AUPAME
www.aupame.com.br
vendas@aupame.com.br

MicroStep-MIS

MSB780, MSB780X

Digital Barometers

Version 1.14

User's Guide

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Authors
Editorial team: Adam Krovina, Ján Mikulka

Firmware version
This version of user guide describes functionality of firmware version 037 and newer.

Address
MicroStep-MIS Monitoring and Information Systems,
Čavojského 1,
841 04 Bratislava 4, Slovakia
Tel.: +421 2 602 00 100, Fax: +421 2 602 00 180,
e-mail: info@microstep-mis.com

MicroStep-MIS develops, manufactures and markets monitoring and information systems. The key fields of our activities are meteorology, aviation, environmental sciences, seismology, power engineering, civil defense and tourism.

MicroStep-MIS operates worldwide. Our core customer groups are airports, meteorological and seismological institutes, environmental authorities, industry, power stations and electricity distribution companies.

Typographical conventions

Throughout this guide, several typographical conventions are used to help reader to follow instructions and identify the important information.

The special notes:

Note: Air must be used as a pressure medium during calibration.

The text input or command:

```
cnf?<cr>
```

The text output:

```
Sleep.
```

Contents

1 Introduction

MicroStep-MIS MSB780 Barometer is designed for measuring absolute atmospheric pressure in meteorological and environmental applications.

MSB780X is extended version of MSB780. It features pressure transducer of the same premium quality as MSB780, but allows using also two and three pressure transducers in one unit. MSB780X comes also in a brand new design with touchscreen display option.

World class accuracy

MSB780 barometer provides excellent accuracy, long term stability and temperature dependence. It is ideal for the most demanding applications, where exactness and durability are required.

Reliability

MSB780 is of a durable hardware design. It is contained in heavy-duty metal enclosure rated IP66. MSB780X version with touchscreen display is rated IP65. MSB780 features self-tests and error reporting via SDI12 and serial lines.

Low power design

MSB780 is a low power consumption microprocessor controlled sensor ideally suited for solar and battery powered applications.

Low power consumption helps to save valuable energy on sites without mains supply.

2 Hardware

2.1 Principle of operation

Sensor measurement principle is based on an oscillating tube, where frequency of oscillation is dependent on density of the air inside. The oscillating tube is placed in vacuum. Measured pressure comes inside the tube. Coil magnetic transducers are used to establish oscillation and also to pick-up the signal.

The principle of measuring density of a gas counts on gas fractures of air. Using other gas as pressure media would give incorrect pressure reading.

Note: Air must be used as a pressure medium during calibration.

2.2 Terminals

The terminals for connecting of wires are placed inside the device – unscrew 4 screws and remove the cover to access the terminals.

The description of MSB780 terminals is in the figure 1. Description of MSB780X terminals is in the figure 2.

If you have the MSB780X version with display, after opening the lid with display, disconnect the display flat cable from the display connector on the mainboard. Before closing the lid, reconnect the flat cable to the connector again, otherwise the display will not operate.

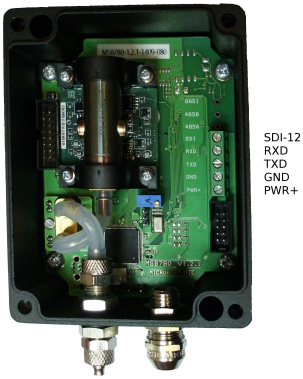


Figure 1: MSB780 terminals

2.3 Power supply

The device is supplied by direct current, typically 12 V, or 24 V. Power supply terminals are marked PWR+ and GND on the mainboard. For voltage range and typical power supply concumption please see Technical Data on page 78.

2.3.1 Power consumption - model with touchscreen display

For models with touchscreen display option the overall power consumption depends on settings "Backlight off" and "Power off time" (Main menu - Display). In order to keep the data on display up to date, the barometer measures continuously whenever the display is on, therefore consumes more power. To conserve power at battery powered installations, set the power off time to the lowest possible

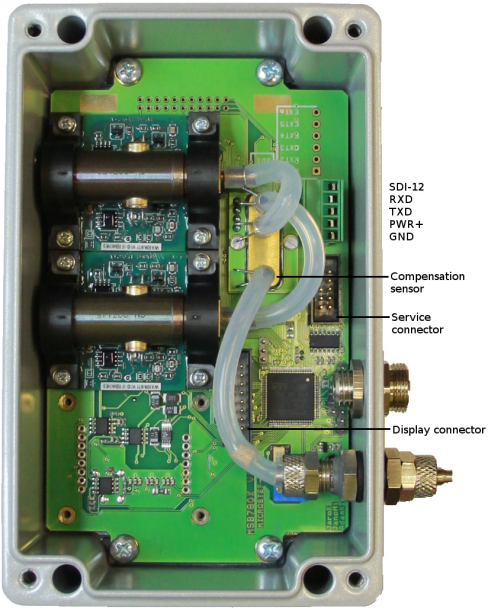


Figure 2: MSB780X terminals

value, for example 30 s. Make sure not to disable the power off time, otherwise the barometer will consume more power while continuously taking measurements. The similar applies to the Backlight off setting, since the display backlight also consumes power. However, when the barometer display shuts off, the backlight goes off as well.

Table 1: MSB780 RS-232 connector wiring

RS-232 cable wiring	
MSB780 or MSB780X terminal	male DB9 pin number
RXD	2
TXD	3
GND	5

Table 2: RS-232 default parameters

RS-232 default parameters	
Baud Rate	9600
Data Bits	8
Parity	None
Stop bits	1

2.4 Serial interface (RS-232)

Serial interface can be used to connect MSB780 or MSB780X sensor to a datalogger, or to a PC. To connect to RS232 computer port, a serial cable is needed.

Wiring of a RS-232 to PC cable with DB9 connector can be found in table 1.

Standard serial interface supports asynchronous communication at speed 9600 bps. Default parameters of RS-232 communication can be found in table 2. Theese parameters may be changed using command `seri`, please refer to section 5.2.8 on page 37.

Table 3: Connecting MSB780 or MSB780X to SDI-12

Connecting MSB780 or MSB780X to SDI-12	
GND	SDI-12 Ground Line
+ V Supply	SDI-12 12 V Line
SDI-12 data line	SDI-12 Data Line

2.5 Connecting MSB780 or MSB780X to PC

To connect MSB780 or MSB780X to PC use serial cable (as described above). If the PC does not feature a RS-232 port, a RS-232 to USB convertor may be used. After the sensor is connected to PC, use a standard terminal program. Set serial line parameters according to section "Serial Interface". Each command is terminated by <cr>, or <cr><lf> ASCII characters. To test the connection and settings, hit Enter. The sensor should reply as follows:

```
cmd??<cr><lf>
```

This reply means, that the sensor did not understand the command.

Note: By default, echo is turned off for MSB780 and MSB780X. If required, echo can be turned on using `echo1<cr>` command.

2.6 SDI-12 interface wiring

To connect MSB780 or MSB780X to SDI-12 bus only 3 wires are needed, see table 3.

Table 4: Service serial port parameters

Service serial port	
Baud Rate	230400
Data Bits	8
Parity	None
Stop bits	1

2.7 Service connector

Service connector enables connection to MSB780 at fixed communication parameters, see table 4. For serial service serial port the same commands as for user RS-232 are valid. Service connector includes power supply connections (PWR+, GND), SDI-12 line and service UART (lines SERVICE_RX, SERVICE_TX). Service UART is not directly compatible with RS-232. Service UART uses 3.3 V voltage level. Direct connection to RS-232 may lead to damage of the barometer. Special service cable with converter is required. This can be ordered from MicroStep-MIS.

In case you have available 3.3 V TTL UART to RS-232 converter available, the service cable may be built-up using schematic in Figure 3.

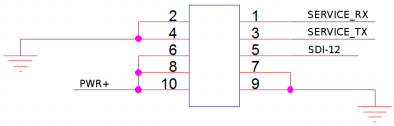


Figure 3: Service connector

Note: Service UART lines SERVICE_RX, SERVICE_TX may not be conneced directly to RS-232.

2.8 Note on onboard trimmer

Please do not adjust the blue trimmer on PCB. It is not meant to be adjusted by user. Adjusting the trimmer would cause incorrect pressure reading.

3 Maintenance

3.1 Cleaning

Clean the barometer enclosure with a soft, lint-free cloth moistened with mild detergent.

Check the hoses inside the barometer. If some dirt or insects got inside, it may cause clogging of the hose and incorrect pressure reading. Replace the hoses, when needed. Order spare parts from MicroStep-MIS.

3.2 Error States

The barometer features self-diagnosis function. Output of the self-diagnosis procedure can be printed using command `errors` discussed in section 5.2.4 on page 35.

3.3 Recommended recalibration interval

Calibration must be done always, when there is a reason to believe, that the device is not within the specified accuracy.

When defining the calibration interval, local long term specifications and other requirements should be considered. Usually the calibration is performed in regular time intervals - for example once per year, or bi-annually.

3.4 Compensation sensor exchange procedure

3.4.1 Compensation sensor - maintenance

To check the compensation sensor for correct function, follow the procedure below. A relative humidity measuring instrument is required for this procedure.

- Open the barometer lid. If you have version MSB780X with display, disconnect the display cable from the connector.
- Disconnect the hoses from the compensation sensor, see figure 4.
- Wait several minutes until the ambient air diffuses into the compensation sensor.
- Check the reading of the humidity sensor through display (diagnostic2 in menu) or using "d" command, as described in section 5.2.2 on page 32.

If the reading comes close to the ambient relative humidity, the sensor is OK and needs no change.

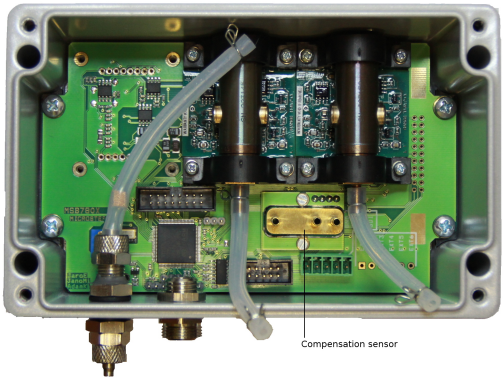


Figure 4: MSB780X - checking / exchanging compensation sensor

If you suspect, that the sensor is not working correctly, it is possible to exchange the compensation sensor by the following procedure:

- Open the barometer lid. If you have version MSB780X with display, disconnect the display cable from the connector.
- Disconnect the hoses from the compensation sensor, see figure 4.
- Unscrew 2 screws holding the compensation sensor and pull the sensor out from the mainboard gently.
- Install a new compensation sensor in place of the old one.
- Fix the new compensation sensor using two screws.
- Reconnect the hoses to the compensation sensor.

Table 5: Relative humidity dependence of MSB780 and MSB780X

Maximum value of pressure correction according to RH		
Temperature	Relative humidity	Correction
-50°C to 10°C	(0 to 100) [% RH]	< 0.1 hPa
-50°C to 23°C	(0 to 100) [% RH]	< 0.2 hPa
-50°C to 40°C	(0 to 80) [% RH]	< 0.4 hPa
-50°C to 60°C	(0 to 100) [% RH]	< 1.2 hPa

- If you have MSB780X version with display, reconnect the display cable to the connector on mainboard.
- Close the barometer lid.

3.4.2 Compensation sensor FAQ

- Why is the purpose of compensation RH sensor?

The resonating pressure sensor is relying on composition of air (mixture of gases). Adding water vapour to air changes the ratio of the gases relative ammount in the composition. This causes very slight differences in pressure reading (according to table 5, depending on temperature and RH). The humidity sensor is used to compensate this systematic error based on known physical dependencies.

- Does the barometer require dry air, or some desiccant cartridge at the pressure input?

The barometer is designed for use without special air conditioning like desiccant cartridges. Compensation sensor compensates the effect of RH on pressure reading.

- How long does the compensation sensor last?

The compensation sensor should last more than 5 years. In conditions with very high humidity and condensation we recommend to check the sensor more often.

- What happens, if the compensation sensor fails or indicates false readings?

The barometer additional error may appear if the compensation sensor does not work right. See table 5 for ranges and limits.

4 Calibration and Adjustment

MSB780 or MSB780X is fully adjusted, compensated and calibrated in factory using a reference traceable to the national standard according to ISO17025.

User of MSB780 or MSB780X is responsible for calibration of the barometer in appropriate interval, or when there is a reason to believe, that the MSB780 or the MSB780X is not performing within acceptable limits. If calibration results show impermissible measurement error, the error can be removed using adjustment commands via serial interface.

Adjusting MSB780 or MSB780X is done by altering the k and q coefficients in the memory. This is done by the command "cset", as discussed in section 5.3.1 on page 50.

MSB780X with more than one pressure transducer has a set of k and q coefficients for each transducer.

The output pressure is computed using formula 1.

$$p_{out} = k.p_{meas} + q \quad (1)$$

where:

p$_{meas}$ is pressure measured by pressure sensor in hPa

k is the corrected pressure gain

q is the corrected pressure offset

p$_{out}$ is pressure on the output of the MSB780 in hPa

Note: Entering new adjustment coefficients overrides their previous values. It is advisable to write down the previous coefficient values, so they are not lost by mistake.

4.1 How to read the current correction values

To get the current correction coefficients values, use the `cnf?<cr>` command, as described in section 5.2.3 on page 32.

4.2 Disabling the correction

It is not possible to turn off correction, MSB780 or MSB780X always uses it to compute the output value. It is however possible to virtually disable the correction by setting the coefficients as follows: k

= 1, q = 0. Theese are the factory defaults. Resetting coefficients to defaults (k = 1, q = 0) can be done using command (adjdef), as described in section 5.3.5 on page 52.

Please write down the old values before altering them, for the case you would like to restore them.

4.3 Adjusting MSB780X with more than one transducer

For MSB780X with more than one pressure transducer, each pressure transducer is adjusted separately. To read the pressure value for each transducer d command must be used. This command is described in chapter 5.2.2 on page 32.

4.4 One pressure point adjustment

Performing adjustment at one pressure point means adjustment of offset. The output value of the barometer is shifted by the same amount at any pressure.

This is done by altering the q coefficient only.

To adjust offset, follow these steps:

1. Read the old coefficient values and write them down. For example k = 1, q = 0. For this use the cnf?<cr> command, as described in section 5.2.3 on page 32.

2. Compare the reading of the MSB780 or MSB780X against a reference.

   For example the MSB780 or MSB780X reads 980.23 hPa, the reference reads 979.99 hPa.

3. Compute the correction. The correction is computed as reference - MSB780 or MSB780X, i.e. 979.99 - 980.23 = -0.24 hPa.

4. Add the computed correction value to the old q coefficient value. In the example 0 + (-0.24) = -0.24. This is the new q value.

5. Write the new k and q values to MSB780 or MSB780X memory using command `cset<cr>`, as documented in section 5.3.1 on page 50.

4.5 Two pressure points adjustment

Adjusting a device in two pressure points changes both coefficinets; gain and offset, i.e. k and q. If you would like to adjust MSB780 or MSB780X using two reference pressure points, follow this procedure:

1. Read the old k and q values, write them down.

2. Set the k and q values to default values, k = 1, q = 0 using `cset<cr>` command.

3. Compare the MSB780 or MSB780X reading against the reference at the first point, write down the values. For example MSB780 or MSB780X: 750.12, reference: 750.35.

4. Compare the MSB780 or MSB780X reading against the reference at the second point, write down the values. For example MSB780 or MSB780X: 1100.5, reference: 1099.30.
5. Compute the coefficients as follows:

$$k = \frac{ref_2 - ref_1}{msb_2 - msb_1} \tag{2}$$

$$q = ref_1 - k * msb_1 \tag{3}$$

where:

ref$_1$ is the reference reading, lower pressure

ref$_2$ is the reference reading, higher pressure

msb$_1$ is the MSB780 or MSB780X reading, lower pressure

msb$_2$ is the MSB780 or MSB780X reading, higher pressure

Example values:

$$k = \frac{1099.3 - 750.35}{1100.5 - 750.12} = \frac{348.95}{350.38} = 0.995919 \tag{4}$$

$$q = 750.35 - 0.995919 * 750.12 = 3.291 \tag{5}$$

6. Write the new k and q values to MSB780 or MSB780X memory using command `cset<cr>`, as documented in section 5.3.1 on page 50.

4.6 More than 2 pressure points adjustment

If you would like to adjust the barometer using more than 2 calibration points, it is required to approximate the calibration points using

a linear regression calculation. Since linear regression is commonly known, we do not discuss it in detail.

To compute coefficients k and q, consider the MSB780 or MSB780X readings being x values and corresponding reference values being the y values. Equations 6 and 7 should be used. Using calculator, computer program or online calculator is advised. After computing the coefficients they need to be stored in MSB780 or MSB780X memory the same way, as in previous section.

$$k = \frac{\sum_{i=1}^{n} x_i y_i - n\bar{x}\bar{y}}{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2} \tag{6}$$

$$q = \bar{y} - k\bar{x} \tag{7}$$

where:

x$_i$ is the MSB780 or MSB780X reading at ith point

y$_i$ is the reference reading at ith point

n is the number of calibration points

Sequence of steps:

1. Read the old k and q values, write them down.
2. Set the k and q values to default values, k = 1, q = 0 using `cset<cr>` command.
3. Compare the MSB780 or MSB780X reading against the reference at the first point, write down the values. For example MSB780: 750.12, reference: 750.35.

4. Repeat the previous point until you have as many calibration points you want.
5. Compute the coefficients using 6 and 7
6. Write the new k and q values to MSB780 or MSB780X memory using command `cset<cr>`, as documented in section 5.3.1 on page 50.

5 Serial interface commands reference

Sensor software enables user to communicate with sensor, collect data, change parameters and analyze possible problems.

5.1 Serial interface command set

Table 6: MSB780(X) commands

MSB780 or MSB780X Commands	
Command	Short description
cnf?	print configuration, probe number and firmware. (See page 32)
errors	print error status message. (See page 35)
p	poll measurement. (See page 31)
sdi12a	set sdi-12 address. (See page 35)
help	displays help. (See page 36)
boot	restart barometer. (See page 36)
d	poll extended measurement. (See page 32)
Continued on next page	

Table 6 – continued from previous page

Command	Short description
seri	set communication settings for user RS232. (See page 37)
cset	set coefficient 'k' and 'q' (Po = k*Pm + q). (See page 50)
hqfe	set altitude for QFE corrected pressure. (See page 53)
hqnh	set altitude for QNH corrected pressure. (See page 54)
tqfe	set temperature for QFE corrected pressure.(See page 56)
hhcp	set height difference for HCP level. (See page 56)
hqfe?	get altitude for QFE corrected pressure. (See page 57)
hqnh?	get altitude for QNH corrected pressure. (See page 57)
tqfe?	get temperature for QFE corrected pressure. (See page 57)
hhcp?	get height difference for HCP level. (See page 58)
unit	change the measurement unit. (See page 46)
unit?	get actual measurement unit. (See page 47)
cnfdef	set default config (HQFE, HQNH, TQFE, seri). (See page 47)
dpmax	set the maximum permissible difference pressure. (See page 51)
dpmax?	get the maximum permissible difference pressure. (See page 52)
flash	switch to bootloader.
adjdef	set default adjust config. (See page 52)
echo1	enable echo. (See page 37)

Continued on next page

Table 6 – continued from previous page

Command	Short description
echo0	disable echo. (See page 38)
form	change output message format. (See page 38)
form?	get actual output message format. (See page 40)
smode	change the user port start-up operating mode. (See page 41)
smode?	get actual user port start-up operating mode. (See page 43)
open	access to command mode in POLL mode. (See page 45)
close	close command mode in POLL mode. (See page 45)
send	read the output message in POLL mode. (See page 46)
addr	change the address in POLL mode. (See page 44)
addr?	get actual address in POLL mode. (See page 45)
intv	change the outputting interval for RUN mode. (See page 43)
intv?	get actual outputting interval for RUN mode. (See page 40)
terminal rs232	temporarily redirect RS232 to service port. (See page 48)
terminal rs485	temporarily redirect RS485 to service port. (See page 49)

Note: Changed settings are immediately stored in FLASH, and will persist after power loss (reset). Storing parameters in FLASH is indicated by printing message:

```
wait..OK<cr><lf>
```

5.2 Basic commands

5.2.1 Poll measurement command ("p" command)

Sensor returns measured pressure, corrected QFE pressure and corrected QNH pressures, all pressures are in hPa or in inHg. Resolutions are three decimal places for hPa and five decimal places for inHg.

The output message format is "pressure,QFE pressure,QNH pressure".

For example:

```
p
1009.066,1010.242,1010.242<cr><lf>
```

The barometer sends reply immediately.

In case the data is not ready (after power-up), the barometer reply is as follows:

```
p
Data not ready<cr><lf>
```

5.2.2 Poll extended measurement command ("d" command)

When using MSB780X version with more than one pressure transducer, it is sometimes necessary to read individual pressure measurements per each transducer, for example during adjustment. To read pressure measurement for each pressure transducer, use the `d` command.

For example:

```
d<cr><lf>
Waiting for data ...  ready<cr><lf>
Baro 1 - P: 1003.023, f:  10379.8193Hz, Vd:  0.604886V,
RH: 35.201<cr><lf>
Baro 2 - P: 1003.002, f:  10412.8271Hz, Vd:  0.602282V,
RH: 35.201<cr><lf>
P result - P: 1003.012, Pqfe:  1003.012,
Pqnh:  1003.012<cr><lf>
```

The example shows result of the `d` command of a two transducer version MSB780X. Pressure measurements for the two transducers follow after P: in hPa unit. The resulting pressure is also outputted.

5.2.3 Print configuration ("cnf?" command)

The command prints various configurable parameters, and also serial number and firmware version (which are not configurable). Furthermore, this command lists the values of correction coefficients k, q.

Example:

```
cnf?<cr>
Conf:<cr><lf>
model                    :  MSB780<cr><lf>
display                  :  not connected<cr><lf>
serial                   :  1.2.11503-173<cr><lf>
fw.  ver                 :  041<cr><lf>
Sensor 1                 :  OK<cr><lf>
Coeff.  'k' sensor 1     :  1.000000<cr><lf>
Coeff.  'q' sensor 1     :  0.000000<cr><lf>
sdi12 adr                :  6<cr><lf>
barometer adr            :  0<cr><lf>
UART speed               :  9600<cr><lf>
UART dataBits            :  8<cr><lf>
UART stopBits            :  1<cr><lf>
UART parity              :  N<cr><lf>
UART echo                :  Off<cr><lf>
UART SMODE               :  RUN<cr><lf>
UART INTV                :  1 s<cr><lf>
RS485 speed              :  9600<cr><lf>
RS485 dataBits           :  8<cr><lf>
RS485 stopBits           :  1<cr><lf>
RS485 parity             :  N<cr><lf>
RS485 echo               :  Off<cr><lf>
RS485 SMODE              :  POLL<cr><lf>
RS485 INTV               :  10 s<cr><lf>
output format            :  "!" 4.2 P \RN<cr><lf>
Actual UART              :  Service<cr><lf>
```

model - model identification.

display - idicates the state of the display.

serial - an unique identifier of the sensor.

fw. ver - indicates the version of the firmware.

Sensor 1 - indicates the state of the sensor.

Coeff. 'k' sensor 1 – correction gain for transducer 1

Coeff. 'q' sensor 1 - correction offset for transducer 1

sdi12 adr - the address of the sensor on SDI-12 bus. To change this, see "sdi12a" command reference.

barometer adr - the address of the barometer in POLL mode

UART speed – serial port speed

UART dataBits – number of data bits

UART stopBits – number of stop bits

UART parity – parity parameter

UART echo - indicates UART echo state

UART SMODE - indicates of UART mode

UART INTV - number of time interval for RUN SMODE in second

output format - actual settings message format for FORM

Actual UART - indicates of using interface

For RS485 interface is same settings as UART interface.

For MSB780X with more than 1 transducer, sensor states and coefficients k and q are displayed for each transducer.

Table 7: Error state iterpretation

Reply	Error interpretation
10000	Pressure sensor error
01000	EEPROM CRC error
00100	Flash CRC error
00010	ADC error
00001	Compensation sensor error

5.2.4 Print error message ("errors" command)

This command can be used to discover communication problem with the sensor element, with the internal digital/analog converter, and to verify FLASH checksum. The `errors` command returns three binary values; 0 means no error, 1 means error state.

Example:

```
errors<cr><lf>
00000(sensor, eeprom, flash, adc, csensor)<cr><lf>
```

In the example, there is no error state indicated (five zeros).

In case of signalized errors, or other problems, please refer to section 9 on page 9.

5.2.5 SDI-12 address change ("sdi12a" command)

This command is used to change the sensor address on SDI-12 bus. The SDI-12 address is one character. It can be number 0 to 9, lower-case character a to z or upper-case character A to Z.

Default SDI-12 address is 0.

```
sdi12a<cr><lf>
New SDI-12 address:  8<cr><lf>
wait..OK<cr><lf>
```

The example shows setting SDI-12 address to 8.

In case of incorrect new address (not within correct ranges, see above), the barometer replies:

```
Wrong format<cr><lf>
```

5.2.6 Display help ("help" command)

The `help` command displays list of available serial interface commands with a short description.

5.2.7 Restart device ("boot" command)

This command can be used to restart the device.

Example:

```
boot<cr><lf>
```

5.2.8 Set communication settings for user RS-232 ("seri" command)

Possible baud rates are the following: 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400.

This command can be used for change UART (RS-232) or RS-485 parameters.

The command affects settings on the port currently connected. If you issue the command via RS-232, the settings will be used only for RS-232.

When connected via service port, the settings of RS-232 or RS-485 may be changed via prior redirection to the respective port - see commands `terminal rs232` or `terminal rs485`.

Example:

```
seri<cr><lf>
SERI: [baud parity databits stopbits] ‘‘9600 n 8 1‘‘<cr><lf>
New values:  19200 n 8 1<cr><lf>
wait..OK<cr><lf>
```

5.2.9 Enable echo ("echo1" command)

To enable echoing characters on RS-232, use this command.

Example:

```
echo1<cr><lf>
Echo is ON<cr><lf>
```

The barometer will echo characters since now.

This command may only be used on RS-232 port or when redirected to the RS-232 port from service port (`terminal rs232` command).

5.2.10 Disable echo ("echo0" command)

To disable echoing characters on RS-232, use this command.

Example:

```
echo0<cr><lf>
Echo is OFF<cr><lf>
```

The barometer will not echo characters since now.

5.2.11 Change output message format ("form" command)

This command is used to set a format of the message being output by MSB780 or MSB780X after `SEND` command, or automatically if run mode is on.

Table 8: Form command fields

Field	Description
/	Restore the message to default. Use alone.
0.0	Restore default number formats.
x.y	Set number of digits and decimal places.

Continued on next page

Table 8 – continued from previous page

Field	Description
quantity	Quantity value or * characters if value not available.
U	Unity symbol as it is (width depends).
U1 ... U9	Unit symbol in the specified number of characters (truncated or space filled as necessary).
"xxx"	String constant (free text).
P	Pressure output (in 0.1 hPa). The reading is written with 5 characters. If the transducer has a fault or has been switched off, the reading is replaced with error status –.
P1	Pressure output from transducer 1, same format as P.
P2	Pressure output from transducer 2, same format as P.
P3	Pressure output from transducer 3, same format as P.
\N	Line feed character. <0x0A>.
\R	Carriage return character. <0x0D>.
\RN	Carriage return and line feed characters. <0x0D><0x0A>.
\T	Horizontal tabulator character <0x09>.
\0...\255	Data byte with the specified decimal value.
ADDR	Device address (left - filled with spaces).
CS2	Modulus-256 checksum of message sent so far, hexadecimal format.
CS4	Modulus-65536 checksum of message sent so far, hexadecimal format.
CSX	NMEA XOR checksum of message sent so far, hexadecimal format.
ERR	Error flags for P_1, P_2 and P_3 (if installed, right - filled with spaces); 0 = no error, 1 = error.

Continued on next page

Table 8 – continued from previous page

Field	Description
SN	Device serial number.

The default output format depends on the device configuration.

Prompt syntax and output example:

```
form<cr><lf>
Write formatted string for FORM: \33 4.2 P \RN<cr><lf>
FORM format is OK<cr><lf>
|! 997.34<cr><lf>
|<cr><lf>
wait..OK<cr><lf>
send<cr><lf>
! 997.33<cr><lf>
```

Restoring the default output message (depends on the device configuration) and output example:

```
form<cr><lf>
Write formatted string for FORM: /<cr><lf>
FORM format is OK<cr><lf>
|! 997.34<cr><lf>
|<cr><lf>
wait..OK<cr><lf>
```

5.2.12 Get actual output message format ("form?" command)

To get actual output message format, use the `form?` command.

Example:

```
form?<cr><lf>
start>P \RN <end<cr><lf>
send<cr><lf>
 997.55<cr><lf>
```

5.2.13 Change the user port start-up operating mode ("smode" command)

Use the command `smode` to set the user port start-up operating mode.

This command can be used for change UART (RS-232) or RS-485 parameters.

The command affects settings on the port currently connected. If you issue the command via RS-232, the settings will be used only for RS-232.

When connected via service port, the settings of RS-232 or RS-485 may be changed via prior redirection to the respective port - see commands `terminal rs232` or `terminal rs485`.

Selected output mode is activated after power outages.

Example:

```
smode<cr><lf>
Select output mode:  STOP RUN POLL SEND
New SMODE:RUN<cr><lf>
wait..OK<cr><lf>
```

Table 9: smode command options

Field	Description
STOP	The barometer will not send message automatically. The barometer will not react to `SEND` command in this mode. Command mode is open all the time.
RUN	The barometer will send message automatically with period set by `intv`. Command mode is open all the time.
POLL	To open command mode, use `open a<cr>`, where "a" stands for address (use command `addr` to change it). To close command mode, send `close<cr>`. To poll message, send command `send a<cr>`. The barometer does not respond to other commands and other addresses. The barometer in POLL mode does not send the message automatically. This mode is useful when using multiple barometers on RS-485 bus.
SEND	The `SEND` command is used to poll message. Command mode is open all the time.

5.2.14 Get actual user port start-up operating mode ("smode?" command)

To get actual user port start-up operating mode, use the `smode?` command.

Example:

```
smode?<cr><lf>
SMODE: RUN<cr><lf>
```

5.2.15 Change the outputting interval for RUN mode (“intv” command)

Use the command `intv` to set the outputting interval for the **RUN** mode.

This command can be used for change UART (RS-232) or RS-485 parameters.

The command affects settings on the port currently connected. If you issue the command via RS-232, the settings will be used only for RS-232.

When connected via service port, the settings of RS-232 or RS-485 may be changed via prior redirection to the respective port - see commands `terminal rs232` or `terminal rs485`.

Example:

```
intv<cr><lf>
Select new interval in seconds:1<cr><lf>
```

```
wait..OK<cr><lf>
```

5.2.16 Get actual the outputting interval for RUN mode ("intv?" command)

To Get actual the outputting interval for RUN mode, use the `intv?` command.

Example:

```
intv?<cr><lf>
INTV: 1 s<cr><lf>
```

5.2.17 Change the address in POLL mode (“addr” command)

Addresses are required only for POLL mode witch is available for RS-232 and RS-485 interface. Use the `addr a` command to set barometer address, where `a` is address (0 . . . 255)(default = 0).

Example: the barometer is configured to address 200.

```
addr<cr><lf>
Select new barometer address:200<cr><lf>
New ADDR 200<cr><lf>
wait..OK<cr><lf>
```

5.2.18 Get actual address in POLL mode ("addr?" command)

To Get actual actual address in POLL mode, use the `addr?` command.

Example:

```
addr?<cr><lf>
ADDR: 200<cr><lf>
```

5.2.19 Access to command mode in POLL mode ("open" command)

When all barometers on the serial RS-232 or RS-485 interface are in POLL mode the `open a`, where `a` is address of baremoter (0 . . . 255) command sets one barometer temporarity to STOP mode so that other commands can be entered.

Example:

```
open 200<cr><lf>
Command mode is opened
```

5.2.20 Close command mode in POLL mode ("close" command)

Use the `close` command to switch the barometer back to the POLL mode.

Example:

```
close<cr><lf>
Command mode is closed
```

5.2.21 Read the output message in POLL mode ("send" command)

Use the `send a` command to reading output message once in POLL mode, where `a` is address of the barometer (0 . . . 255).

Example:

```
send 200<cr><lf>
!  995.17<cr><lf>
```

5.2.22 Change the measurement unit ("unit" command)

MSB780 and MSB780X internally work with hPa unit. Using this command, it is possible to set output data unit to inHg. In this case, the barometer will output data in inHg unit after `p` command, on SDI-12 and on display main screens.

The available units for pressure are:

hPa

inHg

Example:

```
unit<cr><lf>
UNIT:<cr><lf>
```

```
Actual unit hPa<cr><lf>
Available units [ hPa, inHq ] :  hPa<cr><lf>
wait..OK
```

5.2.23 Get actual measurement unit ("unit?" command)

To get actual measurement unit, use the `unit?` command.

Example:

```
unit?<cr><lf>
UNIT: hPa<cr><lf>
```

5.2.24 Set default configuration ("cnfdef" command)

This command set the defaults values for the following constants: TQFE, HQNH, HQFE, Unit, k, q and UART constants.

Example: `cnfdef<cr><lf>`

```
CNFDEF:<cr><lf>
Set default config?  (yes/no):  yes<cr><lf>
Default config - OK<cr><lf>
wait..OK<cr><lf>
```

Default configuration parameters are in table 10.

Table 10: Default configuration parameters

Default configuration parameters		
Parameter	Value	Unit
TQFE	20	°C
HQNH	0	m
HQFE	0	m
Unit	hPa	
k	1	
q	0	
UART Baud rate	9600	Baud
UART parity	None	
UART data bits	8	
UART stop bits	1	

5.2.25 Temporarily redirect RS232 to service port ("terminal rs232" command)

This command redirects RS-232 port to the service port. It may be used only on the service port.

This command is useful when configuring the barometer using service port. It enables user to change settings of RS-232 like Baud rate, data bits, stop bits, echo, interval and smode.

For example, the user would like to set the RS-232 baud rate via service port.

First the user redirects to the RS232 port:

```
terminal rs232<cr><lf>
Terminal mode is active.  Close it with command "tclose"
!<cr><lf>
```

```
RS232 >
```

Now it is possible to enter commands as if the user was connected via RS-232 port.

```
seri<cr><lf>


SERI: [baud parity databits stopbits] for example "9600 n
8 1"
New values:  "19200 n 8 1<cr><lf>"
wait..OK<cr><lf>
```

A new Baud rate has been set for RS-232. To cancel the redirection to the RS-232 port, send:

```
tclose<cr><lf>
Terminal mode was closed !<cr><lf>
```

5.2.26 Temporarily redirect RS-485 to service port ("terminal rs485" command)

This command works in the same way as the previous command, but for RS-485.

5.3 Adjustment commands

5.3.1 Set adjust coefficient ("cset" command)

This command enables to adjust the MSB780 barometer by entering two linear coefficients - offset and gain.

Example:

```
cset<cr><lf>
CSET: [ k q ] ‘‘0.1234’’<cr><lf>
Set new ’k’ coefficient:  1.000156<cr><lf>
k = 1.000156<cr><lf>
Set new ’q’ coefficient:  0.25<cr><lf>
q = 0.25<cr><lf> wait..OK<cr><lf>
```

The output pressure is computed using formula 8.

$$p_{out} = k.p_{meas} + q \tag{8}$$

where:

p$_{meas}$ is pressure measured by pressure sensor in hPa

k is the corrected pressure gain

q is the corrected pressure offset

p$_{out}$ is pressure on the output of the MSB780 in hPa

For MSB780X with more than 1 transducer, there is set of k and q coefficients for each transducer. When using `cset` command, user

is prompted first, which transducer's coefficients are being updated, example for two transducer version:

```
cset<cr><lf>
Select sensor [ 1 2 ] :  1<cr><lf>
CSET for sensor 1 :  [ k q ] "0.1234"<cr><lf>
Set new 'k' coefficient:1.00034<cr><lf>
k = 1.000340<cr><lf>
Set new 'q' coefficient:0.03<cr><lf>
q = 0.030000<cr><lf>
wait..OK<cr><lf>
```

In this example, coefficients for transducer 1 were updated.

5.3.2 Get actual adjust coefficients ("cnf?" command)

To read the actual values of the adjust coefficients k, q, please refer to section 5.2.3 on page 32.

5.3.3 Set the maximum permissible pressure difference ("dpmax" command)

To set a new value of the dpmax parameter, use the `dpmax` command.

Example:

```
dpmax<cr><lf>
DPMAX:
Actual value 1.00 hPa
Pressure scale [hPa, inHg]:  hPa<cr><lf>
```

```
Set dpmax in hPa, ranges +0.00 ..  5.00 :  0.4<cr><lf>
New dpmax is:  0.40 m
wait..OK<cr><lf>
```

5.3.4 Get the maximum permissible pressure difference ("dpmax?" command)

To get the dpmax parameter value, use this command.

Example:

```
dpmax?<cr><lf>
DPMAX: 0.40 hPa<cr><lf>
```

5.3.5 Set default adjustment ("adjdef" command)

This command resets the adjustment coefficients k, q to their default values. For model MSB780X with more pressure transducers, this command resets coefficients for all of them.

Note: It is recommended to write down the previous setting of the coefficients, for the case you would like to return to the previous state.

Actual k, q values can be read using command `cnf?`, as described on page 32.

Example:

```
adjdef<cr><lf>
Set default config?  (yes/no):yes<cr><lf>
```

```
Default adjust config - OK<cr><lf>
wait..OK<cr><lf>
```

5.4 Corrected pressure commands - QFE, QNH, HCP

The following sections refer to setting parameters for corrected pressures QFE, QNH, HCP.

5.4.1 Set altitude for QFE corrected pressure ("hqfe" command)

Example:

```
hqfe<cr><lf>
HQFE:<cr><lf>
Actual value 0.00 m<cr><lf>
Distance scale [ft, m]:  m<cr><lf>
Set altitude in m, ranges -30.00 ..  30.00 :  10<cr><lf>
New altitude is:  10.00m<cr><lf>
wait..OK<cr><lf>
```

Available altitude units are m (meters), ft (feet).

Table of valid altitude ranges for different units is in table 5.2.3.

The corrected QFE pressure is computed using formula 9.

Table 11: Valid ranges for HQFE parameter

Valid ranges for HQFE parameter		
Unit	Minimum	Maximum
m	-30	30
ft	-99	99

$$QFE = p(1 + \frac{h_{QFE} \cdot g}{R \cdot T}) \quad (9)$$

where

p is adjusted output pressure in

h$_{QFE}$ is height difference between the barometer and reference level in m

g is gravitational acceleration 9.81 m.s^{-2}

R is gas constant 287 J.kg$^{-1}K^{-1}$

T is temperature in K

5.4.2 Set altitude for QNH corrected pressure ("hqnh" command)

```
hqnh<cr><lf>
HQNH:<cr><lf>
Actual value 0.00 m<cr><lf>
Distance scale [ft, m]:  m<cr><lf>
Set altitude in m, ranges -30.00 ..  3000.00 :  100<cr><lf>
```

Table 12: Valid ranges for HQNH parameter

Valid ranges for HQNH parameter		
Unit	Minimum	Maximum
m	-30	3000
ft	-99	9900

```
New altitude is:  100.00m<cr><lf>
wait..OK<cr><lf>
```

Available altitude units are m (meters), ft (feet).

Table of valid altitude ranges for different units is in table 12.

The corrected QNH pressure is computed using formula 10.

$$QNH = QFE \cdot exp(\frac{h_{QNH} \cdot g}{T + \frac{\alpha \cdot h_{QNH}}{2}}) \quad (10)$$

where:

h$_{QNH}$ is station elevation in m

g is gravitational acceleration 9.81 m.s^{-2}

R is gas constant 287 J.kg^{-1}K^{-1}

T is standard temperature 288.15 K

α is standard temperature lapse rate -0.0065 K.m^{-1}

Table 13: Valid ranges for HHCP parameter

Valid ranges for HHCP parameter		
Unit	Minimum	Maximum
m	-30	30
ft	-99	99

5.4.3 Set temperature for QFE corrected pressure ("tqfe" command)

```
tqfe<cr><lf>
TQFE:
Actual value 20.00 C<cr><lf>
Temperature scale [C, F, K]: C<cr><lf>
Set temperature in C, ranges -80.00 ..  300.00 :  30<cr><lf>
New temperature is:  30.00C<cr><lf>
wait..OK
```

Available temperature units are °C, °F, K.

5.4.4 Set height difference for HCP level ("hhcp" command)

This command changes the height difference for HCP corrected pressure. The parameter may be inputted either in ft, or in m unit. Limits for this parameter are in table 13.

Example:

```
hhcp<cr><lf>
HHCP:<cr><lf>
```

```
Actual value 0.00 m<cr><lf>
Distance scale[ft, m]:  m<cr><lf>
Set height difference in m,
ranges -30.00 ..  30.00 :  0.1<cr><lf>
wait..OK<cr><lf>
```

In the example the new HHCP parameter was set to 0.1 m.

5.4.5 Get altitude for QFE corrected pressure ("hqfe?" command)

```
hqfe?<cr><lf>
HQFE: 0.00 m<cr><lf>
```

5.4.6 Get altitude for QNH corrected pressure ("hqnh?" command)

```
hqnh?<cr><lf>
HQNH: 100.00 m<cr><lf>
```

5.4.7 Get temperature for QFE corrected pressure ("tqfe?" command)

This command is used to print the temperature value actually being used for QFE correction.

Example:

```
tqfe?<cr><lf>
TQFE: 30.00 C<cr><lf>
```

5.4.8 Get height difference for HCP level ("hhcp" command)

This command is used to print the height difference for HCP corrected pressure.

Example:

```
hhcp?<cr><lf>
HHCP: 0.10 m<cr><lf>
```

6 Display access

This section refers only to MSB780X versions with touchscreen display option.

If your barometer is equipped with the touchscreen display, you can benefit from direct reading of the actual pressure value, pressure trend, graph view and other directly on the barometer.

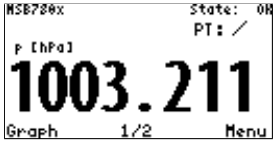
Following functions may be desplayed:

- Actual value of pressure, QNH, QFE, HCP
- Pressure trend
- Graph

- Serial port settings
- SDI-12 settings
- Version and serial number info
- Diagnostic information

6.1 Basic screens

The barometer features two basic screens, which may be switched by tapping on the screen. After power-up or reset, the barometer displays one of them:



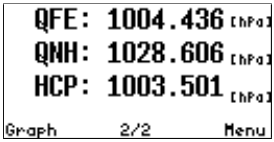
This screen displays the following information:

- Barometer state (State: OK or ERR)
- Pressure trend (PT: icon of trend)
- Measured pressure
- Screen number (1/2)

The screen is divided into three active touch areas:

- Graph - switch to Graph screen
- Menu - switch to Menu
- All the other screen area - switches between the two main screens

The second main screen looks as follows:



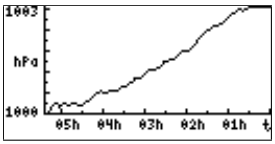
This screen shows the following values:

- QFE
- QNH
- HCP

The touch active areas are the same as on the previous screen.

6.2 Graph display

Graph display is activated by tapping the Graph area on the main screen. Example of the Graph display is in the following picture:



The graph has measured pressure on the vertical axis and time on the horizontal axis.

The scale of vertical axis is switched automatically. Minimum axis span is 1 hPa.

The span of horizontal axis can be switched in Display menu, as described in section 6.7 on page 68.

Tapping anywhere on the screen area switches back to the basic screens.

6.3 Main menu

By tapping the Menu area on a basic screen you enter the Menu:

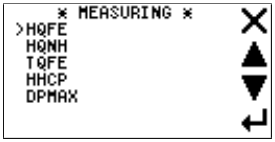
Four icons on the right are used to navigate through the menu. Icons ▲ and ▼ moves the cursor up or down, ✕ leaves the menu or decreases the menu level. The icon ↵ increases the menu level.

6.3.1 Menu structure

- Main menu
  - Measuring
    - HQFE
    - HQNH
    - TQFE
    - HHCP
    - DPMAX
  - Interfaces
    - SDI12
    - RS232
  - System
    - Diagnostic
    - Diagnostic 2
    - Baro sensors
    - Serial number
    - Version
  - Display

6.4 Measuring menu

View of Measuring menu is in the following picture:



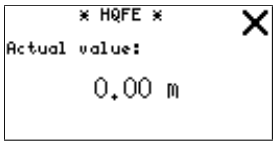
In Measuring menu, you can display values of the following parameters:

- HQFE - Altitude for QFE corrected pressure
- HQNH - Altitude for QNH corrected pressure
- TQFE - Temperature for QFE corrected pressure
- HHCP - Altitude for HCP height corrected pressure
- DPMAX - Maximum permissible difference between pressure transducers

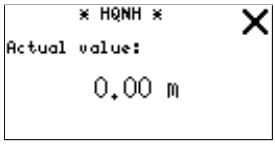
Note: The values cannot be altered using display.

Please use appropriate serial line commands to alter the settings.

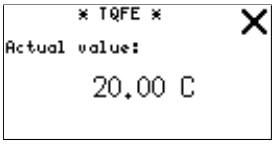
Example screen for HQFE display:



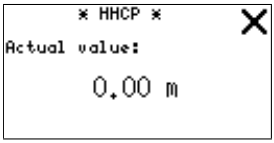
Example screen for HQNH display:



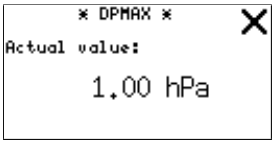
Example screen for TQFE display:



Example screen for HHCP display:



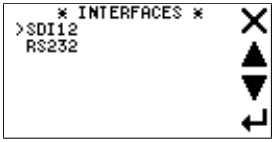
Example screen for DPMAX display:



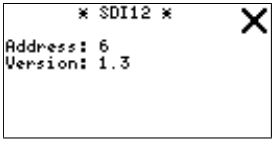
6.5 Interfaces menu

Interfaces menu allows user to display Interfaces settings, such as SDI-12 address of the barometer, or baud rate of RS-232.

Screen of Interfaces menu is in the following picture:

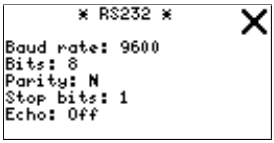


Screen of SDI12 menu is in the following picture:



In this screen you can see the actual SDI-12 address of MSB780 or MSB780X. The SDI-12 address in the example is 6.

Screen of RS232 menu is in the following picture:



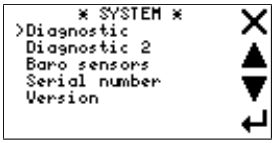
Note: Parameters of interfaces cannot be altered using display. This should prevent from unintentional changes.

Please use serial commands to change the parameters of interfaces.

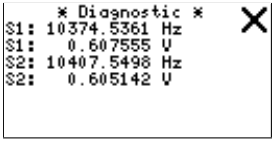
6.6 System menu

In system menu you can browse diagnostic information, firmware version and barometer serial number.

Screen for system menu is on the following picture:

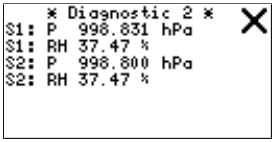


Screen of Diagnostic menu is in the following picture:



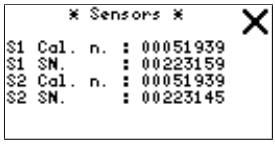
Diagnostic menu displays raw data from pressure transducer(s), it may help solving problems in some cases.

Screen of Diagnostic 2 menu is in the following picture:



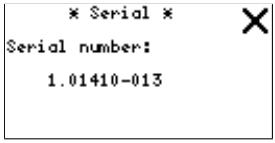
Diagnostic 2 also helps solving problems, it displays pressure from each transducer. If you have version MSB780X with more transducers, there are more pressure values displayed. The example shows case with two pressure transducers.

Screen of Baro sensors menu is in the following picture:



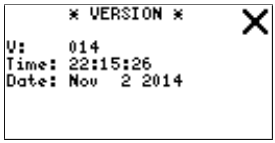
This screen shows serial numbers of the pressure transducers.

Screen of Serial number menu is in the following picture:



This is the serial number of MSB780 or MSB780X.

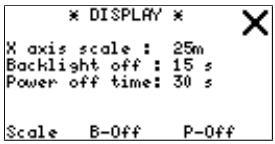
Screen of Version menu is in the following picture:



Version helps identifying the firmware version. It may be helpful when solving problems in some cases.

6.7 Display menu

Screen of Display menu is in the following picture:



The Display menu allows user to alter the following settings:

- X axis scale on graph
- Backlight off timeout
- Power off time

Theese parameters are altered by taping on or holding appropriate areas at the bottom of the screen: Scale, B-Off, P-Off.

The X axis scale can be set to the following values: 25 min, 5 h, 25 h, 10 days, 10 weeks, 10 months.

Backlight off has the following options: On, 15 m, 2 m, 60 s, 30 s, 15 s.

With backlight off set to On, the display backlignt is always on, whenever the display is on.

Power off time can be set to the following values: Dis., 25 m, 15 m, 5 m, 2 m, 30 s.

With power off time set to Dis. the display never shuts down and the barometer will continuously take measurements to keep the readings on the display actual.

Note: The barometer does not enter the power-saving mode, when the display is on.

7 SDI-12 reference

7.1 Introduction to SDI-12

SDI-12 stands for serial data interface at 1200 baud. It is a standard to interface battery powered data recorders with micro-processor based sensors designed for environmental data acquisition (EDA).

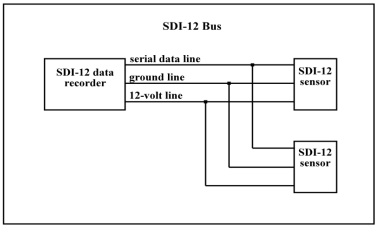


Figure 5: SDI-12 Bus

Only three wires need to be connected when using SDI-12. To use SDI-12 a SDI-12 compliant data recorder is required. Follow the instructions given by the data recorder manufacturer to set up the

SDI-12 communication.

7.2 SDI-12 commands supported by MSB780

All SDI-12 commands start with address (a stands for address), and are terminated by !. All SDI-12 sensor responses start with address (a stands for address), and are terminated by <cr><lf> (which are ASCII characters 0x0d 0x0a).

7.2.1 SDI-12 commands set (alphabetical order)

Table 14: MSB780 SDI-12 commands

MSB780 SDI-12 Commands	
Command	Short description
?!	Address query command. (See page 71)
a!	Acknowledge active command. (See page 71)
aAb!	Address change command. (See page 71)
aC!	Start concurrent measurement command. (See page 72)
aD0!	Send data command. (See page 73)
aI!	Send identification command. (See page 71)
aM!	Start measurement command. (See page 72)
aR0!	Continuous measurement. (See page 73)
aV!	Get verification. (See page 74)
aXD1!	Send data command from transducer 1. (See page 74)
aXD2!	Send data command from transducer 2. (See page 74)
Continued on next page	

Table 14 – continued from previous page

Command	Short description
aXD3!	Send data command from transducer 3. (See page 74)
aXR aXV!	Get extended verification. (See page 75)

7.2.2 Acknowledge Active Command (a!)

This command is used to ensure that a sensor is responding to a data recorder or another SDI-12 device. It asks a sensor to acknowledge its presence on the SDI-12 bus.

Example:

```
0!0<cr><lf>
```

7.2.3 Send Identification Command (aI!)

This command is used to query sensors for their SDI-12 compatibility level, model number, and serial number.

```
0I!013MS-MIS MSB7801.11.2.11505-183 <cr><lf>
```

7.2.4 Address Query Command (?!)

When a question mark (?) is used as the address character with the acknowledge active command (a!), the sensor will respond as if it is being addressed on the SDI-12 bus. For example, if a sensor detects ?!, it will respond with a<CR><LF>, no matter what its

address may be. This will allow a user to determine the address of a sensor. The user should understand that if more than one sensor is connected to the bus, they will all respond, causing a bus contention.

Example:

```
?!0<cr><lf>
```

7.2.5 Address Change Command (aAb!)

This command is used to change barometer's address a to b.

Example:

```
0A4!4<cr><lf>
```

In this example the SDI-12 address was changed from 0 to 4.

7.2.6 Start Measurement Command (aM!)

This command tells the sensor to take a measurement. The sensor does not, however, return the measurement to the data recorder after this command. It returns the time until one or more measurements will be ready and the number of measurements that it will make. The send data (D0!) command must be issued to get the measurement(s).

```
0M!00053<cr><lf>
```

The sensor reply means it will take maximum "0057

" seconds to finish measurement, and one value will be measured.

To tell the data recorder that the sensor has finished its measurement(s) and the data are ready. A service request is issued by the sensor after an M, MC, or V command, when it has finished its measurement. After receiving the service request or after specified time elapses, the data recorder issues aD0! command to get the measured data:

0D0!0+1009.066+1009.066+1021.121<cr><lf>

For MSB780 the value is pressure in [hPa] or [inHg]

7.2.7 Send Data Command (aD0!)

This command is used to get data from the sensor. MSB780 does not distinguish between D0, D1 etc.

7.2.8 Continuous Measurement (aR0!)

This command returns last measured value of pressure. (Pressure is measured periodically, new data is available each measurement period, see Parameters of sensor)

The output message format is "pressure QFE pressure QNH pressure".

Example:

0R0!0+1009.066+1009.066+1021.121<cr><lf>

Table 15: Verification result iterpretation

Reply	Interpretation
+1+0+0+0+0	Pressure sensor error
+0+1+0+0+0	Flash CRC error
+0+0+1+0+0	Copensation sensor error
+0+0+0+1+0	EEPROM CRC error
+0+0+0+0+1	ADC error

For MSB780 the values of pressure are in [hPa] or [inHg]

7.2.9 Get Verification (aV!)

This command starts the verification procedure.

`0V!00005<cr><lf>`

A subsequent `0D0!` command returns verification result.

Example:

`0D0!0+0+0+0+0+0<cr><lf>`

7.2.10 Send data command from transducer 1 (aXD1!)

This command is used to get data from the sensor, specifically from transducer 1. If MSB780 has more then one transducer, it can be use commands `aXD2!` from transducer 2 and `aXD3!` from transducer 3.

Example:

```
0XD1!<cr><lf>

0+999.620+10367.5377+0.600085+50.00+0.103364<cr><lf>
```

Where

0 sdi-12 barometer address

+999.620 pressure in hPa from transducer 1

+10367.5377 frequency in Hz from transducer 1

+0.600085 voltage in V from transducer 1

+50.00 relative humidity

+0.103364 pressure correction

<cr><lf> line terminate

7.2.11 Get extended verification (aXV!)

This command return information about firmware version.

Example:

```
0XV!<cr><lf>

0v.  042,Nov 4 2015,15:45:14<cr><lf>
```

Where

0 sdi-12 barometer address

v. 042 firmware version

Nov 4 2015 date of build firmware

15:45:14 time of build firmware

<cr><lf> line terminate

8 Technical Data

8.1 Performance

Barometric pressure range	500 hPa to 1100 hPa (or as specified)
Linearity	< 0.02 hPa
Hystersis	< 0.02 hPa
Accuracy (at 23 °C)	0.10 hPa
Total accuracy	0.15 hPa (-50 °C to $+80$ °C)
Typical long-term stability	better than ± 0.05 hPa/year
Calibration Traceability	National standard
Warm-up time after power-up	less than 5 seconds

8.2 Operating Environmental

Pressure range	500 hPa to 1100 hPa
Temperature range	-50 °C to $+80$ °C
Relative humidity	(0 to 100) % RH
Overpressure limit	4000 hPa (not affecting sensor calibration)
Burst pressure limit	7000 hPa
Enclosure	IP66, IP65 with display

8.3 Inputs and Outputs

Supply voltage	5 to 35 V DC
Resolution	0.001 hPa
Communication	RS-232, RS-485, SDI-12
Number of transducers	1 to 3

8.4 Power consumption

Option	Power supply current @ 12 V
1 transducer	32 mA
2 transducers	64 mA
3 transducers	96 mA
Display backlight	add 3 mA
Sleep mode	less than 0.1 mA

9 Troubleshooting

This section lists several most common symptoms of problems and actions that should be taken in order to solve them.

Table 16: Troubleshooting

Troubleshooting		
Problem	Possible cause	Solution
Barometer is not working, no signs of functionality.	Incorrect power supply	Measure power supply voltage on terminals PWR+, GND. Check, if measured voltage is within range, refer to section 2.3 on page 13. Check correct polarity of the power supply applied.
	Barometer is damaged	Measure power supply current. Check, if the current is within normal values, refer to section 2.3 on page 13. If the power supply current is zero, or too high, please send the barometer for factory service with a description of the problem.
Continued on next page		

Table 16 – continued from previous page

Problem	Possible cause	Solution
No reply on RS-232	Incorrect serial line parameters - baud rate, data bit count, parity...	Try different RS-232 parameters. All possible settings can be found in section 5.2.8 on page 37. If you have version with display, check settings of RS-232 through display. If you have service cable available, you can use Service serial port with fixed communication settings to access the barometer. Please refer to section 2.7 on page 17.
Continued on next page		

Table 16 – continued from previous page

Problem	Possible cause	Solution
No reply on SDI-12 bus	Wrong SDI-12 address	Use `?!` SDI-12 command to determine barometer's address. During this command, no other device can be connected to the SDI-12 bus. Change the barometer current address using `aAb!` command, please refer to section 7.2.5 on page 72. If you have version with display, you can view the SDI-12 address using it, please refer to section 6.5 on page 64. You can also check current SDI-12 address using user RS-232, or service serial port.
Display is not working, but the barometer responds to commands via interfaces.	Display flat cable is not connected to the mainboard	Open the barometer lid and reconnect the cable.
Compensation sensor error is signalized	Compensation sensor is not installed	Install compensation sensor, please refer to section 3.4 on page 19.

Continued on next page

Table 16 – continued from previous page

Problem	Possible cause	Solution
	Compensation sensor is faulty	If compensation sensor is installed, but there is still the error signalized, the sensor may be faulty. Replace the compensation sensor with a new one. You can order it from MicroStep-MIS.
Other errors are signalized	Barometer is damaged	Please contact MicroStep-MIS service, refer to section 9.1 on page 82.

9.1 In case of problems...

It is recommended to rely on manufacturer service if you experience any problems. Even if you have well trained personnel, it is more probable, that your barometer will be successfully serviced in hands of the designers of the product.

When sending the product back to MicroStep-MIS please try to send a description of problems along with the product. Pack the barometer properly, stuff the package with enough shock-absorbing material in order to prevent it from damage during transport.

If you experience problems with the product, we would like to know about them in order to improve the future designs.

Direct contact in case of problems with MSB780 or MSB780X:
adam.krovina@microstep-mis.com

10 Ordering Information

In table 17 you can find order codes for different configuration of MSB780 or MSB780X barometers.

Table 17: MSB780 and MSB780X ordering information

Order Code	Box type	Number of transducers	LCD Display
MSB780	small	1	No
MSB780X1	big	1	No
MSB780X2	big	2	No
MSB780X3	big	3	No
MSB780X1	big	1	Yes
MSB780X2	big	2	Yes
MSB780X3	big	3	Yes

11 Firmware update

11.1 Hardware required for firmware update

To perform a firmware update of MSB780 or MSB780X a service cable is required. This accessory can be ordered from MicroStep-MIS.

If your PC/notebook features a RS-232 port, you do not need the USB to RS-232 convertor.

If you use the USB to RS-232 convertor, you may need to download a driver. Newer operating systems tend to have the driver installed, or can install it automatically.

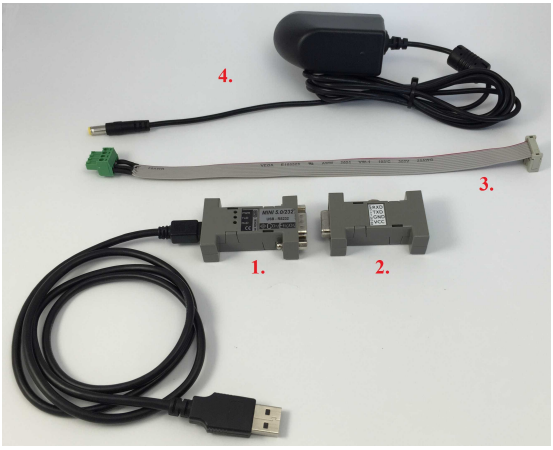


Figure 6: Accessories required for firmware update

1. USB to RS-232 convertor

2. RS-232 to UART convertor
3. Service cable for MSB780 or MSB780X
4. Power supply

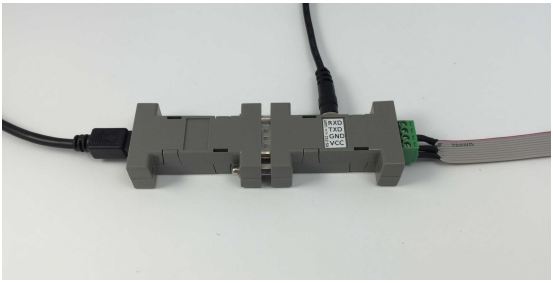


Figure 7: Correct connection of the convertors and cables

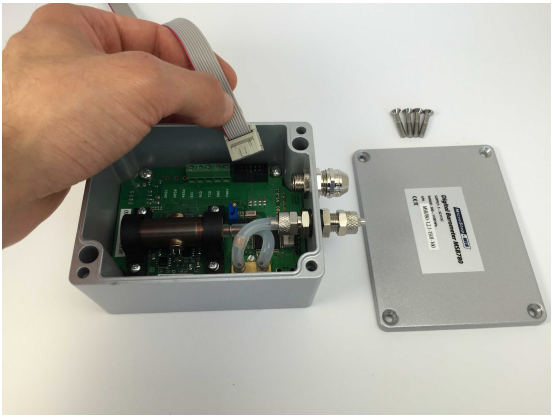


Figure 8: Connecting the service cable to the service connector of the MSB780

11.2 Firmware Loader software

After the service cable has been properly connected, MicroStep-MIS Firmware Loader software can be used to upload a new firmware. You can obtain this software from MicroStep-MIS.

Follow theese steps to upload a new firmware to the barometer:

1. Start the program Microstep-MIS Firmware Loader, as seen in figure 9 and click on button **Open**.
2. Choose the firmware file with .mstepfw suffix. Figure 10.
3. After selecting the firmware file, you can see the information about the firmware, as seen in Figure 11.
4. Select a serial port the barometer is connected to. If there is only one choice, it will be selected automatically.
5. Select baud rate 230400.
6. Click Start button to start the upload. Process of uploading is displayed in Figure 12.
7. After successful transfer of firmware the Configuration is printed. New firmware version number is also displayed (fw. ver). See Figure 13.

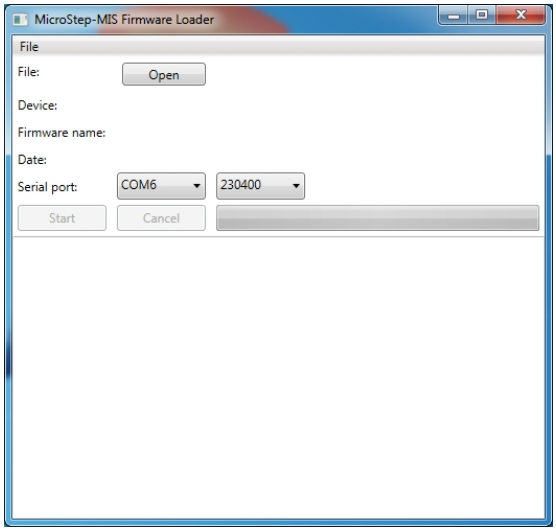


Figure 9: Firmware Loader basic window

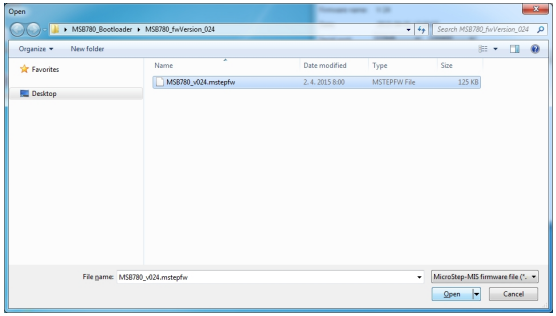


Figure 10: Selecting the firmware file

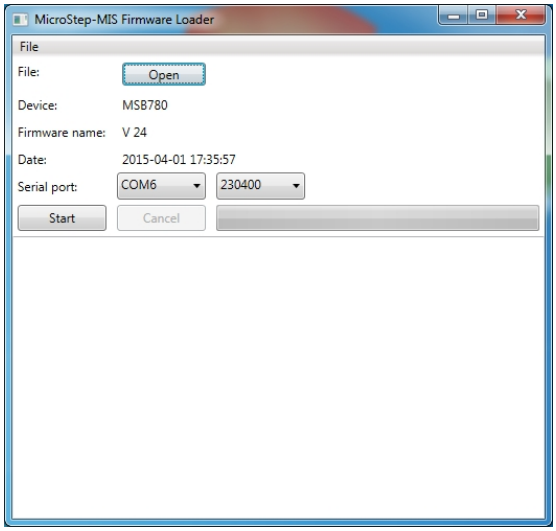


Figure 11: Information about selected firmware

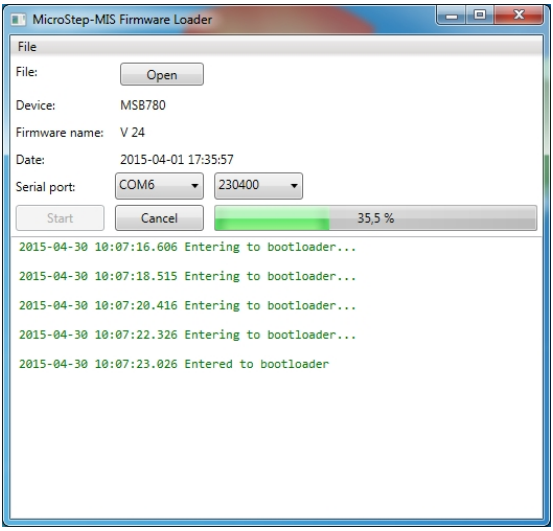


Figure 12: The transferring process

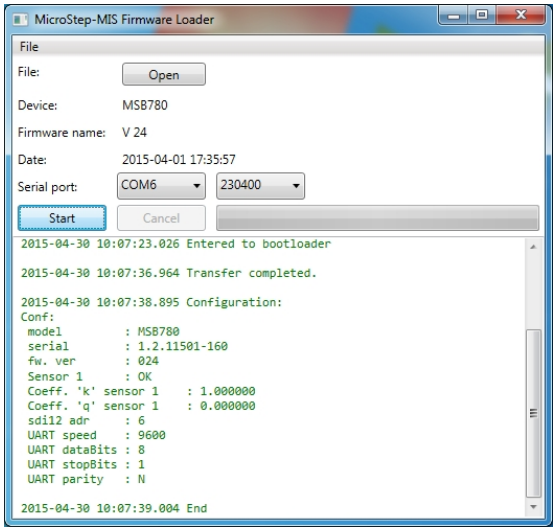


Figure 13: Listing information after successful transfer of firmware

12 History of changes

12.1 V 1.1

- Fixed resolution to three decimal places in [hPa] units.
- Corrected string "0000" to "000" in chapter "Start Measurement Command (aM!).
- Updated "Principle of operation" chapter, added NOTE on calibration.

12.2 V 1.2

- Added Resolution to table "Parameters of sensor".
- Changed Serial interface UART 3.3 V to RS-232.
- Increased level of "Table of contents" to 2
- Removed "analog output" from "Introduction" chapter.
- Added "RS-485 serial interface" to "introduction" chapter.
- Added "5 terminal version" picture

12.3 V 1.2.1

- Added "seri" command
- Added "cset" command

12.4 V 1.2.2

- Added following commands: hqfe, hqnh, tqfe, hqfe?, hqnh?, tqfe?, unit, unit?

12.5 V 1.2.3

- Added Section: Maintenance.

12.6 V 1.2.4

- Added Section: Calibration and Adjustment.

12.7 V 1.3

Changes in this version are connected with hardware version 1.2.1 and firmware version 12 and more.

- Changed picture in section Terminals.
- Changed typical power consumption @12 V from 67 mA to 32 mA. Power consumption has lowered since new hw. ver. 1.2.1.
- Changed terminal markings TX, RX to TXD, RXD.
- Changed line termination from <cr><lf> to <cr>, or <cr><lf>. MSB780 accepts <cr> as an alternative line ending since fw version 12.

- Changed default echo on to default echo off, with an option to turned echo on using a command. This is valid since fw ver, 12.
- Renamed section "Notes on onboard jumper and trimmer" to "Note on onboard trimmer". There is no more jumper on the PCB since fw. ver. 1.2.1.
- Changed example in section "Print configuration...". Since fw. ver. 12, the output of this command looks differently.
- Added section "Get Verification (aV!)", which describes a new SDI-12 command, present since fw. ver. 12.

12.8 V 1.4

Changes in this version are connected with hardware version 1.2.1 and firmware version 14 and more. MSB780X version is first mentioned in this revision.

- Added hyperlinks to the document. References are now clickable in the electronic version.
- Added mention of MSB780X version at many places.
- Added table of supply currents.
- Added sections 2.7, 3.4, 5.2.2, 7.2.5, 7.2.5, 9
- Updated section Maintenance.
- Updated section Calibration and Adjustment
- Added new commands in the section Serial interface command set.

- Added table 7 representing error states.
- Renamed section 5.2.8, and updated.
- Added function HCP and related commands.
- Added section Display access.

12.9 V 1.5

- Updated section 3.4.

12.10 V 1.6

- Updated title photo; MSB780 case changed color from black to silver.
- Updated section 3.4.

12.11 V 1.7

- Updated values in table 5 on page 21.

12.12 V 1.8

- Added section Change firmware of the barometer. Added section Ordering information.

12.13 V 1.9

- Added subsection Change output message format.
- Added subsection Get actual output message format.
- Added subsection Change the user port start-up operating mode.
- Added subsection Get actual the user port start-up operating mode.
- Added subsection Change the outputting interval for RUN mode.
- Added subsection Get actual the outputting interval for RUN mode.

12.14 V 1.10

- Fixed response to aM! command
- Changed response to aD0! command after aV!
- Added warm-up time information

12.15 V 1.11

- Moved table MSB780X approximate power supply current to a new section Power consumption in section Technical Data. Altered Sleep mode consumption from 6 mA to less than 0.1 mA @ 12 V.
- Removed table MSB780 parameters with duplicate parameters from section Intrduction. The parameters remain in section Technical Data.

- Rewritten section Hardware - Power Supply.
- Modified aV! command response.

12.16 V 1.12

- Added items to the cnf? command.
- Added options P, P1, P2, P3 for FORM command.

12.17 V 1.13

- Added commands `terminal rs232` and `terminal rs485`.

12.18 V 1.14

- Added page reference to table MSB780 commands and MSB780 SDI-12 commands.
- Added commands aXD1!, axD2!, aXD3!, aXV! for SDI-12.