User's guide
H-1000-5108-01-A

RENISHAW
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MIH-S

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Renishaw part no: H-1000-5108-01-A

Issued: 08 2005

MIH-S

manual indexable head - serial

user’s guide

CE

FCC (U.S.A)

Information to user (FCC Section 15.105)

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the installation manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case you will be required to correct the interference at your own expense.

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The user is cautioned that any changes or modifications not expressly approved by Renishaw plc or authorised representative could void the user's authority to operate the equipment.

Special accessories (FCC Section 15.27)

The user is also cautioned that any peripheral device installed with this equipment such as a computer, must be connected via a high-quality shielded cable to ensure compliance with FCC limits.

Care of equipment

Renishaw probes and associated systems are precision tools used for obtaining precise measurements and must therefore be treated with care.

Changes to equipment

Renishaw reserves the right to improve, change or modify its hardware or software without incurring any obligations to make changes to Renishaw equipment previously sold.

Warranty

Renishaw plc warrants its equipment provided that it is installed exactly as defined in associated Renishaw documentation.

Prior consent must be obtained from Renishaw if non-Renishaw equipment (e.g. interfaces and/or cabling) is to be used or substituted for Renishaw equipment. Failure to comply with this will invalidate the Renishaw warranty.

Claims under warranty must be made from authorised service centres only, which may be advised by the supplier or distributor.

Patents

The features of Renishaw's manual indexable head and associated products are the subject of the following patents, patent applications and registered designs.

EP 0392660

JP 3,018,015

US 5,088,337

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Contents

1 Introduction

This document is a description of the system design and features of the serial version of the Renishaw MIH (manual indexable head).

1.1 Product summary

The MIH-S (manual indexable head - serial) is a derivative of the established MIH design with enhanced functionality to provide feedback of status and lock position over a serial communications link.

The main aims of the provision of this feedback are to enable the CMM computer to:

- verify that the MIH-S has been moved to a preselected position and locked in place correctly.
- identify any position which the MIH-S is locked into.

Feedback to the CMM computer is in the form of RS232 communications, provided via a separate interface unit which also supplies power to the MIH-S unit. This interface unit is called the MIH-SI (manual indexable head - serial interface).

The MIH system meets all relevant regulations to attain the CE marking and to enable the product to be sold without restriction throughout the global market for the foreseeable future.

NOTE: The MIH-SI does not perform any specific probe interfacing functions, a separate probe interface must be used with the system.

2 MIH-SI (manual indexable head - serial interface)

The MIH-S interfaces with the CMM computer via a separate interface unit - The MIH-SI.

The MIH-SI is a standard 19” rack mountable unit, ⅓ wide by 1U high, compatible with Renishaw’s current design (i.e. PI 200 style laminated front panel).

Dimensions:

Width: 140 mm

Height: 45 mm

Depth: 180 mm

All connections are via the rear panel.

The front panel has LED indicators for the following information:

- Power
- Communications activity
- Communications error

3 Communications

The MIH-S communicates with the MIH-SI using RS485 synchronous protocol.

The CMM computer communicates with the MIH-SI using RS232 communications protocol standards.

No information is sent from the MIH-SI to the RS232 communications link unless it has been specifically requested by the device attached to that link.

3.1 Communications protocol

RS232 communications protocol options are set using a bank of eight internal switches in the MIH-SI. The switches are accessed by removing the top cover of the MIH-SI.

Baud rate	SW1	SW2	SW3
300	On	On	On
600	Off	On	On
1200	On	Off	On
2400	Off	Off	On
4800	On	On	Off
9600	Off	On	Off

Switch	On (disable)	Off (enable)
SW6	1 stop bit	2 stop bits
SW7	No CTS protocol	CTS protocol
SW8	No line feed protocol	Line feed protocol

Serial data transmission is in the following format:

1 start bit

7 data bits

1 or 2 stop bits (set using SW7)

Even parity

NOTE: The factory default communications setting is 9600 baud, 1 stop bit, no CTS, no LF.

4 Command set

4.1 Introduction

The command set has been designed to encompass all general features required for the manual head feedback (e.g. axis positions) and also promotes the use of the specific commands for specialised features.

The MIH-SI interface provides protocol conversion from asynchronous RS232 communications used by the CMM to the synchronous RS485 format by the head microcontroller.

The MIH-S can store 20 memory positions. In each of the 20 memory positions are an A-axis and a B-axis position. The memory positions can be recalled in a particular sequence by storing the memory position number in the appropriate sequence position. There can be 20 sequence positions, but the last sequence position must be an end of sequence marker*, and therefore cannot contain a memory position. The MIH-S is capable of dumping (writing) or reloading (reading) either the memory positions or the sequence positions to and from the CMM.

When the MIH-SI receives a command such as ‘dump memory positions’ it will obtain all the positions from the head before sending them to the CMM. Likewise when reloading the memory positions, the interface will obtain all positions from the CMM before sending them to the head. When dumping memory positions (or sequence positions) the CMM must send a memory number (or sequence number) as a parameter request. The interface will also supply a memory or position number when the positions are being reloaded. If the CMM user wishes to check that the positions loaded to the MIH-SI have been received without error, the CMM should request a memory dump, providing the CMM with memory details which can be used to compare positions.

The MIH-SI will respond to XON / XOFF commands but will not generate them.

* The ‘end or sequence’ marker is equal to 20.

4.2 Head commands

The definition of the command and response <WORD> are given in section 4.6. Commands are divided into 'groups'. The third character of each command is used by the controller to identify the command group and enable the efficient command processing. A comparison table has been generated to show the commands used with the PH9 / PH10 motorised head and the PH50 motorised head with respect to the MIH-S.

4.2.1 CMM to head command - responses

Command description	**MIH-SI**
Position command	
Send new A and B axis target positions.	TARGET POSITION WORD (ref. 4.6.8)
Simple mode commands	
Enter target mode	MuAUT
Dump memory positions	MuMMD
Load memory positions	MuMML
Dump sequence positions	MuMSD
Load sequence positions	MuMSL
Target mode commands	
Exit target mode	MuMAN
Memory transfer commands	
Request next memory position	PARAMETER REQUEST (ref. 4.6.6)
Request next sequence position	PARAMETER REQUEST (ref. 4.6.6)
Memory transfer responses	
Memory position	PARAMETER WORD (ref. 4.6.7)
Sequence position	PARAMETER WORD (ref. 4.6.7)
Data commands	
Request head software version	PARAMETER WORD (ref. 4.6.6)

NOTES:

- "u" is the unit address (default ASCII zero) of a similar product - see section 4.6.1.2).
- POSITION is the A and / or B axis positions for the PH9 / PH10.
- Parameter ident code is a two character ASCII code to identify a particular head parameter.

4.2.2 Head to CMM responses

Message description	MIH-SI
Command responses	
Memory position	PARAMETER WORD (ref. 4.6.7)
Sequence position	PARAMETER WORD (ref. 4.6.7)
Invalid position sent	RESPONSE WORD (ref. 4.6.4)
Valid position sent	RESPONSE WORD (ref. 4.6.4)
Obstruct error	STATUS WORD (ref. 4.6.9)
All mode commands	RESPONSE WORD (ref. 4.6.4)
Head parameter requested	PARAMETER WORD (ref. 4.6.7)
Command not accepted	RESPONSE WORD (ref. 4.6.4)
Command not recognised	RESPONSE WORD (ref. 4.6.4)
Transmission error*	RESPONSE WORD (ref. 4.6.4)
Data responses	
Request next memory position	PARAMETER REQUEST (ref. 4.6.6)
Request next sequence position	PARAMETER REQUEST (ref. 4.6.6)
End of memory transfer	RESPONSE WORD (ref. 4.6.4)

* Transmission errors are comms errors such as parity error, overrun, etc.

4.3 System interface commands

The following commands are handled by the system interface, in this case the MIH-SI. The second character in the command defines its relevance. Those relevant to the manual heads use “M” as the second character and general system interface commands use “G”.

4.3.1 CMM to system commands

Command description	MIH-SI
Head system commands	
Request system status	SMSTA
Read interface software version	SGVER

4.3.2 System to CMM responses

Command description	MIH-SI
Request system status	STATUS WORD (ref. 4.6.9)
Controller software version number	VERSION WORD (ref. 4.6.9)

NOTE: <VERSION> is the software version number in xx.xx format.

4.4 Terminators

The command and response terminators are defined in the table below:

Command terminator	MIH-SI
Commands (CMM - INTERFACE)	<CR>
Responses (INTERFACE - CMM)	<CR>

When using serial communications, the system interface will not send any line feed. Any line feed received will be ignored and will not generate an error.

4.5 Head parameters

The following table lists the manual head parameters currently defined along with their parameter ident codes:

Head parameter	Parameter ident code
Head software version	VR
Memory position number	MP
Sequence number position	SP

4.6 Definitions

4.6.1 Response format

All of the responses have the first two characters in common. These will always by **pu** where:

p = product designator

u = unit address

The responses from the MIH-S to the CMM will also have a response code - **r**.

4.6.1.1 Product designator (p)

The product designator defines the type of product to which the command is addressed. System interface is the unit to which the CMM communication link is connected.

- M = manual head
- S = system interface

4.6.1.2 Unit address (u)

The unit address determines which of a number of similar products connected to the CMM, the command is intended for (e.g. M0AUT requests head 0 to enter target mode, M3AUT requests head 3 to enter target mode). The unit address of the system interface will always be zero. The default value of 0 will be used in a response when only one of a particular product type is present.

4.6.1.3 Response code (r)

The response code will only be sent by the MIH-S to the CMM. The CMM will not send these codes as it is the controlling device. The response code is defined as a single integer representing the following:;

0	Command received and understood	5	Communications error
1	Incorrect number of parameters sent	6	Undefined
2	One or more parameters out of range	8	Undefined
3	Command not recognised	6	Undefined
4	Command not accepted	9	Unsolicited message (unexpected message)

4.6.2 POSN WORD

All positions should be sent in the following format:

A[<sign>]<Angle>B[<sign>]<Angle>

The angle must include one number after the decimal (i.e. ".0" or ".5"). If no decimal or more than one is sent a "command not recognised" error will be generated. Leading zero's must be sent with either axis up to a maximum of three before the decimal point to ensure that the units, tens and hundreds are not confused. Failure to supply these leading zero's or the addition of more than three will cause "command not recognised" error.

4.6.3 POSN NUM

Sequence or memory position numbers should be sent to the interface or CMM in the following format:

<Number>

Where **number** is the value of the memory or sequence position requested in ACSII format. If the position is a "memory position number" the **number** must be between **00** and **19**. If the "memory position number" is being sent as part of a sequence position then the **number** can be **20**. This indicates that the sequence position that contains this number is an "end of sequence" marker. If the position is a "sequence position number" the **number** must be between **01** and **20**. Leading zero's are required to maintain the length of the word.

4.6.4 RESPONSE WORD

The "response word" defines all or part of the response from the MIH-S to the CMM. The "response word" comprises three characters:

- The product designator (**p**)
- The unit address (**u**)
- The response code (**r**)

The product designator will indicate the source of the response and may be "S", in which case the unit address will always be zero.

4.6.5 RESPONSE TYPE

The “response type” is a single, upper-case ASCII character used to identify the type of word:

A	Parameter word
D	Parameter request
N	Target position word
S	Status word
V	Version word

Examples of use are shown in 4.6.6 and 4.6.9.

4.6.6 PARAMETER REQUEST

This will either be sent as a request for the CMM or MIH-S to send parametric data.

The “parameter request” will be sent to the MIH-S from the CMM in the following format, which will invoke the MIH-S to respond with a “parameter word”:

pu<Type><aa><Value>

Type is the “response type” as defined in section 4.6.5.

aa is the identifier of the requested parameter (see section 4.5).

Value is the value of the parameter requested in ASCII format.

Example: **M0DSP12** (Request for sequence position 12)

<Value> may or may not be present in the “parameter request”.

The “parameter request” will be sent to the CMM from the MIH-S in the following format, which will invoke the CMM to respond with a “parameter word”:

pu<Type><aa><Value>

Example: **M00DMP15** (Request for memory position 15)

<Value> will only be present during memory transfer, and will be a “POSN_NUM”. The absence of **<Value>** in other cases will not generate an error.

This request only occurs while transferring memory contents.

4.6.7 PARAMETER WORD

The response to a “parameter request” by the MIH-S to send parametric data from the CMM will be in the following format:

pu<Type><aa><Value>

Type is the “response type” as defined in section 4.6.5.

aa is the identifier of the requested parameter (see section 4.5).

Value is the value of the parameter requested in ASCII format.

This response in only generated while transferring memory contents.

Example: **M0DSP12** (Sequence position 12)

The response to a “parameter request” by the CMM to send parametric data from the MIH-S will be in the following format:

pu<Type><aa><Value>

Example: **M00AVR01.01** (Head software version number)

If transferring memory positions **<Value>** will be a “POSN_WORD”. If transferring sequence positions **<Vaue>** will be “POSN_NUM”.

4.6.8 TARGET POSITION WORD

The “target position word” can be sent from the CMM when the MIH-S is confirmed to be in target mode or at the previous target position. The length of the “target position word” is fixed and the format is:

pu<Type><POSN_WORD>

Type is the response type as defined in section 4.6.5.

Example: **M0NA+105.0B-112.5**

4.6.9 STATUS WORD

The “status word” is a fixed length string of response characters which comprise the product designator, the unit address, the response code, a string of status characters and the axis positions as shown. The “status word” is terminated by a carriage return, i.e. **pur<Type>*SHOAR*<POSN_WORD>** where the status characters, *SHOAR* have the meanings designated in the table below. The number and sequence of the characters is fixed with significance as shown below. **Type** is the response type as defined in section 4.6.5.

Handset status is only present to preserve the length of the status word in line with the PH50 protocol.

The head status part of the status should be interpreted as follows:

- If the status is ‘at target position’ (P) then the head is ‘locked’, there is no datum error and the head is not ‘obstructed’.
- If the status is ‘locked’ (C) then the head is not ‘at target position’, there is no datum error and the head is not obstructed.
- If the status is ‘unlocked’ (Y), then the head is not ‘at target position’, there is no datum error and the head is not obstructed.
- If the status is ‘datum error’ (D) then the head is not ‘at target position’, the ‘lock / unlock’ state is unknown, as is ‘obstruct’ state.
- If the status is ‘obstructed’ (O) then the head is not ‘at target position’ and the ‘lock / unlock’ state is unknown, a ‘datum error’ will follow if the head is locked in this position.

‘Service status’ will always be indeterminate as the MIH-SI will not supply any service information, and is only present to preserve the length of the “status word” in line with the PH50 protocol.

Example: M00SRHTP*A+097.5B-007.5

This would indicate that the system is in automatic mode, the handset is absent (always true with the MIH-S), the MIH-S head is in target mode and it is locked in the target position.

Status word				
Character	**Character name**			
p	Product designator			
u	Unit address			
r	Response code			
Type	Response type = S			
		Code	**Interpretation**	**PH50 equivalent?**
S	System mode	R	Auto mode	Yes
		X	Head absent	Yes
		*	Indeterminate	No
H	Handset status	H	Handset absent	Yes
O	Head mode	A	Auto mode	No
		T	Target mode	No
		*	Indeterminate	Yes
A	Head status	P	At target position	No
		C	Head locked	Yes
		Y	Head unlocked	Yes
		D	Datum error	Yes
		0	Head obstructed	Yes
		*	Indeterminate	Yes
R	Service status	*	Indeterminate	Yes
A±xxx.x	A axis position			
B±xxx.x	B axis position			

4.6.10 VERSION WORD

The “version word” will be sent from the MIH-SI to the CMM as a response to a request for the controller software version number. The format will be:

pu<Type><Version>

Type is the response type as defined in section 4.6.5.

Version is the software version number in xx.xx format.

Example: S00V01.05

4.6.11 Target mode operation

Target mode will operate as follows:

- The CMM will send a command for the head to enter target mode.
- The MIH-SI will respond with a “response word”.
- The CMM should now request the status to check that the MIH-S has entered target mode.
- If the MIH-S is in target mode then the CMM should send the first target position.
- The MIH-S will respond with a “response word”.

The CMM allows sufficient time for the operator to move the MIH-S into the target position and then request the status. If the “head status” is at “target position” the CMM should send the next target position, otherwise it should wait for a short while before requesting the status again. The MIH-S will update the target position when it is unlocked and then locked.

The MIH-S will only exit target mode after it receives the command from the CMM, or if the MIH-SI power supply is lost.

The following diagram is an example of how target mode should be used. This example sends a “target position” from the CMM. The CMM requests the system status until it receives confirmation that the MIH-S is in the “target position”.

The CMM commands the MIH-S to enter target mode.
The MIH-SI response indicates that the command was received and understood.

The CMM requests the system status.
The status that is received indicates that the MIH-S is in target mode.

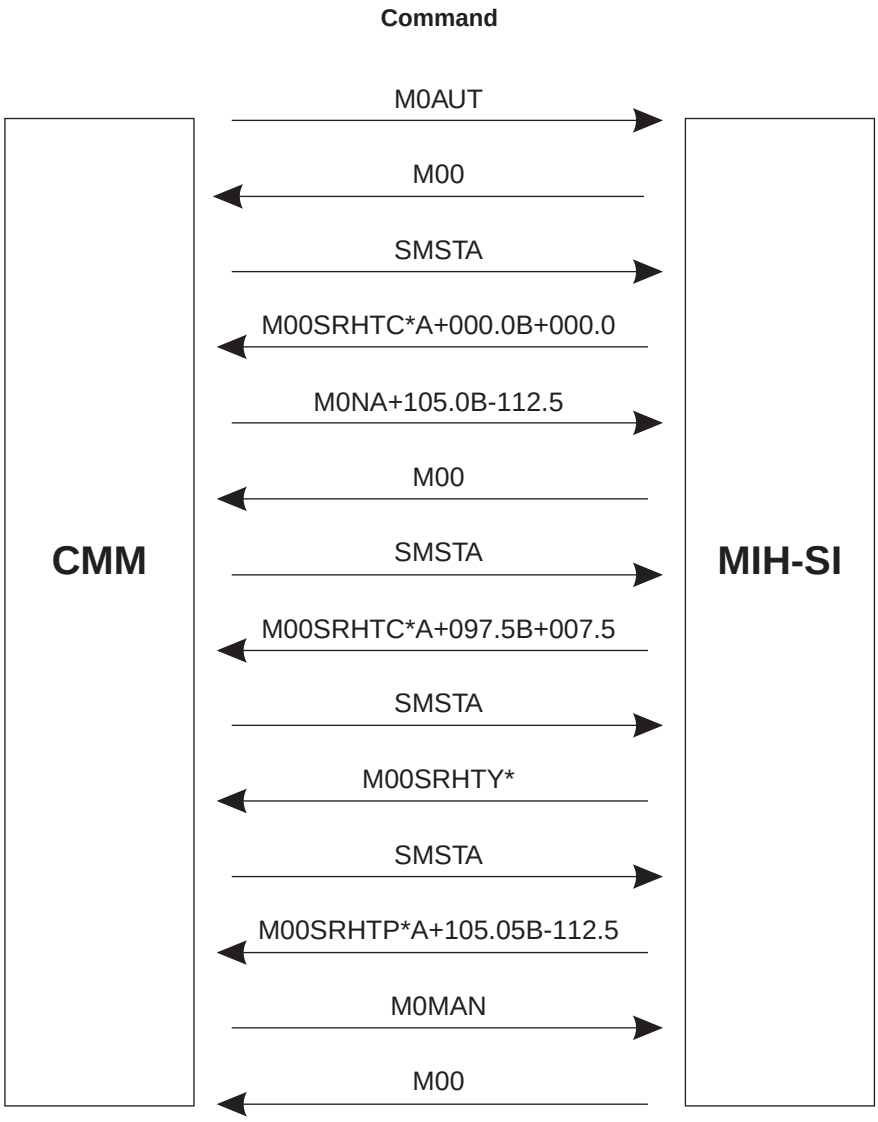
The CMM sends the target position A+105.0, B+112.5 to the MIH-S.
The MIH-SI response indicates that the command was received and understood.

The CMM requests the system status.
The status received indicates that the MIH-S is locked in the wrong position.

The CMM requests the system status.
The status received indicates that the MIH-S is unlocked. The position is not supplied with the status because it is unknown.

The CMM requests the system status.
The status indicates that the head has been locked at the target position. The next target position could be sent now.

The CMM commands the MIH-S to exit target mode.
The MIH-SI response indicates that the command was received and understood.


Command
CMM
MIH-SI
M0AUT
M00
SMSTA
M00SRHTC*A+000.0B+000.0
M0NA+105.0B-112.5
M00
SMSTA
M00SRHTC*A+097.5B+007.5
SMSTA
M00SRHTY*
SMSTA
M00SRHTP*A+105.05B-112.5
M0MAN
M00

4.6.12 Memory dump operation

The “memory dump” will operate as follows:

- The CMM will send the request for the memory dump.
- The MIH-S will respond with a “response word”.
- The MIH-SI will now obtain all memory positions from the MIH-S so the CMM should allow sufficient time for this to happen.
- The CMM should now request the first “memory position” in the format of a “parameter request”.
- The MIH-SI will respond with the first memory position.
- The CMM should now send a request for the next memory position. On receiving this position it should request the next position.
- This process should be repeated until all memory positions have been receive (“sequence dump” operation is very similar).

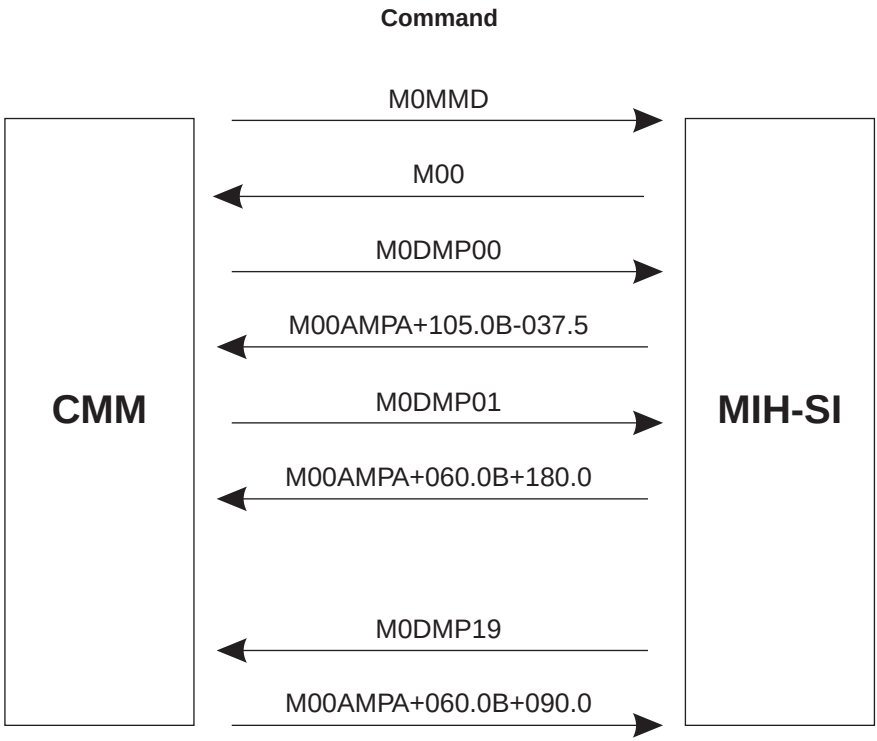
The next diagram gives an example of how the memory dump should be executed.

The CMM sends the request to “dump memory positions”.
The MIH-SI response indicates that the command was received and understood.

The CMM requests memory position ‘00’ (the first memory position).
The MIH-SI responds with memory position ‘00’.

The CMM requests memory position ‘01’ (the second memory position).
The MIH-SI responds with memory position ‘01’.

This is repeated until all the memory positions have been transferred (memory position ‘19’ is the last memory position).


Command
M0MMD
M00
M0DMP00
M00AMPA+105.0B-037.5
CMM
M0DMP01
MIH-SI
M00AMPA+060.0B+180.0
M0DMP19
M00AMPA+060.0B+090.0

4.6.13 Memory load operation

The “memory load” will operate as follows:

- The CMM will send the request for the memory load.
- The MIH-SA will respond with a request for the first memory position in the format of a “parameter request”.
- The CMM should now send the first “memory position” in the format of a “parameter word”.
- The MIH-SI will then request the second “memory position”.
- The CMM should now send the second “memory position”.
- This process should be repeated until all the memory positions have been received (“sequence load” operation is very similar).

The diagram below gives an example of how the memory load should be executed:

The CMM send the request to “load memory positions”.
The MIH-SI requests memory position ‘00’ (the first memory position).

The CMM send memory position ‘00’.
The MIH-SI requests memory position ‘01’ (the second memory position).

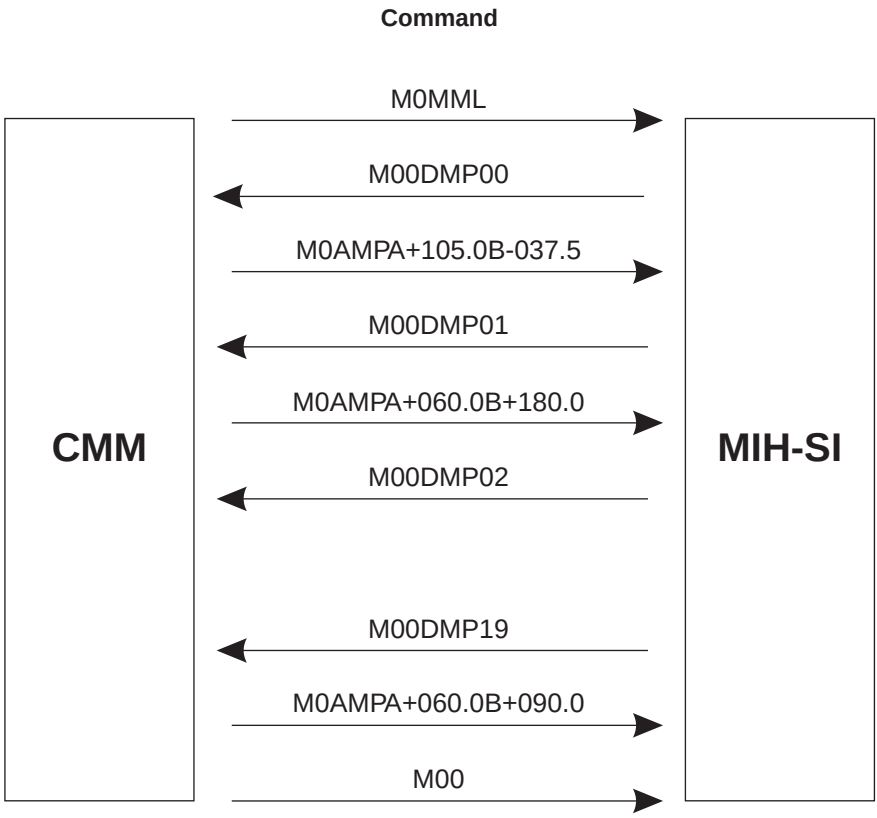
The CMM sends memory position ‘01’.
The MIH-SI requests memory position ‘02’.

This is repeated until memory position ‘19’ is reached.

The MIH-SI requests memory position ‘19’ (the last memory position).
The CMM sends the final memory position.

The MIH-SI responds with a “response word”.

The memory transfer between the CMM and the MIH-SI is now complete. The MIH-SI will now send the memory positions to the MIH-S. This will take approximately one minute.


Command
M0MML
M00DMP00
M0AMPA+105.0B-037.5
M00DMP01
M0AMPA+060.0B+180.0
M00DMP02
M00DMP19
M0AMPA+060.0B+090.0
M00
CMM
MIH-SI

5 Power

5.1 MIH-SI power

The MIH-SI is powered by an external DC 12 V - 30 V supply, connected via a 2.5 mm DC power socket on the rear panel.

5.2 MIH-S power

The MIH-SI supplies power to the MIH-S in place of the standard battery power when it is connected. Selection of either internal (battery) or external (MIH-SI) power is automatic on disconnection of the MIH-SI.

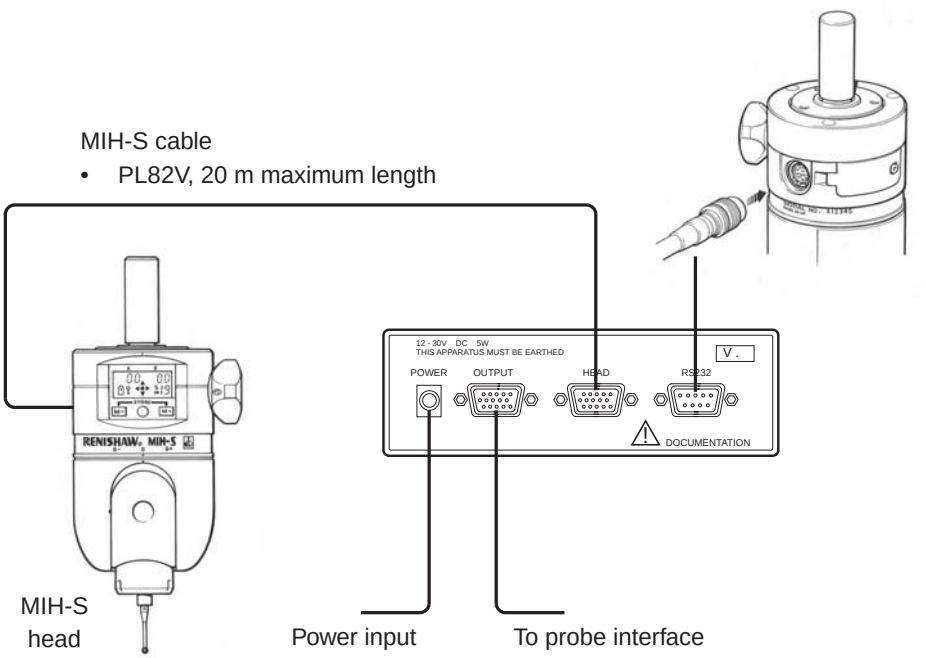
If a battery is fitted to the MIH-S, then if the MIH-SI is disconnected or switched off the positions of the encoders are retained (i.e. redatuming of the MIH-S is not required on return of MIH-SI power).

The full battery operated capabilities of the MIH have been retained, allowing it to operate as a stand-alone unit.

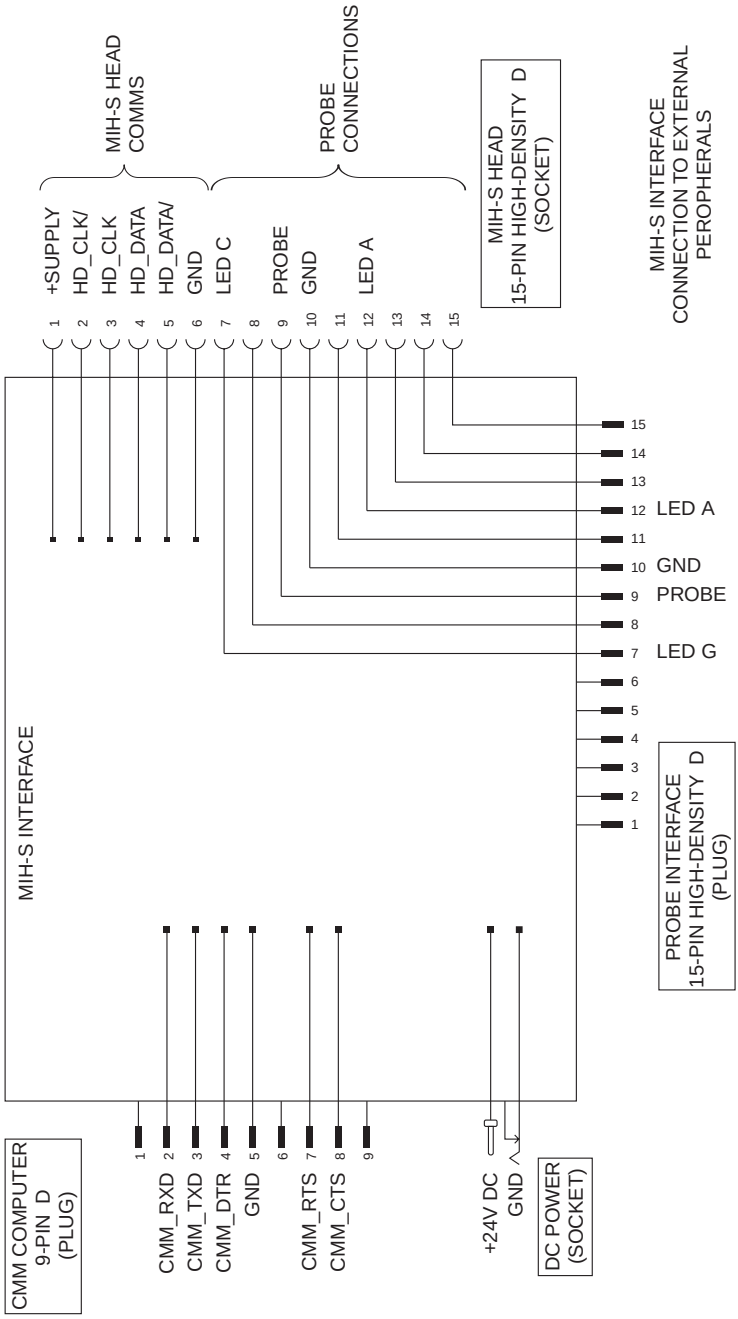
RS232 communication is not available unless the MIH-SI is connected and powered.

6 Connections and signal routing

6.1 System connections



6.2 Connection diagram - MIH-S to MIH-SI



Maximum cable length = 20 m

Cable PL82V (5 m) can be sued to connect the MIH-S to the MIH-SI

6.4 MIH-SI to CMM computer

Standard 9-pin D-type is used to RS232 connection to the MIH-SI.

A standard PC compatible RS232 cable is required.

9-way D-type pin number	Signal
1	-
2	RXD (received data)
3	TXD (transmitted data)
4	DTR (data terminal ready)
5	GND
6	-
7	RTS (request to send signal)
8	CTS (clear to send signal)
9	-

6.5 Probe interfacing

The MIH-SI does not perform any specific probe interfacing functions, a separate probe interface must be used with the system.

The external probe interface is connected to the MIH-SI via a 15-way, high-density D-type connector. Probe and LED control signals are routed directly through the MIH-SI to the MIH-S.

Spare pins on the interface and head connectors have been connected together and routed directly through the MIH-SI to allow extra, non-Renishaw probe signals to be passed through the CMM to the end of the quill.

See section 6.2 for connection diagram and signal routing information.

7 Modes of operation

7.1 Manual mode

In manual mode the MIH-S retains all the functionality of the standard MIH modes and is operated in the same manner as the MIH.

Power may be supplied to the MIH-S either by the MIH-SI or by the internal battery.

The MIH-S may or may not be connected to the MIH-SI.

7.2 Serial mode

Serial mode is only available when the MIH-S is connected to the MIH-SI and is selected using the RS232 communications link on the MIH-SI.

Using the MIH-S system in serial mode enables the following features to be used by the CMM:

- MIH-S status request
  - Head state
    - Locked
    - Unlocked
  - Datum status
    - Datum OK
    - Datum lost
- Current position request
  - If locked
    - A axis
    - B axis
  - If unlocked
    - Status

- Target mode
  - Send target position to MIH-S
  - Request head status
    - Locked in target position
      - A axis
      - B axis
    - Locked in incorrect position
      - A axis
      - B axis
    - Unlocked
  - Clear target position

- Memory mode
  - Read contents of MIH-S memory including sequence memory
  - Load MIH-S memory with position data including sequence memory

- Diagnostics
  - Automatic self-test of MIH-S system is initiated on power up
  - LCD displays manual self test functions as per standard MIH

- Error trapping is provided to identify and signal unrecognised commands received from the CMM computer

7.3 Target mode

Target mode is one of the features available in serial mode. This section gives further explanation of its use.

1 At the appropriate point in the part program the CMM sends the command to enter target mode.

2 While in target mode the CMM polls the MIH-SI at regular intervals for the status of the MIH-S.

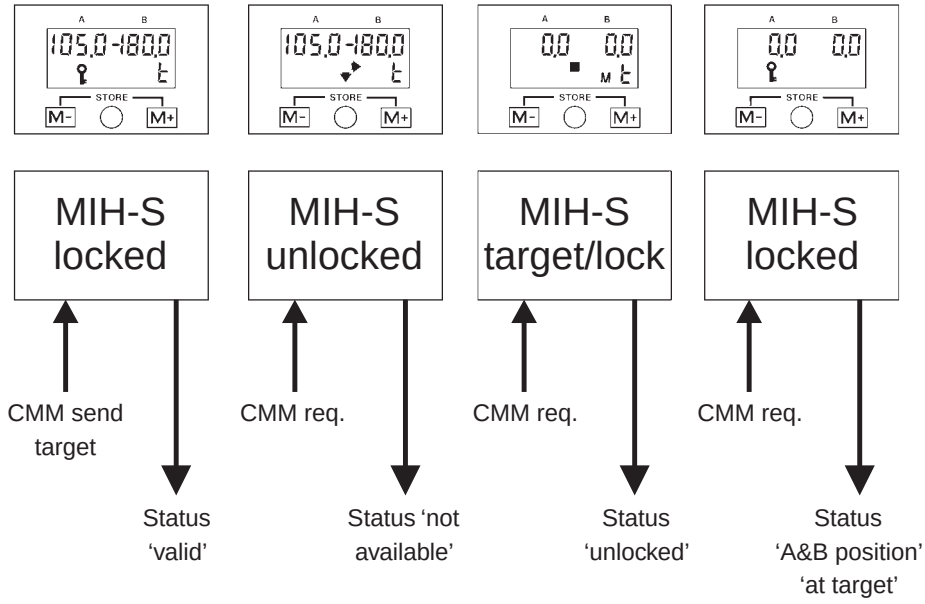
3 The CMM sends the required target position (A axis and B axis).

4 The arrows on the MIH-S display point in the direction of the target position.

5 The operator unlocks the MIH-S and moves it to the target position following the arrows as per normal MIH operation in memory or sequence mode.

6 The operator locks the MIH-S in position and when the next CMM status request is received the MIH-SI reports it to be at the correct target position.

7 Measurement can now continue.



8 MIH-S head

8.1 Measurement performance

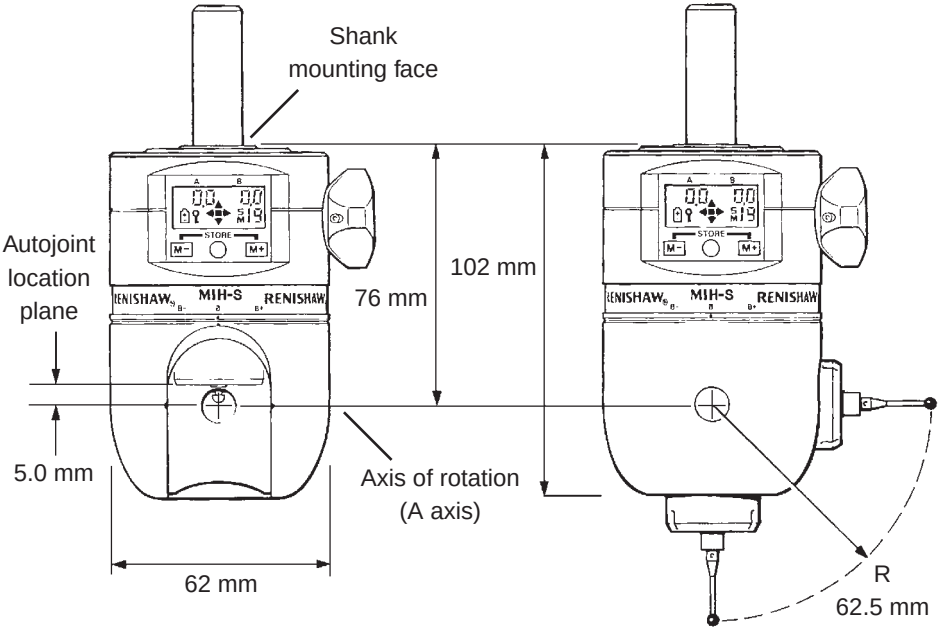
The measurement performance of the MIH-S head is unchanged from that of the standard MIH.

8.2 Measurement functionality

The measurement functionality of the MIH-S head is unchanged from that of the standard MIH:

- Extension bar carrying capability
- Probing system compatibility
- Indexing positions

8.3 Dimensions



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