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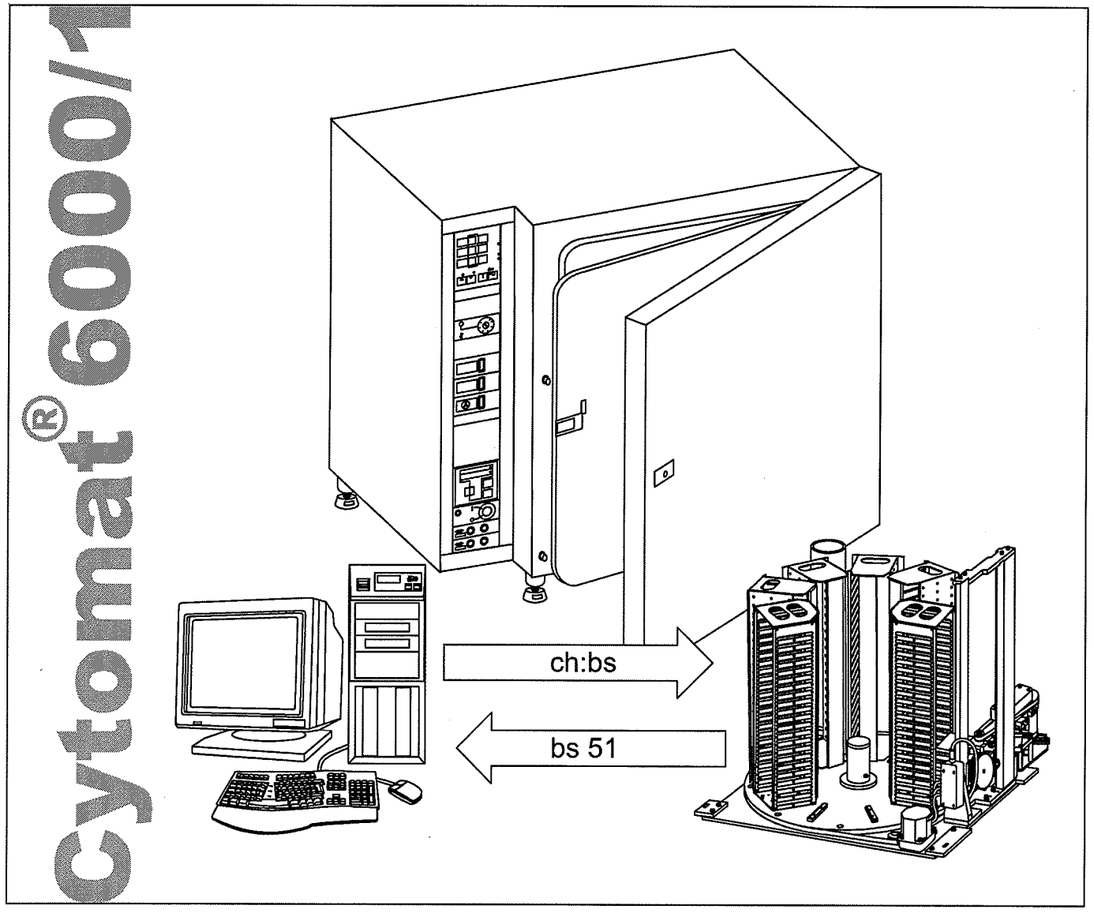
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Automatic Incubator Cytomat® 6000/6001 / Cytomat® Hotel

Software Documentation



Valid: 10.2005 / 50072912 C

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1. General notes

1.1 General notes for adjustment work

This sofware documentation describes the control of the Plate Shuttle System™ (PSS) for the Automatic Incubator Cytomat® 6000/6001 and the Cytomat® Hotel. For tests and adjustments to be carried out on the basis of the software documentation, a profound knowledge of the functions and of the operation of the device is indispensable. Therefore, the following must be observed to prevent accidents and physical damage:

- The automatic incubator must only be operated by trained and authorized personnel.
- Adjustments to the Plate Shuttle System™ (PSS) must be carried out only by persons with a profound basic knowledge of computer science and of the device control who have read and fully understood the operating instructions.
- The contents of this software documentation are subject to change without further notice.
- Concerning translations into foreign languages, the German version of this software documentation is binding.
- Keep this software documentation in the vicinity of the device so that safety instructions and important information for checking and adjusting the Plate Shuttle System™ (PSS) are always accessible.

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1. General notes

1.2 Warranty

Thermo Electron Corporation warrant the operational safety and the operativeness of the automatic incubator Cytomat® 6000/6001 and the Cytomat® Hotel only under the condition that:

- the device is operated and serviced exclusively in accordance with its intended purpose and as described in these operating instructions,
- tests of and adjustments to the Plate Shuttle System™ (PSS) are carried out only on the basis of this software documentation,
- the device is not modified,
- only original spare parts and accessories that have been approved by Thermo Electron Corporation are used,
- inspections and maintenance works are carried out at the specified intervals.

The warranty is valid from the date of delivery of the device to the operator.

1.3 Explanation of symbols



CAUTION!

is used if non-observance may cause medium to minor injuries or damage.

NOTE

is used for applicational hints and useful information.

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2. Description of the software

2.1 Software specifications

2.1.1 Versions

This software documentation describes:

- the software of the Plate Shuttle™ System (PSS) (ID No. 50069773),
- the service software for the Cytomat® 6000/6001 (ID No. 50083010).

2.1.2 Applications:

Upon delivery of the device, the software of the Plate Shuttle™ System (PSS) has been implemented as firmware. The software documentation decribes the command structure for the communication between the Plate Shuttle™ System (PSS) and a software that must be programmed by the operator of the device:

- Test procedures
- Integration into an existing on-site process system
- Error recognition and error correction

The service software is used for testing and adjusting the device-integral movements of the Plate Shuttle™ System (PSS) to the transfer position for the on-site process system:

- Reading and altering the parameters that are relevant for the movements
- Configuration of storage locations
- Adjustment of movements in accordance with the mechanical components of the device (mechanical adjustments are described in the service instructions)

2.2 Interface specifications

- RS 232 interface
- No hardware handshake
- 9600 Baud, 8 bits, no parity, 1 stop bit
- ASCII data format
- Telegram structure including check sum that can be activated

2.3 Delivery of the software

The software is delivered on CD with the device and can also be ordered separately (ID No. 50083010).

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3. Device status queries

3.1 Query and command categories

All actions and movements of the Plate Shuttle™ System (PSS) can be initiated and monitored by queries and commands. Individual motors can be activated and complex, time-optimized movements can be started. Using special status queries, the device status can be read from defined registers and analyzed at any time.
All query responses are generated directly by the Plate Shuttle™ System (PSS). Commands are checked prior to the response in order to prevent the Cytomat 2 from performing an illegal action.

Queries and commands are divided into various categories:

- Queries of the current status, of errors, and of the current movement;
- Commands for complex movements (high-level commands);
- Commands for simple movements (low-level commands)

NOTE – Command syntax

Use small letters for entering queries and commands.

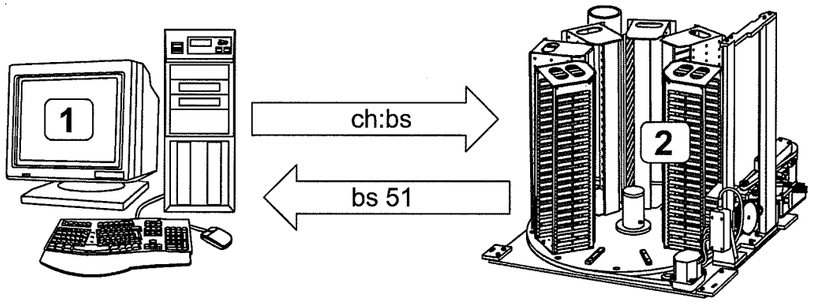
3.2 Examples of queries and commands

3.2.1 Querying the overview register status

The process system can query the current status of the Plate Shuttle™ System (PSS) overview register at any time. This status describes the most important system states:

- Device in operation (busy) or finished (ready);
- The registers for current warnings or errors contain information;
- A plate is located on the handler or transfer station;
- The automatic gate or device door is open

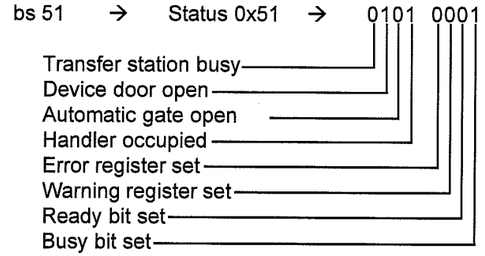
Process system query:
In order to read the contents of the overview register, the process system [1] must send the command **ch:bs<CR>** to the Plate Shuttle™ System (PSS) [2]. The Plate Shuttle™ System (PSS) responds immediately with a telegram with the identifier **bs** and a status byte.



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3. Device status queries

Response of the Plate Shuttle™ System (PSS):
The response of the answer from the Plate Shuttle™ System (PSS) is decoded in accordance with the overview register (see Section 3.3.2).
Example:

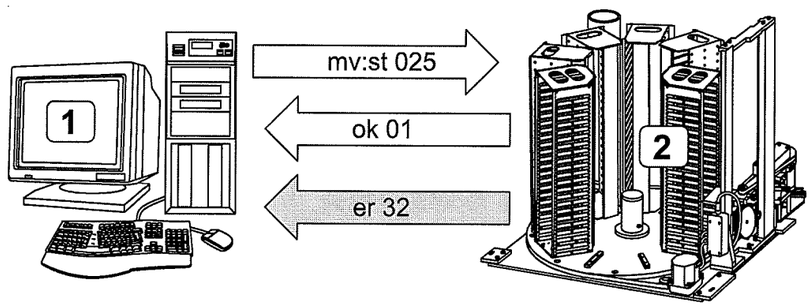


Evaluation of the response:
- The device door is open,
- there is a microtiter plate on the handler,
- the device is operating (busy).

As all registers can be queried at any time, the process system can continuously monitor the status of the Plate Shuttle™ System (PSS).

3.2.2 Unloading microtiter plates (MTPs)

The process system [1] issues a command to retrieve a microtiter plate from storage location 25 in the stacker and place it onto the transfer station. The Plate Shuttle™ System (PSS) [1] receives this command, checks it, and immediately returns a corresponding response to the process system.
If the command is executable, the Plate Shuttle™ System (PSS) confirms it with a response telegram. In this telegram, an **ok** is returned, followed by a status byte. This byte contains the current contents of the overview register. In the example, 0x01 is transmitted. The process system thus receives the confirmation that the command was accepted and has already been initiated, as can be recognized by the set busy bit.



If the Plate Shuttle™ System (PSS) rejects the command, it returns a telegram containing **er** and an error code to the process system. This error code can be used to determine the reason for the rejection. In this example, the error code returned to the process system is **0x32**. According to Section 3.2, this code represents a transfer station busy error message.

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3. Device status queries

When checking the command, the Plate Shuttle™ System (PSS) recognized that there is still a microtiter plate on the transfer station and that an attempt to remove a microtiter plate from storage location 25 and place it on the transfer station would result in an accident. The command is therefore rejected during the initial examination stage.

3.3 Querying the status of the Plate Shuttle™ System (PSS)

3.3.1 Status check bytes

A total of six bytes are available for checking the state of the Plate Shuttle™ System (PSS). Five of these bytes are located in registers and can be read at any time by means of various queries. However, the error code is only created temporarily and is automatically included in the rejection response to a command.

Register	Query command	Section
Overview register	ch:bs	3.3.2
Error code / rejected commands	–	3.4
Warning register	ch:bw	3.5
Error register	ch:be	3.6
Action register	ch:ba	3.7
SWAP station register	ch:sw	3.8

3.3.2 Overview register

The overview register provides an overview of the eight most important status bits in a single byte. These bits are continuously updated and can be individually set. By continuously reading this overview register, the current status of the Plate Shuttle™ System (PSS)can be checked at any time and the progress of the current action can be monitored.

Bit	Definition	Bit not set	Bit set
0	Busy	Device idling	Command is executed, device active
1	Ready	Command not concluded	Last command processed although PSS still busy
2	Warning	No warning	Warning register written to
3	Error	No error	Error register written to
4	Handler	Empty	MTP present
5	Automatic lift door	Closed	Open
6	Device door	Closed	Open
7	Transfer station	Empty	MTP present

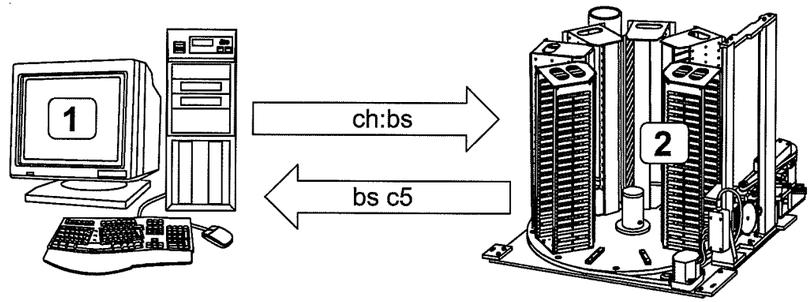
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3. Device status queries

Query from process system [1]:
ch:bs<CR>

Response of Plate Shuttle™ System (PSS) [2]:
bs **<CR>
**Overview byte in two ASCII characters

The following illustration shows how this overview register decodes the system information.



Example:
bs c5 → Status 0xc5 → 1100 0101

Transfer station occupied
Device door open
Automatic gate open
Handler not occupied
Error register not set
Warning register set
Ready bit set
Busy bit set

Evaluation of the response:
In this example, there is a microtiter plate on the transfer station, the device door is open, there is a warning, and the device is operating (busy). To determine why the device has set the warning bit, read the warning register (Section 3.5) and the action register (Section 3.7). Alternately, the process system can simply wait until the busy bit is reset, then test whether the command was executed (ready bit set) or whether the command was concluded with an error (error bit set).
The busy bit and the ready bit are the two most important indicators within this byte. They indicate to the process system the Plate Shuttle™ System (PSS) activity or its readiness to accept a new command. If the busy bit is set, the Plate Shuttle™ System (PSS) is performing an action that must not be interrupted. If this bit is not set, the Plate Shuttle™ System (PSS) is in the standby mode, waiting for new commands.
The ready bit indicates whether the command was successfully concluded. This must not occur simultaneously with the busy bit. For example, in the high-level command, **mv:st ***<CR>**, when moving a microtiter plate from the stacker to the transfer station, the Plate Shuttle™ System (PSS) sets the ready bit befor-

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3. Device status queries

re the busy bit is reset. In this case, the Plate Shuttle™ System (PSS) will set the ready bit once the microtiter plate has been placed on the transfer station and is ready to be retrieved from
the transfer station by the process system. However, because the Plate Shuttle™ System (PSS) must still return the handler to the wait position and then close the automatic gate, the busy bit remains set for some time.
This function of setting the ready bit in advance is carried out for all commands involving the placement of the microtiter plate on the transfer station.

3.4 Error codes

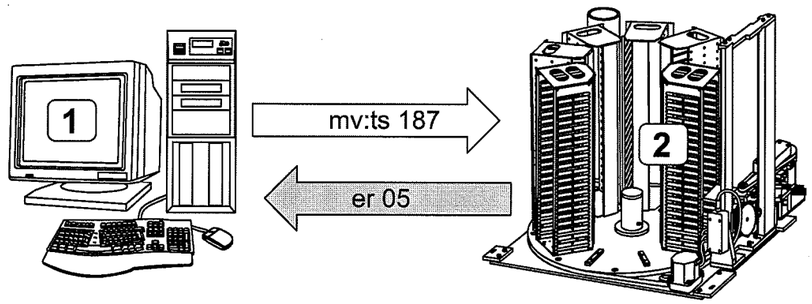
The error code is the only one of the five bytes describing the device status that is not queried by a command. It represents the response to a command that was not executable.
This byte specifies precisely why the most recent command could not be accepted. The following table lists the meanings of the individual error codes.

Value	Error message
0x01	Device still busy, new command not accepted
0x02	Unknown command
0x03	Telegram structure error
0x04	Incorrect parameters in telegram
0x05	Unknown location number specified
0x11	Incorrect handler position
0x12	Command not executable as shovel is extended
0x21	Handler already occupied
0x22	Handler empty
0x31	Transfer station empty
0x32	Transfer station occupied
0x33	Transfer station not in position
0x41	No gate configured
0x42	Automatic lift door not open
0x51	Error while accessing internal memory
0x52	Incorrect password / unauthorized access

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3. Device status queries

The example illustrates the evaluation of the error code.



The process system [1] has requested a command to transport a microtiter plate from the transfer station to location 187. When checking the command, the Plate Shuttle™ System (PSS) [2] recognized that only 170 storage locations have been configured; location 187 is therefore unknown and cannot be accessed.
The Plate Shuttle™ System (PSS) thus rejected the command and returned an error code **0x05** to the process system.

3.5 Warning register

The warning register is only written to if the warning bit has also been set in the overview register. When error processing is active, this register contains the error currently being processed by the built-in error correction function. Once the error has been corrected, this register is deleted.

Value	Definition
0x01	Communication with motor controllers interrupted
0x02	No MTP loaded on handler/shovel
0x03	No MTP unloaded from handler/shovel
0x04	Shovel not extended/handler movement error
0x05	Process timeout
0x06	Automatic lift door not open
0x07	Automatic lift door not closed
0x08	Shovel not retracted
0x09	Initialization due to open device door
0x0C	Transfer station did not rotate

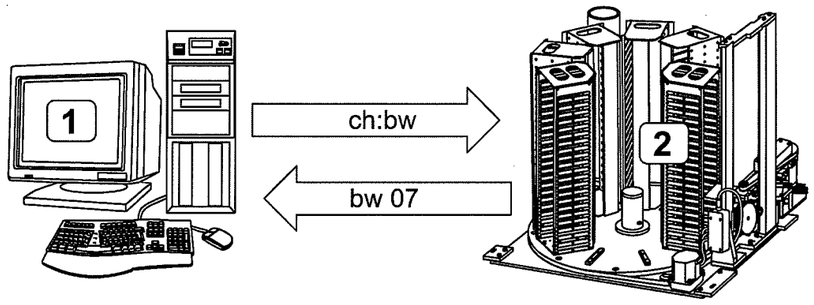
Query from process system:
ch:bw<CR>

Response of Plate Shuttle™ System (PSS):
bw **<CR>
**Warning register in two ASCII characters

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3. Device status queries

The following example illustrates how this register is queried and evaluated:



After evaluating the overview register, the process system [1] determined that the warning bit has been set and therefore the warning register has also been written to. After querying the register with the command **ch:bw<CR>**, the Plate Shuttle™ System (PSS) [2] returns the response **bw 07<CR>**. In the table, the value **0x07** can be allocated to an error message: **Automatic gate not closed**.
Since this message represents the current warning, the Plate Shuttle™ System (PSS) will automatically attempt to correct the error if the error routines have been activated (in this case, the automatic gate must be closed). If the attempt is successful, the warning is deleted, otherwise the error bit is set and the error register is written to.

3.6 Error register

The error register is only written to if the error bit has also been set in the overview register. When error processing is active, this register contains the current error that the built-in error correction function failed to correct. If error processing is inactive, a recognized error is written directly to the error register.

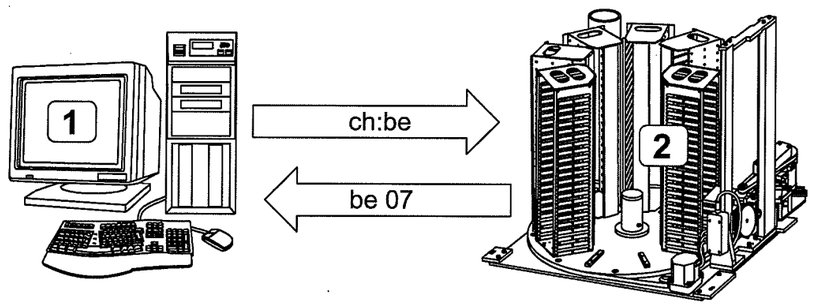
Value	Definition
0x01	Communication with motor controllers interrupted
0x02	No MTP loaded on handler/shovel
0x03	No MTP unloaded from handler/shovel
0x04	Shovel not extended/Automatic unit position error
0x05	Process timeout
0x06	Automatic lift door not open
0x07	Automatic lift door not closed
0x08	Shovel not retracted
0x09	- Not used -
0x0A	Stepper motor controller temperature too high
0x0B	Other stepper motor controller error
0x0C	Transfer station not rotated
0xFF	Fatal error occurred during error routine

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3. Device status queries

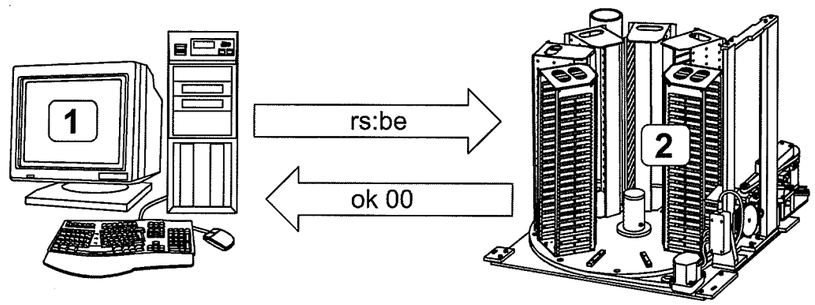
Query from process system [1]:
ch:be<CR>

Response of Plate Shuttle™ System (PSS) [2]:
be **<CR>
**Error register in two ASCII characters



The Plate Shuttle™ System (PSS) responded to the error register query with byte 0x07. The table shows that the error allocated to this value is **Automatic gate not closed**.
If the error routine is active, the system has already unsuccessfully attempted to correct the error. Otherwise, the error was written directly to the register and the Plate Shuttle™ System (PSS) stopped.
The process system [1] must reset the error register and the error bit in the overview register via the interface. The following command is used for this:
rs:be<CR>

Response of Plate Shuttle™ System (PSS):
ok **<CR>
**Overview register in two ASCII characters



After resetting the error bit, the Plate Shuttle™ System (PSS) [2] responds to the command with an **ok** telegram together with the contents of the overview register in which the error bit was reset before.

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3. Device status queries

3.7 Action register

The current movement step is always entered into the action register. This allows all partial steps made by the Plate Shuttle™ System (PSS) to be monitored. If an error occurs and the warning bit or the error bit are set, no new register entries are made so that the last command for which the error occurred can be read out. A new entry is only written to the register after the warning or error bit has been reset.
The byte in the register always contains two pieces of information: the target of the movement and the current state of the movement. To achieve this, the eight bits that make up the byte were subdivided into two parts. The three high-level bits indicate the target, while the five low-level bits indicate the type of movement.

High- level bits:

Value Bit 5-7	Movement target
0x01	Movement target: Init position
0x02	Movement target: Wait position
0x03	Movement target: Stacker
0x04	Movement target: Transfer station

Low-level bits:

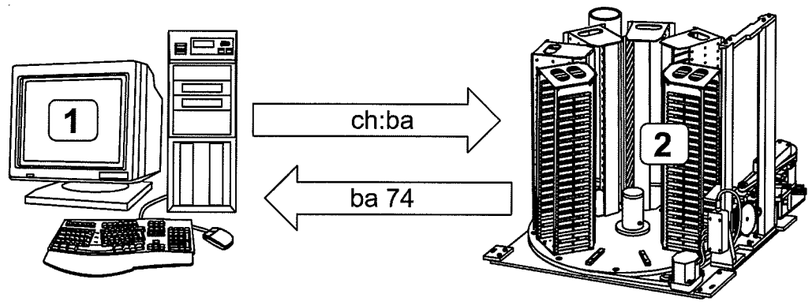
Value Bit 0-4	Current movement or control command
0x01	Movement, height motor to storage position (minus offset)
0x02	Query whether height position reached (minus offset)
0x03	Movement, height motor to storage position (plus offset)
0x04	Query whether height position reached (plus offset)
0x05	Movement, rotation motor to storage location
0x06	Query whether height position reached (plus offset)
0x07	Movement, extend shovel
0x08	Query whether shovel is extended
0x09	Query, shovel extension limit switch
0x0a	Movement, retract shovel
0x0b	Query whether shovel is retracted
0x0c	Close automatic lift door
0x0d	Query whether automatic lift door is closed
0x0e	Open automatic lift door
0x0f	Query whether automatic lift door is open
0x10	Transfer station in position 1
0x11	Query whether transfer station is in position 1
0x12	Transfer station in position 2
0x13	Query whether transfer station is in position 2
0x14	Check MTP on shovel
0x15	Check MTP on transfer station
0x19	Movement, turntable
0x1a	Query, turntable position

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3. Device status queries

Query from process system [1]:
ch:ba<CR>

Response of Plate Shuttle™ System (PSS) [2]:
ba **<CR>
**Action register in two ASCII characters



The Plate Shuttle™ System (PSS) provides the value 0x74 as the contents of the action register. Breaking down and analyzing this byte leads to the following result:

Status 0x74 → 011 1 0100
Target position → 0x03 Target: Stacker
Movement → 0x14 Check Microtiter plate on shovel

In this example, the Plate Shuttle™ System (PSS) handler moves to the stakker and checks whether there is currently a microtiter plate on the shovel.

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3. Device status queries

3.8 SWAP station register

The SWAP station register can only be queried if a SWAP station has actually been configured. This command allows the user to check the position of the SWAP station and the load status of the two plates.

Query from process system [1]:
ch:sw<CR>

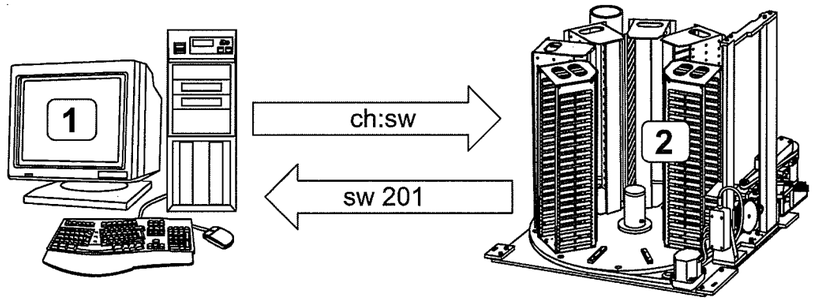
Response of Plate Shuttle™ System (PSS) [2]:
sw *<CR>**
*** Status in three ASCII characters

The three ASCII characters have the following significance:

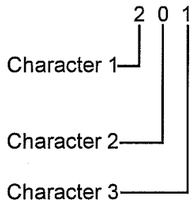
Character 1 — SWAP station position:
1 = Plate 1 immediately in front of automatic gate
2 = Plate 2 immediately in front of automatic gate

Character 2 — Load status of plate in front of automatic gate
0 = Empty
1 = Occupied (microtiter plate loaded)

Character 3 — Load status of plate at processor system
0 = Empty
1 = Occupied (microtiter plate loaded)



The Plate Shuttle™ System (PSS) responded to the SWAP station status query with the character string **201**. Based on the definition above, the following status can be read:



2 = Plate 2 of SWAP station immediately in front of automatic gate

0 = No microtiter plate on plate 2

1 = Microtiter plate on plate 1, facing the on-site process system

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4. Process commands

4.1 Process command structure

The Plate Shuttle™ System (PSS) is activated by process commands. A differentiation is made between two types of commands:

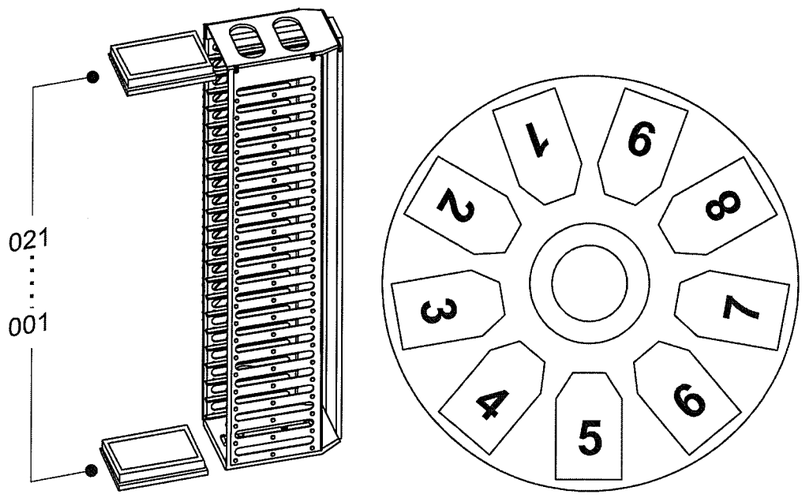
- The complex or high-level commands initiate a fully automated process whereby, for example, a microtiter plate is transported from the stacker to the transfer station. Process movements and processing times are optimized and cannot be influenced.

- The simple or low-level commands are used to activate individual movements of a specific motor. This command set can be used by the process system to generate its own processes.

Upon receipt, the Plate Shuttle™ System (PSS) immediately checks and confirms both high-level as well as low-level commands. Further, all movement processes are examined by an error monitoring function and can be corrected by an error routine which can be optionally activated.

NOTE – Storage locations

**The storage locations in the stackers are numbered from stacker 1 to stacker 9.
The numbering starts with 001 in the lower pitch of stacker 1 and ends in the upper pitch of stacker 9 with number ### (depending on the configuration of the applied stackers; the illustration shows a 21-pitch stacker).**



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4. Process commands

4.2 Complex commands / High-level commands

Complex commands initiate a fully automated movement process in which all motors are activated in a predefined, time-optimized manner. During this type of process, no further commands can be transferred via the interface, while there are no restrictions for querying the current status. This status allows the process to be tracked and monitored at any time.
Immediately upon the receipt of commands, the Plate Shuttle™ System (PSS) controller checks whether they can be executed without error. If error-free processing is not assured, the Plate Shuttle™ System (PSS) immediately rejects the command, otherwise it immediately confirms the command with an **ok** (see also Section 3.3.2).
If these commands involve the movement of microtiter plates into or out of a stacker, the command contains the storage location in the form of a three-digit number in ASCII format. The exact X, Y, and Z parameters for the motors are configured in the electronic unit and do not need to be transferred by the process system. The illustration (Section 4.2) shows the allocation of the individual numbers to the storage locations in the stackers.
Several error correction routines which can be deactivated are also provided for these complex commands (see Section 5).

4.2.1 Overview of high-level commands

Command	Immediate response	Description
mv:ts ###<CR>	ok **<CR>, er **<CR>	• Open automatic lift door • Retrieve MTP from transfer station • Close automatic lift door • Place MTP at indicated storage location **Condition:** MTP on transfer station, handler empty
mv:st ###<CR>	ok **<CR>, er **<CR>	• Retrieve MTP from indicated storage location • Open automatic lift door • Move MTP to transfer station • Close automatic lift door **Condition:** Transfer station and handler empty
mv:sw ###<CR>	ok **<CR>, er **<CR>	• Retrieve MTP from indicated storage location • Move MTP to wait position in front of automatic lift door **Condition:** Handler empty
mv:ws ###<CR>	ok **<CR>, er **<CR>	• Move from wait position to indicated storage location • Unload MTP there and return to wait position **Condition:** MTP on handler
mv:wt<CR>	ok **<CR>, er **<CR>	• Open automatic lift door and place MTP on transfer station • Return to wait position • Close automatic lift door **Condition:** MTP on handler, transfer station empty

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4. Process commands

Command	Immediate response	Description
mv:tw<CR>	ok **<CR>, er **<CR>	• Open automatic lift door and retrieve MTP from transfer station • Return to wait position • Close automatic lift door **Condition:** MTP on transfer station, handler empty
mv:wh<CR>	ok **<CR>, er **<CR>	• Move from wait position to exposed position outside device • Stop at position above transfer station **Condition:** None
mv:hw<CR>	ok **<CR>, er **<CR>	• Return to wait position from exposed position outside device • Close automatic lift door **Condition:** None
mv:hs ###<CR>	ok **<CR>, er **<CR>	• Return with MTP from exposed position outside device to indicated storage location • Move handler to wait position • Close automatic lift door **Condition:** MTP on handler
mv:sh ###<CR>	ok **<CR>, er **<CR>	• Move from wait position to indicated storage location, load MTP and transport to exposed position outside device **Condition:** Handler empty

Key:
Storage location number as three-digit number in ASCII format
** Overview register or error code in two ASCII characters

If the Plate Shuttle™ System (PSS) controller accepts the command, it responds with **ok **<CR>**; otherwise, the response is **er **<CR>.**
In high-level commands, the two characters following the colon indicate the start and target locations of the transport:
s Stacker,
t Transfer station,
w Wait position
h Exposed shovel position outside device.

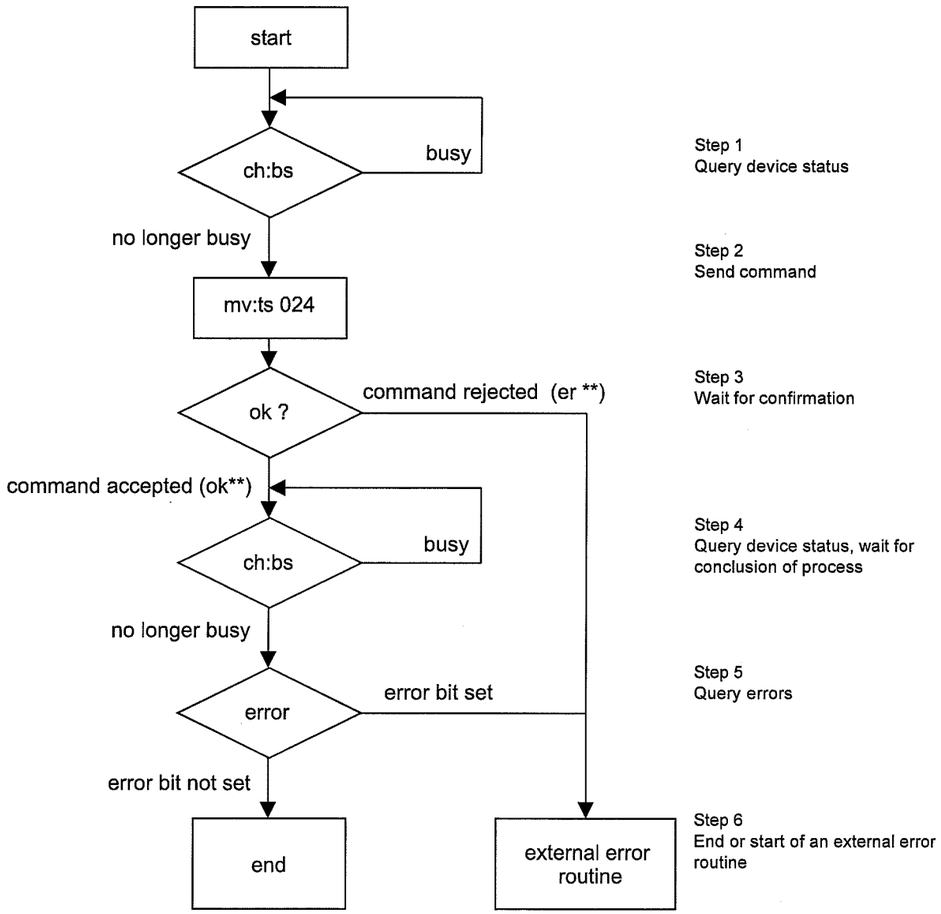
Interpretation of the command: **mv:st 024<CR>**
Transport microtiter plate from storage location (24) of stacker (s) to transfer station (t).

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4. Process commands

4.2.2 Example: Transporting a microtiter plate (MTP) into the device

The illustration shows the process sequence of a complex movement, activated by the command **mv:ts 024**.
A microtiter plate laying on the transfer station is to be transported to storage location 24 within the device chamber.



Step 1
Query device status

Step 2
Send command

Step 3
Wait for confirmation

Step 4
Query device status, wait for conclusion of process

Step 5
Query errors

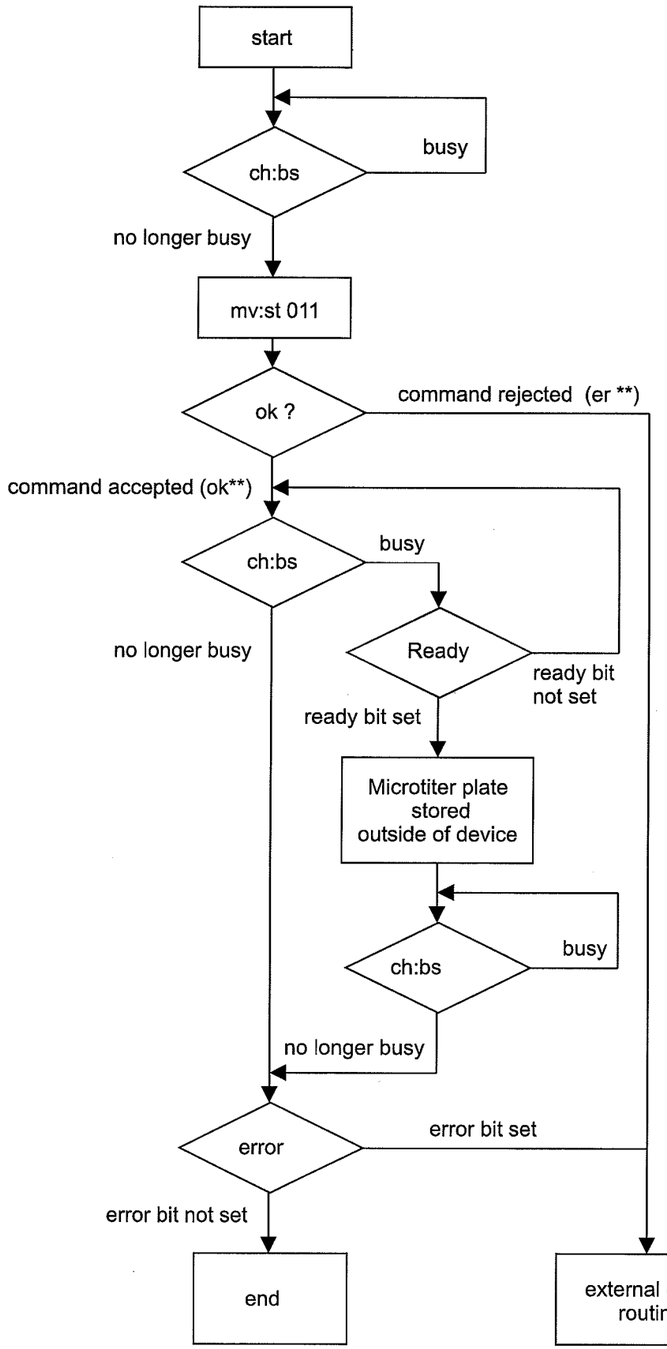
Step 6
End or start of an external error routine

4.2.3 Example: Transporting a microtiter plate (MTP) out of the device

The illustration shows the process sequence of a complex movement, activated by the command **mv:ts 011**.
A microtiter plate is to be transported from storage location 11 in the device chamber to the transfer station.

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4. Process commands



Step 1
Query device status

Step 2
Send command

Step 3
Wait for confirmation

Step 4
Query device status, wait for conclusion of process

Step 5
Query Ready bit

Step 6
Microtiter plate placed on transfer station, access by process system enabled

Step 7
Query device status, wait for conclusion of remaining process

Step 8
Query errors

Step 9
End or start of error routine

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4. Process commands

The ready bit is set as soon as the microtiter plate is placed on the transfer station and the external system can access it. Because the Plate Shuttle™ System (PSS) must still execute the final command steps (close automatic gate, return handler to wait position), the busy bit remains set. Thus both the ready bit and the busy bit are simultaneously present.

The ready bit will not be reset as long as the busy bit is set. When the busy bit is reset, the ready bit only remains present until the next query by the overview register, after which it is retracted by the Plate Shuttle™ System (PSS).

4.3 Simple commands / Low-level commands

Simple commands initiate only the movement of a single motor (e.g. SWAP station, automatic gate or height motor). With these commands, the process system can generate its own processes. No other commands can be transferred during the process, while there are no restrictions for querying the various registers.

Immediately upon the receipt of commands, the Plate Shuttle™ System (PSS) controller checks whether the command can be executed without error. If error-free processing is not assured, the Plate Shuttle™ System (PSS) immediately rejects the command with an error message, otherwise it immediately confirms the command with an **ok** and the status from the overview register (see also Section 3).

If these commands involve the movement of microtiter plates into or out of the stacker, the command contains the storage location in the form of a three-digit number in ASCII format. The start or target of the transfer station is always storage location 000. The illustration in Section 4.1 provides an overview of the storage locations.

A separate error correction function which can be disabled is also available for simple commands (refer to Section "Error Processing").

When programming low-level commands, monitoring the entire process, monitoring microtiter plates on the handler and at the transfer station, and complex error corrections are to be taken over by the process system. All processes must be carefully planned and tested.

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4. Process commands

4.3.1 Overview of low-level commands

Command	Immediate response	Desription
ll:gp 001<CR>	ok **<CR>, er **<CR>	• Close automatic lift door **Condition:** Handler not rotated toward transfer station
ll:gp 002<CR>	ok **<CR>, er **<CR>	• Open automatic lift door **Condition:** None
ll:tp 001<CR>	ok **<CR>, er **<CR>	• Transfer station / Move SWAP station to position 1 **Condition:** Handler not rotated toward transfer station
ll:tp 002<CR>	ok **<CR>, er **<CR>	• Move transfer station / SWAP station to position 2 **Condition:** Handler not rotated toward transfer station
ll:h– ###<CR>	ok **<CR>, er **<CR>	• Lower height motor below storage location ### **Condition:** Shovel retracted or only minimal lift required within storage location; if handler is rotated toward transfer station, lowering is only possible to ll:h– 000<CR>
ll:h+ ###<CR>	ok **<CR>, er **<CR>	• Lift height motor above storage location ### Condition: Shovel retracted or only minimal lift required within storage location; if handler is rotated toward transfer station, lifting is only possible to ll:h+ 000<CR>
ll:dp 001<CR>	ok **<CR>, er **<CR>	• Rotate handler in toward stacker **Condition:** Shovel retracted
ll:dp 002<CR>	ok **<CR>, er **<CR>	• Rotate handler out toward stacker **Condition:** Shovel retracted, handler must have moved to transfer station height, automatic lift door must be open
ll:kp ###<CR>	ok **<CR>, er **<CR>	• Rotate turntable to storage location ### **Condition:** Shovel retracted
ll:sp 002<CR>	ok **<CR>, er **<CR>	• Shovel extended **Condition:** The vertical and rotational position of the handler allows the shovel to be extended
ll:sp 001<CR>	ok **<CR>, er **<CR>	• Retract shovel **Condition:** None
ll:wp<CR>	ok **<CR>, er **<CR>	• Move motors to wait position **Condition:** None
ll:in<CR>	ok **<CR>, er **<CR>	• Reinitialize automatic unit **Condition:** None

Key:
Storage location number as three-digit number in ASCII format
** Overview register or error code in two ASCII characters

If the Plate Shuttle™ System (PSS) controller accepts the command, it responds with **ok **<CR>**; otherwise, the response is **er **<CR>**.

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4. Process commands

In low-level commands, the two characters following the colon indicate the start and end positions of the transport. The command elements have the following significance:

h+/h-	height motor,
dp	rotating motor,
sp	shovel motor
gp	automatic gate motor
kp	turntable motor
tp	mobile transfer station motor
ll:tp 001	rotate SWAP station to position 1
ll:tp 002	rotate SWAP station to position 2

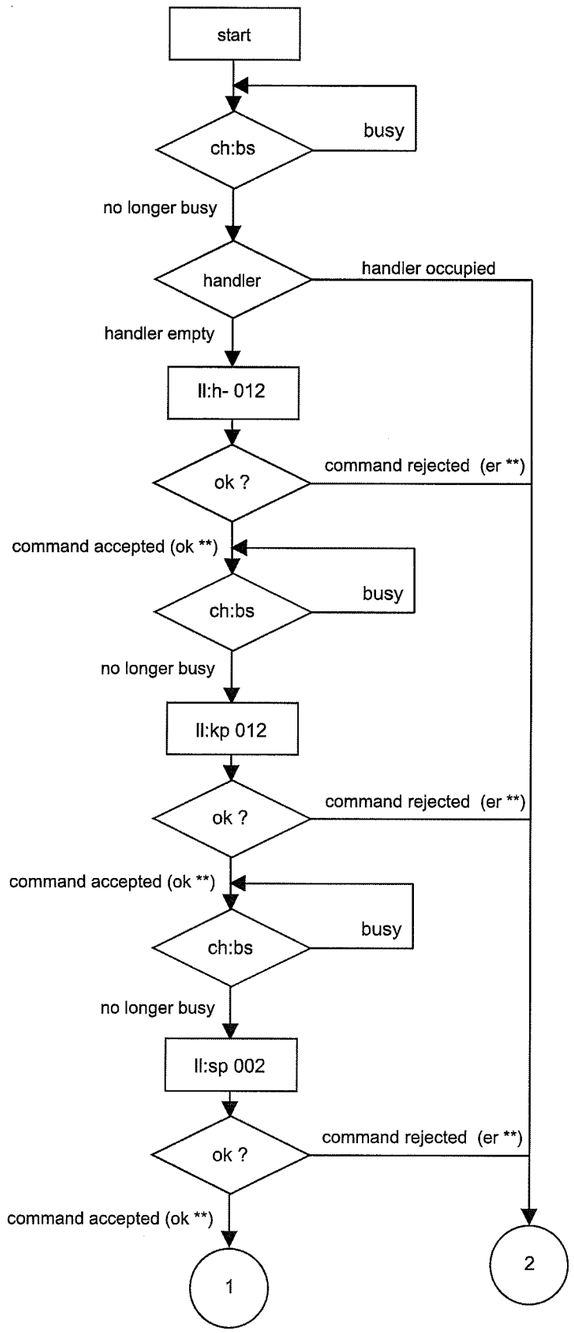
The two commands **ll:wp<CR>** and **ll:in<CR>** are an exception to this rule as they move all three motors and therefore do not correspond to the command structure defined above.

4.3.2 Example: Transporting a microtiter plate (MTP) from the stacker to the wait position

Simple commands can be used by the process system to generate specific processes. As an example, the illustration shows how the complex command **mv:sw 012** can be executed as a sequence of individual, simple commands.
The overview register must be evaluated in order to monitor the Plate Shuttle™ System (PSS). In particular, the bits for recognizing the microtiter plate on the handler or the transfer station must be checked (refer to flowchart, steps 2 and 21).

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4. Process commands



Step 1
Query device status

Step 2
Check handler for microtiter plate on overview register

Step 3
Move handler to location 12 below microtiter plate

Step 4
Wait for confirmation

Step 5
Query device status, wait for process conclusion

Step 6
Move turntable with stacker (location 12) to handler

Step 7
Wait for confirmation

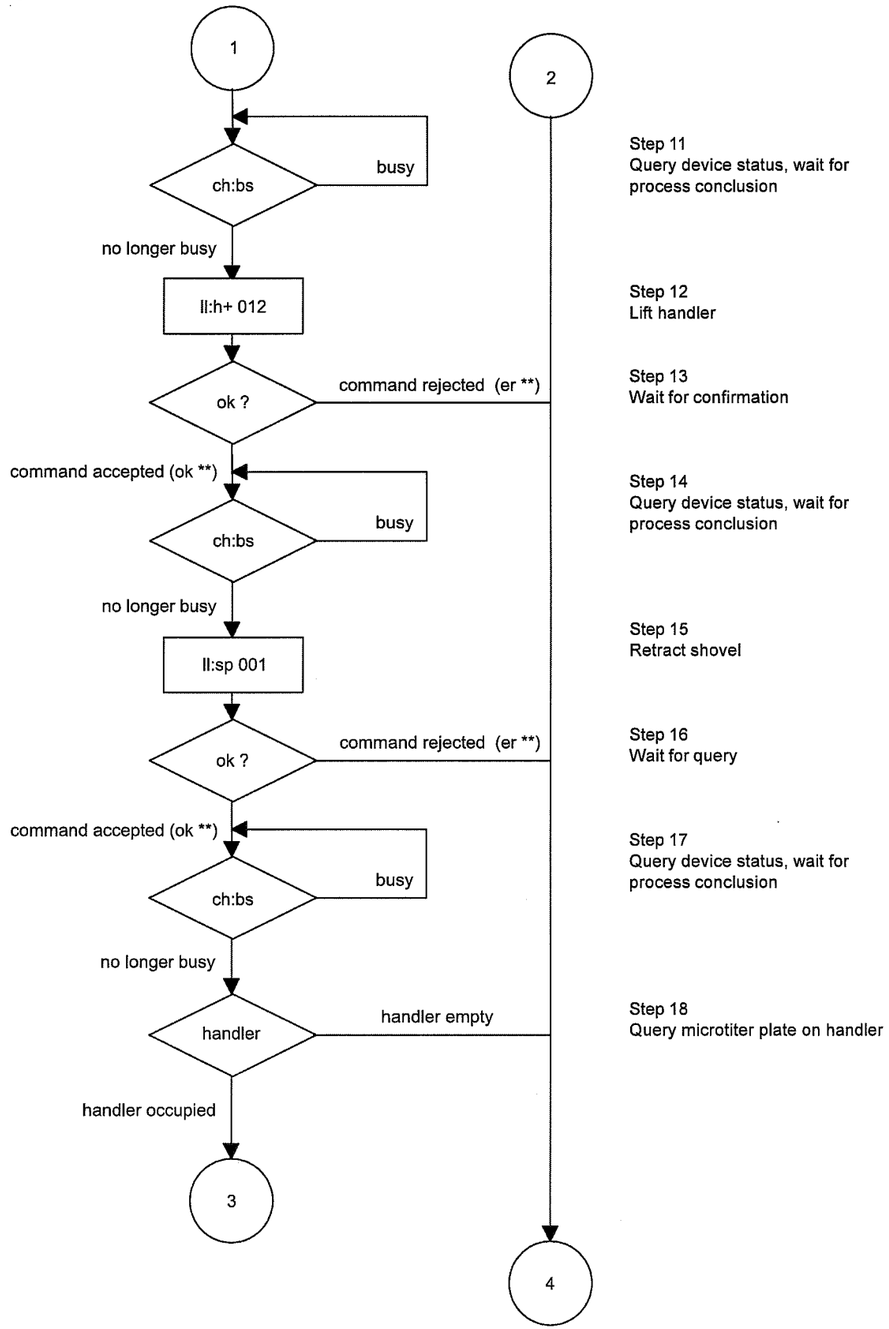
Step 8
Query device status, wait for process conclusion

Step 9
Extend shovel

Step 10
Wait for confirmation

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4. Process commends



Step 11
Query device status, wait for process conclusion

Step 12
Lift handler

Step 13
Wait for confirmation

Step 14
Query device status, wait for process conclusion

Step 15
Retract shovel

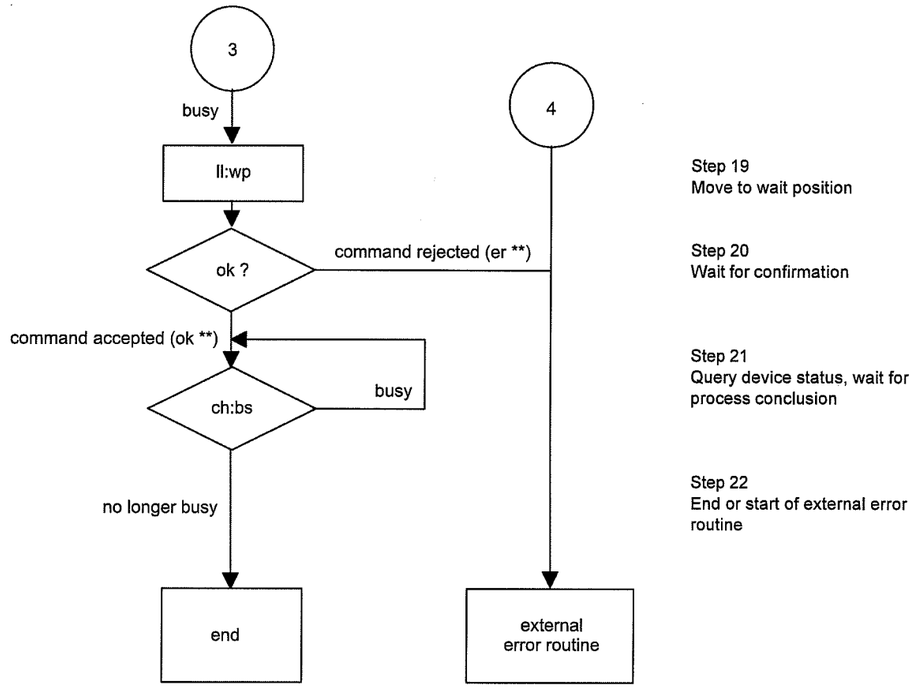
Step 16
Wait for query

Step 17
Query device status, wait for process conclusion

Step 18
Query microtiter plate on handler

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4. Process commands



Step 19
Move to wait position

Step 20
Wait for confirmation

Step 21
Query device status, wait for process conclusion

Step 22
End or start of external error routine

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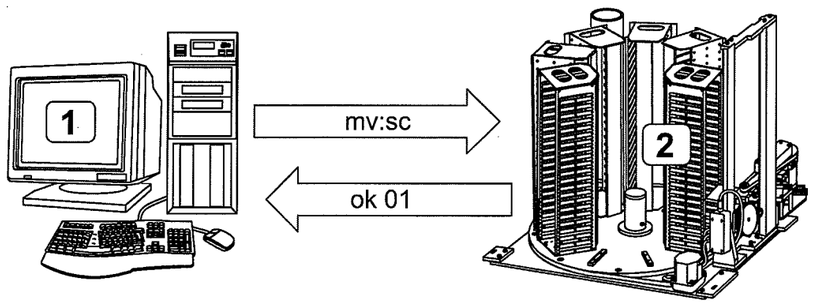
4. Process commands

4.4 Location scan

The location scan can be used to check the load status of the stackers. The Plate Shuttle™ System (PSS) starts a routine that approaches each storage location in sequence and checks for the presence of a microtiter plate. This process may take several minutes.
The Plate Shuttle™ System (PSS) indicates the end of this routine by setting the ready bit. The process system can now query the individual storage locations and receives a response from the Plate Shuttle™ System (PSS) indicating whether a particular location is occupied or empty.
When evaluating the location scan, make sure that there is no further access between the end of the test routine and the readout of the result as any such access would make the scan result invalid.

Query from process system [1]:
mv:sc<CR>

Response of Plate Shuttle™ System (PSS) [2]:
ok **<CR> if check was started,
er **<CR> if command was rejected,
**Overview register in two ASCII characters



Once the Plate Shuttle™ System (PSS) has confirmed the command and started the location scan, the process system can monitor the process by querying the overview register, just as in the case of any high-level command.

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4. Process commands

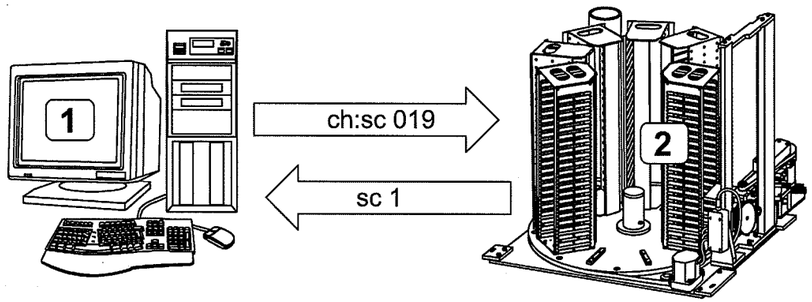
At the end of the location scan, the process system can use the command

ch:sc *<CR>**
*** location number

to query each storage location for occupancy. The Plate Shuttle™ System (PSS) responds as follows:

sc *<CR>
*0 location empty
*1 location occupied

In this example, the process system [1] is querying storage location 19. The Plate Shuttle™ System (PSS) [2] reports this location as being occupied.



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5. Error processing

In all operations with the Plate Shuttle™ System (PSS), the sample must be handled carefully. The software has therefore been designed so that any error during the process is corrected and reported to the process system.
All process system commands are examined for legitimacy directly by the Plate Shuttle™ System (PSS) controller. Immediately at the end of this examination, the process system receives a confirmation or, if the command is rejected, an error message.
The Plate Shuttle™ System (PSS) configuration can be used to activate or deactivate the internal error processing function. With the error routines activated, the Plate Shuttle™ System (PSS) starts its own error routine when an internal error occurs. The activation of this routine is indicated by the setting of the warning bit in the overview register and writing to the warning register.
However, if the error routines are deactivated, the Plate Shuttle™ System (PSS) immediately indicates the occurence of errors by setting the error bit in the overview register while simultaneously writing to the error register. In this way, the Plate Shuttle™ System (PSS) leaves further processing of the error to the process system.

5.1 Checking the process system commands

Each command arriving via the serial interface is checked by the Plate Shuttle™ System (PSS) controller. The following criteria are examined:
- Is the command syntax OK?
- Is the information in the command logical, e.g., has the location number been included?
- Is there a microtiter plate on the transfer station or on the handler system shovel and may/should one be here?
- Is the handler in a position where it can start the desired movement safely?

Once all items have been checked and found to be uncritical, the command request, including the contents of the overview register, is confirmed. In case of a deviation, the command is rejected with an error message. The error message is an error code indicating the cause for the rejection of the command (see also Sections 3.2.1 and Section 3.2.2).

Value	Error message
0x01	Device still busy, new command not accepted
0x02	Command unknown
0x03	Telegram structure error
0x04	Incorrect parameters in telegram
0x05	Unknown location number specified
0x11	Handler position incorrect
0x12	Command cannot be executed, shovel extended
0x21	Handler already occupied
0x22	Handler empty
0x31	Transfer station empty
0x32	Transfer station occupied
0x33	Transfer station not in position
0x41	No gate configured
0x42	Automatic lift door not open
0x51	Error while accessing internal memory
0x52	Password incorrect / unauthorized access

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5. Error processing

5.2 Process control

During the process, the Plate Shuttle™ System (PSS) monitors the following possible sources of error:

- Has the handler reached the required position or could the shovel be extended in this position?
- Was the microtiter plate actually placed on/removed from the handler shovel?
- Was the microtiter plate removed from the handler shovel and placed on or retrieved from the transfer station?
- Does the automatic gate open/close?
- Do all movements take place within the defined running time?

If the Plate Shuttle™ System (PSS) detects an error and the internal error routines are deactivated in the configuration, the Plate Shuttle™ System (PSS) stops. The busy bit is removed in the overview register and the error bit is set. The source of the error is noted in the error register.

However, if the internal error routines have been activated, the Plate Shuttle™ System (PSS) starts one of the error routines. Simultaneously, it sets the warning bit and writes the current error to the warning register. During this time, the busy bit in the overview register remains set. The Plate Shuttle™ System (PSS) can start the following error routines:

- Automatic gate does not close. The automatic gate is opened and, after 5 seconds, closed. If the same error reoccurs, the automatic gate stops in the position it has reached. Error routine duration: < 10 seconds.
  Application: For all errors that occur during the closing of the automatic gate.
- The controllers of all stepper motors are initialized after which all motors are returned to their zero position, the most recent position is approached and, finally, the most recent command is repeated.
  Error routine duration: < 1 minute.
  Application: Internal communications and process errors.
- All motors are returned to their zero position, the most recent position is approached, and the most recent command is repeated.
  Error routine duration: < 1 minute.
- Application: General process errors.

If an error routine concludes with the same error it started with, the Plate Shuttle™ System (PSS) resets the warning bit and deletes the warning register. Simultaneously, it sets the error bit and writes the current error code to the error register. If the error routine is interrupted by another error, the program outputs a fatal error. An error routine is not started from within an ongoing error routine. The Plate Shuttle™ System (PSS) stops immediately. The Plate Shuttle™ System (PSS) resets the warning bit and deletes the warning register. Simultaneously, it sets the error bit and writes the fatal error code to the error register. If an error is detected and not successfully corrected by the error routine, the Plate Shuttle™ System (PSS) stops in the last position. An exception to this rule is the error **microtiter plate not loaded onto the handler/shovel** or **microtiter plate not removed from the handler/shovel**. For these errors, the handler returns to the wait position if the error routine was not successful and the automatic gate is closed. The Plate Shuttle™ System (PSS) is immediately ready for a new command.

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5. Error processing

5.2.1 Example: Mictotiter plate (MTP) not stored in the device

The following diagram illustrates at what time specific errors can be detected during a process. The possible errors are divided into four groups depending on the time at which they occur and the storage location of the microtiter plate.

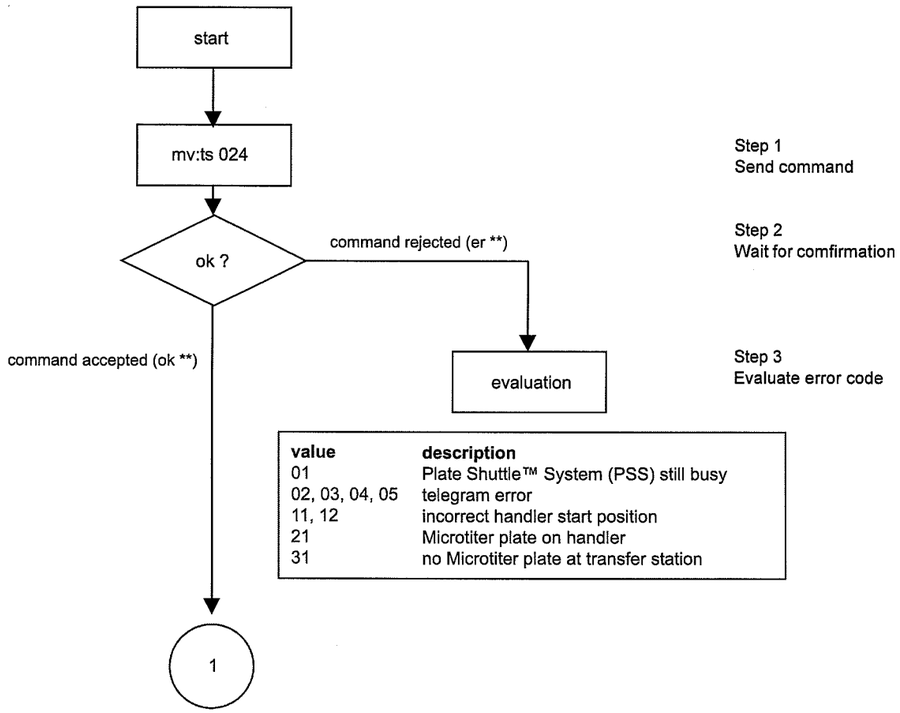
Error processing for error group 1:
Errors can be recognized immediately after the command check (step 2 in the flowchart). The Plate Shuttle™ System (PSS) checks the command it received from the process system. The following errors may be detected during this examination:

- Plate Shuttle™ System (PSS) still busy: A new command cannot be accepted while the previous one is still active.
  Solution: Wait until the busy bit has been reset, then reissue the command.
- Telegram error: The telegram was transmitted improperly, the location number is not correct, or the command is unknown.
  Solution: Check the telegram structure in the process system software, check the location number.
- Handler in an incorrect position: The handler is in the wrong position as a result of an error or previous low-level commands.
  Solution: For most high-level commands, the handler must be in the wait position. The low-level command **II:wp<CR>** can be used to achieve this. If a different start position is required, e.g. for low-level commands, this start position must first be reached by using other low-level commands.
- Microtiter plate on the handler: The handler cannot retrieve a plate from the transfer station because another plate is still on the handler.
  Solution: Move the handler to a storage location to load the microtiter plate or remove microtiter plate from handler, then restart the command.
- No microtiter plate on the transfer station: The Plate Shuttle™ System (PSS) will not start the command because no microtiter plate is seen on the transfer station.
  Solution: The process system must place a microtiter plate on the transfer station, then the command must be restarted.

Once the Plate Shuttle™ System (PSS) confirms the command, the internally programmed process starts immediately. If an error occurs, the error bit in the overview menu is set and the busy bit was reset (Step 6 in the flowchart).

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5. Error processing



Step 1
Send command

Step 2
Wait for comfirmation

Step 3
Evaluate error code

value	description
01	Plate Shuttle™ System (PSS) still busy
02, 03, 04, 05	telegram error
11, 12	incorrect handler start position
21	Microtiter plate on handler
31	no Microtiter plate at transfer station

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5. Error processing

Error processing for error group 2:
Errors that may occur when the microtiter plate is not unloaded from the transfer station:

- Microtiter plate not loaded: The shovel failed to pick up the microtiter plate from the transfer station:
  Solution: Visually inspect the extension length and elevation of the handler above the transfer station. Readjust as required.
- Shovel not extended / handler position error: The handler is in the wrong position and cannot extend the shovel.
  Solution: Check if movement is being obstructed due to objects in the path, check the handler position. Readjust as required.
- Automatic gate faulty / not open: The automatic gate could not be opened.
  Solution: Check the automatic gate.
- Incorrect shovel position: The handler shovel was not retracted.
  Solution: Check the microtiter plate (too heavy or jammed), check the handler position. Readjust as required.

Error processing for error group 3:
Errors that may occur after the microtiter plate has been retrieved from the transfer station:

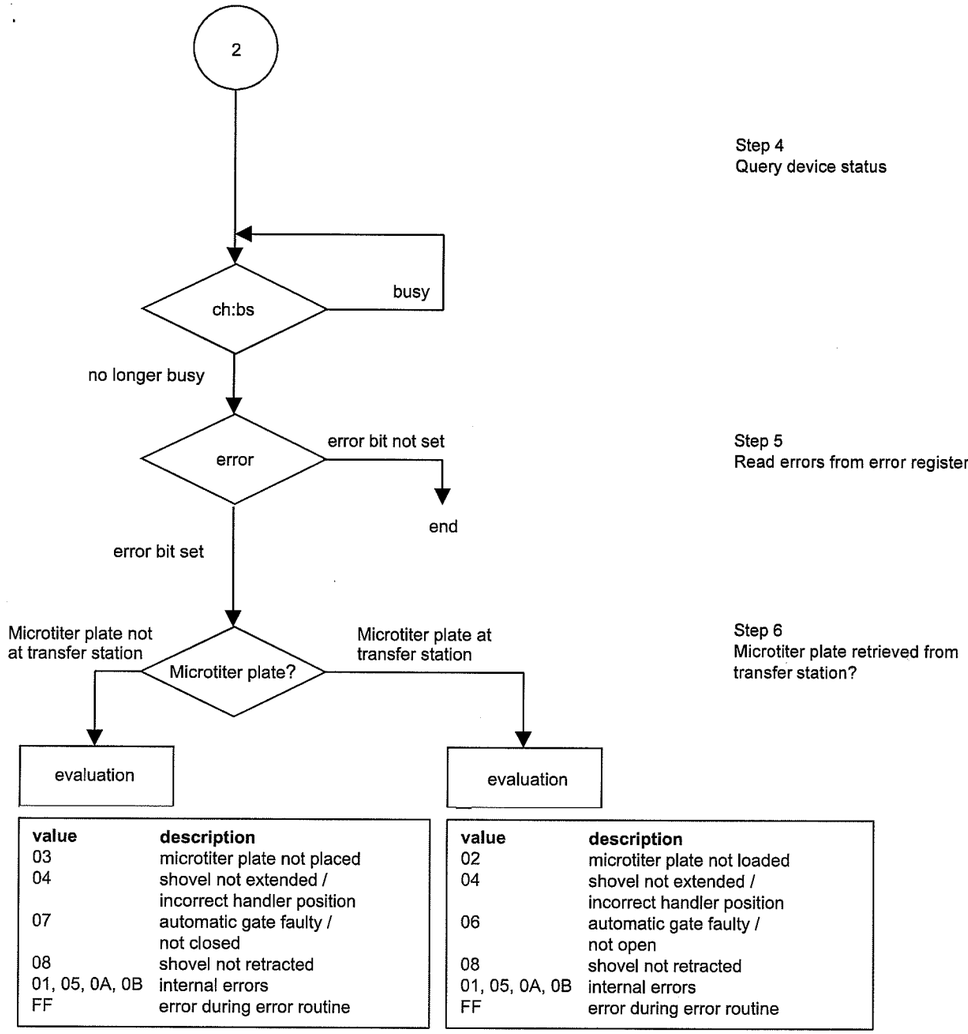
- Microtiter plate not unloaded: The shovel failed to place the microtiter plate in the stacker.
  Solution: Visually inspect the storage location (already occupied?), the extension length and the elevation of the handler in the stacker. Readjust as required.
- Shovel not extended / handler position error: The handler is in the wrong position and cannot extend the shovel.
  Solution: Check if movement is obstructed due to objects in the path, check the handler position. Readjust as required.
- Automatic gate / not closed: The automatic gate could not be closed.
  Solution: Check the automatic gate, check for foreign objects.
- Incorrect shovel position: The handler shovel was not retracted.
  Solution: Check the handler position. Readjust as required. Check the shovel movement.

Error processing for error group 4:
Errors that may occur in both functional states (i.e. when the microtiter plate is not unloaded from the transfer station or after the microtiter plate has been retrieved from the transfer station).

- Internal error: Error in the Plate Shuttle™ System (PSS) controller or in a motor controller.
  Solution: Contact Technical Service.
- Error during the error routine: Several errors occurring simultaneously will prevent the error routines from being successfully concluded.
  Solution: Contact Technical Service.

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5. Error processing



Step 4
Query device status

Step 5
Read errors from error register

Step 6
Microtiter plate retrieved from transfer station?

value	description
03	microtiter plate not placed
04	shovel not extended / incorrect handler position
07	automatic gate faulty / not closed
08	shovel not retracted
01, 05, 0A, 0B	internal errors
FF	error during error routine

value	description
02	microtiter plate not loaded
04	shovel not extended / incorrect handler position
06	automatic gate faulty / not open
08	shovel not retracted
01, 05, 0A, 0B	internal errors
FF	error during error routine

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5. Error processing

5.2.2 Example: Microtiter plate (MTP) not unloaded from the device

When a microtiter plate is to be transported out of the stacker to the transfer station, several errors may occur in the various movement processes. The Plate Shuttle™ System (PSS) may report the following error codes to the process system after checking the received command:

- Plate Shuttle™ System (PSS) still busy: A new command cannot be accepted while the previous one is still active.
  Solution: Wait until the busy bit has been reset, then reissue the command.
- Telegram error: The telegram was either transmitted improperly, the location number is too high, or the command is unknown.
  Solution: Check the telegram structure in the process system software, check the location number.
- Handler in an incorrect position: The handler is in the wrong position as a result of an error or of a previous low-level command.
  Solution: For most high-level commands, the handler must be in the wait position. The low-level command **II:wp<CR>** can be used to achieve this. If a different starting position is required, this starting position must first be reached by using other low-level commands.
- Handler occupied: The handler cannot retrieve a microtiter plate from the transfer station because another microtiter plate is already lying on the handler.
  Solution: First unload the existing microtiter plate, then restart the command.
- Transfer station occupied: The Plate Shuttle™ System (PSS) will not start the command because there is a microtiter plate on the transfer station and the Plate Shuttle™ System (PSS) cannot store some other microtiter plates at this location. (The sensor on the transfer station can check this prior to the confirmation of the command.)
  Solution: The process system must first unload the microtiter plate, then the command must be restarted.

Errors in the movement process can result in the following error messages being set:

- Microtiter plate not loaded: The shovel failed to retrieve the microtiter plate from the stacker.
  Solution: Visually inspect the storage location in the stacker (empty?) and the extension length and elevation of the handler in the stacker. Readjust as required.
- Shovel not extended / handler position error: The handler is in the wrong position and cannot extend the shovel.
  Solution: Check if movement is obstructed due to objects in the path, check the handler position. Readjust as required.
- Incorrect shovel position: The handler shovel was not retracted.
  Solution: Check the microtiter plate (too heavy or jammed), check the handler and stacker position. Readjust as required.

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5. Error processing

- Automatic gate faulty / not open: The automatic gate could not be opened, the handler with the microtiter plate is in the wait position.
  Solution: Check the automatic gate.
- Microtiter plate not unloaded: The shovel failed to place the microtiter plate on the transfer station.
  Solution: Visually inspect the transfer station and the extension length and the elevation of the handler. Readjust as required.
- Automatic gate faulty / not closed: The automatic gate could not be closed.
  Solution: Check the automatic gate, check for foreign objects.
- Internal error: Error in the Plate Shuttle™ System (PSS) controller or in a motor controller.
  Solution: Contact Technical Service.
- Error during the error routine: Several errors occurring simultaneously will prevent the error routines from being successfully concluded.
  Solution: Contact Technical Service.

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6. Communication with telegram structure

To increase data security, a configuration setting allows all communications between the process system and the Plate Shuttle™ System (PSS) to be supplemented by a telegram structure including a checksum (BCC).

If the telegram function is selected in the configuration, all commands described in this software documentation are integrated into the following structure. Please note that the carriage return (CR = 0x0D) normally used to conclude a command or response is no longer transmitted.

< STX | command or response | 0x3B | BCC | ETX >

The semicolon character (hex character 0x3B) separates the command or response from the checksum. The checksum is one byte large and is formed as the XOR link between all bytes of the command or response.

Example of a telegram structure:
In the telegram structure, a query would run as follows:

ch:bs<CR>

The ASCII values of the command are:

c = 0x63
h = 0x68
: = 0x3a
b = 0x62
s = 0x73

XOR link:

BCC = 0x63 XOR 0x68 XOR 0x3a XOR 0x62 XOR 0x73 = 0x20

The command is integrated into the structure:

< STX | c | h | : | b | s | ; |BCC| ETX >
< STX |0x63|0x68|0x3a|0x62|0x73|0x3B|0x20| ETX >

The Plate Shuttle™ System (PSS) could respond as follows:

< STX | o | k | | 0 | 1 | ; |BCC| ETX >
< STX |0x6f|0x6b|0x20|0x30|0x31|0x3B|0x25| ETX >

or, converted to the familiar form:

ok 01<CR>

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7. Description of the service program

The Plate Shuttle™ System (PSS) service program allows the parameters for system settings to be read and partially altered; it also has several functions for starting and monitoring various movement processes.

NOTE – Adjustment

Due to the required setting of mechanical components, the exact adjustment of the Plate Shuttle™ System (PSS) can be carried out only in connection with the service instructions.

NOTE – Disabled functions

Some menu functions of the service program are disabled, i.e. only available to the Technical Service.

CAUTION – Handler collision!

**The movements of the handler are programmed for the specific pitch in the stacker.
If stackers with a higher or lower pitch than previously planned are to be used, the movement of the handler must be readjusted accordingly!
Prior to starting test runs, make sure that the device is in an operative condition.**

7.1 Recommended system requirements

A serial interface connects the automatic incubator to a computer system. The following minimum requirements apply to the hardware configuration of the computer system:

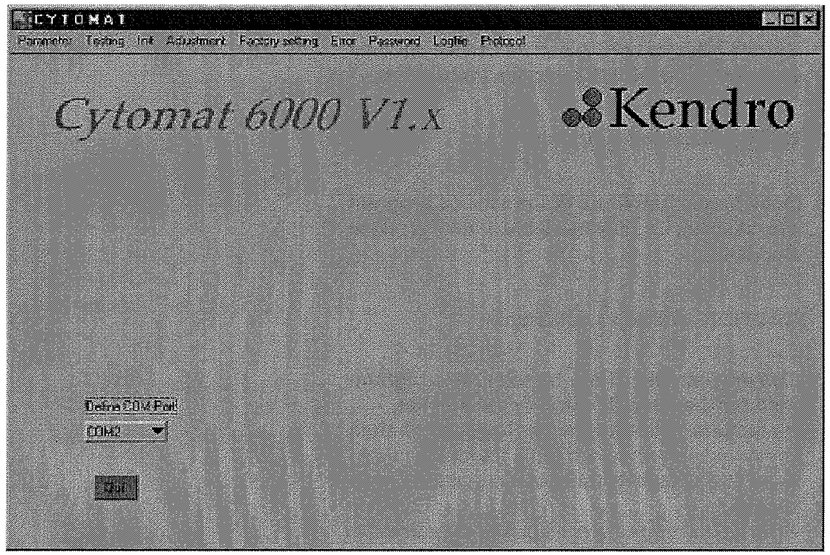
- Pentium 166 or higher
- Windows 95, Windows NT 4.0 or higher
- 16 MB RAM
- 3 MB free disk space
- VGA 1024 * 800 pixel resolution (800 * 600 pixel minimum)

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7. Description of the service program

7.2 Overview of menus and submenus

When the service program is started, the start window opens. After the serial output to which the Plate Shuttle™ System (PSS) is connected has been set using the pull-down menu (**Define COM-Port**), you can select the following program functions using the menu bar.



Parameter

motor parameter

Overview of all motor-specific parameters. All parameters can be read and saved. Read access only.

basic parameter

Overview of all parameters for setting the Plate Shuttle™ System (PSS). All parameters can be read and saved. Read access only.

Testing

free running

Activation of the continuous operation of the Plate Shuttle™ System (PSS).

Init

motors + system

Initialization of the individual stepper motors. Restart of the motor controllers and of the complete Plate Shuttle™ System (PSS).

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7. Description of the service program

Adjustment
transfer station
Menu for adjusting the transfer station and for saving the determined parameters.
stacker pitch configuration
Menu for setting the stacker configuration.

Factory Settings

Error
read error
Use this option to display a table containing the 12 most recent errors saved in the Plate Shuttle™ System (PSS).

Password
set password
Use this option to specify a password for service.

Logfile
logfile on/off
Use this option to enable or disable the logfile function.

Combination of software:
The software versions of the individual components have been fit to match. If incompatible service software versions are detected, a corresponding error message is issued. Please observe the following software version interconnections:

Software version of the Plate Shuttle™ System (PSS)
ID No.: 50069773

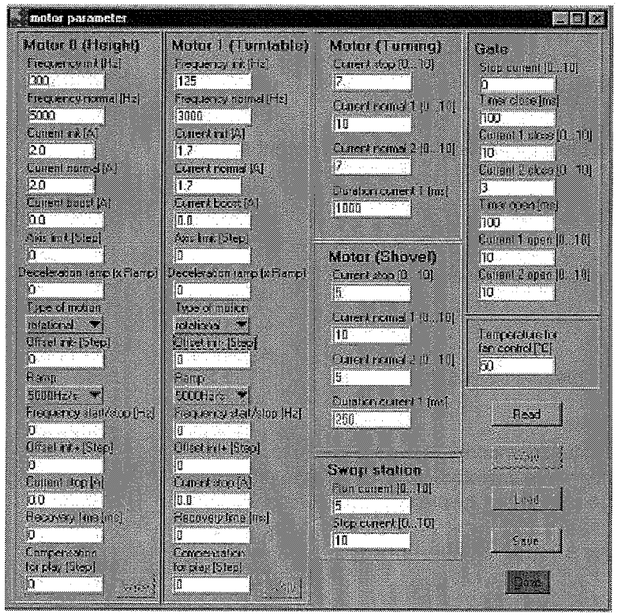
Service program
ID No.: 50083010

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7. Description of the service program

7.3 motor parameter [Parameter menu]

All parameters required for movement of the Plate Shuttle™ System (PSS) can be read and saved from the **motor parameter** submenu. Saved data can be viewed.



Read: Data can be read from the device.
Write: Disabled.
Load: Data can be loaded from a file.
Save: Data can be saved to a file.
Close: Return to overview window.

NOTE – Error detection

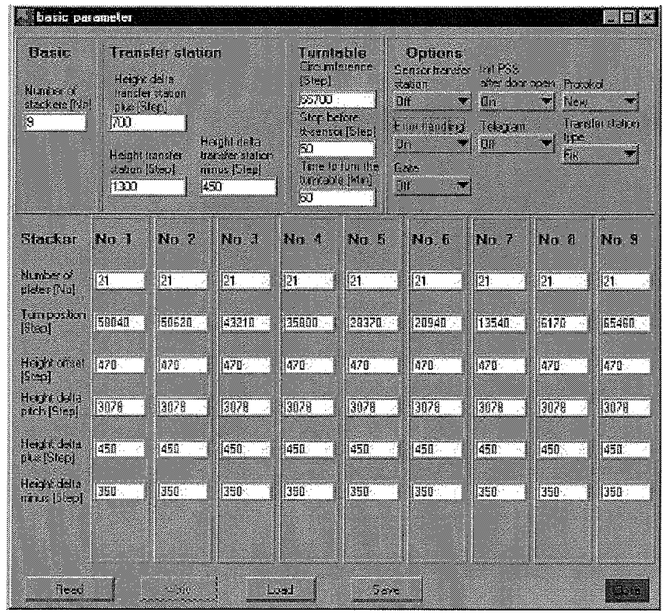
You can use the program functions Read and Save for error detection by sending the parameter settings used for operation to the Technical Service so that setting errors can be corrected and you may receive a functional data record.

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7. Description of the service program

7.4 basic parameter [Parameter menu]

All basic settings that control the movements of the Plate Shuttle™ System (PSS) and the stacker configuration can be read and saved from the **basic parameter** submenu. Saved data can be viewed.



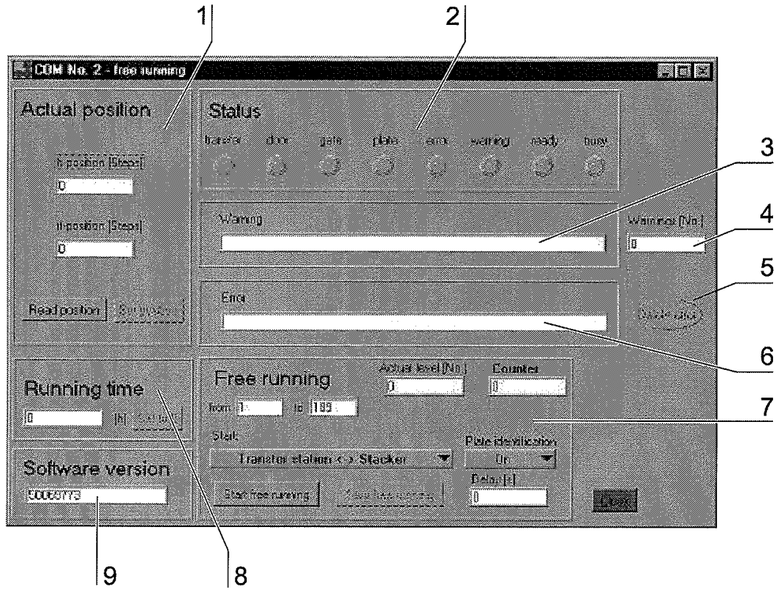
Read: Data can be read from the device.
Write: Disabled.
Load: Data can be loaded from a file.
Save: Data can be saved to a file.
Close: Return to overview window.

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7. Description of the service program

7.5 Free running [Testing menu]

Use the functions in this menu to start various complex test procedures and to track their progress or status in the dialog box. All important registers are continuously queried and displayed. Aside from any current warnings or errors, there is also a counter indicating the number of warnings which occurred during the test.



Dialog box functions

1 Reading the current position of the turntable (tt-position) and of the handler (h-position)
2 LED bar, overview register status
3 Plain text for current warning messages
4 Counter for warnings registered during the test run
5 Deleting errors
6 Plain text for current error messages
7 Modifiable input fields, output fields, selection and start button for test routine
8 Running time for complete movement of Plate Shuttle™ System (PSS)
9 Software version number

NOTE – Turntable equipment

To ensure the trouble-free run of the test routine, the turntable must be equipped with nine stackers.

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7. Description of the service program

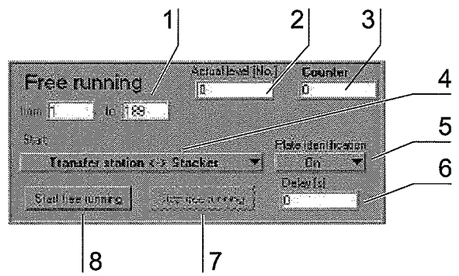
Elements in the Free running dialog box

1 Input field from - to
Setting of the desired storage location in the stackers, from microtiter plate nn to
microtiter plate nn.

2 Actual level [No.]
Number of the currently accessed storage location.

3 Counter
Number of total accesses.

4 Selection button
Test version selection:
Transfer station <—> Stacker
Stacker <—> Wait position
Stacker <—>Transfer station
Wait position <—> Hold position
Hold position <—> Wait position
Start free running <—> Test start
Stop free running <—> Test stop
Run program from file



5 Plate identification
Enable/disable microtiter plate identification.

6 Delay [s]
Delay between two accesses.

7 Stop button
Stopping of the test routine. The entire action is reset. The parameters must be reentered.

8 Start button
Starting of the test routine.

NOTE – Test routine conditions

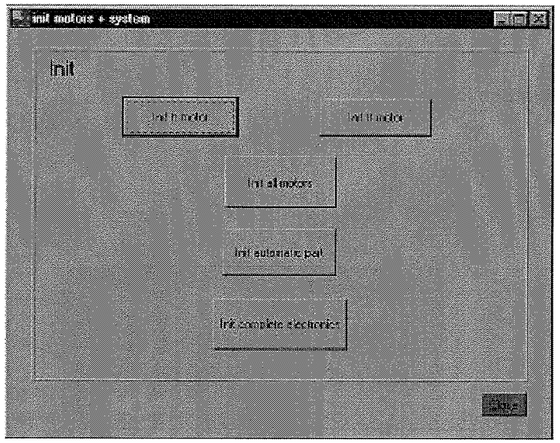
At the start of the test routine, there must always be a microtiter plate at the location that is specified first. When the test routine is to be run without a microtiter plate, you can use the Plate Identification function to disable microtiter plate identification.

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7. Description of the service program

7.6 init motors + system [Init menu]

Use this routine to initialize individual stepper motors and for a restart of the motor controller and of the complete Plate Shuttle™ System (PSS).



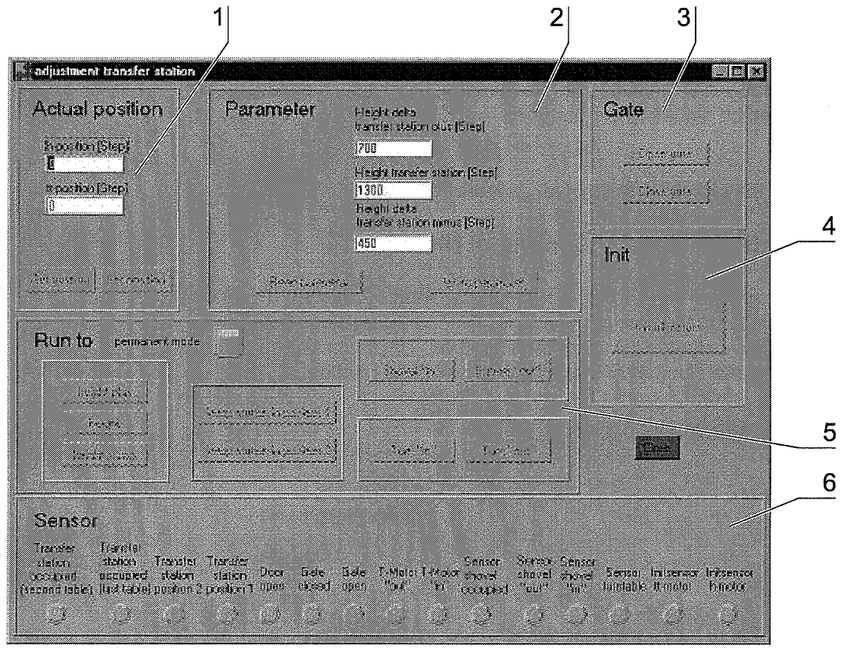
Init h –motor	Initialization of the height motor
Init tt –motor	Initialization of the turntable motor
Init all motors	Initialization of all motors
Init automatic part	Initialization of the automatic unit (automatic lift door, transfer station / handler, lift)
Init complete electronics	Restart of the Plate Shuttle™ System (PSS)

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7. Description of the service program

7.7 adjustment transfer station [Adjustment menu]

This menu (6 dialog boxes) allows adjustment of the handler at the transfer station. All parameters required for the adjustment are available for checking and modification. In addition, any required movements and motor initializations can be started with a button.



1 Actual position
Reading and setting the height position (height motor) and the turntable position (turntable motor).

2 Parameter
Setting the vertical position of the handler or of the shovel to the transfer station.

Height delta transfer station plus	raised height position (+ height offset)
Height transfer station	height position above transfer station
Height delta transfer station minus	lowered height position (- height offset)

Use the **Read parameter** button to read the set parameter values or the **Write parameter** button to save the set parameter values in the Plate Shuttle™ System (PSS).

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7. Description of the service program

3 Gate
Button for opening and closing the automatic gate.

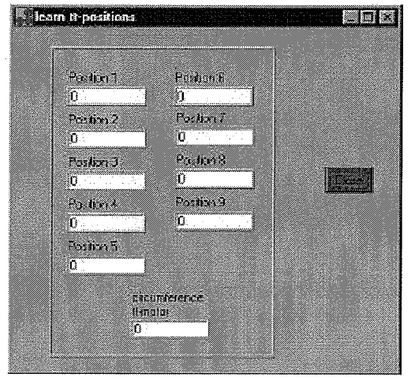
4 Init
Button for initializing all stepper motors.

5 Run to
Real-time correction and buttons for starting the handler / shovel movements and rotations of the rotating transfer station.
If the **Permanent mode** function is enabled, the handler moves to the set or modified position without any other command; otherwise, the movements can be started by actuating the buttons.

6 Sensor
Overview of the switching state of all sensors.

7.8 learn tt-positions [Adjustment menu]

During the start routine, the turntable of the Plate Shuttle™ System (PSS) accesses all markings for the stacker positions. The individual steps determined for this process are output in the corresponding box. The lower box **circumference** shows the total number of steps for one complete rotation.



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7. Description of the service program

7.9 stacker pitch configuration [Adjustment menu]

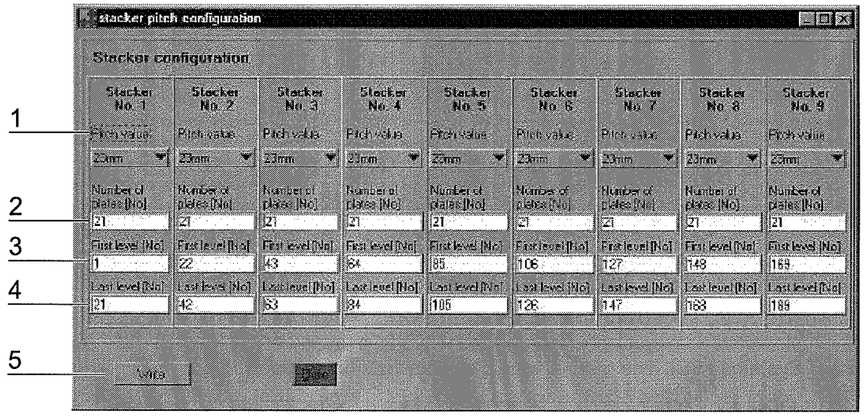
This menu is used for the configuration of the stacker types that are used. The settable parameter is:

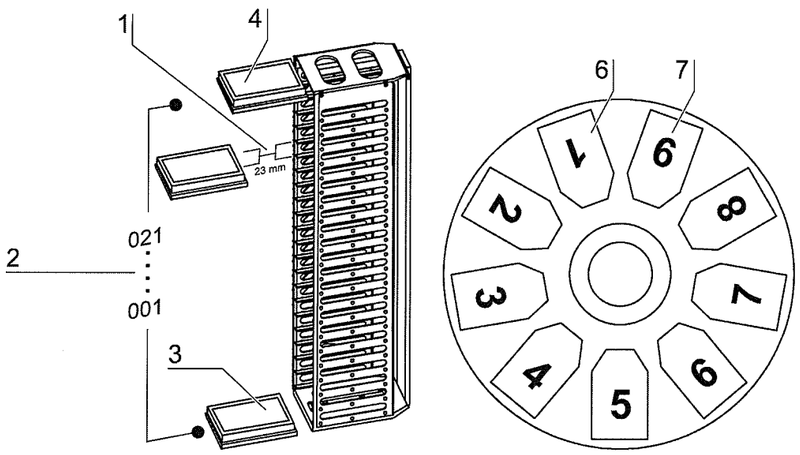
1 Pitch: Vertical spacing of the media plates for the microtiter plates (also limits the height of the loadable microtiter plates).

This parameter is used for several calculations:

2 Number of plates: Maximal number of storage locations available in a stacker.
3 First plate: The lowest location number of a microtiter plate in the stacker.
4 Last plate: The uppermost location number of a microtiter plate in the stacker.

The storage locations are numbered in a sequence, from the lowest location number in the first stacker [6] to the uppermost location number in the ninth stacker [7]. Only after all parameters have been set, the input is read and saved by actuating the **Write** button [5].





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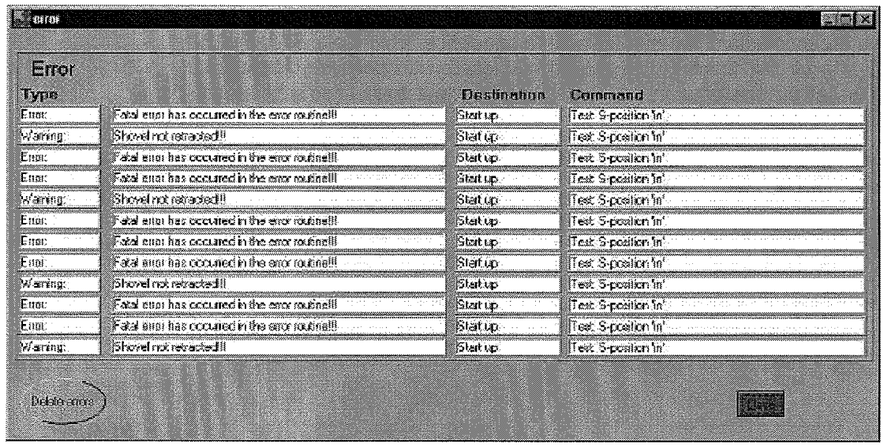
7. Description of the service program

7.10 read error [Error menu]

This menu provides an overview of the 12 most recent errors saved in the Plate Shuttle™ System (PSS). The error list contains the following information:

- type of error (warning or failure),
- brief error description,
- target (destination) of the movement for which the error was detected,
- command or test routine for which the error was detected.

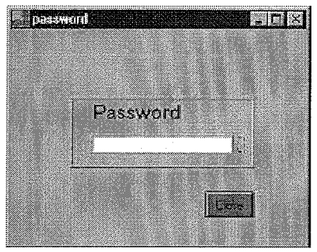
You can use the **Delete errors** button to delete the error list.



In the example above, an error occurred during the start-up routine of the Plate Shuttle™ System (PSS). The routine was interrupted as the shovel was not retracted.
The top line of the error table relates to the most recent error. When the error table is full, the earliest is deleted.

7.11 password [Password menu]

Program functions that are disabled by access protections can be enabled by entering the correct password (usually reserved for Technical Service personnel).

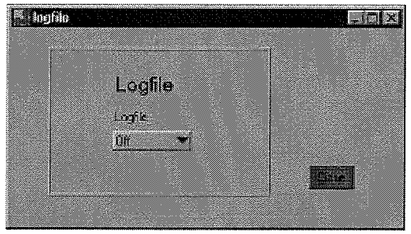


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7. Description of the service program

7.12 logfile on/off [Logfile menu]

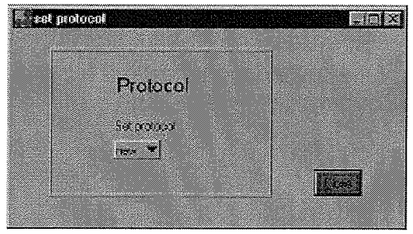
All telegrams transmitted between the service program and the Plate Shuttle™ System (PSS) can be saved to a file.
If this function is enabled (**on**) with the **on/off** button, a file name and the directory in which the file is to be saved are freely selectable.



7.13 set protocol [Protocol menu]

This function allows you to switch between protocol types:

new Protocol as described in this software documentation.
old Protocol as used by a previous version of the Plate Shuttle™ System (PSS).



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8. Annex A , Bar code scanner (optional)

A.1 RS 232 interface bar code scanner

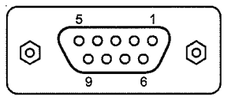
The RS 232 interface has been designed for a cable connection with 9-pin SUB D-connector and a contact assignment of 1:1.

Transfer settings:
The interface must be configured as follows:

Speed:	9600 Baud
Data bits:	7
Stop bits:	1
Parity:	Even

Occupancy of conductors:

Type of connector:	9-Pin SUB-D (female)
Pin 2:	TxD (output)
Pin 3:	RxD (input)
Pin 5:	GND
Pin 7:	CTS
Pin 8:	RTS (output)



Triggering:
The triggering is effected serially from the host computer.

disable decoding	LOFF disables the scanner
enable decoding	LON enables the scanner until the code is decoded.

A.2 Positioning of the scanner

So that the bar code can be recognized from the scanner, the handler must be positioned above the storage location with the low-level command **Ih:h+ ###** (see section 4.3).

A.3 Bar code decoding programs

Following codes are preset by factory:
- Code 93
- ITF
- Code 128
- UPC/EAN

The factory settings can be changed via software. The software and more informations about the bar code scanner are available in the internet.

Note – Freeware

blsetup is a program, compatible to scanner type BL-600 and is offered by Keyence Corporation (www.keyence.com) as freeware.

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8. Annex A , Bar code scanner (optional)

A.4 Technical data bar code scanner

Light source	650 nm, visible laser diode
Scan method	raster
Scan rate	500 scans/s
Min. reflection difference	75 %
Bar codes	Code 39, ITF, Industrial 2 of 5, Coda bar, Code 128, EAN-128, Code 93, EAN/UPC(A-E)
Interface	RS 232
Supply voltage	5 V DC ± 5%
Operating current	330 mA max.
Triggering	Seriell (enable, disable, trigger), opitonal Hardware-Triggering
Data output	Seriell asynchron
Transfer parameters	9600 baud, even parity, 7 databit, 1 stopbit
Enclosure	IP 65
Laser protection class	FDA: class II, DIN/IEC: class 2
Humidity	35 %...85 %, non-condensing
Temperature	0 °C...50 °C

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9. Annex B, Overview of the registers

Overview register	
Bit / Value	**Description**
0 / 0x01	Command is being processed
1 / 0x02	Command executed
2 / 0x04	Warning present
3 / 0x08	Error set
4 / 0x10	Shovel occupied
5 / 0x20	Gate open
6 / 0x40	Device door open
7 / 0x80	Transfer station occupied
Warning register	
Value	**Description**
0x01	Communication with motor controllers interruped
0x02	MTP not loaded on handler/shovel
0x03	MTP not unloaded from handler/shovel
0x04	Shovel not extended/Handler movement error
0x05	Process timeout
0x06	Automatic lift door not open
0x07	Automatic lift door not closed
0x08	Shovel not retracted
0x09	Initialization due to open device door
0x0C	Transfer station not rotated
Error register	
Value	**Description**
0x01	Communication with motor controllers interruped
0x02	MTP not loaded on handler/shovel
0x03	MTP not unloaded from handler/shovel
0x04	Shovel not extended/Automatic unit position error
0x05	Process timeout
0x06	Automatic lift door not open
0x07	Automatic lift door not closed
0x08	Shovel not retracted
0x09	- not used -
0x0A	Stepper motor controller temperature too high
0x0B	Other stepper motor controller error
0x0C	Transfer station not rotated
0xFF	Fatal error occurred during error routine

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9. Annex B, Overview of the registers

Action register	
Value Bit 0-4	**Current movement or control command**
0x01	Movement, height motor to storage location (minus offset)
0x02	Query whether height position reached (minus offset)
0x03	Movement, height motor to storage location (plus offset)
0x04	Query whether height position reached (plus offset)
0x05	Movement, rotating motor to storage location
0x06	Query whether rotational position reached
0x07	Movement, extend shovel
0x08	Query whether shovel has been extended
0x09	Query, shovel extended limit switch
0x0a	Movement, retract shovel
0x0b	Query whether shovel has been retracted
0x0c	Close automatic lift door
0x0d	Query whether automatic lift door has been closed
0x0e	Open automatic lift door
0x0f	Query whether automatic lift door has been opened
0x10	Transfer station in position 1
0x11	Query whether transfer station is in position 1
0x12	Transfer station in position 2
0x13	Query whether transfer station is in position 2
0x14	Test MTP on shovel
0x15	Test MTP on transfer station
0x19	Turntable movement
0x1a	Turntable position query
Value Bit 5-7	**Movement target**
0x01	Movement target: Init position
0x02	Movement target: Wait position
0x03	Movement target: Stacker
0x04	Movement target: Transfer station

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9. Annex B, Overview of the registers

Error codes (responses to rejected commands)	
Value	**Error message**
0x01	Device still busy, new command not accepted
0x02	Command unknown
0x03	Telegram structure error
0x04	Incorrect parameter in telegram
0x05	Unknown location number specified
0x11	Incorrect handler (start) position
0x12	Command cannot be executed as shovel is extended
0x21	Handler already occupied
0x22	Handler empty
0x31	Transfer station empty
0x32	Transfer station occupied
0x33	Transfer station not in position
0x41	No gate configured
0x42	Automatic lift door not open
0x51	Error while accessing internal memory
0x52	Incorrect password / unauthorized access

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10. Annex C, Overview of the commands

Command	Immediate response	Description
Status register query		
ch:bs<CR>	bs xx<CR>	Query overview register
ch:bw<CR>	bw xx<CR>	Check current warning byte
ch:be<CR>	be xx<CR>	Check current error byte
ch:ba<CR>	ba xx<CR>	Query current movement
rs:be<CR>	ok xx<CR>	Delete error bit and error code
ch:sw<CR>	sw xx<CR>	SWAP station register
High-level commands		
mv:ts ###<CR>	ok **<CR>, er **<CR>	• Open automatic lift door • Retrieve MTP from transfer station • Close automatic lift door • Place MTP at specified storage location **Condition:** MTP at transfer station, handler empty
mv:st ###<CR>	ok **<CR>, er **<CR>	• Retrieve MTP from specified storage location • Open automatic lift door • Transport MTP to transfer station • Close automatic lift door **Condition:** Transfer station and handler empty
mv:sw ###<CR>	ok **<CR>, er **<CR>	• Move from wait position to specified storage location • Transport MTP to wait position in front of automatic lift door **Condition:** Handler empty
mv:ws ###<CR>	ok **<CR>, er **<CR>	• Move from wait position to specified storage location • Place MTP there and return to wait position **Condition:** MTP on handler
mv:wt<CR>	ok **<CR>, er **<CR>	• Open automatic lift door and deposit MTP at transfer station • Return to wait position • Close automatic lift door **Condition:** MTP on handler, transfer station empty
mv:tw<CR>	ok **<CR>, er **<CR>	• Open automatic lift door and retrieve MTP from transfer station • Return to wait position • Close automatic lift door **Condition:** MTP at transfer station, handler empty
mv:wh<CR>	ok **<CR>, er **<CR>	• Return to wait position from exposed position outside device • Stop at position above transfer station **Condition:** None

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10. Annex C, Overview of the commands

Command	Immediate response	Description
High-level commands		
mv:hw<CR>	ok **<CR>, er **<CR>	• Return to wait position from exposed position outside device • Close automatic lift door **Condition:** None
mv:hs ###<CR>	ok **<CR>, er **<CR>	• Return with MTP from position above transfer station to specified storage location • Move handler to wait position • Close automatic lift door **Condition:** MTP on handler
mv:sh ###<CR>	ok **<CR>, er **<CR>	• Move from wait position to specified storage location, retrieve MTP and transport it to exposed position outside device **Condition:** Handler empty
Low-level commands		
ll:gp 001<CR>	ok **<CR>, er **<CR>	• Close automatic lift door **Condition:** Handler not rotated toward transfer station
ll:gp 002<CR>	ok **<CR>, er **<CR>	• Open automatic lift door **Condition:** None
ll:tp 001<CR>	ok **<CR>, er **<CR>	• Move transfer station / SWAP station to position 1 **Condition:** Handler not rotated toward transfer station
ll:tp 002<CR>	ok **<CR>, er **<CR>	• Move transfer station / SWAP station to position 2 **Condition:** Handler not rotated to transfer station
ll:h– ###<CR>	ok **<CR>, er **<CR>	• Lower height motor below storage location ### **Condition:** Shovel retracted or only minimal lift required within storage location, if handler is rotated toward transfer station, only lowering to ll:h– 000<CR> is possible
ll:h+ ###<CR>	ok **<CR>, er **<CR>	• Raise height motor above storage location ### Condition: Shovel retracted or only minimal lift required within storage location, if handler is rotated toward transfer station, only raising to ll:h+ 000<CR> is possible
ll:dp 001<CR>	ok **<CR>, er **<CR>	• Rotate handler in to stacker **Condition:** Shovel retracted
ll:dp 002<CR>	ok **<CR>, er **<CR>	• Rotate handler out to transfer station **Condition:** Shovel retracted, handler must have been moved to transfer station height, automatic lift door must be open
ll:kp ###<CR>	ok **<CR>, er **<CR>	• Rotate turntable to storage location ### **Condition:** Shovel retracted
ll:sp 002<CR>	ok **<CR>, er **<CR>	• Shovel extended **Condition:** Handler is in a height and rotating position that allows the shovel to be extended

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10. Annex C, Overview of the commands

Command	Immediate response	Description
Location scan (without bar code)		
ll:sp 001<CR>	ok **<CR>, er **<CR>	• Retract shovel **Condition:** None
ll:wp<CR>	ok **<CR>, er **<CR>	• Move motors to wait position **Condition:** None
ll:in<CR>	ok **<CR>, er **<CR>	• Reinitialize automatic unit **Condition:** None
mv:sc<CR>	ok xx<CR>, er xx<CR>	Start location scan
ch:sc xxx<CR>	sc x<CR>	Check individual storage location after location scan (1 = occupied, 0 = emptyi)

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