

DESIGN BUREAU "FIZELEKTRONPRIBOR"

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Moisture Analyzer (Moisture Meter) FIZEPR-SW100

Technical specification and operation manual
VIGT.415210.100 RE

Part 2. Setup manual and Software description
(rev. 1.05)

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TABLE OF CONTENTS

1. Introduction	3
2. SWPro program for FIZEPR-SW100 moisture meter operation	3
2.1. SOFTWARE IDENTIFICATION	4
2.2. MOISTURE METER CONFIGURATION FILES	4
2.3. MOISTURE METER REMOTE DIAGNOSTICS	5
3. Setting connection parameters	5
3.1. DESCRIPTION OF MOISTURE METER CONNECTION PARAMETERS	5
3.2. MODIFYING MOISTURE METER CONNECTION PARAMETERS	6
4. FIZEPR-SW100 moisture meter measurement algorithm	6
4.1. MAIN PARAMETER MEASURED BY MOISTURE METER, MOISTURE METER OPERATION CONTROL	7
4.2. RESONANT FREQUENCY DETECTION ALGORITHMS	7
4.3. MEASUREMENT RESULTS AVERAGING	10
4.4. "OUT-OF-ORDER" MEASUREMENT FILTERING	11
4.5. APPROXIMATE ESTIMATION OF MEASURED PARAMETERS AND OPERATIONAL CORRECTNESS	11
4.6. AUXILIARY DIAGNOSTIC INFORMATION	12
5. Moisture meter calibration	12
6. Calibration tables	13
6.1. CALIBRATION MANAGEMENT WINDOW	14
6.2. CALIBRATION TABLE MANAGEMENT PROCEDURE	15
6.2.1. <i>Saving tables from file to the moisture meter</i>	15
6.2.2. <i>Saving calibration from the moisture meter to file</i>	15
6.2.3. <i>Editing an existing table</i>	15
6.2.4. <i>Creating a calibration table</i>	16
6.2.5. <i>Calibration table format</i>	16
6.3. CALIBRATION BY SOLIDS	17
7. Current output settings	18
8. Measurement results auto save option	19
8.1. SPECTRUM AUTO SAVE	19
8.2. MEASUREMENT RESULT AUTO RECORDING	19
9. SW100 program for FIZEPR-SW100 moisture meter operation	21
9.1. SOFTWARE IDENTIFICATION	22
9.2. ESTABLISHING CONNECTION WITH THE MOISTURE METER	22
9.3. "MEASUREMENT RESULT" TAB	22
9.4. CURRENT OUTPUT SETUP	23
9.5. "AVERAGING" TAB	24
9.6. "METROLOGY" TAB	24
10. Appendix	26

1. Introduction

1.1. This technical specification and operation manual are intended to familiarize with SWPro and SW100 software (hereinafter – “the program”) of FIZEPR-SW100 moisture analyzers (moisture meters), and with the measurement principle and setup techniques for these moisture meter.

1.2. Software is designed for FIZEPR-SW100 moisture meter setup, operation diagnostic as well as for measurement results representation.

1.3. Software is installed on a personal computer (laptop) with OS Windows XP (or higher). “SWPro.exe” or “SW100.exe” and “Vlagomer.ini” files are required to work with the program. No program installation is required and it can be executed from any location path (folder) where files mentioned above are copied.

1.4. Connection between the PC and the moisture meter is implemented via RS-485 interface using RS232 serial port or USB. Connection via USB port can be done using standard USB - RS485 interface adapters, e.g. OWEN-AS4 by Owen, ACDR.426469.032 by NVP “Bolid”, etc.

1.5. This manual assumes using SWPro and SW100 Versions No. 2.9 (and higher) and moisture meter firmware Version No. 35 (and higher). The specified programs are not intended to be executed from CD. For correct operation programs require to be copied to the PC or flash drive.

2. SWPro program for FIZEPR-SW100 moisture meter operation

SWPro is designed for FIZEPR-SW100 moisture setup, operation diagnostic as well as for measurement result representation.

The main window of the program (see Fig. 1) can be divided into three parts. The upper part of the window consists of menus and shortcuts for moisture meter and software control. The mid-section represents a field for displaying signal (spectrum) charts. The bottom section displays connection parameters and measurement results received from the moisture meter as well as moisture meter main setup parameters.

The program can operate both with the moisture meter connected and without it. These modes are called “Receive” and “Analyze” correspondingly.

In “Receive” mode, the PC receives data from the moisture meter and displays them on the screen in real time. In this mode, moisture meter setting and operation modes also can be changed.

Data received from the moisture meter can be saved by pressing “Save” button on shortcut panel or from menu “File|Save...”.

In “Analyze” mode, no data are received from the moisture meter and no command can be transferred to the moisture meter. This mode allows only reviewing received data or data previously saved to file.

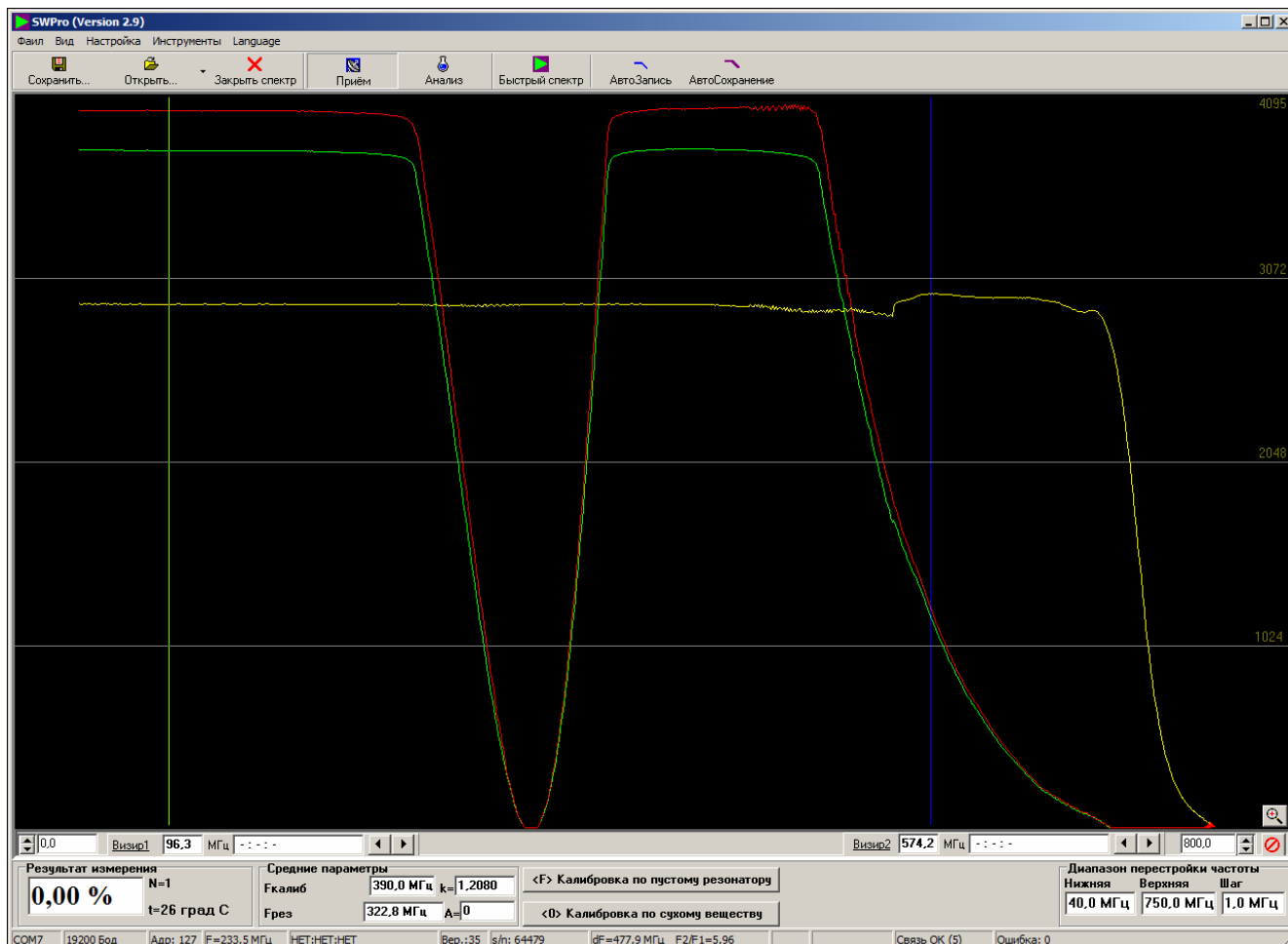


Fig. 1

Files saved earlier can be open by pressing “Open” button from the shortcut panel or using “File|Open...” menu command.

Switching between these two modes is possible using buttons on the shortcut panel with corresponding label names.

When opening a saved file in “Receive” mode, the program automatically switches to “Analyze” mode and data receiving stops.

2.1. Software identification

The program icon, SWPro name (program identifier), and software version number are displayed in the upper left corner in the main window of the program (see Fig. 1).

2.2. Moisture meter configuration files

As specified above, data received from the moisture meter are not only displayed via SWPro program interface, but can be saved to file.

Configuration is saved by selecting “File|Save...” menu item.

Saved configuration files have “.cfg” extension.

Saved data contains all moisture meter settings including current calibration table number as well as calibration table itself (refer to “Calibration tables” section).

In addition, a moisture change graph is saved as it currently displayed in “Moisture graph...”.

“... .cfg” configuration file contains comprehensive information regarding moisture meter operation and can be used for moisture meter diagnostics by the manufacturer or another trained user.

Configuration file can be used for remote moisture meter resetting or factory default reset. This requires file loading to the moisture meter by means of “Setup|Load configuration file to moisture meter...” command.

It is necessary to distinguish between “File|Open...” and “Setup|Load configuration file to moisture meter...” commands.

The first command serves for *viewing* moisture meter saved parameters, as well as spectrum and moisture graphs. For this program switches to “Analyze” mode automatically.

The first command serves for moisture meter *resetting* in accordance with parameters contained in configuration file. Configuration loading to the moisture meter is possible in “Receive” mode only and when communication with the moisture meter is established.

2.3. Moisture meter remote diagnostics

As specified above, saved configuration files enable the user to evaluate moisture meter operability including in remote mode.

This is achieved by sending configuration files by mail or by any other way to the moisture meter manufacturer or authorized dealer.

For sending several configuration files (3-5 times) must be saved with a 1-2 minute interval. Several configuration files enable the user to evaluate how moisture meter condition changes over the time.

3. Setting connection parameters

3.1. Description of moisture meter connection parameters

Data receive from moisture meter and its setup can be done in “Receive” mode only when communication with the moisture meter is established successfully.

Connection parameters are set in setup window (Fig. 2) available from “Setup|Connection parameters...” menu item.

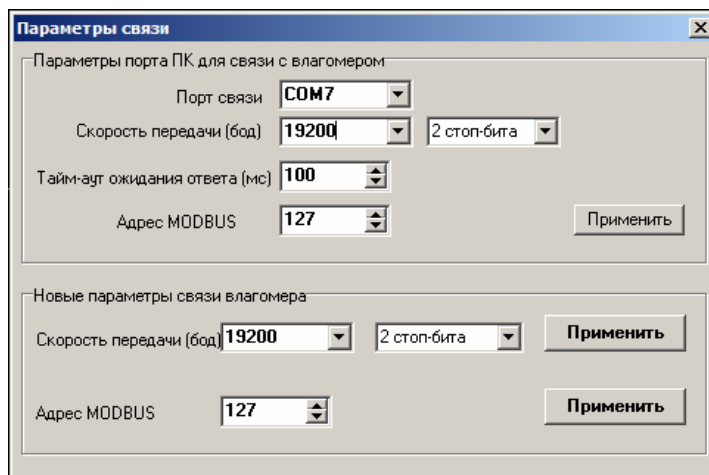


Fig. 2

All settings required to establish connection are located in the upper section of the tab:

- **Communication port** – moisture meter connection port. When using USB-RS485 interface adapters, the operating system (Windows) sets port number for each particular adapter. Windows Device Manager allows the user to obtain a port number and get access to adapter properties (if any). The port number for USB-RS485 interface adapters must be within 3 and 9 inclusively. If not, then the port number can be changed forcibly using Windows Device Manager.

- **Baud rate**, stop bit quantity and MODBUS address are set to values known for this moisture meter. For new moisture meters, default values (specified in the moisture meter certificate) are set.
- “Response timeout” field is used to specify time (in milliseconds) between requests sent to the moisture meter via MODBUS protocol. Optimal timeout for 19200 bauds rate is 100 milliseconds. Recommended timeout is set automatically upon new baud rate selection. However, if connection is unstable due to additional OS timeouts, timeout increase is allowed. Timeout increase over 50% is inappropriate and the root cause of unstable connection must be assumed different.

Once all required parameters are selected, press “Apply” button.

Current connection parameters, namely: selected COM port, baud rate and MODBUS address are displayed in the status line in the bottom of the main window of the program (fields 1, 2 and 3 left to right correspondingly). If the selected port does not exist or it is occupied by another program, then a message about port initialization disability will appear. Fields corresponding to the open port number and baud rate in this case remain blank.

If COM port is selected correctly and RS485 link is connected properly, as well as baud rate, stop bit quantity and MODBUS are defined as required, then “Connection OK” notification will appear in the second right window of status line. Otherwise “No connection” notification will appear.

3.2. Modifying moisture meter connection parameters

If it is necessary to change the moisture meter network address or baud rate, “New moisture meter connection parameters” window contains fields for setting these parameters. Once the parameter is modified, press “Set!” button.

If connection was lost when attempting to modify moisture meter parameters, it is necessary to restore previous values that were set before connection loss and re-establish connection.

Note 1. Moisture meter connection parameters can be modified only(!) when connection with the moisture meter is established.

Note 2. If connection with the moisture meter cannot be established or its settings are unknown, then it is necessary to reset its parameters, and then restore its default settings.

To initiate connection parameter reset and restoration of moisture meter factory settings, press and hold for 5 seconds “Reset” button located on the right side of the lower PCB electronic module under the upper PCB notch (indicated by an arrow in the figure in Appendix 1).

4. FIZEPR-SW100 moisture meter measurement algorithm

Electromagnetic wave deceleration factor in material k_{dec} is calculated by the formula:

$$K_{dec} = f_0 / f_M ,$$

where f_0 – empty sensor (sensor filled with air) resonant frequency;

f_M – sensor resonant frequency when it is filled with controlled material.

It should be noted that f_0 frequency is determined only once during sensor manufacturing (for bulk material moisture meters – after sensor installation on the equipment) and saved in moisture meter CPU. This operation is called “empty resonator calibration”.

Measurement process consists in measuring periodical resonant frequency f_M and calculating wave deceleration factor in material k_{dec} .

Material moisture W is determined based on measured k_{dec} value. Moisture W calculation is performed using calibration tables – tables of correspondence between coefficient k_{dec} , moisture and temperature.

Therefore, main function of the moisture meter is periodical searching for sensor resonant frequency f_M , temperature measurement and moisture value calculation based on these parameters.

4.1. Main parameter measured by the moisture meter, moisture meter operation control

As it was mentioned above, the moisture meter periodically measures resonant frequency and temperature. All other parameters are calculated based on them.

All main measured and calculated parameters are displayed in the bottom of the main window on “Average parameters” and “Measurement result” panels (Fig. 3):

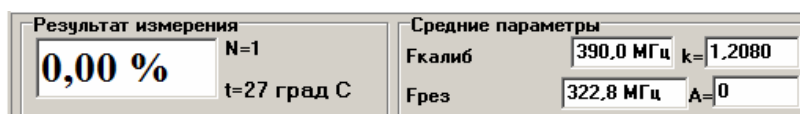


Fig. 3

Average parameters:

- F_{calib} – empty sensor resonant frequency (f_0);
- F_{res} – average resonant frequency currently measured by the moisture meter (f_M);
- k – electromagnetic wave deceleration factor in material ($k_{dec} = f_0 / f_M$);
- A – output signal level (voltage) at resonant point.

“Measurement result” window indicates moisture in percentage calculated based on calibration tables as well as temperature ($t = \dots$ Deg C) and current measurement averaging parameter ($N = \dots$).

4.2. Resonant frequency detection algorithms

Resonant frequency is detected by high-frequency generator tuning and sensor input voltage $U(f)$ measurement.

The result is a voltage $U(f)$ / frequency dependence (function) implemented in the moisture meter CPU as an array of paired values (U, f). In SWPro, this dependence is indicated by red curve in the graph (spectrum).

Generator frequency tuning is performed starting from minimum frequency F_{min} to maximum frequency F_{max} with F_S interval.

F_{min} , F_{max} and F_S frequency values are set in “Setup|Frequency tuning range” dialog box (Fig. 4).

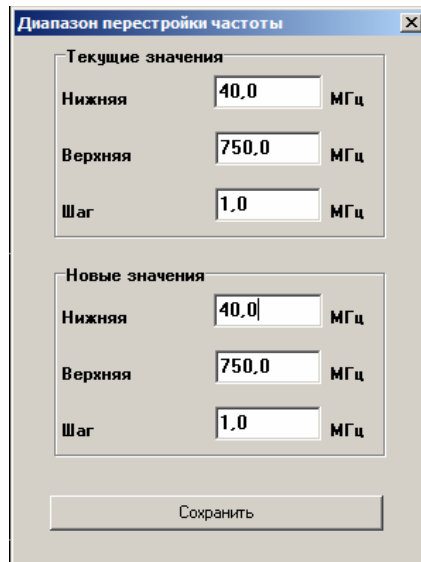


Fig. 4

By default $F_{\min}=40$ MHz, $F_{\max}=750$ MHz, frequency step $F_S=1$ MHz.

Enter new values in the bottom part of the window and then press “Save” button.

The moisture meter will generate frequencies in a specified range and with given frequency step.

At each step the moisture meter digitizes voltage levels at sensor input and generator output and calculates their ratio. SWPro allows visualizing these voltages in the form of voltage-frequency dependency graphs (signal frequency spectrum). Generator output voltage is drawn by a yellow curve and non-normalized voltage at sensor input is shown in green.

$U(f)$ voltage (red curve) indicates sensor input voltage normalized to generator output voltage.

There are several resonant frequency detection algorithms based on the mentioned above array (U, f).

Algorithm selection is performed in “Algorithm setup” dialog box, “Setup|Algorithm setup” menu (Fig. 5).

Algorithm 0

Resonant frequency is taken equal to frequency at which $U(f)$ voltage has a minimum value in the set $F_{\min} - F_{\max}$ tuning range.

Resonant frequency detection accuracy is equal to frequency step F_S .

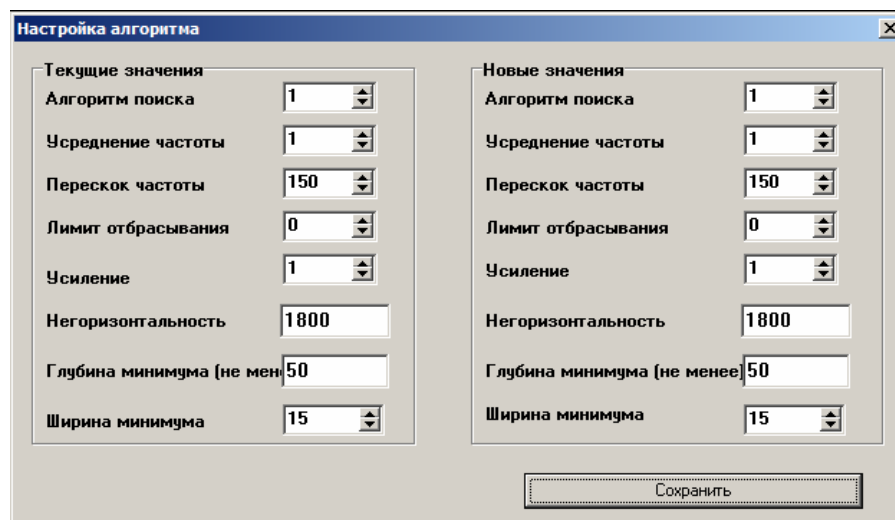


Fig. 5

Algorithm 1

Resonant frequency is taken equal to frequency at which the curve has a sufficiently deep signal minimum that meet the conditions specified in detection algorithm settings. If there are several minimums, then one with the lowest lower frequency will be selected out of all (the first left minimum).

The minimum is sought by analyzing $U(f)$ levels within the $df = f_2 - f_1$ frequency range (df is set in “Setup|Algorithm setup|Minimum width” menu). df value is expressed in F_s frequency step. This frequency detection range is formed consequently from each point of $U(f)$ graph to the right side.

The minimum considered found when the following three conditions are fulfilled simultaneously in the next analyzed $f_2 - f_1$ frequency range:

1) $U(f_1) \leq U(f_2)$. This condition indicates that analysis uses only that df range, for which the graph point corresponding to the right end is higher or equal to point corresponding to the left end (see Fig. 1).

2) $Dp > Dp_0$ where Dp_0 is set by “Minimum depth” parameter represented in ADC samples (refer to “Setup|Algorithm setup|Minimum depth” menu). “Minimum depth” determines the minimum “convexity” level.

3) $U(f_2) - U(f_1) < U_{\max}$ where U_{\max} is set by “Non-horizontality” parameter from “Setup|Algorithm setup|Non-horizontality” menu. This parameter allows to filter possible interference spikes on $U(f)$ graph having high front steepness.

If the conditions mentioned above are fulfilled, then fM resonant frequency is determined by the following formula: $fM = (f_1 + f_2)/2$.

Resonant frequency detection accuracy under this algorithm is 0.1 MHz.

If no minimum satisfying to these conditions is found, then frequency found according to Algorithm 0 (absolute minimum) with accuracy equal to F_s step will be taken as the minimum.

Algorithm 2

Frequency found according to Algorithm 0 is taken as resonant frequency, but if the absolute minimum is located on the lower frequency than it by more than “Frequency jumping” value (refer to Section 4.4), then frequency found according to Algorithm 1 will be taken as the minimum.

Algorithm 3

Absolute minimum frequency found in the frequency range that meets the same conditions as the Algorithm 1 range is taken as resonant frequency. In addition, its detection accuracy must be equal to the frequency step.

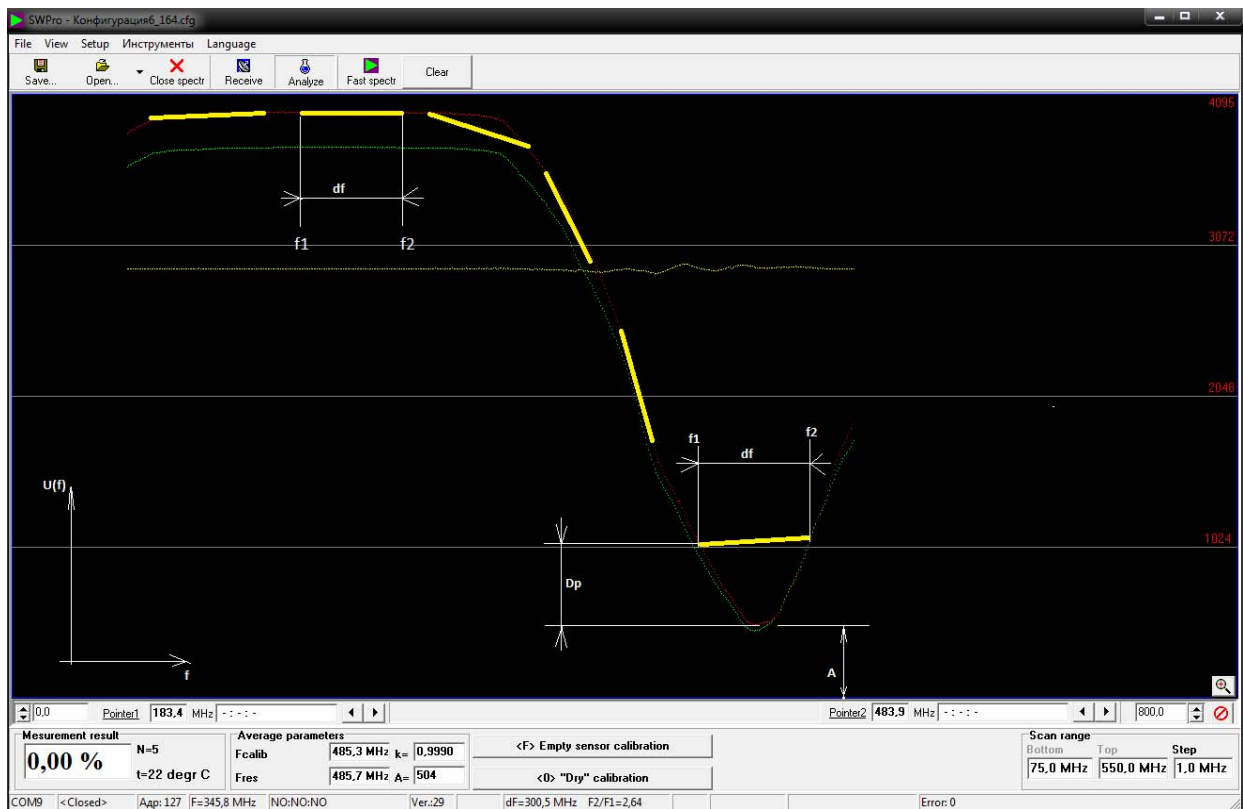


Fig. 6

Algorithm 4

Resonant frequency is taken as a cross point of chords drawn through cross points of the main section found according to Algorithm 1 and cross point of the section drawn between the main segment and absolute minimum point.

Algorithm 5

Resonant frequency is taken as frequency determined using the double bisection method, thus specifying the minimum found by the regular bisection method. That is frequency corresponding to the cross point of a line drawn through the bisecting point of sections mentioned in Algorithm 4 and a line drawn at the absolute minimum level.

4.3. Measurement results averaging

During real signal measurement, results are influenced not only by the measured value but also extrinsic disturbing factors: instrument electronic board noise and manufacturing process specifics. For the moisture meter, the following factors could exist:

- Fluctuations in measured material properties associated e.g. with gas bubbles or deposit spots in hydraulic flow
- Liquid banding, irregular water spread in the liquid volume.

As a result frequency measured by the moisture meter can vary from measurement to measurement leading to calculated moisture value fluctuation. The impact of these factors can be reduced using averaging.

Moisture calculations during frequency averaging use not the currently measured frequency value, but the average value based on recent N measurements.

N parameter – “Frequency averaging” set in “Algorithm setup” window.

In SW100 “Averaging” tab is used for this (refer to Section 9.4).

With N parameter value set equal to 0 or 1, averaging is disabled.

Note. Remembered that measurement time (time of valid measurement result settling) is in direct proportion to the averaging constant value and approximately equal to the triple measurement time interval value. For example, if the measurement time interval is 1 sec, then settling time is equal to 3 sec.

4.4. “Out-of-order” measurement filtering

“Out-of-order” measurement filtering allows excluding from the averaging process values that considerably differ from average values throughout the averaging period. This filtration type prevents process the impact of sudden process changes.

Filtering is performed based on the following algorithm.

During the next resonant frequency measurement averaged frequency is compared with currently measured frequency, and if deviation is greater than “Frequency jumping” parameter, then the average value is applied instead of currently measured “out-of-order” frequency. At the same time measurement and averaging processes continue as if there is no any jump.

“Frequency jumping” parameter is set in “Algorithm setup” window in tenths of MHz.

“Out-of-order” measurement filtering is controlled using “Truncation limit” parameter in “Algorithm setup” window.

If this parameter is equal to 0, then filtration is disabled.

If the parameter is equal to 1, then truncation of one random “out-of-order” measurement is performed and averaging continues.

If the parameter is equal to 2, then two consequently “out-of-order” measurements are allowed.

If the parameter is equal to 3, then three measurements are allowed and so on.

If “drop-out” continues more times than it is specified in settings, then resonant frequency is considered changed and averaging process restarts using currently measured values.

If filtering is disabled (“Truncation limit” = 0), then averaging starting from beginning every time when regular measured resonant frequency deviating from average more than specified “Frequency jumping” parameter.

“Out-of-order” measurement filtering make sense only if measurement result averaging is enabled (refer to Section 4.3) since a decision regarding truncation of the next measured value is made based on comparison with an average value.

4.5. Approximate estimation of measured parameters and operational correctness

Spectrum graphs provide a general idea about moisture meter operation and make it possible to evaluate its correctness. Resonant frequency value during sensor filling with material can be identified based on spectrum – by a resonant curve appearance. The signal minimum must be clearly visible on the resonant curve of an operable moisture meter.

Frequency value where the signal minimum is reached can be identified with “Hairline” tool accurate within MHz units.

There are two such hairlines in SWPro. Hairline is enabled and disabled by means of “View|Hairline 1...” or “View|Hairline 2...” menu items.

Each hairline has a corresponding field (under the spectrum graph) indicating frequency where the hairline is “located” and signal amplitudes measured on this frequency.

Hairlines are moved by means of left mouse clicks. To identify frequency, move the hairline to a desired place on spectrum and read a frequency value in the field corresponding to the hairline number.

If signal minimum frequency identified by this technique is approximately equal (accurate within MHz units) to frequency measured by the moisture meter (F_{res}), then it means that the moisture meter is set correctly and functional.

4.6. Auxiliary diagnostic information

To enable/disable auxiliary diagnostic information windows, double click on the panel located to the left of “Tuning interval” panel (right bottom part of the main window). As a result, auxiliary parameter windows will appear instead of calibration buttons (Fig. 7).

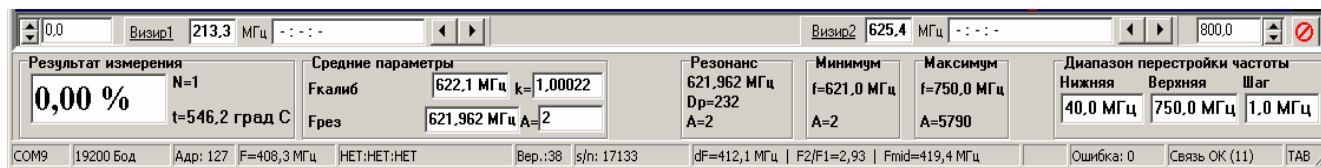


Fig. 7

“Minimum” window displays frequency f where sensor input voltage has a minimum value (detection based on Algorithm 0). Minimum signal value is indicated as A value.

“Maximum” window displays frequency f where sensor input voltage has a maximum value also indicated as A value.

“Resonance” windows contains the following information:

f – resonant frequency detected according to the currently selected algorithm.

A – signal level at the minimum point on df interval (see Fig. 6).

Dp – “minimum depth” measured according to Algorithm 1 (see Fig. 6).

Note 1. Dp can be used to estimate sensitivity margin during frequency detection according to Algorithm 1. So Dp value must be higher than Dp_0 specified in “Setup|Algorithm setup|Minimum depth” settings in order to ensure reliable device performance.

Note 2. Dp value is relevant only if the minimum found meets the three conditions of Algorithm 1. In other cases, the displayed value is not determined and can be any figure.

Note 3. Absolute equality of frequencies in “Minimum” and “Resonance” can evidence that the minimum is not found according to Algorithm 1.

5. Moisture meter calibration

The moisture value is calculated using calibration tables that define one-to-one correspondence between measured deceleration factor k_{dec} and material moisture W at a certain temperature.

Empty sensor resonant frequency f_0 is determined once during sensor manufacturing (for bulk material moisture meters – after sensor installation on equipment) and saved in the device internal memory. This process is called empty resonator calibration, and frequency f_0 is called moisture meter *calibration frequency*.

So calibration frequency f_0 is saved in the moisture meter memory by a user command when the moisture meter sensor is empty (not filled with controlled material).

Based on the physical significance of calibration, deceleration factor k_{dec} measured by the moisture meter after calibration must be equal to: $k_{dec} = 1 \pm 0.0002$.

If deceleration factor k_{dec} measured by the moisture meter deviates from 1 (provided that the sensor is empty) more than by 0.0002, this can be due to the insufficiently cleaned and dried internal surface of the moisture meter. Incorrect calibration may be a reason as well, and in this case moisture meter re-calibration is required.

Calibration is performed on the clean and dry sensor only. To ensure such calibration, the sensor of the liquid material moisture meter must be rinsed with organic solvent or alcohol and thoroughly dried.

Calibration can be performed in two ways:

Method 1. By pressing “Empty resonator calibration” button. The moisture meter saves currently measured frequency to its internal memory.

Method 2. Direct frequency value entering (accurate within tenths of MHz). For this select “Setup|Calibration frequency...” menu item. Enter in the appeared box (Fig. 8) a desired value obtained based on frequency measured by the moisture meter, rated value of this parameter or a value determined by any other method (e.g. if sensor resonant frequency is beyond the moisture meter tuning range).

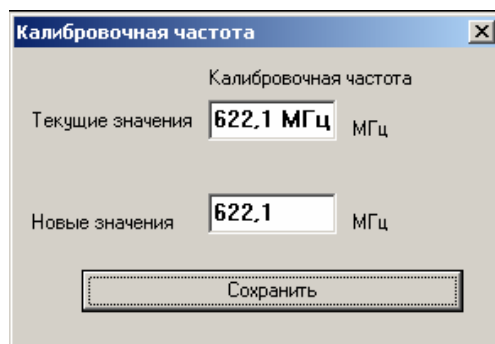


Fig. 8

6. Calibration tables

By its operating principle, the moisture meter is a permittivity (ϵ_r) meter. Permittivity (or k_{dec}) conversion to moisture W is performed by the CPU based on calibration tables providing correspondence between the specified parameters. In general, there is a dedicated functional dependency between permittivity and moisture content for each controlled material. However, this functional dependency is linked to a specific material temperature.

Moisture meter can store up to 100 different calibrations.

Switching between calibrations can be done in a calibration dialog box or via MODBUS interface by means of registers specified in Part 1, Section 12.

In some cases during automated system design, it is more practical to convert permittivity to moisture content not by the moisture meter CPU, but by means of an automated system itself. This solution can be convenient when there is a need for fast calibration change in the manufacturing process (e.g. when dosing different types of materials) since it eliminates the need to program complex algorithms for calibration switching using communication links.

In this case, only temperature and deceleration factor value converted to moisture content in the external control system are received from the moisture meter.

Each calibration is a table of correspondence between deceleration factor k_{dec} (function of ϵ_r) and moisture content W . There are four such tables for each material and each of them is compiled for a specific temperature. The first table is prepared for the lowest material temperature, and the fourth one is for highest temperature.

Note. Deceleration factor k_{dec} is the ratio of air-filled sensor resonant frequency to resonant frequency of the sensor filled with controlled material. This factor is equal to the ratio of electromagnetic wave velocity in vacuum (air) to electromagnetic wave velocity in the material (refer to Section 4). This parameter is also known in technical literature as material refractive index. At low dissipative losses for electromagnetic wave propagating in the material, refractive index is connected with permittivity through the following expression:

$$\epsilon_r = k_{dec}^2 .$$

The calibration table is a set of 15 points (paired values of k_{dec} , W) used by the CPU to set $W = W(k_{dec})$ function. Moisture content W is calculated by the CPU by linear interpolation of deceleration factor k_{dec} intermediate values to a corresponding segment of $W = W(k_{dec})$ function.

6.1. Calibration management window

To get access to tables from the SWPro main window select “Setup|Calibration tables...” menu item. After that a window will appear (Fig. 9) with “Calibration tables” caption containing controls and display elements required to view and edit tables. This window is completely identical to the same window in SW100 by its appearance and functionality (refer to Section 9).

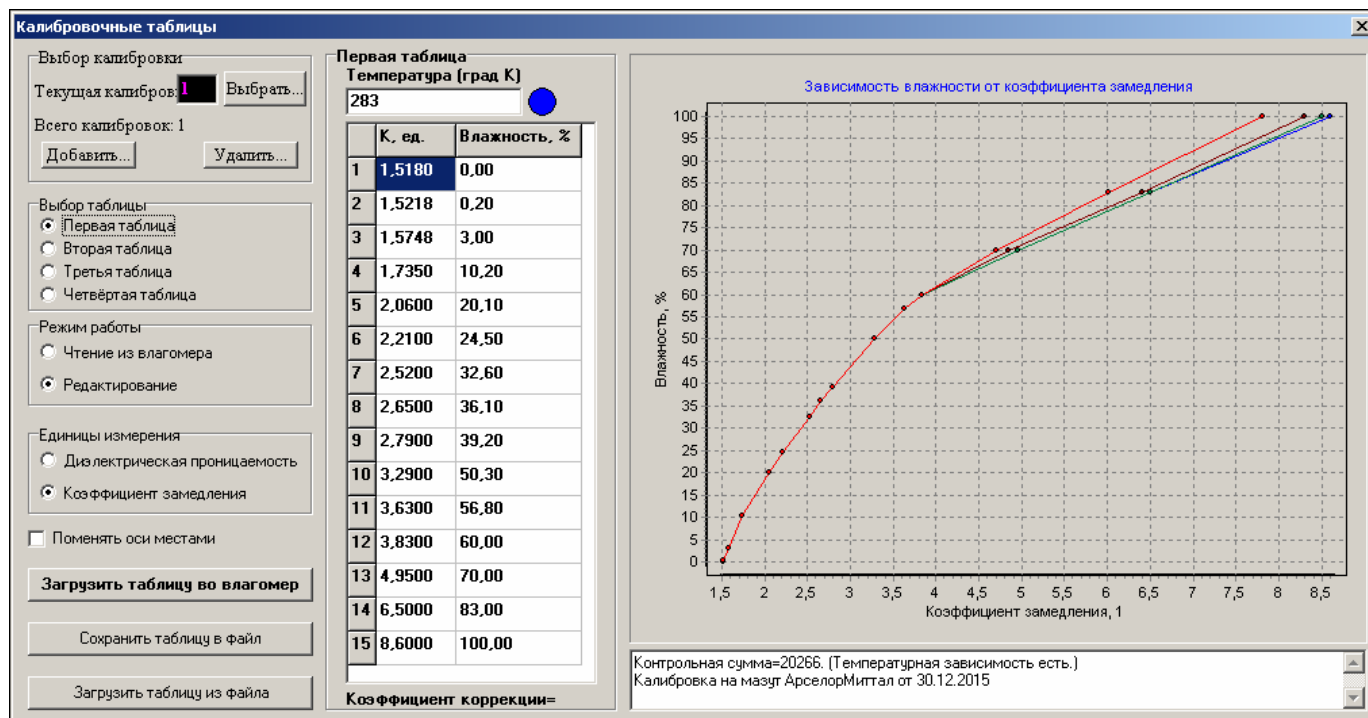


Fig. 9

For convenience window can be conditionally divided into three parts:

- Left part contains window controls
- Middle part contains current conversion table
- Right part contains the table data chart.

When first opened, this window shows the data from the first table stored in the moisture meter memory (it is assumed that connection with the moisture meter has already been established).

The displayed table is chosen by selecting a desired item on “Table selection” panel. At that, the upper section of the table displays a temperature corresponding to this table. “Measurement units” table allows the user to select representation of a parameter measured by the device as deceleration factor k_{dec} or relative permittivity ϵ_r .

Correction factor shows if calibration offset calculated after “Calibration by solids” (refer to Section 6.3) is used. For newly created or edited tables correction factor is equal to zero.

There are two table management modes: “Read” and “Edit” switching in the corresponding “Mode” field.

“Read” mode (enabled by default) allows only viewing tables saved in the moisture meter memory.

“Edit” mode allows editing tables, saving calibration to the moisture meter, saving calibration to file and opening calibration from file.

Since each calibration contains four tables, it is necessary to select desired calibration first. It can be done in the upper left corner of the window by entering the calibration number in “Current calibration number” field.

The total quantity of calibrations saved to the moisture meter is shown under this field.

Note. Remember that calibration selected in such a way is saved to the moisture meter memory and further calculations in operation mode will be done based on it.

When it is required to add calibration or delete the existing one, press “Add” or “Delete” buttons, respectively.

For fast identification SWPro (as well as SW100) calculates current calibration checksum and displays it in the field under the graph. Upon moisture meter delivery, checksums for all calibrations saved in the moisture meter are listed in its certificate. Therefore, it is possible to identify calibration integrity without their row-to-row comparison.

Once calibration is selected, proceed to calibration table management.

6.2. Calibration table management procedure

6.2.1. Saving tables from file to the moisture meter

Calibration tables are saved to the moisture meter as follows:

- 1) Establish connection with the moisture meter.
- 2) Open calibration management window (Fig. 9).
- 3) Switch to “Edit” mode.
- 4) Press “Open table from file...” button, and select a desired file in the appeared standard dialog box.
- 5) Then press “Save table to moisture meter” button.

Note 1. When creating and editing tables, note that a table with a lesser number must correspond to a lower temperature table.

Note 2. If a characteristic independent from temperature is used for this measured material, then the same data are entered to all the four moisture meter tables, but the temperature must be specified manually in accordance with *Note 1* before saving to the moisture meter (Step 5).

6.2.2. Saving calibration from the moisture meter to file

To save tables stored in the moisture meter memory proceed as follows:

- 1) Switch to “Edit” mode.
- 2) Press “ Save table to file...” button, and specify a desired file name in the appeared standard dialog box.

6.2.3. Editing an existing table

If calibration curves are need to be corrected during the moisture meter operation, it is recommended to adhere to the following procedure:

- 1) Switch to “Edit” mode.
- 2) Save tables stored in the moisture meter memory in accordance with Section 6.2.2.
- 3) Enter desired changes to the current table (or open a new one from file).
- 4) Save it to the moisture meter.
- 5) Save calibration to file in accordance with Section 6.2.2.

6.2.4. Creating a calibration table

To create a new calibration curve it is much more convenient to prepare a table using any commonly known specialized program (e.g. MS Excel) and save it in a format suitable for saving to the moisture meter by means of SW100 or SWPro.

For table editing and saving these programs use the standard CSV format (comma-separated variables) supported particularly by the MS Excel table editor.

6.2.5. Calibration table format

Moisture meter calibration curve is a set of four tables, CSV or Excel files. Each table consists of fifteen rows defining correspondence between deceleration factor k_{dec} and moisture content W .

An example of an Excel table format is shown below:

F	283	
1	1.57	0
2	1.76	8.44
3	1.94	15.5
4	2.06	20.1
5	2.21	24.5
6	2.52	32.6
7	2.65	36.1
8	2.79	39.2
9	3.04	44.8
10	3.29	50.3
11	3.63	56.8
12	3.83	60
13	4.95	70
14	6.75	83
15	9.15	100
F	298	
1	1.57	0
2	1.76	8.44
3	1.94	15.5
4	2.06	20.1
5	2.21	24.5
6	2.52	32.6
7	2.65	36.1
8	2.79	39.2
9	3.04	44.8
10	3.29	50.3
11	3.63	56.8
12	3.83	60
13	4.95	70
14	6.75	83
15	9.15	100
F	308	
1	1.57	0
2	1.76	8.44
3	1.94	15.5
4	2.06	20.1
5	2.21	24.5
6	2.52	32.6
7	2.65	36.1
8	2.79	39.2
9	3.04	44.8
10	3.29	50.3
11	3.63	56.8
12	3.83	60
13	4.95	70
14	6.75	83
15	9.15	100
F	318	
1	1.57	0
2	1.76	8.44
3	1.94	15.5
4	2.06	20.1
5	2.21	24.5
6	2.52	32.6
7	2.65	36.1

8	2.79	39.2
9	3.04	44.8
10	3.29	50.3
11	3.63	56.8
12	3.83	60
13	4.95	70
14	6.75	83
15	9.15	100

A calibration table is compiled according to the following rules.

The first row is used to specify temperature (Degrees Kelvin) corresponding to this table. The first cell must contain the service symbol F (Latin). The second cell must contain a temperature value in Degrees Kelvin. The third cell is empty.

All subsequent rows are used to represent calibration curve reference points. Each row contains three columns. The first column indicates the point sequence number – from 1 to 15. The second one shows the material deceleration factor value. The third one provides a corresponding moisture content value in percentage terms. The table must be filled so that a cell with a lesser sequence number corresponds to a point with a lower deceleration factor value.

When compiling tables, it is necessary to specify deceleration factor with not more than four decimal digits, and moisture with not more than two decimal digits.

Note 1. The table must not contain deceleration factors less than 1.

Note 2. If the calibration table contains at least one deceleration factor higher than 13, then the number of decimal digits automatically reduces to 2 with the corresponding rounding of earlier entered values. In this case, the value of the least used factor in table must be less than 50.

Note 3. Each table must contain 15 calibration points. If the quantity of calibration points is less than fifteen, then all existing points are entered to the table according to the rules mentioned above, and missing rows are filled by copying (duplicating) of a row with the highest deceleration factor value for this table.

An Excel table created according to these rules is saved in CSV format. After this the table is ready to be used by SW100 and SWPro programs.

6.3. Calibration by solids

Calibration by solids may be required for calibration curve adjustment e.g. in case of oil grade change.

The principle of calibration by solids is that the moisture meter automatically adds a certain value (correction factor) to measured deceleration factor without calibration table modification, i.e. actually executing the parallel shift of a calibration dependency graph along the abscissa axis (see Fig. 9).

The correction factor K_{corr} value used to specify deceleration factor accuracy is calculated automatically by pressing “Calibration by solids” button. The moisture meter performs calculations according to the following formula:

$$K_{corr} = K_{dec. tab} - K_{dec. meas.},$$

where K_{corr} – correction factor (deceleration factor shift value)

$K_{dec. tab}$ – deceleration factor from the first row of the first temperature table for current calibration

$K_{dec. meas.}$ – correction factor measured at the time of calibration.

Important! Calibration by solids requires that the material used for calibration be moisture-free.

Once calibration by solids is finished, the K_{corr} value will always be added to measured deceleration factor $K_{dec. meas}$ in the moisture meter:

$$K_{meas. corr.} = K_{dec. meas} + K_{corr},$$

where $K_{meas. corr.}$ – corrected deceleration factor to be used for moisture content calculation based on calibration tables.

The correction factor K_{corr} value may be both positive and negative. The correction factor K_{corr} module must not exceed 0.32767. The correction factor value is shown in “Calibration tables” window directly under the calibration table (Fig. 9).

Note 1. A too high correction factor K_{corr} value (greater than 0.01...0.02) may indicate that it is unsuitable for this material, and full calibration based on a new material must be performed instead of calibration by solids.

Note 2. To reset (zero) correction factor K_{corr} , it is necessary to reload the initial calibration table by means of “Calibration tables” window (Fig. 9).

7. Current output settings

Select “Setup|Current output...” menu item to adjust moisture meter current output (4-20 mA current loop) parameters.

After that the corresponding window will appear as shown in Fig. 10.

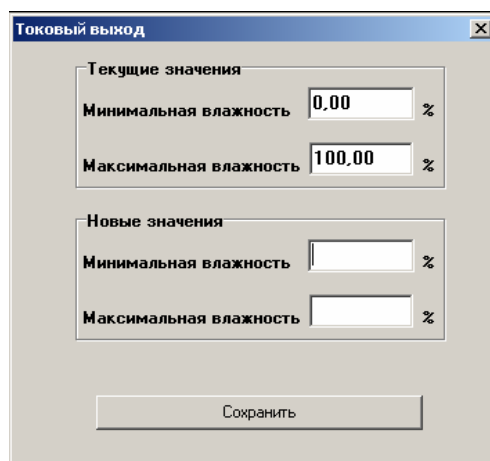


Fig. 10

Actual current output settings are shown in the upper part of this window.

A new setting can be entered in the lower part.

Minimum moisture content corresponds to 4 mA output current and maximum moisture content corresponds to 20 mA.

Press “Save” button to apply new settings.

Note. Current output parameter settings have no impact on the measurement range and moisture content value sent via MODBUS interface and displayed in corresponding SW100 and SWPro program windows (Fig. 1, 13 and 15).

8. Measurement results auto save option

8.1. Spectrum auto save

When analyzing new materials or performing moisture meter diagnostics, it may be required to automatically save moisture meter configuration files without the operator presence. For this configuration file auto save mode is provided in SWPro (configuration files saving with the last measured spectrum).

Auto save mode is managed using a special dialog box (Fig. 11) available from “Tools|Auto save...” menu.

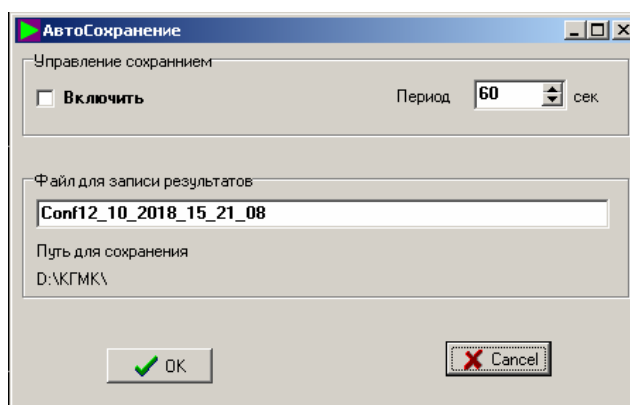


Fig. 11

This window allows the user to enable/disable auto save and define a saving interval.

A file saving path and current “.cfg” file name pattern can be specified in the “Results record file” field.

Online enabling/disabling of auto save mode can be executed by means of “Auto save” button in the main window of the program.

Note. A path for saving files is the same as for the last saved configuration file, so in order to modify a saving path it is required to save a spectrum manually using “File|Save...” menu.

8.2. Measurement result auto recording

The moisture meter contains no internal measurement result archive. However, SWPro provides for automatic measurement result saving in a text file in comma-separated values format - csv. The format is fully supported by the MS Excel table editor.

Auto recording mode management using dialog box (Fig. 12), available from “Tools|Auto recording...” menu.

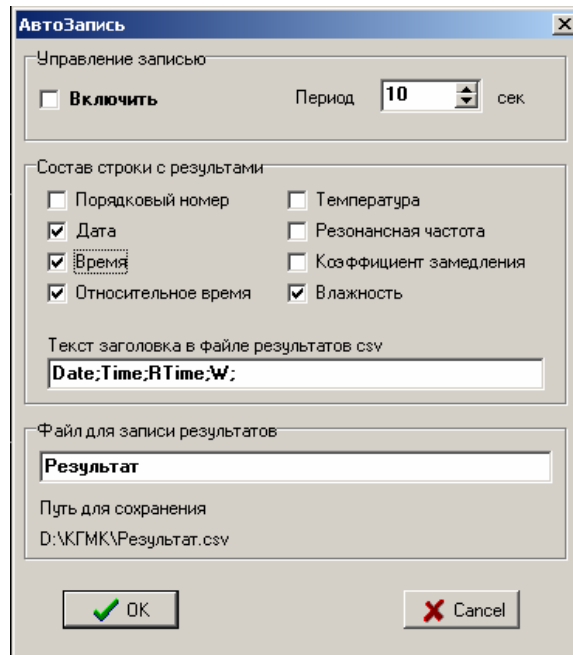


Fig. 12

Measurement result recording to file is performed row-by-row with an interval specified in the corresponding field.

The presence and purpose of particular columns are specified in “Measurement result row structure”. The file can contain the following parameters recorded to corresponding columns:

Data (column)	Description	Measurement units	Reference character in the caption row
Sequence number	Measurement sequence number from the time of mode selection	-	N
Date	Date determined by PC clock	Year, month, day	Date
Time	Time determined by PC clock	Hours, minutes, seconds	Time
Relative time	Time since Record mode enabled	Seconds	RTime
Temperature	Temperature measured by moisture meter	Degrees Celsius	T
Resonant frequency	Resonant frequency measured by the moisture meter	MHz	F
Deceleration factor	Deceleration factor	-	K
Moisture content	Calculated moisture content	%	W

Text in the “Result record file caption text” is recorded to first row to identify the data structure in the file afterwards.

The file name is specified in “Results record file” field (without extension). “.csv” extension will be added automatically.

Online enabling/disabling of auto recording mode can be executed by means of “Auto recording” button in the main window of the program (Fig. 1).

Note 1. A path for saving files is the same as for the last saved configuration file, so in order to modify the saving path it is required to save the spectrum manually using “File|Save...” menu.

Note 2. When recording is stopped, it is necessary to carefully observe the column structure. In case of its accidental change data confusion may occur. A solution is to specify a new file name to continue recording.

Note 3. Setting “Enable” flag in the management window (Fig. 12) and pressing “Ok” button creates a new file with a file name specified in the management dialog box that may lead to the loss of previously saved data. Therefore, to continue recording specify a new file name for newly recorded data.

Note 4. It is not recommended to open a file used for recording when auto recording mode is enabled. It may lead to access error and program crash.

9. SW100 program for FIZEPR-SW100 moisture meter operation

SW100 software provides execution of the following functions:

- Digital representation of the current moisture content value on the computer display
- Measured moisture content representation in the form of a graph showing the current moisture value and its variation in time
- Moisture meter control, setting specific operation modes.

The program contains the main window displaying the current moisture content value in a digital form and current moisture meter settings as well as an auxiliary window displaying the manufacturing process graph (Fig. 13).

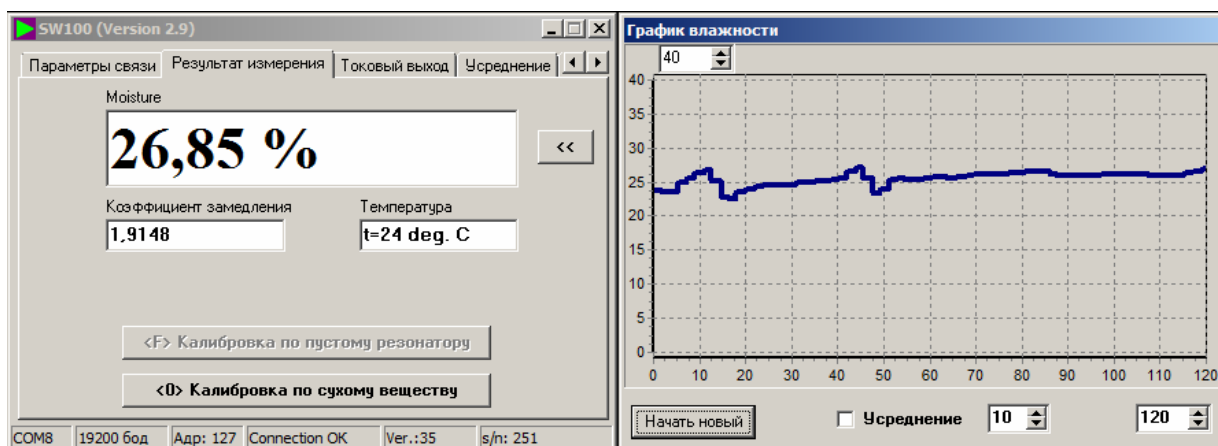


Fig. 13

The upper part of the main program window contains 6 tabs providing moisture meter mode management and setup.

The lower part of the main window contains a status line for displaying service information. It is divided into five fields:

- 1) The first field displays the name of a serial port for moisture meter connection
- 2) The second field displays the specified port baud rate (bit/sec)
- 3) The third field contains the moisture meter MODBUS address
- 4) The fourth field indicates the data communication status message:
“Connection OK” – connection is established, “No connection” – connection is not established, if this field is blank, that means that the serial port is not selected.
- 5) The fifth field displays the moisture meter firmware version number
- 6) The sixth field displays the moisture meter serial number.

9.1. Software identification

The upper left corner of the main window shows the program icon, SW100 name (program identifier) and software version number (see Fig. 14).

9.2. Establishing connection with the moisture meter

To receive data from the moisture meter or modify any of its settings it is required to establish connection with the moisture meter.

Connection parameter setup is performed in “Connection parameters” tab (Fig. 14).

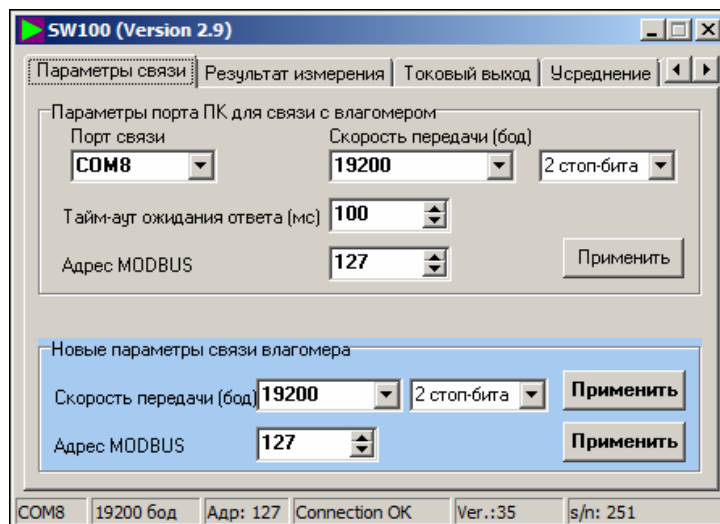


Fig. 14

All settings required for establishing connection are located in the upper part of the tab. Once all required parameters are selected, press “Apply” button.

“Connection OK” caption in the status line at the window bottom will indicate that connection is established successfully.

There are fields intended to modify the moisture meter MODBUS address or baud rate in the “New moisture meter connection parameters” window (blue background). Once all required parameters are modified, press “Apply” button.

A detailed description of connection parameters is provided in Section 3 of this manual.

9.3. “Measurement result” tab

This tab (Fig. 15) contains fields displaying directly measured parameters: “Moisture content”, “Deceleration factor” and “Temperature”.

Double click the mouse left button on “Deceleration factor” field displays controlled material permittivity.

“>>” button shows an auxiliary window with the moisture chart to observe a graph of moisture variation in time.

“Empty resonator calibration” button allows performing moisture meter fine-tuning after installation on site. This calibration is mandatory for bulk material moisture meters such as FIZEPR-SW100.10.4 and similar. For details, refer to Section 5 of this manual.

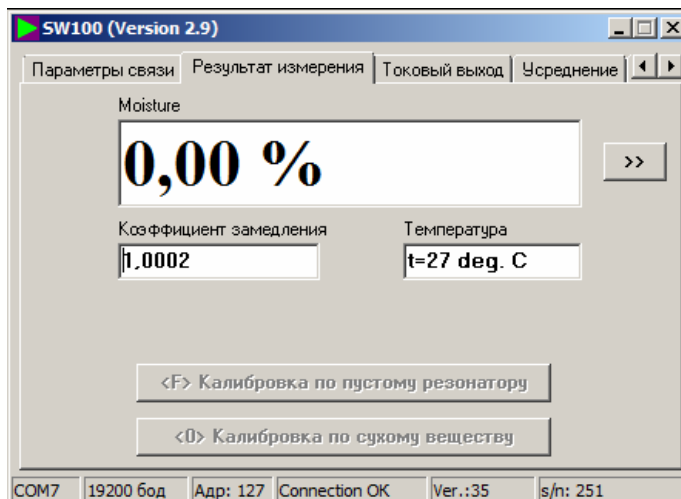


Fig. 15

“Calibration by solids” button shifts the moisture meter performance curve without creating a new calibration. It may be required when the controlled material incompletely corresponds to calibration determined by the manufacturer, but deviations are insignificant. Calibration by solids requires that the “dry” material used for calibration be moisture-free. Refer to Section 6.3 for details.

After calibration by the dehydrated material the moisture meter will remember curve offset and will operate with regard to this offset. Calibration tables themselves remain unchanged.

To restore the calibration curve to initial state (to remove offset) it is required to rewrite calibration tables in accordance with Section 6.2.

Perform calibration by solids or empty resonator calibration only when you are sure about the correctness of your actions.

“Empty resonator calibration” and “Calibration by solids” buttons are available only after switching to “Calibration mode”. Switching to calibration mode is performed on the “Metrology” tab (refer to Section 9.5, Fig. 18 below).

9.4. Current output setup

This tab (Fig. 16) indicates 4-20 mA current loop calibration factors: minimum moisture content corresponding to 4 mA current and maximum moisture content corresponding to 20 mA current.

For current output scale modification it is required to specify new minimum and maximum moisture values in “New values” field and press “Save” button.

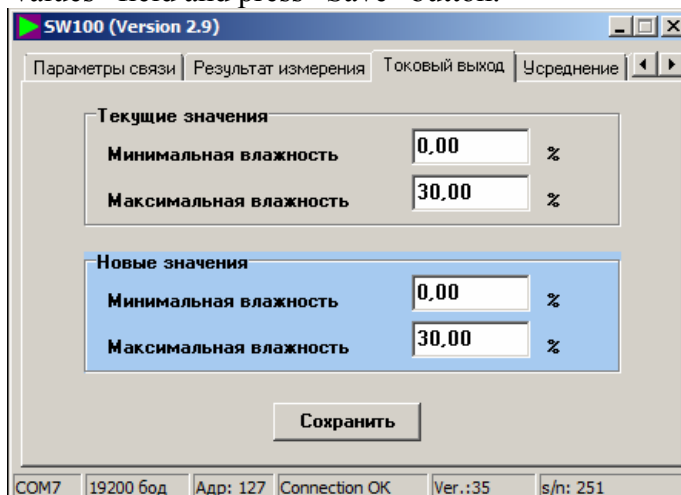


Fig. 16

Note. Current output parameter settings modification has no impact on the measurement range and moisture content value sent via MODBUS interface and displayed in the corresponding SW100 and SWPro windows (Fig. 1, 13 and 15).

9.5. “Averaging” tab

“Averaging” tab (Fig. 17) allows the user to modify result averaging constant defining the number of measurements used to calculate the average moisture value.

Remember that the measurement time (the time of obtaining the most reliable measurement result) in a direct proportion to the averaging constant value.

Refer to section 4.3 for details.

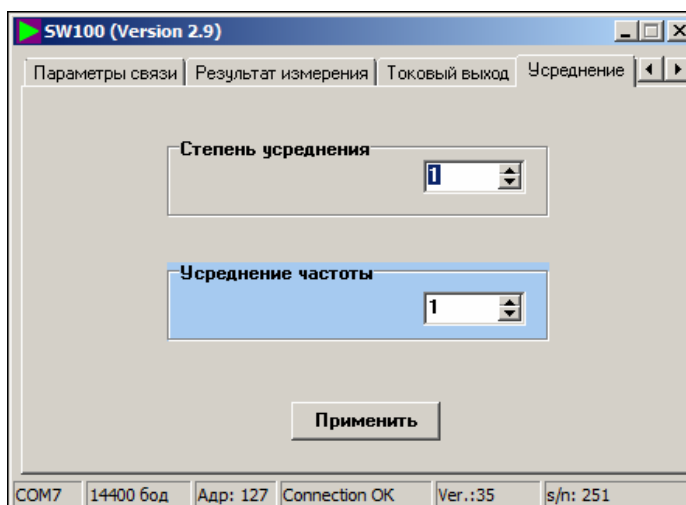


Fig. 17

9.6. “Metrology” tab

“Metrology” tab (Fig. 18) contains four buttons: “Calibration tables”, “Save configuration to moisture meter from file”, “Save moisture meter configuration to file”, “Calibration mode”.

When it is required to modify calibration tables, press “Calibration tables”. This will open the window with a corresponding name (refer to Section 6).

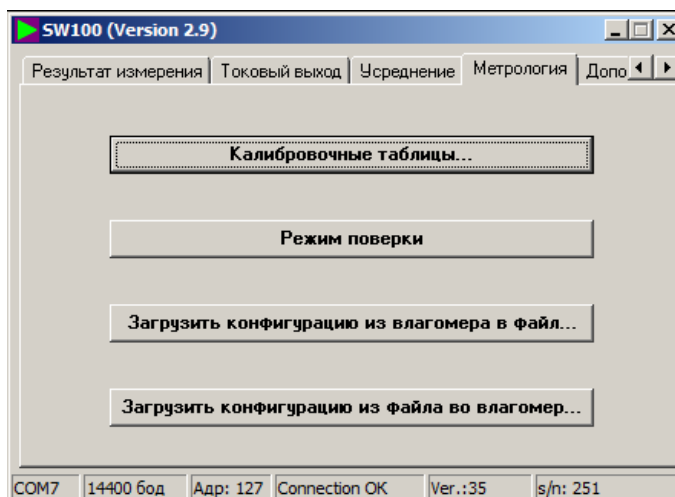


Fig. 18

“Save moisture configuration to file” button is used for current configuration saving to a file with “.cfg” extension used for moisture meter operation control and diagnostics. When pressed, this button opens a dialog box used to specify the file name and saving path. This file can be sent to the manufacturer for moisture meter diagnostics. The same file is used for saving the spectrum and moisture variation graph with the same capacity as it is currently represented in the corresponding window.

“Save configuration to moisture meter from file” button is used to save a calibration table in the form of a file with “.cfg” extension to the moisture meter.

This option can be used for fast moisture meter resetting caused, for example, by the need to adjust calibration based on the controlled material laboratory analysis. Refer to sections 5 and 6 for details.

10. Appendix

Appendix 1

Appearance of the VIGT.415210.101-02 electronic module (explosion-proof version) with its upper cover removed

