Installation and User Manual
POLARMOIST WCM411

Polarmatic

Contents:

1. Introduction

This document is the installation and user manual of Water Content Monitor WCM411 moisture sensor. The sensor is designed to measure moisture in coarse and fine materials on belt conveyors or flowing down out of silos. The sensor sends infrared light and measures the amount of retro-reflected light. The measurement is based on absorption of infrared light while passing through a thin water layer on the surface of the material being measured. The sensor is of solid state design and does not have moving nor wearing parts.

The sensor has been pre-calibrated in the factory for granite based stone aggregate with particle size distribution of about 0-8 mm. The sensor will be calibrated in the working environment by taking first one sample and adjusting the reading. When there will be calibration data over a broader range of moisture, the calibration can be redone taking into account scaling of the response. Windows PC based VipuNet user interface supports calibration by book keeping all the reference measurements and by setting the calibration parameters of the sensor.

VipuNet program collects the data messages from the sensor and stores them on the computer with date and time. The program shows also the numeric moisture reading and graphs it as a function of time on the screen. In addition to supporting the sensor calibration the program can be used for upgrading the sensor firmware or setting up all the parameters of the sensor.

2. Mechanical Installation

The sensor is typically installed over a belt conveyor at a distance of about 0.70 – 0.90 meters from the aggregate when measured from the top of the sensor. The sensor is normally delivered with a protection tube, which can be equipped with a connector of pressurized air to arrange a counter flow to prevent contamination of the sensor window. An optional heater is also available to prevent condensation of moisture on the sensor window.

The protection tube is about 500 mm long and the lower end is of 100 mm in diameter. The sensor is located in the upper end of the tube. The tube can be fixed with M8 mm bolts to other fixed structures like L bars. Fig. 1 shows an example of installation over a silo belt feeder and Fig. 2 under a silo sector hedge door.

Fig. 1.   WCM411 moisture sensor installed over a silo belt feeder to measure dropping aggregate. The sensor is located in the black plastic hat at the upper end of the protection tube.

Fig. 2.   Moisture sensor installed under a silo hedge door. This sensor is equipped with a heater element.

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The measuring beam is formally about 10 cm at a distance of 1 m. The sensor must see only the material to be measured and no other targets under its beam. One can check the location of the measurement spot by moving hand or white paper while following the signal output. The measurement result is most reliable when taken from a moving sample, because a standing aggregate may be optically inhomogeneous causing unwanted offset of reading.

The visor of the protection tube should be turned against possible flow of dust or stones released by operation of pneumatic valves. When using heated moist aggregates, the visor should be turned down to prevent moisture getting collected in the tube while the moisture is flowing upwards. In that case the possible pneumatic shocks should be prevented with additional shields.

Rotation of the sensor around its axis should be as in Fig. 3. The yellow line passing through the transmitters is then parallel to the surface of the sample. Movement of the sample is preferentially to the same direction or vertical to the line passing through the transmitters.
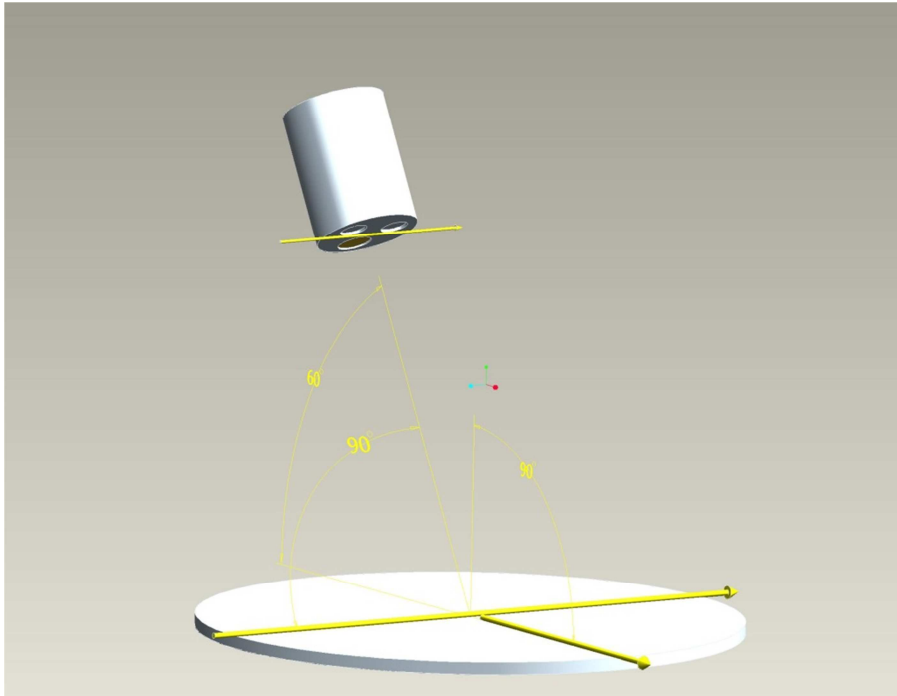

Fig. 3.   The sensor angle of rotation should be adjusted to make the yellow line through the transmitters parallel to the sample surface. The tilting angle (60° in the figure) can be much more vertical, but nevertheless less than 90°.

3. Electrical Connections

The sensor is delivered with a 10 m sensor cable (WCMCABLE) and a power supply unit (POWER 12V). The sensor cable can be extended according to Fig. 4. The connections can be done with standard junction boxes with screw connections. In Fig. 5 there is a photograph of a junction box, which can be ordered separately and which contains quick connections for sensor cable leads and twisted pair cable leads of type Jamak 2*(2+1)*0.5 mm². In Fig. 6 there are the corresponding junctions at the other end of the extension cable. Observe that the extension cables in Figs. 5 and 6 are different.
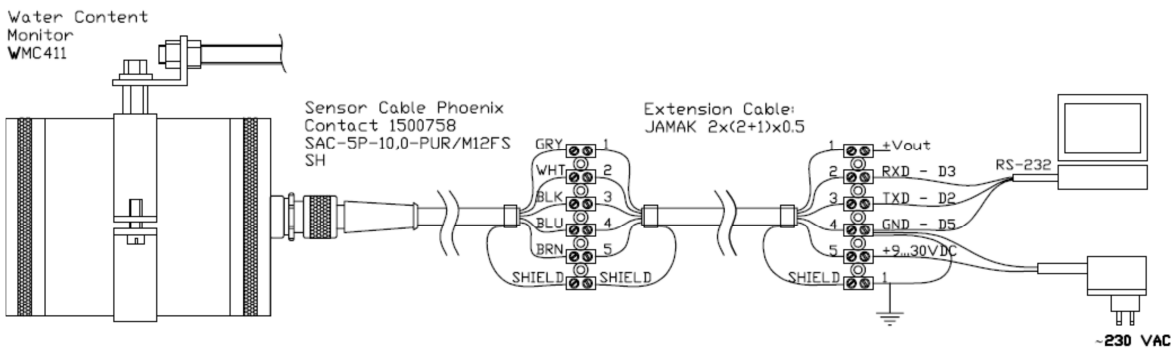

Fig. 4.   Sensor cabling to a PC and connection of power supply. If an extension cable is needed, install the connection box in the silo within 10 meters from the sensor location and in the control room a few meters from the PC.
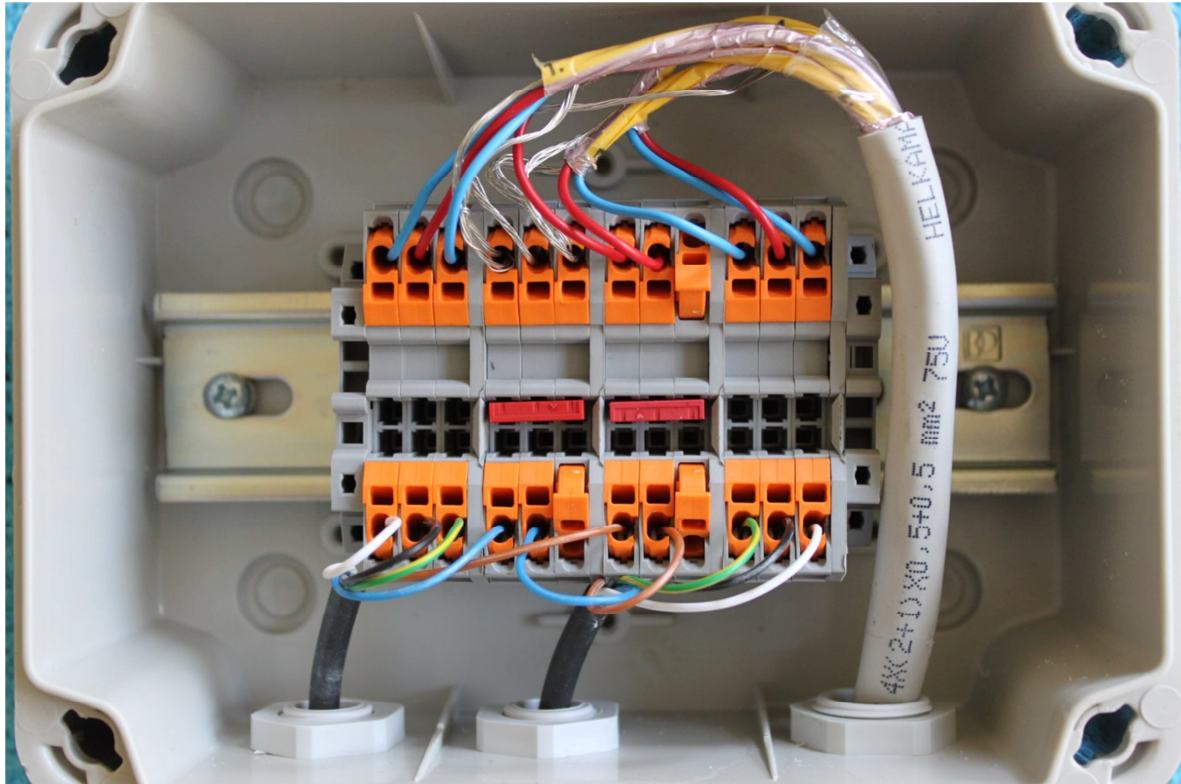
Fig. 5.   Junction box in the silo room for two sensors using a connection cable type Jamak 4x(2+1) x 0.5 mm². Connect the sensor cable leads in the following order by color: white, black, grey (or yellow-green), blue and brown according to the photo and as a mirror image for the second sensor for other items than operating voltage and ground. Note the red potential equalizers for operating voltage (brown) and grounds (blue) in the middle.
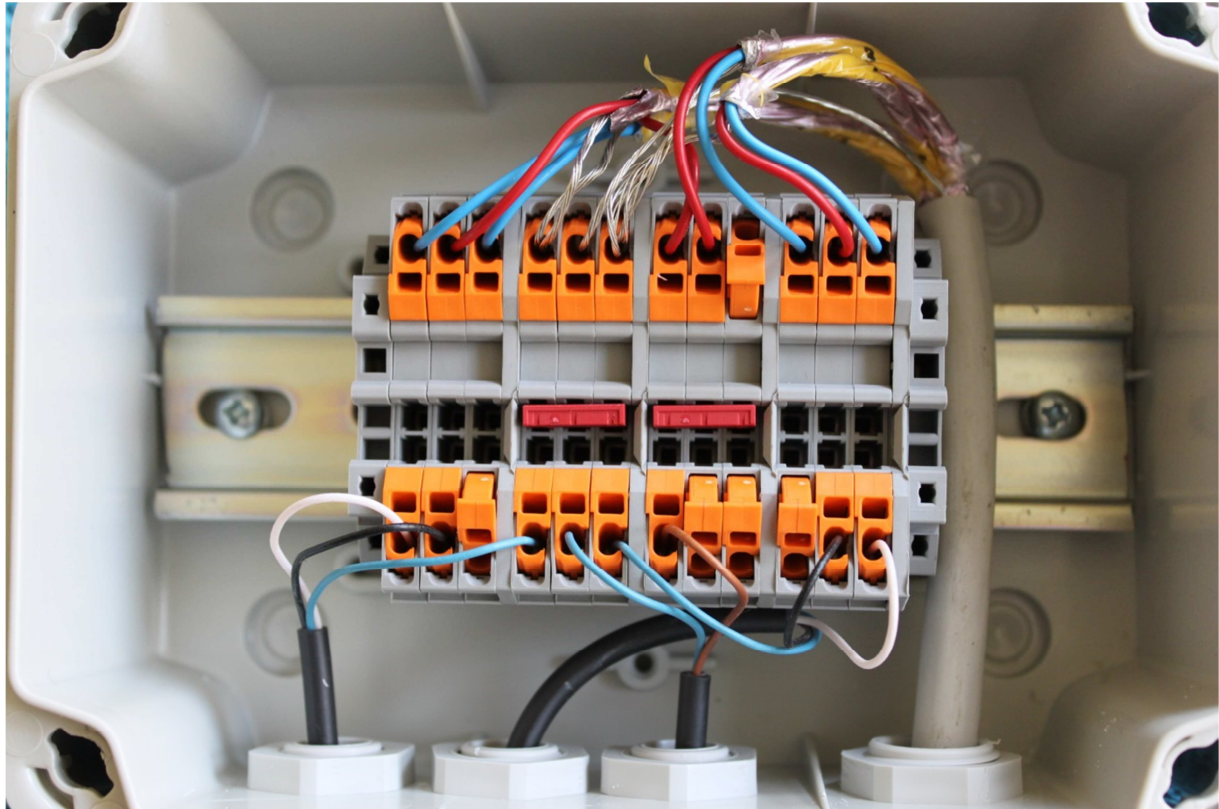
Fig. 6.   Connection box in the control room. Follow the same order of colors as in the silo room. Down on the left first the serial interface cable of sensor 1, second the serial cable of sensor 2 and third the operating voltage supply. Observe the red potential equalizers for the ground lead (blue) and the power supply lead (brown).

Current loop output of 4…20 mA is available from the +Vout (GRY, grey or yellow-green) lead of Fig. 4 according to a connection in Fig. 7. The inputs of the current meter must be isolated from the sensor potential so that all current supplied to the input is fully returned to the sensor. Observe also that the current loop output is supplied from the power supply voltage (+V = 9 – 30 VDC BRN, brown lead) of the sensor and the current is returned by the grey (GRY) lead to the sensor.

WCM411   +V   **Voltage meter**

BRN

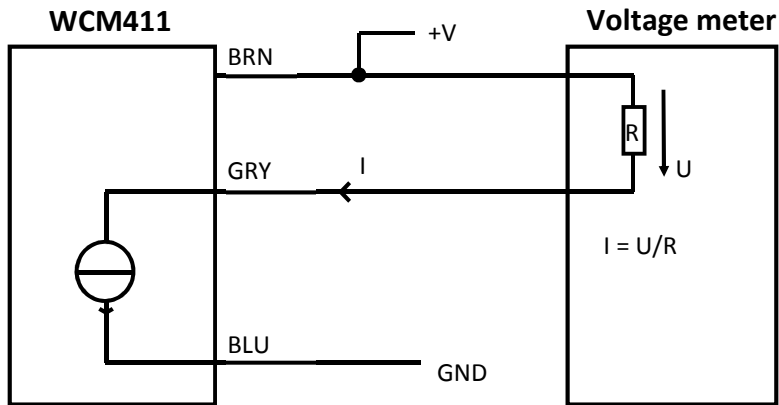GRY   I

R   U

I = U/R

BLU

GND

Fig. 7.   Current loop connections for 4…20 mA output. Use an isolated input current meter to guarantee that all current taken from the power supply voltage is returned to the sensor. The sensor adjusts the current loop output 4…20 mA to correspond to 0…16 % of moisture so that subtracting number 4 from the measured mA reading produces the moisture reading.

4. Checking the Performance

Connect the sensor according to the figure 4 to a free RS232 serial port of your PC. If there are no free serial ports, use a USB port and an RS232/USB converter like ATEN UC-232A. Start a terminal program or the VipuNet program supplied with the sensor. Set the port to 38400 bits/s, 8N1 and handshaking to NONE. Connect the power supply (230 VAC). The sensor should send the following output to the terminal program:

```
WCM411 V 2.10T 2009-08-12
```

If there is no output, check the connections of power supply and the sensor cabling as well as the settings of the terminal program. If there is output with funny characters, the bit rate is likely different in the terminal program and the sensor.

After the first line the sensor outputs a line of an ASCII message at a speed of about one line per second depending of the settings. The line consists of three of more numbers separated by commas like below:

```
32.68, 36.19, 2.27, 35.3, 732.1, 294.2, 0.0, 266.2, 0.0
```

The first two numbers are the signals and the third number corresponds to the current measured moisture. The sensor has been calibrated in the factory to output moisture of a concrete aggregate with particle distribution of about 0 - 8 mm. The output must be calibrated to the local sample material and measuring conditions. For details look at section 7. Calibration.

5. Command Mode, Commands and Parameters

In normal use the sensor parameters are set with the help of VipuNet program. In this chapter we show, how the parameters can be set in a so-called Command Mode with any terminal program. When the connection to the sensor with a terminal program has been opened, start by pressing "Esc" key on the keyboard, then write the commands shown in italics below and finally press "Enter":

"Esc"	Press "Esc"-button
open	Write "open" and press "Enter"
>conf	Write "conf" and press "Enter"

```
 1 coef_A       1.000
 2 coef_B       0.000
… …
… …

22 Signal Max 1000.00
23 Noise Min    0.000
>close
```

"Close" command closes the command Mode. It will also be closed automatically in 10 seconds when there is no input from the keyboard.

```
CLOSED


WCM411 V 2.10T 2009-08-12

32.68, 36.19, 2.27, 35.3, 732.1, 294.2, 0.0, 266.2, 0.0
```

To change any parameter, go first to the command mode and then write CONF, the parameter order number and a new value of the same parameter as below:

>*conf 1   0.90*

The sensor will respond to this by writing the whole parameter list with the new value for the changed parameter. Observe that period is used as the decimal separator.

A listing of all the parameters with a short explanation is:

```
>conf                              ' Write "conf" and presse "Enter"
 1 coef_A        1.000             ' Scaling factor of the second signal, preset in the factory.
 2 coef_B        0.000             ' Offset of the second signal, normally set to 0.0, will be set in the
                                     factory
 3 filter_len    3.000             ' determines the sensor response time
 4 coef_S0       0.000             ' Offset of moisture, look at Calibration
 5 coef_S1       0.000             ' not in use
 6 coef_S2     100.000             ' Scaling of moisture, look at Calibration
 7 coef_D        0.000             ' not in use
 8 coef_S1DAC 161.770              ' 4…20 mA current loop scaling, calibrated in the factory to
                                     correspond to 0…16 %
 9 coef_S0DAC 637.200              ' 4…20 mA current loop offset, calibrated in the factory to
                                     correspond to 0…16 %
10 samp count  55.000             ' number of measurements in one pulse
11 data count 360.000             ' number of pulses per one line of output. With this setting the
                                     sensor will output about one line per second and the result
                                     corresponds to the median of the  number of measurements as
                                     specified in filter_len.
12 offset_L1    0.000             ' offset of the first signal, set to zero.
13 I laser    1000.00             ' not in use
14 dirt sc      0.500             ' compensation parameter, set to 0.500.
15 V1 clean   790.865             ' LED1 reference value
16 V2 clean   592.047             ' LED2 reference value
17 T  clean    30.750             ' reference temperature
18 TS SC1       0.830             ' scaling of surface temperature
19 TS SC0       0.000             ' offset of surface temperature
20 Median Len   3.000             ' median length
21 Signal Min   0.000             ' Min signal 1: measurement is active, if the signal 1 is larger than
                                     is value
22 Signal Max 1000.00             ' Max signal 1: measurement is active, if the signal 1 is smaller
                                     than is value
23 Noise Min    0.000             ' Noise limit: measurement is active, if the noise level shown by he
                                     meter window on the right side is larger than this number.
```

List of commands:

OPEN	Changes to the command mode, responses the prompt ">".
CLEAN	Shows the reference level of back reflection
CLEAN ON	Saves the reference level of back reflection
CONF	Lists the parameters, look above.
CONF n xxx.xx	Parameter "n" is given a new value xxx.xx, use **period** as a decimal separator.
BAUD n	Shows or sets the serial port bit rate:
	$\qquad$ n=0, 115200 bits/s
	$\qquad$ n=1, 38400 bits/s
	$\qquad$ n=2, 9600 bits/s
OUT n	Sets or shows the output mode:
	$\qquad$ n=0, short message format
	$\qquad$ n=1, long message format
MODE	Measurement principle, default 0.
LOAD	Changes to downloading a new firmware.
CLOSE	Closes the command mode. Closes automatically, if there is no keyboard input for 10 seconds, use space bar for additional time.
VER	Shows the version of the firmware.

6. VipuNet Program Installation and Use

VipuNet is used for following the measured moisture numerically and graphically, for saving the collected data with date and time to a file in C:\VipuNet\data, for book keeping of calibration and reference values and for setting automatically the parameters according to the calibration result. The program runs in Windows PC's and has been developed by Microsoft Visual.net tools.

To install VipuNet follow these instructions:
- if the program is delivered in VipuNet.zp format, change the name to VipuNet.zip.
- unzip the Vipunet.zip to the directory C:/VipuNet.
- start the installation by clicking Setup.exe
- the setup may need .NET Framework support files from Microsoft. If you do not have an internet connection, these files can be installed with a separate installer program.
- VipuNet starts at the end of the installation and asks for setting the serial port in the Settings. Press OK button and then Settings, look at Fig. 8. Give a name to the material, when it is asked for.
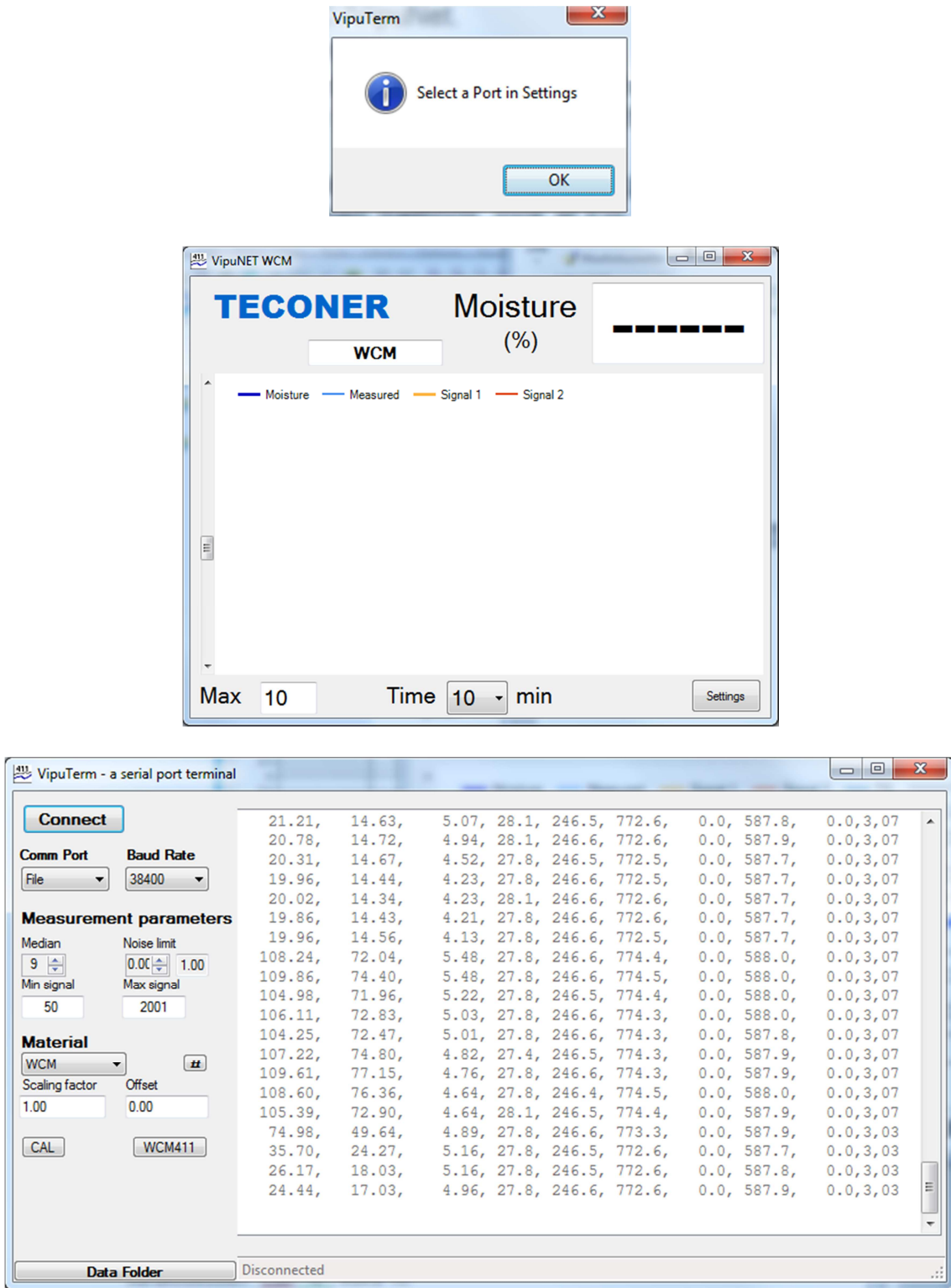
Fig. 8. The main views of the VipuNet program. In the setting window of VipuTerm one can see a list of the last output lines from the sensor. The first two numbers are the signals and the third is the moisture reading. In this case only the lines with Signal 1 (first value) larger than 50 affect the result

VipuNet settings:

- Connect/Disconnect –button starts / stops collecting data
- Comm Port
  - a list of available com ports. In Fig. 8 there is one port COM3 and File available for a data input. The latter can be used to reanalyze previously collected data.
  - if you do not know, which port your is connected, you can search it out by Windows Control Panel -> Manage Devices -> Ports or by trial and error.
- Baud Rate
  - default speed is 38400 bit/s. If this does not work, try other rates by BAUD command.
- Median
  - the number (9) in the window shows the number of measurements used for outputting the median of these measurements as a result.
  - if the output rate is 2 messages per second and the material flows 4 seconds under the sensor, then an optimal median is 8. If the median is larger than this value, the result will be affected by previous sample. A smaller median gives weight to the end of the sampling.
- Noise limit
  - this setting adjusts the measurement over a belt to the time when the belt is moving and causing some noise of the data. If the Noise limit is 0.00, measurement is on all the time (assuming Min and Max Signal settings do not prevent measurement). By adjusting the Noise limit to a suitable number, the measurement can be synchronized with the moving sample.
  - the window on the right shows the current level of noise.
- Min signal (50)
  - If Signal 1, the first number of the message line, is larger than Min signal, measurement is active. Min signal can be set to stop measurement with small signals. This is useful with silo sector hedges, since without a material flow the signals are typically very small and there is no reason to measure. When the flow start Signal 1 grows, and when it is bigger than the Min signal, the measurement is initiated
  - Observe that all the message lines are output on the terminal window, although only those values, which are collected during an active measurement time, affect the result and are recorded to the data file.
- Max signal
  - sets the upper limit of signal 1 for an active measurement state. Usually not in use, and the max value 2001 is kept.
- Material
  - the name of the material currently in use given during the first start-up. It is possible to edit the names of materials by editing the VipuNet.ini file.
  - if you select New from the list, you can create a new material with its own Scaling factor and Offset. Observe that these settings have a meaning only in the VipuNet display windows, but they do not change the internal calibration values of the sensor.
- #
  - this button can be used to remove a material from the list.
- Scaling factor
  - scales the moisture readings obtained from the sensor. Default value 1.00 means no change of the reading in the VipuNet display.

- Offset
  - this value is added to the VipuNet moisture reading. Default value 0.00 means no change of the reading in the VipuNet display.
- CAL
  - this button opens up a Calibration window, look at the *Calibration*.
- WCM411
  - this button starts a firmware upgrade process.
- Data folder
  - when selecting File in the Comm Port window, Data Folder shows the location of the selected file.

7. Calibration

The sensor output is linear with practical moisture levels of typical aggregates. Thus an accurate calibration can be done by determining a Scaling factor (parameter **6 coef_S1**) and Offset (parameter **4 coef_S0**) for each material. Although the sensor is pre-calibrated in the factory, it is necessary to calibrate the sensor after installation to correspond to the right material and measuring environment.

If the sensor is used only for measuring moisture in one material, the calibration values should be stored in the sensor parameters permanently. In cases when the sensor is used for measuring many different materials, then the sensor parameters should be stored to correspond to the mostly used material. In this case the parameters of the other materials can be set in the VipuNet Scaling factor and Offset for the given material.

The CAL button of the Settings window can be used to keep book of sampling and reference values as well as automatic storing of the calibration result in the sensor parameter list. For calibration it is recommended to take samples over a wide range of moisture to guarantee a representative result. For concrete aggregates a suitable low moisture reading should be in the range 2-3 % and a corresponding high reading in 4-5 % so that the low and high reading differ about 2 % at least. If these samples are not available for the time of first calibration, do not worry, since the calibration can be continued or redone whenever possible.

Press Sample button to take a sample and give a name to it. If you are using the sensor in a continuous measurement mode, i.e. the measurement is active all the time, pressing the sample button must be synchronized with the sample taking. If you are using Min and Max signal or Noise limit settings to activate the measurement, it is enough to press the Sample button prior to the next activation of measurement.
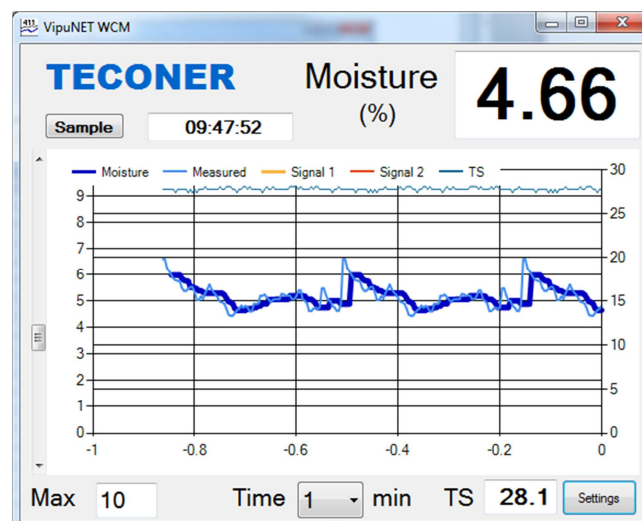

Fig. 9.   When taking a sample, press the button Sample. The program synchronizes the sample to the last active measurement result.

The right moisture content of the samples can be determined by weighing the sample as wet m(wet) and after drying it in oven m(dry). The moisture reading can be calculated as

$$moisture = 100 * [\ m(wet) - m(dry)\ ] / m(dry) \qquad (\%)$$

This number should be filled in the CAL window of Fig. 10 in the "Lab. %" -column on the corresponding row.
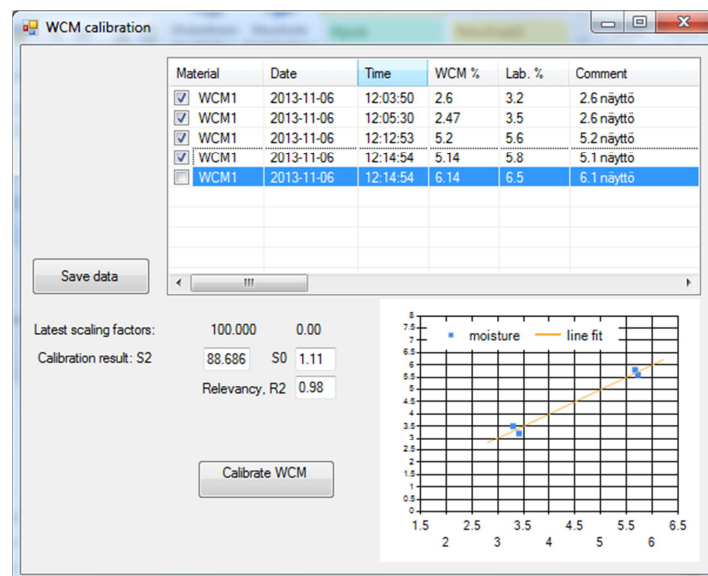

Fig. 10.   VipuNet CAL window. The graph shows the best fitting to the calibration data. If the points do not deviate from the line too much, the Relevancy, R2 readings will be close to 1.00.

CAL window shows all collected samples of the given material. A given point can be removed from the calibration by unmarking it prior to pressing Save data. The line "Latest scaling factors" shows the current calibration parameters of the sensor as 100.00 and 0.00 in Fig. 10. The Calibration result shows new values of S2 or the parameter 6 with value 88.686 and S0 or the parameter 4 with value 1.11. If the relevancy number is printed with red color, then the reference points are too close to each other for determining the scaling factor. In this case the calibration can still be done by setting only the offset and the scaling factor remains unchanged.

When there is a satisfactory amount of calibration data, the sensor calibration parameters can be set by pressing "Calibrate WCM". After a while the CAL window shows the new stored calibration values and the calibration is done. Nevertheless, the calibration can be continued with these and new reference values whenever wanted. If the material changes or there is some other change, the old calibration points can be removed by renaming or deleting the file C:/VipuNet/Samples2014.txt.

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8. VipuNet Program Settings

VipuNet should be installed in the folder C:\VipuNet. Fig. 11 shows a typical view of the VipuNet folder.
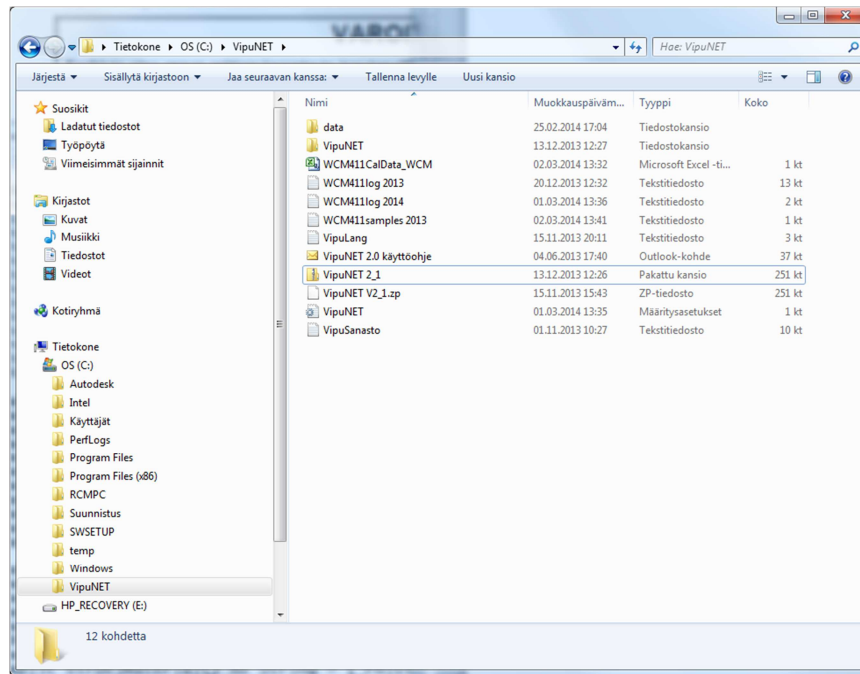

Fig. 11. The files of the VipuNet folder. Some of these files are created only after using the program.

Basic settings of the program are in the VipuNet.ini file. A typical content of the file with explanation is:

[Lang]	' Language settings
Lang=0	' Languages: Finnish (0), English (1), Swedish (2), German (3), Russian (4)
[Paths]	
LogPath=C:\VipuNET\data	' folder for data logging
[Settings]	
Median=9	' Median value
Low Signal=50	' Current value of Min signal
Noise limit=0.000	' Current value of Noise limit
[Materials]	
Material=1	' number of materials
Material 1=WCM; 1.00; 0.00	' name, Scaling factor and Offset of material 1.
[Port]	
Port=COM6	'Serial port 6 is in use
BaudRate=38400	'Bit rate is 38400 bit/s

The message lines are stored in a file named by the date, e.g. "WCM 2014-02-28.txt", the content of which is like:

```
2014-02-28, 09:32:21,  89.86,  59.63,  5.53, 27.8, 246.5, 774.5,  0.0, 588.2,  0.0,3,39
2014-02-28, 09:32:21,  91.00,  61.15,  5.53, 27.4, 246.5, 774.4,  0.0, 588.2,  0.0,3,39
2014-02-28, 09:32:22,  90.31,  61.86,  5.34, 27.8, 246.6, 774.5,  0.0, 588.3,  0.0,3,39
2014-02-28, 09:32:22,  89.96,  61.97,  5.04, 27.4, 246.6, 774.4,  0.0, 588.2,  0.0,3,39
2014-02-28, 09:32:22,  83.81,  56.89,  5.04, 27.8, 246.5, 774.3,  0.0, 588.2,  0.0,3,39
             … …
```

After date and time there are comma separated values S1, S2, … and so on, where the first four are signal 1, signal 2, moisture and sensor temperature (optionally sample surface temperature). The rest are internal sensor measurements for factory use.

The file WCMlog2014.txt contains a log of the user interaction as below:

```
VipuNET started at, 2014-02-28, 11:06:50PC MY COMPUTER
Material: WCM; 1.00 ; -5.00
2014-02-28, 11:07:58; New Offset: WCM; 1.00 ; 0.00
2014-03-01, 13:35:56; Material: WCM; 1.00 ; 0.00

VipuNET started at, 2014-03-01, 13:36:01PC MY COMPUTER
Material: WCM; 1.00 ; 0.00
```

The file WCM411samples2014.txt contains the sensor readings at the time of taking calibration samples and the reference values used for the calibration with the CAL window:

```
2013-11-06;12:03:50; WCM411; 100.000;0.000; WCM1; user;1.00;0.00; moisture; 2.69;2.69;2.69;2.69;2.69;2.6;2.6;2.45;2.45;2.45; comment; 2.6 näyttö
2013-11-06;12:05:30; WCM411; 100.000;0.000; WCM1; user;1.00;0.00; moisture; 2.5;2.5;2.53;2.52;2.51;2.51;2.3;2.45;2.45;2.45; comment; 2.6 näyttö
2013-11-06;12:12:53; WCM411; 100.000;0.000; WCM1; user;1.00;0.00; moisture; 5.27;5.27;5.27;5.29;5.29;5.29;5.09;5.09;5.09;5.09; comment; 5.2 näyttö
2013-11-06;12:14:54; WCM411; 100.000;0.000; WCM1; user;1.00;0.00; moisture; 5.21;5.21;5.21;5.21;5.12;5.12;5.07;5.07;5.07;5.07; comment; 5.1 näyttö
2013-11-06;12:14:54; WCM411; 100.000;0.000; WCM1; user;1.00;0.00; moisture; 6.21;6.21;6.21;6.21;6.12;6.12;6.07;6.07;6.07;6.07; comment; 6.1 näyttö
```

The above list corresponds to the CAL window in Fig. 10

The file VipuLang.txt contains the words used in the user interface with a short explanation to enable selection of words for translations to other languages. The used words are in the order Finnish (0), English (1), Swedish (2), German (3) and Russian (4).

If VipuNet program is used with more than one sensor connected to the same computer, then a new subfolder like C:\VipuNet\WCM2-silo2 must be created for each additional sensor, in which the name of the directory starts with the letters WCM. This folder contains the corresponding files as the main folder for the first sensor. The settings for each sensor can be adjusted in the subfolders.

9. Specifications

Sensor type:	WCM411
Power supply:	9 … 30 VDC
Power consumption:	less than 1 W without internal heating
Temperature range:	0 … 40 °C
Resolution:	0.1 %
Accuracy:	0.3 % by weight (short time, homogeneous sample)
	0.6 % by weight (long time, homogeneous sample)
Range:	1 … 10 % (aggregates)
	1 … 20 % (fine aggregates)
Response time:	0.2 … 10 s (tunable)
Noise level:	< 0.03 % with one second response time
Meas. distance:	0.6 … 0.8 m (default distance, tuned in factory)
Output:	RS-232 serial data (max. speed 115200 bit/s)
	4 … 20 mA per 0 … 16 % by weight (tunable)