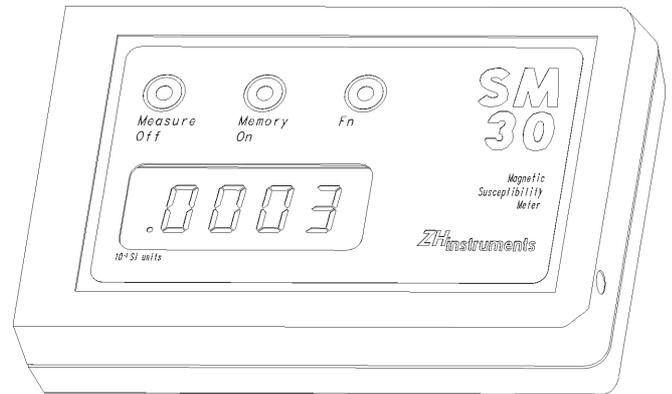


# ZH instruments

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## Magnetic susceptibility meter **SM-30**

### USER'S MANUAL



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# **1.GENERAL INFORMATION**

## **1.1 Application**

The SM-30 meter is intended for measuring the magnetic susceptibility of rock. Owing to its high sensitivity, it is capable of measuring rock with a very low susceptibility. It can also measure diamagnetic substances. The meter reaches its peak sensitivity within a very few seconds after switch-on. By employing a very sophisticated way of processing the signal, the meter can efficiently reduce the influence of external electromagnetic disturbances and the noise of electronic circuits. Its low weight and small size make this instrument ideal for use out-of-doors.

## 1.2 Specification

SENSITIVITY.....	1x10 <sup>-7</sup> SI Units
MAX MEASURED VALUE.....	1SI
DIMENSIONS.....	100 x 65 x 25 mm
WEIGHT.....	0.150 kg
OPERATING FREQUENCY.....	8kHz
MEASUREMENT TIME	
• .....	basic mode approx. 5s
• .....	drift correction modes approx. 8s
DIGITAL DISPLAY.....	LCD 4digit,10mm high
CONTROLS.....	3 push buttons
DATA MEMORY.....	up to 250 measurements
PICK-UP COIL SIZE	50 mm in diameter
OPERATING TEMPERATURE.....	-20°C to +50°C
BATTERY.....	2 Lithium 3V type CR2430
BATTERY LIFE.....	typically 80 hours
COMMUNICATION WITH COMPUTER.....	RS232

## **2. DESCRIPTION OF INSTRUMENT**

### **2.1 General description**

The susceptibility meter is enclosed in a box, which has a front panel with push buttons and a four-digit 10mm character display. In order to get the right value in SI, the user must multiply the reading by a constant  $10^{-3}$ .

Behind the front panel there is a buzzer, which monitors by way of acoustics the operation of the meter. On the right-hand side of the cover there is a connector for communication with a computer. A communication cable is delivered as part of the set. On the bottom side of the cover there is a little cubicle holding two Li batteries.

The 50mm pickup coil is placed on the left-hand side parallel with the bottom part of the cover (see figure 6).

## **2.2 Operating principles**

The meter contains an oscillator with a pickup coil. The frequency of the oscillator depends on the distance of the meter from rock. The change in frequency is proportional to the amount of susceptibility of the rock. In order to find out about the change, it is necessary to measure the oscillator frequency twice. The first measurement is performed near the rock. This is called *pick-up step*.

The second measurement is carried out when the meter is away from the rock (free air measurement). The second phase is called *compensation step*.

After the second step is finished, both values are subtracted and displayed. Both the steps are initiated by the operator.

The above mentioned mode is called *basic mode* or *mode 1*.

When measuring rock of very low susceptibility, it is possible that the oscillator thermal drift becomes greater than the effect of the rock. In this case it is necessary to measure not only the susceptibility, but also the thermal drift. The thermal drift and susceptibility values are then compared. The thermal drift measurement requires that two measurements away from rock are carried out, which means that there have to be three steps altogether. Two steps are performed without rock and one is performed with rock. The SM-30 meter offers two ways of correcting the drift. The first mode is called *extrapolation mode* or *mode 2*.

The second mode is called interpolation mode or mode 3.

When measuring places that are situated very close to one another, it is best to use scanning mode.

This mode corrects the thermal drift as well and the measurement is very quick, although the drift correction is not so precise as in the extrapolation or interpolation mode.

### **2.2.1 Basic modes A and B**

The function of the meter is shown in Figure 1a. Figure 1b shows the way the oscillator frequency is affected by the measured object. It also shows the frequency difference in both the steps. The difference is used as ground for the calculation of magnetic susceptibility. Figure 1 deals with an ideal case, when there is no thermal drift. Susceptibility is calculated using the formula

$$\mathbf{susc} = \mathbf{f}_2 - \mathbf{f}_1$$

After the compensation step is finished, the value **susc** is displayed.

Figure 2 shows the effects of thermal drift during Basic mode. It shows that the oscillator frequency is not only influenced by the measured rock during the pickup step, but it changes without any apparent reason and causes measurement error.

The SM-30 has two basic modes A and B. The only difference between modes A and B is in the length of the pick-up and compensation steps. The basic mode B has these steps 4 times faster than mode A. Mode B is suitable for measuring medium and high susceptibility.

### **2.2.2 Extrapolation mode**

Thermal drift correction is described in Figure 3. The time elapsed during the pickup step and the first compensation step depends on the operator. The time lag between the second and first compensation steps is set automatically and it is  $t$  as well. It is then quite easy to measure the value of drift.

$$\mathbf{drift} = \mathbf{f}_3 - \mathbf{f}_2$$

It is valid that

$$\mathbf{susc} + \mathbf{drift} = \mathbf{f}_2 - \mathbf{f}_1$$

Furthermore

$$\mathbf{susc} = \mathbf{f}_2 - \mathbf{f}_1 - (\mathbf{f}_3 - \mathbf{f}_2) = 2\mathbf{f}_2 - \mathbf{f}_1 - \mathbf{f}_3$$

The correction of drift is performed automatically according to the last equation. After the first compensation step is finished, the display shows first the uncorrected  $f_2 - f_1$  value. After the second compensation step is finished, the value is corrected and the display shows the value  $2f_2 - f_1 - f_3$ .

### 2.2.3 Interpolation mode

This method requires that the user put the meter near rock during the second step. The first and third steps are compensation steps. The third step of this mode (the second compensation step) is initiated automatically. Figure 4 makes it possible to derive

$$\text{susc} = (f_1 + f_3)/2 - f_2 = -1/2 (2f_2 - f_1 - f_3)$$

The reading is corrected after the second compensation step and the display shows the value  $-1/2 (2f_2 - f_1 - f_3)$ .

### 2.2.4 Scanning mode

The principle is clear from Figure 5, which shows the *block* of measurement. The first and last steps are compensation (free air). The first compensation step is initiated by the left button. Afterwards come pickup steps (near the rock), which are started by the left button as well. The measurement is finished with the second compensation steps, initiated by the **middle button**. The display shows

after each pickup step the susceptibility value, calculated similar to the Basic mode. This calculation takes into consideration the value measured during the first compensation step fc1. The susceptibility is stored in the operation memory of the processor together with the time elapsed since the first compensation step (see Figure 5). After performing the second - final - compensation step (**middle button**), drift correction is made using interpolation. The corrected susceptibility values are stored in memory registers to be displayed in the usual manner. The total number of pickup steps in one block is 20. After the 20<sup>th</sup> pick-up step the instrument warns the operator that measured block has to be terminated by second compensation step.

### **2.2.5 Averaging mode**

This mode is very similar to Scanning mode (mode 4). The only difference is in the very end of measuring procedure. After the **middle button** is pressed and drift correction is done, the average value is calculated and put into memory register (see Figure 5).

### **2.2.6 Comparison of modes**

Both basic modes are simple and yet applicable in most situations. Basic mode B is suitable for medium and high susceptibility. Extrapolation mode is useful when measuring low susceptibility rock. The operation of the meter is the same as during the Basic mode, only the correction of the final value takes a few seconds longer.

The advantages of the interpolation method can be seen in the equations in 2.2.2 and 2.2.3. A comparison of both calculations shows that the Interpolation mode requires the result to be divided by -2. This means that the value is twice as precise as with the extrapolation method. The correct value is obtained by processing the data in the same way as with extrapolation method and dividing it by -2.

The interpolation method offers twice as effective noise reduction as the extrapolation method. It is, however, less similar to the basic modes used in most measurements.

The interpolation method is useful when dealing with samples of very low susceptibility.

The scanning mode is best in such cases as measuring a number of points on a profile. Core is a good example. In order to measure  $n$  values it is necessary to measure the frequency  $n+2$  times, while during extrapolation or interpolation method it is necessary to perform  $3n$  measurements.

The disadvantage of the scanning mode lies in the lesser ability to reduce drift. This is especially the case when the number of pickup steps between two compensation steps is too high.

Due to the lower reduction of drift, the readings are displayed with the definition of  $10^{-6}$  SI.

The following table makes it possible to compare the six usual modes.

	<b>object measurement &amp; init.</b>	<b>object measurement &amp; init.</b>	<b>object measurement &amp; init.</b>	<b>resolution [SI Units]</b>
<b>basic modes*) A &amp; B</b>	rock press left button	free air press left button	----- -----	10 <sup>-6</sup>
<b>extrapolation mode (drift correction)</b>	rock press left button	free air press left button	free air automatically	10 <sup>-7</sup>
<b>interpolation mode (drift correction)</b>	free air press left button	rock press left button	free air automatically	10 <sup>-7</sup>
<b>scanning mode</b>	free air press left button	rock n-times press left button	free air press right button	10 <sup>-6</sup>
<b>averaging mode</b>	free air press left button	rock n-times press left button	free air press right button	10 <sup>-7</sup>

\*) Basic mode B has 4 times faster measuring time than basic mode A.

### 3. OPERATION

#### 3.1 Switching instrument ON and OFF

The meter is switched on by pressing the middle button. The meter displays within 0.2 seconds of switchon the mode number used before the meter was switched off. After the button is released, the last susceptibility value is displayed and the buzzer gives a short beep. The modes are numbered as follows:

basic mode A.....	-1--
extrapolation mode.....	-2--
interpolation mode.....	-3--
scanning mode.....	-4--
averaging mode.....	-5--
basic mode B.....	-6--

The respective modes are given the same numbers during the setting up of modes (see next chapter).

The meter is switched off by pressing the left button and holding it until the buzzer gives a short beep to indicate switchoff. The time is approximately 5 seconds. The meter also displays the word **OFF**. After the button is released, the display goes off and the meter is off as well.

The meter switches itself off after no button has been pressed for three minutes. The meter gives a beep to indicate switchoff.

## **3.2 Setting and indication of mode**

By pressing the right button first and then pressing the left button without releasing the right one the user can display the number of mode according to the table in the previous chapter. By pressing the left button a second time, the user sets up a mode with a number greater by 1. Mode 6 is followed by mode 1. After finishing this procedure, the set mode is used.

## **3.3 Measuring susceptibility of rock**

### **3.3.1 Basic modes A, B**

If necessary, switch the instrument into the Basic mode indicated by **-1--** or by **-6--**. The only difference between modes A and B is in the length of the pick-up and compensation steps. The basic mode B has these steps 4 times faster than mode A.

The switched on meter is put near the rock and the operator presses the left button. The meter gives a high-pitched beep and when the operator releases the button, the meter is performing the pickup step, or measuring frequency near rock. During the frequency measurement the buzzer is giving a low-pitched beep. The display shows the middle three horizontal segments. The pickup step takes

approximately 2 seconds. After the pickup step is finished, the buzzer goes silent and the number of the memory register prepared to store the value is displayed.

Now the operator removes the meter from the rock and presses the left button. The buzzer is emitting a high-pitched beep. After the button is released, the meter is performing the compensating step, which means - in this case - one measurement away from the rock. During the frequency measurement the buzzer is giving a low-pitched beep and the three middle horizontal segments are displayed. The compensating step is as long as the pickup step, that is 2 seconds. The buzzer goes silent when this step is finished and the value of magnetic susceptibility is displayed. The displayed value must be multiplied by  $10^{-3}$  to be according to the SI.

Basic mode displays readings with the resolution of  $10^{-6}$  SI.

### **3.3.2 Extrapolation mode**

If necessary, switch the instrument into the Extrapolation mode indicated by **-2--**

The switched on meter is put near the rock and the operator presses the left button. The meter gives a high-pitched beep and when the operator releases the button, the meter is performing the pickup step, or measuring frequency near rock. During the frequency measurement the buzzer is giving a low-pitched beep. The display shows the middle three horizontal segments. The pickup step takes approximately 2 seconds. After the pickup step is finished, the buzzer goes silent and the number of the memory register prepared to store value is displayed.

Now the operator removes the meter from the rock and presses the left button. The buzzer is emitting a high-pitched beep. After the button is released, the meter is performing the first compensating step, which means frequency measurement away from the rock. During the frequency measurement the buzzer is giving a low-pitched beep and the three middle horizontal segments are displayed. The frequency measurement is as long as the pickup step, that is approximately 2 seconds. The buzzer goes silent when this step is finished and the measured value is displayed. The same value would constitute the final reading when measuring in the Basic mode. Now the operator holds the meter away from the rock. In a few seconds, the buzzer starts giving a low-pitched beep to indicate the second compensating step, which means the second frequency measurement away from the rock. After the step is finished, the corrected value of magnetic susceptibility is displayed. The obtained value is not affected by the linear part of drift. The displayed value must be multiplied by  $10^{-3}$  to be according to the SI.

Extrapolation mode displays readings with the resolution of  $10^{-7}$  SI.

### **3.3.3 Interpolation mode**

If necessary, switch the instrument into the Interpolation mode, indicated by **-3-**

Now the operator removes the meter from the rock and presses the left button. The buzzer is emitting a high-pitched beep. After the button is released, the

meter is performing the first compensating step, which means frequency measurement away from the rock. During the frequency measurement the buzzer is giving a low-pitched beep and the three middle horizontal segments are displayed. The first compensating step is approximately 2 seconds long. The buzzer goes silent when this step is finished and the number of the memory register prepared to store value is displayed.

The meter is now put near the rock and the operator presses the left button again. The buzzer gives a high-pitched beep and when the operator releases the button, the meter is performing the pickup step, or measuring frequency near the rock. During the frequency measurement the buzzer is giving a low-pitched beep. The display shows the middle three horizontal segments. The pickup step is as long as the first compensating step, that is approximately 2 seconds. After the frequency measurement is finished, the buzzer goes silent and the measured value is displayed. The same value would constitute the final reading when measuring in the Basic mode. Now the operator holds the meter away from the rock. In a few seconds, the buzzer starts giving a low-pitched beep to indicate the second compensating step, which means the second frequency measurement away from the rock. After the step is finished, the corrected value of magnetic susceptibility is displayed. The obtained value is not affected by the linear part of drift. The result must be multiplied by  $10^{-3}$  to be in the SI units. Interpolation mode displays readings with the resolution of  $10^{-7}$  SI.

### 3.3.4 Scanning mode

If necessary, switch the instrument into the Scanning mode, indicated by **-4--**

The operator removes the meter from the rock and presses the left button. The buzzer is emitting a high-pitched beep. After the button is released, the meter is performing the first compensating step, which means frequency measurement away from the rock. During the frequency measurement the buzzer is giving a low-pitched beep and the three middle horizontal segments are displayed. The first compensating step is approximately 2 seconds long. The buzzer goes silent when this step is finished and the number **.0000** is displayed.

The meter is now put near the rock and the operator presses the left button again. The buzzer gives a high-pitched beep and when the operator releases the button, the meter is performing the pickup step, or measuring frequency near the rock. During the frequency measurement the buzzer is giving a low-pitched beep. The display shows **-:1** which says that the measurement was first in the block.

The frequency measurement is as long as the first compensating step, that is approximately 2 seconds. The buzzer goes silent when this step is finished and the measured value is displayed. The same value would constitute the final reading when measuring in the Basic mode. The operator now puts the meter elsewhere and measures frequency near the rock. **-:2** is displayed.

The number indicates that the measurement is the second in the block. Analogically, it is possible to measure more places. The maximum number of measurements is 20. Finally, the operator removes the meter away from the rock and by pressing the middle button initiates the second compensating step. After the second compensating step is finished, the display shows the difference between the first and second compensating steps, or the drift during the measurement. At the end of the second compensating step the meter performs interpolation corrections of drifts and the corrected data is stored in the memory registers.

There is one character before the first value and after the last one respectively. The former is displayed as two opening brackets and the latter is displayed as two closing brackets. The length of the block may be up to 22 memory registers. When feeding the data to a computer, the software delivered as part of the package replaces these characters with the words "begin" and "end". Should two blocks follow close after each other, the opening character of the new block replaces the closing character of the previous one.

When the Scanning mode is initiated, the meter checks the number of available memory registers. If there are not enough such registers, the meter does not measure in this mode and the buzzer gives a few short beeps. The meter must have at least 21 available memory registers when starting the Scanning mode. In other words, the Register Pointer must be set to **229** or lower (see next chapter).

### 3.3.5 Averaging mode

If necessary, switch the instrument into the Averaging mode, indicated by **-5--**

The operator removes the meter from the rock and presses the left button. The buzzer is emitting a high-pitched beep. After the button is released, the meter is performing the first compensating step, which means frequency measurement away from the rock. During the frequency measurement the buzzer is giving a low-pitched beep and the three middle horizontal segments are displayed. The first compensating step is approximately 2 seconds long. The buzzer goes silent when this step is finished and the number **.0000** is displayed.

The meter is now put near the rock and the operator presses the left button again. The buzzer gives a high-pitched beep and when the operator releases the button, the meter is performing the pickup step, or measuring frequency near the rock. During the frequency measurement the buzzer is giving a low-pitched beep. The display shows **A:1** which says that the measurement was first in the block.

The frequency measurement is as long as the first compensating step, that is approximately 2 seconds. The buzzer goes silent when this step is finished and the measured value is displayed. The same value would constitute the final reading when measuring in the Basic mode. The operator now puts the meter elsewhere and measures frequency near the rock. **A:2** is displayed.

The number indicates that the measurement is the second in the block. Analogically, it is possible to measure more places. The maximum number of measurements is 20. Finally, the operator removes the meter away from the rock and by pressing the middle button initiates the second compensating step. At the end of the second compensating step the meter performs interpolation corrections of drifts and the mean value of corrected data is displayed and stored in the memory register.

There are two possibilities how to terminate the measurement procedure (see Figure 7.):

- a) Push and release the middle button sooner than the second compensation step is terminated. The average value is shown on the display (fig. 7a,c bold line).
- b) Push, release, push and keep the middle button. When the second compensation step is finished, the drift is shown on display. After releasing the middle button the average value is shown on display. (fig. 7a,d dotted line).

### **3.4 Memory registers**

The SM-30 meter has 250 memory registers to store the measured data. In addition, the meter always stores the value measured before switchoff and it automatically displays this value after switchover.

The memory registers are named **R1, R2,..., R250**.

The memory register is chosen using Register pointer RP. The contents of the RP are available for use.

The memory registers can be used as follows:

1. Saving. The displayed value obtained during the last measurement is saved by pressing the middle button. When the operator presses the button, the register number to store the data is displayed. The data is saved when the operator releases the button. During the procedure the RP is incremented and the next value is stored in a register with a higher number. It is possible to save data until the **R250** register is full. The buzzer gives a beep if an attempt to save data is unsuccessful. Moreover, **FL** is displayed instead of RP number.

2. The number not obtained directly before pressing the right button is not saved. By pressing the right button, the operator can view the contents of RP and by releasing it, they can view the contents of the indicated register. The RP is incremented and by pressing the middle button repeatedly the user can view the memory. The registers are viewed in a cyclical fashion, which means that **R1** comes after **R250**.

The contents of the memory registers can be browsed also by pressing the right button. In this case, the number of the following register is lower than the previous one. Cyclical browsing is implemented as well (**R250** comes after **R0**).

3. In order to delete the registers the user must press the right button and then press the remaining two buttons without releasing the right one. The RP is set to 1 and the contents of all registers are deleted. Four dots are displayed when a deleted register is read.

During the deletion process the display shows **:CL**

4. If the user wants to view the registers after the measurement without saving the last reading, it is necessary to press (at least once) the right button, or to switch the meter off and on. Although the last measured value is displayed after switchon, it is not saved in a memory register when pressing the middle button.

### **3.5 Battery replacement**

1. Slide off the lid on the bottom of the meter. There are two Li batteries held in place by a strip and two screws.
2. Partly unscrew the screw which is in the corner. Unscrew the other one completely.
3. Replace the batteries.
4. Fasten the strip.
5. Slide the lid back in place.

## **3.6 Communication with computer**

### **3.6.1 General information**

The instrument can be connected to a computer by a special cable, which is delivered as part of the package. The computer end of the cable has a 9-pin Canon connector. The communication is 9600 Bd. The computer software must set the output **DTR** = 1 (positive) and the output **RTS** = 0 (negative). The communication is in ASCII strings.

### **3.6.2 Instrument operation using computer**

Using a computer the operator can emulate the function of both buttons. The ASCII character

**"1"** emulates the left button. Similarly, the ASCII character

**"2"** emulates the middle button and ASCII character

**"3"** emulates the right button. The character

**"r"** asks for sending all the registers. The character

"v" asks for the software version.

### 3.6.3 Transfer of data to computer

The meter automatically sends the currently displayed data to the serial channel.

For further use in the text let us define the term **<data>** as a string of ASCII characters having the form

**-xxx.xxxxx** in the case of a negative figure (10 byte) and

**xxx.xxxxx** in the case of a positive figure (9 byte).

The character **x** substitutes ASCII character of digit in the range **1..9**

The meter sends more valid places than are the currently displayed data. This is useful for the noise evaluation of the meter. The number of places is not fixed and depends on the measuring mode.

Similarly, let us define the term **<reg>** as a string of two numeric ASCII characters denoting a register number.

#### a) Reading obtained in the Basic mode

**M<data><LF>**

eg. **M-000.256<LF>**

b) Reading obtained in the Drift correction mode

**M<data1><space> .... M<data2><LF>**

The dots stand for the elapsed time.

eg. **M000.006<space> M-000.002<LF>**

c) Saving data in a memory register

**W<reg>I<data><LF>**

eg. **W03I-023.123<LF>**

If there is memory overflow, the character "**O**" is sent instead of the data.

d) Reading a memory register

**R<reg>I<data><LF>**

eg. **R23I000.452<LF>**

e) Reading obtained during the scanning mode

**GB<LF>** - signifies beginning of the data block of the scanning mode

**G<reg>I<data><LF>**

- measured data

**GE<LF>**

- signifies end of the data block of the scanning mode

eg. **GB<LF>**

**G100I000.452<LF>**

**G101I000.401<LF>**

**G102I000.392<LF>**

**GE<LF>**

It is impossible to switch on the meter using a computer or to read the last measured value, displayed right after switchon.

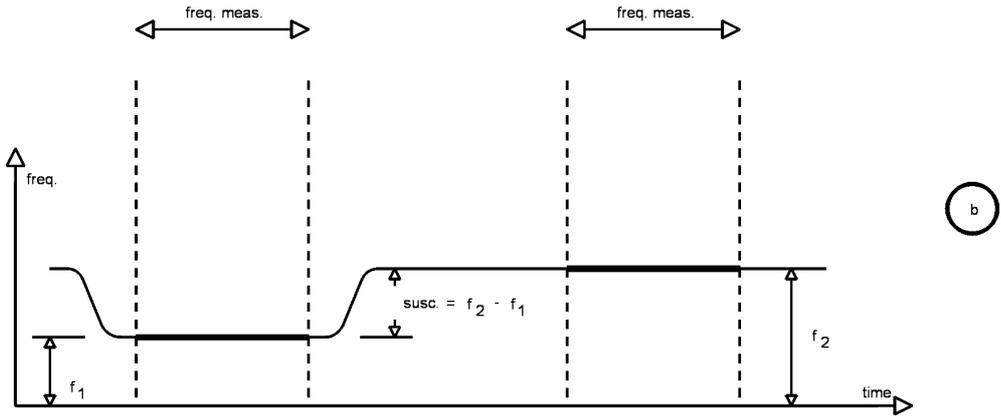
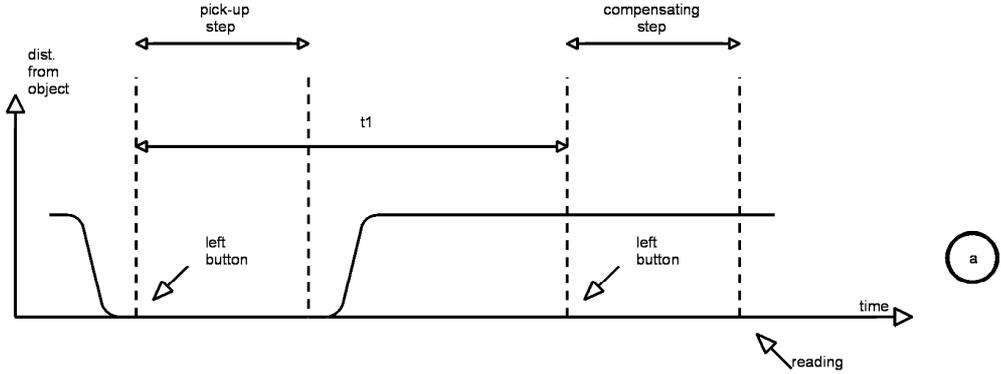
### **3.7 Error messages**

- **Err** - The step was not initiated close enough after the previous step.
- **LO BAT** - The batteries are low. It is possible to keep working some time after the first warning.
- **FL** - The memory registers are full.

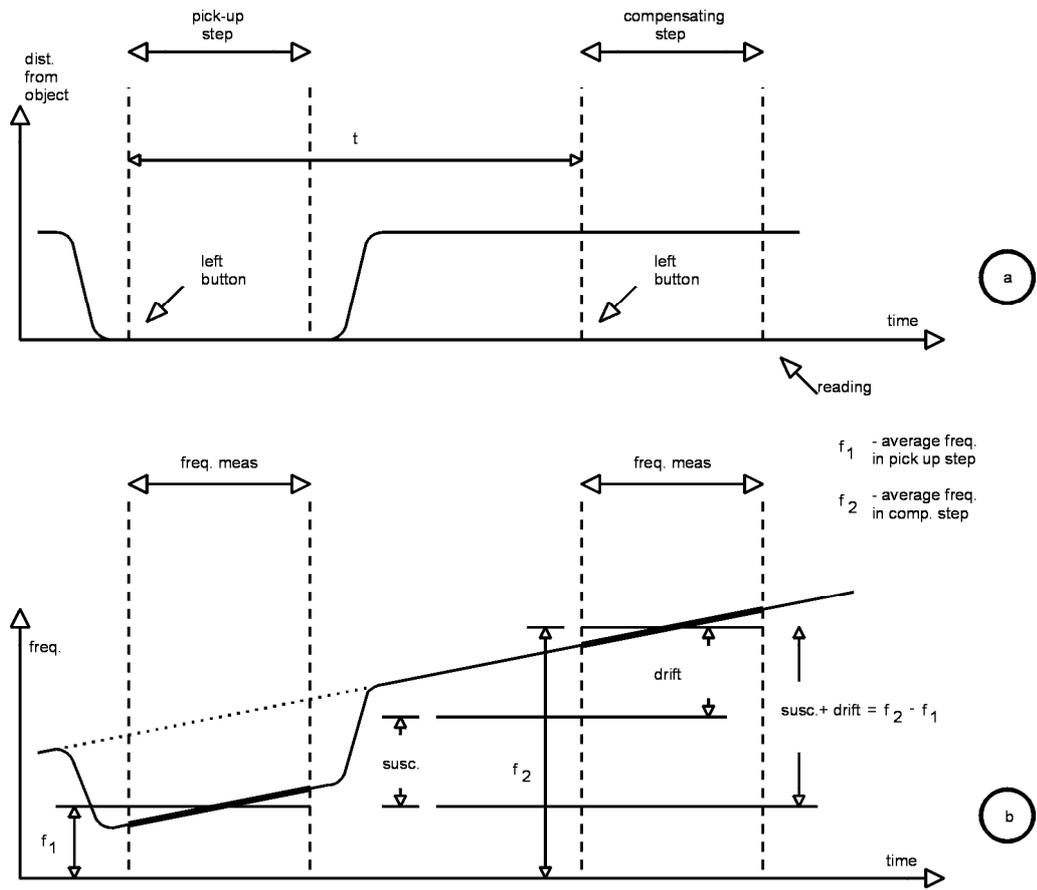
- **OL** - The instrument is overloaded - the measured susceptibility exceeds the limits of the meter (i.e. measured value  $> 1$  SI).

# 4 Figures

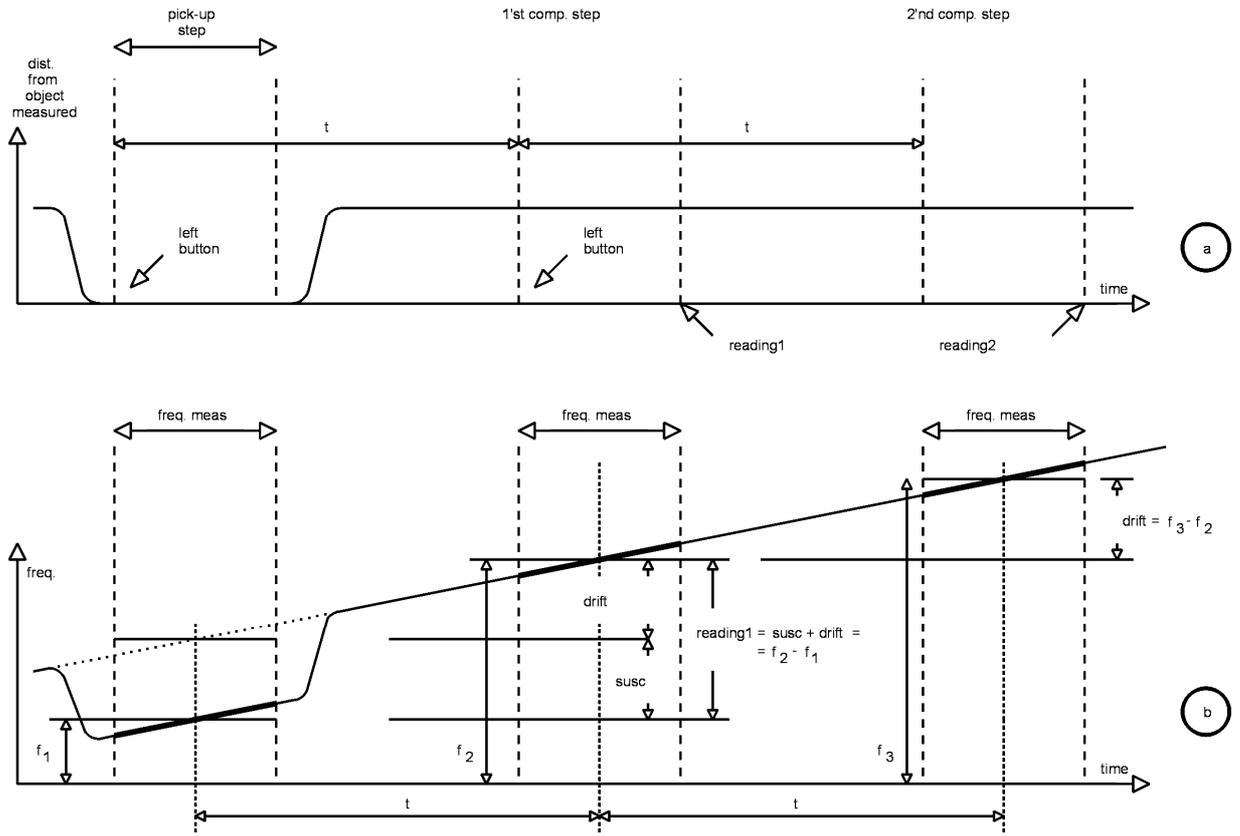
## 4.1 Figure 1



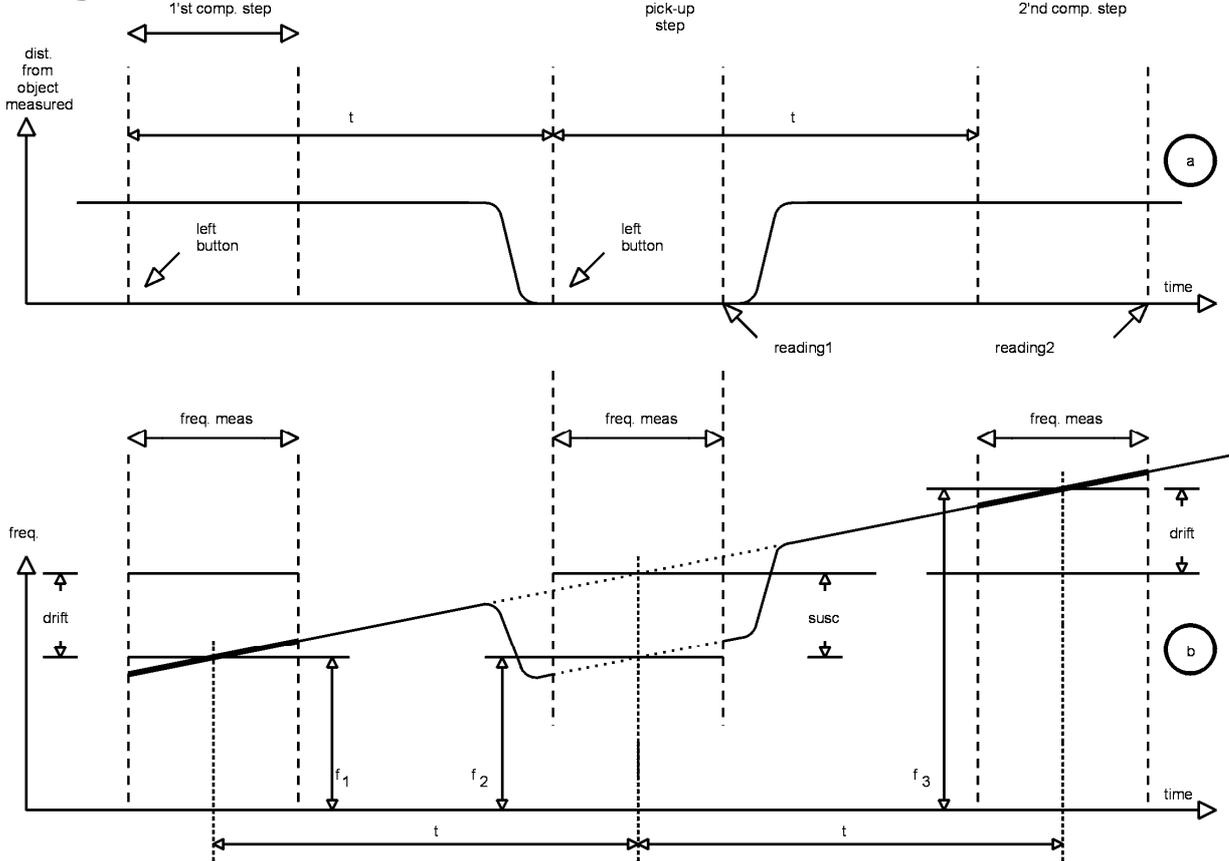
## 4.2 Figure 2



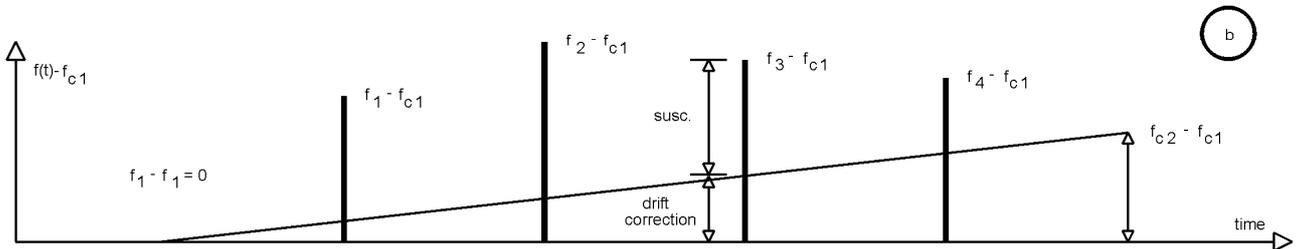
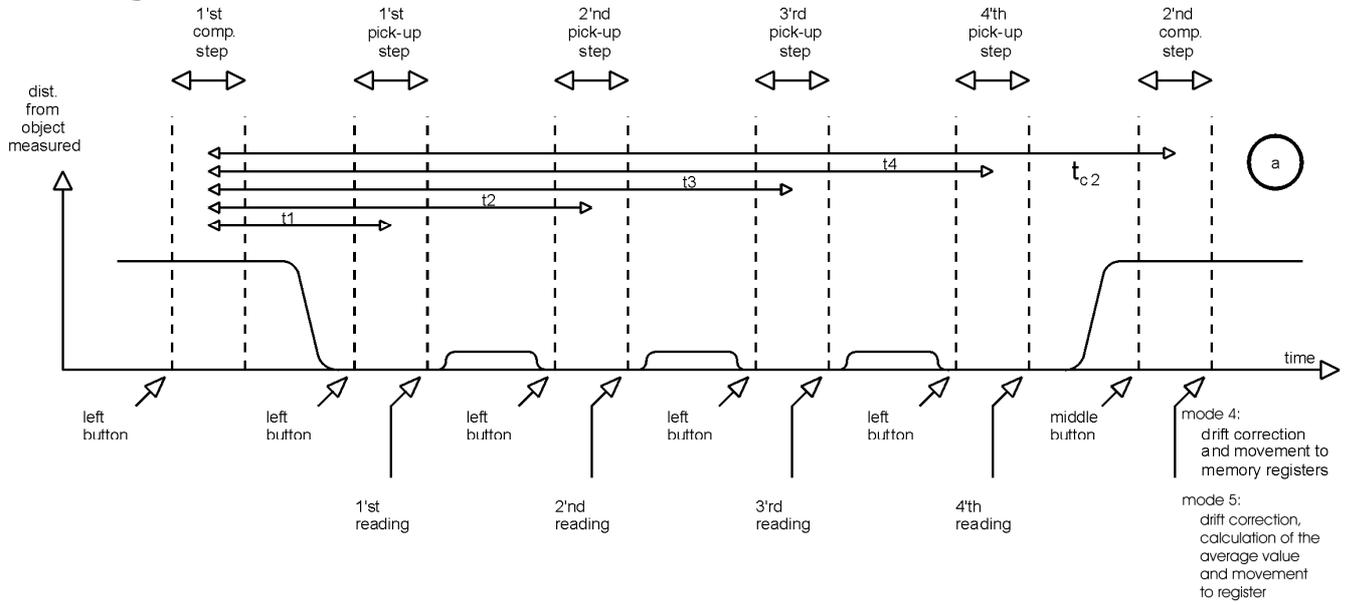
### 4.3 Figure 3



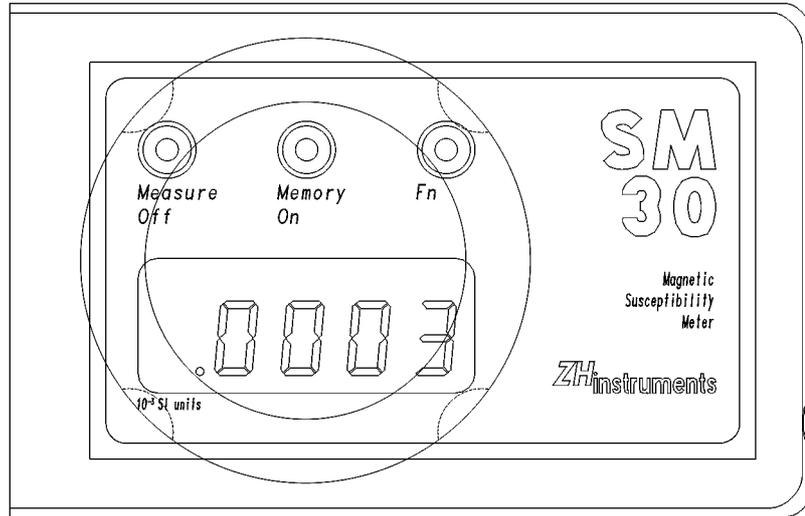
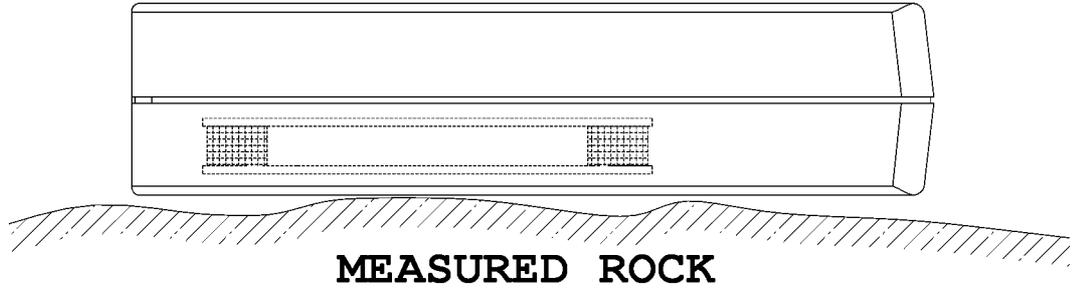
# 4.4 Figure 4



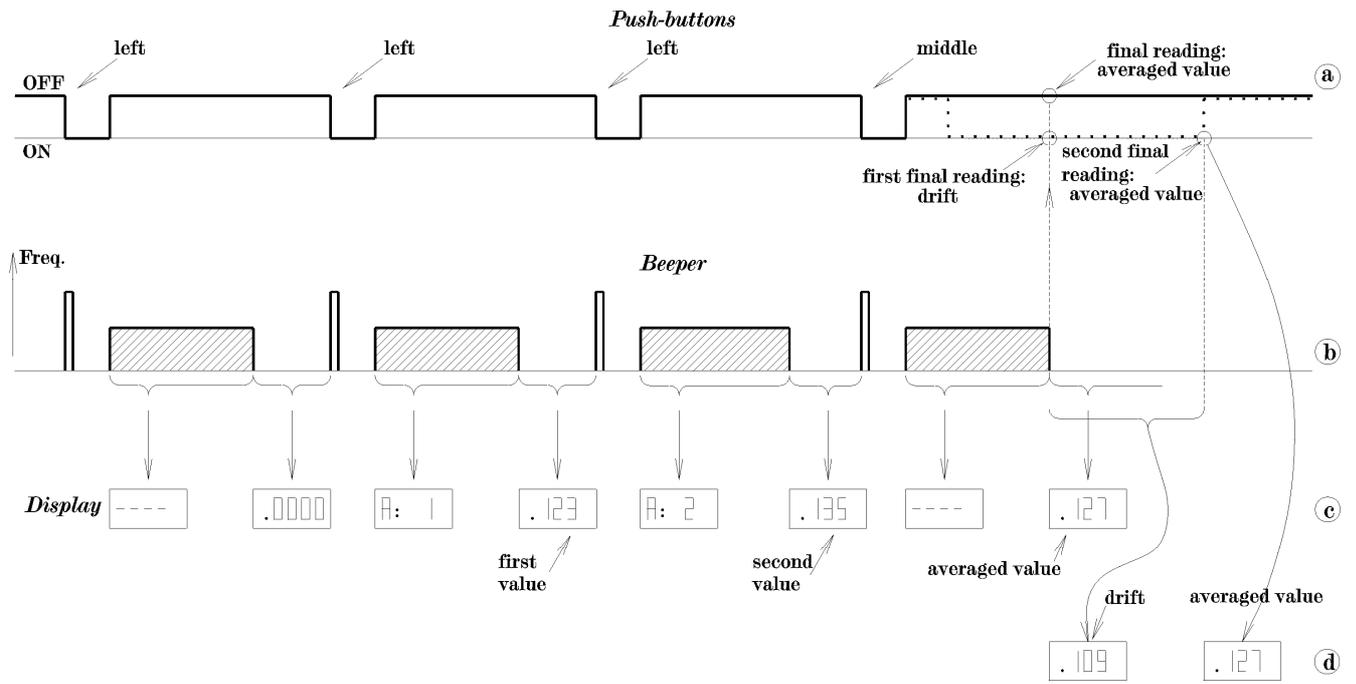
# 4.5 Figure 5



## 4.6 Figure 6



# 4.7 Figure 7



## **5. APPENDICES**

### **5.1 SM30 software**

One programme is supplied with the SM30 instrument that supports communication with a personal computer. The programme can import data from the SM30 memory registers and both of them can also control SM30. The up-to-date version SM30W can visualize the collected data in a chart and can be used for testing noise and temperature stability of the instrument.

### **5.2 SM30 programme for Windows**

#### **5.2.1 Installation**

The computer communicates with susceptibility meter SM-30 through an attached cable connected via USB port. The driver and software complete installation is saved on the USB flash disc. The software installation can be downloaded from our websites: [www.zh instruments.com/assets/sm30w.zip](http://www.zh instruments.com/assets/sm30w.zip)

It is necessary to install USB drivers (folder USB driver). For communication with SM 30, you just need to copy the files into the folder created by you on the harddisc. These are Sm30W.exe and Komun.dll

### **5.2.2 USB Driver installation**

We recommend installing USB driver before the first plug-in of the communication cable to the computer.

Start the application `CDM21XXX_setup.exe`, this will install the drivers from the USB driver folder. These are certified FTDI drivers by Microsoft.

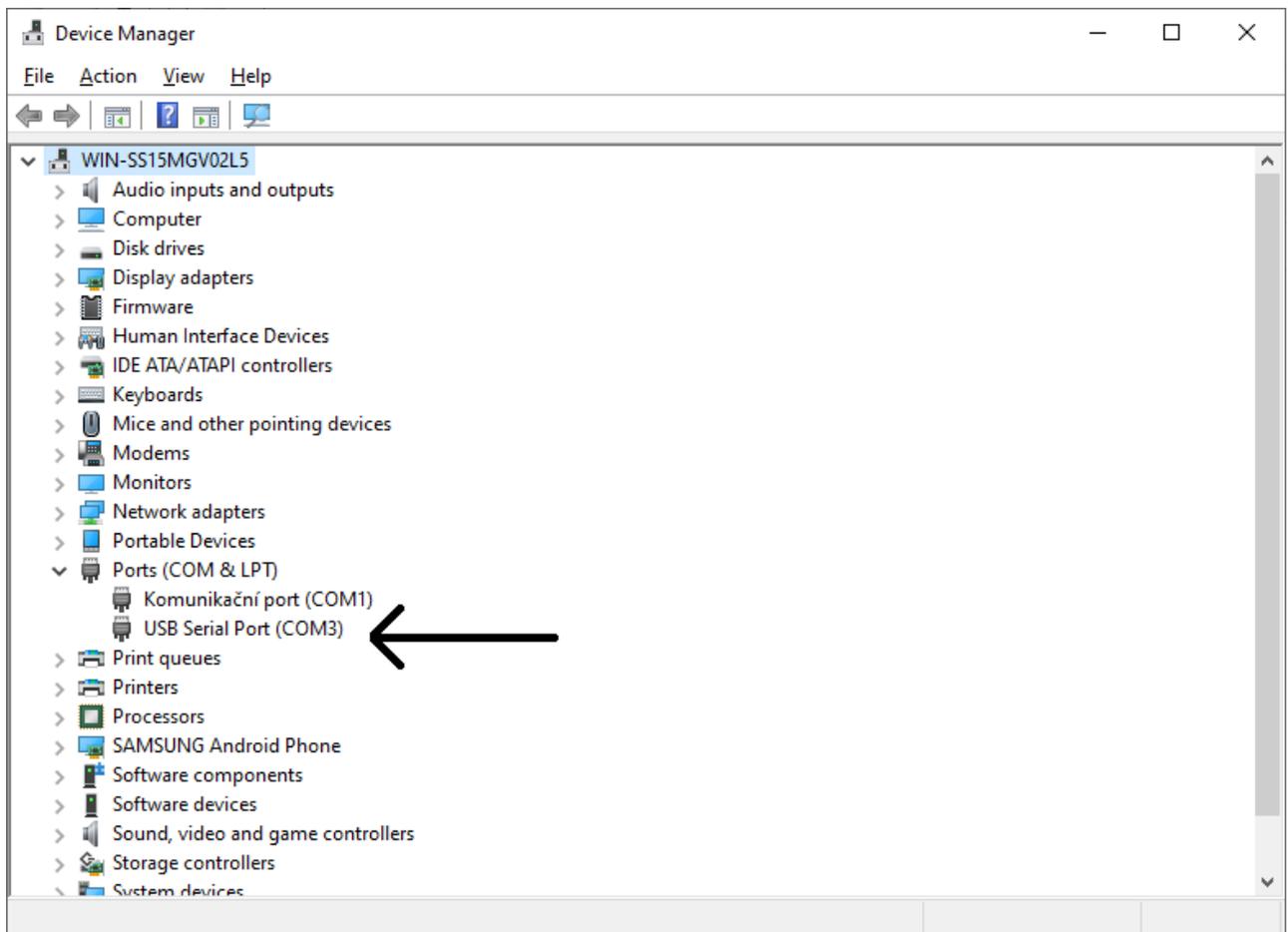
If you inserted the communication cable into the computer before the installation of drivers, it will not be a problem.

The computer finds a new device and ask for the driver.

We set the path for driver to the folder USB driver on USB flash disc.

In some cases, the PC downloads the driver from the internet itself.

After installing the driver and connecting the communication cable, start the Device manager in PC. In the Device manager, under the item Ports (COM @ LPT), you will find a new device USB Serial Port (COM X). Any number 1-255 may appear instead of the letter X. See following picture.



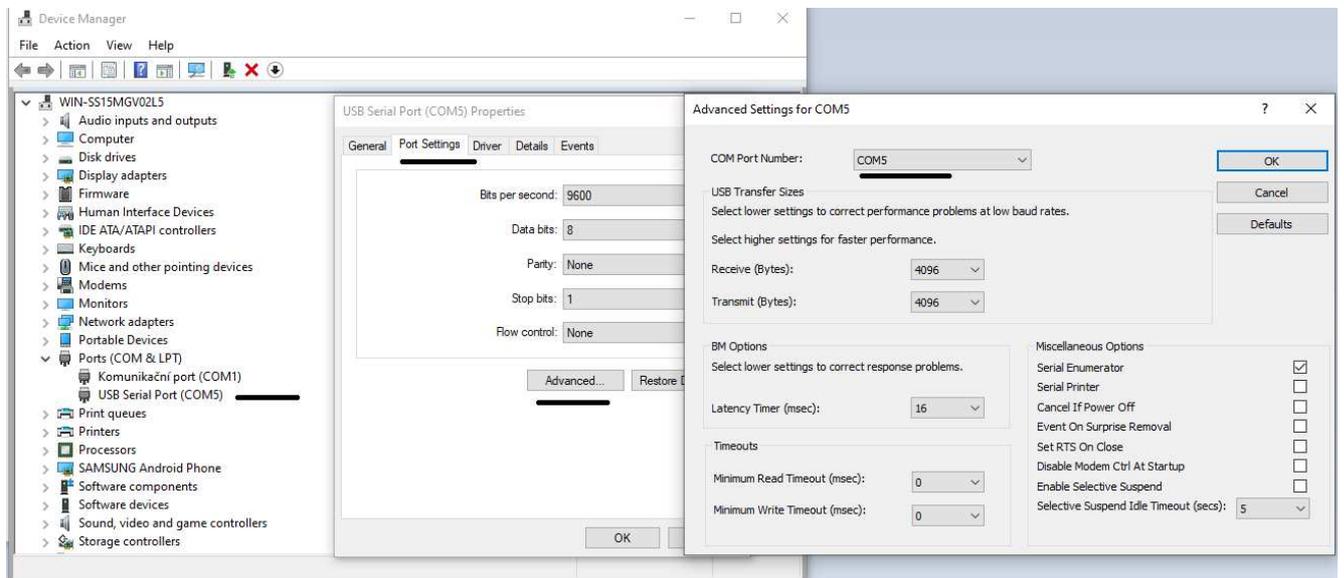
In most cases, port Com1 or port Com2 will appear.

The program for communication with the SM30 supports only Com1 to Com4 ports.

If we see the number greater than 4, it is needed to remap this port to the range of 1-4.

Following steps are required to remap the range:

In the device manager, you will select the following procedure on the USB item Serial Port (COM X)->Properties->Port settings->Advanced->Com port number. We will remap a port from the range 1-4. Everything can be seen in the following picture.



Now everything is ready for work with SM30.

### 5.2.2 Reading memory registers

- Choose **Registers** on the right-hand side of the window panel (default setting)
- Choose the **Device** menu on the top toolbar and choose **Read registers** in the menu.

The smaller window on the right-hand side will start to display the data that are being transferred from SM-30. When all 250 registers have been read, the register pointer is set to 1. At the same time, the collected data are visualized in a chart. If the values are too great, the chart may disappear in places and it may be necessary to adjust the vertical scale. If the data have been collected in mode 4 (scanning), the charts of individual blocks will be displayed separately. Data collected in mode 5 (averaging) will be visualized as separate dots.

### **5.2.3 Communicating with the computer on-line**

SM30 can be controlled using a computer by pressing the keys 1,2,3 or by clicking on commands in the **Device** menu. It is impossible to use a computer for operating the instrument in such situations when two or more buttons of the instrument need to be pressed simultaneously.

The **Test** option serves to test the instrument. During the test the SM30 instrument is triggered every 15 seconds. If the instrument is in mode 1, the data that are being collected are visualized in one chart. In modes 2 and 3, two charts are shown: one of them displays the data collected in mode 1 and the other displays the data collected in mode 2 or 3. The numerical values are shown in the right-hand side window.

During on-line tests, data are fed to the computer with the resolution of  $10^{-8}$  SI.

#### 5.2.4 Handling the charts

The length of a chart can be 100 or 250 points. To toggle chart lengths, click on **N** or **W** on the top toolbar. It is possible to adjust the vertical scale in a similar way, that is by clicking on **+** or **-** on the top toolbar. The **Undo** option is activated by clicking on the arrow on the top toolbar. Each axis has a numerical scale. Values on the scales must be multiplied by a constant that is a power of 10. The number after the asterisk stands for the exponent.

The **Zoom** option displays details. By pressing the left mouse button and moving the mouse simultaneously it is possible to draw a rectangle that can be enlarged. The enlargement is done by double-clicking on the rectangle with the left mouse button. The chart may be switched to its original size by clicking on the arrow on the top toolbar.

The whole chart can be moved with a mouse after pressing Shift on the keyboard and the left mouse button simultaneously.

After pressing the right mouse button, a menu appears. Commands in the menu allow the user to hide or display various chart components.

The **Properties** option allows the user to choose a chart colour. It also allows the user to hide the selected charts.

The **View** menu allows the user to hide the table with numbers on the right-hand side of the panel.

### 5.2.5 Saving the data

Collected data may be saved on the hard drive for later use. The data are saved in the XML format. Some applications, however, find it more suitable to use a format containing the ordinal number and the susceptibility value on the same line. To save the data in such a format, choose **Export** in the **File** menu.

### 5.3 Finite thickness layer correction

Thickness [mm]	Percentage of reading [%]
1	12.46

2	23.02
3	32.02
4	39.71
5	46.39
6	52.18
7	57.19
8	61.60
9	65.41
10	68.81
12	74.42
14	78.83
16	82.35
18	85.15
20	87.42
22	89.27
24	90.82
26	92.07
28	93.14
30	93.98
35	95.65
40	96.72
<b>Thickness [mm]</b>	<b>Percentage of reading [%]</b>
45	97.50
50	98.09
55	98.45

60	98.75
65	98.99
70	99.17
100	99.70
500	100.00

Table shows the dependence of the measured susceptibility on the thickness of the layer. The table also helps to find out the effect of thickness of the additional air gap.

Example: Suppose the rock with thickness 20mm and air gap between SM-30 and the rock layer 2mm. The reduction of the reading is:

$$89.27\% - 23.02\% = 66.25\%$$

The display shows 66.25% of the susceptibility value of the layer with infinite thickness.

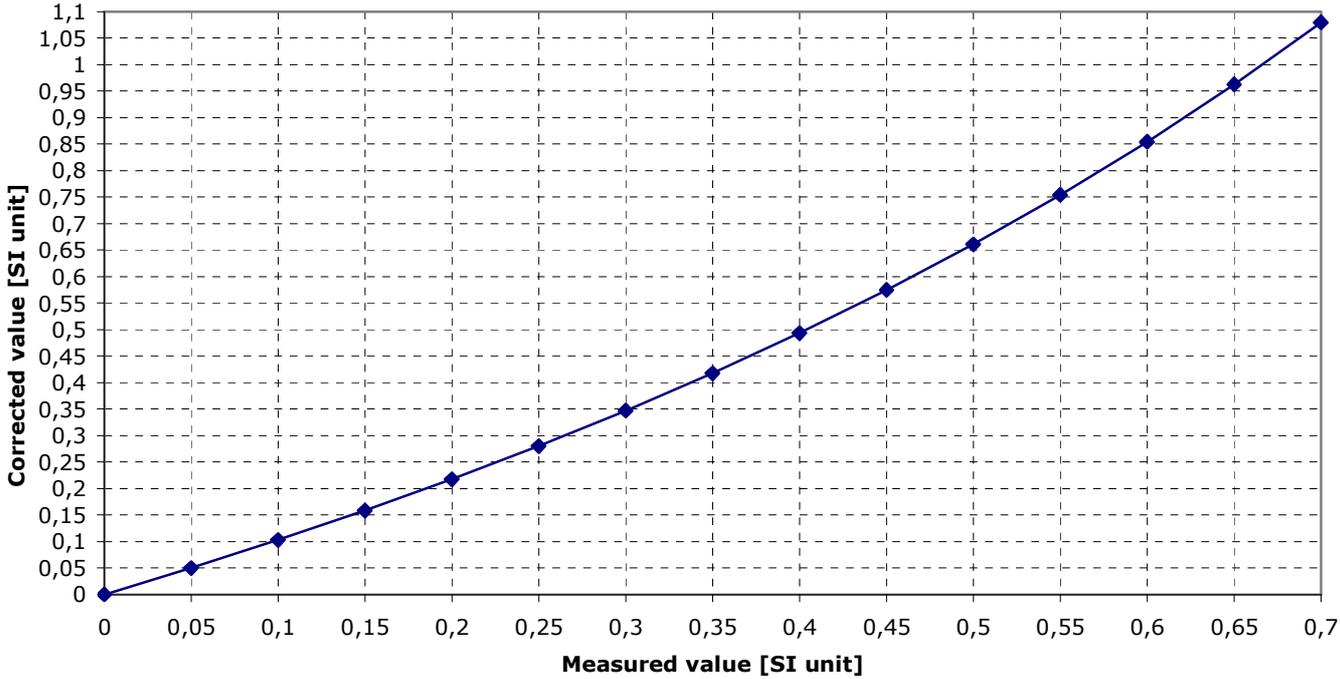
#### 5.4 Conductivity effect

The conductivity looks like negative susceptibility. The table show apparent susceptibility for several values of conductivity. The measured layer is supposed to have zero susceptibility and infinity thickness.

Conductivity [S/m]	Apparent susceptibility [SI units]
0.000	0

0.001	0
0.010	0
0.100	0
1.000	0
10.00	$-0.0029 \times 10^{-3}$
100.0	$-0.0917 \times 10^{-3}$

# 5.5 The demagnetisation factor correction



The demagnetization causes nonlinearity when the rocks with high susceptibility is measured. For keeping the error in acceptable bounds, the values greater than  $50 \times 10^{-3}$  SI units are corrected. The correction function is shown on the above graph. The function is piecewise linear with 14 stages.

## 5.6 Drill Core correction factor

The SM-30 instrument can be used for measuring susceptibility of drill cores. The measured value must be multiplied by the correction factor, CF. The correction factor depends on:

- Drill Core diameter, D [mm]
- Drill Core length, L [mm]
- Drill Core susc. measured by the instrument, Measured Value [SI units]  
note: The correction factor is dependent on the measured susceptibility because of the demagnetization effect.

$$\text{Corrected\_Value} = \text{Measured\_Value} * \text{CF} \text{ [SI Units]}$$

Following tables show correction factor (CF) for drill cores with diameters:

- D = 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 and 100 [mm]  
and with length:
- L = 400, 300, 200, 100, 80 and 60 [mm]

The rows 1..3 (0.001, 0.01, 0.1 [SI]) show that the dependency of the correction factor on the demagnetization effect is not significant. It means that the choice of the correct row is not critical.

Core Diameter 30 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	2,54490	2,54496	2,54540	2,56542	2,60918	2,77343
0,01	2,54729	2,54736	2,54301	2,56767	2,61118	2,77191
0,1	2,57073	2,57078	2,57121	2,58960	2,63062	2,78966
1	2,76225	2,76229	2,76241	2,76386	2,78111	2,90093

Core Diameter 35 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	2,26273	2,26279	2,26326	2,28313	2,32420	2,47241
0,01	2,26472	2,26478	2,26525	2,28497	2,32582	2,47365
0,1	2,28413	2,28418	2,28463	2,30284	2,34152	2,48563
1	2,43985	2,43988	2,43991	2,44163	2,46059	2,57557

Core Diameter 40 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	2,06436	2,06443	2,06494	2,08481	2,12394	2,26061
0,01	2,06606	2,06613	2,06393	2,08636	2,12530	2,26165
0,1	2,08257	2,08264	2,06562	2,10133	2,13838	2,27174
1	2,21304	2,21306	2,21193	2,21547	2,23602	2,34731

Core Diameter 45 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,91866	1,91873	1,91927	1,93924	1,97689	2,10503
0,01	1,92013	1,92021	1,92074	1,94056	1,97806	2,10593
0,1	1,93447	1,93454	1,93503	1,95338	1,98922	2,11462
1	2,04627	2,04628	2,04615	2,04963	2,07156	2,18001

Core Diameter 50 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,80740	1,80748	1,80806	1,82814	1,86462	1,98599
0,01	1,80870	1,80878	1,80676	1,82930	1,86563	1,98678
0,1	1,82136	1,82144	1,82196	1,84048	1,85396	1,99442
1	1,91899	1,91898	1,91880	1,92341	1,94646	2,05230

Core Diameter 55 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,72033	1,72042	1,72103	1,74126	1,77674	1,89278
0,01	1,72149	1,72158	1,72219	1,74228	1,77763	1,89348
0,1	1,73279	1,73287	1,73343	1,75215	1,78619	1,90027
1	1,81907	1,81905	1,81882	1,82461	1,84857	1,95226

Core Diameter 60 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,64998	1,65008	1,65074	1,67108	1,74057	1,81743
0,01	1,65103	1,65113	1,65178	1,67199	1,70651	1,81805
0,1	1,66135	1,66131	1,66190	1,68080	1,71415	1,82416
1	1,73836	1,73832	1,73806	1,74500	1,76963	1,87142

Core Diameter 65 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,59255	1,59265	1,59335	1,61380	1,64771	1,75571
0,01	1,59351	1,59361	1,59431	1,61463	1,64842	1,75628
0,1	1,60278	1,60287	1,60350	1,62258	1,65532	1,76183
1	1,67247	1,67243	1,67215	1,68018	1,70537	1,80535

Core Diameter 70 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,54423	1,54434	1,54508	1,56561	1,59887	1,70381
0,01	1,54511	1,54522	1,54596	1,56637	1,59952	1,70433
0,1	1,55360	1,55369	1,55435	1,57359	1,60578	1,70939
1	1,61697	1,61691	1,61663	1,62566	1,65123	1,74962

Core Diameter 75 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,50347	1,50359	1,50437	1,52498	1,55765	1,65976
0,01	1,50266	1,50278	1,50357	1,52429	1,55705	1,65929
0,1	1,49488	1,49501	1,49589	1,51771	1,55133	1,65465
1	1,43958	1,43987	1,44163	1,47205	1,51104	1,61817

Core Diameter 80 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,46830	1,46843	1,46926	1,48991	1,52207	1,62186
0,01	1,46755	1,46768	1,46852	1,48928	1,52152	1,62143
0,1	1,46035	1,46049	1,46142	1,48322	1,51626	1,61715
1	1,40930	1,40962	1,41144	1,44122	1,47905	1,58299

Core Diameter 85 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,43787	1,43800	1,43887	1,45956	1,49124	1,58882
0,01	1,43717	1,43731	1,43818	1,45897	1,49074	1,58842
0,1	1,43047	1,43062	1,43158	1,45336	1,48587	1,58446
1	1,38310	1,38344	1,38531	1,41449	1,45130	1,55234

Core Diameter 90 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,41141	1,41156	1,41246	1,43318	1,46441	1,56038
0,01	1,41076	1,41091	1,41182	1,43263	1,46394	1,56000
0,1	1,40449	1,40466	1,40566	1,42741	1,45942	1,55632
1	1,36032	1,36067	1,36259	1,39122	1,42709	1,52591

Core Diameter 95 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,38774	1,38790	1,38883	1,40957	1,44043	1,53461
0,01	1,38713	1,38728	1,38823	1,40906	1,44000	1,53426
0,1	1,38126	1,38143	1,38247	1,40418	1,43578	1,53084
1	1,33995	1,34033	1,34228	1,37040	1,40549	1,50205

Core Diameter 100 mm						
Kappa [SI]	Core Length [mm]					
	400	300	200	100	80	60
0,001	1,36691	1,36707	1,36804	1,38878	1,41928	1,51194
0,01	1,36634	1,36650	1,36748	1,38830	1,41887	1,51162
0,1	1,36081	1,36099	1,36207	1,38373	1,41493	1,50841
1	1,32202	1,32242	1,32439	1,35202	1,38642	1,48106

Position of the drill core when measured by SM-30 instrument.

