of the configuration registers of the boards.

Examples:

Command: `?DBINFO`

Answer:

```
$
Channels 1,2
  No daughter board installed.
Channels 3,4
  No daughter board installed.
Channels 5,6
  Board: Universal SSI and Analog (+-10V,+-5V,+10V)
$
```

Command: `?DBINFO *`

Answer:

```
$
Channels 1,2
  No daughter board installed.
Channels 3,4
  No daughter board installed.
Channels 5,6
  Board: Universal SSI and Analog (+-10V,+-5V,+10V)
    registers CH5:
      CFG addr = 0 (0x41) -  value = 0x0187
      SSI addr = 1 (0x43) -  value = 0x0000
    registers CH6:
      CFG addr = 0 (0x42) -  value = 0x0187
      SSI addr = 1 (0x44) -  value = 0x0000
$
```

DFORMAT / ?DFORMAT

Set/query data format

Syntax:

DFORMAT [{DEC | HEXA}] [{NOSWAP | BSWAP | WSWAP | WBSWAP}]

Description:

Selects the data format used by the data memory read queries.

The DEC or HEXA keywords select whether the ASCII data returned by the ?EDAT and ?HDAT queries is formatted in decimal or hexadecimal format respectively.

The swap keywords select the swapping operation applied to the 32-bit binary data returned by the ?*EDAT and ?*HDAT queries. MUSST stores data internally in big endian byte ordering. The possible options are:

`NOSWAP` - No swapping (big endian).
`BSWAP` - Byte swapping. Only bytes are swapped within each 16-bit word.
`WSWAP` - Word swapping. Only both 16-bit words are swapped.
`WBSWAP` - Word and byte swapping. Both bytes and words are swapped. (little endian)

If binary data is read into a computer with a little endian processor, like an Intel x86, WBSWAP swapping mode should be selected.

Syntax:

?DFORMAT

Answer:

{DEC | HEXA} {NOSWAP | BSWAP | WSWAP | WBSWAP}

Description:

Returns a list of the operation flags that are currently NOT set.

Examples:

Command:	`?DFORMAT`
Answer:	`HEXA BWSWAP`
Command:	`DFORMAT DEC`
Command:	`?DFORMAT`
Answer:	`DEC BWSWAP`

EBUFF / ?EBUFF

Set/query current event buffer

Syntax:

EBUFF [<buffN>]

Description:

Selects the current buffer used for even data storage. Valid buffer numbers <buffN> go from 0 to <nOfBuff>-1, where <nOfBuff>is the total number of buffers available as returned by the ?ESIZE query.

If the buffer number <buffN> is not specified, the current buffer is set to 0.

Syntax:

?EBUFF

Answer:

<buffN>

Description:

Returns the current buffer used for even data storage.

Examples:

Command:	`?ESIZE`
Answer:	`1024 128`
Command:	`EBUFF 32`
Command:	`?EBUFF`
Answer:	`32`
Command:	`EBUFF`
Command:	`?EBUFF`
Answer:	`0`

ECHO

Switch echo mode on

Syntax:

ECHO

Description:

This mode is intended to be used when the instrument is connected to a dumb character terminal through one its serial ports. In this mode the characters received by the unit are sent back to the terminal and error messages are produced as soon as the corresponding errors are detected.

If the instrument is controlled by a program running in host computer the echo mode should be switched off (see NOECHO command). In this case the error messages can be requested by means of the ?ERR query.

This command has no effect if the module is controller by the GPIB interface.

Example:

Command: `ECHO`

?EDAT / ?*EDAT

Read event data memory

Syntax:

?EDAT <nVal> [<buffN> [<offset>]]

?*EDAT <nVal> [<buffN> [<offset>]]

Answer:

(<nVal> data values)

Description:

Returns <nVal> data values from the event data memory area. The values start at offset <offset> in the buffer <buffN>. If <buffN> and/or <offset> are not specified, the current buffer number and offset are used.

The ?EDAT query returns data in ASCII format, while ?*EDAT returns them in binary mode. The DFORMAT command can be used to select the ASCII format or the binary swapping mode used.

Example:

```
Command:   DFORMAT HEXA
Command:   ?EDAT 5
Answer:    $
           0x00458F31
           0x0047C320
           0x00528F31
           0xDE459F20
           0xEF9A82C7
           $
Command:   ?*EDAT 100
Answer:    <100 32-bit binary values (400 bytes) transferred>
```

EPTR / ?EPTR

Set/query event memory pointer

Syntax:

EPTR <offset> [<buffN>]

Description:

Sets the internal event data memory pointer to point to the data position at offset <offset> in the buffer number <buffN>.

Syntax:

?EPTR

Answer:

<offset> <buffN>

Description:

Returns the current position of the event data memory pointer.

Example:

Command:	`EPTR 0 0`
Command:	`?EPTR`
Answer:	`0 0`
Command:	`EPTR 100 2`
Command:	`?EPTR`
Answer:	`100 2`

?ERR

Query last error

Syntax:

?ERR

Answer:

{OK | <errorMessage>}

Description:

Returns the string “OK” if the execution of the last command was successful or an error message describing the error in the last command.

Example:

Command:	`?VER`
Answer:	`MUSST 01.00a`
Command:	`?ERR`
Answer:	`OK`
Command:	`?VERSION`
Answer:	`ERROR`
Command:	`?ERR`
Answer:	`Command not recognised.`

ESIZE / ?ESIZE

Set/query event buffer size

Syntax:

ESIZE <bufSize> [<nOfBuff>]

Description:

Requests allocation of <nOfBuff> data buffers for event data storage. Each buffer should have capacity to allocate <buffSize> 32-bit data values. If the <nOfBuff> parameter is not specified it is defaulted to 1.

MUSST shares its internal data memory (2 MByte = 512 KValues) among event data storage and histogram data. The internal allocation algorithm always tries to satisfy both ESIZE and HSIZE memory requests. However it is not guaranteed that both are compatible. Therefore it is recommended to use the ?ESIZE and ?HSIZE query to check the actual memory allocation and verify whether the memory requests have been satisfied or not.

Syntax:

?ESIZE

Answer:

<bufSize> <nOfBuff>

Description:

Returns the actual buffer memory allocation for event data storage. Both <buffSize> and <nOfBuff> may not be identical to the values requested by the ESIZE command.

Buffer size are always rounded to a power of 2 and more buffer than those requested may be allocated.

Example:

Command:	`ESIZE 1000`
Command:	`?ESIZE`
Answer:	`1024 1`

EVENT

Enable/disable/force event generation

Syntax:

EVENT {ENABLE | DISABLE | FORCE}

Description:

Sets the enable/disable event generation flag or forces an event condition.

The enable/disable event generation flag authorises or forbids the generation of events in the module.

An event condition is generated by means of the keyword FORCE even if events were disabled. As a side effect, after forcing an event condition the enable/disable flag is set to ENABLE.

Syntax:

?EVENT

Answer:

{ENABLE | DISABLE}

Description:

Queries the status of enable/disable event generation flag.

Examples:

Command:	`EVENT DISABLE`
Command:	`?EVENT`
Answer:	`DISABLE`
Command:	`EVENT FORCE`
Command:	`?EVENT`
Answer:	`ENABLE`

GPIB / ?GPIB

Set/query GPIB address and bus load

Syntax:

GPIB [<gpibAddr>] [{X1 | X10}]

Description:

Sets the address of the GPIB interface and the equivalent electrical load.

The address must be a number between 1 and 31.

The equivalent electrical load can be set to either one instrument (X1) or 10 instruments (X10). The electrical load has an influence on the maximum length of the GPIB cable. The GPIB standard specifies a maximum cable length of 2 meters per instrument connected to the bus, the total bus length is limited to 20 meters and the number of instrument loads is set to 15.

Therefore when the electrical load is set to X10, a single MUSST module can be connected to a GPIB controller with a 20 meter long cable and be in full conformity with the GPIB standard. In addition lab tests and measurements have shown that those limits can be safely raised in practice.

Syntax:

?GPIB

Answer:

<gpibAddr> {X1 | X10}

Description:

Returns the address of the GPIB interface and the equivalent electrical load.

Examples:

Command:	`GPIB 13`
Command:	`?GPIB`
Answer:	`13 X10`
Command:	`GPIB X1`
Command:	`?GPIB`
Answer:	`13 X1`

HBUFF / ?HBUFF

Set/query current histogram buffer

Syntax:

HBUFF [<buffN>]

Description:

Selects the current buffer used for histogram (MCA) data storage. Valid buffer numbers <buffN> go from 0 to <nOfBuff>-1, where <nOfBuff>is the total number of buffers available as returned by the ?HSIZE query.

If the buffer number <buffN> is not specified, the current histogram data storage buffer is set to 0.

Syntax:

?HBUFF

Answer:

<buffN>

Description:

Returns the current buffer used for histogram (MCA) data storage.

Examples:

Command:	`?HSIZE`
Answer:	`1024 128`
Command:	`HBUFF 32`
Command:	`?HBUFF`
Answer:	`32`
Command:	`HBUFF`
Command:	`?HBUFF`
Answer:	`0`

?HDAT / ?*HDAT

Read histogram data memory

Syntax:

?HDAT <nVal> [<buffN> [<offset>]]

?*HDAT <nVal> [<buffN> [<offset>]]

Answer:

(<nVal> data values)

Description:

Returns <nVal> data values from the histogram (MCA) memory area. The values start at offset <offset> in the buffer <buffN>. If <buffN> and/or <offset> are not specified, the current buffer number and offset are used.

The ?HDAT query returns data in ASCII format, while ?*HDAT returns them in binary mode. The DFORMAT command can be used to select the ASCII format or the binary swapping mode used.

Example:

Command: `DFORMAT DEC`

Command: `?HDAT 10 2 0`

Answer:
```
$
234
567
789
815
1434
1510
1503
1473
1100
431
$
```

Command: `?*HDAT 1024`

Answer: `<1024 32-bit binary values (4 Kbytes) transferred>`

?HDWVER

Query hardware version

Syntax:

?HDWVER

Answer:

X.Y.Z / **A.B**

Description:

Returns the version number X.Y.Z / A.B of the MUSST hardware.
Where:
X is the main programmable logic circuit version
Y is the main printed circuit board version
Z is the main printed circuit board configuration version
A is the inputs/outputs programmable logic circuit version
B is the inputs/outputs printed circuit board version

Example:

Command: `?HDWVER`

Answer: `1.0.0 / 1.0`

?HELP

Query list of available commands

Syntax:

?HELP

Description:

Returns the list of available commands and queries.

Example:

Command: `?HELP`

Answer:

```
$
     RESET
            ?HDWVER
            ?STATE
            ?RETCODE
     CLEAR
            ?LIST
       RUN
      STOP
     ABORT
      CONT
      STEP
     EVENT  ?EVENT
      INCR
            ?INSTR
     RUNCT
            ?VARINFO
       VAR  ?VAR
   VARINIT
     BREAK  ?BREAK
       ICB  ?ICB
    TMRCFG  ?TMRCFG
     CHCFG  ?CHCFG
    SSICFG  ?SSICFG
     IOCFG  ?IOCFG
     ALIAS  ?ALIAS
     DBCMD
        CH  ?CH
     TIMER  ?TIMER
        IO  ?IO
     BTRIG  ?BTRIG
            ?VAL
     ESIZE  ?ESIZE
     HSIZE  ?HSIZE
     EBUFF  ?EBUFF
     HBUFF  ?HBUFF
      EPTR  ?EPTR
            ?EDAT
            ?*EDAT
            ?HDAT
            ?*HDAT
   HMEMCLR  ?HMEMCLR
   DFORMAT  ?DFORMAT
      GPIB  ?GPIB
            ?INFO
            ?DBINFO
       ECHO
     NOECHO
            ?ERR
       ADDR  ?ADDR
            ?CHAIN
       NAME  ?NAME
            ?VER
            ?HELP
$
```

HMEMCLR / ?HMEMCLR

Set/query histogram memory autoclear

Syntax:

HMEMCLR [{ON | OFF}] {FULL | [<firstBuff> [<lastBuff>]]}

Description:

Sets/clears the histogram autoclear feature by means of the ON and OFF keywords. When the autoclear feature is set, the histogram (MCA) data memory is automatically cleared as it is read by means of the ?HDAT or ?*HDAT queries. This feature saves time by avoiding wasting time in filling the histogram memory buffers with zeros.

The HMEMCLR command can also be used to actually clear the histogram memory buffers. If the <firstBuff> and <last Buff> buffer numbers are specified, the whole buffer range from <firstBuff> to <last Buff> is cleared. If the FULL keyword is used, the whole histogram memory area is cleared.

Syntax:

?HMEMCLR

Answer:

{ON | OFF}

Description:

Returns the histogram autoclear flag.

Examples:

Command:	`?HMEMCLR`
Answer:	`OFF`
Command:	`HMEMCLR ON FULL`
Command:	`?HMEMCLR`
Answer:	`ON`

HSIZE / ?HSIZE

Set/query histogram buffer size

Syntax:

HSIZE <bufSize> [<nOfBuff>]

Description:

Requests allocation of <nOfBuff> data buffers for histogram (MCA) data. Each buffer should have capacity to allocate <buffSize> 32-bit data values. If the <nOfBuff> parameter is not specified it is defaulted to 1.

MUSST shares its internal data memory (2 MByte = 512 KValues) among event data storage and histogram data. The internal allocation algorithm always tries to satisfy both ESIZE and HSIZE memory requests. However it is not guaranteed that both are compatible. Therefore it is recommended to use the ?ESIZE and ?HSIZE query to check the actual memory allocation and verify whether the memory requests have been satisfied or not.

Syntax:

?HSIZE

Answer:

<bufSize> <nOfBuff>

Description:

Returns the actual buffer memory allocation histogram (MCA) data. Both <buffSize> and <nOfBuff> may not be identical to the values requested by the HSIZE command.

Buffer size are always rounded to a power of 2 and more buffer than those requested may be allocated.

Example:

Command:	`HSIZE 1000`
Command:	`?HSIZE`
Answer:	`1024 1`

ICB / ?ICB

Write/read byte from ICB bus

Syntax:

ICB <icb_addr> <databyte>

Description:

Writes the byte <databyte> at the address <icb_addr> in the ICB bus.

Syntax:

?ICB <icb_addr>

Answer:

<databyte>

Description:

Reads and returns the content of the address <icb_addr> from the ICB bus.

Examples:

Command:	`ICB 5 31`
Command:	`?ICB 5`
Answer:	`31`

INCR

Increments SOFT mode channels

Syntax:

INCR [<cnt>]

Description:

Increments all the input channels configured in SOFT mode by <cnt> counts. If <cnt> is not specified the SOFT counters are incremented by 1.

Examples:

Command:	`?CHCFG CH1`
Answer:	`SOFT`
Command:	`?CH CH1`
Answer:	`0 RUN`
Command:	`INCR 5`
Command:	`?CH CH1`
Answer:	`5 RUN`

?INFO

Query module configuration

Syntax:

?INFO

Description:

Returns a multiline answer with the current configuration.

The information is presented as a list of valid commands with the appropriate parameters that can be sent back to the module in the case that reconfiguration is needed.

Example:

Command: `?INFO`

Answer:

```
$
MUSST 01.00  -  Current settings:
  NAME "no name"
  ADDR ""
MUSST 01.00  -  Current settings:
  NAME "no name"
  ADDR ""

  TMRCFG 1MHZ
  ALIAS CLEAR
  CHCFG CH1 CNT
  CHCFG CH2 ENC ALIAS PHI
  CHCFG CH3 CNT
  CHCFG CH4 CNT
  CHCFG CH5 CNT
  CHCFG CH6 CNT
  IOCFG 0xFF00
  ALIAS IO3 SHUTCMD
  ALIAS IO12 SHUTSTATE
  DFORMAT HEXA WBSWAP
  HMEMCLR ON
  GPIB 13 X10
$
```

?INSTR

Query current program instruction

Syntax:

?INSTR [TIME] [CODE] [ASM]

Answer:

<line_n> <uc_addr> [<time>ns] [: <ucode>] [: <line>]

Description:

Returns the number <line_n> of the program line and the microcode address <uc_addr> of the current instruction. This command can only be issued when the sequencer is not executing a program. The current instruction is the next to be executed.

If the TIME keyword is passed as parameter and sequencer was stopped after running in stepping mode, the query returns also the execution time in nanoseconds.

The keywords ASM and CODE keywords can be optionally used to request the disassembled microcode of the current instruction and the source code of the corresponding program line respectively.

Example:

Command:	`?INSTR`
Answer:	`4 0x009`
Command:	`?INSTR ASM CODE`
Answer:	`4 0x009 : #JZ 0x00B : IF B == 1 THEN`

IO / ?IO

Set/query logic values of I/O lines

Syntax:

IO { <ioVal> [<ioMask>] | IO*n* | !IO*n* | ~IO*n* | <bitAlias> | !< bitAlias >| ~< bitAlias >} …

Description:

Sets I/O lines to the specified logic values (1's or 0's). The I/O lines can be specified either as bit blocks or by individual identifiers. Only the output lines are affected by this command. If an input line is specified to be set to a certain logic value, the command is accepted but there is no effect.

Blocks of logic lines are specified by pairs <ioVal>, <ioMask> of 16-bit binary values. <ioVal> contains the binary values of the 16 I/O lines, while <ioMask> is a bit mask that selects which lines are actually affected. Only those output lines whose corresponding bits in <ioMask> are 1 are set to the corresponding value in <ioVal>. If <ioMask> is not specified, all the output bits are set to their values in <ioVal>.

Individual bits can be specified either by generic identifiers IO*n* or by valid system alias. If a bit identifier is present in the parameter list with no preceding character, the bit is set to the logic level 1. If the identifier is preceded by a '!' character, the output line is set to the logic level 0. The logic values of output lines can be toggled if their bit identifiers are preceded by the character '~'.

Syntax:

?IO [{IO*n* | <bitAlias> | $IO}] …

Answer:

{0 | 1} …

Description:

Returns the logic values of I/O lines. The values of individual lines are requested by generic identifiers IO*n* or by valid system alias and are returned as the digits 0 and 1. The values of all the I/O lines can be requested by the $IO keyword and are returned as a 16-bit value in hexadecimal format.

More than one bit or $IO block can be requested in the same ?IO query. Values are returned in the same order than requested in the argument list.

Examples:

```
Command:   ALIAS IO4 SHOPEN
Command:   IO !SHOPEN IO2 ~IO1
Command:   IO 0x0003 0x000F
Command:   ?IO SHOPEN $IO IO2
Answer:    0 0x0007 1
```

IOCFG / ?IOCFG

Set/query direction I/O lines

Syntax:

IOCFG <dirMask>

Description:

Sets the direction (input or output) of the I/O lines provided the configuration is not hardware blocked.

The 16 I/O lines are divided in 4 groups of 4 lines and the direction of each group is defined by the 16-bit mask <dirMask>.

Direction setting of each line inside a group is not allowed: all of the 4 lines should be configured either as inputs or outputs. This limits the possible values of <dirMask> to 0x0000, 0x000F, 0x00F0, 0x00FF, 0x0F00, 0x0F0F, 0x0FF0, 0x0FFF, 0xF000, 0xF00F, 0xF0F0, 0xF0FF, 0xFF00 (default value), 0xFF0F, 0xFFF0 and 0xFFFF.

If the n^{th} bit in <dirMask> is set to 1, the n^{th} I/O line is configured as an output. Conversely, a bit set to 0 configures the correspondent I/O line as an input.

Syntax:

?IOCFG

Answer:

<dirMask>

Description:

Returns the direction of the I/O lines as the 16-bit mask <dirMask>. If the n^{th} I/O line is configured as output, the n^{th} bit in <dirMask> is set to 1, otherwise it is set to 0.

Examples:

Command:	`IOCFG 0xFF00`
Command:	`?IOCFG`
Answer:	`0xFF00`

?LIST

Query program code

Syntax:

?LIST [CODE] [NUM] [ERR] [ASM] [PFX] [VAR]

Description:

Returns program currently loaded in the module. The optional flags are:

CODE	- Lists source code lines.
NUM	- Lists line numbers both for source code and disassembled microcode.
ASM	- Lists disassembled microcode.
PFX	- Adds a '+' prefix to all the source code lines
ERR	- Lists program errors.
VAR	- List program variables.

Example:

Command:
```
?LIST CODE ASM NUM
```

Answer:
```
$
MUSST 01.00  -  Current settings:
  NAME "no name"
  SRANGE 0 10
  SPEED 2 50
  INHIBIT OFF LOW
$
```

NAME / ?NAME

Set/query module name

Syntax:

NAME <appName>

Description:

Sets the internal module name to the ASCII string <appName>. This name is only used for identification purposes and user convenience.

The maximum length is 20 characters.

Syntax:

?NAME

Answer:

<appName>

Description:

Returns the application name field.

Examples:

Command:	`NAME DEV01`
Command:	`?NAME`
Answer:	`DEV01`
Command:	`NAME "Main Synchro Unit"`
Command:	`?NAME`
Answer:	`Main Synchro Unit`

NOECHO

Cancel echo mode

Syntax:

NOECHO

Description:

Switches the echo mode off. See the ECHO command for more details. Only applies for serial line communication.

Example:

Command: `NOECHO`

RESET

Module reset

Syntax:

RESET [DEFAULT]

Description:

With no parameters this command reinitialises the module keeping the current configuration. With the DEFAULT parameter it also resets the internal configuration and the non-volatile memory to default values.

Examples:

Command: `RESET`

?RETCODE

Query exit or stop code

Syntax:

?RETCODE [LAST]

Answer:

{<retCode> | <bkpN> | <errMsg>}

Description:

If the module is coming from an EXIT or STOP statements, this query returns the exit or stop code <retCode>. If there was not return code it returns an empty string.

If the module is in the BREAK state, ?RETCODE returns the breakpoint number <bkpN>. If it is in ERROR state, this query returns the string <errMsg> describing the error condition.

If the LAST keyword is used, the query returns the value returned by the last EXIT or STOP statements.

Example:

Command: `?RETCODE`

Answer: `23`

RUN

Execute program

Syntax:

RUN [<entryPoint>] [<nBreakP>]

Description:

With no parameters this command starts execution of the main program loaded in the module. The main program is the “anonymous” one with no name defined in the PROG declaration. By default, execution starts at the first line of the program.

The <entryPoint> parameter is a program name or a program label that indicates the point from where the execution should be carried out.

The program execution is stopped by breakpoints. However, a defined number of breakpoints can be skipped during the execution by means of the <nBreakP> parameter.

Examples:

Command: `RUN MYPROG 5`

RUNCT

Run counters

Syntax:

RUNCT [<ctTime>]

Description:

Starts the system timer, all the counting channels and the MCA. All the counting channels are previously cleared.

If the counting time <ctTime> is specified, the counters run for that time. The counting time <ctTime> unit is given by the system timer timebase. If no counting time is specified, the system waits for an external gate signal applied to the front panel *TRIG in* connector.

A 100ns pulse is generated at *TRIG out A* in both beginning and end of counting time. In its turn, *TRIG out B* is set to high logic level during the counting time.

Examples:

Command: `RUNCT 1000000`

SSICFG / ?SSICFG

Set/query the configuration of SSI input channels

Syntax:

SSICFG {CHn|<alias>} [*nb*] [*fclk*] [*delay*] [{ACTIVE|PASSIVE}] [{BINARY|GRAY}] [*stb*]

where *fclk* is one of:

{25MHZ | 12.5MHZ | 5MHZ | 2.5MHZ | 1.25MHZ | 500KHZ | 250KHZ | 125KHZ}

and *delay* one of:

{NODELAY | 5US | 10US | 20US | 30US | 50US | 100US | 500US}

Description:

Sets the configuration parameters for an SSI input. The SSI mode requires that a daughter board with the required capabilities is installed for the particular channel and that the mode has been selected by means of the CHCFG command.

The number of data bits is set to *nb* and the coding to either BINARY or GRAY. The interface can be configured in ACTIVE or PASSIVE modes. When the channel is set in active mode, MUSST generates the transfer clock that is sent to the external device. The clock frequency is set to *fclk* and the time delay between data frames is set to *delay*. In passive mode MUSST only listens to the clock and data lines and both *fclk* and *delay* have no effect.

The pattern of status bits is described by the string *stb*. The string must include as many dot ('.') characters as status bits are in the SSI frame (from 1 to 8). Certain dot characters in the string *stb* may be substituted by the 'S', 'E' or 'O' to instruct MUSST to process the stop or parity bits. The last character corresponds always to the stop bit and if it is represented by 'S' in the status bit string, the stop bit is checked at every data frame. If one of the other status bits is a parity bit, it may be used to check the data integrity. In the case that there is a parity bit and it is identified in the string *stb* either by the 'E' or 'O' characters, a parity check is performed to verify the data integrity. The parity is assumed to be even or odd depending on which of the two characters is used..

Syntax:

?SSICFG {CHn | <alias>}

Answer:

nb fclk delay* {ACTIVE | PASSIVE} {BINARY | GRAY} *stb

Description:

Returns the configuration of the SSI interface for channel CH*n*.

Examples:

```
Command:   SSICFG CH3 24 PASSIVE ..S
Command:   ?SSICFG CH3
Answer:    24 5MHZ NODELAY PASSIVE BINARY ..S
Command:   SSICFG CH3 100US GRAY E..
```

?STATE

Query module state

Syntax:

?STATE [RETCODE]

Answer:

<state> [{<retCode> | <bkpN> | <errMsg>}]

Description:

Returns the current state of the module as one of the following strings:

State	Meaning
NOPROG	No program loaded in the sequencer
BADPROG	Program loaded in the module but not valid (errors or incomplete).
IDLE	Program loaded in the sequencer and ready to run.
RUN	Program running.
BREAK	Program stopped at a breakpoint.
STOP	Program halted at a STOP line, by a STOP command or after stepping.
ERROR	Program exception occurred (stack overflow, array index out of bounds).

The RETCODE keyword can be used to request the associated return code. Depending on the current state of the module, the return code will be the exit or stop code <retCode>, the breakpoint number <bkpN> or the error message <errMsg> as it would be returned by the ?RETCODE query.

Example:

```
Command:    ?STATE
Answer:     IDLE
Command:    ?RETCODE
Answer:     327
Command:    ?STATE RETCODE
Answer:     IDLE 327
```

STEP

Step program

Syntax:

STEP [{<nLines> | -<nInstr>}]

Description:

Executes program in stepping mode for <nLines> program lines or <nInstr> microcode instructions.

Examples:

Command: `STEP`

Command: `STEP 10`

Command: `STEP -1`

STOP

Stop program execution

Syntax:

STOP

Description:

Stops program execution. Execution can be continued by the CONT command.

Examples:

Command:	`RUN`
Command:	`?STATE`
Answer:	`RUN`
Command:	`STOP`
Command:	`?STATE`
Answer:	`STOP`
Command:	`CONT`
Command:	`?STATE`
Answer:	`RUN`

TIMER / ?TIMER

Set/query main timer value

Syntax:

TIMER [<newValue>] [{RUN | STOP}]

Description:

Loads the system timer with the value <newValue>. This command can also be used to start or stop the timer by means of the RUN and STOP keywords.

Syntax:

?TIMER

Answer:

<value> {RUN | STOP}

Description:

Returns the current timer value an its running state.

Examples:

Command:	`TIMER 0 STOP`
Command:	`?TIMER`
Answer:	`0 STOP`
Command:	`TIMER RUN`
Command:	`?TIMER`
Answer:	`1897446 RUN`

TMRCFG / ?TMRCFG

Set/query main timer timebase

Syntax:

TMRCFG {1KHZ | 10KHZ | 100KHZ | 1MHZ | 10MHZ | 50MHZ}

Description:

Selects the frequency of the timebase used by the system timer.

Syntax:

?TMRCFG

Answer:

{1KHZ | 10KHZ | 100KHZ | 1MHZ | 10MHZ | 50MHZ}

Description:

Returns the current timebase used by the system timer.

Examples:

Command:	`TMRCFG 1MHZ`
Command:	`?TMRCFG`
Answer:	`1MHZ`

?VAL

Query channels, timer and/or I/O values

Syntax:

?VAL [{TIMER | CHn | IOn | <alias> | $IO | $MCA | $ALL} …]

Answer:

Answer: <value> …

Description:

The ?VAL query returns current values of the system timer, the input channels or the I/O lines. The query arguments are treated as a list of requested values. ?VAL returns the current values in the same order as they are present in the argument list.

Input channel and I/O lines can be specified either by means of generic identifiers CH*n* and IO*n*, or by system aliases. The system timer must be specified by the built-in alias TIMER.

The full block of I/O lines can be requested as a single 16-bit value by means of the $IO keyword.

The $MCA keyword can be used to request the following 4 values related to MCA acquisition: the system timer, the total number of MCA counts, the MCA lifetime and the MCA deadtime. The last three correspond to input channels configured in MCA, MCALT and MCADT modes respectively. See the CHCFG command for details. If no channels are configured in any of those modes, the corresponding value is returned by the ?VAL query is -1. If more that one input channel is configured in the same MCA related mode, something that is probably useless but possible, only the value of the first one is used.

The $ALL keyword can be used as a shortcut to request the values of the system timer and all the input channels and I/O lines. In practice the $ALL keyword returns 8 values and is equivalent to the sequence: TIMER CH1 CH2 CH3 CH4 CH5 CH6 $IO.

?VAL queries with no arguments are interpreted as ?VAL $ALL.

Examples:

Command: `?ALIAS`

Answer:
```
$
CH1 PHI
IO3 SHCMD
$
```

Command: `?VAL CH3 IO11 TIMER SHCMD`

Answer: `87363543 0 16738372 1`

Command: `?VAL`

Answer: `16738372 14564 -5353667 0 87363543 34556 0 0x0F70`

Command: `?VAL PHI $IO`

Answer: `-5353667 0x0F70`

Command: `?VAL $MCA`

Answer: `16738372 34556 -1 -1`

VAR / ?VAR

Write/read program variables

Syntax:

VAR <varName> <varValue>

VAR <arrayName>[*array_range*] {*value_list* | *function*(par, …)}

Description:

Loads the program scalar variable <varName> with the value <varValue> or a range of the array <arrayName> with a set of values.

Array ranges are specified by subarray syntax in the form of *array*[<i>:<f>] where <i> and <f> are the first and last elements of the array range to load. If <i> and <f> are not specified, the whole array is loaded.

A program array can be loaded either by a list of values or by the result of evaluation of an initialisation function. The list of values is a comma separated set of numbers delimited between curly brackets. The number of values in the list must match the number of array elements to load.

Array initialisation functions require as arguments at least the first and last value to load in the array range. It calculates the intermediate values following the appropriate functional dependence. Initialisation functions may need additional arguments. The available functions are:

`FILL(<v0>, <v1>)` - Fills the array or subarray with values uniformly distributed between <v0> and <v1>.

`BRAGG(<th0>, <th1>, <th0deg>)` - Assumes that the array or subarray is to be loaded with values corresponding to the diffraction angle of a crystal that must fulfil the Bragg law. The angle goes from <th0> to <th1> in MUSST units, that should always be integer numbers. The module fills the array or subarray with angle values that correspond to constant photon energy intervals. The BRAGG() function requires an additional floating point argument <th0deg> that must correspond to the initial angle <th0> but expressed in degrees.

Syntax:

?VAR {<varName> | <arrayName>[*array_range*]}

Answer:

<varValue> or a multiline answer with all the values of the subarray elements.

Description:

Returns the current value of the program variable <varName> or a range of elements of the array <arrayName>[].

Examples:

```
Command:    ?VARINFO MYVAR
Answer:     1 SIGNED
Command:    VAR MYVAR -55
Command:    ?MYVAR
```

Answer: -55

Command: ?VARINFO MYARR

Answer: 10 UNSIGNED

Command: ?VAR MYARR[2:5]

Answer:
```
$
0
0
0
0
$
```

Command: VAR MYARR[2:5] FILL(30, 40)

Command: ?VAR MYARR[2:5]

Answer:
```
$
30
33
37
40
$
```

VARINFO

Query variable information

Syntax:

?VARINFO <varName>

Answer:

<nElem> [[ALIAS {TIMER | CH*n* | IO*n*}] {SIGNED | UNSIGNED | BOOLEAN}]

Description:

Returns the number of data elements <nElem> of the program variable <varName> and its type. The number of elements is 1 for scalar variables and the corresponding vector length for arrays.

If the variable is a program or system alias, the ?VARINFO query returns the ALIAS keyword and the channel or I/O line identifier.

Examples:

Command:	`?VARINFO MYARR`
Answer:	`10 UNSIGNED`
Command:	`?VARINFO PHI`
Answer:	`1 ALIAS CH2 SIGNED`

VARINIT

Reset program variables

Syntax:

VARINIT [<varName> …]

Description:

Forces the unit to reload the list of program variables <varName> with their initial values. Variables with no explicit initial value are set to zero.

If the list of variables is missing, the VARINIT command reloads all the variables in the current program.

Examples:

Command: `VARINIT MYVAR1 MYVAR2`

Command: `VARINIT`

?VER

Query firmware version

Syntax:

?VER

Answer:

MUSST XX.YYa

Description:

Returns the version number XX.YY of the firmware.

Example:

Command: `?VER`

Command: `MUSST 01.00`

Appendix A. MUSST COMMAND QUICK REFERENCE

CONFIGURATION

ALIAS {CH*n* | IO*n* | <alias>} <new_alias>
ALIAS CLEAR [{CH*n* | IO*n* | <alias>}]
?ALIAS [{CH*n* | IO*n* | <alias>}]
Define/delete/query system aliases

TMRCFG {1KHZ | 10KHZ | 100 KHZ | 1MHZ | 10MHZ | 50MHZ}
?TMRCFG
Set/query the timebase of the main timer

CHCFG {CH*n* | <alias>} [*chan_source*] [*options*] [ALIAS [<new_alias>]]
?CHCFG {CH*n* | <alias>}
Set/query the configuration of input channels

SSICFG {CH*n*|<alias>} [*nbit*] [*clk*] [*delay*] [{ACTIVE|PASSIVE}][{BINARY|GRAY}] [<stbts>]
?SSICFG {CH*n* | <alias>}
Set/query the configuration of SSI input channels

IOCFG <dir_mask>
?IOCFG
Set/query the direction of the input/output TTL lines

CH {CH*n* | <alias>} [<new_value>] [{RUN | STOP}]
?CH {CH*n* | <alias>}
Set/query input channel values and state

TIMER [<new_value>] [{RUN | STOP}]
?TIMER
Set/query the main timer value and state

IO {<ioval> [<iomask>], IO*n*, !IO*n*, ~IO*n*, <alias>, !<alias>}, ~<alias>} ......
?IO [{IO*n* | <bitalias>} ...]
Set/query the logic values of the TTL I/O lines

BTRIG {0 | 1}
?BTRIG
Set/query the logic value of the TRIG B output signal

?VAL [{TIMER | CH*n* | IO*n* | <alias> | $IO | $MCA | $ALL} ...]
Query channel, timer and/or IO values

?INFO
Query the summary of the module configuration

?DBINFO [*]
Query the list of installed daughter boards

DBCMD {CH*n* | <alias>} [{RESET | SSIRAW | SSINORMAL | OUT {0|1} | REG <add> <val>}]
Execute daughter command specific command

PROGRAM CONTROL

CLEAR
Delete the current program

+*program_line*
Add a new code line to the current program

?LIST [CODE] [PFX] [ASM] [NUM] [ERR] [VAR]
List the current program and/or variables

RUN [<entry_point>] [<n_bkp>]
Execute program and skip <n_bkp> breakpoints (default is 0)

STOP
Stop program execution

CONT [<n_bkp>]
Continue program execution and skip <n_bkp> breakpoints (default is 0)

ABORT
Abort program execution

?RETCODE [LAST]
Query the exit or stop code

?STATE [RETCODE]
Query the current module state. Possible states are:

NOPROG	- No program is loaded in the sequencer
PROG	- A program is loaded in the unit but not in the sequencer
IDLE	- A program loaded in sequencer
RUN	- The loaded program is running
BREAK	- The program is stopped at a breakpoint
STOP	- The program is stopped (after STOP, breakpoint, STEP instruction, …)
ERROR	- A program exception occurred (stack overflow, ...)

VAR <var_name> <value>
VAR <array_name>[<range>] {*value_list* | *function*(pars, ...)}
?VAR <var_name>
?VAR <array_name>[<range>]
Initialise/read program variables. Sub-array syntax and initialisation functions (FILL(), BRAGG(), …) are allowed

EVENT {ENABLE | DISABLE | FORCE} **?EVENT** Enable/disable/force event generation
INCR [<cnt>] Increment counters configured in SOFT mode
RUNCT [<timer_cts>] Run the main timer, counters and multichannel scaler for <timer_cts> or driven by an external gate

DEBUGGING

STEP [<entry_point>] {<n_lin> | -<n_inst>} Step the program by <n_lin> program lines or <n_inst> microcode instructions
BREAK {ADD [<line>] | {CLEAR | ENABLE | DISABLE} [{<bkn> | ALL}]} **?BREAK [<bkn>] [ASM] [CODE]** Manage/list breakpoints
?INSTR [CODE] [ASM] Query the current program instruction
?VARINFO <var_name> Query the dimension and the type of the variable <var_name>
VARINIT [<var_name> …] Forces the unit to reset a list of variables to their initial values

DATA BUFFERS

ESIZE <buffer_size> [<n_of_buffers>] **?ESIZE** Set/query the size and number of memory buffers allocated to event storage.
HSIZE <buffer_size> [<n_of_buffers>] **?HSIZE** Set/query the size and number of memory buffers allocated to MCA storage.
EBUFF [<buffer_no>] **?EBUFF** Set/ query the buffer number currently selected for event storage
HBUFF [<buffer_no>] **?HBUFF** Set/query the buffer number to be used for MCA storage
EPTR [<data_point> [<buffer_no>]] **?EPTR** Set/query the data point and buffer number to be written at the next event storage
?EDAT <nval> [<buffer_n> [<first_addr>]] **?*EDAT <nval> [<buffer_n> [<first_addr>]]** Read <nval> values from <buffer_n> in the event storage memory area
?HDAT <nval> [<buffer_n> [<first_addr>]] **?*HDAT <nval> [<buffer_n> [<first_addr>]]** Read <nval> values from <buffer_n> in the histogram storage memory area
DFORMAT [{HEXA | DEC}] [{NOSWAP | BSWAP | WSWAP | WBSWAP}] **?DFORMAT** Set/query the format of the ?EDAT, ?*EDAT, ?HDAT, ?*HDAT commands
HMEMCLR [{ON | OFF}] {FULL | [<first_buffer> [<last_buffer]]} **?HMEMCLR** Set/query the autoclear mode (ON or OFF) for access to the histogram memory or clear the specified histogram memory buffers

SYSTEM

RESET [DEFAULT] Module reset
?VER Query the firmware version
?HDWVER Query the hardware version as “x.y.z / a.b”
NAME **?NAME** Set/query the module name
?HELP Query the list of available commands
?ERR Query last error
ECHO **NOECHO** Select/cancel echo mode
ADDR **?ADDR** Set/query the serial line address
?CHAIN Query the secondary serial port status
GPIB [<addr>] [{x1 | x10}] **?GPIB** Set/query the GIPB address and/or the bus load
ICB <icb_address> <databyte> **?ICB <icb_address>** Write/read a single data byte to from the ICB bus

Appendix B. COMMUNICATION PROTOCOL

This section covers the communication protocol implemented in a number of instruments developed in the Instrument Support Group at the ESRF. An instrument that adheres to this protocol and conventions is referred as an *isgdevice*. The information is presented here in a generic way and most of the information applies to any *isgdevice*. Some of the options, like GPIB communication or binary transfer, may not be implemented in a particular instrument and therefore the related information should be ignored.

B.1. Communication port

An *isgdevice* is equipped with one or more communication ports. A communication port may be an asynchronous serial line or a GPIB interface. The type and number of ports as well as the electrical interface (RS232 or RS422) depend on the particular instrument.
In the most general case an *isgdevice* is equipped with a RS232 port, a RS422 port and a GPIB interface.

B.1.1. Serial line ports

Serial line ports are asynchronous serial ports electrically compatible with either the RS232 or RS422 specification. In most of the *isgdevices* there are two serial ports available, one of each type. Any of the ports can be used to communicate with the host computer.

The primary port is the one through which the *isgdevice* receives commands and requests. There is no special configuration procedure to select the primary port. After power-up the device listens to all the available ports and the first one it receives valid data through is selected as primary. All other ports are treated as secondary.

A secondary serial line port in an *isgdevice* can be used to connect another *isgdevice*. In this way an unlimited number of *isgdevices* can be connected in a daisy chain configuration and controlled from a single primary communication port. The following figure shows an example of a host computer communicating to three different devices using this feature.

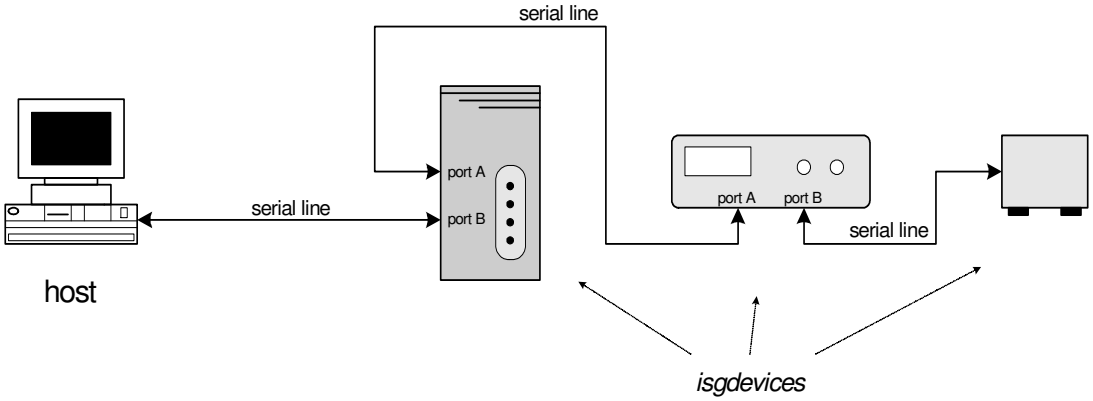


Figure 7: isgdevices

The serial ports operate at the following settings:

Baudrate	9600
Parity	NO
Stop bits	1

In normal mode command and response messages are transferred as lines of printable ASCII characters. The only exception is binary transfer, a special feature described in B.6 only supported by a few *isgdevices*.
Commands messages sent to an *isgdevice* by a serial port must be formatted as sequences of printable characters terminated by a "*carriage return*" (ASCII 0x0D). Additional control characters, like "*line feed*", are ignored.
Response messages produced by the device consist on lines terminated by a "*carriage return*" + "*line feed*" character sequence (ASCII 0x0D 0x0A).

B.1.2. GPIB interface

Some *isgdevices* include a communication interface compliant with the GPIB (IEEE-488.1) standard. Every *isgdevice* with this type of interface has a default GPIB address. The procedure for changing the address as well as the default value depends on the type of device. The addressing conventions and characters described in B.2.2 only apply to serial line communication and should not be used when the *isgdevice* is accessed by its GPIB interface.

Command messages sent to the device must be always terminated by an EOI bus signal or a terminator character. Both characters "*carriage return*" (ASCII 0x0D) and "*line feed*" (ASCII 0x0A) may be used as message terminators.

Response messages produced by the device when it is addressed as talker consist on lines terminated by a "*carriage return*" + "*line feed*" character sequence (ASCII 0x0D 0x0A) as in the case of serial lines. The EOI bus signal is activated with the last character of every message line.

B.2. Syntax conventions

In the most usual case remote control is implemented by an application program running in a host computer that sends commands and requests to the *isgdevice* as sequences of ASCII characters. The syntax rules are described below. See B.5 for practical examples.

B.2.1. Commands and requests

- Command lines consist of a command keyword optionally followed by parameters.
  - The number and type of parameters depend on the particular command.
  - The way a command line is terminated depends on the type of communication port (see B.1).
- Command keywords are not case sensitive.
  - The device converts internally all the characters to uppercase before any syntax checking.
  - Parameters are also converted to uppercase unless they are enclosed between double quotes (″″, ASCII 0x22).
- Commands may be optionally preceded by the acknowledge character.
  - The acknowledge character is a hash symbol (`#`, ASCII 0x23) that must appear in the command line immediately before the first character of the command keyword.
- Normal (non query) commands never produce response messages unless the acknowledge character is used.
  - Non query command keywords always start by an alphabetical character (A to Z). Exceptions are binary transfer commands (see B.6) that start by an asterisk character (*, ASCII 0x2A).
  - If the acknowledge character is used, the device produces the response string `OK` if the command execution was successful.
  - If the acknowledge character is used and the command does not executes successfully, the device produces either the string `ERROR` or a string containing a human readable error message. The behaviour depends on the current setting of the *echo* mode (see B.4).
- Requests are query commands that produce response messages from the device.
  - Requests keywords always start by a question mark character (`?`, ASCII 0x3F).
  - If the request is successful the content of the response message depends on the particular request.
  - If request fails the device produces either the string `ERROR` or a string containing a human readable error message. The behaviour depends on the current setting of the *echo* mode (see B.4).
  - The acknowledge character has no effect when used with requests.
- Response messages consist of one or more ASCII character lines.
  - The way every line in a response message is terminated depends on the type of communication port (see B.1).
  - A response message may contain either the output of a request, an acknowledgement keyword (`OK` or `ERROR`) or a human readable error message.
  - When a response message consists of more than one line, the first and last lines contain a single dollar character (`$`, ASCII 0x3F).

B.2.2. Addressing

- The addressing features allow to dialogue with more than one *isgdevice* connected by the serial line ports in a daisychain configuration (see B.1.1). All the addressing prefixes and characters described in this section do not apply for GPIB communication and should not be used in that case.
  - If the command line does not include any addressing character, the command is accepted and executed by the first device in the communication chain.

- Commands and requests may be preceded by any number of skip characters and/or an addressing prefix.

- The skip character is the “greater than” symbol (`>`, ASCII 0x3E) and can be used to address an *isgdevice* placed at a given physical position in the communication chain.
  - When a device founds a skip character as the first character of a command line, it ignores the content of the line and forwards the remaining characters to the next device in the communication chain.
  - If a host computer connected to a chain of *isgdevices*, sends a command line starting with *n* skip characters, the *n* first devices in the chain will ignore the command. The command line with the skip characters removed will be forwarded to the *n*+1 device in the chain.

- An addressing prefix consists of an optional alphanumerical address string followed by a colon character (`:`, ASCII 0x3A).
  - The address string must start by a numeric character (0-9) and consists of any combination of numbers and alphabetical (A-Z) characters.
  - A command line with an address string will be interpreted and executed only by the first device in the communication chain whose internal address matches the one in the address string.
  - Once one of the devices recognises the address string as its own, the command line will not be further forwarded to the remaining devices in the chain.
  - Leading zeros in the address string are ignored for identification purposes but can be used to access *isgdevices* whose internal address begins with a non-numeric character.

- An addressing prefix consisting of only the colon character (`:`) with no address string is interpreted as a broadcast command. In that case the command line is forwarded to all the devices in the communication chain.

B.3. Common commands

The following commands are implemented in all *isgdevices* regardless of their specific functionality:

Command	Description
ECHO	Activates the *echo* mode. Must be used only in interactive mode with dumb terminals (see B.4).
NOECHO	Cancels the *echo* mode. Echo mode should not be active when the device is controlled by a computer program (see B.4).
?ERR	Returns the error message corresponding to the last command or request issued to the device. Returns the keyword OK if no error happened during the last command.
ADDR <devaddr>	Sets the module address to the string <devaddr>. Any leading zeroes are removed from <devaddr>. It can be formed by any combination of up to 9 alphanumerical characters.
?ADDR	Returns the current address of the device. If no address has been set, returns an empty string.
?CHAIN	Returns the status and type of the secondary communication port. The status indicates if there is another *isgdevice* connected to the secondary port by the strings YES or NO. The port type is one the strings: NONE, RS232, RS422, BOTH
NAME <devname>	Sets the module private name to the string <devname>. <devname> may include any combination of up to 20 printable characters, including whitespaces.
?NAME	Returns the current module private name.
?VER	Returns the type of isgdevice and its firmware version as a string in the form: <type> XX.YY
?HELP	Returns a list of the available commands

B.4. Terminal mode

When an *isgdevice* is accessed through a serial port (primary port), two possible communication modes are available that can be selected with the commands `ECHO` and `NOECHO`. The differences between these two modes are described below. If the primary port is not a serial port (GPIB interface), the device accepts the `ECHO` and `NOECHO` commands but it always responds as if it were set in the noecho mode.

Echo mode (terminal mode)

This mode should be used when an *isgdevice* is connected to a dumb terminal. In this case the user types commands on the keyboard and reads the answers and error messages on the terminal screen without computer intervention. This mode is usually not active by default and the user has to send the `ECHO` command every time the device is powered on.

In echo mode all the characters sent to the device are echoed back to the terminal. The device also sends human-readable messages to be printed on the terminal screen whenever an error is detected in commands or requests.
Case conversion takes place before the characters are sent back to the terminal, therefore characters are echoed back as uppercase even if they are typed and sent to the device as lowercase.
The backspace character (ASCII 0x08) has the effect of deleting the last character received by the device. In this way a minimum editing functionality is provided.

Noecho mode (host computer)

This is usually the default. In this mode no characters are echoed and no error messages are returned unless they are explicitly requested by means of the `?ERR` request. This mode is intended to be used when a program running in a host computer communicates with the controller, sending commands and analysing the answers.

B.5. Examples

In the following examples it is assumed that the device is in “noecho” mode.

Commands and requests

#1	Command: Answer:	NOECHO *…no answer…*	Sets the device in “noecho” mode
#2	Command: Answer:	?VER MOCO 01.02	Queries the type and version number of the device.
#3	Command: Answer:	NAME “My Device“ *…no answer…*	Sets the private name of the device. There is no response message.
#4	Command: Answer:	#NAME “My Device“ OK	If the acknowledge character is used, the device produces an “OK” response message

Errors

#5	Command: Answer:	?ERR OK	If no error happened during the last command or request.
#6	Command: Answer:	? VER ERROR	Errors in requests (extra white space in this case) always produce a response message.
#7	Command: Answer:	?ERR Command not recognised.	If an error happened, returns the corresponding error message.
#8	Command: Answer:	NAME *…no answer…*	Errors in commands (missing parameter in this case) do not produce response messages.
#9	Command: Answer:	#NAME ERROR	If the acknowledge character is used, the device produces a response message.
#10	Command: Answer:	?ERR Wrong Number of Parameter(s).	If an error happened, returns the corresponding error message.

Addressing (assumes daisy chaining of at least three *isgdevices*)

#11	Command: Answer:	:NOECHO *…no answer…*	Sends the NOECHO command to all the devices in the chain (broadcast).
#12	Command: Answer:	?ADDR 12	Queries the address of the first device in the communication chain.
#13	Command: Answer:	>>?ADDR LFT3	Queries the address of the third device in the chain (skips the first two devices in the chain).
#14	Command: Answer:	12:?VER MOCO 01.02	Queries the version of the device with address “12”.
#15	Command: Answer:	0LFT3:?VER OPIOM 01.00	Queries the version of the device with address “LFT3”.
#16	Command: Answer:	>>?VER OPIOM 01.00	Queries the version of the third device in the chain.

B.6. Binary transfer

Binary transfer is a special mode that extends the standard protocol allowing faster data transfer. Most of the *isdevices* do not implement binary transfer and therefore this section is not relevant to them. Binary blocks have a maximum size of 65535 data bytes (0xFFFF).

Binary transfer commands or requests are initiated by ASCII command lines that follow the same rules than ordinary commands or requests (see B.2.1). The only difference is that binary transfer command lines must include an asterisk character (*, ASCII 0x2A) in the command or request keyword. Non-query commands keywords must start by an asterisk character. Request keywords must include the asterisk as the first character after the question mark.

Once the *isgdevice* has received the ASCII command line, the data is transferred as a binary block. In the case of non-query commands, the binary data block is sent from the host computer to the device. In case of binary requests, the device sends the binary block to the host (serial line) or puts it in its output buffer ready to be read by the host (GPIB).

If the device finds an error in a command line containing a binary request, instead of the binary block, it produces the string `ERROR`.
The acknowledge character (`#`, ASCII 0x23) can be used in the same way that with non-binary commands. If it is included in a non-query command line, the device produces an acknowledgement keyword (`ERROR` or `OK`) to signal if the command line contained errors or not. The acknowledge character has no effect in the case of binary requests.

Although binary transfer is initiated in the same way for both serial line and GPIB communication, the format of the binary data blocks and the management of the end of transfer condition are different in both cases.

B.6.1. Serial port binary blocks

In the case of transfer through a serial port, the binary block contains the binary data and 4 extra bytes. The structure of the block is the following:

byte Number	content
0	0xFF (signature)
1	DataSize (MSB)
2	DataSize (LSB)
3	data byte (first)
…	…
DataSize + 2	data byte (last)
DataSize + 3	Checksum

The first byte contains always the value 0xFF (255) and can be used the signature of the block. The next two bytes contain the number of data bytes to transfer. The last byte contains the check sum value that is used to verify data integrity.

The checksum value is calculated as the lower 8-bits of the sum of all the bytes in the binary block with exception of the signature byte (and the checksum byte itself).

B.6.2. GPIB binary blocks

In the case of transfer by GPIB the binary block does not contain any additional control or protocol byte. Only the actual data bytes are transferred. The EOI line is asserted during the transfer of the last data byte to signal the end of the transmission.

Appendix C. ELECTRICAL DESCRIPTION

C.1. Digital I/Os

A simplified diagram of one digital input/output circuit is depicted in the figure below. There are 16 of such circuit in a MUSST module.

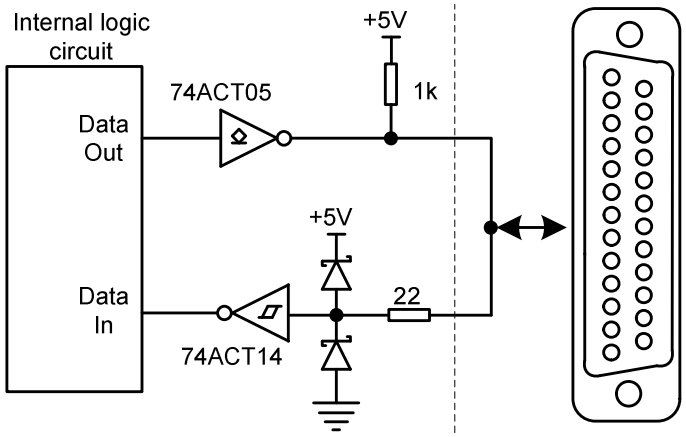


Figure 8: MUSST single digital input/output internal diagram

Despite the fact that the inputs and outputs are associated with logical inverters, the user does not need to take it into account since the internal logic circuit makes the necessary conversions.

C.2. Input channels

The next figure depicts a single MUSST digital differential input. Each MUSST channel has 3 of these circuits and the pairs of input signals are identified as *IN0+*, *IN0-*, *IN1+*, *IN1-*, *IN2+* and *IN2-*. For analogue signals, see Table 5.

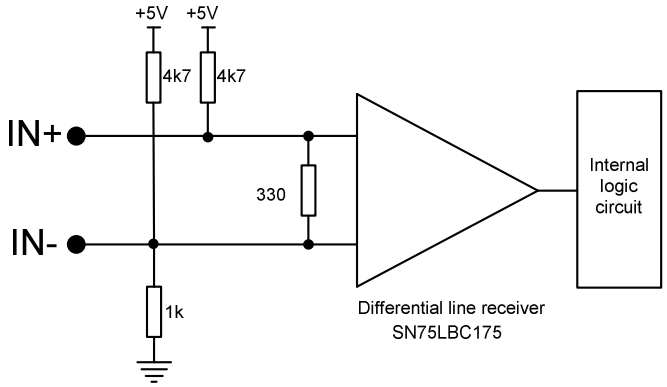


Figure 9: MUSST digital differential input

For single-ended TTL signals, one should use the input IN+ and the ground, keeping IN- open. The following table summarises the input signals configurations.

Table 10: input signals configurations

digital input type	digital input connection
differential	use inputs IN+ and IN-
single-ended TTL	use input IN+ and GND, keep IN- open

C.3. Rear panel *TRIG*

The figure below depicts the internal structure of this signal.

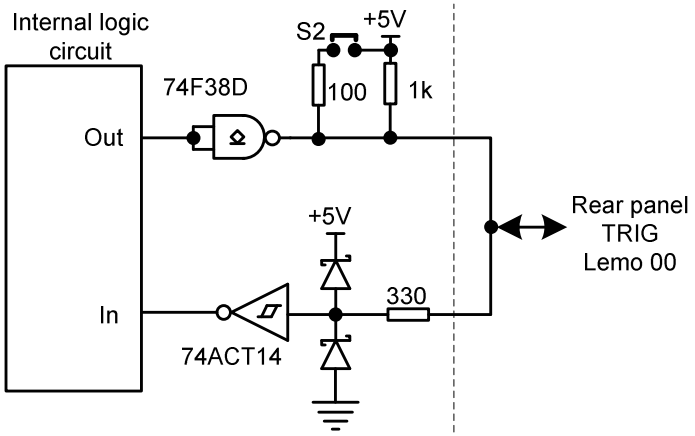


Figure 10:Rear Panel TRIG signal internal diagram

Note that the pull-up resistance value can be changed by means of the S2 strap located on the internal board.

C.4. Spectroscopy ADC and ICB

The next table gives a brief description of this interface signals. Note that the direction is given for MUSST side, i.e., “input” means that that signal is an input for MUSST.

Table 11: Canberra® data interface signals description

Signal	Direction	Description
ADC00 – ADC15	input	ADC data bus
READY	input	Data Ready – ADC indicates that data is available to transfer
ENDATA	output	Enable Data – MUSST enables ADC 3-state buffers to deliver data into the data bus
ACEPT	output	Data Accepted – MUSST signals the ADC that the data has been accepted
INB	input	Inhibit – ADC signals that the data available to transfer is to be discarded but the transfer cycle should be terminated.
ENC	output	Enable Converter – MUSST enables or disables the ADC.
CDT	input	Composite Dead Time – indicates that the ADC or the associated amplifier is busy and cannot accept another input event. MUSST uses this signal to gate the internal dead time counter.

The figure below depicts the timing diagram of the communication between MUSST as an Acquisition Module for Multi-Channel Analysing applications and a commercial spectroscopy ADC using the Canberra® data interface. Note that all the signals are active low.

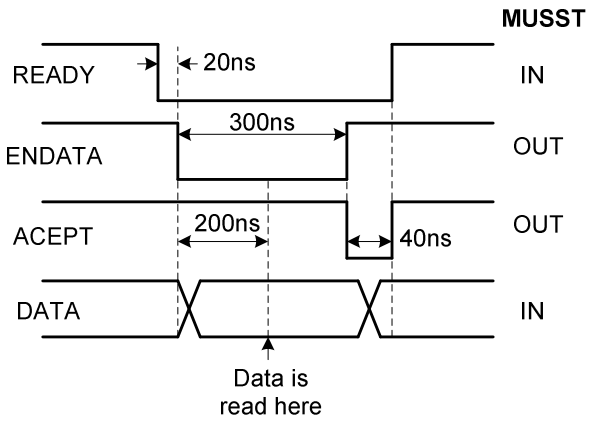


Figure 11: Spectroscopy ADC data interface timing diagram

The next figure gives an overview of how signals of this interface are treated internally. The figure shows one input and one output of this interface.

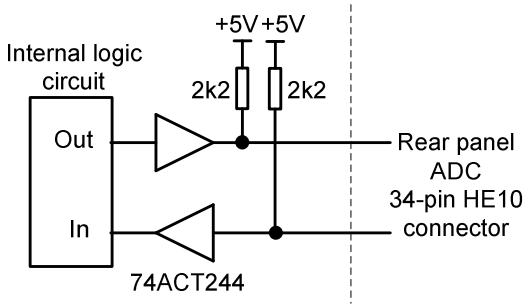


Figure 12: MUSST spectroscopy ADC interface internal implementation

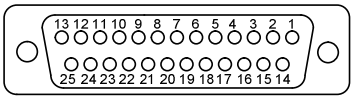
Appendix D. CABLING SUMMARY

The MUSST cabling diagrams are summarised in this Appendix for quick reference purposes.

D.1. Trigger signals and auxiliar channel inputs

Lemo® coaxial 00-series: FFS.00.250.NTCE24

D.2. Digital I/Os

Digital Inputs/Outputs		
Front panel *25-pin female sub-D connector*  front view		
Pin	**Signal**	**Default Direction**
1	I/O 0	INPUT
2	I/O 1	
3	I/O 2	
4	I/O 3	
5	I/O 4	
6	I/O 5	
7	I/O 6	
8	I/O 7	
9	I/O 8	OUTPUT
10	I/O 9	
11	I/O 10	
12	I/O 11	
13	I/O 12	
15	I/O 13	
18	I/O 14	
21	I/O 15	
24, 25	+5V (200mA max.)	
14, 16, 17, 19, 20, 22 and 23	ground	

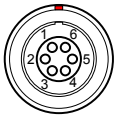
D.3. Input channels

Channel input signals plug		
cable Ø (mm)		
max.	min.	Lemo® 1B series part number
4.0	3.1	FGG.1B.306.CLAD42
5.0	4.1	FGG.1B.306.CLAD52
6.0	5.1	FGG.1B.306.CLAD62
7.0	6.1	FGG.1B.306.CLAD72
7.5	7.1	FGG.1B.306.CLAD76

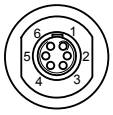
MUSST input signals (external connection for the user)

front panel socket

Lemo® ENG.1B.306.CLL



front view



rear view

plug for the front panel socket

Lemo® 1B series FGG.1B.306.CLADxy (xy depends on cable diameter: see table above)

rear view

Pin	Signal
1	IN0+
2	IN0-
3	IN1+
4	IN1-
5	IN2+
6	IN2-
ground tag/shield	ground

MUSST input signals cabling

plug for the front panel socket
Lemo®
FGG.1B.306.CLADxy
(xy depends on cable diameter: see table above)

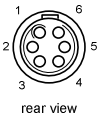
rear view

signal type / mode	single-ended signals		differential signals	
	signal	**plug pin**	**signal**	**plug pin**
up	counter up	1	counter up +	1
			counter up -	2
	gate	3	gate +	3
			gate -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
down	counter down	1	counter down +	1
			counter down -	2
	gate	3	gate +	3
			gate -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
up-down with direction	counter up-down	1	counter +	1
			counter -	2
	direction	3	direction +	3
			direction -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
up-down with two inputs	counter up	1	counter up +	1
			counter up -	2
	counter down	3	counter down +	3
			counter down -	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
quadrature (counter or encoder)	counter 0°	1	counter 0°+	1
			counter 0°-	2
	counter 90°	3	counter 90°+	3
			counter 90°-	4
	preset	5	preset +	5
			preset -	6
	ground	shield	ground	shield
analogue signals (check daughter card manual)	signal	3	signal+	3
			signal-	4
	ground	4 + shield	ground	shield

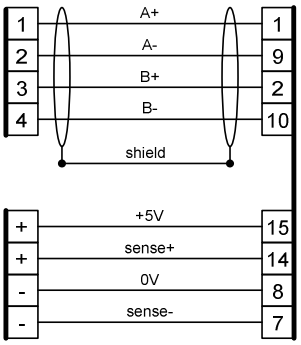
MUSST incremental encoder adapter cable

(using ESRF incremental encoder standard pin-out)

LEMO
FGG.1B.306.CLAD76
(cable Ø: 7.1 to 7.5 mm)

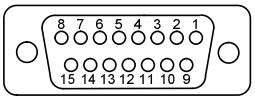


rear view



5V
power supply

15-pin female Sub D
connector

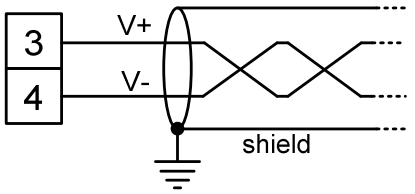


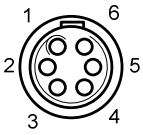
female - front view

MUSST analogue inputs (when using daughter cards)

LEMO®
FGG.1B.306.CLAD76
(cable Ø: 7.1 to 7.5 mm)

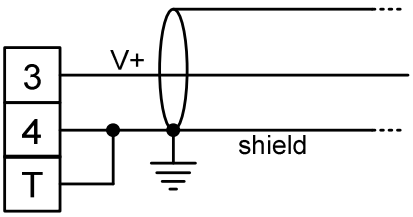
Differential signal





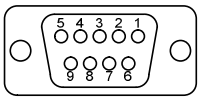
rear view

Single-ended signal



T - earthing tag

D.4. Serial line



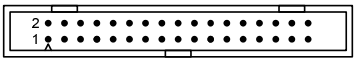
Female 9-pin Sub D

Pin	Port	Signal	Direction
2	RS232	TXD	OUT
3		RXD	IN
5	common	GND	-
8	RS422	TXD+	OUT
9		TXD-	OUT
6		RXD+	IN
7		RXD-	IN

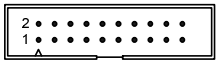
D.5. Spectroscopy ADC

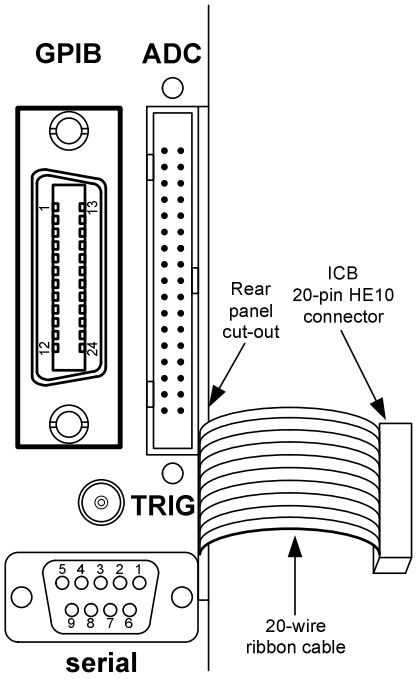
Canberra®
Spectroscopy ADC data interface

Rear panel spectroscopy ADC
34-pin HE10 Canberra® data interface connector



Pin	Signal	Pin	Signal
1	GND	2	ACEPT
3	GND	4	ENDATA
5	GND	6	CDT
7	GND	8	ENC
9	GND	10	READY
11	GND	12	INB
13	NC	14	ADC00
15	ADC07	16	ADC01
17	ADC08	18	ADC02
19	ADC09	20	ADC03
21	ADC10	22	ADC04
23	ADC11	24	ADC05
25	ADC12	26	ADC06
27	ADC14	28	ADC15
29	NC	30	NC
31	NC	32	NC
33	NC	34	ADC13

Canberra® ICB Instrument Control Bus			
Rear panel Instrument Control Bus  			
Pin	**Signal**	**Pin**	**Signal**
1	GND	2	LD0 (data)
3	LD1 (data)	4	GND
5	LD2 (data)	6	LD3 (data)
7	GND	8	LD4 (data)
9	LD5 (data)	10	GND
11	LD6 (data)	12	LD7 (data)
13	GND	14	LWE (write enable)
15	GND	16	LDS (data strobe)
17	GND	18	LAS (address strobe)
19	GND	20	NC



MUSST ICB cable	
20-wire ribbon cable	length: mm
20-pin female HE10 connector	3M Part Number: 3421-6600 Tyco Part Number: 1437024-7 Tyco Part Number: 0-0746285-4 Harting Part Number: 09185206803
Molex® 20-pin Milli-Grid female connector	Molex Part Number: 51110-2050
Molex® Milli-Gird contacts for female connector	Molex Part Number: 50394-8100
Molex® Milli-Grid crimp tool	Molex Part Number: 69008-0959

Appendix E. ACCESSORIES

- *MUSST Extender*

MUSST digital I/Os cabling adapter: 25-pin Sub D to BNC.
Simplifies cabling of digital signals by using standard BNC connectors.

- *MUSST ICB cable*

Canberra® ICB cable to connect a spectroscopy ADC to MUSST.
Spectroscopy ADCs can be programmed by MUSST through the ICB interface.

- *MUSST ADC1*

MUSST 2-channel 16-bit 40kHz sampling ADC daughter card.
Input range selectable among: +/-5V, +/-10V and 0-10V.

- *MUSST UDC*

MUSST 2-channel “universal” daughter card.
Analogue input range selectable among: +/-5V, +/-10V and 0-10V.
Can communicate with external devices (absolute encoders) through a serial synchronous interface (SSI).