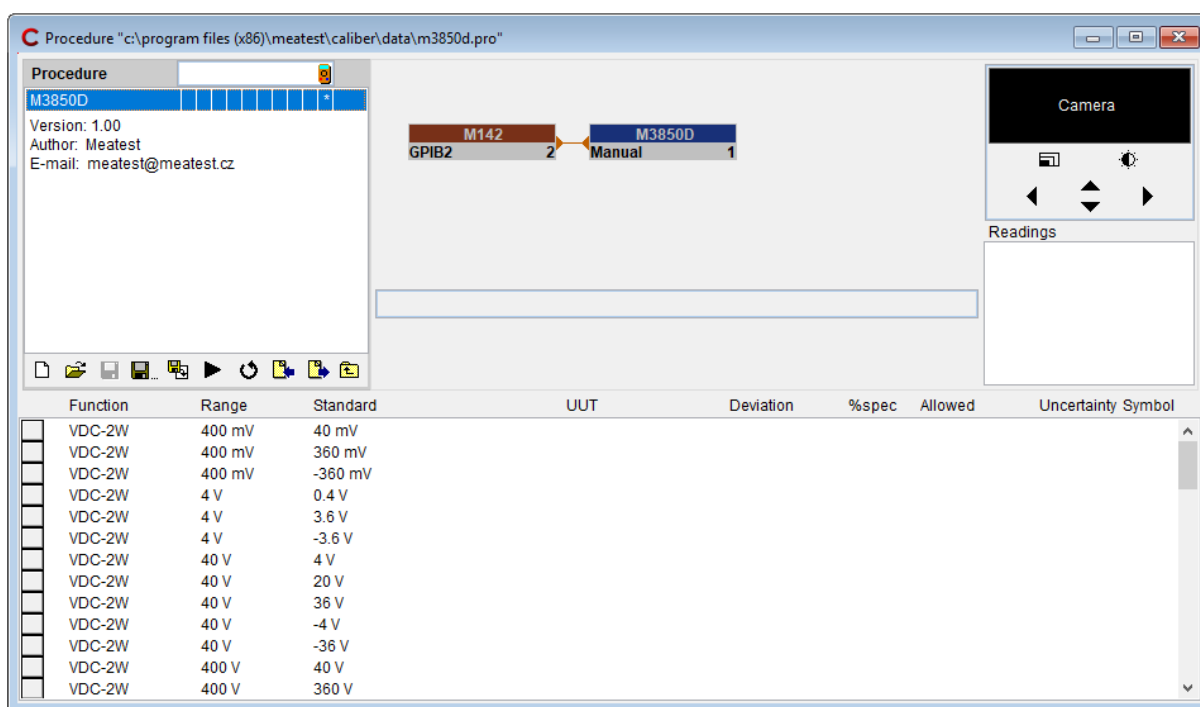


# CALIBER *Automatic calibrations of instruments*

## User's Guide

**MEATEST**ANALOG  
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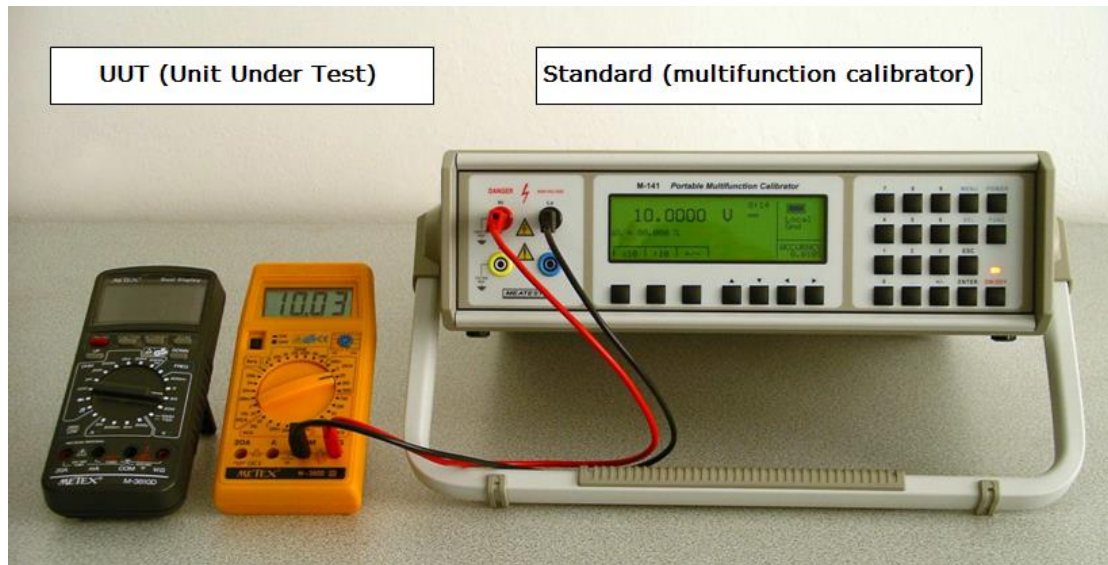
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## 1. Quick Start

### 1.1. Determination

The CALIBER program is intended for automatic calibrations of instruments by means of a standard. Except of the unit under test and the standard unit, a computer with Windows XP/Vista/7/8/10 Operating System is being necessary. Output of the CALIBER program represents a physically performed calibration with a calibration record – a table with measured and evaluated data (the test report).



Instrument Configuration for Calibration:

Measured Protocol:

Function	Range	Standard	UUT	Deviation	%spe	Allowed	Uncert.	
VDC-2W	200 mV	20.0 mV	20.0 mV	-0 uV	0	200 uV	62 uV	ok
VDC-2W	200 mV	180.0 mV	180.6 mV	620 uV	62	1003 uV	71 uV	ok
VDC-2W	200 mV	-180.0 mV	-180.7 mV	-690 uV	-69	1003 uV	69 uV	ok
VDC-2W	2 V	0.200 V	0.200 V	-0.00 mV	0	2.00 mV	0.58 mV	ok
VDC-2W	2 V	1.800 V	1.807 V	7.00 mV	70	10.04 mV	0.58 mV	ok
VDC-2W	2 V	-1.800 V	-1.807 V	-6.80 mV	-68	10.03 mV	0.64 mV	ok
...								

The instruments can be either manually or automatically (by computer) operated. In automatic mode the interface RS232 or GPIB can be used, eventually any other interfaces (USB, Ethernet, RS485, ...) which utilize the industry VISA standard.

### 1.1.1. Parts of Caliber Program

The Caliber program consists of four basic units:

**Procedures**

**Instrument Cards**

**User Functions**

**Wizard Rules**

The program is based on automatic calibration of measuring instruments which shall be performed according to before prepared calibration process or so called Calibration Procedure. The basic module of the Caliber program called **Procedures** is intended for processing of these calibration procedures. By means of this unit there is possible to develop and modify the calibration procedures and to carry out calibrations directly. For calibration used instruments are very important for the particular calibration procedure. In the most simply case a procedure can be created by a list of instruments and a list of selected functions, ranges and points of a tested instrument.

An instrument shall be specified by its instrument Card in the Caliber program. The instrument card contains the whole instrument description. There are especially lists of supported functions, range specifications, technical data and methods of instrument operation. The module called **Instrument Cards** is intended for processing instrument cards. Existing card can be easily used for any calibration in any configuration and the program shall automatically know the all of instrument features.

The module **User Functions** allows to develop new functions and to certain extend to modify the existing ones. The function represents a supported instrument feature category, which is consequently being used for all the Caliber system. For example V-DC (direct voltage) or FREQ (frequency) can be functions.

The module **Wizard Rules** is intended for development of regulations which shall be used for automatic calibration procedure developments.

It can be say in simplified way that the instrument Cards are specifying features of objects participating on a calibration, and the Calibration Procedures are specifying relations among these objects. The Calibration Procedure stipulates which instrument shall take part in the calibration and what function they shall perform (i.e. instruments under test, sources, standards) and at which points the calibration shall be carried out.

A calibration procedure shall be created interactively and it does not require programmatic knowledge of a technician. The CALIBER program can be used either independently or as a program unit of the WinQbase database environment. If it is used independently the program output shall be represented only by a calibration report. If it is used with the database of WinQbase the CALIBER program results shall be transferred into this database and a user can utilize all the WinQbase features for another operation. Below will be described operation of the CALIBER program as independent one.

## 1.2. System Structure

- control unit PC 1.5 GHz and more, monitor SVGA, RAM 1 GB
- Operating System of MS Windows XP/VISTA/7/8/10
- software facility of Caliber
- to calibration necessary instruments + connecting cables
- National instruments GPIB card for communication via IEEE488 (other manufacturers are not supported)

## 1.3. Program Installation

In this section installation of the Caliber program will be described if being used independently. If being used as a part of WinQbase program its installation shall be performed automatically during WinQbase installation. The program of Caliber is being distributed on CD ROM disc.

### **Caliber program installation:**

This installation shall be performed under user's account with administrator permissions.

The CD ROM having been inserted, a control menu shall be displayed and selection of installation of the Caliber program is possible. If the CD ROM is not initiated automatically, you can find the installation by means of the "Install\Software\Caliber.zip" package. Unpack (unzip) the package and run the installation by opening the "CaliberSetup.exe" file from newly unpacked folder.

First the program shall offer a language version and after it an installation guide shall be initiated. Available languages are: English, German, Russian, Hungarian, Slovak and Czech.

The installation guide consists of following points:

- Assignment of a place in the computer where the installation shall be located – we recommend to confirm the offered Caliber's position.
- Performing of the installation itself.
- Computer restart.

The computer restart having performed, let the installation CD ROM in its driver and switch on the new installed program in the „Start“ menu. The operating system may read some other information from the installation CD. The program shall be started automatically in a demo-mode and it can be activated after entering of the “ Registration Code “, see the section of “ Program Registration “. Program having started, the CD ROM can be removed.

If you are using the **GPIB Card** (National Instruments interface is required) it will be necessary to install a particular controller by means of the installation CD delivered along with the GPIB card.

If you are using a **camera** to scan measured values it will be necessary to install a particular controller by means of the installation CD delivered along with the camera.

If you are using VISA interface it will be necessary to install VISA driver. This driver is accessible from Caliber installation CD via start menu (it is located in “install/drivers” directory).

### **Uninstall the program**

The program can be removed off the computer by means of the “Installation or De-Installation of Programs” item in Control Panels.

## 1.4. Program Operation

### 1.4.1. Measure Task Development

To perform a calibration, we need an instrument to be calibrated and an instrument (or instruments) for its test. It is possible to use maximally 20 instruments for one calibration point. For the whole calibration procedure the number of instruments is not limited (each of the points can use other instruments). The limitation given by program purposes is only one unit under test (UUT) which shall be the same for the whole calibration procedure.

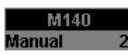


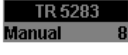
The Caliber program allows measure task development by means of five basic types of instruments:

- a) **UUT** (Unit Under Test) – an instrument to be calibrated, i.e. an instrument to be tested. It is not of importance if it is a signal source or a measuring instrument. An instrument being calibrated can be a multi-meter, a resistance decade, process calibrator, etc. A converter can be used as UUT as well, only certain regulations shall be observed. The UUT is always being differentiated by blue color in the program.
- b) **Standard** – a standard instrument being connected with the UUT (it is intended for conventionally right value estimation by the program). A standard can be a signal source (calibrator) or a measuring instrument (multi-meter, scales). The standard is always being differentiated by red color in the program.
- c) **Source** – a signal source. A signal source shall be present at each measuring task. It can be used at standard's position (calibrator), as UUT (calibration of a decade resistance) or can be used as a source only.
- d) **Converter** – it converts a measured signal. It can convert physical values (a current shunt, a frequency/voltage converter), eventually value transfer (a transformer, a current coil with 50 turns). A converter cannot be used separately, it must be connected with a source (a 50 turns coil behind the calibrator) or with a measuring instrument (a current shunt). The program does not allow transducer connecting with the UUT. However such a limitation can be avoided by another range of a measuring instrument to be calibrated (e.g. 5 kV range for a multi-meter with a high-voltage probe). The transducer connected with the standard is always being differentiated by red color in the program.
- e) **Switch** – it is an instrument which can be operated along with other ones during a calibration, but it has not any influence to calibration results (it is not any standard, any UUT, either a source or a transducer). It can be used as an automated terminal switch etc.

The condition of any instrument usage is being represented by existing of particular instrument Cards. There is necessary to specify a UUT, a Standard and a Source for every measure task. The transducer cannot be used obligatory. There shall be necessary to select particular operation method for each of the instruments, i.e. manual operation for the GPIB, RS232, VISA buses or for a camera.

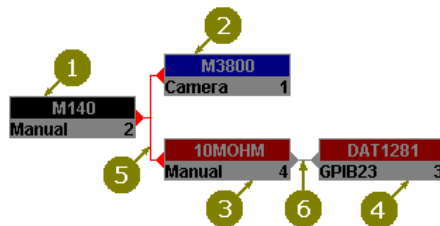


Instruments are divided in terms of signal flows into following groups:

- a)  Source – it possess an output signal, it does not have any inputs. It is creating a signal.
- b)  Meter – it possess an input signal, it does not have any outputs. It is measuring a signal.
- c)  Converter – it possess both input and output signal. The signal is being transformed.
- d)  Switch – it is similar as the measuring instrument, it has only input signal, but any measured value is not expected.

### Instruments scheme

All in the program used instruments shall be connected together in terms of the signal which is demonstrated by a connecting line of grey (6) or orange (5) color. The **orange line** means that the instrument is connected with the master bus, i.e. all values are set exactly as the UUT



1. Source
2. UUT (meter)
3. Standard converter
4. Standard (meter)
5. Master signal bus
6. Transformed bus

(2) is, also as it is determined by the calibration procedure. The **grey line** means that values have

been transformed by the converter (3) and they can differ from the UUT. Several converters can be serial connected and the values can be step by step transformed in direction always from the master bus. For better clarity it is possible after selection of a particular calibration point to move a mouse cursor on the instrument and look at how quantity and value the instrument shall be set on (having transformed by the converter).

### Instrument displaying within a procedure

Each of instruments shall be displayed as a rectangle in the program. There is an instrument



1. Instrument name
2. Instrument use (color)
3. Instrument type
4. Communication type
5. Instrument index

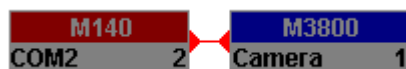
name (1) in the upper half of the rectangle. The lower half is divided in two parts. A communication bus type (4) is being displayed

by which the instrument is controlled eventually along which bus the value from the instrument is counted. There is instrument index (5) in the right part. This index serves to unique identification of each of the instruments even if they have the same name (the same instrument can be used in one procedure many times). On the left and right part of the instrument can be displayed a hook which determines signal connections (3) among the

instruments. The source has a hook only at its right side, the converter has a hook on both its sides and the switch has not any hook. Rectangle's background color symbolizes an instrument position (2), i.e. blue stands for a UUT, red for a standard, grey for all other instruments which value is not important in terms of calibration results. It is suitable in terms of instrument circuitry to situate sources in left part of the surface and measuring instruments and switches in right part of the surface, converters then among these instruments. The instruments can be transferred on the surface by left mouse click and pulling the mouse at the same time. Instrument transferring is possible only if the instrument circuitry is actually in terms of a given point, a range and a procedure. The circuitry will be actually if it is displayed in thick letters of the instruments.

### Measure Task Examples:

#### a) Calibration of the METEX M3800 multi-meter by the MEATEST M140 calibrator



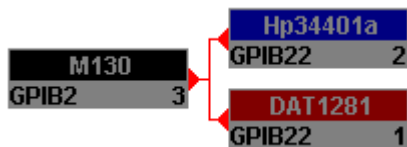
The calibrator is being used as a source and as a standard at the same time. It is controlled through RS232 bus (COM2 of the computer). Values from the measuring instrument are counted by a camera.

#### b) Calibration of the MEATEST M612 decade by the DATRON 1281 multi-meter



The decade represents an instrument under test and a signal source at the same time. It is controlled through RS232 bus (COM1 of the computer). The precise multi-meter of DATRON 1281 connected with GPIB bus of address 22 represents a standard.

#### c) Calibration of the multi-meter HP34401 by the multi-meter DATRON 1281 and the calibrator MEATEST M130



HP34401A is an instrument under test. The multi-meter DATRON 1281 is being used as a standard and the calibrator MEATEST M130 as a signal source. All the Instruments are connected through GPIB bus.


#### d) Calibration of 20A range of calibrator MEATEST M140 by the multi-meter DATRON 1281 with shunt BURSTER 10 mΩ

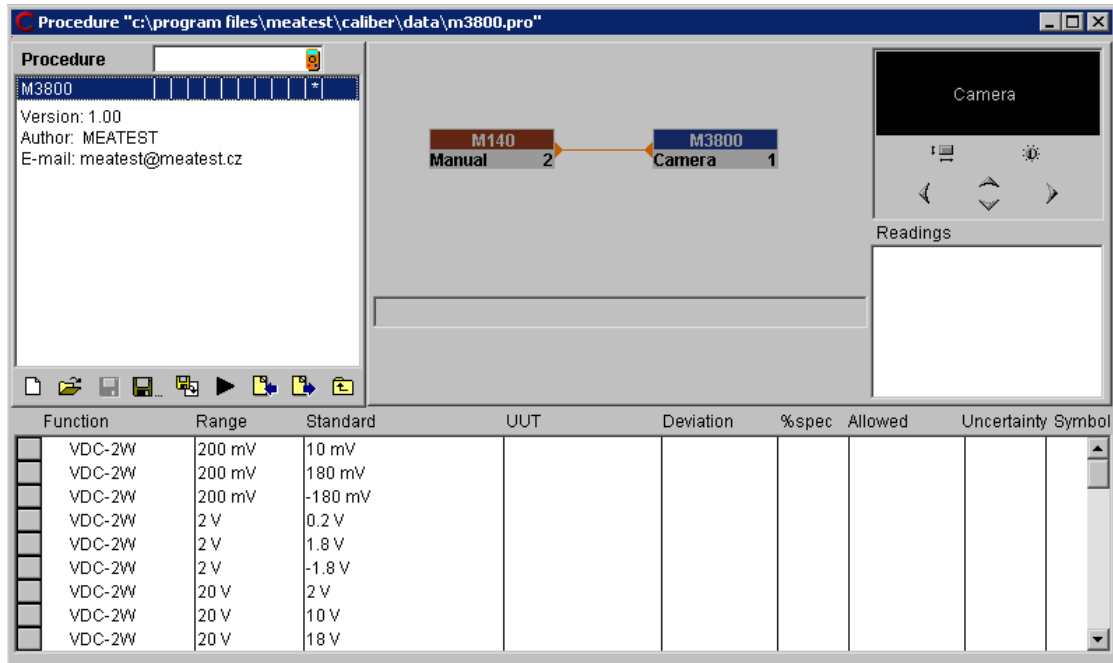


M140 is an instrument under calibration and a signal source at the same time. DATRON 1281 with

shunt 10 mΩ is a standard measuring instrument. All the instruments except from the converter are connected through GPIB bus.

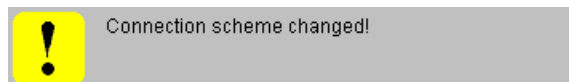
### 1.4.2. Calibration According to Developed Procedure

Start module “Procedures” (menu “Window” in upper menu bar) in “Caliber” program. In upper bar of the Status Window press the button  “Open” and select procedure M3800.



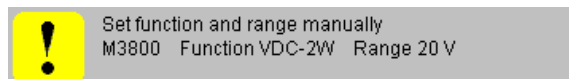
Connect instruments displayed in “Instrument scheme” window. If there is no camera scanning available it will be necessary to set reading M3800 to manual mode. It will be performed by right mouse clicking on instrument „M3800“ and selecting of item “Instrument configuration” from the menu. The field “Instrument response” shall be set to “Manual” and then press „OK“. There is possible to select a point in the test report window, which the calibration shall be started from. We select point 1 and press the key “Run Calibration”. The calibration can be stop by pressing ESC key any time.

First the program shall drawn attention to change of input terminal connection (there is



an actual connections of terminals in the program’s status window), then shall open instruments that will take part in the calibration and it shall perform every stipulated check values step by step.

Ranges or functions having changed, an operator shall be prompted to set the



instrument.

There shall be necessary to set measured values by means of a keyboard without camera scanning. The program requires performing a set of ten measurements for each of the calibration points. Measurement’s number can be modified by changing of the item „No. of

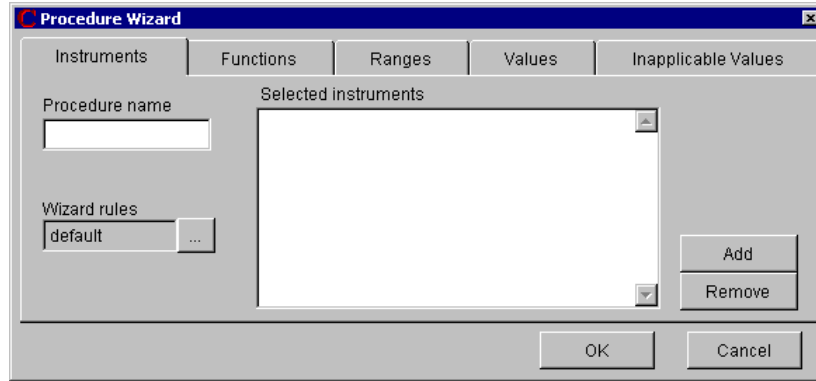
UUT readings“ in the “Measurement parameters” window. The “Uncertainty” window can be displayed after program stop (by the ESC-key) by pressing of the right mouse above the program’s status window.

The calibration can be stopped by pressing ESC key any time. It can be started by “Run Calibration” key from any point again. If there is a measured value recorded in a particular point already, it shall be overwritten by a new one.

If the calibration starts from WinQbase system the output protocol shall be automatically written down into the calibration database for particular identification sheet after closing of “Procedure” module. Without the database superstructure the performed calibration is to be written down into a file. Press the right mouse button above test report’s window and select item “Export“ in order to do it. Having not saved, the measured protocol shall be lost after closing of “Procedure” module.

### 1.4.3. New Calibration Procedure Development (Calibration Methods)

Open “Procedures” module in “Caliber” program. Press “New” - button in the upper bar of the status window. A Procedure wizard shall be open.



**Procedure Name** – a generated procedure shall be saved under this name.

**Wizard Rules** – a choice of rules for development of a calibration procedure. A user can have several rule sets describing selection of calibration points for particular functions. For details see the section “Wizard rules”.

**Selected Instruments** – a list of instruments for calibration performance.

**To Add** – it will add another item into the list of instruments.

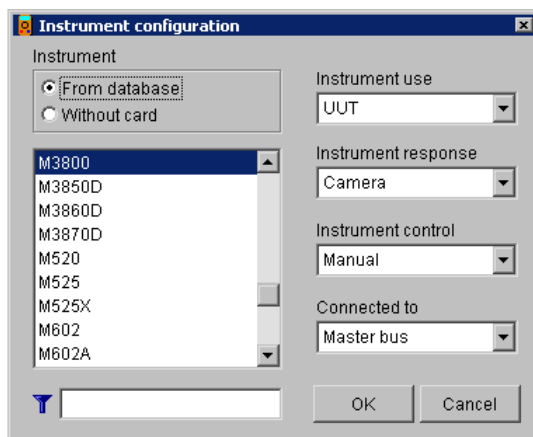
**To Remove** – it will remove an item from the list of instruments.

**OK** – it will finish the wizard and transfer selected functions, ranges and values into the procedure.

**Cancel** – operation of the wizard will be finished.

Respect the following process for procedure development:

- a) **Step 1 – Instrument Selection.** Write text determination of created methodology into



„**Procedure Name**“-window. Mostly it shall be a type of a checked instrument, e.g. M3800 for the multi-meter Metex 3800 type. Maximal number of characters is 12. **Wizard Rules** are to be remained on „default“. If some other development regulations for calibration points are required, they can be selected. Mostly different rules are used for check of sources or decades. The rules

denominated as „default“ are intended usually for tests of multi-meters. Set instruments, which are to be used for calibration, into „Selected **Instruments**“- listbox. Firstly set an

instrument under test (UUT), select it from the database and assign a function (“Instrument use”) and control method (“Instrument response” - Measuring by means of, “Instrument control” - Adjustment by means of) for it. The same way is to be used for selection of other instruments (Source, Standard). Converters, switches and instruments to be connected behind converters cannot be written down among selected instruments, they must be set by editing of the procedure itself. If the wizard is being used, there is no possible to select from “Connected to” – field. There is a fixed selected item “Master Bus” here. The master bus is a signal bus (functions, ranges and values) valid for the UUT. For procedure development, the instrument under test (UUT) is the most important one and it must be set as the only one. Selection of functions, ranges and calibration points is being performed according to the UUT. At other instruments (Standards and Sources) must be only checked if their measurement (generation) abilities are suitable for test of the given instrument. If there is no “Instrument Card” for the required instrument, it shall be created. For details see the section “Instrument Card Module”. “Function” – page having activated, switch to the next step.

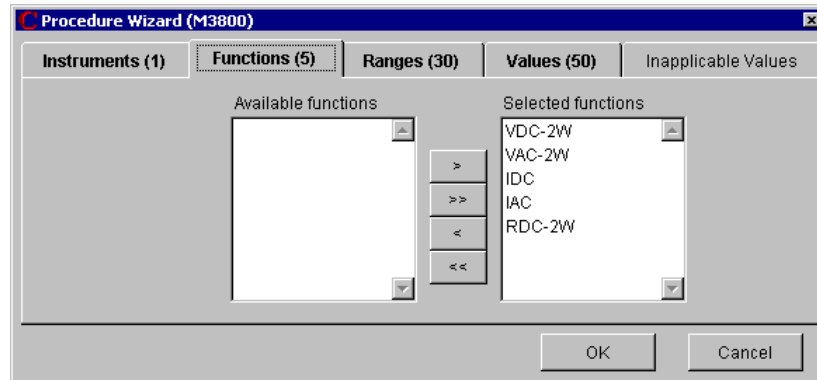
*Note: Only instruments with their created cards can be used for generation of a new procedure, except for the instrument under test for which can be created a procedure without its instrument card. The performed calibration record does not contain any evaluation and there are only deviation and uncertainty in each of the test report's lines. Fields for allowed deviation and specifications*

The screenshot shows the 'Instrument configuration' dialog box. It has two main columns. The left column contains 'Instrument' with radio buttons for 'From database' and 'Without card' (selected), 'Instrument name' with a text box containing 'MT520', and an unchecked checkbox for 'Analog meter'. The right column contains 'Instrument use' with a dropdown menu showing 'UUT', 'Instrument response' with a dropdown menu showing 'Manual', 'Instrument control' with a dropdown menu showing 'Manual', and 'Connected to' with a dropdown menu showing 'Master bus'. At the bottom right are 'OK' and 'Cancel' buttons.

*percentages are blank. The procedure generation is not performed automatically in such a case and checked functions, ranges and points must be set. Procedure development without instrument cards represents only an emergency solution suitable rather for quick check of basic functions of a unit under test but not for the calibration itself.*

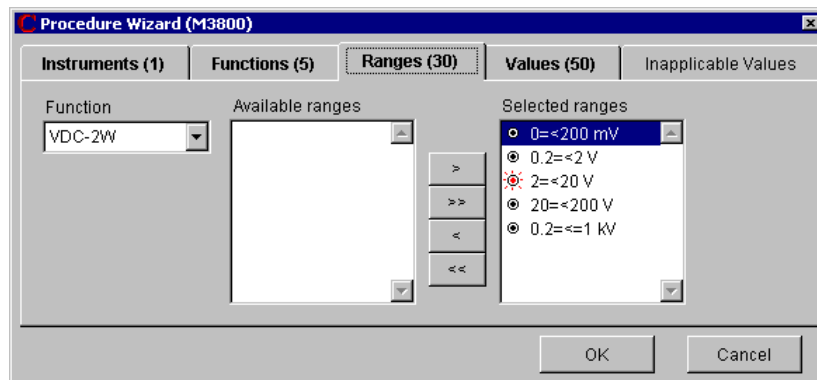
*If we set the instrument of “Without the instrument Card” it shall be necessary to write down only its name and to select its position. Other steps must be performed manually (selection of functions, ranges and points).*

- b) **Step 2 – Function Selection.** The wizard shall propose functions that shall be contained

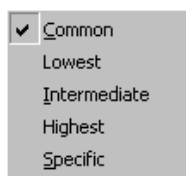


in a procedure. By means of arrows for shift of one item ( >, < ), eventually of all items ( >>, << ), number of selected functions can be reduced. Functions which are not defined in Instrument card of the UUT cannot be used for the procedure. “Ranges” – page having activated, switch to the next step.

- c) **Step 3 – Range Selection.** The wizard shall propose functions that shall be contained in a



procedure. The “Range Type” shall be assigned for each of ranges (it is only for automatic composition of calibration procedures – see below). According to the “Range Type” and the selected “Wizard Rules”, calibration points are specified in the next step. The “Range Type” can be modified. Press the right mouse button above the selected range. There are following types to be selected:



**Common** – the range without special status (= it is neither lowest nor highest, nor intermediate or specific).

**Lowest**– the lowest range.

**Intermediate** – the range situated in the middle. Each of the functions contains only one range. If number of ranges is even a higher range is observed as the intermediate one.

**Highest** – the highest range.

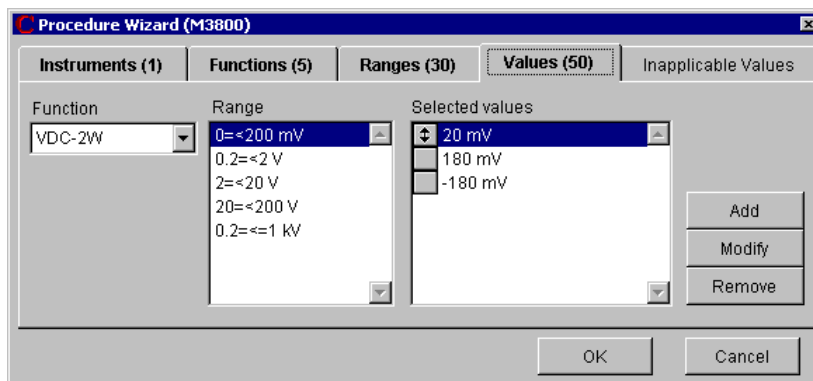
**Specific** – it is a range which value is situated within fix defined period of particular magnitude (e.g. a voltage higher than 200 V, etc.).

„Common“ and „Specific“ range types can be contained many times in one function, „Lowest“, „Intermediate“ and „Highest“ only once.

Point generation rules cannot be defined for every range types. If it is not defined a particular range type for some functions it shall be suppressed in the menu (i.e. it cannot be selected). On the contrary, for every function specific ranges can be defined (e.g. higher than 2 A, etc.). If there is such a definition, it shall be displayed in the range type menu. Number of ranges selected for instrument check up can be reduced by means of arrows for one item shift ( >, < ) or for all items shift ( >>, << ). The ranges not defined in the UUT instrument card cannot be added into a procedure. Also it is not possible to add range types which are not defined in the “Wizard Rules”. For more detail see the section “Wizard Rules Module”. “Values” – page having activated, switch to the next step.

*Note: Range types correspond with specification according to the EA 10/15 document describing the digital multi-meter test methodology.*

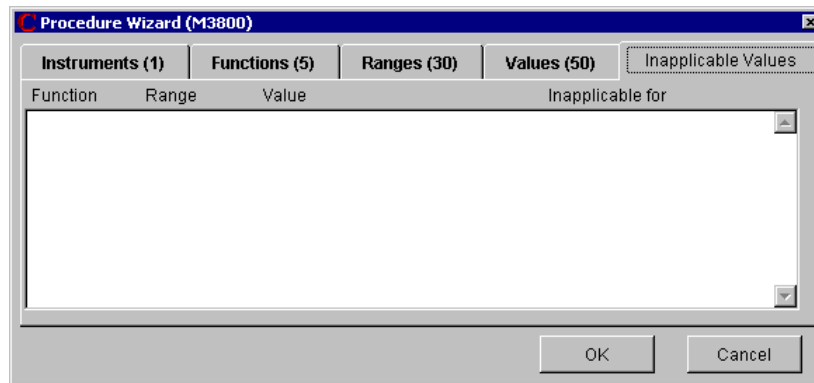
d) **Step 4 – Value Selection.** The wizard shall propose calibration points for each of the



ranges and functions contained in a procedure according to the “Range Type” and selected “Wizard Rules”. In terms of ranges there shall be possible to change particular point sequence, change the points, reduced or added them. By means of step-by step selection of particular “Functions” and “Ranges” it is possible to check all the points. “Inapplicable values” – page having activated, switch to the next step.



- e) **Step 5 – Inapplicable values (Disagreements).** Finally the wizard shall write a list of



values which are not able to be set on some of the used instruments. If this list is not blank, it will be possible to return to some of the previous steps to correct these values. If the procedure is finished with not permitted values for some instruments, some difficulties may occur during program run. Press the “OK” key to create a calibration procedure for the instrument under test. This procedure can be saved by means of the “Save” or “Save As” keys. In the WinQbase environment it will be sufficient to finish only the Caliber program. In this way, automatic transfer of the created procedure into database environment shall be performed.


**Notes:**

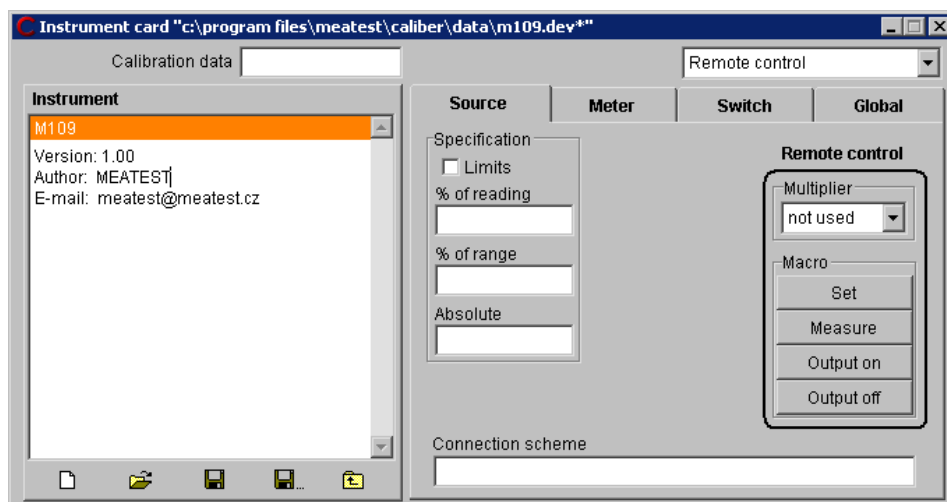
*The wizard for procedure development is the only one way how to create a new procedure. However, if a procedure is already developed, it can be changed interactively. We can add and remove particular functions, ranges and calibration points.*

*The wizard represents a very easy and quick way of new procedure creating. However, it doesn't make possible to perform some special combinations, e.g. changing of instruments during the calibration. Such changes are to be performed additionally within the created procedure.*

*You can exit the wizard by pressing the OK key already in the first step after set a procedure name and instrument selection. The particular calibration points can be additionally written in the manual mode.*

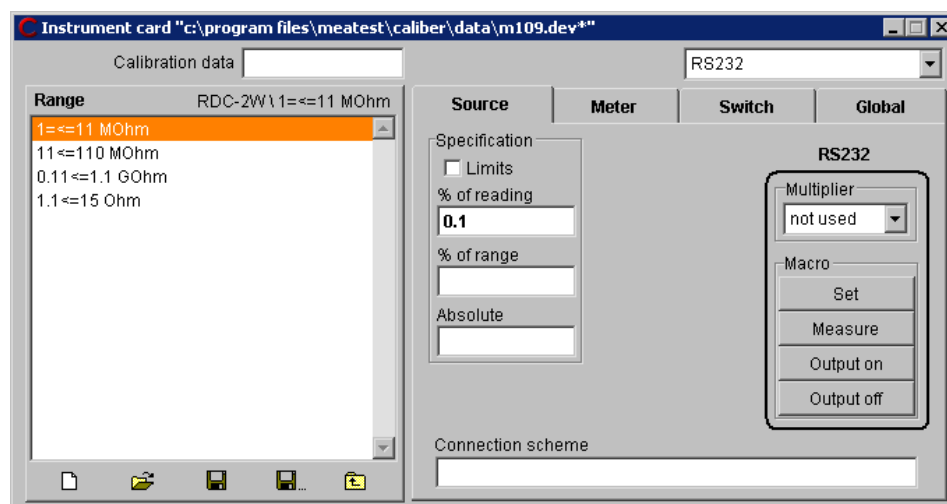
#### 1.4.4. Instrument Card Development (Decade MEATEST M109)

Start the “Instrument Cards” module in the „Caliber“ program (the “Window” menu in the upper menu bar, the “Instrument Card” item). Press the “New” button (  ) in the lower bar of the Status Window and set M109 name.



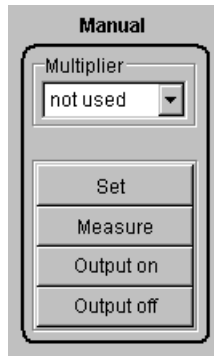
Set the mouse on „M109“ bar in the status window with “Instrument” name and by double mouse click switch the status window on the “Function” level. Press the right mouse button to add RDC-2W function. Switch to the “Ranges” level and add four ranges of the instrument and their specification according to the M109 specification. The ranges must be always set in basic units (V, A,  $\Omega$ , Hz etc.).

Press the “Back” key in the lower bar of the status window to return to the “Instrument” basic level and add the connection of “H,L” input terminals. A part of the card describing



metrological properties of the instrument is finished. There is necessary to add way of control only.

For decades without remote control, select “Manual” control mode in the upper bar.

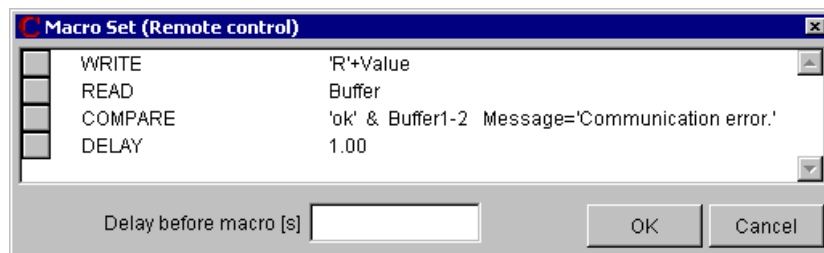


The „Set“ option is to be in the implicit “Automatic” position. Each time decade value is changed, an operator shall be prompted to set the instrument.

Switch the „Measure“ option to the “Nominal value” position. The program supposes that a value set on the decade is the required one.

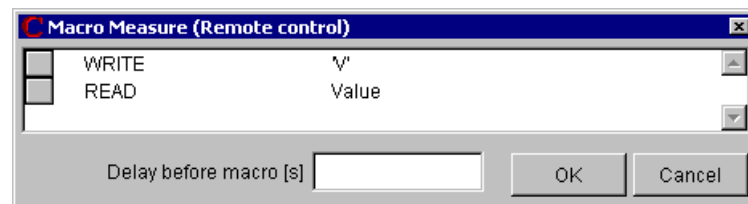
Switch „Output on“ and „Output off“ options to “None” position.


The M109 can be controlled by means of the RS232 bus. Select the “Remote control” type in the upper bar. All these settings shall be performed on the “Instrument” basic level because they shall be valid for each of the functions and ranges. The decade uses the MΩ units for RS232 bus communication, because of it set the multiplier to „mega“. The “Set” and “Measure” macros are to be filled according to the commands for decade control. The “Set” macro consists of a value record by the “R” command + value, counting of decade’s response. If there is the “ok” response, a 1 sec delay shall follow for value fixation. If the response is not „ok“, the program shall interrupt with




„Communication error“ message.

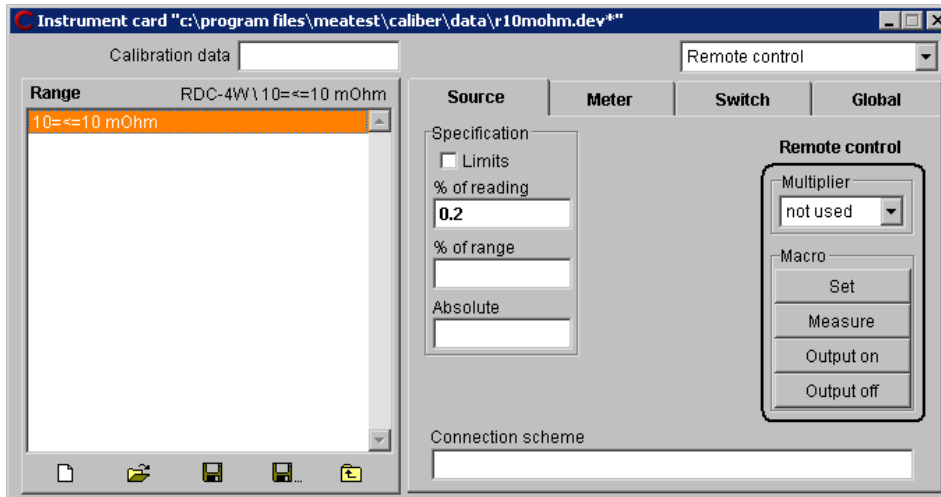
The „Measure“ macro consists of the „V“ command record (value counting requirement) and of set value counting.



Press the “Save” button (  ), in the upper bar of the status window and set the name to the instrument card.

### 1.4.5. Instrument Card Development (Resistance 10 mΩ)

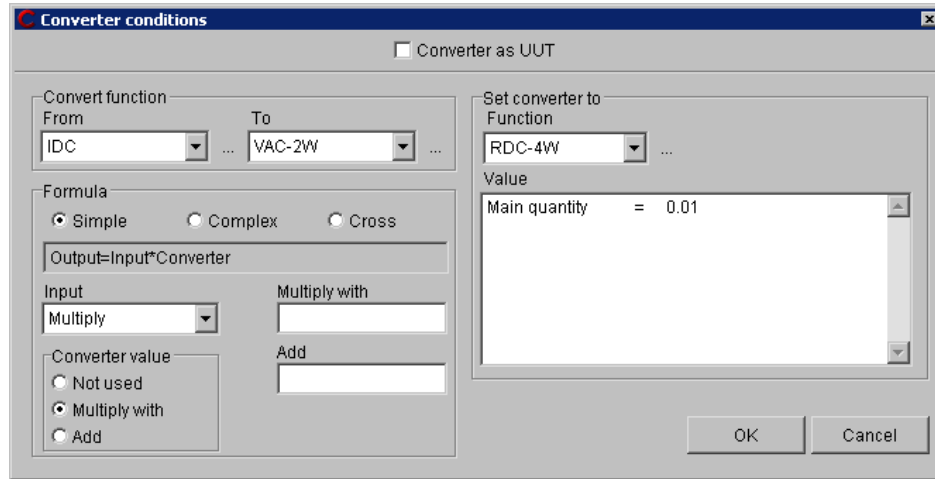
Start the “Instrument Cards” module in the „Caliber“ program (the “Window” menu in the upper menu bar, the “Instrument Card” item). Press the “New” button (  ) in the lower bar of the Status Window and set R10MOHM name (the program doesn’t differ small and capital letters in the name).




The resistance can be used as a source of 10 mΩ value and also as a current/voltage converter with 0.01 Ω conversion constant. Both those characteristics can be described in one instrument card. Resistance use depends on its source or transducer function.

Set the mouse on the „R10MOHM“ bar in the “Instrument” status window and switch the status window to the “Function” level by double mouse click. Press the right mouse button to add RDC-4W function and also RAC-4W function if alternating quantity of the resistance is known. Switch to the “Ranges” level and add a range from 0.01 to 0.01 for both the functions. Switch to „Frequency“ in alternating range and set a frequency range (e.g. 40 Hz - 80 Hz). Set the Allowed deviation limit resistance in the specification window. Add terminal description in the “Connection scheme” field (e.g. Hu,Hi,Li,Lu). Switch the control to “Manual” and the cards to “Settings”. Switch the „Output on“ and „Output off“ to “None”, the “Measure” panel switch to the “Fixed value” and set it into the particular field. If the value changes after re-calibration, it can be overwritten here. Hereby the part of the card describing the 10 mΩ source has been finished.

Now it is necessary to describe resistance's properties for the current/voltage converter function. Switch to "Global" page in the instrument card. Press the right mouse button in the "Converter Conditions" listbox and select "Add". Fill up the displayed window according to the figure.

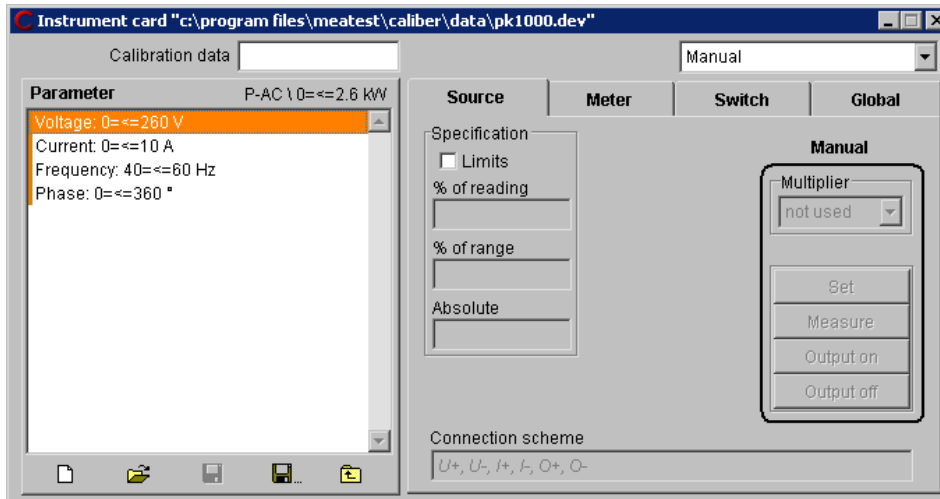


The converter shall convert the IDC function to VDC-2W one. It itself shall be set to the RDC-4W function with nominal value of 0.01. The function and value, which the converter has been set to, are significant for transfer calculation and measuring uncertainty. However the nominal value will not be used for real calculation but the measured one (it can be affected in the "Source" page in the "Measure" panel – there shall be set the "Fixed value" in our case).

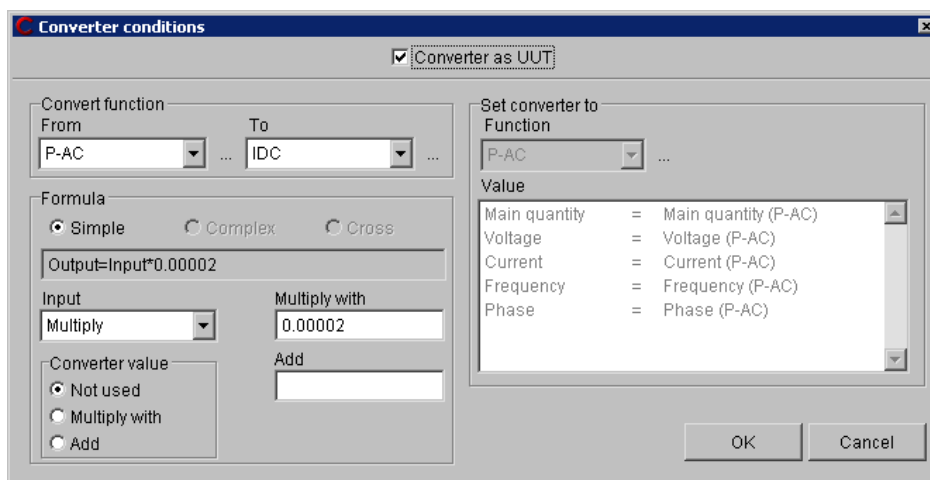
Press the "Save" button (  ) in the lower bar of the Status window, set a name and the instrument card shall be saved.

### 1.4.6. Power Converter Instrument Card Development

There is a real converter for single phase power conversion to DC current. By such a way developed card can be also used for converter check, i.e. the instrument can be configured as the UUT converter.



Let's create a new instrument card called „PK1000“. We set “Connection scheme” in general for the whole instrument, i.e. „U+,U-,I+,I-,O+,O-“, (U – input potential terminals, I – input current terminals, O – output current terminals). Set a new function in the „P-AC“ source mode. Let's create the 0=2600W range. The 2600W value has been obtained according to maximal permissible parameters of the converter (260V, 10A). The range is only one because the „P-AC“ function is multi-parametric one. Set a converter's specification valid for this range, i.e. „Absolute Error =1W“. If this error cannot be specified in the instrument card, it will be not filled, however shall be set for procedure development. Now let's create particular parameter ranges, i.e. for voltage 0=260V, for current 0=10A, for frequency 40=60Hz, for phase 0=360°. Now set the converter's conditions in the instrument card in the “Global” page according to the following figure:

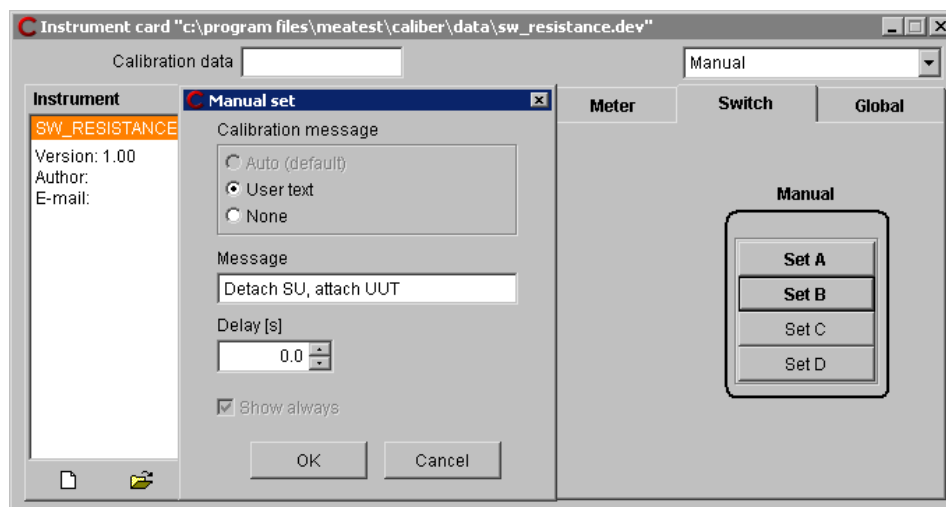


Firstly check the “Converter as UUT” field. In that way the converter’s parameters shall be set in order to use the converter as the UUT. The converter shall convert power (PAC) to current (IDC) and a converting multiplying constant is to be written down into the “Add” field. The converter value shall not be added to the formula. The converter is to be set to the same function as the input converter function. The converter value must stay as being set automatically by the program (the whole right part of the panel). It is the basic condition of converter’s usage as a UUT.

The card shall be used only in the manual mode. A “Manual” panel shall be set to the “Calibration message” and “None” options. The instrument shall not be set any way, i.e. no setting shall be made during calibration. Herewith the instrument card is finished.

### 1.4.7. Switch Instrument Card Development

There is a simple switch card for switching of terminals in the middle of a calibration point. It can be used for calibration of resistance ranges of a checked measuring instrument by means of an standard measuring instrument, if it is not possible to connect both of the measuring instruments at the same time, i.e. firstly the measurement shall be performed by means of the standard and then by the UUT measuring instrument. The card is developed for manual control (there is not a real instrument), but if it is a real switch with remote control ability it shall be suitable do add a remote control. The measurement mode is to be adapted to use the card during the procedure. A practical example for usage of the switch – see Procedure development for a resistance meter.



- Start the “Instrument Cards” module (the “Window” menu in the upper menu bar, the “Instrument Card” item). Press the “New” button in the lower bar of the Status Window and set the SW\_RESISTANCE name.
- Now select the “Manual” communication type.
- Select the “Switch” page in the card window.
- Set to the manual Set A option. As "Calibration message" select the “User Text”. Write “Detach UUT, attach Standard” into the “Message” field.
- Set to the Manual Set B option. As "Calibration message" select the “User Text”. Write “Detach Standard, attach UUT” into the “Message” field.
- Press the “Save” button in the lower bar of the Status window to finish the card.



#### 1.4.8. Resistance Meter Procedure Development

There is a test of a resistance meter by means of a standard measuring instrument and an auxiliary source. In such a case there is not possible to connect the checked measuring instrument and the standard at the same time, because they themselves are generating current and measurement results will be nonsense because it. The measurement must be made on the standard first and then on the UUT. The instruments shall be switched among each other. There is possible to use the "Switch" instrument for that purpose, which has already been created. There is only a shortened demonstrative procedure to understand the program features.

- Start the "Procedure" module in the „Caliber“ program. Press the "New" button in the lower bar of the Status window to start the Procedure wizard.
- Write KE2000R in the "Procedure name" window. Select instruments for the calibration. Press the "Add" key. From the list select the KE2000 instrument, an instrument position use to „UUT“, instrument response and control set to „Manual“, connected to the "Master bus" and press the „OK“ key. Press the "Add" key. From the list select the DAT1281 instrument, an instrument use set to „UUT“, instrument response and control set to „Manual“, connected to the "Master bus" and press the „OK“ key. Press the "Add" key again, select the M602 decade, a instrument use set to „Source“, instrument response and control set to „Manual“, connected to the "Master bus" and press the „OK“ key. If one of the instruments is available, it can be selected way of communication along the bus.
- Start the "Functions" page to come to the next step – Function selection. Firstly shall be removed all functions from the selection by means of the "<<" key. Then select the RDC-2W function from the left column of "Functions available" and by means of the ">" key transfer it into the "Selected functions" list as the only one controlled function.
- Start the "Ranges" page to come to the next step – Range selection. The wizard shall automatically propose all the ranges being defined in the KE2000 card and assign a range type for them. The range types are defined according to "Wizard Rules". The 1.2MOhm, 12MOhm and 120MOhm ranges shall be removed because they cannot be set on the source.
- Start the "Values" page to come to the next step – Value selection. The wizard shall automatically propose calibration points according to the "Wizard Rules". The calibration points can be added, removed, eventually adapted.
- Start the last "Inapplicable values" page to come to the next step – Inapplicable values. There are values displayed here that cannot be set at any of the instruments. If the list is not blank, it is possible to come back into the "Values" page and to remove those points eventually to change them.
- Press the „OK“ key to create a calibration procedure for the UUT.

- Now we are in the procedure module again and all settings shall be performed on the whole procedure level, i.e. there shall be selected the "Procedure" level in the Status window.

- Let's add a switch instrument into instrument scheme. Click with the right mouse button on the instrument scheme window and select the "Add Instrument" item from the menu. The "Instrument configuration" panel will appear. Select an instrument from the "SW\_RESISTANCE" database, set Instrument use to "Switch", Instrument response to "Manual", Instrument control to "Manual", Connected to "Master bus". Confirm it by "OK". The instrument appears in the instrument scheme. By means of the mouse it is possible to move the instrument to any place in the scheme in order to be well-arranged.

- Now the Measurement mode shall to be changed to exert the switch function. In the procedure status window click by the right mouse button on the procedure name, select the "Measurement mode" item from the menu. The "Measurement mode" panel appears. Firstly there shall be secured that the measuring on the standard is being performed in one step, not in two ones. Click by the right mouse button on the "Second half measure" item by the standards and select the "Remove" item from the menu. Click by the right mouse button on the "First half measure" item by the standards and select the "Modify" item and change to the "Measure" item. Now add an operation for terminal switching between the UUT and the Standard. Click by the right mouse button on the action list, select the item "Add" from the menu. The "Measurement mode Action" panel appears. From the instrument field select "Switches", from the Action field select "Set B", from the condition field select "None". Press the "OK" key to confirm. The operation appears at the end of the task list. Transfer it among the "Measure" operations on the UUT and "Measure" operations on the Standard. Now adjust loops for unstable measurements, it will not be one loop but two ones, particularly for the UUT and the Standard in order not be necessary to switch the terminals permanently if one of the measuring instruments is unstable. Click by the right mouse button on the "Measure" action at the standard and select the "Begin of Measure loop" item. Click by the right mouse button again and select the "End of Measure loop" item. Click by the right mouse button on the "Measure" action at the UUT and select the "Begin of Measure loop" item. Click by the right mouse button again and select the "End of Measure loop" item. Press the "OK" button to confirm.

*Note: Remember that the Caliber program shall not display the "Connection scheme" window when the switch is being used. If you want to display this window, it shall be selected the "Enable" item in the "Connection scheme" field in the "Measurement Mode" panel.*

- Press the "Save" button in the lower bar of the procedure status window. The procedure is herewith finished and it can be started by the "Run Calibration" button. Since all the instruments are in manual mode, the instruments cannot be present at calibration start, i.e. the calibration can be only "simulated".

#### 1.4.9. Power Converter Procedure Development

There is a test of single-phase power converter to direct current. In similar way there is possible to perform test of any converters. For that purpose (the converter represents an UTT), two standards are necessary. One of them shall be in the converter's input, another one in output (direct current measurement). The value in the converter's input is considered as a standard value in terms of the Caliber program, the value in the converter's output as an UUT value. The input converter's value is the main value, i.e. its function, range and value is the same as a function, a range and a value in the test report. The value in the converter's output is direct current in our case, but for program's purpose is back converted into power. Despite of the fact that the value of the standard measuring instrument in the converter's output is being considered as the UUT value, the uncertainty of this measuring instrument is considered as standard's uncertainty along with uncertainty of the standard in the converter's input. The M140 calibrator shall be used as a source and a standard in the converter's input at the same time. As a standard in the converter's output the multi-meter of Datron 1281 shall be used. The PK1000 shall be used as a converter (creating procedure is a part of this manual). There is a shortened demonstrative procedure to understand program's features.

- Start the "Procedure" module in the „Caliber“ program. Press the "New" button in the lower bar of the Status window to start the Procedure wizard.
- Write PK1000x in the "Procedure name" window. Select instruments for the calibration. Press the "Add" key. From the list select the PK1000 instrument, an instrument use set to „UUT & Converter“, instrument response and control set to „Manual“, connected to the "Master bus" and press the „OK“ key. Press the "Add" key. Select the M140 calibrator, an instrument use set to „Standard & Source“, instrument response and control set to „Manual“, connected to the "Master bus" and press the „OK“ key. We don't add any other instruments at this moment.
- Start the "Functions" page to come to the next step – Function selection. The wizard shall automatically propose functions contained in the "Instrument card" of PK1000 which were not used in the procedure so far. The instrument contains only one P-AC function which shall stay.
- Start the "Ranges" page to come to the next step – Range selection. The wizard shall automatically propose all the ranges being defined in the PK1000 card and assign a range type for them. The instrument contains only one 2.6 kW range which shall stay. Because the power converter uses a more-parametric function (P-AC), it is only one range in the instrument card. However number of ranges in the procedure can be higher. There must be a condition fulfilled that any of the ranges cannot exceed the limits of the basic range (0 to 2.6 kW in our case). The ranges cannot be added in the wizard but in the following adaptation of the procedure.

- Start the "Values" page to come to the next step – Value selection. The wizard shall not create any values. For more-parametric functions there are no "Wizard Rules" and the values shall be created manually. Press the "Add" button to add one calibration point and set the power value of 0.4kW and particular parameters: Voltage=200V, Current=2A, Frequency=50Hz, Phase=0°. Press the "OK" button to confirm.
- Inapplicable Values of calibration points cannot be checked by means of the wizard, because it doesn't support the more-parametric functions.
- Press the „OK“ key to finish the wizard and to come into the procedure module.
- Now add a standard measuring instrument into the converter's output in the "Instrument scheme". Click by the right mouse button on any spot in the "Instrument scheme" window to open a menu. Select the "Add Instrument" item. The instrument configuration panel appears. Select the "Dat1281", set Instrument use to "Standard", Instrument response and Instrument control to "Manual" (eventually GPIB or RS232 if you have a multi-meter), connected to "PK1000". Press the "OK" button to confirm. By means of the mouse it is possible to move the instrument to any place in the scheme in order to be well-arranged.
- Now must be set uncertainties of the standard calibration source of M140 for each of calibration points, because these values are not contained in the instrument card. Set the value level in the procedure status window and select a calibration point for which the precision shall be set. Click by the right mouse button to open a menu from which select the "Evaluation" item. The "Evaluation" panel will appear, in which values and uncertainties of the UUT and Standard can be changed. From the list select the "Standard accuracy (Dmax\_s) [W]" item and press the "Modify" button. The „Evaluation formula" panel appears. By means of numeric keys set the "0.288W" value, which is accuracy of the M140 calibrator for the 400W value (at parameters of 200V, 2A, 50Hz, PF=1). Confirm it by the "OK" button and return to the "Evaluation" panel. Press the "OK" button again to return to the Procedure module. If the procedure contains more calibration points, this setting shall be done for all the calibration points.
- Press the "Save" button in the lower bar of the procedure status window to save the procedure which can be started by the "Run Calibration" button now. Despite that we don't have any of the used instruments, there is possible to try the procedure if every instruments are in the manual mode. During the calibration, the Caliber program shall ask for value of the standard multi-meter Datron 1281 and there is expected the 0.00308A value for the 400W value, which is to be set.

## ***1.5. Practical Calibration Instructions***

### **1.5.1. Measuring Circuitry**

Correct ways of measuring circuitry are to be respected when accurate multi-meters with accuracy more than 0.005% are being used as standard instruments, e.g. DATRON 1281, HP 3458.

#### Ground Connection of the Measuring Circuitry

When a calibrator and one or more multi-meters are connected among each other, there is always a risk of “ground loops”. These loops are constituted by connections of measuring terminals along with connections of supply cables with power networks. Through the ground loops high currents can flow, usually the alternating and synchronous ones with the first or second harmonic component of power supply current. Presence of these currents is being expressed itself as data instability on the tested measuring instrument. This instability is mainly evident in alternating ranges for frequencies of 50, 100, 200, 400 Hz, also for power network frequency multiples. For higher frequencies of measuring signals this instability is not practically significant. The instability will cause a comparatively slow and regular fluctuation of signal amplitude. The beat frequency is determined by difference between the power supply frequency and the frequency of the calibrator’s signal.

Effects of the ground loops can be eliminated by following steps:

- a) All the ground outlets must be connected in one point, the best is in a Lo terminal of calibrators (star connection). Calibration must not be performed with no-grounded measuring circuits.
- b) Main supplies of the calibrator of the control computer and both of the multi-meters must be connected with one supply list or with a main supply socket.
- c) If above mentioned measurements prove ad little sufficient ones, a low frequency toroid choke can be connected in the main supply inlet of the calibrator or the multi-meter. The choke can be made by winding of a few turns of a supply cord on a permalloy core of 7 – 10 cm diameter.
- d) Finally, if network interferences ere too big, their effect can be reduced by calibration performance at non-harmonic multiplies of the main supply frequency, e.g. 60, 120 Hz (only for calibrations of alternating voltage and current ranges).

### **1.5.2. Voltage Range Calibration**

The most practically way for the voltage range calibration is the connecting of multi-meters directly with calibrator’s input terminals. Mainly for low voltage calibrations, when it is necessary to perform comparison with uncertainty of hundredths of nV to units of  $\mu\text{V}$ , it shall be used cupper wires with gilded terminations soldered with low-thermal solders. We neither unnecessarily touch input and output terminals nor allow local warming of some parts

of measuring circuitries (e.g. by ventilators, heat radiators, etc). Having connected them, we will wait till a thermal voltage get stabilized and balanced. For extremely accurate measurements of low voltages it shall be better to connect input terminals of the standard multi-meter with input terminals of the multi-meter under test, which way is also very suitable if the multi-meter under test possess a lower input resistance. The connection of the standard multi-meter is being equivalent to the four-terminal connection of the calibrator.

If the 10, 100 mV range of the calibrator is used, it is necessary to take into consideration that output resistances of some calibrators can be 50 - 100  $\Omega$  and they cannot be loaded.

### 1.5.3. Current Range Calibration

#### *Calibration for Low Alternating Currents*

For calibration of low current ranges there can be considered that each capacity connected parallel to input terminals of a measuring instrument (and also a capacity of the used calibrator) represents an alternating shunt. Part of the calibrated current generated by the calibrator is running out off the connected measuring instrument and is running through this shunt. The value of this stray current is being proportional to the load voltage and it depends on the measuring instrument (on its input impedance) and on the measuring frequency. Free laid shorter wires are as the most suitable for connection of both of the multi-meters and the calibrators. Coaxial cables are completely unsuitable for this purpose.

#### *Calibration for Heavy Currents*

For calibration of the 1 and 10 A (100A at M-150S) current ranges there is necessary to connect together a calibrator and a multi-meter under test with sufficient strong cables. At all the connection through which currents are running is more suitable to tighten wires under terminals in order to reduce contact resistances.

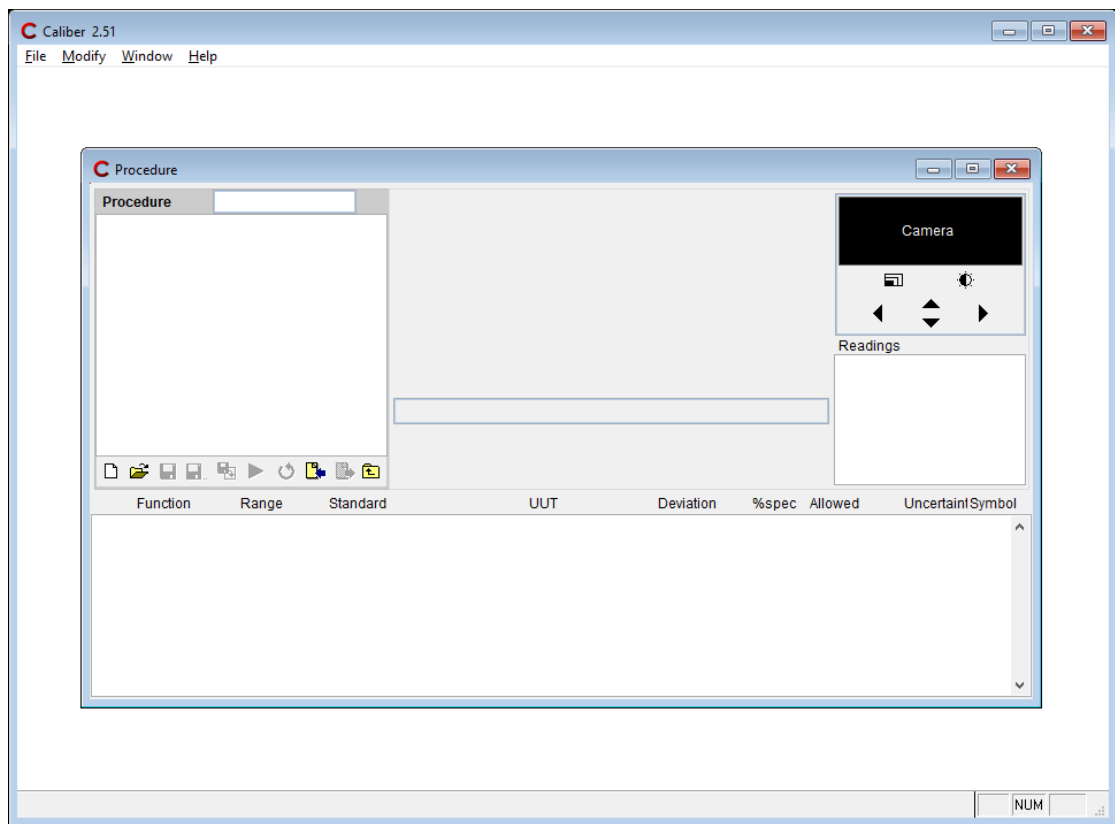
#### **WARNING!**

Most of the portable multi-meters have their maximal input current of 2 A. Their connection with calibrators with adjusted input currents higher than 2 A can result in multi-meter's damage. The only way of using a standard multi-meter for a calibration consists in usage of a precise and properly sized shunt.

## 2. Detailed Program Description

The „Caliber“ program represents a program system to perform measuring instrument calibrations automatically. It can be used independently or along with the WinQbase program for registration of measuring instruments and their calibration. The program can be incorporated into the WinQbase by setting of command and measuring file name for the „Caliber“ – more details see the WinQbase-manual, section of „Measuring instrument groups“. In that manual there is described program's behavior by its independent usage because it is the only way of describing of all its features. During program's run under the WinQbase system, the registration program takes over some of its functions.

The program having started, a basic screen appears:



The screen consists of three following parts:

1. The upper menu program bar (it contains menus for module selection, editing functions and help).
2. The program desktop (it displays active windows of the program – modules – after the start the “Procedure” module).
3. The lower information line (it displays information about a selected object, program operation and keyboard status).

A required activity can be started by click (press the left mouse button) on a selected object. Program control is intuitive one with common custom practice of the WINDOWS.

In the lower information line the program will automatically display the help for the selected object. In addition to, at some objects a description shall be displayed next to the mouse cursor. The displaying can be switched off in the menu bar from the “Help” menu (the “Show tooltips” item).

### Upper Menu Bar

**File** **Exit** shall finish program operation.

File	Exit
------	------

Modify	
<u>U</u> ndo	Ctrl+Z
<u>R</u> edo	Ctrl+R
<u>C</u> ut	Ctrl+X
<u>C</u> opy	Ctrl+C
<u>P</u> aste	Ctrl+V
S <u>e</u> lect all	Ctrl+A
<u>F</u> ind...	Ctrl+F
<u>R</u> eplace...	Ctrl+L
C <u>o</u> nfiguration...	Ctrl+O

**U**ndo shall cancel the last performed activity.

**R**edo shall perform the last cancelled activity.

**C**ut shall remove the designed text and save it in memory.

**C**opy shall copy the designed text in memory.

**P**aste shall insert the last in memory saved text in place of the cursor.

**S**elect all shall design the whole text as a block.

**F**ind... allow searching in the displayed text.

**R**eplace... allow automatic changes in the designed text.

**C**onfiguration... global program settings

Window
<u>P</u> rocedures
<u>I</u> nstrument cards
<u>U</u> ser functions
<u>W</u> izard rules

**P**rocedures It is a module for work with calibration procedures (calibrations, modifications and creations of calibration procedures).

**I**nstrument cards It is a module for work with instrument definitions (instrument features as functions, ranges, specifications, way of controls).

**U**ser functions It is an auxiliary module for work with functions (new function development, modifications of existing ones).

**W**izard rules It is an auxiliary module for definitions of rules used for development of calibration procedures by the program.

Help
<u>C</u> aliber help F1
<input checked="" type="checkbox"/> <u>S</u> how tooltips
<u>A</u> bout Caliber

**C**aliber help F1 shall display the help content of the Caliber program.

**S**how tooltips shall prohibit or permit displaying of short prompt instructions at buttons during mouse cursor movements.

**A**bout Caliber shall display information about the program and allows program registration.



## 2.1. “Procedure“ Module


It is intended for calibration performances in terms of prepared calibration procedures (methodologies). Except calibrations it makes possible developments, modifications and testing of calibration procedures.

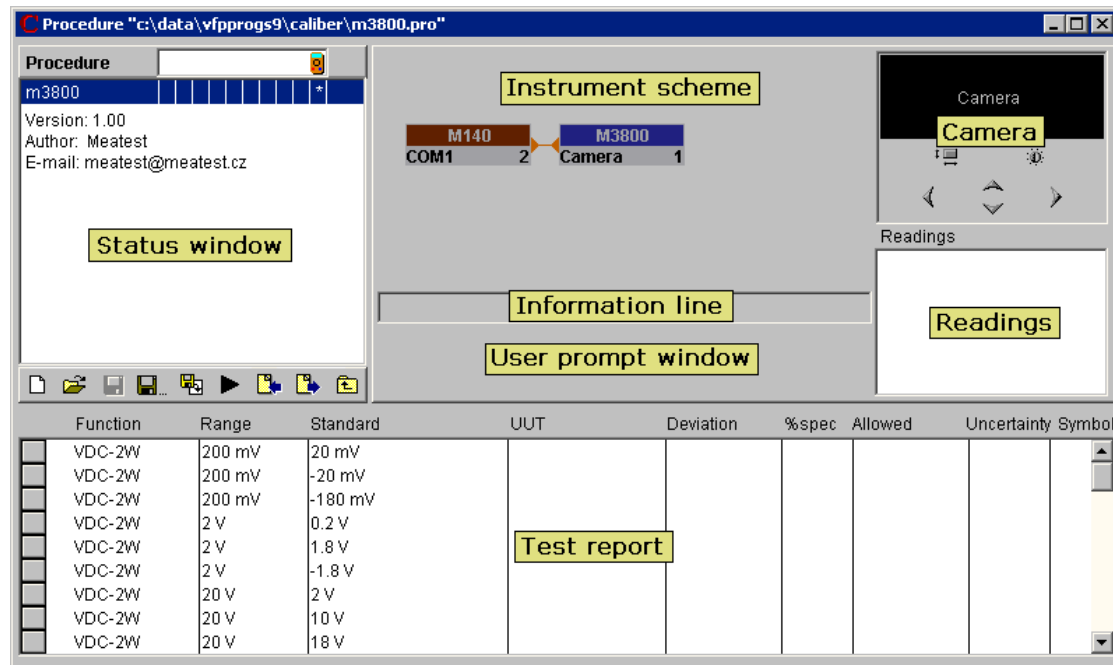
The calibration procedure determines functions being checked, ranges and points, instruments used to calibrations and way of instrument connections. Features of those instruments as way of control, specifications, allowed value ranges are determined by so called instrument cards.

The “procedure” module performs all the control operations, measurement evaluations, uncertainty calculations and generation of calibration protocols. During measuring of an instrument under test there can be possible to set required information, to stop the program, to skip check of functions, of ranges or points, eventually it is possible to insert points at which the procedure performance shall be stopped. There is also possible to change sequences of checked points, uncertainty calculations, numbers of measures, eventually instruments used in the calibration.

The program shall be controlled by means of a mouse or by setting of required values from a keyboard. The calibration can be stopped by pressing the „ESC“ key.

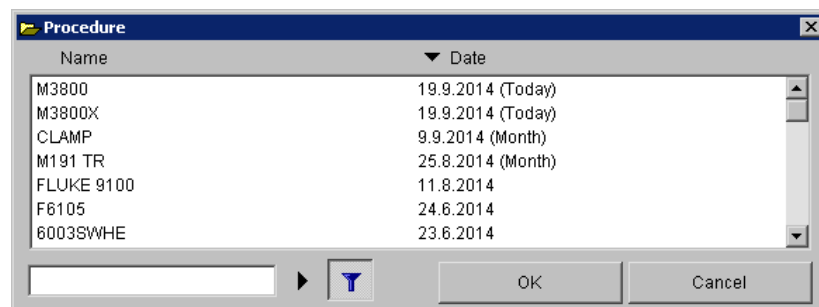
### 2.1.1. Screen Description of the “Procedure” Module



The procedure module having opened and the M3800 methodology having loaded (press the  „Open“ key and select the M3800 methodology, which represents a standard delivery part) the following panel shall appear:



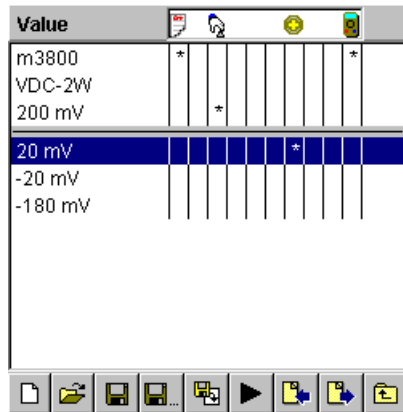
There is a *Status window* in the upper corner. It displays the procedure structure (hierarchy) – procedure -> function -> ranges -> calibration points. In the middle part of the panel there is an *Instrument scheme* displayed – instruments used for the calibration and their configuration. In a *Camera* window there is displayed a running video from the camera (if a camera scanning is used), control keys for picture shift, resolution adjustment (zoom) and external condition adjustment (brightness, contrast, etc.). There is an *Information line* below the instruments which describes just performed operation during the calibration. Below the information line there is displayed *User prompt window*. In the right *Readings* window there are displayed particular measured values. In the upper half of the screen there is a *Test report* displayed with all the calibration points which is being continuously supplemented during the calibration. The test report contains the calibration point under the sequence of their performance.

**Open dialog** – for opening documents it is used following dialog. This dialog supports



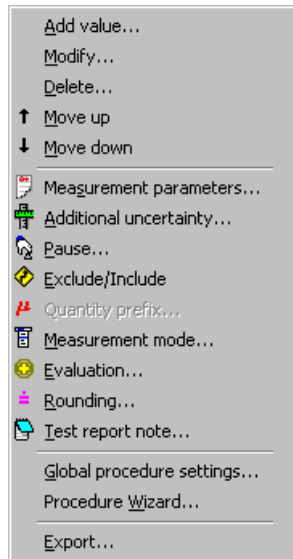
sorting by name and by date (not supported under WinQbase system). There is also possible to lookup  or/and filter  the document titles.

### Status Window



It is intended for displaying of tested functions, ranges or points of an instrument under calibration according to the displayed hierarchy level. The window's hierarchy is: Procedure->Function->Range->Value. The procedure has the highest hierarchy level, the value the lowest one. Click with the mouse on the procedure name (usually the name of an instrument under test) shall perform switch the display to checked functions. Click on a selected function shall display ranges of this function and further is possible to go to particular check points. The button with symbol is intended for back movements. During transition to lower hierarchy level there shall be also displayed contents of the superior level and contents of the actual level is separated by a horizontal line. If the "Value" level is selected, there shall be a "procedure name" in the first line, a "function name" in the second one, a "range" in the third one, after it a separator follows along with all the values belonged to the calibration range. The actual hierarchy level is determined by an inscription in the upper part of the window. On the right side of the inscription there is a list of icons symbolizing the particular procedure adjustment. These icons correspond with particular columns of the status window in which a position of this particular adjustment is being indicated by the „\*“ symbol. This setting can be changed by the right mouse click on the selected line of the status window. The last icon () symbolizes the instrument scheme and its setting cannot be changed by means of the status window menu, but in the instrument scheme only. One can see all the particular adjustments valid for the given calibration point best inclusive the level for which that change has been permitted, if the status window level of "Value" has been selected. For each of the calibration points it is valid only the adjustment defined at the lowest level. If the adjustment is defined for a given value, it shall be used and the superior adjustment shall be ignored. If an adjustment is not defined for a point but for a range, an adjustment valid for the range shall be used etc. If the highest level is selected, i.e. the procedure, the procedure's description is displayed under the procedure's name. This description can be changed. There is used to be given a version, an author, e-mail or other additional information about the procedure.

Press the right mouse button in the status window to display the following menu according to the selected line:



**Add value...** It shall add another item into the calibration procedure. The item can be a function, a range, eventually another value. It depends on the just displayed hierarchy level “function-range-value”. All the added values are displayed in the Test report window at the same time.

**Modify...** It make possible to change a selected item (a function, a range, a value).

**Delete...** It shall remove a selected item (a function, a range, a value) from the list.

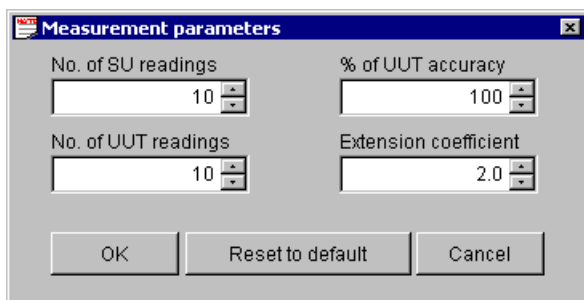
**Move up...** It shall shift a selected item to the first upper position.

**Move down...** It shall shift a selected item to the first lower position.

**Measurement parameters...** It shall set an extension coefficient for calculation of uncertainties, measured numbers add allowed specification utilization for selected items (procedures, ranges, values). Particular uncertainty settings are being indicated by the symbol



Meanings of the particular items:



*No. of SU readings*

It means how many repeated readings are being performed by the standard measuring instrument. If a signal source represents a standard, only one reading shall be made (test of source adjustment). One of the uncertainty components shall be determined from a reading set (A type).

*No. of UUT readings*


It means how many repeated readings are being performed by the measuring instrument under the calibration. If a UUT represents a signal source, only one reading shall be made (test of source adjustment). One of the uncertainty components shall be determined from a reading set (A type).


*Note:* 10 repeated measurements are recommended to right evaluation of the calibration uncertainty of A type. Only in this case the uncertainty shall be calculated accurately according to the EA-4/02 document.


**% of UUT accuracy** It means how is Allowed specification utilization for the UUT. E.g., if it is set instead of the implicit 100% value only 70%, the program shall check if the measured deviation is smaller than 70% of the Allowed specification.


**Extension coefficient** It is the extension coefficient used for calculation of a standard extended calibration uncertainty. The implicitly adjusted value is 2.0.

**Reset to default** It cancels the special measurement parameter adjustment. The measured parameters returns to that according to the implicitly adjustment (10 readings, 100 % of specification,  $k_u = 2.0$ ) or to an adjustment defined in higher level.

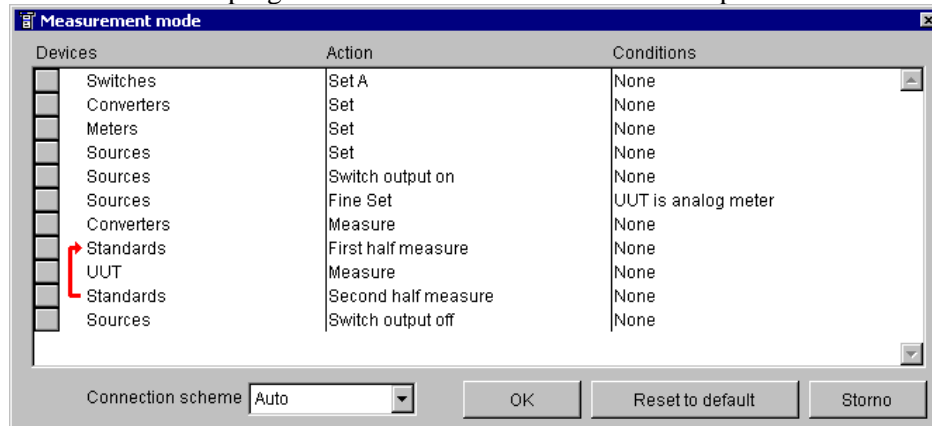
**Additional uncertainty...** set parameters of an uncertainty calculation for selected items (functions, ranges, values). The particular uncertainty setting is indicated by the  symbol.

**Pause...** inserts a stop point into the program. The inserted point is indicated by the  symbol. To set a pause, an operator shall fill up a text message (a report) or select a file to be displayed. The file can be a text document (TXT) or a figure (JPG, GIF, BMP, DIB). Press the right mouse button on the file list to open a menu for adding, removing or displaying of the file. The message or file shall be displayed if the program during calibration performance met a point (a function, a range) designed as "Pause".

**Include/Exclude** allows to skip a value (a range, a function). The excluding is indicated by the  symbol. The omitted item shall not be calibrated and included into the calibration report. By excluding of functions or ranges it is possible to shorten a big calibration procedure (i.e. to perform calibration for only one function).

**Quantity prefix** allows to set a prefix (micro, mili, kilo etc.), which shall be used in a test report. The prefix can be defined only for the range level and it shall be valid for the whole range. Changes of the implicit prefix is indicated by the symbol . The prefix is defined only in exceptional cases because it is automatically set by the program according to the range's size.

**Measurement mode** is a list of tasks being performed by the Caliber program during the calibration. The program has a defined measurement process to be used during the



calibration. The measurement mode allows to add and remove actions (adjustments, measurements, terminal switch on, terminal switch off) for particular instrument categories (sources, measuring instruments, converters, UUTs, standards) or for a particular instrument from the instrument scheme. For mode modifications it is suitable to use instrument categories, (if it is possible), not particular instrument types to maintain the measurement mode valid even if the instrument scheme gets changed. Operation sequence is to be changed easily. In addition to, a section of operations being repeated (at most 3 times) can be defined if some measurement proves to be unstable for some of the measuring instruments in the section. This is demonstrated by red markings in the left part of the task lists. Also a few those sections can be defined, e.g. for each of the measuring instruments separately. The operation shall be performed during the calibration only if there is an instrument of that category in the “Instrument scheme”, if e.g. no converter is used in the instrument scheme, if no operation shall be performed on the converters and the program shall not report it as an error. There is possible to “Add”, “Remove” or “Modify” any operation by pressing the right mouse button on the required section. “Measurement mode Action” panel will be shown:

*Devices* – It can be selected a general category (a standard, an UUT, a source...) or a particular instrument suitable for this operation (M3800). General categories are the following:

*Sources* – an operation shall be performed on all the sources.

*Meters* - an operation shall be performed on all the measuring instruments.

*UUT* - an operation shall be performed on an instrument under test (it can be a meter, a source or a converter).

*Standards* - an operation shall be performed on all the standards (it can be a meter or a source).

*Switches* - an operation shall be performed on all the switches.

*Converters* - an operation shall be performed on all the converters.

*Action* – it can be selected one of the following options:

*Set* – it shall set a function, a range, a value and parameters of the instrument (not available for a switch).

*Fine Set* – for additional setting of an analog measuring instrument (only for sources available).

*Switch output on* – It shall switch instrument's terminals on (only for sources and converters available).

*Switch output off* – It shall switch instrument's terminals off (only for sources and converters available).

*Measure* – It shall perform a set of measurements or one measurement in case of a source (not available for a switch).

*First half measure* – It shall perform the 1<sup>st</sup> half of a set of measurements (only for meters available).

*Second half measure* – It shall perform the 2<sup>nd</sup> half of a set of measurements (only for meters available).

*Set A* – It shall perform A setting (only for a switch available).

*Set B* – It shall perform B setting (only for a switch available).

*Set C* – It shall perform C setting (only for a switch available).

*Set D* – It shall perform D setting (only for a switch available).

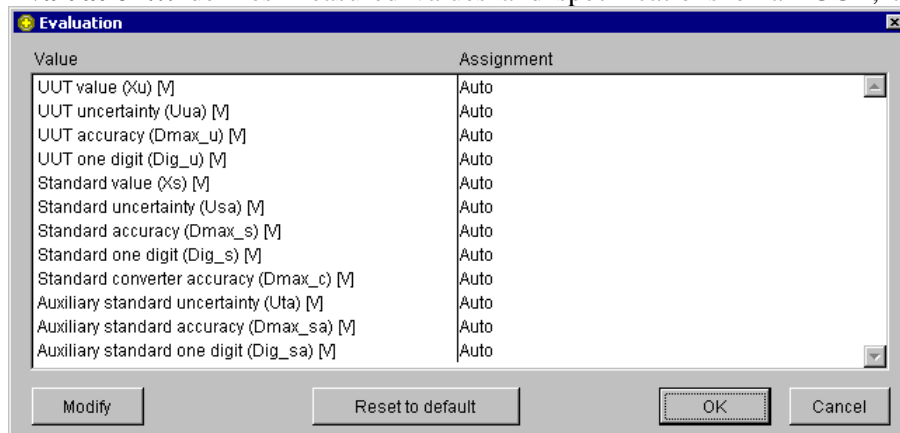
*Conditions* – It shall be a condition defined, under which an operation is to be performed:

*None* – an operation shall be always performed.

*UUT is analog meter* – an operation shall be performed if the UUT is an analog measuring instrument.

*UUT is not analog meter* – an operation shall be performed if the UUT is not an analog measuring instrument.

**Evaluation...** defines measured values and specifications of an UUT, a Standard and an



auxiliary standard. The program automatically assigns values for the UUT and the Standard. Values of the auxiliary standard are in principle zeros. Only in case of converter's test an

instrument connected behind the converter (UUT) is automatically set as an auxiliary standard. In that case as a standard serves a measuring instrument or a source connected with a converter's input. A user can change any items from the list and these values shall be part of uncertainty calculations or they can serve as values in the Test report.

*UUT value ( $X_u$ )* – measured value of an UUT contained in the Test report

*UUT uncertainty ( $U_{ua}$ )* – uncertainty calculated from a measurement set

*UUT accuracy ( $D_{max\_u}$ )* – limit error of an UUT proven from the instrument card

*UUT one digit ( $Dig\_u$ )* – size of one digit proven from the instrument card

*Standard value ( $X_s$ )* – measured value of a standard contained in the Test report

*Standard uncertainty ( $U_{sa}$ )* – uncertainty calculated from a measurement set of the standard

*Standard accuracy ( $D_{max\_s}$ )* – limit error of a standard proven from the instrument card

*Standard one digit ( $Dig\_s$ )* – size of one standard digit proven from the instrument card

*Standard converter accuracy ( $D_{max\_c}$ )* – standard uncertainty due the limit error of a converter

*Auxiliary standard uncertainty ( $U_{ta}$ )* – uncertainty calculated from a measurement set of the auxiliary standard

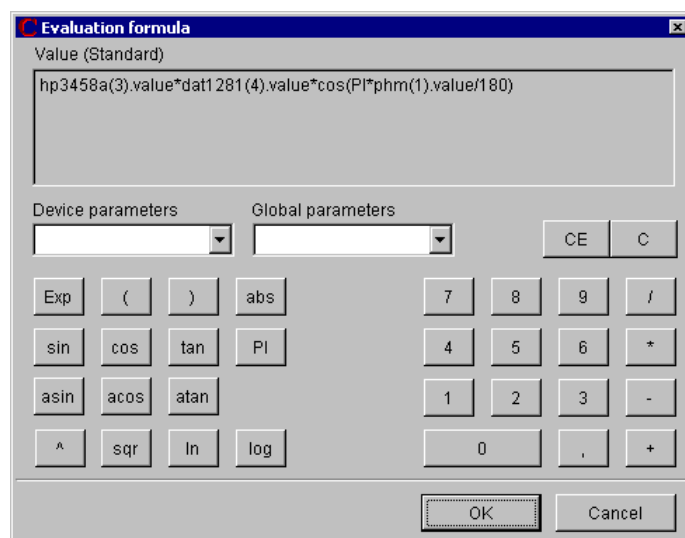
*Auxiliary standard accuracy ( $D_{max\_sa}$ )* – limit error of an auxiliary standard proven from the instrument card

*Auxiliary standard one digit ( $Dig\_sa$ )* – limit error of an auxiliary standard proven from the instrument card.

If the “Auto” assignment is selected, the program shall assign the values from measurements and instrument cards as supposed. A user can change this feature according to the following panel:

Evaluation formula - in this panel an equation for calculation of required values can be defined. It can be possible to add common mathematic functions (sin, cos, log), numeric values (0...9), mathematic operators (+-\*/), instrument parameters (e.g. a measured value, an uncertainty, an accuracy) or global parameters (if there are any parameters for a particular level in a particular function, e.g. a

frequency). All these items can be combined together and create more complicated equations. In the figure there is a calculation example for a standard value. There are three standard

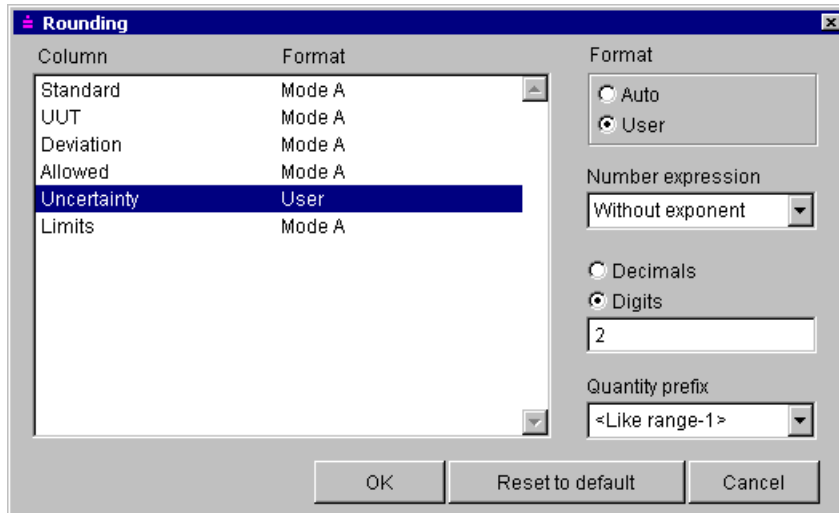




instruments (HP3458 as a voltmeter, DAT1281 as an ampere-meter, PHM as a phase meter) for calculation of a resulted power  $P=U*I*\cos(\varnothing)$ .

*Note: Remember that instrument parameters are in units of the particular instruments but the result value must be always in global units, i.e. that valid for the UUT. Goniometrical functions count an angle always in radians. If a parameter is in grades, it must be recalculated.*

**Rounding...** allows to change the rounding method for particular columns of the test report.



A column can be selected from a column list within also the used rounding method is contained. There are three automatic formats:

**-Mode A**

*UUT* – according to the UUT digit numbers or the uncertainty (shorter expression), a unit like a range

*Standard* – according to the UUT digit numbers or the uncertainty (shorter expression), a unit like a range

*Allowed* – according to the uncertainty, a unit order lower than a range

*Deviation* – according to the uncertainty, a unit order lower than a range

*Uncertainty* – two valid digits, a unit order lower than a range

*Limits* – shortest possible expression, a unit like a range (the limits are placed into "Allowed column" in test report)

**-Mode B**

*UUT* – according to the UUT digit numbers, a unit like a range

*Standard* – according to the standard digit numbers, a unit like a range

*Allowed* – two valid digits, a unit like a range

*Deviation* – two valid digits, a unit like a range

*Uncertainty* – two valid digits, exponential expression, a unit like a range

*Limits* – shortest possible expression, a unit like a range (the limits are placed into "Allowed column" in test report)

#### -Mode C

*UUT* – according to the UUT digit numbers, a unit like a range

*Standard* – according to the UUT digit numbers, a unit like a range

*Allowed* – according to the uncertainty, a unit order lower than a range

*Deviation* – according to the uncertainty, a unit order lower than a range

*Uncertainty* – two valid digits, a unit order lower than a range

*Limits* – shortest possible expression, a unit like a range (the limits are placed into "Allowed column" in test report)

If the "User" mode is selected for a selected column, following options shall appear:

*Number expression* – determines display type – Without exponent (120.5) or With exponent (1.205e+2)

*Decimals* – number of digits behind the decimal point

*Digits* – total number of significant digits either in front of or behind the decimal point (uncertainty is usually expressed with 2 significant digits)

*Quantity prefix* – it can be selected a particular prefix (mili, micro, kilo) or a prefix in relation to the prefix used for the range. If the „mili“ prefix is selected for the range along with the „<Like range-1>“ item, it shall be used the „micro“ prefix, if the „< Like range -2>“ item is selected, it shall be used the „nano“ prefix.

Atto – 1e-15

Femto – 1e-12

Piko – 1e-9

Nano – 1e-6

Micro – 1e-3

None – 1e+0

Kilo – 1e+3

Mega – 1e+6

Giga – 1e+9

Tera – 1e+12

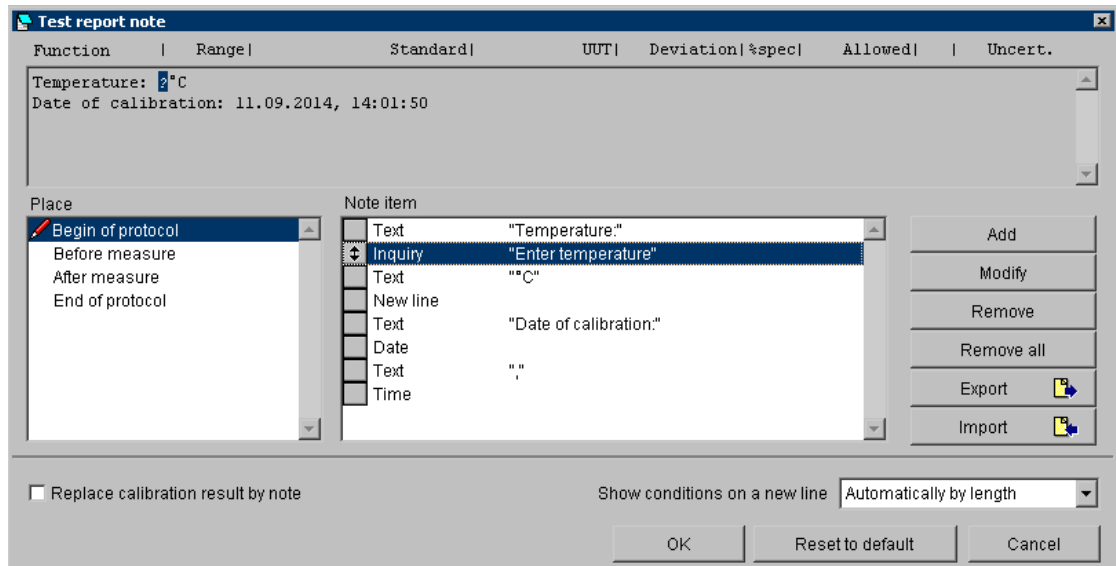
< Like range -3> - range \* 1e-9

< Like range -2> - range \* 1e-6

<Like range -1> - range \*1e-3

< Like range > - range

**Test report note...** allows writing additional information in an output test report. There is a text box in upper part of window. This text box shows selected note in form the note will be displayed in test report too. Caption of this text box is composed of column labels, so user can create notes in accordance to this lay-out. Up to four notes can be defined in this panel for individual placement of note. Note can consists of one or more lines.



*Place* – position of a note in terms of the output record. Notes for "Begin of protocol" and "End of protocol" placement are evaluated only once per all calibration. Note specification is marked with an icon. There are following options:

*Begin of protocol* – a note shall be situated at the very beginning of the test report

*Before measure* – a note shall be situated in front of the calibration point

*After measure* – a note shall be situated behind the calibration point

*End of protocol* – a note shall be situated at the very end of the test record

*Note item* – list of note items composed for given placement. Order of the items can be changed here, items can be added, modified and removed.

*Add* – a new item shall be inserted into a note

*Remove* – a selected item shall be removed

*Remove all* – the whole note for particular placement shall be deleted

*Export* – exports the contents of the "Note item" window into the file. The file will have the \*.nte extension.

*Import* – imports note from the file. The note can be imported only from earlier exported files (\*.nte). Before importing you need to select "Place".

*Replace calibration result by note* – this checkbox allows to suppress exporting calibration results. Instead of the calibration result this test report note is exported. Despite this suppression all calculations are done and individual calibration columns can be placed into note.

*Show conditions on a new line* – determines the way the measured standard value and measurement parameters are written into test report. If the content of the "Standard" column is too long and would not fit into the specified column width, so the contents of the column splits into two lines, the first one will contain measured standard value and the second one measurement parameters. This behavior can be set to one of the following options:

*Automatically by length* – a new line is created only if the content of the "Standard" column is too long.

*Always* – new line is created each time and measurement parameters are always placed on the new line.

*Never* – the new line will never be created. If the parameters do not fit in the "Standard" column, remaining parameters will be cut.

**Note item...** is discrete part of all note.

*Note item type* – a basic element from which a note can be composed:

*Text* – a fixed text inserted into the test report note

*Inquiry* – it shall display an inquiry during a calibration and an answer to it shall be inserted into the test report note

*Date* – an actual date shall be inserted into the test report note from the computer

*Time* – an actual time shall be inserted into the test report note from the computer

*Value* – a numeric value of an instrument parameter shall be inserted into the test report

*New line* – crossing to a new line shall be secured in the test report note

*Column* – test report column shall be inserted into test report note

*List of Standards* – places any of the parameters from the List of Standards

*Text* – text that will be inserted into test report or query message that will be shown during calibration (see Note item type).

*Instrument* – “instrument” together with “parameter” define numeric value that will be inserted into the test report. List of instruments is given by an actual instrument scheme.

*Parameter (for "Value" note item type)* – parameter of an instrument:

- value* – average value taken from set of readings
- uncertainty* – uncertainty calculated from measurement set
- accuracy* – limit error proven from the instrument card
- one digit* – size of one digit proven from the instrument card
- reading1-20* – individual reading made during calibration

*Parameter (for "List of Standards" note item type)* – parameter of a standard:

- Order* – one based Standard device index
- Model* – item is read from the calibration data file
- Manufacturer* – item is read from the calibration data file
- Serial number* – item is read from the device or from the procedure
- Due date* – item is read from the calibration data file
- Description* – item is read from the calibration data file

*Column* – test report calibration column inserted into note:

- Function* – function of UUT
- Range* – range of UUT
- Standard* – measured standard value and list of function parameters. Before calibration it contains nominal value of calibration point.
- UUT* – measured UUT value
- Deviation* – deviation of UUT relative to Standard
- %spec* – "Deviation" to "Allowed" rate expressed in percentage ( $= \text{Deviation} / \text{Allowed} * 100 \%$ )
- Allowed* – allowed accuracy of UUT
- Uncertainty* – total uncertainty
- Symbol* – test report symbols such as "~" - unstable reading, "R" - all calculations done relative to range or PASS vs FAILED

*Length* – length of the source string which shall be inserted into the note. If the source string is shorter, it shall be completed by spaces, if it is longer, it shall be shortened.

*Justify* – it shall set a justification of the source string to the total length:

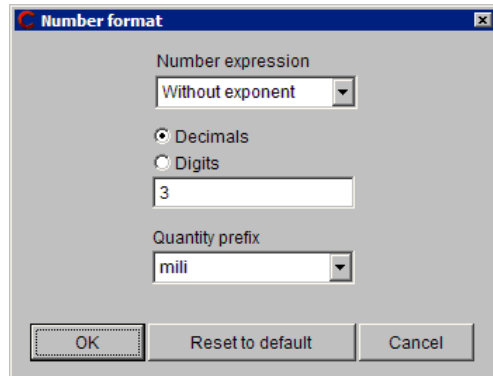
- Left* – justification to the left, spaces shall be on the right side of the string
- Right* – justification to the right, spaces shall be on the left side of the string
- Center* – justification to the middle, spaces shall be on both the sides of the string

*From* – "from" and "to" allows to take substring from source string. "From" - means initial position of the source string (1 – based index)

*To* – end position of the source string (1 – based index)

*Format* - this button brings up Number format panel that allows define display form of numeric value. Available only for "value" note item type.

**Number format...** allows to define the way the number is displayed.



*Number expression* – determines display type:

*Without exponent* - exponent will not be used in expression (120.5)

*With exponent* - exponent will be used in expression (1.205e+2)

*Decimals* – number of digits behind the decimal point

*Digits* – total number of significant digits either in front of or behind the decimal point (uncertainty is usually expressed with 2 significant digits)

*Quantity prefix* – it can be selected a particular prefix (Atto – 1e-15, Femto – 1e-12, Pico – 1e-9, Nano – 1e-6, Micro – 1e-3, None – 1e+0, Kilo – 1e+3, Mega – 1e+6, Giga – 1e+9, Tera – 1e+12)

**Global procedure settings...** it is valid for the whole calibration procedure. In terms of the global set, program's behavior can be estimated if a gross error occurs ("Deviation error" – a measured value exceeds the allowed error more than five times) and if a communication error occurs ("Communication error" – an instrument doesn't communicate with the computer along the bus). If the particular fields are checked, the calibration shall be interrupted by these events and operator's action is required. If it be to the contrary, the calibration shall continue with another check point. An implicit setting means that the calibration shall stop in case of any error. A part of global settings is furthermore a sign, which characterizes check results at the end of every report lines. If the point is right, there shall be written „ok“. If a measured error is in a range where cannot be definitely decided if the point is right or not because of the uncertainty (Allowed error – uncertainty < |measured error| < Allowed error + uncertainty), the sign determined by the "Failed in band" field shall be written down. If a point is out of given specifications (|measured error| > Allowed error + uncertainty), the sign determined by

the “Failed” field shall be written down. If we don’t want to perform this evaluation, we shall select the “not used” sign for failed.

**Procedure Wizard...** allows add a function under test into the calibration procedure. Detailed description of the wizard is contained in the “New procedure development” section. A user can by means of it add other checked functions into an existing procedure and the wizard shall automatically generate checked ranges and values. The wizard allows add other checked functions only. There is not possible to use it for editing of existing functions which are already contained in the calibration procedure. The functions, which are contained in the procedure, are no way affected. The functions added by the wizard shall be ranged always at the procedure end.

**Export...** performs export of the calibration procedure structure into a text file. The file contains a function, a range, a value and standards used for each of calibration points.

Following control keys are situated in the lower bar of the “Status window”:



**New** – starts a wizard for a new calibration procedure development. Details see below.



**Open** – opens an already created calibration procedure. The procedure has the “.pro” prefix in the file mode.



**Save** – writes a performed calibration procedure.



**Save as** – writes a calibration procedure under a new name.



**Reload instruments** – renews instrument cards used in an open calibration procedure.

Namely the open calibration procedure has saved also cards of used instruments in the computer memory. If it is anything changed in the instrument card (in the “Instrument cards” module), an instrument update must be carried out in the calibration procedure. This update can be performed by pressing of a described key or by new counting of the whole calibration procedure.



**Run calibration** – begins performance of a calibration procedure. The procedure can be open from any point eventually it can continue from any point.



**Recalibrate point** – starts executing one calibration point. This function is useful after all calibration is done for recalibration individual calibration point.



**Import** – imports a calibration procedure created by means the „Export“ button. The calibration procedure is in the „pre“ format which also contains definitions of used instruments (instrument cards) and definitions of used functions (user functions). The format is suitable for data transfer among users.

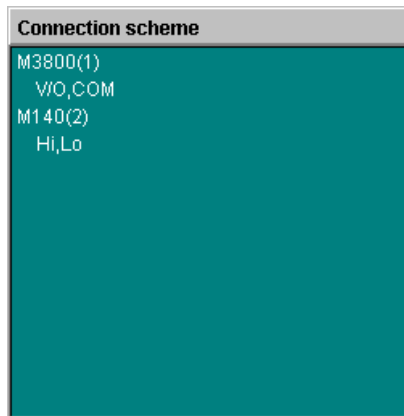


**Export** – exports a calibration procedure in the „pre“ format which also contains definitions of used instruments (instrument cards) and definitions of used functions (user functions). The format is suitable for data transfer among users.



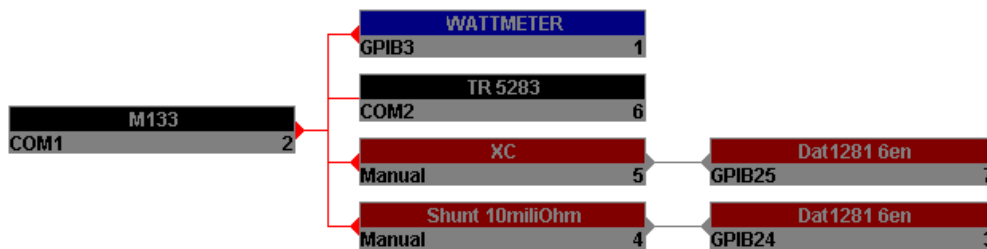
**Back** – serves to shift one level up in hierarchy calibration procedure – function – range – point. Nesting (shift one level down) shall be performed by mouse click on a selected item.

### Connection scheme Window



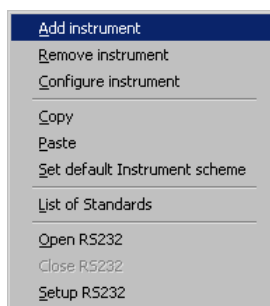
During calibration the “Status window” is being substituted by the “Connection scheme” window. There are described used connecting terminals for every active instrument here. For each change of terminal connections, a text description of a new connection appears, the program performance stops and an operator is prompted that the terminals are to be reconnected.

### Instrument Scheme Window



It is intended for displaying of instruments used for a calibration and of their status and control way. For each of the instrument there is given its name (according to the instrument card), way of control (GPIB, COM, VISA, Manual, Camera), its index to be easy identified and a graphic interpretation of signal connecting among the instruments.

Press the right mouse button on an instrument to open the following menu:



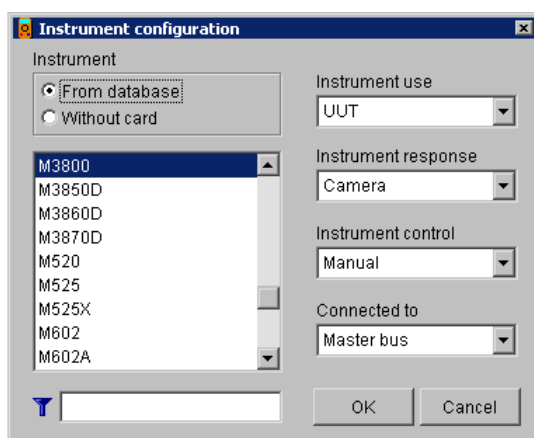
**Add instrument** shall add another instrument participating in the calibration. The operation can be performed on level of procedure, function, range or point. The required level must be preset in the “Status window”. A new instrument is valid only for a level on which it has been added. It can be made a quite particular instrument configuration (e.g. for one calibration point). Instrument names written in thick letters are valid for a just active level. Instrument names written in thin letters are defined on higher level.

**Remove instrument** shall remove instrument participating in the calibration. The operation can be again performed on level of procedure, function, range or point and it is valid for this level only. E.g. an instrument removing on the range level shall not affect other ranges and function any way. Removing all the instruments on the given level shall cause that they shall be implicitly set according to the higher level.

**Configure instrument** shall open a menu for change of an instrument, its function and its way of control:



**Instrument configuration** – basic instrument configuration. **Instrument** can be



selected from the instrument database (there is the “Instrument card” for it). It is possible to filter items in the listbox by using filter text field (Y). The instrument under test (UUT) can be also used without an instrument card. There is the „\*” sign in front of a name of the instrument without a card. These instruments can be controlled only manually. **Instrument use** describes instrument’s function. Basic

instrument’s functions are the UUT (instrument being measured), the Source, the Standard, the Converter and the Switch. The source function can be assigned to functions of the standard or the measured instrument. For every instrument can be selected different way of measuring (value counting) and setting (instrument control). There are five ways of **Instrument response** – by means of RS232, GPIB, VISA, the Camera and Manual; four ways of **Instrument control** – by means of RS232, GPIB, VISA and Manual. At the most cases there is selected the same way of measuring and setting; except from the camera measurement with usually manual settings. **Connected to** – assigns a bus or another instrument which is an actual instrument connected to. *None* – no instrument is connected either to any instrument, or to the master bus. *Master bus* – an instrument is connected to the signal master bus – functions and parameters are the same as for a measured instrument (UUT). *<Converter name>* - an instrument is connected to a converter, functions and parameters are transformed by the converter.

**Copy** – copies actual Instrument scheme into clipboard.

**Paste** – inserts Instrument scheme into actual procedure level from clipboard.

**Set default Instrument scheme** – a particular instrument scheme on existing level shall be cancelled and the scheme shall be also set according to a superior definition.

**List of Standards** – scans all the instruments (instrument cards) used in the procedure and determine whether any of them contains a reference to a set of calibration data. If so, it is automatically included in the following list:

Model	Manufacturer	Serial number	Due Date	Description	Calibration data	Instrument card	Export
M140	Meatest	411241	10.7.2015	Multifunction calibrator	M140.cal	M140.dev	Yes
HP3458A	Hewlett Packard	653854241	15.5.2015	Multimeter	HP3458A.cal	HP3458A.dev	Yes

List of standards can serve as a watch list of standards, or as a tool for sharing calibration data. The list contains the following columns:

*Model* - model designation. The item is read from the file \*.cal and identifier is referred as "Model" in the file.

*Manufacturer* - manufacturer. The item is read from the file \*.cal and identifier is referred as "Manufacturer" in the file.

*Serial number* - serial number. The item is read from the device or can be set by user on the serial number panel.

*Due Date* - date to which the calibration certificate is valid. The item is read from the file \*.cal and identifier is referred as "CalibrationDate" in the file.

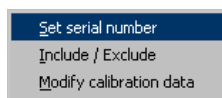
*Description* - brief description of the instrument, which can be used in the test report note. The item is read from the file \*.cal and identifier is referred as "Description" in the file.

*Calibration data* - name of the file that contains the calibration data. Program detects this name automatically by searching all instrument cards used in procedure.

*Instrument card* - list of instrument cards for the particular calibration data file (\*.cal).

*Export* - determines whether the standard contained in the List of standards will be part of export when used in the Test report Note. Can be changed by pressing the right mouse button and selecting "Include / Exclude" item from the menu.

After pressing the right mouse button over the List of standards the following menu appears:



*Set serial number* - displays the panel for the selection of serial number.

*Include / Exclude* - includes or excludes instrument from the List of standards during export.

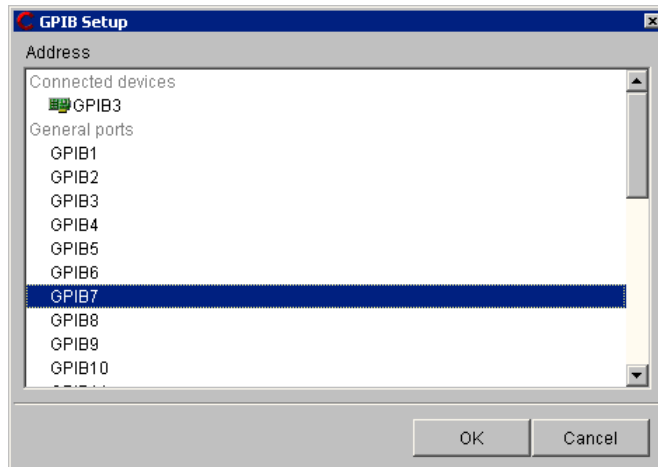
*Modify calibration data* - opens set of calibration data (\*.cal file) for editing in text form.

*Calibration data folder* - file path settings can be done in the Configuration panel.

**Open** performs instrument opening by carrying out of the "Open" macro. This item is especially intended for camera opening or for tuning purposes. Instrument's opening and closing shall be performed automatically during a calibration.

**Close** performs instrument closing by carrying out of the "Close" macro. This item is especially intended for tuning purposes. Instrument's opening and closing shall be performed automatically during a calibration.

**Setup** item shall be active only for automatic control ways (RS232, GPIB, VISA and the Camera). It defines parameters for particular interface setting. According to way of control it has following panels:

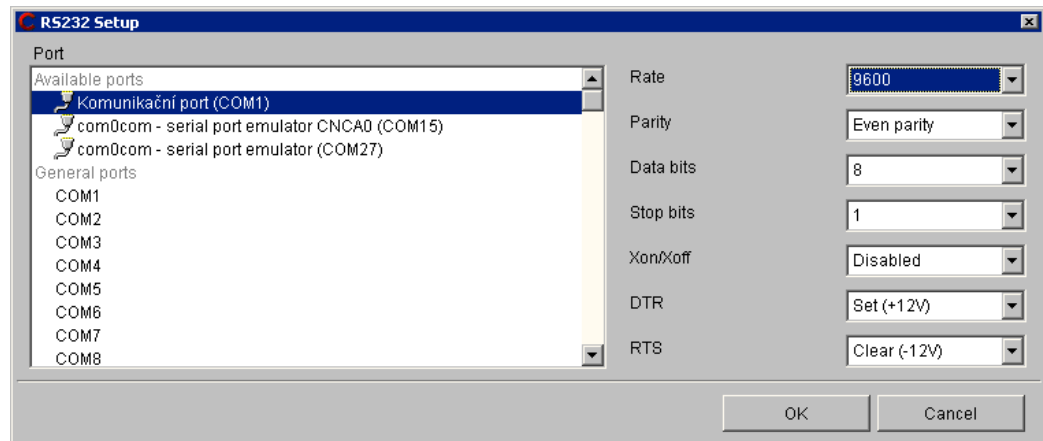


**GPIB Setup** - an instrument is controlled along the GPIB bus. The computer must be equipped with the GPIB card for this purpose. For GPIB control an address of a connected instrument can be set. The permitted address range is 1 to 30. The "0" address is assigned to the computer.

*Connected devices* - list of all GPIB devices found on this computer. The Port Search Mode can be changed in the Configuration panel - the General tab.

*General ports* - list of all GPIB addresses from 1 to 30.

**RS232 Setup** - an instrument is controlled along the RS232 bus. The computer shall have an empty RS232 port. For the RS232 control there can be set a number of the

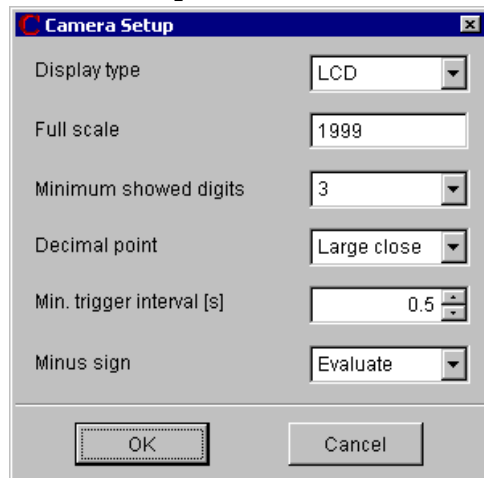


Com port, communication speed, parity, number of data bits, number of stop bits, communication program control (Xon/Xoff) and static status of DTR and RTS signals. Option of static settings for those signals is necessary for communication with some simply instruments which use the above mentioned signals for interface supply.

*Available ports* - list of all COM ports found on this computer. The Port Search Mode can be changed in the Configuration panel - the General tab.

*General ports* - list of all COM ports from COM1 to COM256.

**Camera Setup** - measured values are scanned from an instrument by means of a digital



camera. The Cam-Ocr unit for camera scanning is to be available for this purpose. The instrument cannot be controlled this way. Following parameters should be set for a camera scanning:

*Display type* – LCD (dark signs on a light background) or LED (light signs on dark background)

*Full scale* – the highest displayed number on the instrument display (decimal point not included)

*Minimum showed digits* – minimal number of digits which can be shown on the display

*Decimal point* – „No“ (the instrument doesn't use a decimal point), „Small close“ (decimal point size is approximately the same as an half of segment width), „Small far“ (a small point with distance from a segment more than an half of segment width), „Large close“ (decimal point size is approximately the same as of segment width), „Large far“ (a large point with distance from a segment more than segment width), „Auto “ (the program doesn't evaluate the decimal point from the display, but set it automatically according the expected value – suitable for bad legible displays).

*Min. trigger interval* – time in seconds after its passing the instrument will display a new value. The camera shall scan particular measurements during this time period which can be extended for picture evaluation time (if the computer speed is not sufficient).

*Minus sign* – if it is selected the “Evaluate” mode of sign evaluation, the program is trying to read the sign from the display. If the “Auto” mode is selected, the program shall not evaluate the sign from the display, but set it according to its expected value – it is suitable for displays with bad legible signs, e.g. because of additional symbols around the sign.

### Camera window

It displays running video from a connected camera during opening of the instrument on which measurement reading by means of a camera is selected. After camera opening, its parameters can be set.

*Format* – camera resolution can be set

*Setting* – brightness, contrast and other by camera supported parameters can be set

*Move left* – camera window can be moved to the left

*Move right* – camera window can be moved to the right

*Move up* – camera window can be moved up

*Move down* – camera window can be moved down

### **Readings window**

It is intended for displaying of particular measurements from active instruments. While the test report contains mean values calculated from sets of measurements, the particular measurements are shown in the Readings window.

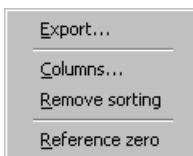
### **Test report window**

It displays all the calibration points and measured values. This window is sequentially filled with measured and calculated values.

Sequence of particular point performance can be changed. These changes don't affect the form of the resulted test report which is to be arranged according to functions, ranges and values being adjusted in the status window. If you wish to change calibration point sequence, move the mouse cursor on a shift field situated in the left side of every line in the test report window. Keep the left mouse button pressed and move the mouse up and down to transfer the selected point. Suitable calibration point rearrangement makes the calibration itself easy because number of output terminal reconnections can be minimized.

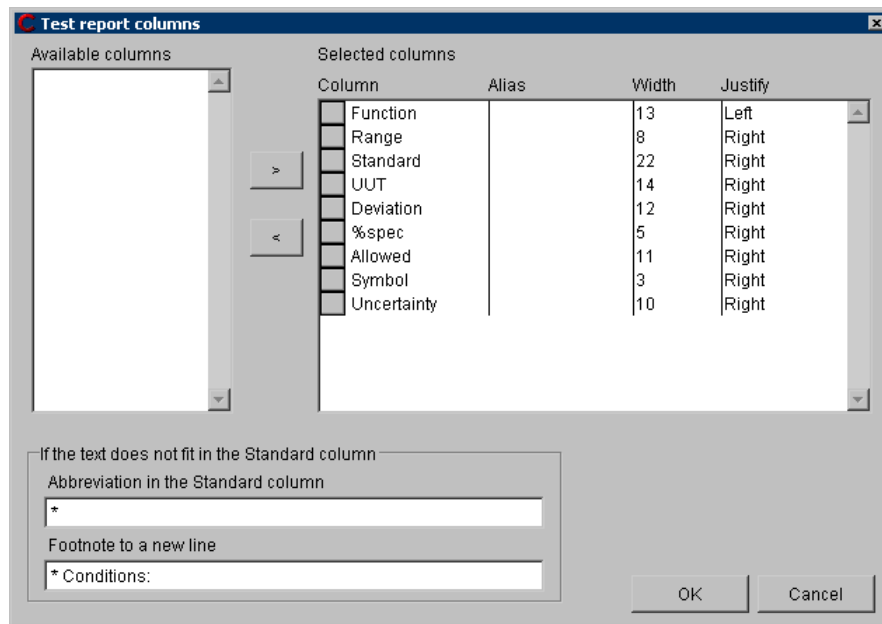
During procedure modification the test can be started from any point. The program automatically supervises correct connections of output terminals and instrument adjustments.

The right mouse button having pressed on the test report, the following menu appears:



**Export...** exports the test report lines, which have already been checked, into a text file. Output file form is given by column selection and their sequencing.

**Columns...** allows select and arrange test report columns during export. The setting made



here is valid for the current procedure. If you want to set columns for all procedures, use the Configuration panel, the Test report tab.

**Available columns** – list of all unfiled columns.

*Function* - function of UUT

*Range* - range of UUT

*Standard* - measured standard value and list of function parameters. Before calibration it contains nominal value of calibration point.

*UUT* - measured UUT value


*Deviation* - deviation of UUT relative to Standard

*%spec* - "Deviation" to "Allowed" rate expressed in percentage ( $= \text{Deviation} / \text{Allowed} * 100 \%$ )

*Allowed* - allowed accuracy of UUT

*Uncertainty* - total uncertainty

*Symbol* - test report symbols such as "~" - unstable reading, "R" - all calculations done relative to range or PASS vs FAILED (see Global procedure settings)

**Selected columns** – list of columns that will be contained in test report. Order of columns can be rearranged using following symbol . Double-click on any line item to start column editing.

*Column* - the default column name that can not be changed.

*Alias* - name of the column that is exported in the test report and can be set by user. If not set, then the default column name is used.

*Width* - the width of the column in the test report.

*Justify* - alignment of the column.



- selected item from the "Available columns" listbox moves into the "Selected columns" listbox, it means the column will be included in test report.



- removes column from the "Selected columns" listbox.

**If the text does not fit in the Standard column** – "Standard" column contains the measured value and additional measurement parameters. Use this tool to select the symbols that are used when the "Standard" column is divided into two lines due to the long text. This behavior affects also "Show condition on a new line" setting on the Test report Note.

*Abbreviation in the Standard column* – this abbreviation will fill in "Standard" column next to the measured value of the standard. It is possible to enter the empty text.

*Footnote to a new line* – the text that is entered at the beginning of a new line followed by the measurement parameters. It is possible to enter the empty text.

**Remove sorting** ranges test report lines according to the status window of a procedure. Calibration run shall be performed in the same sequence as the points have been defined.

**Reference zero** adds special meaning to the selected point. During calibration of this marked point the estimated deviation of an instrument under test shall be saved and it shall be distracted from this instrument in the next calibration points. This deviation doesn't affect either a standard value or a tested instrument value in the test report, but it affects the deviation and following calculations. It is intended e.g. for resistance decade tests, if it is necessary to read zero resistance values. This point is marked by the symbol in the test report.

### 2.1.2. Calibration Procedure Modification

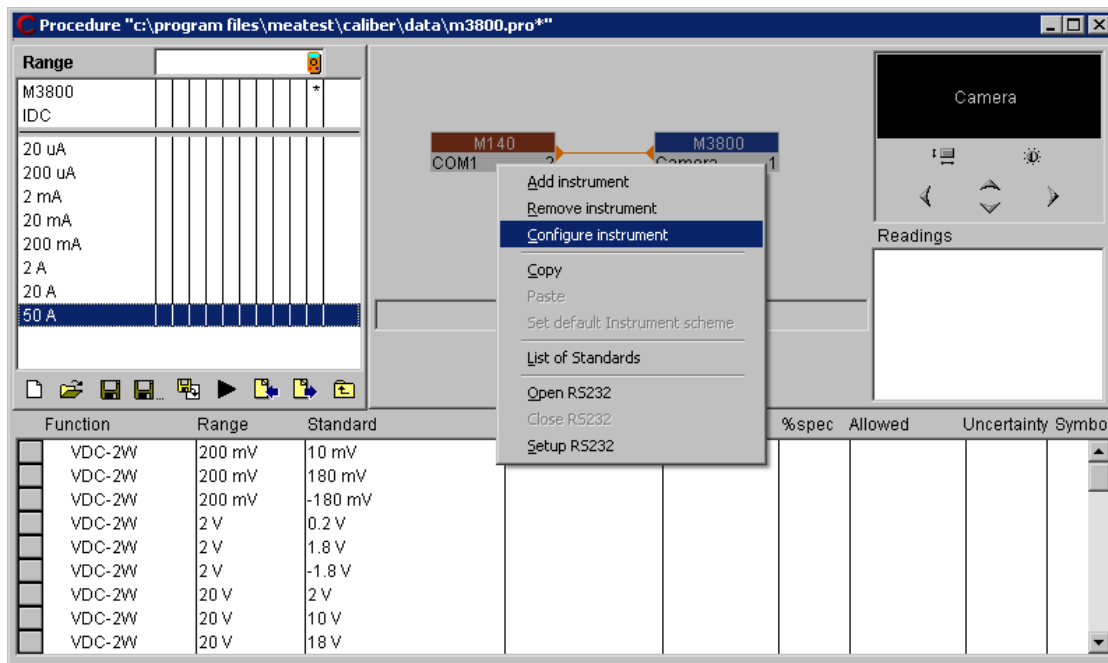
A new procedure created by means of the wizard can be straight used or modified.

The calibration procedure structure, which is shown in the left side of the status window, has following levels: “Procedure - Function – Range – calibration point”. On all these levels there can be modified, added and removed particular items. Modification menu appears after pressing the right mouse button on a selected item.

Particular instruments used for calibration can be changed. The procedure wizard can namely define only one instrument set which shall be used for the whole calibration then. It may happen that some functions, ranges and UUT values cannot be checked by means of standard instruments. Then other standards or signal sources (e.g. a current calibrator up to 100 A, a resistance standard 100 MOhm etc.) can be used for the calibration of the instrument.

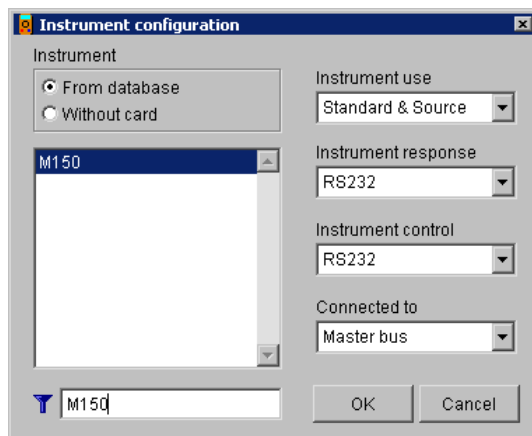
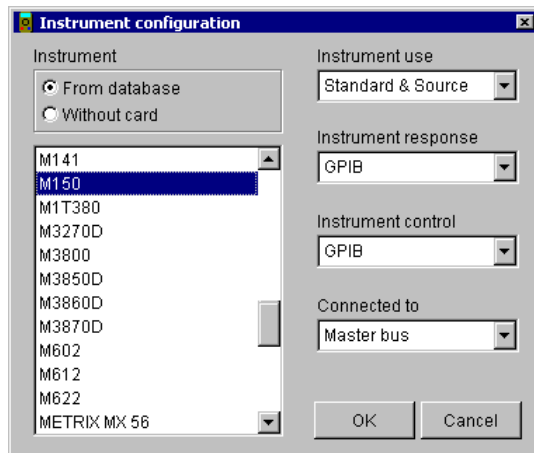
To use another instrument, there shall be a particular instrument card available. If we have for example an instrument which is to be tested by means of the M140 calibrator and whose one range of 50 A is to be tested by the current calibrator M150, first we generate the whole methodology of testing with the M140 calibrator by means of the wizard (see the previous section). In the created procedure the M140 calibrator (it is also used as a standard) shall be on its 50 A range substituted by the M150 calibrator. Proceed as follows:

- Find a current function (AC or DC) and the 50 A range in the status window.
- Change the M140 standard instrument on this selected level. Click with the right mouse button on the M140 calibrator to open a menu displayed at the figure.





- Select the “Instrument configuration” item and instead of the M140 calibrator select the M150 calibrator from the list.

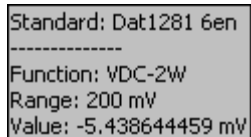


- The performed change is valid only for the level on which it has been carried out. It is the 50 A range in our case.

### 2.1.3. Calibration Procedure Test

Now the new developed procedure can be tested. For good transparency, a list of most common tuning operations follows:

- a) Test of opening/closing of particular instruments. Press the right mouse button on an instrument in the instrument scheme to open the menu and after it to start macro for opening or closing of the instrument. If mistakes occur use the GPIB bus to check installation of the GPIB card, for RS232 especially communication adjustment both in the program and in the instrument and correctness of connections in general. Further check if the instruments are on. If a new developed instrument card is being tested, a mistake can be in macro for instrument opening/closing. There can be used the log NI Spy (National Instruments) program for the GPIB bus which records all the communication along the bus.
- b) If there are not any instruments connected with the computer, a new procedure can be tested so that all the instruments shall be switched to manual control (press the right mouse button on the instrument a select an instrument configuration item). In manual control mode set all the values from the keyboard. At the same time you can test roughly calibration procedure inclusive error and uncertainty calculations. The correct indication of instrument or input terminal connection changes by the program can be checked as well.
- c) Settings all the instruments in terms of their use during calibration in every calibration point can be checked. Select a required calibration point in the Status window or direct in the Test report window and follow the "bubble" help about instrument settings: Line 1



```
Standard: Dat1281 6en
-----
Function: VDC-2W
Range: 200 mV
Value: -5.438644459 mV
```

contains Instrument use and Instrument name, line 2 is a separator, line 3 contains a function assigned to the instrument, line 4 contains an assigned range, line 5 contains a nominal value valid for the calibration point. If the instrument

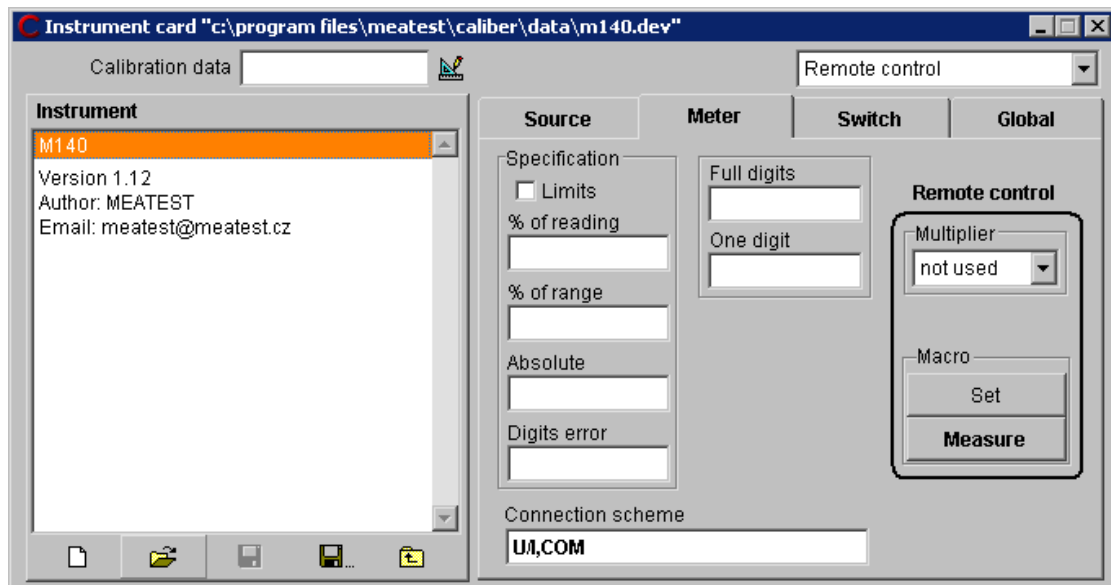
function contains some parameters, the following lines shall contain value of these parameters. The help is advantageous especially for converters when there are completely different functions assigned to instrument behind a converter, see e.g. the previous figure with test of a thermocouple ("TC T S90" represents a master function), but after transformation with the converter (Thermocouple), the standard multi-meter shall already measure DC voltage ( "VDC-2W" function).

- d) The procedure allows many of particular settings. In case of doubt during the calibration, all these settings can be checked up in the procedure Status window. If the "value" item is selected in the Status window, all the settings performed on superior levels can be shown a checked by means of icons id the title of the Status window.
- e) The procedure can be open from any calibration point. Press the left mouse button to activate a line from which the procedure shall start (this line get highlight). Then press the "Run Calibration" key. The running calibration can be stopped by the "ESC" key.

## 2.2. “Instrument Card” Module

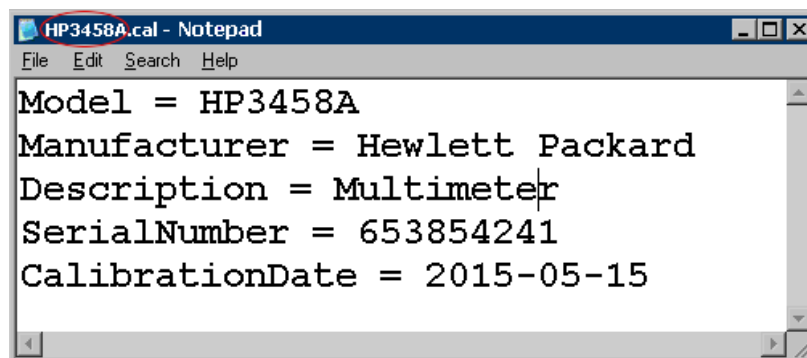
Presence of the instrument card is necessary for an instrument in a calibration procedure. While new calibration procedure takes about 5 minutes time, the new instrument card development takes more time. A user’s manual is necessary for that purpose, which describes functions, ranges and specifications of an instrument. If the instrument can be controlled by a computer, remote control command description is necessary too. You can download final instrument card from the [www.meatest.cz](http://www.meatest.cz) website free of charge.

The “Instrument card” module having started and the M140 card having count, the following panel appears:



The upper left part of the panel contains a calibration data field. This field can contain name of the Calibration data file without path and extension (\*.cal). These are files that the system uses as a repository of standard values or as data to create a List of Standards. The files must be located in a shared folder for the calibration data (the path can be set in the Configuration panel on the “Calibration data” tab). The system uses the calibration data only when the file name is written to “Calibration data” field.

Calibration data file is a plain text file without formatting. Each such file must contain the following items in the following order:



*Model* - device type. This is only a text description that can be exported in Test report Note (List of Standards item).

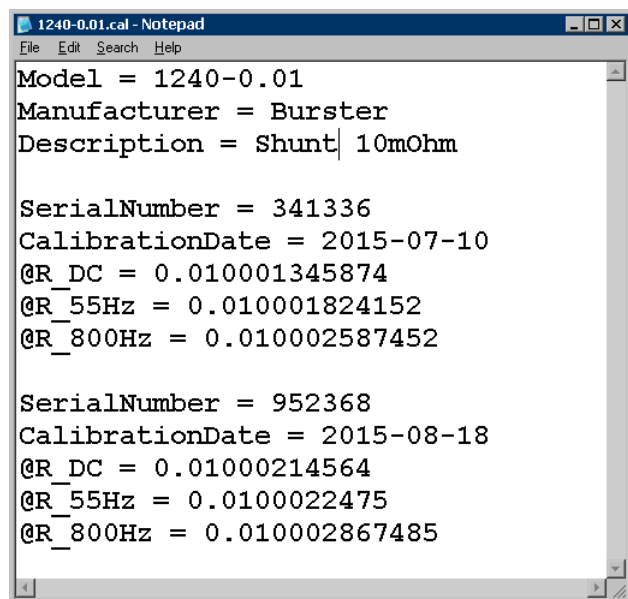
*Manufacturer* - manufacturer. This is only a text description that can be exported in Test report Note (List of Standards item).

*Description* - a short device description. This is only a text description that can be exported in Test report Note (List of Standards item).

*SerialNumber* - serial number. It can be several serial numbers in one file and the system automatically selects the data for the required serial number.

*CalibrationDate* - the expiry of the calibration (must be in the format YYYY-MM-DD). This date is checked during calibration and message is displayed if the date is expired.

If calibration data file is used as a repository of standard values, the date of calibration must be followed by the list of standard values. Here is an example of a shunt:



```

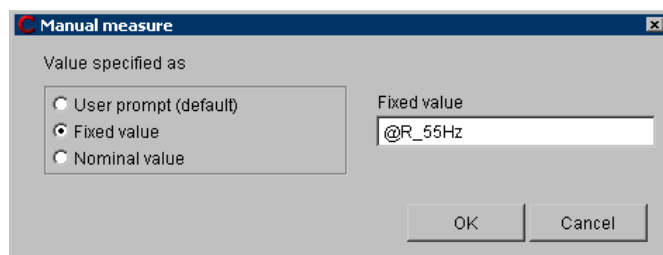
1240-0.01.cal - Notepad
File Edit Search Help
Model = 1240-0.01
Manufacturer = Burster
Description = Shunt| 10mOhm

SerialNumber = 341336
CalibrationDate = 2015-07-10
@R_DC = 0.010001345874
@R_55Hz = 0.010001824152
@R_800Hz = 0.010002587452

SerialNumber = 952368
CalibrationDate = 2015-08-18
@R_DC = 0.01000214564
@R_55Hz = 0.0100022475
@R_800Hz = 0.010002867485

```

Each standard value must start with "@" and then continue with a short unique label for the file. This label can be then used on the instrument card in the Manual measure:




The left part of the panel under the Calibration data field contains a status window which displays the instrument card structure (name, functions, ranges and parameters). The proper level is always being shown in the status window title. All other settings in the right part of the panel (specifications, macros, terminal circuitry) are valid for actual selected level and an item of the status window.

„*Instrument*“ level – the highest level of the status window display the instrument name and below this name a note (usually with instrument card version or author's name and his e-mail address). The note can be edited by a user any way. Its maximal size is 200 characters.

„*Function*“ level – perform double click by the left mouse button on the card name in the status window to go to the function level. If the “Source” page is selected in the right part of the panel, a source shall be created; if “Meter”, then a measuring instrument. If it is not sure what is to be created, a rule is valid that if it is not a meter (the instrument indicates no measured value), there is a source. The third page called "Switch" is intended for creating switch instrument type. Press the right mouse button to display a menu and then add or remove a function. Here can be set all the functions which shall be contained in the instrument.

„*Range*“ level - perform double click by the left mouse button on the function name to go to the range level. Here it is possible to add, change or remove ranges. If ranges are to be created, proceed from lowest to highest range. For more parametric functions usually one range is to be selected which covers all the options of this given instrument function. The actual range can be set during procedure development by a user, if the instrument is used as a UUT.

„*Parameter*“ level – By double mouse click on the developed range you come to the parameter level. This is valid only if a given function contains a parameter. The program differs if a function contains one parameter (e.g. the VAC-2W contains a frequency, i.e. one parameter) or more parameters (PAC). At one-parameter functions the program behaves as at ranges or functions. At more-parameter functions on parameter level there is not possible to set specifications, terminal connections and macros except only the remote setting macro. Macro can be set for any parameter. The Caliber program behaves a little differently during calibration, i.e. it is executing all the macros valid for all the parameters consequentially after each other. The macro is then signed by the symbol  in the instrument card. A user also can write down only one setting macro on the range level (it is more suitable if an instrument can be controlled this way) or more macros for particular parameters.

On the right panel side there is a switch to select way of instrument control. One instrument can have more control ways. For each of the switch positions another set of control elements is assigned (on the right side of a framed field). Ways of control follow:

- a) **Remote control** – control elements (a multiplier and macros for instrument control) are the same for all remote buses (GPIB, RS232, VISA). If macros have been defined for that common control way, it is no longer necessary to write macros for GPIB, RS232 or VISA except the “Open” and “Close” macros at the „Setup“ definition. The „Remote control“ is a recommended option for all the instruments containing even one type of these buses. In future the instrument card can be extended about another communication type. The other options as GPIB, RS232 or VISA are suitable only in case of different communication along different buses but it is not so common.

- b)  **GPIB**  – control elements (a multiplier and macros for instrument control) are for the GPIB bus. It shall be used only if it is required to differentiate macros from another communication type, e.g. from RS232, otherwise the “Remote control” item is to be used.
- c)  **RS232**  – control elements (a multiplier and macros for instrument control) are for the RS232 bus. It shall be used only if it is required to differentiate macros from another communication type, e.g. from GPIB, otherwise the “Remote control” item is to be used.
- d)  **VISA**  – control elements (a multiplier and macros for instrument control) are for the VISA interface. It shall be used only if it is required to differentiate macros from another communication type, e.g. from GPIB, otherwise the “Remote control” item is to be used.
- e)  **Camera**  – control elements (a multiplier) for camera scanning.
- f)  **Manual**  – control elements (a multiplier and macros for instrument control) for manual control.

There are four cards in the right panel part describing instrument features in functions “Source”, “Meter”, “Switch” and “Global”. At sources and meters the pages contain specifications, control commands and description of output terminal connections. The switch setting contains only “Set” control commands. The global setting describes such features as an instrument initialization, setting parameters of buses and a camera, transfer characteristics of converters. For the pages there are following windows (some of them cannot be present according to card types or control ways):

**Specification** allows set accuracy for the given instrument. The specification can be set on level of instruments, ranges or parameters. It can consist of up to four components: „% of a reading “ and „% of a range“ are set in per cents. The “Absolute” error is set in units of a selected function (always in basic ones, an exponential record is possible) and the “Digits error” is set in digit numbers (only for measuring instruments). It is also possible to use limits as specification if an instrument is used as UUT. By checking “Limit” checkbox, two fields are shown: “Low limit” – defines minimal possible absolute value of an instrument, “High limit” – defines

maximal value.

**Full digits** is set only for measuring instruments. It indicates a resolution of digital measuring instruments (it is at most set for function with relative evaluation). In case of an analog instrument, the „ANALOG“ text is being used.

**One digit** also allows set a resolution of a digital measuring instrument. It is set in units of measured magnitude and indicates resolution for one digit (it is at most set for function with relative evaluation).

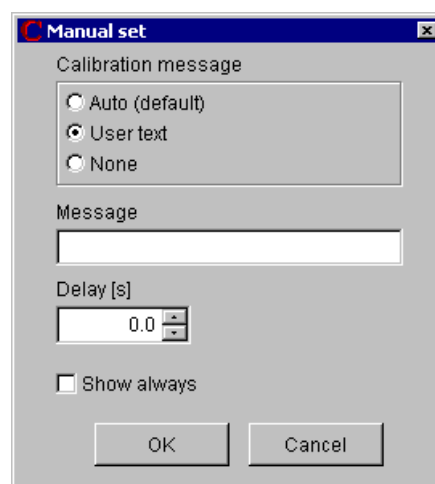


**Multiplier** can be set for both a source and a meter (measuring instrument). It allows set values during instrument readings (or during records into the instrument) in different units as basic ones. It is implicitly set to “not used”, but it can be selected any prefix in the „atto“ (1e-18) to „tera“ (1e+12) ranges.

**Macros** are setting strings describing instrument control way by means of GPIB, RS232 or VISA buses. The „Set“ and „Measure“ macros can be set for sources and measures controlled by a computer. The “Output on” and “Output off” are to be set for sources controlled by a computer only. For details see the “Macro Development” section”.

**Manual control** has following elements available (there are no macros):

**Manual set** – allows determine a text which shall be shown during the “Instrument set” operation if manual control is used during a calibration. This setting can be defined for sources, meters and switches. For sources and switches the setting shall be performed at every point of calibration, for measures only if ranges or functions change (it can be changed by the “Show always” item). If the “Manual set” is not defined the program itself shall automatically generate necessary messages /except from the switches). The same panel is being used also for the “Output on” and “Output off” operations. The “A set”, “B set”, “C set” and “D set” operations can be defined for switches that way. Messages during calibration are shown in the “User prompt window”.



*Text during calibration provides three options:*

*Auto (default)* – the program shall stop at every measured value and the automatic text appears with requirement to set a source to a proper value. At a measuring instrument the program shall stop for every change of a function or a range. The automatic text cannot be used for a switch-instrument and there must be set the “User text”.

*User text* – the program shall be stop according to the same rules as for the “Automatic” items. Program having stop, a message from the “Message” window shall be written down.

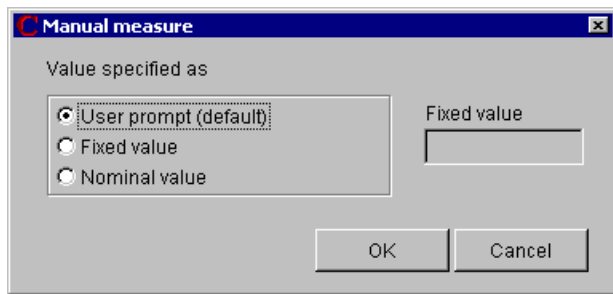
*None* – the program won’t stop for this selection. An operator cannot set a function, a range or a value. This selection is suitable for e.g. a source when terminals are switched on and off, if the source has not terminal switching off.

*Message* – the user text displayed during the calibration in the “User prompt window”.

**Delay** – if a time it is set, the program after message displaying (if there is any) shall wait for a set time. The delay is being count even from the moment of message confirming by a user.

**Show always** – allows open a message for an operator during a calibration at every calibration point (it is valid for measuring instruments only).

**Manual measure** – allows define value counting way which is being set for a source during calibration. The set shall be effective only if the value from the instrument is being count



manually. The program is trying to find out a source value if it is used as a Standard or a UUT. The item is only for manual measuring of the source. For a measuring instrument it is always necessary to set an actual instrument's value.

**User prompt (default)** – a magnitude of a value being set for the source by the user during a calibration.

**Fixed value** – a magnitude of a value being set for the source is fix given by the in the “Fixed value” field stated value“. The value can be a reference to a calibration data file (\*.cal).

**Nominal value** – it is set automatically by the program as a nominal point's value for a magnitude of a value being set for the source.

**Output on** – this item is for manual source settings only. It allows define source's behavior during switching on of output terminals. Options are the same as for the set item.

**Output off** – this item is for manual source settings only. It allows define source's behavior during switching off of output terminals. Options are the same as for the set item.

**Connection scheme** represents a text which briefly characterizes active terminals. The



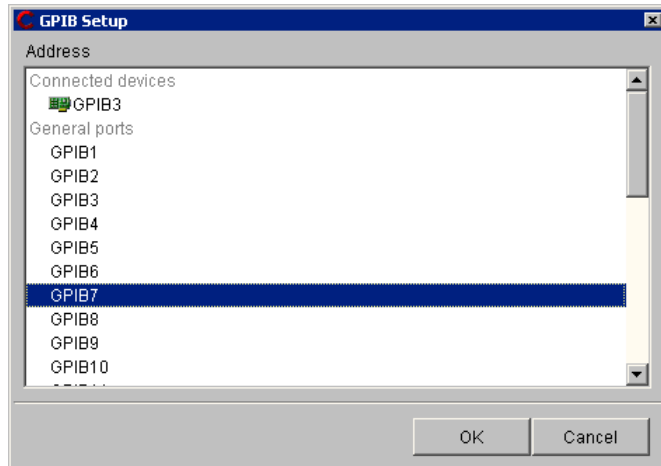
terminals are at most set on the function level (different terminals are for voltages as for currents). A short text denomination is suitable, e.g. Hu,Lu or V+,COM etc.

*Note: The text itself describing the connection can be selected any way according to local usage. But there is important that different connections shall be written by different texts. In terms of a program text change during a calibration, a message about terminal connection changes shall be generated.*



### Global setup

**Setup** – this item shall be active only for automatic controls (RS232, GPIB, VISA and Camera). It defines setup parameters for particular interfaces. Macros for instrument openings and closing and bus settings can be defined by the “Setup” key (details see in the “Macro development” section). The bus setup has following menus according to the control way:



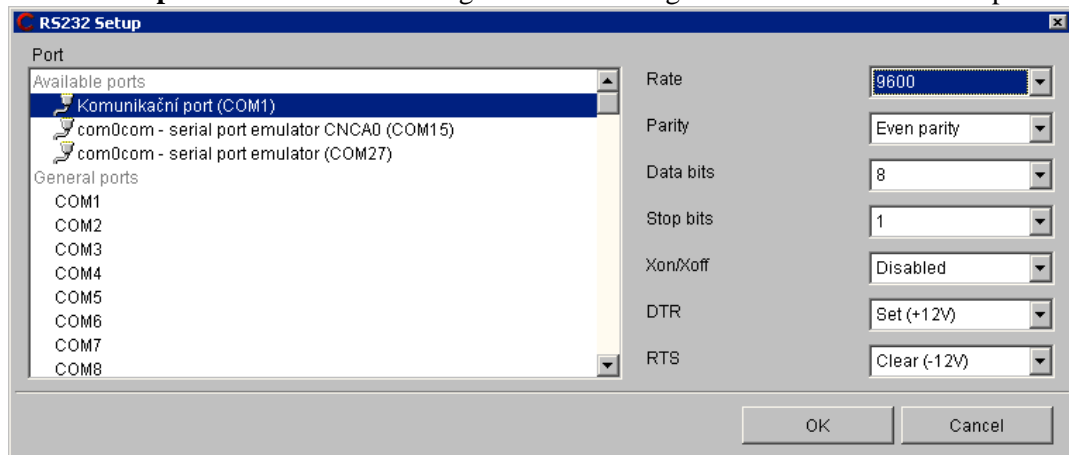
**GPIB Setup** - an instrument is being controlled along the GPIB bus. The computer must be equipped with the GPIB card. For the GPIB control, an address of a connected instrument can be set. The permitted address range is 1 to 30. The „0“ address is determined for the computer.

*Connected devices* - list of all GPIB devices found on this computer.

The Port Search Mode can be changed in the Configuration panel - the General tab.

*General ports* - list of all GPIB addresses from 1 to 30.

**RS232 Setup** - an instrument is being controlled along the RS232 bus. The computer must

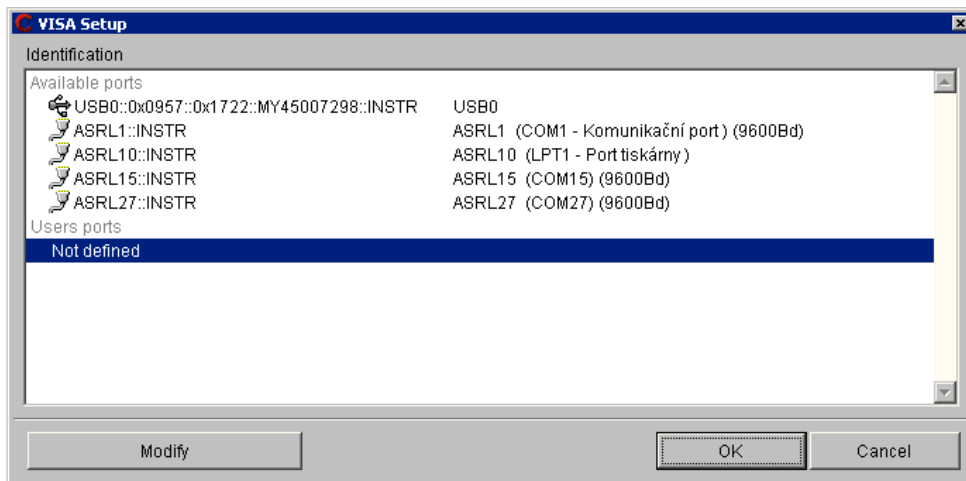


have the RS232 port free. For the RS232 control, a number of the Com port, communication speed, parity, data bit number, stop bit number, program communication control (Xon/Xoff) and static status of the DTR and RTS signals can be set. Static set options for these signals is necessary for communication with some simple instruments using the above mentioned signals for interface supply.

*Available ports* - list of all COM ports found on this computer. The Port Search Mode can be changed in the Configuration panel - the General tab.

*General ports* - list of all COM ports from COM1 to COM256.

**VISA Setup** - an instrument is being controlled along the VISA bus. The computer must have

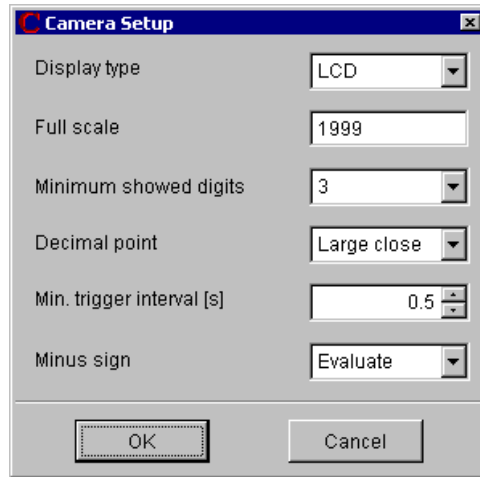


installed the VISA driver. An identification instrument string shall be set for the VISA control. The computer connection with an instrument can be performed along any bus (USB, LAN, RS232), the VISA controller (not the Caliber program) shall secure this connection.

*Available ports* - list of all VISA ports found on this computer. The Port Search Mode can be changed in the Configuration panel - the General tab.

*Users ports* - list of user defined ports. At this port, you can directly enter the name of the VISA resource name. The identification string can be taken from instrument Remote I/O setup screen or you can use National Instruments “VISA Interactive Control” utility.

**Camera Setup** - measured values are being read by means of a digital camera from the instrument. The Cam-Ocr scanning unit is to be available for this purpose. The instrument cannot be controlled such a way. For reading of measured values the following parameters should be set:



**Display type** – LCD (dark signs on a light background) or LED (light signs on dark background)

**Full scale** – the highest displayed number on the instrument display (decimal point not included)

**Minimum showed digits** – minimal number of digits which can be shown on the display

**Decimal point** – „None“ (the instrument doesn't use a decimal point), „Small close“ (decimal point size is approximately the

same as an half of segment width), „Small far“ (a small point with distance from a segment more than an half of segment width), „Large close“ (decimal point size is approximately the same as of segment width), „Large far“ (a small point with distance from a segment more than segment width), „Auto “ (the program doesn't evaluate the decimal point from the display, but set it automatically according the expected value – suitable for bad legible displays).

**Min. trigger interval** – time in seconds after its passing the instrument will display a new value. The camera shall scan particular measurements during this time period which can be extended for picture evaluation time (if the computer speed is not sufficient).

**Minus sign** – if it is selected the “Evaluate” mode of sign evaluation, the program is trying to read the sign from the display. If the “Auto” mode is selected, the program shall not evaluate the sign from the display, but set it according to its expected value – it is suitable for displays with bad legible signs, e.g. because of additional symbols around the sign.

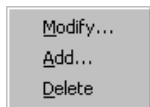
**Converter conditions** – they are displaying overview of all the conversing conditions, which a converter can convert. During calibration the program automatically selects an appropriate conversion according to an input and output function.

*Converter* represents an instrument connected between a signal bus and another instrument. It can change a function, a value or parameters coming into another instrument. It is possible to arrange more converters after each other. The converter is defined by three points (functions), by an input, by an output and by its own setting. The converter is transforming an input to an output and it can work in both of directions. Converters are divided into two types:

*Real converters* represent real instruments. They are to be set to functions which is not void. A current shunt (a resistor transferring voltages to currents) can be given as an example. The real converters can have a defined specification (it is its accuracy) and this specification is being counted as one of measurement uncertainty components. These converters must have their card filled up in the source mode.

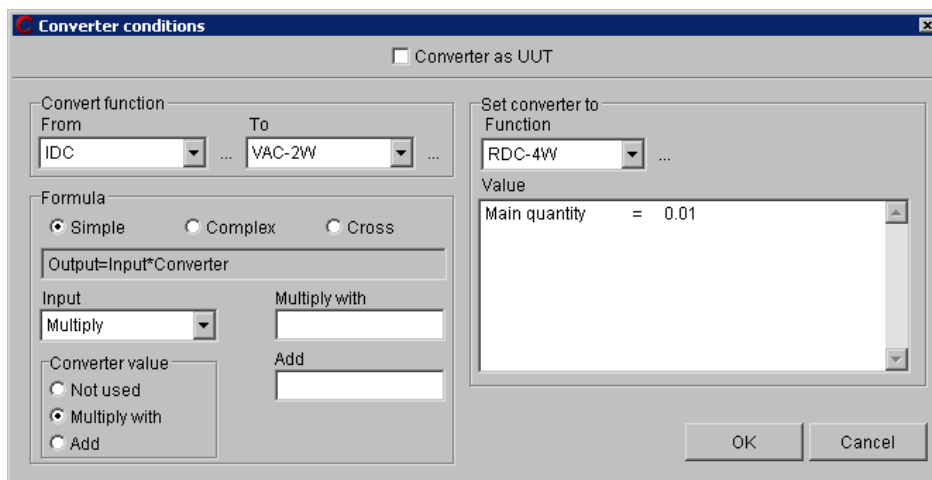
*Virtual converters* are intended only for conversion of one function to another one or for value recalculations. They are being set to the „void“ function and their instrument cards are not be filled up either in source nor measure mode. There are no real instruments and they have zero error because of it. A converter converting two-terminal resistors to four terminal ones can be used as an example. We must use it if we need check a two-terminal measuring instrument by a four-terminal standard. Namely the Caliber program requires the same function set on all the instruments unless converter is used.

Press the right mouse button to open a menu with following items:



**Modify** – an editing window of the selected conversion shall be open

Converter conditions define a way of the magnitude conversion and a magnitude and a value which the converter itself shall be set to. In the figure there is an example of a current/voltage converter with conversion constant of 0.01 (10 mΩ resistor).



**Converter as UUT** – if this field is checked, the program shall secure using of a converter in position of the instrument under test. The as an UUT used converter is to be set as its output function is. The value of the converter cannot be used in a formula, only a simple formula can be used.

#### Convert function:

**From** – input value of the converter (defined by a function)

**To** – output value of the converter (defined by a function)

**Set converter to:**

**Function** – a function which the converter is to be set to. For virtual converter (i.e. function or value converters being not represented by a real instrument) it shall be given „void“ here. Converter functions and ranges cannot be filled up as for a real source or measurement instrument. For real converters their actual function must be set. E.g. for a current shunt the RDC-4W or also RAC-4W function is to be set, if the shunt can also be used for alternating current. In this case the particular function (e.g. RDC-4W), range (e.g.  $0.1 \leq 0.1$ ) and specification is to be filled up as for a real source.

**Value** – it is a value which the converter is to be set to. All the parameters are to be defined here if the function contains any. A fixed value (a constant) or a parameter being contained in the input function is assigned to particular values. The program during its operation shall set a function, a range and parameters which shall be set as for any other instruments. The converter card must contain the required function and range in the source mode (a converter is being considered as a source). Real value of the converter can be taken of the instrument card during a calibration, in manual mode the value can be required from a user or to be fixed set in the instrument card. The fixed set value can be naturally changed e.g. after a new standard resistor calibration which is being used as a current/voltage converter. If a function called "void" is selected, it is not necessary to set a value and fill up a specification and function in the instrument card. Such a converter then only converts by means of a multiplying and adding constant and its own value won't appear in an equation (it is especially used for function conversion, if the converter itself is only virtual one).

**Formula** – defines conversion ratio between input and output. There are three of formula types:

**Simple** – a simple equation. The program is automatically performing back and forth conversions.

**Input** - input value calculation form

*Multiply* - input value is directly used ( $\text{Input} = \text{Input value}$ )

*Divide* - applies the inverse of the input ( $\text{Input} = 1 / \text{Input value}$ )

**Converter value** – adds or removes the "Converter value" from the formula

*Not used* - converter value not used in formula ( $\text{Output} = \text{Input} * A + B$ )

*Multiply with* - converter value will be multiplied ( $\text{Output} = \text{Input} * A * \text{Converter} + B$ )

**Add** - converter value will be added (Output = Input \* A + Converter + B)

**Multiply with** – determines the A constant in the formula

**Add** – determines the B constant in the formula

**Complex** – defines a complicated complex equation. There can be more equations. They are divided by a range of the input magnitude. The program is able to perform back and forth conversions. The equation can be set together from common mathematic functions (sin, cos, log), numeric values (0...9), mathematic operators (+-\*/) or input values of a converter. Goniometric functions count an angle in radians, if degrees are used, a recalculation is to be performed.

**Formula** - list of defined formulas. By right mouse click over the list next menu will be shown:

**Add** - adds next formula into the formula list. Formula is created using Converter formula panel.

**Modify** - allows formula modification.

**Remove** - removes selected formula from the list.

**Thermocouple** - this checkbox is intended only for thermocouple converters. If it is checked special calculation is performed during transformation with sense of thermocouple cold junction. Do not check this box in other cases.

**Import** - this feature allows import raw input data from text file, which make base for creating converter. No interpolation of values is done here. Source format must be following:

<input converter value> <separator> <output converter value> <CRLF>

<input converter value> <separator> <output converter value> <CRLF>

...

*Note:* Separator can be ":", ";" or TAB. Maximal row count is 200. Input range of converter is defined by <input converter value> on the first row of source file and <input converter value> on the last row.

**Cross** – any value recalculation are not performed, only parameters of input and output function are redirected. Different functions with some same parameters can be converted among each other.

**Up** - moves parameter in the right part of listbox one step up.

**Down** - moves parameter in the right part of listbox one step down.

Following control keys are situated in the lower bar of the “Status window”:



**New** – shall create a new instrument card.



**Open** – shall open an already created instrument card.



**Save** – shall write a modified instrument card in a file (database).



**Save as** – shall write a modified instrument card under a new name in a file (database).



**Back** – is intended for move to one level up in a hierarchy: instrument – function – range – parameter. Nesting (move to one level down) shall be performed by a mouse click on a selected item.

### 2.2.1. Item Displaying Regulations

Particular items (specification, terminal circuitry and control way) can be set for any level in a hierarchy: instrument – function – range – parameter. The item set on higher level is implicitly valid for all lower levels. If an item is set on more levels for one point, the item set on the lowest level shall be used for control and calculations. For easy orientation in an instrument card the items being set are displayed in different letter types:

- a) **Normal** – an item is not set yet.
- b) **Thick letters** – an item is set on the just shown level.
- c) *Italics* – an item is set on the higher level and is implicitly valid for the level displayed.

Item setting is not mandatory. However if an unset item is needed during instrument calibration an error message appear that the requested item has not been filled up.

### 2.2.2. Development of Macros

Any communication with an instrument through remote control (RS232, GPIB, VISA) in the Caliber system can be only performed by means of macros. A macro represents a command sequence (Write and Read) for communication with an instrument completed by some additional options as comparison of counted values etc. The program is performing particular macros during a calibration. Macros are divided into particular categories called actions. There can be the “Measure macro” for value reading from an instrument, the “Setup macro” for assignment of a function and of a range, the “Output on macro”, “Output off macro” for sources or the “Open/close macro” for instrument’s initialization. The sequence of macro executing is given by a measuring mode during calibration. The “Open” macro shall be performed for every instrument use in a calibration if the instrument was not open yet. The “Close” macro shall be performed if an instrument scheme changes or a calibration completes and the instrument was open before. Macros can be written for all the buses together (Remote control) or particularly for each of the buses (RS232, GPIB, VISA). All macros are saved in an instrument card. The instruction manual of the given instrument is needed to write down remote control commands.

The program works with six basic macro types:

- **Open** initializes an instrument connected to the computer.
- **Close** closes the communication along the computer bus.
- **Setup** sets an instrument to a correct function, range and value.
- **Measure** reads a measured value on a measuring instrument and a set value on a source.
- **Output on** connects output terminals, it is used only for a signal source.
- **Output off** disconnects output terminals, it is used only for a signal source.

The “Close” and “Open” macros are parts of the “Global set” of an instrument and are so valid for the whole instrument regardless of a function, a range or a value. The “Set” and “Measure” macros are in both the “Meter” instrument card and the “Source” card. The “Set” macro can be also in the “Switch” card marked as the “Set A”, “Set B”, “Set C” or “Set D”. These macros can be defined on any level (Instrument-Function-Range-Parameter). The “Output on” and “Output off” macros are in the “Source” card only.

Macros are composed of particular commands which can be combined any way. There are following commands:

- **Write** sends a string into an instrument.
- **Read** reads a string from an instrument into a program variable.
- **Delay** inserts a delay in a macro.
- **Message** calls up a message.
- **Compare** allows comparison of an instrument string with a fixed one.

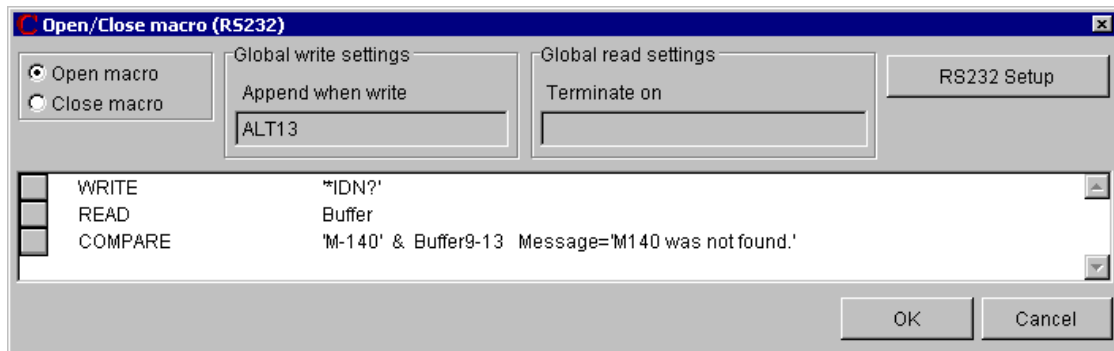


- **Numeric compare** allow compare a number counted from an instrument.

Every macro line (command) is being displayed in two columns in the program:

- Key word *determines an operation to be performed. An example: „WRITE“, „READ“, „COMPARE“ etc.*
- Parameter *contains texts and variables with them an operation determined by the Key word shall be preformed*

### Open macro



It is defined for the GPIB, RS232 and VISA buses. There is an open macro of the M140 calibrator in the figure. The „Global write settings“ window contains a string (sign) which shall be sent to an instrument after every “WRITE” command. An ending string for M140 is CR (ALT13). The „Global read settings“ window contains a string (sign) which means a message end. Reading can be also finished when a certain number of signs are received. If both of the options are being set (finishing when a string is received and finishing after receiving of certain sign number), a reading shall be finished if any of these conditions has been fulfilled. The “Global read settings“ window stays unused in most of cases, except from some instruments controlled along the RS232 bus, for some of them it is not possible to synchronize readings. The “RS232 Setup” key is intended for bus parameter setup. A macro can be saved by the “OK” key. Following commands are used for the macro in the picture:

**WRITE** – it shall send the „\*IDN?“ string ended with the CR (ALT13) sign in a calibrator.

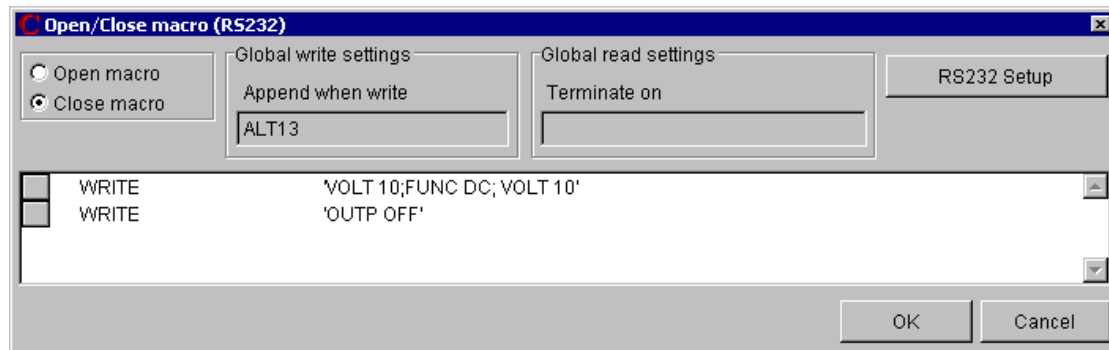
**READ** – it shall read a calibrator’s answer and save it into a variable called “Buffer”.

**COMPARE** – it shall compare the „M-140“ string with 9-13 signs saved in the buffer variable. If they are different, a „ M-140 was not found“ message appears and a calibration shall be finished.

The open macro is common for both the source and the measuring instrument. If the instrument has the GPIB and also RS232 bus, the macro shall be defined separately for both the buses. Details to particular macro commands see the “Macro Command Syntax” section”.

*Note: It is possible to read serial number from the instrument in the Open macro for the purpose of using calibration data or writing note to output test report. In such a case reading to the variable labeled "Serial Number" must be done.*

### Close macro



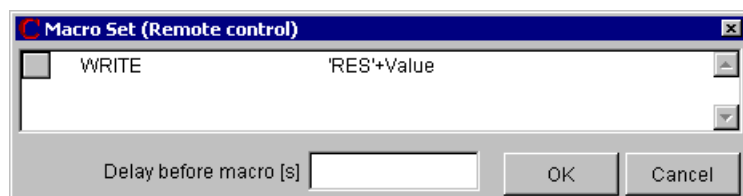
It is defined for the GPIB, RS232 and VISA buses. There is a close macro of the M140 calibrator in the figure. The “Global write settings”, “Global read settings” windows, the “RS232 Setup” and „OK“ keys have been described at the “Open macro”. Following commands are used for the macro in the figure:

**WRITE** – it shall send the „VOLT 10;FUNC DC;VOLT 10“ string ended with the CR (ALT13) sign in a calibrator.

**WRITE** – it shall send the „OUTP OFF“ string ended with the CR (ALT13) sign in a calibrator.

The close macro is common for both the source and the meter. If the instrument has the GPIB and also RS232 bus, the macro shall be defined separately for both the buses. Details to particular macro commands see the “Macro Command Syntax” section”.

### Macro Set

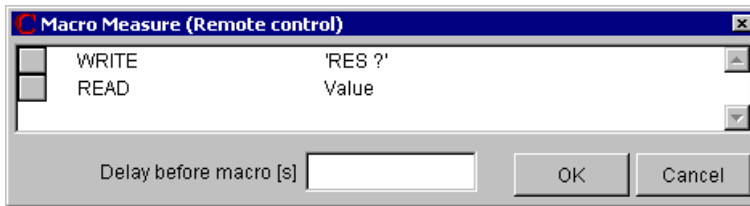


It is defined for the GPIB, RS232 and VISA buses. There is a macro set of the M140 calibrator in the figure, which shall set the calibrator to the R-2W function in source mode. Following commands are used for the macro in the figure:

**WRITE** – it shall send the „RES“ string in a calibrator. Nominal value of the check point and the report shall be ended by a sign defined in the open / close macro - CR (ALT13).

The Macro Set can be common for all the buses (Remote control). The source and the measuring instrument have an independent macro. For the source, the macro sets a function, a range and a value. The macro sets a function and a range for the measuring instrument. Details to particular macro commands see the “Macro Command Syntax” section”.

### Macro Measure



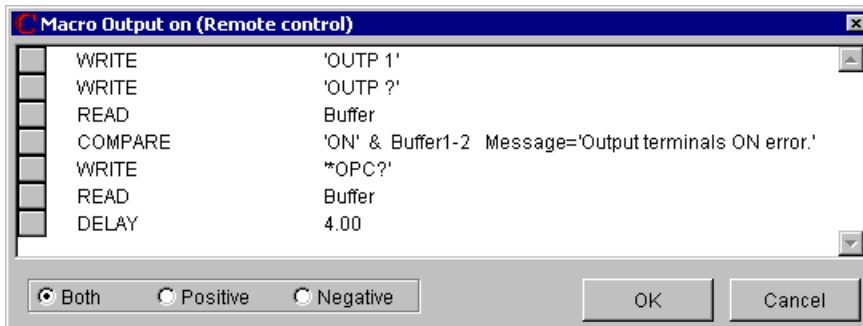
It is defined for the GPIB, RS232 and VISA buses. There is a macro of the M140 calibrator measurement in the R-2W function in source mode in the figure. Following commands are used for the macro in the figure:

**WRITE** – it shall send the „RES ?“ string in a calibrator and the report shall be ended by a sign defined in the open / close macro - CR (ALT13).

**READ** – it shall count a calibrator’s answer to the Value variable.

Macro measure can be common for all the buses (Remote control). The source and the meter have an independent macro. At the source, the macro checks a value being set for the source (one measure shall be performed). At the measuring instrument, the macro starts and performs one measure (it shall be performed more measurements – mostly 10). Details to particular macro commands see the “Macro Command Syntax” section”.

### Macro Output on



It is defined for the GPIB, RS232 and VISA buses. There is a macro Output on for the M140 calibration the VDC-2W function in the figure. Following commands are used for the macro in the figure:

**WRITE** – it shall send the „OUTP 1“ string in a calibrator and the report shall be ended by a sign defined in the open / close macro - CR (ALT13).

**WRITE** – it shall send the „OUTP ?“ string in a calibrator and the report shall be ended by a sign defined in the open / close macro - CR (ALT13).

**READ** – it shall count a calibrator’s answer to the Buffer variable.

**COMPARE** – it shall compare the „ON“ string with 1-2 signs saved in the Buffer variable. If they differ, the “Output terminals ON error” message shall be displayed and finished calibration.

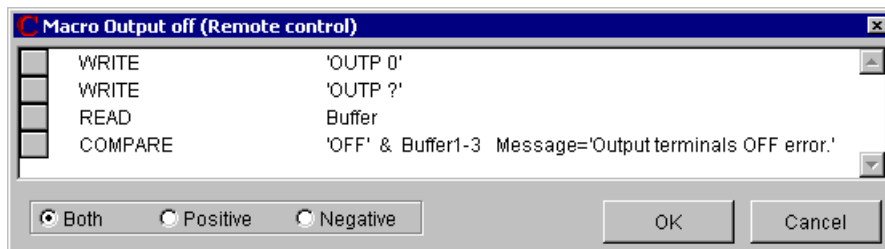
**WRITE** – it shall send the „\*OPC?“ string in a calibrator and the report shall be ended by a sign defined in the open / close macro - CR (ALT13).

**READ** – it shall count a calibrator’s answer to the Buffer variable.

**DELAY** – it shall wait 4 seconds to output value stabilization.

In the lower bar of the window there is the “Both”, “Positive” and “Negative” switch. If the source has the same command for switching positive and negative polarity on, it can be sufficient to define a macro for the “Both” switch position. Some sources have different commands for switching positive and negative polarity on. Then one macro must be defined for the “Positive” switch position and another one for the “Negative” switch position. The Macro Output on can be common for all the buses (Remote control) and there it is only for the source. Details to particular macro commands see the “Macro Command Syntax” section.

### Macro Output off



It is defined for the GPIB, RS232 and VISA buses. There is a macro Output off for the M140 calibrator in the figure. Following commands are used for the macro in the figure:

**WRITE** – it shall send the „OUTP 0“ string in a calibrator and the report shall be ended by a sign defined in the open / close macro - CR (ALT13).

**WRITE** – it shall send the „OUTP ?“ string in a calibrator and the report shall be ended by a sign defined in the open / close macro - CR (ALT13).

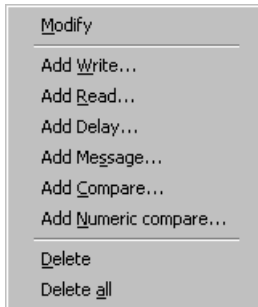
**READ** – it shall count a calibrator’s answer to the Buffer variable.

**COMPARE** – it shall compare the „OFF“ string with 1-3 signs saved in the Buffer variable. If they differ, the “Output terminals OFF error” message shall be displayed and finished calibration.

In the lower bar of the window there is the “Both”, “Positive” and “Negative” switch. If the source has the same command for switching positive and negative polarity off, it can be sufficient to define a macro for the “Both” switch position. Some sources have different commands for switching positive and negative polarity off. Then one macro must be defined for the “Positive” switch position and another one for the “Negative” switch position. The Macro Output off can be common for all the buses (Remote control) and there it is only for the source. Details to particular macro commands see the “Macro Command Syntax” section.

### 2.2.3. Macro Command Syntax

Press the right mouse key on the window for macro entry to open the following menu:



**Modify** – opens a window for selected macro command modifying.

**Add Write** – opens a window for write command adding.

**Add Read** – opens a window for read command adding.

**Add Delay** – opens a window for delay command adding..

**Add Message** – opens a window for message command adding.

**Add Compare**– opens a window for compare command adding.

**Add Numeric compare** – opens a window for numeric compare command adding.

**Delete** – removes a selected macro command.

**Delete all** – removes all macro commands.

Macros works with following objects:

- a) **Text** – consists of series of the standard ASCII signs (32... 255 codes). It must not contain control signs (0... 31codes).
- b) **Alternative code** – one ASCII sign (0... 255). It allows records of any ASCII signs inclusive control ones (0... 31 codes).
- c) **Variable** – macros use numeric variables (value and parameters) and one text variable (buffer). The “Value” variable contains a nominal value of a check point and it can be written or read (in the read macro). The “Parameter” variables (their count and names are determined by a selected function) contain values of next point parameters (e.g. frequency of alternating magnitudes) and they can be written only (to be sent into instruments). The “Buffer” text variable is intended for universal purposes and it can be written and read. Values which are saved in it are mostly intended for comparison of two strings (responds read from instruments and expected values). The “Serial number” text variable is used for reading serial number from an instrument. The reading must be done in Open macro to this variable. The Serial number can be then used for selection of the proper Calibration data of a Standard or can be printed in output Test report.

**Window for Add / Modify of WRITE Command.**

The screenshot shows a window titled "WRITE". Inside, there's a text field containing the string `'DCV 0.1,FILT_ON,RESL8,FAST_OFF'`. Below this, there are three rows of input fields, each with an "Add" button:

- Write string:** The same string as the main field.
- Text:** An empty text box.
- Alt code:** A numeric input set to 0, followed by the text "NUL".
- Variable:** A dropdown menu (currently empty), followed by "From" and "To" numeric inputs (both set to 0).

At the bottom right, there are "OK" and "Cancel" buttons.

It allows send a string composed of constants and variables into an instrument. The string can be composed of “Texts”, “Alternative codes” and “Variables”. Particular parts can be entered by its writing and pressing the particular “Add” key. By setting of “From” and “To” positions for text variables can be selected only a part of the string. The WRITE command being modified, a particular command part shall be selected by pressing the left mouse button in the “Write string” field. The selected part shall be highlighted and moved into an editing field (“Text”, “Alternative code” or “Variable”) which it has been created in. Here it can be modified. Press the right mouse button on a selected part to open a menu for its deleting.

**Window for Add / Modify of READ Command.**

The screenshot shows a window titled "READ". Inside, there's a text field labeled "Value". Below this, there are several sections:

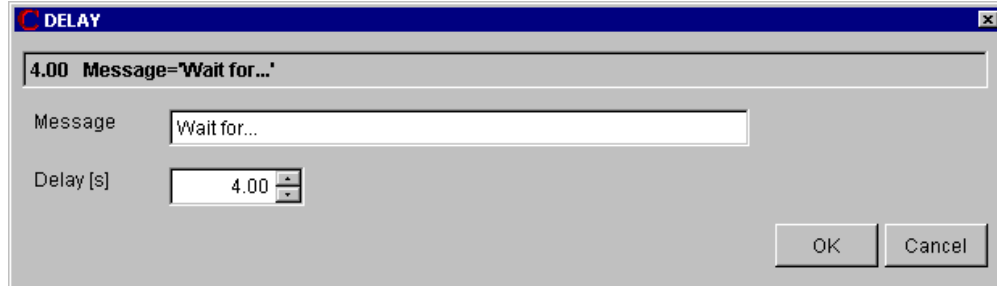
- Terminate on:** An empty text box.
- Text:** An empty text box with an "Add" button.
- Alt code:** A numeric input set to 0, followed by the text "NUL" with an "Add" button.
- Max. Count:** A numeric input set to 0.
- Read to:** A dropdown menu set to "Value".
- From:** A numeric input set to 0.
- To:** A numeric input set to 0.
- Fragment:** A numeric input set to 1.

At the bottom right, there are "OK" and "Cancel" buttons.

It allows reading of a value or a text from an instrument. Its result can be counted into the “Value” variable, if it is a measurement result or adjusted value, into the “Buffer” variable, if it is a text for another operation (e.g. a comparison), eventually into the “Serial number” variable. The string can be composed of “Texts”, “Alternative codes” and “Variables”. Particular parts can be entered by its writing and pressing the particular “Add” key. By setting of “From” and “To” positions for text variables can be selected only a part of the string. The “Fragment” can be selected too. The Fragment represents a part of the string separated by the “,” comma. The Fragment which equals one means a whole string, the fragment which equals two means a sting behind the first comma etc. The WRITE command being modified, a

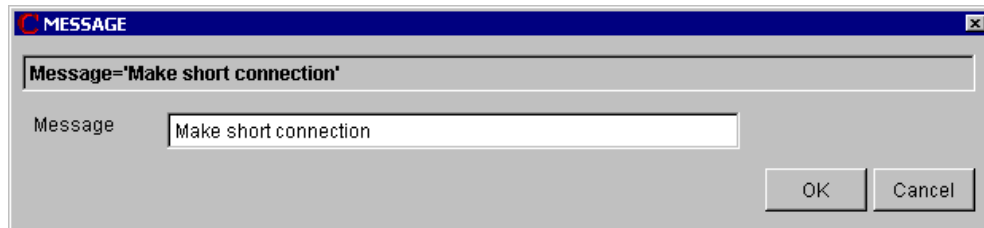
particular command part shall be selected by pressing the left mouse button in the “Terminate on” field.

#### Window for Add / Modify of DELAY Command.



This command shall interrupt program performance for time period set in the “Delay” window. The time can be set in 0 to 999 seconds interval. During the delay, a text written in the “Message” field appears on the screen. The “Delay” command can be suitable used for tuning of new written macros. Enter the “Delay” command with the next command description in front of every macro command. If the macro operation stops with an error message, it can be properly assessed which command was an error cause.

#### Window for Add / Modify of MESSAGE Command.



This command shall interrupt program performance and display a text in the “Message” window. Press the „Enter“ key to proceed the program. The message prompts an operator to perform an activity which cannot be performed automatically.

**Window for Add / Modify of COMPARE Command.**

**COMPARE**

'ON' & Buffer1-2 Message='Output terminals ON error.'

First string: 'ON'

Second string: Buffer1-2

Text: [ ] Add

Alt code: 0 NUL Add

Variable: [ ] From: 0 To: 0 Add

If condition is not met:

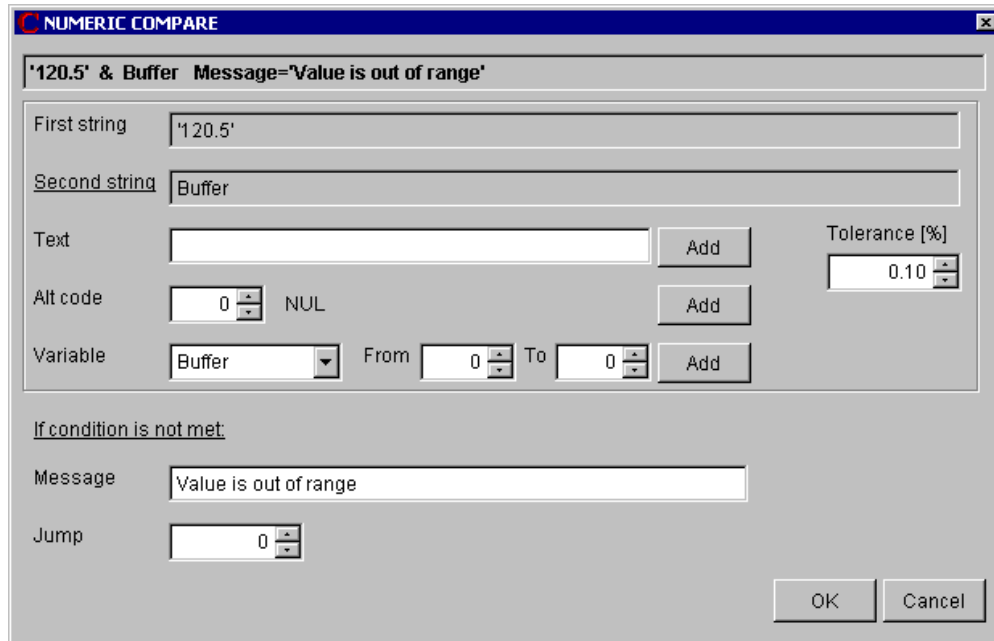
Message: Output terminals ON error.

Jump: 0

OK Cancel

This command shall compare two strings. If they are different, it shall interrupt program performance and display a text in the “Message” window. In the “Jump” field, number of macro lines can be set that shall be jumped if the condition is not fulfilled. The zero value means that no jump shall be done. The plus value means one jump forwards, i.e. it is a conditioned jump (can be used for macro parts jumping if a controlled instrument doesn’t contain a function part). The negative value shall return the program back, i.e. it is a conditioned loop (can be used for waiting on an instrument response especially if a response long is, there shall be constantly tested if an instrument is ready). If the “Jump” field is not zero, the field “Message” needs not be filled, if no message is to be shown. To develop a compare command, firstly two strings are to be set, which shall be compared. A string is to be made so that first a required string is to be selected by click on its name (“The first string” or “The second string”) and then items “Text”, “Alternative code” or “Variable” are to be added. Mostly a fixed text containing the “Buffer” variable with foregoing “Read” command is being compared. In the figure there is comparing of the first two characters of the “Buffer” variable with the “ON” text. If they are different, the program shall end with the “Output terminals ON error” message. The same rules as for the “Read” and “Write” commands are valid for development and modify of text strings.



**Window for Add / Modify of NUMERIC COMPARE Command.**


**NUMERIC COMPARE**

'120.5' & Buffer Message='Value is out of range'

First string: '120.5'

Second string: Buffer

Text: [ ] Add

Alt code: 0 NUL Add

Variable: Buffer From: 0 To: 0 Add

Tolerance [%]: 0.10

If condition is not met:

Message: Value is out of range

Jump: 0

OK Cancel

This command shall compare two numeric values. If they are different of more percent than in the “Tolerance” window has been set, it shall interrupt program performance and display a text in the “Message” window. In the “Jump” field, number of macro lines can be set that shall be jumped if the condition is not fulfilled. The zero value means that no jump shall be done. The plus value means one jump forwards, i.e. it is a conditioned jump. The negative value shall return the program back, i.e. it is a conditioned loop. If the “Jump” field is not zero, the field “Message” needs not be filled, if no message is to be shown. To develop a compare command, firstly two strings are to be set, which shall be compared. A string is to be made so that first a required string is to be selected by click on its name (“The first string” or “The second string”) and then items “Text”, “Alternative code” or “Variable” are to be added. Mostly a fixed text containing the “Buffer” variable with foregoing “Read” command is being compared. The program shall convert text values to numbers before comparing. The same rules as for the “Read” and “Write” commands are valid for development and modify of text strings.

### 2.3. “User Functions” Module

For a calibration of any instrument, a particular instrument card, a calibration procedure and defined functions are necessary. The instrument card defines features of used instruments. The calibration procedure defines relations between instruments and calibration points. The functions are being used by the program internally and their task is to match adjustments of particular instruments to the same function. New functions can be defined just by this program module. The Caliber program having been installed, a set of basic functions shall be counted.

Functions are divided into:

- *Absolute ones*

Absolute function values begin at a fixed point (-200 °C) and end at another fixed point (+800 °C). BMC is set in units of a measured magnitude. Examples of absolute functions are temperature ranges of multi-meters, thermometers etc.

- *Relative ones*

Relative function values start at zero or nearly at zero (0 V) and end at a fixed point (1000 V). BMC is set in percents. Examples of absolute functions are voltage ranges of multi-meters.

Evaluation method can be selected for every function regardless of this resolution. The adjusted evaluation method affects only expression of measured and calculated values in the calibration report. There are following functions from this point of view:

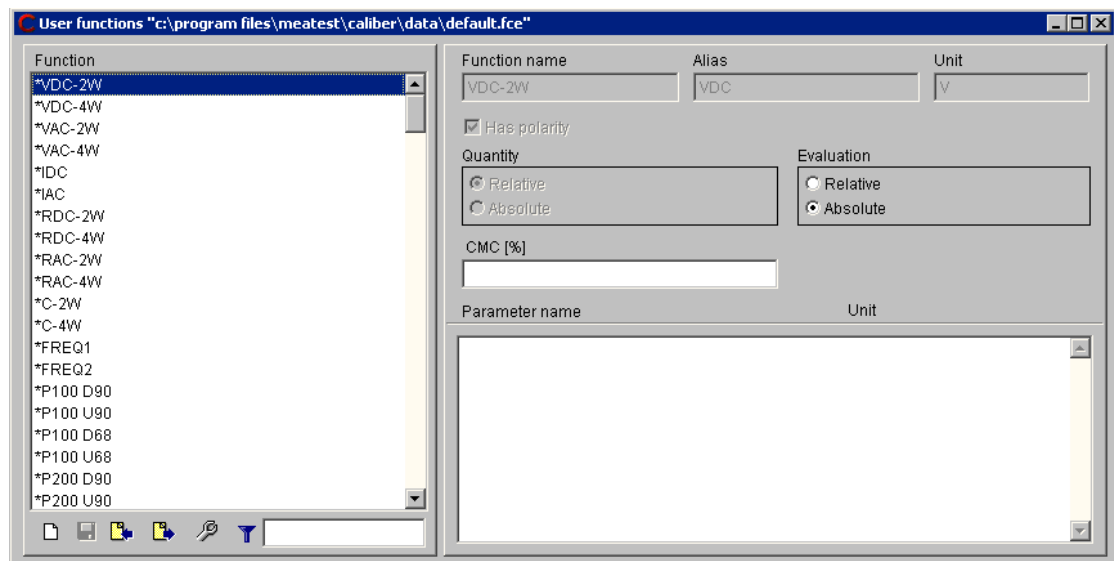
- *Functions with absolute evaluation*

Deviations and uncertainties are expressed in values of a measured magnitude. Absolute evaluation can be selected for both absolute and relative functions. Implicit adjustments after installation represent the “absolute evaluation” for all the functions.


- *Functions with relative evaluation*

Deviations and uncertainties are expressed in percents. Relative evaluation can be selected for relative functions only.

The „User functions“ module having opened, the following panel appears:



This panel is intended for editing and development of functions. It allows access to definitions and function features which are being used by the program. The functions are divided into **basic** ones (there are marked by an asterisk in the program) which no feature change is permitted for except from the „CMC“ and „Evaluation method“ ones; and **user** functions which the „Quantity“ and „With polarity“ field change is permitted for in addition to.

A listbox allowing function selection is situated in the left part of the window. Items here can be filtered using filter tool under the listbox (  ). The right panel part is intended for function description. Every function is given by these parameters:

**Function name** – it is composed of maximal ten characters and should characterize the given function best way.

**Alias** – function name used in test report. The alias for the function can be set in the Configuration panel - on the "Regional" tab.

**Unit** – it is composed of maximal four characters and shall be written in basic form (V, Pa, K etc.). The program automatically adds proper prefixes to it.

**Has polarity** – by the field checked it shall be marked that a given function allows setting both positive and negative values. For functions with polarity it is e.g. valid a specification of the 20 to 200 V range for the +20 to +200 values, however also the –20 to –200 ones. For functions without polarity it is necessary to create an independent -20 to - 200 V range for the –20 to –200 values.

**Quantity** – the setting affects way of BMC set and some behavior during calibration. It shall be set according the function type (absolute / relative).

**Evaluation** – the setting affects a test report form **only**. Allowed errors, deviations and measurement uncertainties can be evaluated as relative or absolute ones. For accuracy of implicitly defined functions, the absolute evaluation is preferred.

**CMC** – it gives the best measurement ability of a particular laboratory. If for the given function the better measurement uncertainty is evaluated then the CMC is, shall be the evaluated uncertainty substituted by the here given number in the test report. This item can be changed even for basic functions marked by asterisk. Every laboratory should fill the CMC field for every function according its measurement ability after program's installation. The CMC can be set either as relative or as absolute one, it depends if the given function is a relative or absolute one.

**Parameter name** – the item consists of maximal ten characters and is not mandatory one. It is only at functions with so called next parameter (e.g. alternating voltage with its frequency as the parameter). A function can contain more these parameters.

Following control keys are situated in the lower window edge:



**New** – adds a new user function.



**Save** – writes the modified function table into a file (database).



**Import** – imports functions created by means of the „Export“ button in the program. It is checked during the import if a given function exists in the system. The list shall be completed only by functions with a different definition.



**Export** – exports functions in the „fce“ format. The format is suitable to function definition transfer among users.

The Export and Import however are not very often used keys, because a function definition is being automatically transferred with a procedure in the „pre“ format. If it is being imported a procedure with a new function, this function shall be added in the program automatically.

## New function

This panel allows to append new function to Caliber system. This panel is accessible via the User functions module. Every function consists of its name and unit, optionally it can contain one or more parameters.

Function name	Unit
PDC	W

Parameter name	Unit
Voltage	V
Current	A

Buttons: Add, Delete, OK, Cancel

*Note: Be careful, all names and units entered here cannot be changed in future. Function cannot be deleted, only new one can be created. Additionally, only the translation of functions, parameters, and units into a local form can be done.*

**Function name** - it is composed of maximal ten characters and should characterize the given function best way. The function name should be defined in English for better compatibility when exchanging instrument cards and procedures around the world. This name can then be converted to a local form using the Configuration panel on the "Regional" tab, the "Function" sub-tab.

**Unit** - main function unit. It is composed of maximal four characters and shall be written in basic form (V, Pa, K etc.). The program automatically adds proper prefixes to it. The units must first be created using the Configuration panel on the "Regional" tab and the "Units" sub-tab.

**Parameter name** - the item consists of maximal ten characters and is not mandatory one. It is only at functions with so called next parameter (e.g. alternating voltage with its frequency as the parameter). A function can contain more these parameters. The parameters must first be created using the Configuration panel on the "Regional" tab and the "Parameters" sub-tab.

**Unit** - parameter unit. It is composed of maximal four characters and shall be written in basic form (V, Pa, K etc.). The program automatically adds proper prefixes to it. The units must first be created using the Configuration panel on the "Regional" tab and the "Units" sub-tab. Units are common to both functions and parameters.

**Add** - adds new parameter into parameter list.

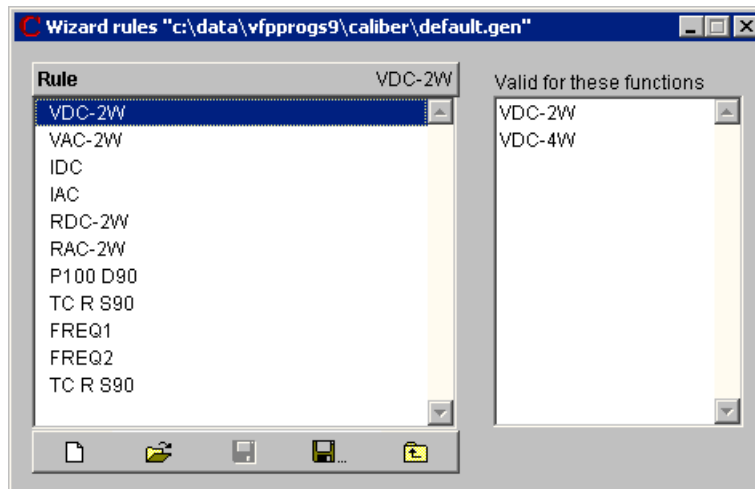
**Delete** - removes parameter from parameter list.

**OK** - closes panel and saves changes. New function will added into system list of functions.

**Cancel** - closes panel and discards changes.

## 2.4. “Wizard Rules“ Module

The „Wizard rules“ module having been opened, the following panel appears:



The panel is intended for development and editing of rules according to which a Procedure wizard shall automatically generate calibration points. The program allows create more “Rules” and save them under their names. There is possible to determine in the wizard according to which rule set the points shall be generated. It is suitable to have e.g. other rules for check of sources and different ones for check of measuring instruments.






Having been installed, the program contains a basic set of “rules” for check point generating contained in the “default.gen” file. The file contains the following rules:

- VDC-2W rule      for DC voltages (VDC-2W, VDC-4W functions)
- VAC-2W rule      for AC voltages (VAC-2W, VAC-4W functions)
- IDC rule          for DC currents (IDC function)
- IAC rule          for AC currents (IAC function)
- RDC-2W rule      for DC resistance, capacitance and inductance (RDC-2W, RDC-4W, R-TRUE, R-HIGH, C-2W, C-4W, L-2W, L-4W functions)

*Note:              A calibration procedure cannot be automatically generated without use of the “Rules”. The rules cannot be developed for functions having more than one parameter. The procedure than must be put together separately.*

There is a status window in the left upper corner. It displays a structure of counted rules – rule name (function name), scale, range type and check points. On the right there are displayed functions, which the given rule is valid for.

There are control keys situated in the lower bar of the status window:

-  **New** – creates a new rule set for point generating.
-  **Open** – opens an already created rule set.
-  **Save** – shall write a modified rule set in a file (database).
-  **Save as** – shall write a modified rule set under a new name in a file (database).
-  **Back** – is intended for move to one level up in a hierarchy: instrument – scale – range type – values. Nesting (move to one level down) shall be performed by a mouse click on a selected item.

### 2.4.1. Development of „Wizard rules“

The rule set has the following structure:

**Rule** – its name is derived from function name. One rule can be valid for more functions. By double mouse click on any of the rules in the status window we can move to a lower level- in the scale.

**Scale** – describes length of a scale (number of digits) of an instrument under test. Sources having not a scale length given in its instrument card are observed as having a scale of 2000 digits length. Instruments with longer scale have usually more check points than instruments with shorter scales. A user can define a scale in any way. For every function a few scales can be created with different rules for point generating. Recommended process for set up of calibration points is to be found in the EA-10/15 recommendation.

**Range type** – characterizes a range according to its location in reference to other ranges. There are following range types:

**Highest** – the highest range for a given function. The highest range for most of multi-meters for the VDC-2W function is the 1000V range.

**Lowest** – the lowest range for given function.

**Intermediate** – the range in the middle (for voltage usually the 20V range). If number of ranges is even, the higher range from two middle ones is observed as intermediate.

**Specific** – the range given by a fixed interval of a measured quantity. It is e.g. the range higher than 100 V or the range lower than 200 Ohms. Validity for the 30V to 150V ranges can be also given.

**Common** – satisfies all ranges. The lower priority must be given to this range type.

*Note: Range types have been determined according to the EA-10/15 recommendation.*

During procedure generating the program is going through all defined range types and it shall use the firstly found one satisfying the required range. It means in practice that range

priority (sequence of evaluations) is given by the sequence of range type definition. If the range sequence needs to be changed, it can be performed in the status window. Point the mouse cursor at a field for movement located on the left side of each of the range types. Press the left mouse key, keep it pressed and move the mouse up or down to move the selected range type.

**Values** – defines calibration points for given range types. Calibration points are inserted in the procedure in the same sequence as they are given here. This sequence can be changed by the left mouse button.

Ways of adding functions, ranges, points and module control are the same as at the “Procedure” module. Press the right mouse button on a selected item to open a menu. The item can be “Add”, “Modify” or “Delete” then.

Standard delivered „Default.gen“ rules have following definitions of point generating for the direct voltage function:

For multi-meters up to 15,000 digits inclusive the check points of 10%, 50%, 90%, -10%, -90% range in the middle range and for other ranges the points of 10%, 90%, -90% range are generating.

For multi-meters from 15,000 digits to 25,000 digits inclusive the check points of 10%, 30%, 50%, 70%, 90%, -10%, -90% range in the middle range and for other ranges the points of 10%, 90%, -90% range are generating.

For multi-meters from 25,000 digits to 15,000,000 digits inclusive the check points of 10%, 50%, 90%, -90% range in the > 200V range, the 10%, 30%, 50%, 70%, 90%, -10%, -90% range in the middle range and for other ranges the points of 10%, 90%, -90% range are generating.

For multi-meters over 15,000,000 digits the check points of 10%, 50%, 90%, -90% range in the > 200V range, the 10%, 30%, 50%, 70%, 90%, -10%, -90% range in the middle range and for other ranges the points of 10%, 50%, 90%, -90% range are generating.

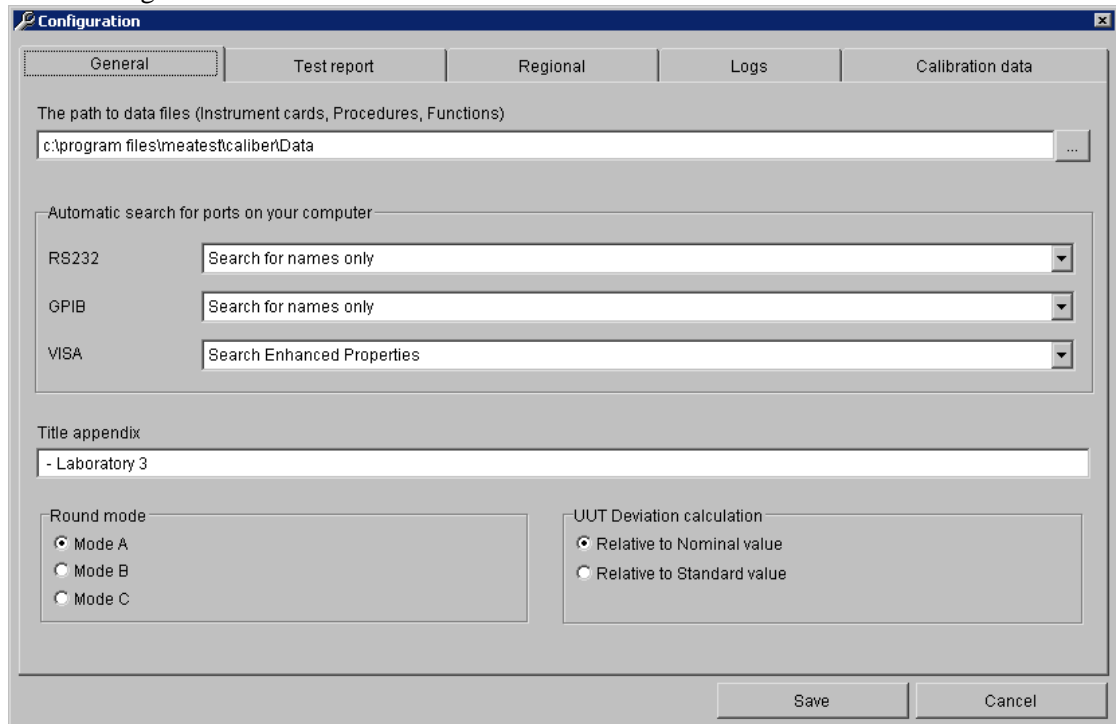


## 2.5. “Configuration” panel

The "Configuration" panel is intended for global setting of the program properties. The settings are valid unless overwritten with the settings in the "Procedure" module. The settings are further divided into five tabs:

### 2.5.1. General

**General** - you can set the path to data files, search for ports on your computer, and other settings.



**The path to data files** – determines the location of the data files, such as instrument cards, procedures, user functions, and calibration point generation rules. The program will only open those files that are in the folder. You cannot open files from other folders. This setting is ignored if the program is running from WinQbase.

**Automatic search for ports on your computer** – allows you to set up the search for available ports when choosing them. Settings are made for RS232, GPIB and VISA.

- *Do not search* – the program will not detect the presence of physical ports or devices.
- *Search for names only* – searches for the presence of physical ports, GPIB device addresses, VISA device identifier.
- *Search Enhanced Properties* – the offer is only available for VISA ports and allows you to get some additional information by trying to open the port.

**Title appendix** – allows you to enter additional text, which will then be displayed after the program name in the top bar of the main window and in the lower Windows bar. It serves to better identify the program.

**Round mode** – allows you to choose the default mode when rounding columns in the output test report. The modes are the same as in the Rounding panel, which is available in the Procedure module. The settings you make here will only apply if this setting is not set in the Procedure module or the "Default Settings" in the Procedure module is performed.

**UUT Deviation calculation** – determines the method of calculating the UUT deviation for each calibration point.

- *Relative to nominal value* – the UUT deviation is determined by the value measured by UUT.
- *Relative to Standard value* – the UUT deviation is determined by the value measured by Standard.

### 2.5.2. Test report

**Test report** - allows you to set the form of the test report, the names and order of the columns, the evaluation symbols and their comments.

The screenshot shows the 'Configuration' dialog box with the 'Test report' tab selected. The 'Test report form' section contains a table with the following columns: Function, Range, Standard, UUT, Deviation, Allowed, and Uncert. Below the table, there is a list of evaluation symbols and their descriptions:

Function	Range	Standard	UUT	Deviation	Allowed	Uncert.
ok	...	passed				
*	...	fail				
?	...	measured deviation in interval allowed deviation ± uncertainty				
~	...	unstable value				
R	...	measured deviation and uncertainty of range				
***Canceled by operator***						

At the bottom of the dialog, there are buttons for 'Test report columns', 'Footer caption', 'Pass', 'Fail', 'Pass with uncertainty', 'Unstable reading', 'Value relative to range', 'Canceled by operator', 'Save', and 'Cancel'.

**Test report form** – the visual form of the resulting report without measured data with all symbols used. You can change the settings by double-clicking the left mouse button on the

required test report line. If one of the rows is missing (by setting it out), you can include it using the buttons below the test report window.

**Test report columns** – allows you to set the number of columns, their widths and names. To edit, the Test report columns panel is used. This panel is the same as in the Procedure module. The settings you make here are used only if the settings in the Procedure module is not set or the "Default setting" is performed in the Procedure module.

**Footer caption** – allows you to customize the default "Symbol description" footer caption that appears at the end of the test report.

**Pass** – allows you to set the symbol and comment for the result of the calibration point that it has complied with.

**Fail** – allows you to set the symbol and comment for the result of the calibration point that failed.

**Pass with uncertainty** – allows you to set a symbol and comment for the result of a calibration point that has complied with the error margin + - measurement uncertainty.

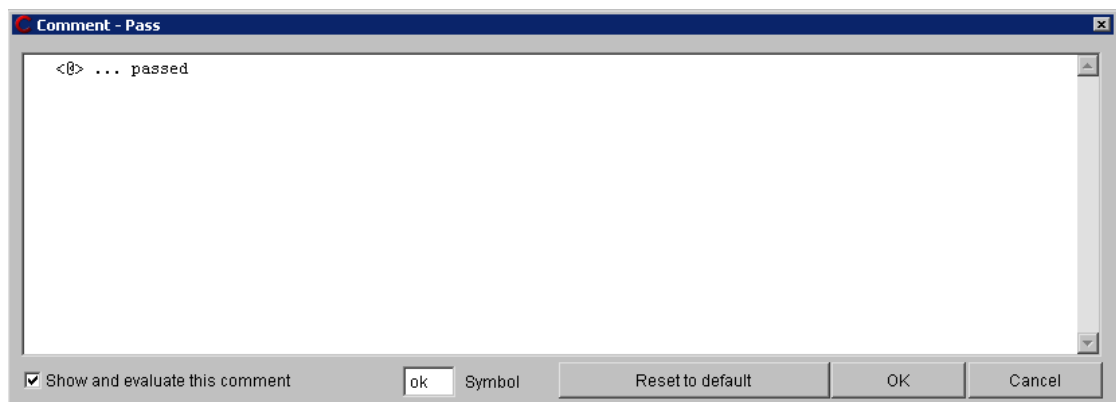
**Unstable reading** – allows you to set a symbol and comment for a calibration point that has been showing unstable readings.

**Value relative to range** – allows you to set the symbol and comment for the calibration point that used the calculation of the deviations relative to the range and not to the value. Such a symbol is used only when the relative evaluation of the variations (in percent) is set and the measured value is close to zero.

**Canceled by operator** – allows you to set the text that appears at the end of the test report if the calibration has not been completed and the calibration runs under WinQbase.

## Comment

The "Comment" panel is used to set the protocol footer. With this panel, you can also set the evaluation symbols that can be displayed on each line of the test report.



**Comment** – an edit field for writing the desired comment text. The comment appears at the end of the test report if it is valid for actual test report. It is also possible to create multi-line comments. The comment type can be seen in the comment title. The comment may show the

"<@>" string anywhere, which will be replaced with the selected symbol in the output test report. The symbol can be entered in this panel or in the Global procedure settings.

**Show and evaluate this comment** – disables or allows the display of this type of comment in the test report.

**Symbol** – allows you to enter a symbol for the selected comment type.

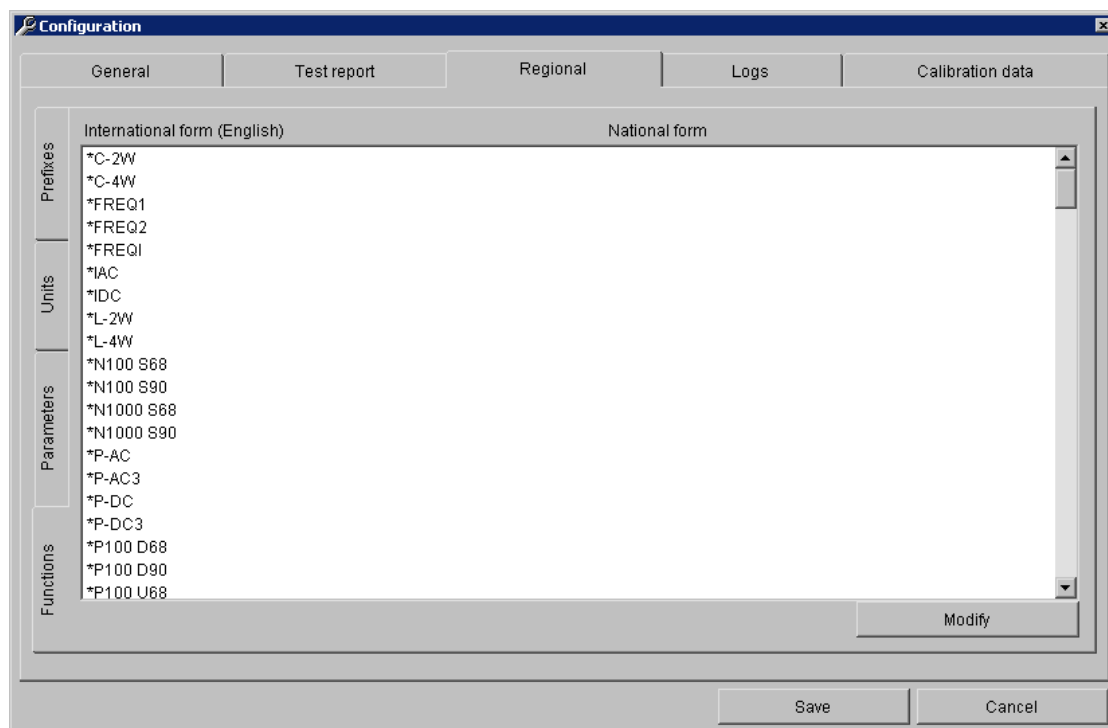
**Reset to default** – sets the default comment and symbol for that comment type, and closes the panel.

**OK** – the settings will be transferred to the Configuration - Test report panel and the panel will close.

**Cancel** – closes the panel and ignores the changes.

### 2.5.3. Regional

**Regional** - allows you to set localized forms of function names, parameters, and units. These national forms will then be displayed in the exported test report. Functions, parameters, and units are used in the User functions module and are key to Caliber system identification and Instrument card and Procedure sharing worldwide. It is therefore necessary to use English names for them. Therefore, the "Regional" tab is used to locate them in the locale. The location is then divided into four additional tabs for better clarity.



**Functions** – a list of all Caliber functions. Functions are defined in the User functions module. This tab can be used for translation into the national format to be used in the test report when exporting. If the translation is not done, the original name will be used.

**Parameters** – a list of all parameters - quantities. Parameters are defined here - both English and National, and can then be used to create a new function in the User function module. Parameter translation is used on all Caliber panels.

**Units** – a list of all units of quantities for use in the system. Units can be added and edited here, and their English and National forms are entered if needed. Units are entered without prefixes, because prefixes are created automatically by the system.

**Prefixes** – unit prefixes are pre-set for each language, but can be changed.

**Save** - all settings made on all tabs will be saved and set as "Default".

**Cancel** - closes the panel and ignores the changes.

### 2.5.4. Logs

**Logs** - logs are used to set up and view calibration log entries. This is not a regular export of test reports, but additional calibration information. They allow you to store individual instrument readings, or to preserve unrounded results. Records are created in the background while calibration runs without user intervention. Recording is done in a text file and initialized when the procedure is opened.

Configuration

General | Test report | Regional | **Logs** | Calibration data

What will be logged  
Standard Readings, UUT Readings, Test report line

Output file name  
logXXXXXX.txt

The path to log files  
\\server\logs

File name	Procedure	Size	Date
LOG000001.TXT	M3800	257 B	1.6.2015
LOG000002.TXT	M3800	546 B	1.6.2015
LOG000003.TXT	140U FL2	267 B	1.6.2015
LOG000004.TXT	M3800	259 B	21.7.2015
LOG000005.TXT	M3800	260 B	21.7.2015
LOG000006.TXT	M3800	399 B	19.8.2015
LOG000007.TXT	M3800	266 B	19.8.2015
LOG000008.TXT	UNITES06	270 B	11.9.2015
LOG000009.TXT	M3800	265 B	7.10.2015
LOG000010.TXT	UNITES06	270 B	30.10.2015
LOG000011.TXT	M3800	266 B	3.11.2015
LOG000012.TXT	M3800	578 B	3.11.2015
LOG000013.TXT	M3800	416 B	3.11.2015

View

Save Cancel

**What will be logged** – determines the contents of the record.

- *Disabled* – logs will not be created.
- *Test report line* – each row is saved in the same format as for test report export. The difference is that the rows of the log are sorted according to the calibration run and not by the Status Window.

- *Standard readings, UUT readings, Test report line* – stores each row in the same format as the test report export, supplemented by individual Standard and UUT readings.
- *Standard readings, UUT readings, Test report line without rounding* – stores each row as when the test report is exported, but the results are not rounded, the standard and UUT readings are filled in.
- *Test report line without rounding* – stores each row as when the test report is exported, but the results are not rounded.

**Output file name** – name of the file with logged records:

- *Protocol.txt* – the fixed name "Protocol.txt" is used to the "Local" folder where the program is installed.
- *Result.txt* – the fixed name "Result.txt" is used to the "Local" folder where the program is installed.
- *LogXXXXXX.txt* – dynamic file name - XXXXXX is a six-digit number that is constantly increasing from number 1 above. The path to the files is set by the "The path to log files" setting.

**The path to log files** – folder to which records are stored. The settings are only available for files with the dynamic file name "LogXXXXXX.txt".

**File name** – the column contains the names of the text files that are in the logs folder. Clicking on the column heading sorts the records by filename.

**Procedure** - the name of the procedure that the log was made with. Clicking on the column heading sorts the records by the procedure name.

**Size** - size of log in bytes. Clicking on the column heading sorts the records by file size.

**Date** - date the log was created. Clicking on the column heading sorts the records by date.

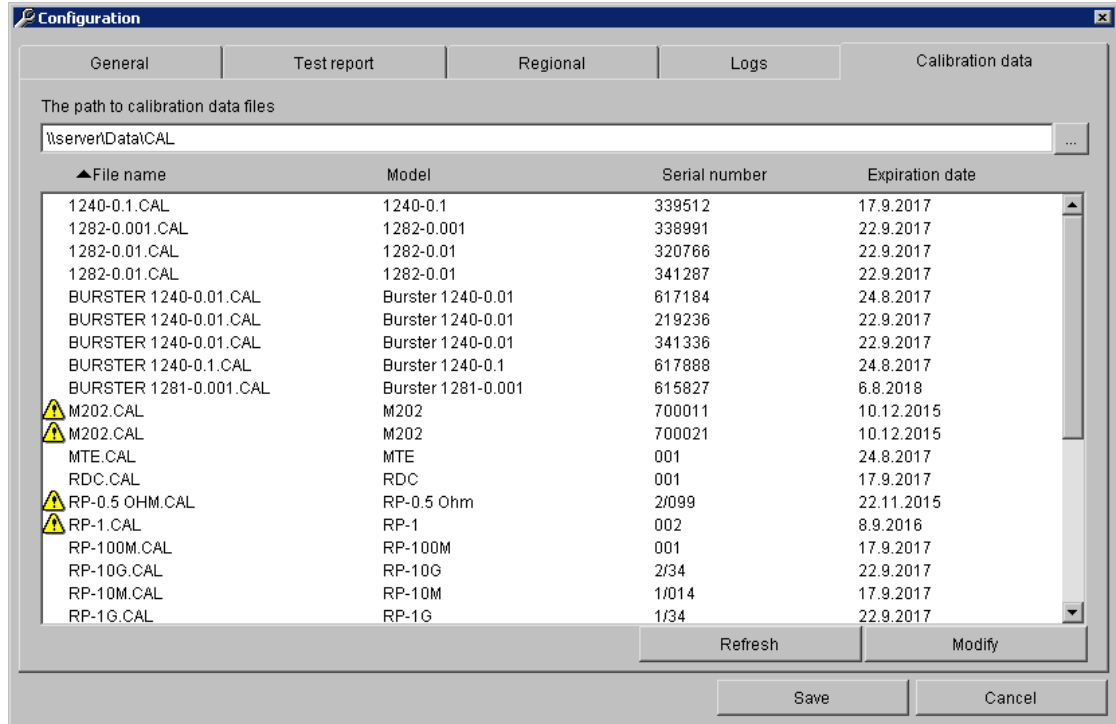
**View** - opens the selected file selected for viewing.

**Save** - all settings made on all tabs will be saved and set as "Default".

**Cancel** - closes the panel and ignores the changes.

### 2.5.5. Calibration data

**Calibration data** - on this tab you can view and edit calibration data for instrument cards. You can also see the expiration date of their calibration. A detailed description of the calibration data can be found [here](#).



**The path to calibration data files** – the folder where all instrument calibration data are located.

**File name** – this column contains the file names of the calibration data that are in the specified folder. Clicking on the column heading sorts the records by file name.

**Model** – list of devices found in calibration data files. Clicking on the column heading sorts the records by model.

**Serial number** – serial number to the model found. Clicking on the column heading sorts the records by serial number.

**Expiration date** – the date on which the instrument calibration data is valid. If the date has already expired, an exclamation point in the yellow triangle appears before the name of the calibration file. Clicking on the column heading sorts the records by the expiration date. This may be appropriate for detecting instruments with expired calibration.

**Refresh** – reconsiders the calibration data folder and updates the list.

**Modify** – opens the selected file to edit. The meaning of the individual rows in the file is described [here](#).

**Save** - all settings made on all tabs will be saved and set as "Default".

**Cancel** - closes the panel and ignores the changes.

## 2.6. Measuring Procedure

For every point a measuring is being performed in these steps:

- a) Adjustment of the automatic terminal switch (if it is used).
- b) Adjustment of a function and range of the converters (if they are used).
- c) Adjustment of a function and range of the measuring instruments.
- d) Adjustment of a function and range of the sources.
- e) Switch on output terminals of sources (if a source is equipped with this option).
- f) Additional adjustment during an analog meter instrument test (the UUT must be used as an analog measuring instrument).
- g) Counting of all the converter values (if they are used).
- h) Counting of a standard value. If a source is in standard function, one measurement shall be performed (a value set on the source shall be counted). If a measuring instrument is a standard, set of measurements shall be performed.

*Note: If the standard measurement instrument is manually controlled, a half of measurements written down in the “No. of SU readings” item shall be performed. If the measurement number is odd, a half of measurements rounded up shall be performed.*

*If the standard measurement instrument is controlled another as manually way, one extra measurement shall be performed before the measurement set itself. This first measurement shall not be cont towards other evaluations.*

- i) Counting of a tested instrument value: If a source is instrument under test, one measurement shall be performed (a value set on the source shall be counted). If a measuring instrument is a standard, set of measurements shall be performed.

*Note: If the instrument under test is manually controlled, number of measurements written down in the “No. of UUT readings” item shall be performed. If the instrument is controlled another as manually way, one extra measurement shall be performed. This first measurement shall not be cont towards other evaluations.*

- j) If a meter is a standard, set of measurements by this standard instrument shall be performed. Mean of both measurement sets (h,j points) shall be set as the standard value.

*Note: By means of a standard measuring instrument a half of measurements written down in the “No. of Standard readings” item shall be performed. If the measurement number is odd, a half of measurements rounded down shall be performed. Measurement number doesn't depend on instrument's way of control.*

- k) Calculations and measurement checks in terms of value scatter shall be performed (see below). If discrepancy is found, the process shall be repeated from h point.
- l) Switch off output terminals of sources (if a source is equipped with this option).



*Note: If a user interrupts the program in middle of described process run (by pressing the ESC key during calibration), the output source terminals shall go always off.*

If a gross error occurs at evaluation (5 times larger deviation than the allowed error), the program stops (implicit “Global procedure settings”) and check of this point can be repeated. If the procedure is set that even in case of gross error it is continuing, the program is continuing to the next calibration point.

A user can change a measuring procedure from the “Measurement mode” panel in the procedure status window. A measuring procedure can be changed for one calibration point, range, function or the whole procedure.

## 2.7. Measurement Error and Uncertainty Calculation

### 2.6.1. Used Abbreviations

**L1**

Relative accuracy from value stated in the instrument card [%] (e.g. 0.1%).

**L2**

Relative accuracy from range stated in the instrument card [%] (e.g. 0.05%).

**L3**

Absolute error in units of measured quantity stated in the instrument card (e.g. 5mV).

**L4**

Absolute error in digit number stated in the instrument card (e.g. 2 digits).

**Rng\_u**

An end range value of the instrument under test in units of measured quantity stated in the instrument card (e.g. 20V).

**Dig\_u**

Resolution of one digit of the instrument under test in units of measured quantity. It can be stated direct in the instrument card or it can be calculated from digit number and range (range / digit number), (e.g. 100mV/digit).

**Dig\_s**

Resolution of one digit of the standard instrument in units of measured quantity (if a converter is used, then after recalculation by this converter). It can be stated direct in the instrument card or it can be calculated from digit number and range (range / digit number), (e.g. 10mV/digit).

**Dig\_sa**

Resolution of one digit of the auxiliary standard instrument in units of measured quantity (if a converter is used, then after recalculation by this converter). It can be stated direct in the instrument card or it can be calculated from digit number and range (range / digit number), (e.g. 10mV/digit).

**Dmax\_u**

Accuracy of the instrument under test in units of measured quantity. It shall be calculated according to data stated in the instrument card (see the 2.6.2 Measurement Error Calculation section), (e.g. 100mV).

**Dmax\_s**

Accuracy of the standard instrument in units of measured quantity (if a converter is used, then after recalculation by this converter). It shall be calculated according to data stated in the instrument card (see the 2.6.2 Measurement Error Calculation section), (e.g. 10mV).

**Dmax\_sa**

Accuracy of the auxiliary standard instrument in units of measured quantity (if a converter is used, then after recalculation by this converter). It shall be calculated according to data stated in the instrument card (see the 2.6.2 Measurement Error Calculation section), (e.g. 10mV).

#### **Dmax\_c**

Accuracy of the real converter in units of measured quantity. It shall be calculated according to data stated in the instrument card converted to measured quantity by the converting function itself (see the 2.6.2 Measurement Error Calculation section). This error equals zero if the converter is under test or a virtual converter (it makes an arithmetic operation only and doesn't affect the measured quantity).

#### **Xu**

Value measured (adjusted) by the instrument under test. The value (Xu) equals the adjusted value at the source under test. At the measuring instrument under test it is calculated as measurement medium without gross errors.

$$X_u = \sum a_j / j$$

#### **Xs**

Value measured (adjusted) by the standard (if a converter is used, then after recalculation by this converter). The value (Xs) equals the adjusted value at the standard sources. At the standard measuring instruments it is calculated as measurement medium without gross errors.

$$X_s = \sum a_j / j$$

#### **Xsa**

Value measured (adjusted) by the auxiliary standard (if a converter is used, then after recalculation by this converter). The value (Xsa) equals the adjusted value at the standard sources. At the standard measuring instruments it is calculated as measurement medium without gross errors.

$$X_{sa} = \sum a_j / j$$

Note: An auxiliary standard is mostly used for measurement of an output of a converter under test.

**Gross error identification** is made in terms of comparison of measured values:

$$|a_j - X| > 2.5 * z_{aj}$$

where the z is the mean-square deviation

$$z_{aj} = \sqrt{(\sum (a_j - X)^2 / j)}$$

and X are the Xu, Xs or Xsa values.

If the above mentioned condition is fulfilled for any measurement etc., the whole measuring procedure shall be repeated at the given check point. If the measurement set fails even after the third repetition, it shall be used and a „~“ –unstable note appears at the end of the particular line.

### 2.6.2. Calculation of UUT deviations

The way of deviation calculation is fixed determined by the program. Internally the program performs every calculation in units of a measured quantity. If a relative expression is required, a recalculation shall be made according to rules stated in 2.6.4 Relative Value Representation section.

**Allowed deviation** is determined by the following formula:

$$Dmax\_u = |Xu| * L1 / 100\% + Rng\_u * L2 / 100\% + L3 + Dig\_u * L4$$

Note: In similar way limit deviations of all other instruments shall be calculated (Dmax\_s, Dmax\_sa, Dmax\_c). If a converter is being used, the result shall be converted to units of the measured quantity.

**Deviation of an instrument under test** shall be calculated according to the following relation:

$$d = Xu - Xs \quad \text{if a source of a meter are being tested}$$

or

$$d = Xsa - Xs \quad \text{if a converter is being tested}$$

### 2.6.3. Calculation of Measurement Uncertainty

The way of measurement uncertainty calculation is fixed determined by the program according to EA-4/02. Internally the program performs every calculation in units of a measured quantity. If a relative expression is required, a recalculation shall be made according to rules stated in 2.6.4 Relative Value Representation section. If the calculated measurement error is in the 'limit allowed error +/- uncertainty' interval, the particular line shall be marked by the „?“ symbol. In terms of “Global procedure settings” of the procedure „?“ symbol can be replaced by another symbol (adjustment can be performed in the “Failed in band” field). In the same way a uncertainty can be removed from measurement evaluations by selecting the “None” parameter.

For each of the points the **standard extended measurement uncertainty** has been calculated.

$$U = k_u * u_c$$

where is

**k<sub>u</sub>** - extension coefficient set by the control file (implicitly k<sub>u</sub>=2)

**u<sub>c</sub>** - combined standard uncertainty according to the formula:

$$u_c = \sqrt{u_a^2 + u_b^2 + u_{ud}^2 + u_{ua}^2 + u_{sd}^2 + u_{sa}^2 + u_{sb}^2 + u_{td}^2 + u_{ta}^2 + u_{tb}^2 + u_{cb}^2}$$

**u<sub>a</sub>** - general uncertainty of A type. It shall be used only if any of the uncertainty sources of A type is not used in calculations by the program. It can be adjusted separately for every function, range or point under test. In very most of cases, the implicit 0.0 value shall be proper. A user will set this uncertainty in the “Additional uncertainty” panel. For absolute quantities, the uncertainty equals to the by user given value. For relative quantities the following formula is valid:

$$u_a = \text{by user given value} * |X_s| / 100$$

**u<sub>b</sub>** - general uncertainty of B type. It shall be used only if any of the uncertainty sources of B type is not used in calculations by the program. It can be adjusted separately for every function, range or point under test. If this uncertainty is not defined by a user and an instrument under test is an analog measuring instrument, the program shall automatically set a uncertainty according to a allowed error of the measuring instrument according to the following formula:

$$u_b = D_{\max\_u} / (\sqrt{3} * 10)$$

If a user set a uncertainty in the “Additional uncertainty” panel, then for absolute quantities the uncertainty shall equal to the by user given value. For relative quantities the following formula is valid:

$$u_b = \text{by user given value} * |X_s| / 100$$

**u<sub>ud</sub>** - uncertainty caused by final resolution of the measuring instrument under test  
(if a source is the measuring instrument under test, the value equals zero)

$$u_{ud} = 0.29 * \text{Dig}_u$$

**u<sub>ua</sub>** - uncertainty A type determined from j measurements a<sub>j</sub> of the measuring instrument under test

$$u_{ua} = \sqrt{(\sum(a_j - \bar{X}_u)^2) / (j * (j - 1))}$$

**u<sub>sd</sub>** - uncertainty caused by final resolution of the standard measuring instrument  
(if a source is the standard, the value equals zero)

$$u_{sd} = 0.29 * \text{Dig}_s$$

**u<sub>sa</sub>** - uncertainty A type determined from j measurements a<sub>j</sub> of the standard measuring instrument (if a source is the standard, the value equals zero)

$$u_{sa} = \sqrt{(\sum(a_j - \bar{X}_s)^2) / (j * (j - 1))}$$

**u<sub>sb</sub>** - uncertainty caused by the limit standard error

$$u_{sb} = D_{max\_s} / \sqrt{3}$$

**u<sub>td</sub>** - uncertainty caused by final resolution of the auxiliary standard measuring instrument  
(if a source is the standard, the value equals zero)

$$u_{td} = 0.29 * Dig\_sa$$

**u<sub>ta</sub>** - uncertainty A type determined from j measurements a<sub>j</sub> of the auxiliary standard measuring instrument (if a source is the standard, the value equals zero)

$$u_{ta} = \sqrt{(\sum(a_j - X_{sa})^2) / (j * (j - 1))}$$

**u<sub>tb</sub>** - uncertainty caused by the limit auxiliary standard error

$$u_{tb} = D_{max\_sa} / \sqrt{3}$$

**u<sub>cb</sub>** - uncertainty caused by the limit error of the converter connected with the standard

$$u_{cb} = D_{max\_c} / \sqrt{3}$$

#### 2.6.4. Relative Value Representation

Internally the program performs every calculation in units of a measured quantity. If a relative expression is required, a recalculation of absolute values to relative ones in reference to the standard value (X<sub>s</sub>). Conversion is made according to the following formula:

$$\text{Relative} = \text{Absolute} * 100\% / |X_s|$$

If X<sub>s</sub> is lower than one hundredth of measuring range, the program shall express the value in reference to the range of the instrument under test (Rng<sub>u</sub>) during relative estimations. This fact shall be then marked by the „R“ letter at the end of a particular line in the test report:

$$\text{Relative (range)} = \text{Absolute} * 100\% / Rng\_u$$

## 2.8. Test Report Format

The appearance of the Test report is preset in the program and can be individually changed in the Configuration panel on the Test report tab. Some settings can also be changed in the Procedure module.

For every line a measurement uncertainty is stipulated and it is given if the particular measurement fulfills the measuring instrument specification. Accuracy of a standard represents an essential part of the measurement uncertainty. For the accurate calculation see the 2.5 and 2.6 sections. Following default symbols can appear at the end of every line:

- \* measured error is higher than the allowed one
- ~ measured error is unstable (see section No. 2.5)
- R all errors and uncertainties are in reference to the range
- ? measured error is in the interval of limit error +/- measurement uncertainty
- ok if a check point is ok

Test report sample:

Function	Range	Standard	UUT	Deviation	%spe	Allowed	Uncertainty	
VDC-2W	200 mV	20.0 mV	20.0 mV	-0 uV	0	200 uV	62 uV	ok
VDC-2W	200 mV	180.0 mV	180.6 mV	620 uV	62	1003 uV	71 uV	ok
VDC-2W	200 mV	-180.0 mV	-180.7 mV	-690 uV	-69	1003 uV	69 uV	ok
VDC-2W	2 V	0.200 V	0.200 V	-0.00 mV	0	2.00 mV	0.58 mV	ok
VDC-2W	2 V	1.800 V	1.807 V	7.00 mV	70	10.04 mV	0.58 mV	ok
VDC-2W	2 V	-1.800 V	-1.807 V	-6.80 mV	-68	10.03 mV	0.64 mV	ok
VDC-2W	20 V	2.00 V	2.00 V	0.0 mV	0	20.0 mV	5.8 mV	ok
VDC-2W	20 V	10.00 V	10.04 V	40.0 mV	66	60.2 mV	5.8 mV	ok
VDC-2W	20 V	18.00 V	18.07 V	70.0 mV	70	100.4 mV	5.8 mV	ok
VDC-2W	20 V	-2.00 V	-2.00 V	0.0 mV	0	20.0 mV	5.8 mV	ok
VDC-2W	20 V	-18.00 V	-18.07 V	-71.0 mV	-71	100.4 mV	6.1 mV	ok
VDC-2W	200 V	20.0 V	20.1 V	100 mV	50	201 mV	58 mV	ok
VDC-2W	200 V	180.0 V	180.8 V	830 mV	83	1004 mV	65 mV	ok

### Column meanings:

- Function** - function of the instrument under test (VDC-2W, VAC-2W, IDC, .....).
- Range** - range of the instrument under test. The program shall automatically generate a prefix of quantity value which can be changed in the procedure status window by means of the “Quantity prefix” panel.
- Standard** - calibration point (its standard value) completed by a parameter. If there are more parameters and their values cannot be written into wide of the „Standard“ field, the (\*) reference shall be generated and the parameters shall be written as a note in the next line of the test report. Units inclusive prefixes are determined according to the range. Number of displayed positions is being limited by a measurement uncertainty (if the uncertainty is displayed with resolution of 10 mV, the standard value shall also be displayed with this resolution). For measuring instrument is their position

number additionally limited by the display position number of the measuring instrument under test. For resulting display there shall be used such a rule which determines the lower resolution. Number of displayed positions and value prefixes can be changed in the “Rounding” panel.

**UUT**

- value having been measured by the instrument under test (an arithmetic mean of more measurements). Units inclusive their prefixes are determined according to their range. Number of displayed positions is limited by a measurement uncertainty (if the uncertainty is displayed with resolution of 10 mV, the standard value shall also be displayed with this resolution). For measuring instrument is their position number additionally limited by the display position number of the measuring instrument under test. For resulting display there shall be used such a rule which determines the lower resolution. Number of displayed positions and value prefixes can be changed in the “Rounding” panel.

**Deviation**

- error of the instrument under test (see section No. 2.5). Number of displayed digits is given by a measurement uncertainty. If absolute evaluation is being used, the used units have their prefix with lower place value than the range. Number of displayed positions and value prefixes can be changed in the “Rounding” panel. This column is empty if specification of an UUT device is defined as “Limit”.

**% spe**

- specification utilization percent ( $= \text{Deviation} / \text{Allowed} * 100 \%$ ). The value is displayed with percent units. If the specification utilization is higher than 999 %, the value of 999% shall be given. This column is empty if specification of an UUT device is defined as “Limit”.

**Allowed**

- allowed error of an instrument under test. There are two ways of displaying value in this column. If allowed error of an UUT device is specified as “Limit”:

Shortest expression of limit is applied. Evaluation of all columns is forced to “Absolute”. Prefix and unit is determined according to UUT range. For example expression can take form:

$>100 \text{ MOhm}$  – for low limit

$<15 \text{ mOhm}$  – for high limit

$45...55 \text{ Hz}$  – for both limits

If specification is not defined as limit:

Allowed error is calculated from four fields (% of reading, % of range, absolute error, digit error). Number of displayed digits is given by a measurement uncertainty. If absolute evaluation is being used, the used units have their prefix with lower place value than the range. Number of displayed positions and value prefixes can be changed in the “Rounding” panel.



**Uncertainty**      - extended measurement uncertainty for  $k_u = xxx$  (see section No. 2.5).  
Number of displayed digits is limited to two valid positions. If absolute evaluation is being used, the used units have their prefix with lower place value than the range. Number of displayed positions and value prefixes can be changed in the “Rounding” panel.

## 2.9. Testing Procedure

The testing procedure called „TEST” represents an integral part of program delivery. This procedure allows check of every important functions of the „Caliber“ program as e.g. correctness of procedure interpretation, correctness of error calculations, of measurement uncertainties etc. The testing procedure doesn't need any instruments.

At checking of program equipment operation we proceed as follows: Start the calibration according to the „TEST“ procedure. If we are working in WinQbase environment, it is suitable to create a separate identification sheet for testing purposes. Further we follow the program instructions. If the “Write instrument value” program prompt appears, set sequentially points from the following table:

Function, check point	Entered value
<b>V-DC, 10.0 V</b>	<b>10.01</b>
<b>A-AC, 1.0 A</b>	<b>0.98</b>
<b>O-2W, 100 Ω</b>	<b>100.0</b>

The testing procedure shall run quite automatically and their result shall be a calibration sheet with the measured values as follows:

Function	Range	Standard	UUT	Deviation	%spe	Allowed	Uncertainty	
VDC-2W	20 V	10.000 V	10.010 V	10 mV	50	20 mV	13 mV	?
IAC	2 A	1.0000 A; 60 Hz	0.9800 A	-20.0 mA	-999	2.0 mA	1.3 mA	*
RDC-2W	200 Ohm	100.00 Ohm	100.00 Ohm	0 mOhm	0	200 mOhm	127 mOhm	ok
-----								
? ... measured value is within the allowed deviation ± measurement uncertainty interval								
* ... failed								
ok ... ok								

Let's compare the measured report with the above shown sample. If some discrepancies occur, check if some overwriting (failure) of the „TEST“ procedure doesn't happen.

According to own consideration of yours, the test reports can be filed. If the test results shall be stored regularly, you win option in terms of program correctness back-check.

*Note: The testing procedure is to be imported before its first usage (the „test.pre“ file).*

## **2.10. Program Registration**

The computer, which Caliber is installed on, checks the Registration code after start and if there is not any registration code (Caliber is not registered) or it's invalid, the program is converted into a limited demo mode. Every registration code also contains its validity period within which the program can be updated. If a newer version of the Caliber program has been installed as that one supported by the registration code, the program shall be automatically converted into the demo mode, even if the foregoing registration code was valid for the older program version.

### ***Demo- version***

Having been installed, the Caliber program shall start automatically in the demo mode. This mode doesn't allow saving and printing of the calibration report. In addition to, there cannot be used the „CamOCR“ unit for camera scanning. The program determines this mode as "Demo mode".

### ***Light version***

This mode requires presence of the Meatest calibrator for procedure run and at the same time the program registration with a valid registration code in reference to a particular calibrator type. The light mode allows full utilization of all the program features (except from the CamOCR unit if it has not been bought). The program determines this mode as "Light mode".

### ***Full version***

This mode requires only set the valid registration code without reference to a particular calibrator type. It allows full utilization of all the program features (the CamOCR unit only if it has been bought). The program does not determine this mode.

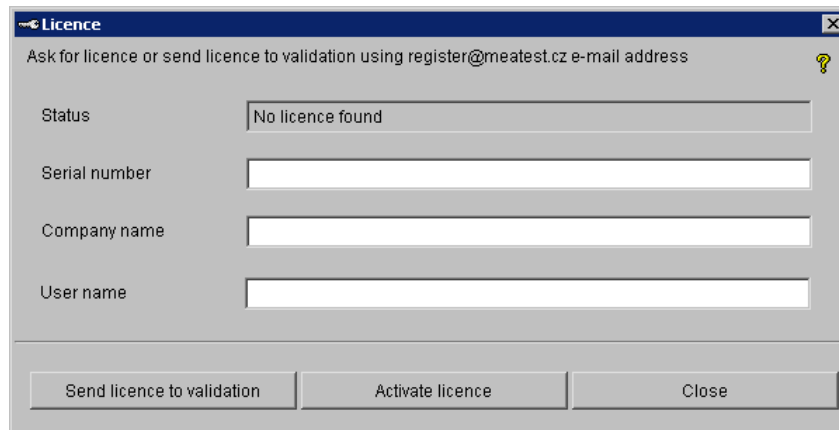
### ***Calibration mode***

This mode is evoked, when Caliber is run from WinQbase environment and new calibration is initiated. This mode requires the valid registration code. This mode is intended only for calibration execution and it does not allow any procedure modification. Only Procedure module is run in this mode and no other module can be run. The program determines this mode as "Calibration mode".

### ***Program registration***

The program can be registered during its run by means of the “Help” menu and by the “About Caliber” item activation. The registration consists of two steps:

#### ***Step 1 – Company identification***

A screenshot of a Windows-style dialog box titled "Licence". The dialog box has a blue title bar with a close button (X) in the top right corner. Below the title bar, the text "Ask for licence or send licence to validation using register@meatest.cz e-mail address" is displayed, followed by a yellow question mark icon. The main area of the dialog box contains four labels on the left and corresponding text input fields on the right: "Status" with the text "No licence found", "Serial number", "Company name", and "User name". At the bottom of the dialog box, there are three buttons: "Send licence to validation", "Activate licence", and "Close".

Set the Serial number, Company name and User name who the license is to be registered to. Serial number you can get from “Licence agreement” which is supplied with program package. Press the button “Send licence to validation“. Program will ask for the path where to save the file with the information about the user. Send this file “SNXXXXXXXXX (QUERY).LCN“ as attachment to the email [register@meatest.cz](mailto:register@meatest.cz).

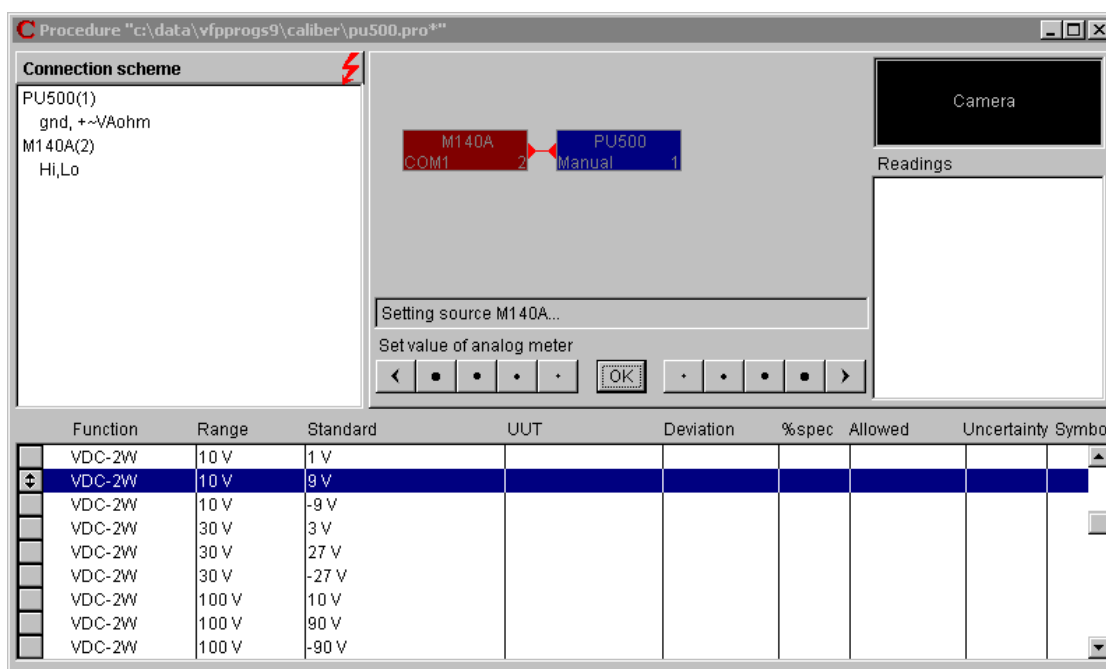
#### ***Step 2 – Licence activation***

In response to the email you will receive the activation file “SNXXXXXXXXX (ACTIVE).LCN“. Use this file to complete the activation by pressing the “Activate licence“ button.

## 2.11. Special Calibration Types

### 2.10.1. Analog meters

Program Caliber up its version 1.15 allows perform check of analog instruments. For this purpose an adjustable signal source with sufficient resolution for continuous adjustment of measuring instruments is required. E.g. check of resistance ranges cannot be done by means of standard resistors, but by resistor decades.



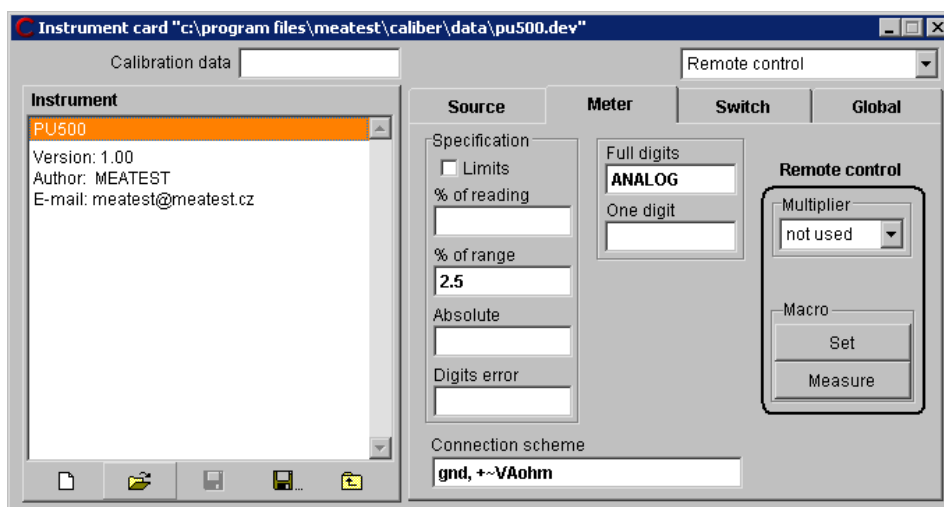
For analog measurement instrument check the program allows additional continuous adjustment for every calibration point on a signal source that a measuring pointer is in alignment with match mark of the calibration point. Additional adjustment of the source can be carried out by **a mouse**. Eleven keys situated in the “User prompt window” are intended for that purpose. The adjusted value can be reduced by means of five keys with the left arrow and increased by the right five keys. The keys have different sensitivity. The outer keys have the largest step (corresponding with the tested measuring instrument class). The adjoining keys have 4 times lower sensitivity of the step. The analog instrument having set to the check point, an operator press the “OK” button and the program shall read the conventionally right value of measured quantity from a standard instrument. The deviation of the measuring instrument shall be calculated as value difference. The additional adjustment can be also performed by means of **a keyboard**. The “UP” and “DOWN” keyboard arrows are intended for adjustment step change, the “LEFT” and “RIGHT” arrows for decreasing or increasing of the calibrator output voltage. If the analog instrument check is performed by means of **a manually adjustable source**, the above shown screen shall not be displayed. The source is being directly adjusted, not by the computer.

In **uncertainty calculation**, the A type uncertainty due to analog instrument reading uncertainty shall be added to the calculated measurement uncertainty (see section No. 2.2).

The program sets this uncertainty as 10% of allowed error of the measuring instrument. If a laboratory has determined some other uncertainty of pointer reading, the adjustment of uncertainties can be used direct in a calibration procedure (see section No. 2.1.1).

**Check points** for analog measuring instruments are to be set according to instrument types separately. The check should be done in principle in the signed scale points. It is strictly recommended to modify the check points after automatic procedure generating according to particular measuring instrument's requirements.

The Caliber program considers a measuring instrument under test as analog one (it allows continuous adjustment of the check point), if in the **“Full digits”** field there is the **“ANALOG”** text in the particular instrument card. An analog measuring instrument is so identified in terms of the “Instrument card”.

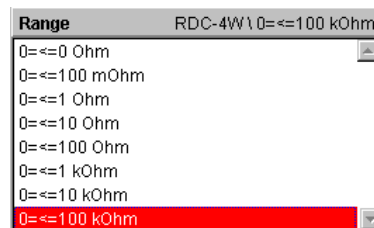


### 2.10.2. Calibration of Decades

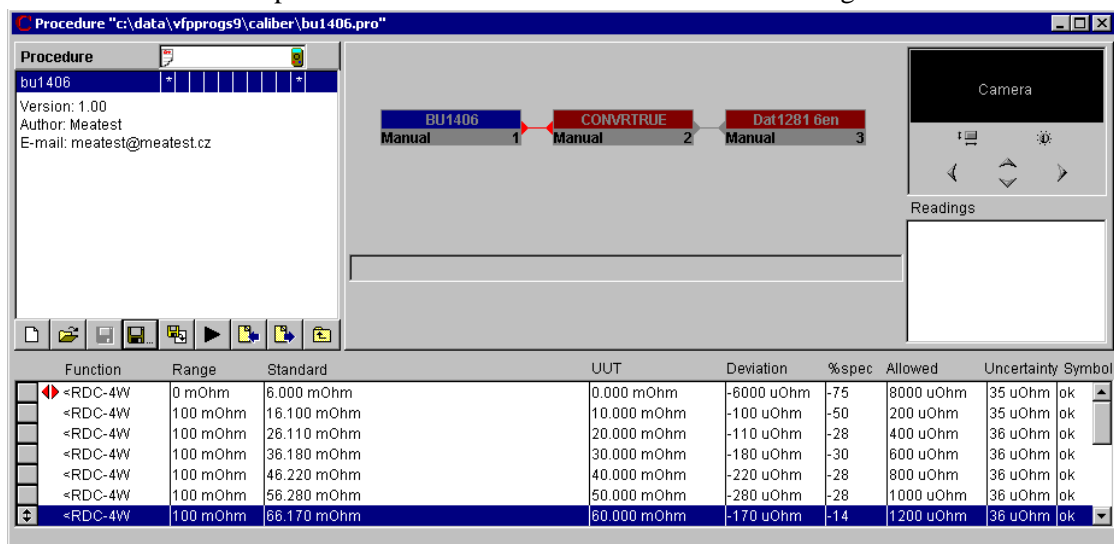
The Caliber program has a special procedure for decade calibrations by means of which so called “Reference zero” (zero resistor of decade – R0) can be subtracted from each of the check points.

The instrument card of a classic resistance decade must have a separate range for every decade place value (rotary switch) plus one range for zero point check.

E.g. for the Burster decade of 1406 type with  $R_0 < 10 \text{ m}\Omega$  and ranges from  $10 \text{ m}\Omega$  to  $100 \text{ k}\Omega$ , the following ranges can be selected:



The calibration procedure of this decade shall have the following form:



The first procedure line is marked as the “Reference zero” (◄). The „Deviation“ value from the first line shall be automatically distracted from the deviations measured on the next lines. The “Reference zero” marking can be done so that we point by mouse at the line, press the right mouse button and select the “Reference zero” from the menu.

*Note: A calibration procedure for a resistance decade can be developed by means of “Procedure Wizard”, but the particular calibration points are to be added into the procedure. The wizard namely selects only a few points for each of the ranges.*

*Note: A converter labeled as CONVRTRUE is a part of above shown calibration procedure. There is a virtual instrument only converting a function of two-terminal resistor measurement (R2W) to four-terminal measurement of the TRUE OHM type (DATRON1281 function). The converter allows measurement of two-terminal decades as the four-terminal ones.*

### 3. Terminology

This section explains meanings of some less common terms used in this User's Guide.

**Caliber** – comprehensive calibration system intended for calibrations of measuring instruments. It consists of several program modules. A program output is represented by the “Test report” with calculated errors and uncertainties of the measurement. Instruments can be controlled by a computer (automatically) or manually (by hand).

**Standard** – (SU – Standard Unit) standard instrument by means of it a conventionally right value can be established during calibration (the instrument under test is connected with it). The standard instrument can be both a source and a measuring instrument.

**Auxiliary standard** – another standard instrument. The caliber program offers another (auxiliary) standard for check of converters by which a response of the converter under test can be measured. In this case the auxiliary standard is being involved in calculations of measurement deviations and uncertainties. If the auxiliary standard is not connected behind the converter in a UUT position, its influence shall not be involved into the resulting uncertainty.

**Function** – by the Caliber system checked function. A function is mostly defined by a physical quantity (voltage, current, resistance, ...), however it can be defined also way of connections (VDC-2W ... direct two-terminal voltage) or way of measurement (R-TRUE ... resistors being measured for both positive and negative signal polarity). Utilizing of existing functions represents a standard procedure. A user shall complete a new function if he is creating an instrument card for adjustment of a new still not defined function.

Absolute and relative functions are differed by the program. The absolute functions have set resolution of one bit and BMC in absolute value. The relative functions have set digit number on the range and BMC in percents. Regardless of that differentiation, absolute or relative measured values expression can be set (it determines way of error and uncertainty evaluation in the test report).

**GPB** – (General-Purpose Interface Bus) is a parallel bus for remote control of measuring instruments. It allows parallel connection of more instruments which have different addresses. A card for the GPB bus control must be installed in the computer to use this bus in the Caliber program.

**Master bus** – called also „Master signal bus“ is a virtual connection among an instrument under test and other instruments. At every calibration point are function, range and value set on this bus the main checked parameters being set in a UUT and they are also written down in the output record (a table of both measured and calculated values).

**Hierarchy** – the Caliber system defines a fixed hierarchy in terms of which a user is moving by the work with calibration procedures and instrument cards. The highest level of this hierarchy is the “Calibration procedure” (at work in the “Procedures” module), eventually the “Instrument card” (at work in the “Instrument cards” module), both of them being represented through their names. The lower level consists of checked “Functions” defined in the “User



functions” module. Below the functions there are checked “Ranges”. On the lowest level there are checked “Points” in case of a calibration procedure. The lowest level in the “Instrument card” consists of the “Ranges” and if a given function has a defined parameter, the lowest level is represented by the “Parameter”.

**Value** – variable used by the program which represents a value of the measured quantity. It is being used in macros as the variable.

**Calibration procedure** – set describing the methodology of calibrations. It defines instruments used in a calibration and points at which a calibration is being performed. The “Procedures” program module is intended for modifications and creations of calibration procedures.

**Instrument card** – set describing instrument’s features. Metrologic features of an instrument are defined here (functions, ranges, specification etc.) and way of instrument control (commands of GPIB, RS232, VISA). Existing of an instrument card is a necessary condition of its using in a calibration procedure.

**Macro** – sequence of commands defining instrument control. Detailed description of commands, which a macro can be composed of, is contained in the “Instrument card module” section. Opening instrument, setting instrument, reading instrument eventually switching output terminal on/off are defined in the instrument card by means of the macros.

**„Instrument card“ module** – program unit of the Caliber system intended for work with instrument cards (development and modification).

**„Wizard rules“ module** – program unit of the Caliber system intended for work with the “Generating” rules files (development and modification).

**„Procedures“ module** – program unit of the Caliber system intended for work with the calibration procedures (development and modification) and for calibration performances.

**„User functions“ module** – program unit of the Caliber system intended for work with the function definitions (development and modification).

**Parameter** – describes an additional quantity of a checked function. E.g. for alternating voltage, its frequency is the parameter, or for a thermocouple, a temperature of its remote junction is the parameter. Parameters are never checked quantities, however they can affect accuracy of instruments (the accuracy is defined for different parameter values) and calibration procedure generating (according to the range of allowed parameter values for tan instrument under test).

**Wizard rules** – (generating rules) set describing a way of check point development by the Caliber system for new created calibration procedures. There can be possible to create a few sets containing different generating rules and at creation of a new calibration procedure it can be only selected such rules according that the procedure can be created. There can be created other rules for calibration procedures for measuring instruments and other ones for calibrators or decades.

**Converter** – converts measured signals. It allows conversation of quantities (current shunt, voltage / frequency converter), eventually value conversation (transformer, current inductor with 50 coils). The program doesn't allow connect a converter to a UUT. Converters can be divided to real ones, which convert a measured signal, or virtual ones, which performs a mathematic operation (e.g. recalculation of a voltage to a temperature of a thermo-element) and they doesn't affect the measurement accuracy. A special category is represented by a converter in position of an instrument under test. Such a converter must fulfill certain conditions secured in the instrument card by the "Converter as UUT" denomination in the "Converter conditions". The converter used as a UUT must be set the same way as its input function. Also the converter value cannot be involved in a formula. It can be used a simple formula only.

**Reference zero** – denomination of a calibration point that changes way of evaluation off all the other points belonging to the same function. At check of such denominated point, the found deviation of an instrument under test shall be saved in a memory and it shall be subtracted automatically from this instrument at next calibration points. This deviation doesn't affect either a standard value or checked instrument value in the test report, but it shall affect a deviation and following calculations. It is intended for e.g. check of resistance decades when the zero resistance value is to be subtracted.

**RS232** – serial bus. It allows remote control of measuring instruments by the computer. Its disadvantage is that only one instrument can be connected to the bus. A big advantage is that practically every computer is being equipped with this bus.

**Buffer** – variable used for temporary data saving by the program. A typical usage example is counting of response of an instrument controlled by the computer and its following processing.

**SU** – (Standard Unit) see the STANDARD.

**UUT** (Unit Under Test) – instrument under calibration. A source a measuring instrument or a converter can be the instrument under calibration.

**VISA** – (Virtual Instrument Software Architecture) is a standard for instrument control through different bus types (GPIB, RS232, Ethernet, USB, ...).

**WinQbase** – the MEATEST program equipment for identification and calibration of measuring instruments. It can be used as a program superstructure of the Caliber system. It provides identification of measuring instruments, of calibration sheets, record print, measuring instrument selection according to diverse criteria etc.

**Connection scheme** – (terminal connection) an item (text) in an instrument card, which describes instrument terminals being utilized. The terminal connection mostly shall change if an instrument function changes. The text describing terminal connections shall be as short as possible. Abbreviations named on an instrument are recommended. During calibration an operator shall be prompted to connection change every time when a change of "Terminal connection" happens for some of used instruments.