TECHNOLOGIES

# HVM Series
# High Voltage Switch Matrix


## User's Manual

# Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

The symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The symbol on an instrument shows that it can source or measure 1000 volts or more. Use standard safety precautions to avoid personal contact with these voltages.

The symbol indicates a connection terminal to the equipment frame.

The symbol indicates a connection terminal to safety ground.

**WARNING:**
This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the manual for complete product specifications.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. ALWAYS remove power from the entire test system before connecting or disconnecting cables!

Before operating an instrument, ensure the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use. Only use high quality cables free from any defects.

Instrumentation and accessories shall never be connected to humans.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired. Do not exceed the maximum voltage levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument.

The power cord supplied contains a separate protective earth (safety ground) wire for use with grounded outlets. When proper connections are made, the instrument chassis is connected to power-line ground through the ground wire in the power cord. In the event of a failure, not using a properly grounded protective earth and grounded outlet may result in personal injury or death due to electric shock. Do not replace detachable mains supply cords with inadequately rated cords. Failure to use properly rated cords may result in personal injury or death due to electric shock.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform service procedures.

# Introduction

The mb-Technologies HVM high voltage switch series is a computer-controlled switching matrix designed for semiconductor characterization applications. It connects a number of instruments - connected to the matrix inputs - to test structures connected to the matrix outputs.

The connection is done using a high voltage relay matrix with guarded contacts. Optionally, triple-switch FORCE, SENSE and GUARD relays are used at each switch point to support low-leakage Kelvin measurements. Connections are shown on the front panel dot matrix display.

The base system supports a switch matrix with up to 12 inputs and 12 outputs. Expansion units can be added to increase the number of outputs.

**CAUTION**: It is highly recommended to switch the relays without any voltage or current applied. This is referred as cold switching. Please note the switching capabilities under voltage or current is limited. Also the lifetime my be affected (see *Specifications*).

The switch matrix supports a discharge feature which connects the relay matrix to ground using 1MΩ resistors. Discharge can be activated either by software, with a push button on the front panel or using a control line of the digital I/O interface.

Various communication interfaces are supported. The equipment can also be controlled from the front panel for testing and debugging purposes.

# Installation

When you receive and open the box, check the packaging material and the equipment for any signs of damage like dents, scratches, cuts or water marks.

Check the components list:

- Switch matrix
- Mounting flanges (2) w/ screws (6)
- User's manual
- Power cable (may not be included for certain areas)

For an expansion unit please check the following components:

- Switch matrix expansion unit
- Mounting flanges (2) w/ screws (6)
- Communication cable
- Input connection cables (optional, number and type depends on the matrix connectors)
- Power cable (may not be included for certain areas)

**WARNING**: This equipment is heavy and may only be lifted or moved by 2 persons. It's recommended to hold it on the left and right side.

After unpacking, connect the power cable and power the equipment using the rear side switch and the front panel push button. If installing an expansion unit, connect use the communication cable with either SYNC connector, also connect all matrix inputs between the units.

Wait until the power-on tests have finished then check the operation by executing a self-test (see *Self-Test*).

GPIB, USB, LAN or RS232 communication connectors are available. Please note communications cables are not included. You may need to set the communication parameters before it can be used (see *Communication Setup*).

If the equipment is to be installed in a rack or cabinet, mount the flanges using a cross-tip screwdriver PZ2.

**WARNING:** If installed in a rack or cabinet, the equipment should be screwed-on to prevent falling out.

**WARNING:** When installing this equipment in places where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided, in close proximity to the equipment and within easy reach of the operator.

**WARNING:** Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

**WARNING:** The switch matrix comes with connectors equipped to the users requirements. These connectors may be of different type. While the relay matrix can always handle high voltage, some connectors may be rated much lower voltage, e.g. BNC/Triaxial connectors are rated 500 V only. It is the user's responsibility only to use voltages which can be handled by the connectors.
Depending on the interface options installed, GPIB, USB, LAN or RS232 connectors may be available. The interface to be used is selected using the front panel (see *Setup* section below).

For safety and noise reasons a separate ground connection is recommended using the ground tab marked with this symbol.

# Self-Test

## Power-On Self-Test:

After powered on, the equipment executes a series of internal tests. This takes about 20 seconds. The device cannot be accessed during this time. The display shows the model, the serial number and the hardware and firmware versions.

## Relay Matrix Test:

The power-on self-test does not include testing the relay matrix. This test can be invoked either manually using the TEST button or by software (see *Command Reference*).

Disconnect all measurement cables before starting the relay test! The test may fail if cables are connected.

Any problems found by these tests are shown on the display.

# Communication Setup

Press the MENU button, then 1 (SETUP) to select the communication interface and options. Select the interface and proceed with OK then set the options for this interface.

Any interface can be used, but only one interface can be used at a certain time. Once the interface is used, it is shown in the front panel.

Do not use the interface connectors of the expansion box, if there are any.

## *USB Setup:*

Connecting the switch matrix to a PC by USB installs a virtual serial communication port. Usually the driver is already installed in your operating system or found automatically. If you get an error message you can download the VCP driver from https://ftdichip.com/drivers/vcp-drivers/. Installation guides for various operating systems can found at http://www.ftdichip.com/Support/Documents/InstallGuides.htm.

Please check the Device Manager in your Control Panel to identify the new USB serial port in the *COM & LPT* section. The communication settings like baud rate and parity don't care as these settings are just virtual however it is recommended to change the BM latency timer from "16 ms" to "2 ms" (right click the port and select *Properties*, *Port Settings*, *Advanced*).

Alternatively the USB port can be accessed directly using the D2XX library which is installed with the same driver as described above.

You can then communicate using this serial port and the commands described in *Command Reference*

This installation only needs to be done once. The port automatically becomes available each time the switch is connected and turned on.

### *LAN Setup:*

Connect the switch to your local network and turn it on. Press SETUP, select 1 (SETUP), 3 (LAN) and press OK. Either select AUTO to use automatic DHCP configuration or MANUAL to define your own network settings. In manual mode the IP address, the address of the gateway, the DNS server and the network mask can be defined. The switch can be accessed through TCP/IP port 10001 using the IP address of the switch.

Alternatively a virtual serial port can be assigned to the switch. The switch can then be accessed like any serial communication device. Install the software *Com Port Redirector* from https://www.lantronix.com/products/com-port-redirector/ and start the *CPR Manager*. Press *Add/Remove* and check an unused port number, then press OK. Select the new port then press *Search for Devices*. The switch should show up in the *Device List* window. Right click it and select *Add To Settings*. Click *Save* in the command bar to install the device driver. Accept the firewall warning. You may need administrator rights to do this. This will install a new serial port. You can then communicate using this port and the commands described in *Command Reference*. The communication port's settings like baud rate and parity don't care as these settings are just virtual.

This installation only needs to be done once. The port automatically becomes available each time the switch is connected to the network and turned on. It may take up a few seconds up to a minute until the switch is recognized by the network. If connected to a network the IP address of the switch is shown on the display. Also the IP address of the controlling computer is shown.

### *GPIB Setup:*

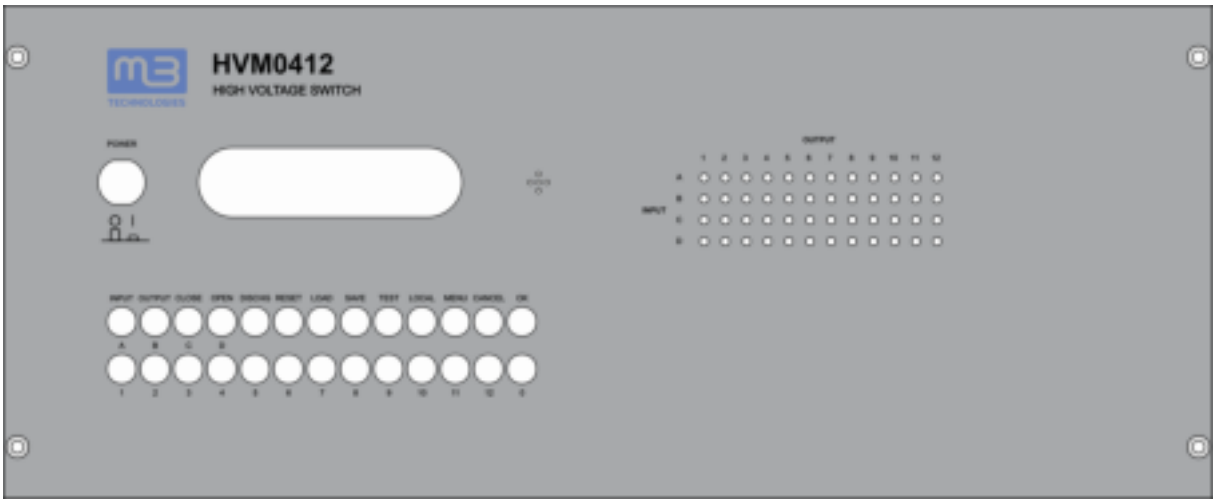
Press MENU, select 1 (SETUP), 1 (GPIB) and press OK. Enter the GPIB address to be used. Press OK to save the settings.

### *RS232 Setup:*

Press MENU, select 1 (SETUP), 4 (RS232) and press OK. Select the baud rate and press OK to save the settings. The communication uses 8 bits, no parity, 1 stop bit. It only supports the TXD and RXD. Handshake lines are not used.

## Display and Keyboard

In most cases the switch matrix will be controlled by software using the communication interfaces. The display and keyboard is useful for debugging purposes.




The front panel has several push-buttons, a color graphics display and a led matrix display. The dot matrix display shows the relay status all the time. A green dot indicates a connection between the row and column shown.

| | |
|---|---|
| **POWER:** | Used to turn the unit on or off. Please also note the power switch on the backside panel. |
| **INPUT, OUTPUT** | Used to select relays. |
| **CLOSE, OPEN** | Turns the selected relays on or off. |
| **DISCHG** | Toggles the discharge relays. |
| **RESET** | Opens all relays. Press twice to clear the LOAD/SAVE memory. |
| **LOAD, SAVE** | Used to store up to 10 configurations or reload them. |
| **TEST** | Starts the self-test (see *Self-Test* section). |
| **LOCAL** | Unlocks the keyboard in case it was locked by the software. |
| **MENU** | Switch settings and system information. |
| **OK, CANCEL** | Used to confirm or cancel commands. |
| **A to L, 1 to 12, 0** | Used for selecting relays or entering numbers. |

To operate the switch manually use the front panel display and keyboard: Press the INPUT or OUTPUT button then one of the letters/numbers buttons in the second row. A full row or column can be selected with '0'. Press CLOSE or OPEN to change the status, then press OK. The relay is switched immediately. This is also shown on the matrix display.

Note a maximum of 25 relays can be closed at any time.

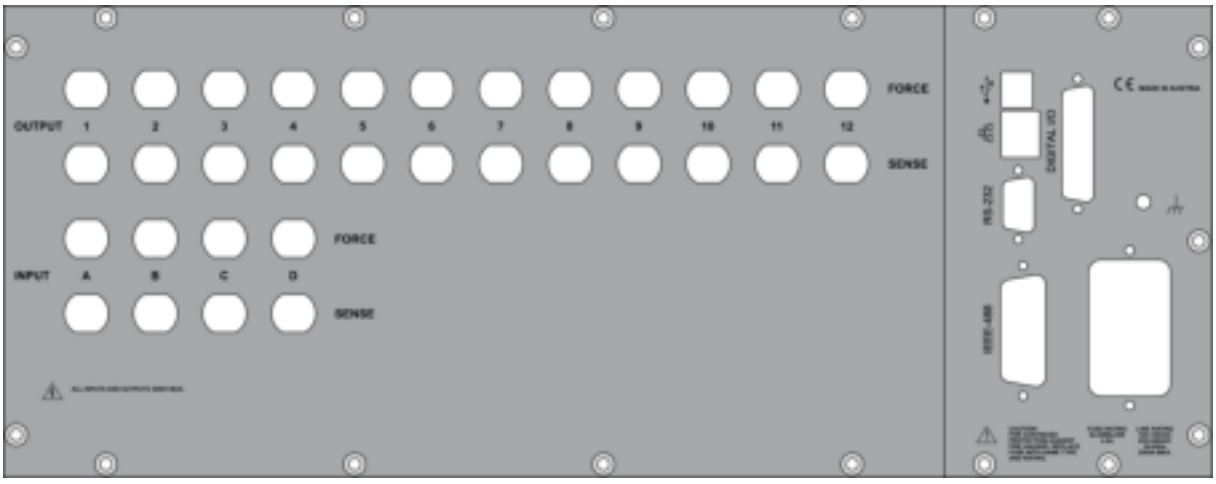
**CAUTION**: It is highly recommended to switch the relays without any voltage or current applied. This is referred as cold switching. Please note the switching capabilities under voltage or current is limited. Also the lifetime may be affected (see Specifications).

The SAVE button stores the current matrix configuration. You can choose one of 12 memory slots by pressing a number key and OK. The LOAD button restores a previously saved setup. The memory is retained when power is turned off.

The RESET button opens all relays. When pressing RESET twice, the LOAD/SAVE memory is cleared.

If the switch is controlled by software it changes to REMOTE mode and the keyboard is locked. This is shown by the REMOTE indicator on the display. If the software does not release the equipment after use the switch can be released manually by pressing the LOCAL key twice.

# Backside Panel




The backside panel has connectors for the matrix inputs and outputs. The switch matrix comes with connectors equipped to the users requirements. These connectors may be of different type. While the relay matrix can always handle high voltage, some connectors may be rated much lower voltage, e.g. BNC/Triaxial connectors are rated 500 V only. It is the user's responsibility only to use voltages which can be handled by the connectors.

Each input and output may have one connector, or two: FORCE and SENSE. If SENSE is not used it can be left open. FORCE and SENSE is connected internally with a 10MΩ resistor.

**WARNING**: Do not try to use non-matching connectors or wires.

**WARNING**: The maximum voltage rating for each connector is labeled on the backside panel. Do not apply any higher voltage. This also applies to connections through the matrix.

The right side of the backside panel has USB, LAN, RS232 and GPIB communication interfaces, a digital I/O connector, a ground connector stub and the main power jack connector with integrated switch and fuses installed. Depending on the configuration some of the communication interfaces may not be available.

# Maintenance

**WARNING:** This equipment does not contain any user serviceable parts inside. Only properly trained service personnel may open the equipment and perform service procedures.

**WARNING:** Disconnect all external power from the equipment and the line cord before performing any maintenance. Failure to disconnect all power may expose you to hazardous voltages, that if contacted could cause personal injury or death.

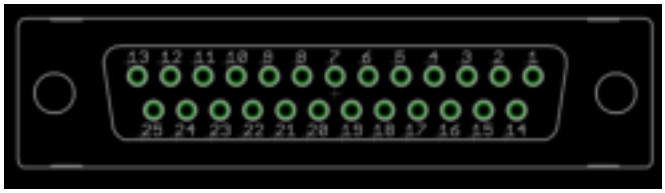
**CAUTION:** For continued protection against fire hazards, replace fuse with same type and rating. To replace the fuse, open the fuse drawer between main power jack and power-on switch with a flat head screwdriver.

Fuse rating: 4A slow blow, 250V (5 x 20mm).

To clean the instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument.

# Digital I/O Port

The Digital I/O Port is an optional SUBD 25 pin connector located on the backside of the switch:




It provides 16 general digital input/output signals, 4 status lines and 5V power.

The 16 general signals can be used for any purpose and are controlled by communication interface commands. Each line can be defined to be either input or output. All lines confirms to general CMOS signals levels (5 V). The meaning of the 4 status signals is defined in the following table:

| Pin | Function | Description |
|---|---|---|
| 1 | Input/Output #1 | General input or output |
| 2 | Input/Output #2 | General input or output |
| 3 | Input/Output #3 | General input or output |
| 4 | Input/Output #4 | General input or output |
| 5 | Input/Output #5 | General input or output |
| 6 | Input/Output #6 | General input or output |
| 7 | Input/Output #7 | General input or output |
| 8 | Input/Output #8 | General input or output |
| 9 | Input/Output #9 | General input or output |
| 10 | Input/Output #10 | General input or output |
| 11 | Input/Output #11 | General input or output |
| 12 | Input/Output #12 | General input or output |

| | | |
|---|---|---|
| 13 | Input/Output #13 | General input or output |
| 14 | Input/Output #14 | General input or output |
| 15 | Input/Output #15 | General input or output |
| 16 | Input/Output #16 | General input or output |
| 17 | BUSY (Output) | HIGH when the switch is executing a command, LOW when idle. |
| 18 | WAIT (Input) | When pulled HIGH the switch suspends execution. Commands are still accepted but queued in the internal command buffer until this input becomes LOW or the switch is reset.<br>This pin in LOW when unconnected. |
| 19 | DISCHARGE (Input) | When HIGH, all Force/Sense/Guard inputs of the matrix are connected to ground using 1 MΩ resistors, when LOW, DISCHARGE is disabled.<br>This pin in LOW when unconnected. |
| 20 | RESET (Input) | When HIGH, all relays are opened and the internal buffers are cleared.<br>This pin in LOW when unconnected. |
| 21 | | Not used |
| 22 | +5 V | 100 mA max current, short circuit protected. |
| 23 | | |
| 24 | Ground | Connected to case ground. |
| 25 | | |

# Command Reference

These commands are used for GPIB, USB, LAN and RS232 communication. GPIB hardware supported functions like serial and parallel poll are not available for USB, LAN or RS232 communication.

Commands are limited to 200 bytes.

Except for GPIB communication all commands and queries need to be terminated with <LF> (0x0A). Answer strings are also terminated with <LF>. If a command does not have a response it is acknowledged with an empty string and the terminating character.

Please note GPIB commands are not terminated as this is handled by the bus protocol.

## Syntax

A command is build from keywords, parameters and delimiters:

| | |
|---|---|
| UPPERCASE | Required letters for a keyword |
| lowercase | Optional letters for a keyword |
| *italic* | Parameter |
| , | Delimiter |
| [ ] | Square brackets are used to enclose optional keywords |
| ( ) | These characters are ignored |

## Parameters

Numerical parameters are accepted in decimal, binary, octal and hexadecimal, e.g.:

| | |
|---|---|
| 105 | decimal |
| #B1101001 | binary |
| #Q151 | octal |
| #H69 | hexadecimal |

### Relay numbers

Relays are specified by a letter defining the matrix input (A to L) followed by a number defining the matrix output (1 to 12).

Alternatively a relay can be specified by a 5 digit number biioo, where b=board (always 1), ii=input and oo=output. The number can be preceded by an @ character. This option is included for compatibility reasons.

Examples:

| | |
|---|---|
| A3 | Input 1, output 3 |
| 10206 | Input 2, output 6 |

### Relay list

Various command accept a list of relays. A relay list is a list of relay numbers delimited by comma (','). The list may be enclosed by parenthesis.

Examples:
A2,B3,C4
(@10102,10203,10404)

## *Commands*

### *IDN?

Queries identification string

Response:
manufacturer, model number, serial number, hardware version, software version

| Example: | Response: |
|---|---|
| `*IDN?` | `MB-TECHNOLOGIES,HVM0412,10035,5.2,5.0.121` |

### *OPC?

Waits until all pending operations are complete then returns 1.

Response:

| | |
|---|---|
| 1 | Operations complete |

| Example: | Response: |
|---|---|
| `*OPC?` | `1` |

Please note it may take a while until the *OPC? command is finished and the response is returned. Ensure your software does not run into some timeout.

### *RST

Resets the instrument and opens all relays.

### *TST

Starts execution of the relay matrix self-test. Depending on the matrix size the test may take up to 1 minute to finish.

Disconnect all measurement cables before starting the self-test! The test may fail if cables are connected.

### *TST?

Queries the result of the relay matrix self-test.

Response:

| | |
|---|---|
| 0 | Self-test passed |
| n (relay, …) | Self-test failed , n=number of failing relays, list of failing relays follows |

| Example: | Response: |
|---|---|
| *TST | |
| *OPC? | 1 |
| *TST? | 2 (A2,B4) |

## *REM

Set device to remote mode which disables the keyboard.

## *LOC

Set device to remote mode which enabled the keyboard.

## [:][ROUTe:]CLOSe[:LIST] r*elay_list*

Closes the relays specified in the list.

*relay_list:*
List of relay numbers.

Example:
```
CLOSE A1,B3,H6
:ROUT:CLOS:LIST (@10101,10102,10201,10202)
```

## [:][ROUTe:]CLOSe[:LIST]? r*elay_list*

Queries the close status of the relays specified in the list.

*relay_list:*
List of relay numbers.

Response for each relay (delimited by ','):

| | |
|---|---|
| 1 | Relay is closed |
| 0 | Relay is opened |

| Example: | Response: |
|---|---|
| `OPEN ALL` | |
| `CLOSE A1,B2` | |
| `CLOSE:LIST? A1,B1,B2,B3` | `1,0,1,0` |

## [:][ROUTe:]OPEN[:CARD] ALL

Opens all relays including the DISCHARGE relay.

Example:
```
OPEN ALL
```

## [:][ROUTe:]OPEN[:LIST] r*elay_list*

Opens the relays specified in the list.

*relay_list:*
List of relay numbers.

Example:
```
OPEN A1,B3,H6
:ROUT:OPEN:LIST (@10101,10102,10201,10202)
```

## [:][ROUTe:]OPEN[:LIST]? relay_list

Queries the open status of the relays specified in the list.

*relay_list:*
List of relay numbers.

Response for each relay (delimited by ','):

| | |
|---|---|
| 1 | Relay is opened |
| 0 | Relay is close |

| Example: | Response: |
|---|---|
| `OPEN ALL` | |
| `CLOSE A1,B2` | |
| `:ROUT:OPEN:LIST? (@A1,B1,B2,B3)` | `0,1,0,1` |

## [:][ROUTe:]DISCharge?

Read the logic level of the DISCHARGE line.

Response:

| | |
|---|---|
| 0 or 1 | 0=NORMAL, 1=DISCHARGE |

## [:][ROUTe:]DISCharge *value*

Activates DISCHARGE or - if not activated by the external signal - disabled it. Note DISCHARGE cannot be deactivated by software if the external signal on the digital I/O connector (pin 19) activated.

*value:*

| | |
|---|---|
| 0 or 1 | 0=NORMAL, 1=DISCHARGE |

## [:][ROUTe:]FUNCtion *config*

Sets the configuration mode.

*config*:

| | |
|---|---|
| ACONfig | Auto config mode |
| NCONfig | Normal config mode |

This command is included for compatibility reasons but is ignored.

## [:][ROUTe:]FUNCtion?

Queries the configuration mode.

## [:][ROUTe:]CONNection:RULE ALL,*rule*

Sets the connection rule.

*rule*:

| | |
|---|---|
| FREE | An input port can connect to multiple output ports. |
| SROUte: | An input port can connect to one output port only. |

## [:][ROUTe:]CONNection:RULE? ALL

Queries the connection rule.

Response:

| | |
|---|---|
| FREE | An input port can connect to multiple output ports. |
| SROUte: | An input port can connect to one output port only. |

## [:][ROUTe:]CONNection:SEQuence ALL,*sequence*

Sets the connection sequence.

*sequence*:

| | |
|---|---|
| NSEQ | No sequence |
| BBM | Break before make |
| MBBR | Make before break |

## [:][ROUTe:]CONNection: SEQuence?

Queries the connection sequence.

Response:

| | |
|---|---|
| NSEQ | No sequence |
| BBM | Break before make |
| MBBR | Make before break |

## [:]DIGital:[DEFine:]INPput *line*

Defines a digital I/O line to work as input.

*line*:
1 to 16

## [:]DIGital:[DEFine:]OUTput *line*

Defines a digital I/O line to work as output.

*line*:
1 to 16

## [:]DIGital:[DEFine:]INPut:Byte *byte*

Defines a group of 8 digital I/O lines to work as input.

*byte*:

| | |
|---|---|
| 1 or 2 | 1 = line 1 to 8, 2=line 9 to 16. |

## [:]DIGital:[DEFine:]OUTput:Byte *byte*

Defines a group of 8 digital I/O lines to work as output.

*byte*:

| | |
|---|---|
| 1 or 2 | 1 = line 1 to 8, 2=line 9 to 16. |

## [:]DIGital:[DEFine:]INPut:Word

Defines all 16 digital I/O lines to work as input.

## [:]DIGital:[DEFine:]OUTput:Word

Defines all 16 digital I/O lines to work as output.

## [:]DIGital? *line*

Read the logic level of a digital I/O line.

*line:*
1 to 16

Response:

| | |
|---|---|
| 0 or 1 | 0=LOW, 1=HIGH |

## [:]DIGital:Byte? *byte*

Read the logic level of a group of 8 digital I/O lines.

*byte*:

| | |
|---|---|
| 1 or 2 | 1 = line 1 to 8, 2=line 9 to 16. |

Response:

| | |
|---|---|
| 0 to 255 | Binary coded value |

## [:]DIGital:Word*?*

Read the logic level of all 16 digital I/O lines.

Response:
0 to 65535 Binary coded value

## [:]DIGital *line*, *level*

Sets the logic output level of a digital I/O line.

*line:*
1 to 16

*level:*
0 or 1 0=LOW, 1=HIGH

## [:]DIGital:Byte *byte*, *value*

Sets the logic output level of 8 digital I/O lines.

*byte*:
1 or 2 1 = line 1 to 8, 2=line 9 to 16.

*value:*
0 to 255 Binary coded value

## [:]DIGital:Word *value*

Sets the logic output level of all 16 digital I/O lines.

*value:*
0 to 65536 Binary coded value

## [:]DIGital:Status:Wait?

Read the logic level of the WAIT line (pin 18).

Response:
0 or 1 0=BUSY, 1=WAIT

## [:]DIGital:SAve

Saves the current status of the 16 digital I/O interface lines (input/output, level) to nonvolatile memory. The status is restored with the DIGital:Load command and at power-on.

## [:]DIGital:Load

Restores the status of the 16 digital I/O interface lines (input/output, level) from nonvolatile memory.

## [:]DIGital:Reset

Resets the status of the 16 digital I/O interface lines (input/output, level) to defaults (all input).

## [:]SYStem:STAtus:RELaycount? r*elay_list*

For each relay in the switch the total number of switching cycles is counted and stored in nonvolatile memory. This command returns these counters for the relays found in *relay_list.*

*relay_list:*
List of relay numbers.

Example:
```
SYSTEM:STATUS:RELAYCOUNT? A1,B1,C1
```

Result:

```
10211 127 902
```

## [:]SYStem:Board:Serial? *board*

Returns the PCB serial numbers and fabrication dates of the installed electronics boards.

*board*:

| | |
|---|---|
| 1 to 12 | Relay board |
| 101 | Logic board |
| 102 | Power board |
| 103 | Display board |
| 104 | Backplane board |

Response:
*serial, date*

Example:
```
SYSTEM:BOARD:SERIAL? 101
```

Result:
```
DEABCCE3,20161217
```

Remarks:
The serial numbers are returned as 32 bit hex numbers, the fabrication data in YYYYMMDD format.

## [:]COVer:LOCK

This command is only available if a protection cover is connected. It locks the cover. Note the cover must be closed for this command. Locking the cover also activates the interlock switch.

## [:]COVer:UNLOCK

This command is only available if a protection cover is connected. It unlocks the cover. If any matrix relays are closed at this time, they will be opened. Unlocking the cover also deactivates the interlock switch.

## [:]COVer?

This command is only available if a protection cover is connected. Returns the cover status.

Response:

```
0                COVER OPEN
1                COVER CLOSED BUT UNLOCKED
2                COVER CLOSED AND LOCKED
3                COVER SENSE SWITCHES FAILED
```

## [:]SYStem:ERRor?

Errors are saved in a temporary storage. This command queries the first error in the list. The error is then removed from the list. The error list is cleared at power-on and when executing the *RST command.

Response:
*number*,*description*

| Example: | Response: |
|---|---|
| `:SYST:ERR?` | `-100,Command error` |
| `:SYST:ERR?` | `-220,Parameter error` |
| `:SYST:ERR?` | `0,No error` |

# Specifications

| Parameter | Value | Conditions |
|---|---|---|
| Isolation Voltage | 3000V | Between any unconnected input or output and any other input or output or ground. |
| Isolation Voltage between Force and Guard or Sense and Guard of the same input or output | 500V | Force and Sense (if available) are usually connected. Guard is assumed to be driven at the same voltage. |
| Carry Current | 2A DC<br>5A pulsed | Maximum current for indefinite periods of time between any input or output connector while connection is closed.<br>Pulsed current is specified for 1:10 duty cycle max. |
| Leakage Current | <300pA after 10s<br><30pA typical after 60s | Test voltage: 3kV, Leakage is measured between any unconnected input or output or ground. Guard is actively driven. |
| Isolation Resistance | >1x$10^{13}$ Ω after 10s<br>>1x$10^{14}$ Ω typical after 60s | Measured between any unconnected input or output or ground. Guard is actively driven. |
| Switching Voltage | 1000V | Voltage across one relay contact before the contact is closed or after it is opened. |
| Switching Current | 1A | Current through one relay contact before it is opened or after it is closed. |
| Switching Power | 30W | Voltage across one relay contact before the contact is closed or after it is opened times then current through the same contact before it is opened or after it is closed. |
| Contact Resistance | <1Ω | Resistance between any connected input and output. |
| Switching Time | 5ms | Time to open or close a contact without communication overhead. |
| Lifetime<br>Low power | >$10^{8}$ | Switching operations at low power (< 1W) or cold switching. |
| Lifetime<br>Rated power | >$10^{6}$ | Switching operations at rated power (30W). |
| Environment<br>(Operating) | 5°C to 40°C<br>5% to 80% RH<br>0 to 2000m | For indoor use only |
| Environment<br>(Storage) | -40°C to 70°C<br>5% to 90% RH<br>0 to 10000m | |
| Power Requirements | 100-120V or 220-240V,<br>50 to 60Hz, 200VA max. | |
| Dimensions | 48 x 63 x 18cm | W x D x H<br>Expansion units are the same size |
| Weight | 24 to 35kg | Depending on the configuration |

# Contact

For any questions please contact:

mb-Technologies GmbH
Dreikreuzweg 8
8280 Fuerstenfeld
Austria

+43 664 73522586
office@mb-technologies.com