CONTENT

1. Basic information

1.1 Introduction

Program CALIBER is aimed for automatic and semiautomatic calibration of meters of electric quantities. Calibration system consists of PC controller with printer, calibrator or another source of standard values and quantities (standard unit - SU) and device under test (UUT). Operation environment Windows 95/98/ME/NT/2000 is required.

Software is protected against unauthorised copying by hardlock. If SW doesn't find hardlock on the print port, program will run automatically in DEMO mode only. Finished calibration of UUT is real result of calibration system. As a document about calibration, test report with all measured and evaluated values is created.

In CALIBER program four basic program module are available. Automatic calibration of UUTs is controlled by **Calibration procedure**. Calibration procedure is list of calibration points in that order, how they will be executed during calibration. Calibration procedure is different for different models of UUT. Calibration procedures for various UUT are created in CALIBER program too. For running, creating and editing of calibration procedures, program module "Procedures" is aimed. Calibration procedure can be created in program CALIBER only, if **Instrument cards** of the instruments, which will take part in the calibration (both SU and UUT), exist. Instrument card contains description of the instruments including definition of functions, ranges, accuracy and mean of control or scanning displayed values as well. For creating and editing of instrument cards program module "Instrument card" is prepared. Normally for Instrument card of an instrument creating, operation manual of the instrument is necessary. In operation manual all information about instrument including control commands in case of remote control should be looked up. Program module **User functions** allows creation of new user's defined measuring functions of an instrument. Only instruments which functions are defined in program module "Users function" can be used for calibration. Program module **Wizard rules** serves for convenient and easy new Calibration procedures creation.

In general, "Instrument cards" determines action of the instruments which are connected to the calibration system. "Calibration procedures" define procedure of the calibration, point by point. All basic program modules are created in interactive way. Its generation doesn't require knowledge of programming.

Program CALIBER can be used either independently or as a part of database software package WINQBASE. When used independently, the result of the calibration is test report. Test report is table with list of calibration points with results of calibration, like UUT deviation, calibration uncertainty, etc. When CALIBER is used with WINQBASE, calibration results are transferred into database system. In database whole calibration certificate, whose part also test report is, is created. All features of WINQBASE are available for calibration certificate modifying.

Both standard instruments (SU) and devices under test (UUT) can be controlled remotely via GPIB bus or RS-232 serial line or they can be controlled manually. In manual mode, on UUT indicated values (readings) have to be transferred to the CALIBER program via PC keyboard or they can be scanned digitally with Camera module. Scanning with camera module is possible for digital meters with 7-segment numbers only.

CALIBER program is specialised for calibration of electric quantity meters. New functions for non-electric quantities can be defined by user and appropriate calibration procedures generated.

As above mentioned, program CALIBER consists of four program modules:

a) **Procedure** – module works with calibration procedures. It enables its creating, editing, testing and executing.

b) **Instrument card** – module works with instruments. To the every instrument which is used for calibration, its own Instrument card must exist. In the card information about ranges, accuracy, mean of control, mean of reading transfer and terminal connection are saved.

c) **Function** – program module works with measuring functions (DCV, ACV, DCI, R, etc.). It enables its creating and editing. During calibration or calibration procedure generation only functions here defined can be used.

d) **Wizard rules** – program module works with rules, according to calibrating points in newly created calibration procedures are generated. It enables easy creation and editing of calibration procedures.

1.2 System

Following requirements should meet components of calibration system:

- Personal computer Pentium 166 MHz or better, monitor SVGA, RAM 32 MB. If GPIB bus is used to control measuring instruments, appropriate GPIB card must be installed in PC. Recommended type is PCI GPIB card (National Instruments).
- Operating system MS Windows 95/98/2000/ME.
- Program CALIBER or software package WinQbase
- Measuring and calibrating instruments
- Cables for remote control, if it is used.
- Test cables

1.3 Basic principle of calibration

Philosophy of calibrations recognises following categories:

Point of view what is calibrated object and what is standard object (master)

a) **UUT** – instrument to be calibrated (unit under test).

b) **SU** – instrument which carries standard value (standard unit)

c) **Auxiliary source** – instrument, which is of auxiliary use. It doesn't carry standard value. It is used usually as source of test signal. Typical example is calibration of less accurate meter (UUT) with more accurate meter (SU).

Point of view what is source object and what is meter object

d) **Source** – generator of signal.

e) **Meter –** meter (indicator) of signal

f) **Converter** – recalculates value of signal. It enables conversion of quantities (current shunt, voltage/current converter, voltage/frequency converter) or values (transformator, current coil). Converter cannot be used alone. It can be used as transformer of standard value setting on SU, or it can transform value of auxiliary source. Converter cannot be used for recalculation of UUT value.

Both source and meter can create UUT. Both source and meter can create SU.

Note: *In the most frequent applications calibrator is used as Standard&source and UUT is meter (Multimeter is calibrated with calibrator).*

Source of standard value can be active (voltage source) or passive (resistance decade, capacitance standard, etc.)

Also combination of Standard unit - meter, UUT – meter and a source of non-calibrated signal can be used (UUT multimeter is calibrated with SU multimeter. Auxiliary source of non-calibrated voltage and current is used as source of signal).

In every calibration procedure, in all calibration points and in one moment only one source of standard value, one meter, one converter, one UUT and one SU may be used, i.e. in every calibration point at maximum 5 instruments can be connected together. For example 1x UUT, 1x SU, 1x Source, 2x Converter.

Way of control point of view

One of following ways of control must be selected in every calibration procedure: manual, remote via GPIB bus or remote via RS232. Scanning displayed values through Camera module can be set too, if camera module is connected to the calibration system. The only condition for creating of new calibration procedure is presence of Instrument cards for instruments, which are to be used in the calibration procedure. Instrument card describes metrology parameters of the instrument and method of control. New cards can be created in program module "Instrument card". During calibration process, instruments and devices used for calibration can be changed.

Examples

a) For calibration of multimeter METEX 4650 calibrator MEATEST M140 as Standard&source is used.
   M4650 … UUT, meter (it measures value and it is unit under test)
   M140 … Standard & source (it generates value and this value is standard=master value)

b) For calibration of RTD simulator (resistance decade) MEATEST M612 multimeter DATRON 1281 as standard is used.
   M612 … UUT & source (it generates resistance values and it is unit under test)
   DATRON1281 … meter, standard (it measures value, measured value is standard value)

c) For HP 34401A 61/2 digit multimeter calibration, calibrator MEATEST M140 as source and multimeter DATRON 1281 as standard can be used.
   HP34401A … meter, UUT (it measures value and it is unit under test)
   M140 … source (it is only source of value, it is not source of standard value)
   DATRON1281 … SU, meter (it is meter and its reading form calibration point of view is standard value)

1.4 Measuring circuit connection

When using accurate multimeters as standard instruments, whose accuracy is higher than 0.005%, for example DATRON 1281, HP3458A and similar, it is necessary to observe correct connecting of measuring circuit.

1.4.1 Grounding a measuring circuit

When calibrator is connected with one or more other instruments with power line supplying, there is always a danger of **"ground loops"**. These loops are created by connecting of signal terminals (input, output) together with power line cords connected to the power system distribution network. Considerable currents can flow through the ground loops, usually alternating and synchronous with the first or second harmonic of the frequency of power line. Practically their presence results instability of the display reading of the meter (either UUT or SU). This instability is especially evident when AC ranges are calibrated on frequencies 50, 100, 200, 400 Hz, i.e. multiples of power line frequency. It does virtually not exert at higher values of the measuring signal frequency. Instability can prove as a relatively slow and regular fluctuation of the signal amplitude. Dominant interference frequency is determined by the difference of the exact power line frequency and signal frequency set up on source.

Take following steps to eliminate the effects of ground loops:

a) Connect all ground terminals in one point.

b) Connect Lo terminals with ground in one point. The best is Lo terminal of the calibrator. Do not calibrate with a non-grounded measuring circuit.

c) Connect all power line cords of all instruments, including personal computer into one power line socket of the distribution frame.

d) If the above-mentioned steps are not efficient enough, use low-frequency toroidal choke on power line cord of the calibrator or of the multimeter. You can make a choke by reeling several turns of power line cord onto a permaloy toroidal core with 7 – 10 cm in diameter.

e) Finally, if the system interference is too high, you can lower its influence on calibration at disharmonious multiples of system frequency, for example 60, 120 Hz (applies only for calibration of alternating voltage and current ranges).

1.4.2 Voltage ranges calibration

When calibrating voltage ranges, connect UUT multimeter directly to output terminals of the calibrator. Especially when low voltage ranges are calibrated, where it is necessary to measure with uncertainties in terms of μV, you have to use cuprous wires with gilt terminals soldered by a low-thermal solder. Touch neither the wires and banana nor the output terminals unnecessarily and do not allow any parts of the measuring circuit to heat locally (for example from a fan, heating, etc.). When instruments are connected, wait until thermoelectric voltage is steady and balanced. When is used external SU-multimeter with calibrator-source for UUT calibration, it is more suitable to connect input terminals of the standard multimeter to input terminals of the multimeter being tested instead to the calibrator output terminals to avoid error of loads. This method is also suitable if the multimeter being tested has lower input resistance. Connecting an external standard multimeter to the input terminals of the multimeter being tested is equalled to connecting a calibrator with four wire technique.

If your calibrator is equipped on voltage ranges 10, 100mV (20, 200 mV) with resistance divider only, you have to take into consideration that the calibrator output resistance can be quite high, depending on the type of calibrator, and that it cannot be loaded excessively.

1.4.3 Current ranges calibration

Calibrating of low AC current

When calibrating low current ranges you must perceive that each capacity connected collaterally to input terminals of an instrument (and thus the used calibrator as well), creates an alternating capacitance shunt. Part of the calibrated current generated by calibrator passes by the connected instrument and flows through this shunt. Intensity of this erroneous current is proportional to a load voltage and therefore depends on the instrument (its input impedance) and the measuring frequency. The most appropriate way of connecting multimeter to the output terminals of calibrator is to use short, loosely placed wires. Using coaxial cables is not suitable here.

Calibration of high current

When calibrating on current ranges over 1 A, you have to connect the calibrator and the calibrated multimeter using sufficiently thick cables.

C A U T I O N !

Maximal input current of most accurate multimeters is 1 to 3 A. Connection to a calibrator with the set output current higher than maximal allowed current can result in damaging the multimeter. The only way to execute calibration of higher currents using standard multimeter is to use an accurate and sufficiently powerful, dimensioned resistance shunt.

2. Program CALIBER

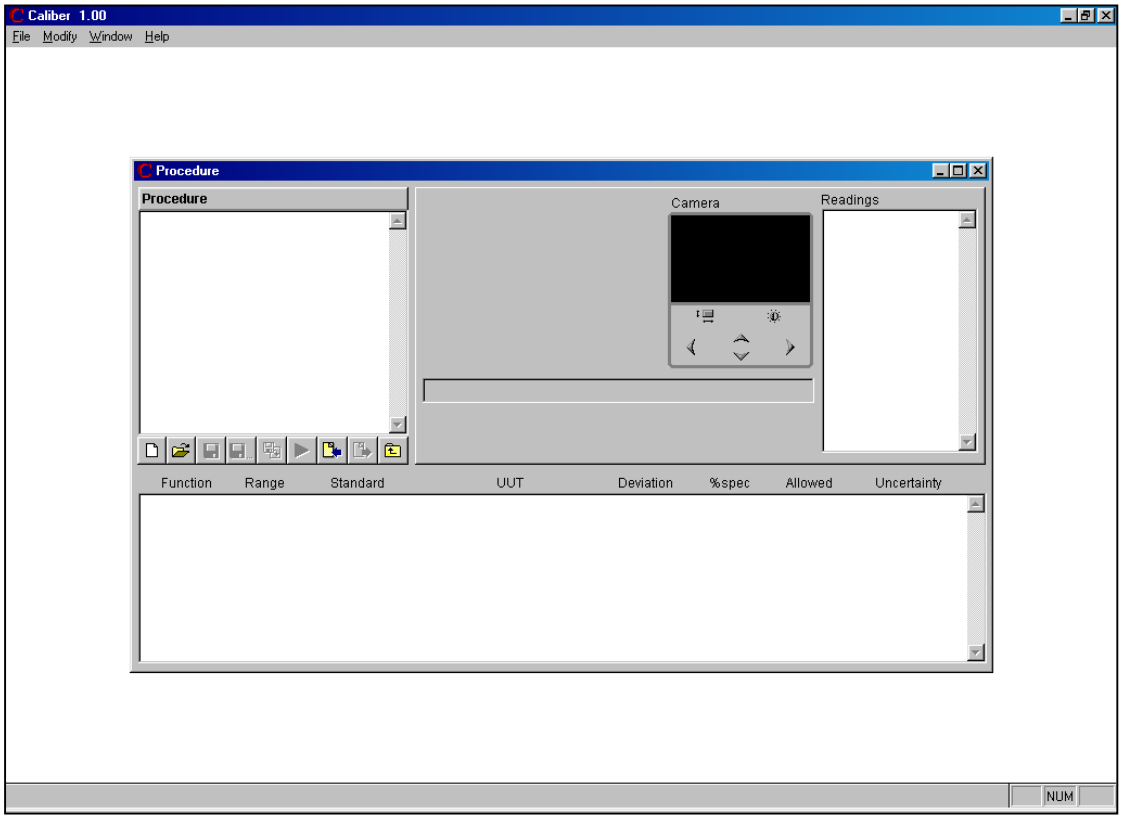
CALIBER is software for automatic and semiautomatic calibration of measuring instruments. It can be used either alone or with database WinQbase. Program WinQbase is aimed for creating of inventory of measuring instruments and for creating of inventory of calibrations. To implement Caliber into WinQbase, name „Caliber“ have to be set as name of “Procedure generator” and “Calibration engine”.

2.1 Starting with CALIBER

In this operation manual features of CALIBER software are described as alone used program.

Install CALIBER software to your computer. Put CD ROM to your CD drive and run file SETUP.EXE in the folder ../CALIBER/ENGLISH/DISK1. After installing, icon is automatically created in your Program group.

Start CALIBER program. Following screen will appear:



Note: *DEMO version will be automatically started, if no hardlock was found on PC parallel port. See chapter 2.9.*

After starting, basic window of program module “Procedures” is displayed. Window consists of two main parts:

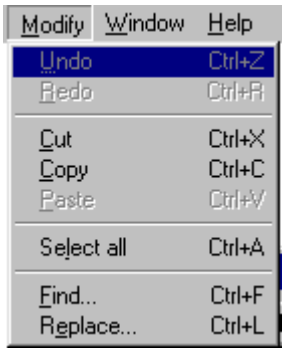
1. Main menu – menu is located in top line. Items from the menu are used for program modules starting. Editing function and help feature is located here too.
2. Working area – active program windows are displayed here.

Required function can be activated by clicking (mouse left button) on the appropriate item in menu. Control of program uses common used features of system Windows.

In bottom - in information line, program automatically displays short help for selected item. Short description is also displayed next to the mouse pointer in some cases. Help displaying can be switched off in menu “Help” (item “Show tips”)

Main menu

Modify Modify item with its menu is available only, when program in an edit mode is.



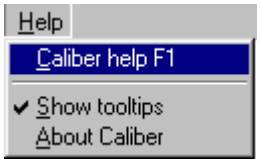
Undo	cancels last performed operation
Redo	executes last cancelled operation
Cut	removes signed text and insert into clipboard
Copy	copies signed text into clipboard
Paste	inserts text from the clipboard on place of mouse cursor
Select all	signs text as block.
Find	searches in displayed text
Replace	automatic exchange in selected text

Example: Open any calibration procedure. Push the button “Open” and click on appropriate file. Calibration procedure is opened. Place mouse cursor into the status field “Procedure” to the part where remarks are written. Now “Modify” menu is active and it can be used for remark editing.

Window Window item is main item of Main menu. It contains four program modules. All modes of CALIBER can be start here.

Procedures	module for work with calibration procedures
Instrument cards	module for work with instrument definition
User function	module for work with measuring functions
Wizard rules	module for work with rules for calibration procedure generation

Help Help item serves for displaying of build-in help.



Caliber help F1 It displays content of Help.

Show ToolTips When it is ticked, short help is displayed during cursor moving across the icon, button, etc.

About Caliber It will display information about program.

2.2 Calibration procedures

The module is used for calibration of UUT, based on already existing calibration procedures. Except it, module enables also editing and testing of new calibration procedures.

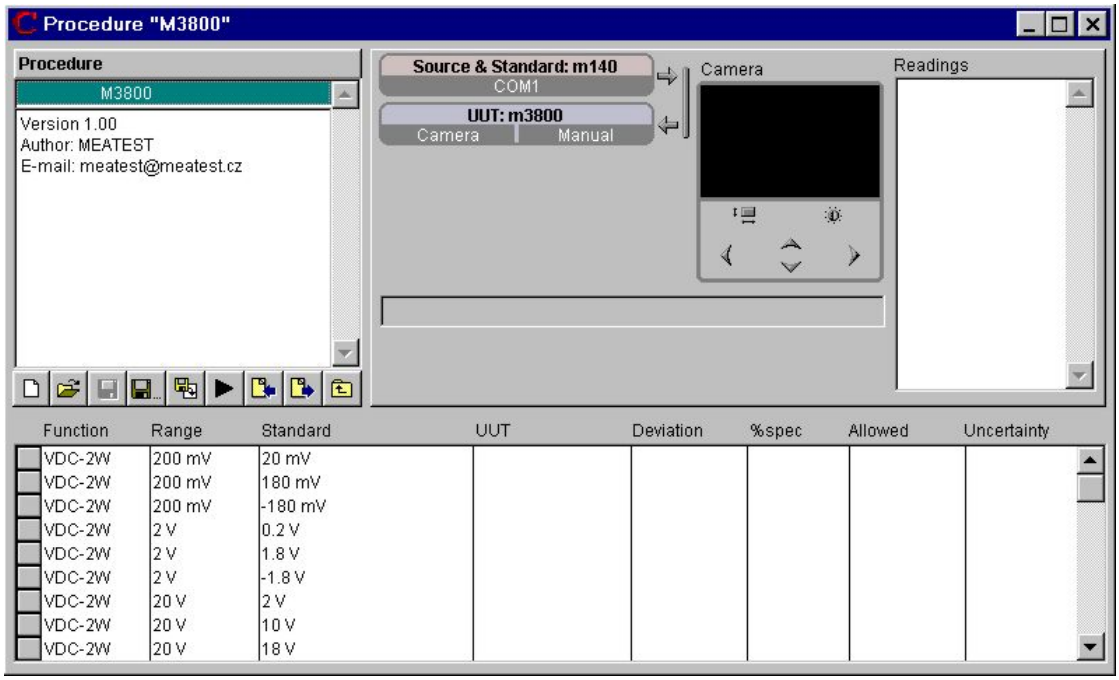
Calibration procedure is file, which contains list of functions, ranges and points in the ranges which are to be calibrated, instruments used for calibration and their connection. Other features of the instruments used for calibration in the calibration procedure like method of control (manually, RS232, GPIB), specification (accuracy on various ranges and functions) and limits of ranges belong to the Instrument card.

Module „Procedure" controls all communication between PC and instruments. It makes all measurement evaluation, uncertainty evaluation and generates calibration certificate. During calibration, appropriate data can be typed into fields (if it is prescribed in calibration procedure), program can be cancelled, one or more calibrating functions, ranges or points can be left out. Also break points where program interrupts calibration can be set. Order of calibrated functions, ranges, points, number of repeated readings, used instruments and method of uncertainty evaluation can be changed during calibration too.

Program module "Procedures" can be controlled with mouse or via keyboard. By pushing the button ESC currently running calibration procedure is interrupted.

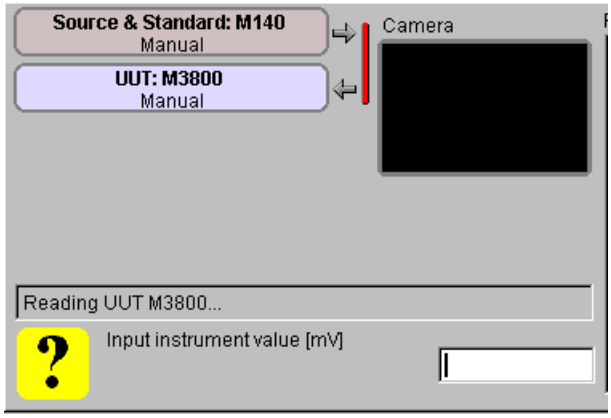
2.2.1 Description of module „Procedures“ screen

Following panel is displayed after running module “Procedures” and opening any calibration procedure. Calibration procedure M3800 is used as example in the picture bellow. To load procedure, push the button “Open“ and choose procedure M3800. This



calibration procedure is standard part of software package CALIBER.

In left upper side status window is located. It describes structure of procedure, i.e. name with comment, functions, ranges and calibration points. In the middle part active instruments (i.e. those that will be used during calibration) are displayed. Under name of the instrument, method of control is signed. In window “Camera”, live picture of video from camera is displayed (if camera module is used for UUT value scanning) and control buttons for setting resolution (zoom), position of picture and correction of external light conditions like contrast, brightness, etc. setting as well. Information line is placed under the instruments declaration.

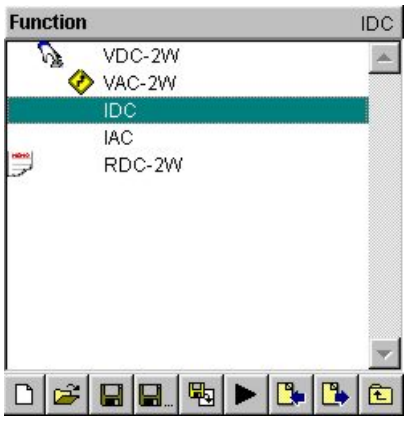


Actually running step of calibration procedure is commented here. If calibration isn’t yet started, information line will be empty. Under the information line, field with comments is displayed and input window for typing values during calibration as well.

In right side window labelled “Readings”, real readings or set up values of UUT and SU are rolling during calibration. In bottom table list of calibration points is displayed. On the beginning of calibration columns with calibration results are empty. During calibration, measured and evaluated data are filled in appropriate fields according to the process of calibration.

Calibration points are set out in the order they will be performed.

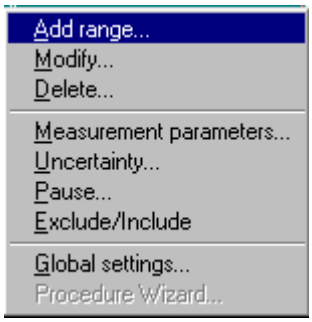
2.2.1.1 Status window



In calibration procedure, calibrated functions, ranges and calibration points are displayed here. By clicking the mouse pointer on the name of procedure (it is usually type name of the calibrated instrument) list of calibrated functions is opened. By clicking the mouse pointer on a function, ranges are displayed and similarly calibration points can be displayed too when you click on the row with a range. Notice that during moving among levels appropriate label of status window is changed. To move up among levels use button . Notice, that when you set active line in level “Values” in Status window, according to it also active line will change its position in the table with calibration points bellow.

Note: Every calibration procedure consists of list of UUT measuring functions, which are to be calibrated. Every measuring function contains list of ranges of UUT and every range must contain at minimum one calibration point.

By clicking right mouse button on line with name of function, range or calibration point, menu for editing of parameters in appropriate level is displayed:



Add value… It adds new value (range, function) into list. You can edit already existing procedure here, too.

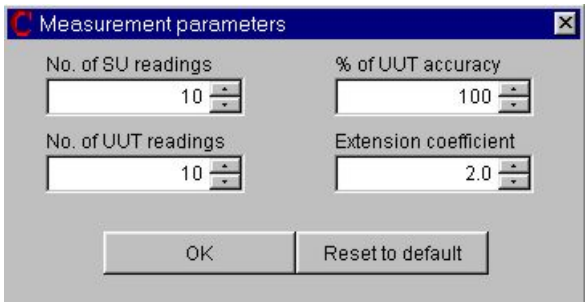
Modify… It involves to change chosen value (range, function).

Delete… It deletes value (range, function) from the list.

Measurement parameters… You can open window for new setting of parameters for calibration process, like number of repeated readings, allowed percents of specification where UUT is still OK, etc. The point (function, range or calibration point) where uncertainty evaluation is individually set up, is signed with symbol .

Items are following:

Extension coefficient extension coefficient of calibration uncertainty. See chapter 2.6. Standard value is pre-set to 2.0.



No. of SU readings means how many repeated readings of standard instrument (SU) will be performed in the calibration point or points. This variable is taken into account only if SU is meter. From the repeated measurements partial calibration uncertainty due to the instability of SU is calculated. This uncertainty is uncertainty of type A.

No. of UUT readings means how many repeated readings of UUT will be performed in the calibration point or points. This variable is used only if UUT is meter. This variable is taken into account only if SU is meter. From the repeated measurements partial calibration uncertainty due to the instability of UUT is calculated. This uncertainty is uncertainty of type A.

Note: *If SU or UUT is source, only one reading is taken into account. Also if SU – meter or UUT – meter is not remotely controlled, it is better to set value 1 here, otherwise program will request in the field pre-set number of repeated readings.*

10 repeated readings is recommended for correct evaluation of calibration uncertainty type A. Only in this case, exact calculation of calibration uncertainty according to the EA-4/02 document is performed.

If any other number between 3 and 9 are set up here, calibration uncertainty is calculated too, but the calculation formula is exactly correct for k_u factor equals 2.0.

% of UUT accuracy means allowed percentage of specification, where the UUT is considered as “in specification”. For example if parameter is changed from implicit value 100 % to the value 70 %, program checks if measured deviation of UUT is inside 70 % of specification and only in this case the calibration result in the calibration point is “PASS”.

To change this parameter is allowed also during running the calibration. You can interrupt the calibration procedure, to change parameters and continue in the procedure.

Even this change is possible, the most common way is to use one kind of evaluation for whole calibration procedure.

Reset to default It enables to return to the implicit setting. This feature can be useful, if you test uncertainty parameters and you want to return to the start configuration.

Uncertainty… You can open window for new setting of parameters for calibration uncertainty evaluation. The point (function, range or calibration point) where uncertainty evaluation is individually set up, is signed with symbol .

Components for calibration uncertainty calculation are following:

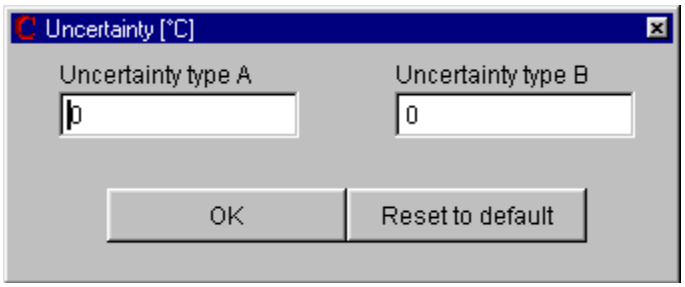
Uncertainty type A Uncertainty of type A, see standard EA-4/02 for uncertainty definition. Fix value can be type here, if this type of calibration uncertainty is known. If uncertainty is not known, set “0”. Enter uncertainty in such unit, which is displayed above the field.

Uncertainty type B Uncertainty of type B, see appropriate standard for uncertainty evaluation. Fix value can be type here, if this type of calibration uncertainty is known. If uncertainty is not known, set “0”. Enter uncertainty in such unit, which is displayed above the field.

As far as units is concerned, there are two possibilities. Either is requested uncertainty type A in relative expression, i.e. in “%”, or in absolute expression, i.e. in unit of the function (for example for voltage function you will be asked to enter value in “V”). Which type of expression is used depends on definition of the function (it can be relative or absolute, see list of functions in item User functions, field “Quantity”). This rule is valid both for uncertainty of type A and B as well.

After activating the function Uncertainty, program automatically display window for setting uncertainty of type A and B in correct values. For relative functions:

and for absolute function (temperature function is here as sample)



You can set up Uncertainty on levels function, range or calibration point. You cannot set uncertainty on the level procedure.

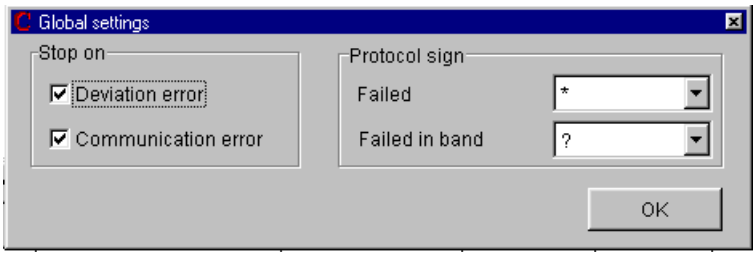
Pause… inserts break point into the program. Break point is indicated with symbol . If a delay is set too, message can be added which is displayed on the screen, when calibration will come to this point.

Exclude/include enables to leave out any value or values (range, function). Leaving out is indicated with symbol.

All above described functions (Add value, Modify, Delete, Measurement parameters, Uncertainty, Pause, Exclude) can be used on level of whole procedure, function, range or calibration point. (uncertainty on levels function, range, ,point). Next features can be set for whole calibration procedure only.

Global settings... Way of going on can be set here in case of course error. Course error arises when measured or scanned value is much higher or lower than expected value or in case of error due to the problem in communication (i.e. any instrument does not communicate with PC), see later.

If appropriate fields are ticked, calibration is interrupted in case of this error and manual correction is requested. In opposite case calibration procedure goes on to the next calibration point. Implicit setting is to stop calibration in case of detected any error.



A part of global settings is also type of special character, which is printed in each row of Test report and which characterises result of calibration. If the calibration in the calibration point is OK, letters “ok” are written on the end of the row. If the result is in area where it is not possible to decide if calibration is in specification or out of specification due to the calibration uncertainty, character with meaning “Failed in band” is written to the row. If the calibration result is out of specification, character with meaning “Failed” is typed to the row.

Note: The conditions here set-up are valid for currently loaded calibration procedure.

Procedure wizard...

This item enables to create a new part of calibration procedure which is appended to the edited procedure. New part is appended on the end of original procedure. This new part may contain another instrument as source and standard than original calibration procedure. Procedure wizard is available in the levels "Procedure" or "Function" in selected Calibration procedure (see label in the top line of status window). Function of "Procedure wizard" is the same in both levels.

Note: *This feature can be very important, because it enables to change type of SU to cover calibration points with several SU.*

In fact this feature enables to add new functions or new ranges for UUT calibration, which miss in the instrument-standard in original calibration procedure.

Example: *Typical example is calibration of high resistance ranges of multimeter. With M-140 you can calibrate ranges up to 50 MOhm. But if UUT multimeter contains also resistance ranges higher than 50 MOhm, high resistance decade or single resistance standards should be used. In this case use "Procedure wizard". In 1. Step add resistance decade or resistance standard and remove original standard (calibrator). Specify resistance decade as standard&source with „Instrument response" = manual, „Instrument control" = manual. In 2. Step select only RDC-2W function. In 3. step select appropriate UUT range, which will be calibrated with resistance decade. In 4. step confirm generated calibration points. In 5. step check if there is any inapplicable calibration point. No one point should be here. If any point is still in the table, return one or more steps and correct setting.*

After finishing the wizard, new part of calibration procedure is created and append to already existed calibration procedure. It can be "save" or "save as" or started.

Under the "Status window" buttons for calibration procedure handling are located :

 **New** run wizard for new procedure creating. See below.

 **Open** opens existing procedure.

 **Save** saves into file (database) changed procedure.

 **Save as** saves into file (database) changed procedure under new name.

Save as function can be easily used for creating of new procedures and instrument cards, for instruments and calibration procedures similar to the original one. It is possible to copy original procedure/instrument card under new name and modify only some parameters.

Actualise instrument restores Instrument cards used in edited procedure. Function should be used if Instrument card is changed during editing the procedure. Just opened procedure remembers Instrument card in original form, not in newly changed. Its actualisation can be performed with pushing this button or with new opening the whole procedure.

Run calibration starts executing calibration procedure. Calibration procedure can be started from any calibration point or it can continue from any of these points. This feature is in some cases limited (when calibration procedure is running from database WinQbase).

Import imports calibration procedure which was created previously with button "Export". The procedure is in format "pre". This format contains instrument cards and definition of functions. This format is suitable for transferring procedures among users. It is not necessary to use this function, when calibration procedure creation and calibration executing is done on the same computer.

Export exports procedure in format "pre". See function "Import"

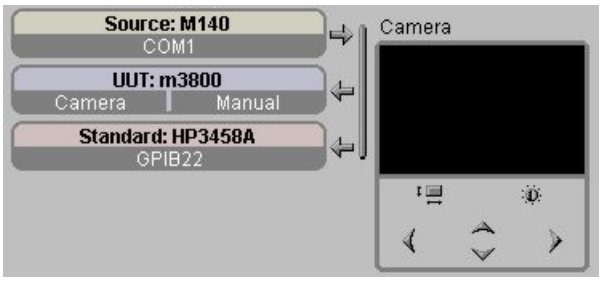
Back It is used for moving from lower level to the higher level in hierarchy procedure – function – range – point. Moving down (from higher level to lower level) can be performed with clicking of mouse button while mouse pointer is placed on selected item.

2.2.1.2 Connection scheme window

During calibration procedure executing, "Status window" is replaced by window "Connection scheme". Terminals of active instruments, which must be interconnected are displayed here. Always when change of connection have to be arrange during calibration, simple description of new connection is displayed in this window and program is interrupted. Warning to do this change is displayed too, in the middle of the screen.

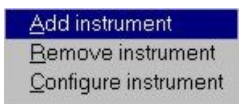
2.2.1.3 Active instrument window

In the window, information is displayed about instruments, which are used during calibration. Other information like function (UUT, Source, Standard, Converter), name (instrument card)



and way of control and scanning (GPIB, COM, manual, camera module) for every instrument is written here. If camera module is used for scanning value of any instrument, live picture is displayed in right side window. To ensure status or edit these parameters, sub-menu must be recalled, as follows.

By pushing the right mouse button over the instrument (upper half of the square) following sub-menu will appear:



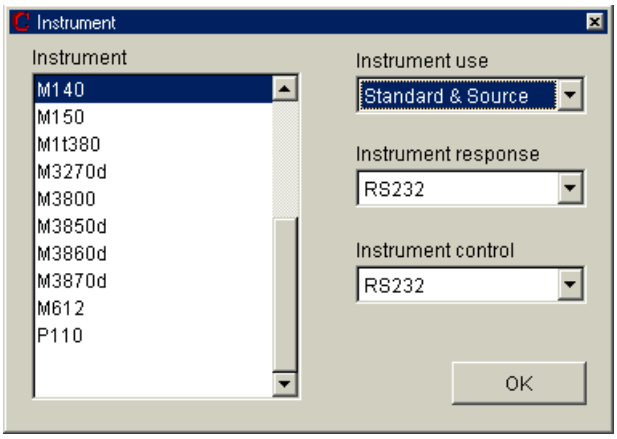
Add instrument Function adds next instrument taking part in calibration. Adding can be performed in level procedure, range or calibration point. Desired level have to be set in Status window. New instrument is valid only for the level where change was done. It enables to create special configuration of instrument for example for one point only. The names of instruments in bold letters are valid for just active level. The names of instruments in normal letters are defined in higher level.

Remove instrument It removes instrument from calibration procedure. Again, operation can be performed in procedure, range or point level and it is valid for this level only. For example removing the instrument in range level doesn't influence other ranges and functions. Removing of all instruments in the chosen level results, that the instruments are set according

to the setting in higher level. It is recommended to be careful when removing an instrument in procedure level, because no implicit setting is further available.

Configure instrument It recalls menu, which involves to change the instrument, its use and method of control:

Instrument must be selected from database of instruments (i.e. Instrument card must exist before).



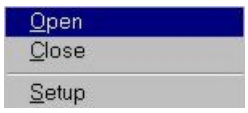
Instrument use describes instrument function in calibration procedure. Basic functions are UUT, Source, SU, UUT&Source, SU&Source and Converter. Function Source can be combined with function Standard or UUT.

Every instrument must have defined method of reading value and method of control.

Instrument response means method of transferring data from UUT/SU to the computer. Four methods can be used for transferring measured or indicated value from UUT /SU: RS-232, GPIB, manual, Camera module

Instrument control means method of UUT/SU control. Three methods of control are available: RS-232, GPIB and manual. Usually the same method of scanning and control is used. Exception is scanning via Camera module, where control is normally manual ("Instrument control" = manual, "Measure by" = Camera).

By pushing the right mouse button over the instrument (grey field) next sub-menu is recalled. Sub-menu allows to make manual changes in area of communication with instrument:



Open After clicking, macro "Open" is executed and instrument is opened for communication. The function is aimed for procedure testing purpose. During calibration opening communication of instruments is performed automatically. "Open" macro is enable both for manually controlled instruments and for remotely controlled instruments.

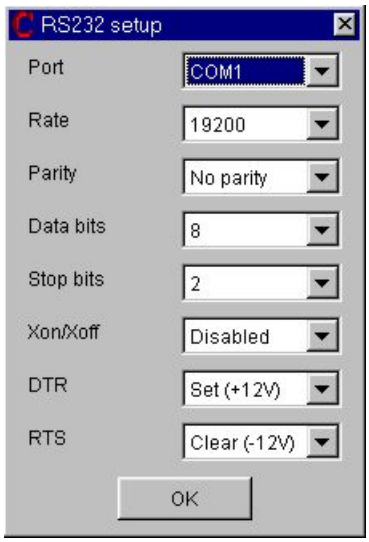
Close After clicking, macro "Close" is executed and instrument is closed for communication. The function is aimed for procedure testing purpose. During calibration opening and closing of instruments is performed automatically. "Close" macro is enable both for manually controlled instruments and for remotely controlled instruments.

Setup Item is active only when remote control or scanning is chosen (RS232, GPIB and Camera). It defines parameters of interfaces. You can check status or you can modify parameters. If you modify parameters, new setting is valid for currently loaded calibration procedure.

Depending on way of control, one of following menus will appear:

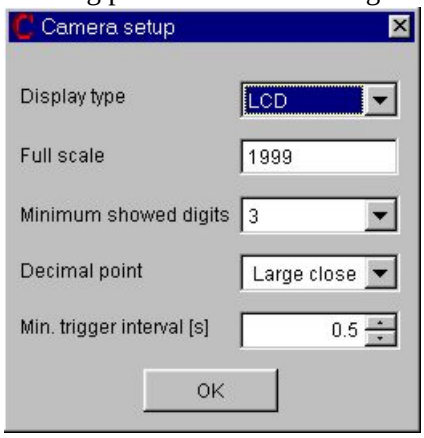
- Instrument is controlled via **GPIB** bus. PC have to be equipped with GPIB card. GPIB address of the instrument must be set here in range 1 to 30. Address „0“ is reserved for PC.

- The instrument is controlled via **RS-232** line. In this case a free RS port must be available in PC. Number of port, communication speed, parity, number of stop bits, number of data bits, Xon/Xoff and meaning of signals DTR and RTS can be set here. Possibility of setting of meaning DTR and RTS signals is important for some simpler instruments, especially those ones which use the signals for interface supplying.



- Measured values are scanned via **Camera module**. Camera module must be connected to USB post of PC in this case. Instrument cannot be controlled over Camera module. Camera module serves for reading only.

Following parameters of scanning can be set:



Display type - *LCD* (dark number on light background) or *LED* (light numbers on dark background)

Full scale – the highest displayed number (decimal point is not considered)

Minimum shown digits – minimal number of digits, which can meter display.

Note: *To recognise this number, switch UUT on and read number of digits on the display. Don't connect input terminals.*

Decimal point *No* instruments doesn't use decimal point

Small size of decimal point is approx. half of one segment width

Small separated small decimal point in distance from a segment more than half width of segment.

Large decimal point size is approx. The same as segment width.

Large separated large decimal point in distance from a segment more than half width of segment.

Note: *Both minimum shown digits and decimal point are important for reliable reading of camera module and recognising displayed number. These information makes better condition for sub-program which transfer live image of camera module to the number.*

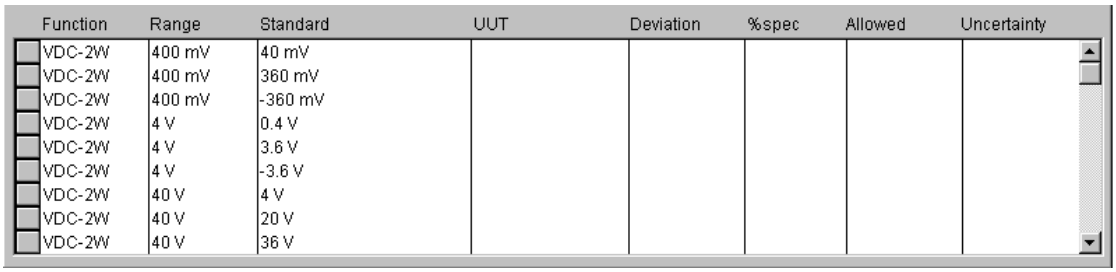
Min. trigger interval [s] – period after that new value is scanned.

2.2.1.4 Readings window

In the window, real readings from active instruments are displayed during calibration. In case of repeated readings, all single readings are rolling here.

2.2.1.5 Test report window

In the window all calibrated points and all measured values are displayed. During calibration, calculated values are written to the appropriate columns.



Function	Range	Standard	UUT	Deviation	%spec	Allowed	Uncertainty
VDC-2W	400 mV	40 mV					
VDC-2W	400 mV	360 mV					
VDC-2W	400 mV	-360 mV					
VDC-2W	4 V	0.4 V					
VDC-2W	4 V	3.6 V					
VDC-2W	4 V	-3.6 V					
VDC-2W	40 V	4 V					
VDC-2W	40 V	20 V					
VDC-2W	40 V	36 V					

Order of calibrating points can be changed. If change of calibration point order is requested, place mouse pointer on the field for moving, located on the left side in every line, in window Protocol. Click left mouse button, hold it and move the pointer up or down as requested. Right order of calibration points makes calibration easier, reduce number of necessary re-connections and shorten calibration time. After editing or interrupting calibration procedure, procedure can be launched from any calibration point.

Changing the order of calibration points doesn't influence basic form and order of output test report. The report is arranged in order of functions, ranges and calibration points according to the form in status window.

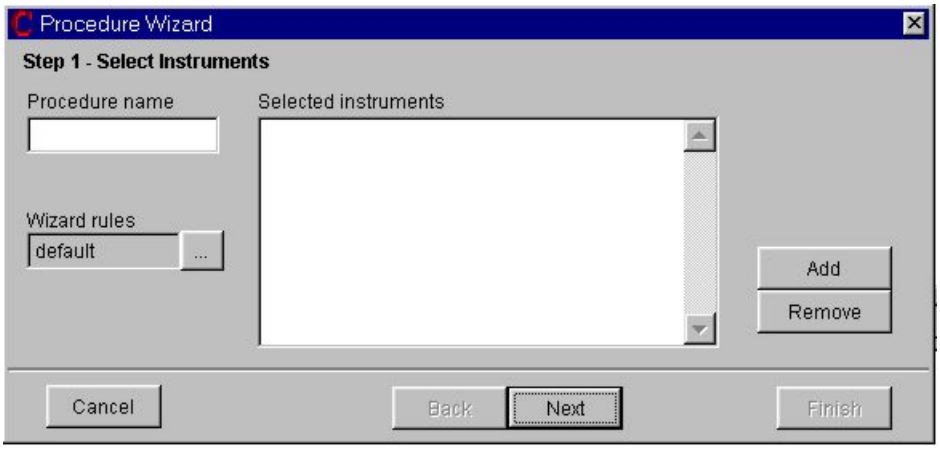
2.2.2 New calibration procedure creation

For new calibration procedure creation Procedure wizard is used. Creation consists of five steps. In these steps instruments, functions, ranges, calibration points are defined. In the last step compliance of new calibration procedure is checked.

Note: *Procedure wizard is the only way, how to generate new calibration procedure. Nevertheless when a calibration procedure is already created, it can be completely modified. Functions, ranges and calibration points can be added or removed or edited and instrument – standard can be exchanged for some calibration points if necessary.*

On one side procedure wizard makes calibration procedure generation very simple and fast. On the other side it doesn't allow to make special configurations.

To create new procedure activate module "Procedure" in program CALIBER. Push the button „New". Form of the 1. step of Procedure wizard is displayed.



Procedure name – under this name new procedure is generated and saved.

Wizard rules – set of rules for Wizard can be set up here. Several set of rules can be defined. Set of rules describes method of automatic creating of calibration point for various ranges. See chapter "Calibration points generation" for more details.

Note: *before starting new calibration procedure creation, assure that "Wizard rules" contains rules for all functions of UUT. If any function defined in "Instrument card" of UUT miss in "Wizard rules", program module cannot generate calibration points for this function. In the structure of calibration procedure, this function will be included(see Status window), but no one calibration point is generated. In this case calibration points manually can be added for function, which is unknown for "Wizard rules".*

Selected instruments list of instruments used for calibration.

Add adds new instrument to the list.

Remove deletes item from the list.

Cancel closes procedure wizard without saving.

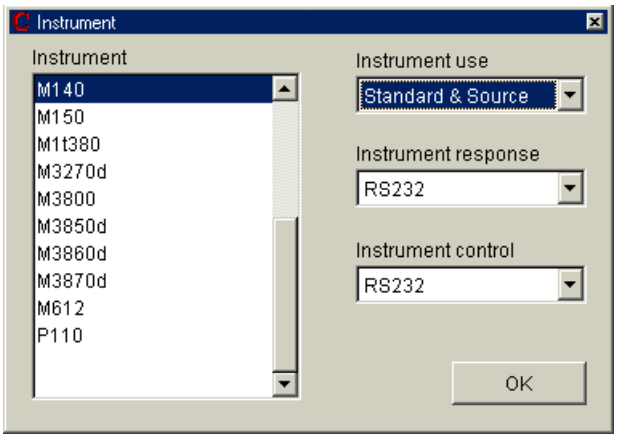
Back one step back.

Next next step of procedure wizard.

Finish finished automatically all steps of procedure wizard.

Procedure for new calibration procedure generating consists of 5 steps:

Step 1 – Instrument selection. Write name of new procedure to the window „Procedure name“. It is model name of UUT usually. For example for multimetr METEX model 3800 it can be M3800. Maximal name length is 12 characters. Wizard rules will stay „default“. If another wizard rules are required, it can be chosen. Normally different wizard rules are used for generating of calibration procedures for meters and calibration procedures for sources. That ones signed as „default“ are suitable for generation of procedures for multimeters. Instruments which take part in the calibration have to be written into window “Selected instruments”. Choose model of UUT from the database and choose its appropriate function (Instrument use) and method of control (Instrument control) and method of reading



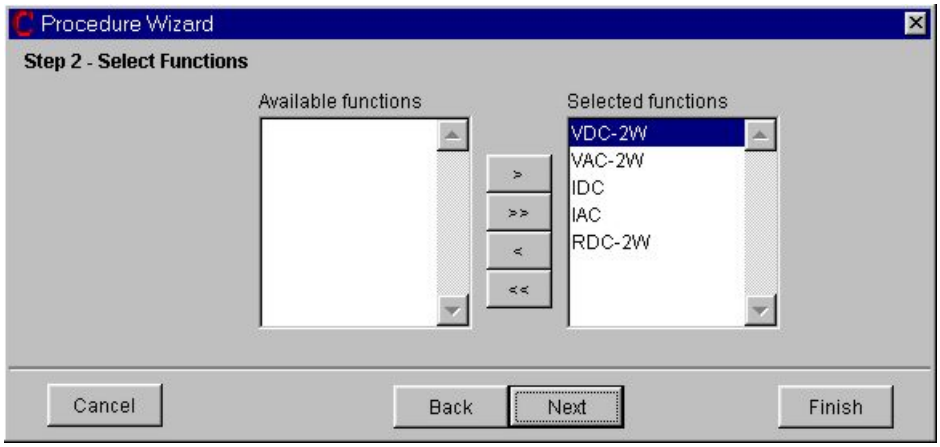
(Instrument response). For example for UUT multimeter METEX 3800, Instrument use = UUT, Instrument response = Manual and Instrument control = Manual (Multimeter is UUT and will be set up and red manually). Use the same way to select all other instruments and specify their features.

Converters cannot be selected in window Selected instrument in this step.

If Instrument card doesn’t exist, it must be created before. See chapter “Module Instrument card”.

Push the button “Next” to continue.

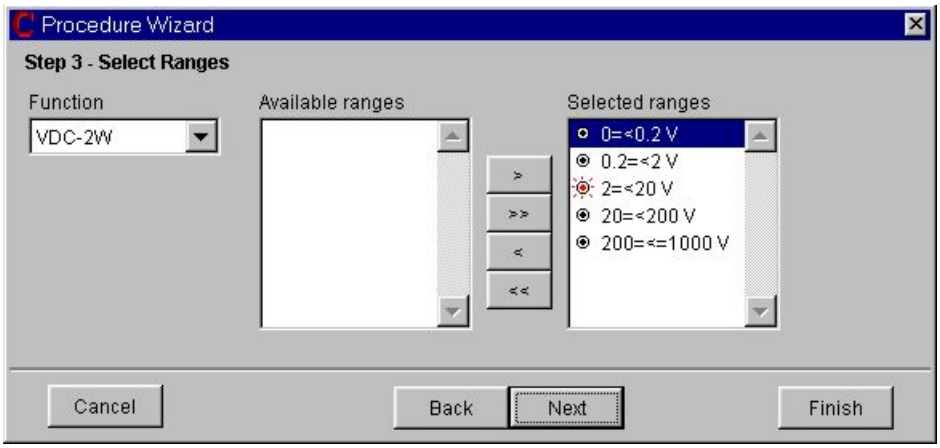
Step 2 – Function selection.



Wizard offers all those functions, which the procedure can consist of. With arrow buttons (>, <) and (>>, <<) number of functions can be changed (decreased) in the procedure. It is not possible to add functions which are not defined in the Instrument card of UUT.

Push the button „Next“ to continue.

Step 3 – Range selection. Wizard offers all ranges for all functions which the procedure will



consist of. According to the Type of range and Wizard rules, calibrated points are generated in next step. Type of range can be changed after pushing the right mouse button when its pointer is over the name of range. Following types of ranges are offered:

Common – it is range without any special priority.

Lowest – the lowest range.

Intermediate – range in the middle.

Highest – the highest range.

Specific – range, which values lay inside any fix defined limits (for example voltage higher than 200 V, etc.).

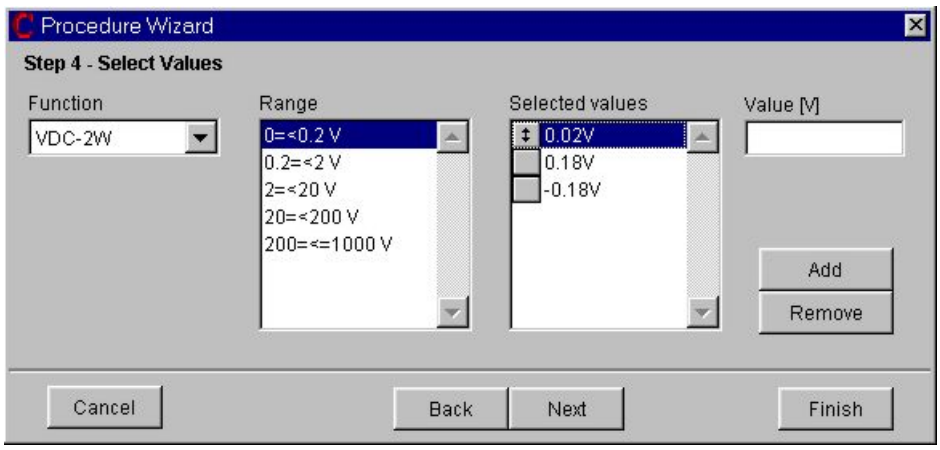
Note: *Intermediate range is marked with red star in the Procedure Wizard window.*

Normally, not all above described types of range are allowed to select for the ranges in window ”Selected ranges” Which type of range may be selected for certain UUT range depends on setting of this the range in the Instrument card of the instrument. Range types, which cannot be selected are disabled after recalling menu for range specifying.

On the other side, for every function it is possible to define specific range. If such definition exists, it will appear in menu of available ranges. With arrow buttons (>, <) and (>>, <<) number of functions can be changed (decreased) in the procedure. It is not possible to add ranges, which are not defined in the Instrument card. For more details see chapter “ Calibration points generation”.

Push the button „Next“ to continue.

Step 4 – Calibration points selection. According to the Rules of calibration points generation and Type of range, wizard offers calibration suitable points. In each range, order of



calibration points can be changed, calibration points can be deleted or new ones added. Calibration points in all ranges and all function cannot be manually overwritten here.

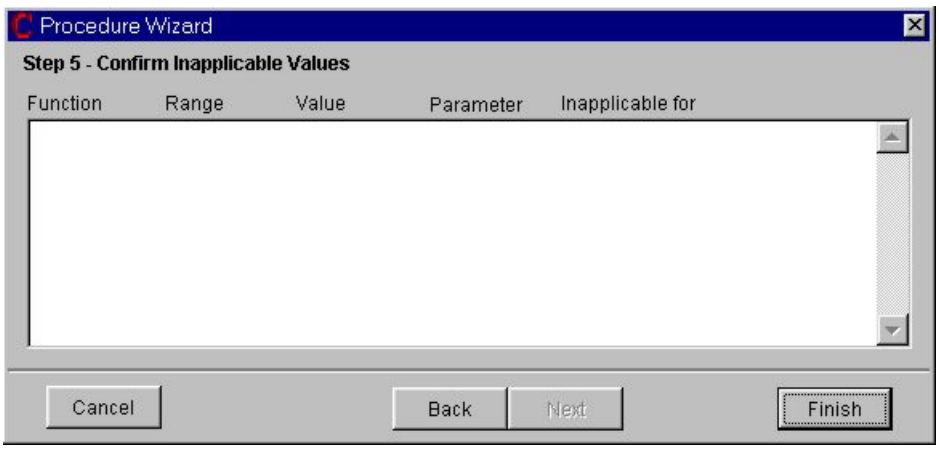
Push the button „Next“ to continue.

Step 5 – List of non-tested points. Before new procedure finishing, wizard will write out list of all points, which cannot be set on any of instruments. If the list is not empty, you can return one step back and make a make correction in calibration points to meet possibilities of the instruments. It is not recommended to use calibration procedure, which contains points out of instrument limits.

Error will be signalised during the calibration in such case. By pushing the button “Finish” creating of new calibration procedure is finished. New procedure can be saved after pushing the button Save or Save as.

Note: *The reason, why not-empty list of inapplicable values is generated, is mostly related with fact, that standard instrument cannot cover the ranges of UUT. In*

this case, there are two ways, how to solve it. The first way is to remove these



calibration points (ranges, functions) and don't calibrate them. The second way is to let these calibration points in the calibration procedure. But a new instrument - source of standard value, should be added to the calibration procedure to cover inapplicable values. This operation cannot be done here, but after finishing new calibration procedure, in window "Calibration procedure, see chapter 2.3.3.

If calibration procedure with existed non-applicable values is used, action of program during calibration depends on setting in "Global setting", see chapter 2.2.1.1. If field "Stop on" – "Communication error" is ticked, the calibration will be interrupted, message with short comment is displayed and manual control is asked. If this field is not ticked, calibration procedure ignores this error, it doesn't perform calibration in this point and continue with next calibration point.

2.2.3 Calibration procedure editing

Editing of functions, ranges, and calibration points in calibration procedure

When new calibration procedure is successfully created with Wizard help, it can be directly used or it can be edited.

The structure of calibration procedure can be followed in "Status window" on left side. Again three levels are available: Function – Range – Calibration value. All these items can be modified, deleted or added new ones. Way of control is described in last chapter.

Changing of standard unit

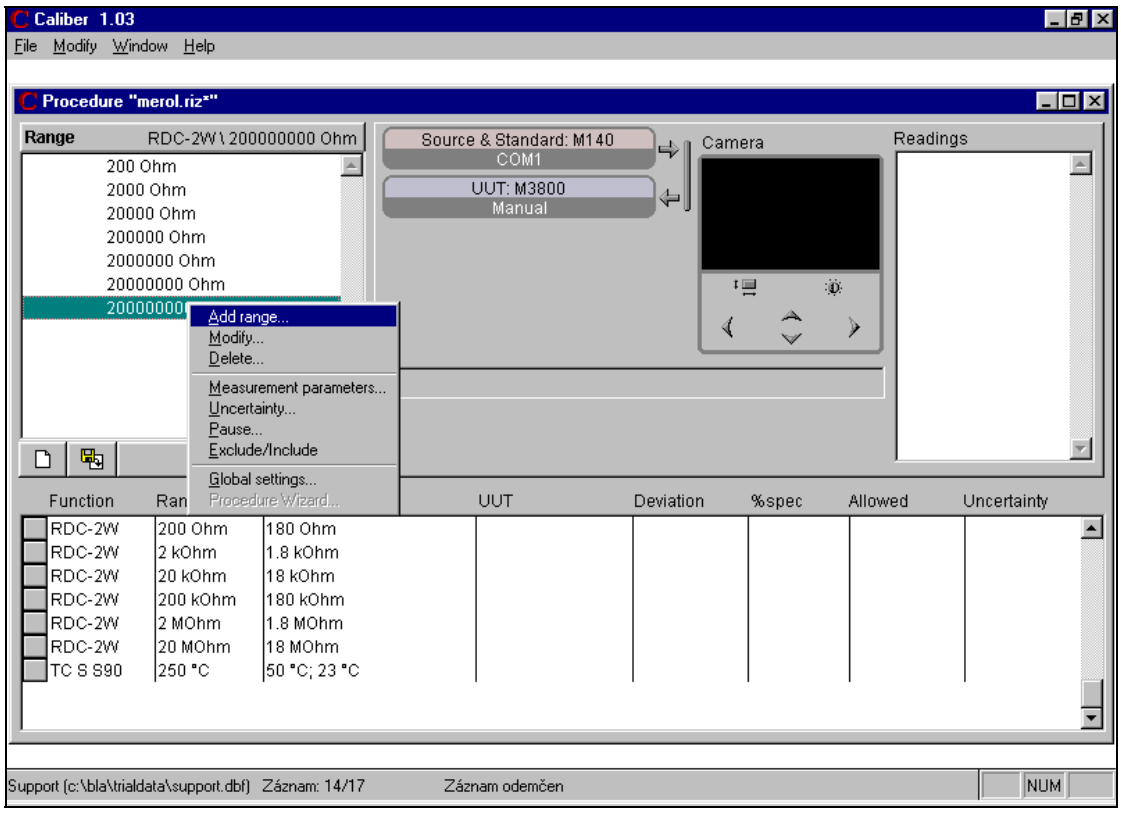
There could arise also need to use another SU than was declared in Step 1 of "Procedure wizard" for calibrating of one or more functions, ranges or calibration points. Typical example is multimeter (UUT) with resistance range, for which cannot be used calibrator, because of its range limitation (multimeter works to 200 MOhm, calibrator upper limit value is 50 MOhm, 100 MOhm point is requested to calibrate, external standard resistor with nominal value 100 MOhm must be used).

This example requires to exchange SU during calibration. Modification of calibration procedure cannot be done directly in "Procedure wizard". It may be performed after calibration procedure finishing, in edit mode. Instrument card of the SU (resistance standard) must exist before editing the procedure.

Example: *Add resistance range 200 MOhm and calibration point 100 MOhm to the already generated calibration procedure. Use for calibration resistance standard RP-100M.*

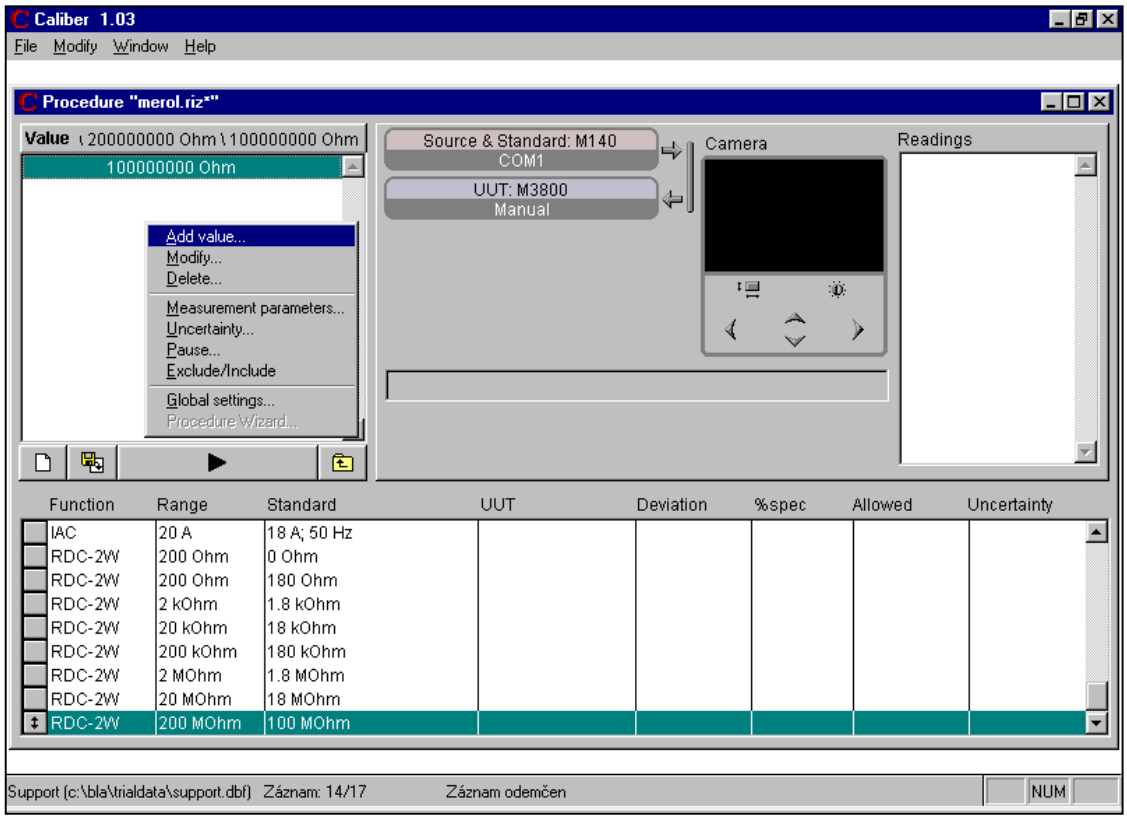
Procedure:

- Load calibration procedure. Set level "Range" in function RDC-2W in Status window
- Click right mouse button while pointer is placed in the Status window. Menu will appear.
- Select "Add range" and into the next field type 200 000 000 Ohm. New line with range 200 MOhm is appended to the existed ranges in Status window.

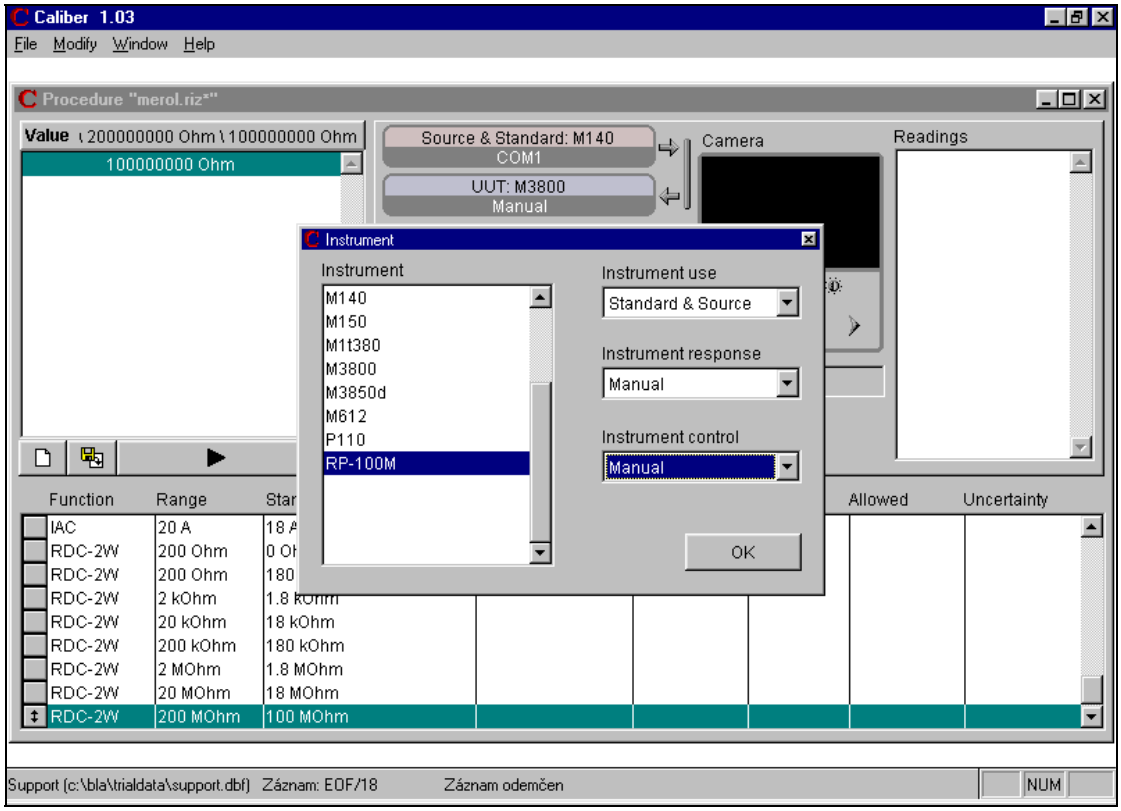


- Double click on row with new range. Window "Value" will appear.

- Click right mouse button while pointer is placed in the Status window. Menu will appear.
- Select “Add value” and into the next field type 100 000 000 Ohm. New line with value 100 MOhm is created both in Status window and in list of calibration points bellow.



- New calibration point was added to the procedure. Now, still SU must be exchanged for this point.
- While Status window is in level “Value” , place mouse cursor on the pink field with name of SU. Click with right mouse button and menu will appear.
- Select item “Configure instrument” and choose from the list of instruments Resistance standard RP-100M. Set fields “Instrument use” to Source&standard, „Instrument response“ to Manual, „Instrument control“ to Manual. Confirm it.



Standard unit was changed to RP-100M with manual way of control. The modification is valid for calibration point 100 MOhm.

This procedure allows to edit calibration procedure including instrument - standard unit. If you exchange standard unit in level range, this change is valid for whole range. If you exchange standard unit in level function, new SU is supposed to use in all points of the range during calibration.

2.2.4 Testing

When new calibration procedure is successfully created, it should be tested. The most common test steps are following:

a) **Interface test.** If an instrument is connected to PC, open/close functions (communication on interface) can be tested.

Load calibration procedure. Connect interface cables to the instruments. Push the right mouse button on the label with method of control in active instrument window (GPIB or RS-232 should be here). Menu for communication opening and closing of active instruments is called. Click on item “Open”. If the instrument is properly connected and

its interface parameters are correctly set up, it will come over to remote control mode. Activate “Close” item. Instrument should come over back to the manual mode. In case of error, the first check if active instrument is switched on and remote cables are connected correctly. If GPIB bus is used for communication, check GPIB card appropriate installation. If new Instrument card is tested, error can arise as failure in Macro Open/Close. Following warning will appear, when an error occurs.

b) **Manual test of calibration procedure structure.** New calibration procedure can be tested in manual mode. It doesn’t depend here, if the instrument is equipped with remote control or not. Use right mouse button to recall modify menu. while mouse pointer is located on the label of instrument. Select item “Configure instrument” and change function in fields “Instrument response” and “Instrument control” to Manual.

Note: To test new calibration procedure in this way, do above mentioned modifying in the level of Calibration procedure where you want to test it. (i.e. level Procedure – Function – Range, label is displayed in top line of status window).

During manual control, calibration points can be set from the keyboard also manually. Process of the calibration procedure can be easily followed, including uncertainty and deviation evaluations, warnings when connection of input/output terminals have to be changed, etc.

c) Procedure can be started from **any calibration point**. To start it, select the line which have to be started the calibration procedure from and push the button “Run calibration”. Calibration can be cancelled with button “ESC”.

d) **Order of calibration points** in the procedure can be changed too. With this feature number of re-connection of wires can be sometimes reduced. For example when clamp A-meters are calibrated, the same current coil can be used for both AC and DC ranges, i.e. these calibration points should lay in non-interrupted string. Change in calibration points order does not influence order in which calibration points are written into calibration report. In the calibration report order of calibration points is controlled via functions and ranges.

To change the order of calibration points, place mouse cursor on the field for moving (left side in each line of protocol window), push the left mouse button, hold it and move the cursor up or down.

Some practical hints

- Before creation of new calibration procedure ensure, that correct Instrument cards of all instruments (including converters) exist in active directory ../CALIBER
- Before creation of new calibration procedure ensure, that correct “Wizard rules” which will be used for calibration procedure generation contains rules for all ranges of UUT.
- When both Instrument cards and Wizard rule are correct, calibration procedure generation is very simple and quick. The most important is step 1. Here you have to decide, what instrument is to be calibrated (UUT), what is standard (SU), what is source and what is meter. In steps 2, 3, 4 you can confirm only suggested structure of calibration procedure and in step 5 you can check if any non-acceptable points exist. After pushing the button “Finish” calibration procedure is created.

2.3 Instrument cards

Instrument card is basic program module. For every instrument either manually or remotely controlled which takes part in calibration process, must exist its own Instrument card. In the Instrument card all features of the instrument like its functions, ranges, specification, way of communication, etc. are described. Features, which are not described in the instrument card cannot be used during calibration.

There are two basic points of view of instruments:

- related to the kind of instrument, **meter** or **source**. Instrument can be source (calibrator) or meter (multimeter) or sourse&meter (M-140 Multifunction calibrator with build-in meter)
- related to the method of communication. Instrument can communicate via **GPIB** or via **RS-232** or via **camera** module or **manually** only. From Instrument card point of view all combination are possible. Which combination or single possibility is allowed depends on real feature of the instrument.

Instrument card can be newly created or edited older one in this program module.

After starting CALIBER, automatically is loaded program module “Procedures”. Select in main menu item “Window” and choose “Instrument card”. Empty from of Instrument card module will appear. Push the button Open and load an instrument. Form of Instrument card file is *.dev. Following panel is displayed with M-140 calibrator.

On left side Status window “Instrument” is displayed. In the window, structure of Instrument card is shown in several levels (name of instrument card – functions of instrument – ranges of

instrument). On the top level, name of the instrument and user's note are shown. In the note, version of Instrument card and author name usually is written**.**

Note: When new Instrument card is created, following identification under the name of new card is pre-set: Version: 1.00
Author:
E-mail:

Note can be edited. Maximal length is 200 characters.

In upper part of the panel, switch for method of control/scanning is located. For an instrument you can use more ways of control/scanning. Possibilities are as follows:

a) ***GPIB*** – there are parameter settings here when the instrument is controlled via GPIB bus, i.e. both control commands from PC and response of the instrument to the PC are sent through GPIB bus. In PC GPIB card must be installed.

b) ***RS232*** – there are parameter settings here, when the instrument is controlled via RS-232 interface, i.e. both control commands from PC and response of the instrument to the PC are sent through GPIB bus. In PC a free RS-232 port have to be available.

c) ***Camera*** – setting of camera module is available here. Use this feature and set the parameters only if you suppose scanning of instrument display via camera module. It is mostly for meters without interface.

d) ***Manual*** – setting of parameters when instrument is manually controlled.

e) ***GPIB+RS232*** is special item. It means that controlling and scanning (reading) of the instrument use the same commands for both RS-232 and GPIB. This feature allows to create macros "Set", "Measure", "Output on", "Output off". Theses macros are used for RS-232 and GPIB remote control with the same syntax form and it is not necessary to create macros for GPIB and RS-232 separately.

   Macros "Open" and "Close" must be set independently for RS-232 and GPIB. Select position RS-232 (GPIB) and activate folder "Global". In the form push the button "Set-up" to create macros.

   Note: Macro is list of commands for instrument remote control via RS-232 or GPIB bus, see later inn this chapter.

   Note: If an instrument is equipped with both GPIB and RS-232 interfaces, commands (macros) for both of them have to be defined. If you define commands for RS-232 interface only, you can use only RS-232, but not GPIB. If you define commands neither for RS-232 nor for GPIB, you can use the instrument in manual mode only. On the other hand if you define parameters of Camera in its instrument card, you can scan display of the instrument with camera (instrument must be equipped with appropriate form of display, i.e. seven-segment type) or read display manually and type it manually to the field "Measured value" during calibration .

On the bottom side of status window keys for editing, opening, saving of instrument card are located :


New – new instrument card creation


Open – open already existing instrument card


Save – saves edited instrument card to the file


Save as – saves edited instrument card to the file under new name


Back – the key is used for moving up among levels of instrument card, i.e. instrument – function – range – point. Click with mouse cursor located on the name of selected item to move down.

Note: *Instrument cards are recommended to save into the current directory, i.e. to the directory ../CALIBER. They can be saved anywhere on disk, but during calibration it must be available in that source directory, from where the Instrument card was recalled during Calibration procedure creating. To avoid problems, use priority directory CALIBER..*

*Instrument card file must be in form *.dev.*

On right side of the panel there are three folders. The “Source” and “Meter” folders describe features of the instrument when used as source or meter. The last folder is folder of Global setting of the instrument. “Source” and “Meter” folders contain specification, commands for remote control, description of output terminals, etc. Global settings contains description of such features like instrument initialisation, parameters of interface, parameters of Camera module (if used) or transfer function of converter on card of converters.

The part of folders containing specification and connection scheme is always common for all methods of remote/manual control. To the communication parameter setting is related part of the folder in frame, where label of currently active interface is written.

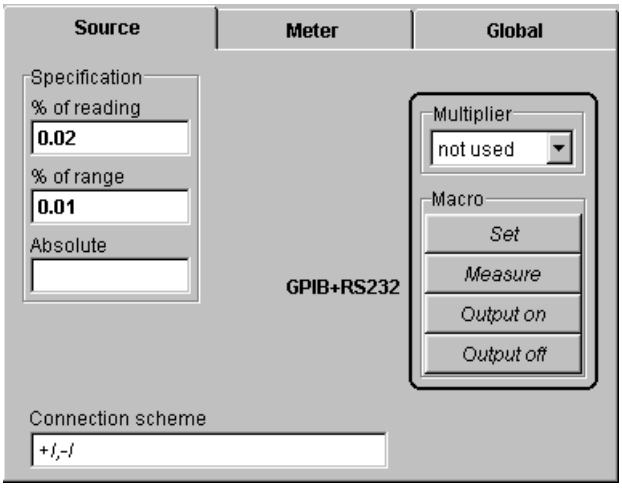
2.3.1 Card of source

Instrument card of instrument-source describes features of the instrument, when it is used as source. Specification, commands for remote control and connection of output terminals are recorded here. Fields in Source folder must be filled in (calibrator, resistance decade, etc.). If the instrument is converter (see chapter 2.3.3), fields in the folder Source in Instrument card must be fill in too.

Note: *Source card is not requested to fill in, if the instrument is a meter (multimeter, A-meter etc.). But if you have an instrument, which combines both functions, i.e. it is generator and it can also measure (like M-140 Multifunction calibrator with internal multimeter), both Source card and Meter card should be filled in. For*

example, if Source card is filled in and Meter card is not filled in for M-140 calibrator, you cannot use it as meter, but you can use it as source.

Form of the source folder is following:

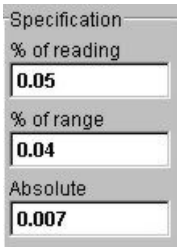


Following fields are available:

Specification field enables to set accuracy of the instrument. Specification can be set in one of following levels:

- one accuracy for the whole instrument, i.e. accuracy here set is valid for all functions, ranges, etc.
- different accuracy for different functions, i.e. accuracy here set is valid for all ranges of one function
- different accuracy for ranges, i.e. each range can have different accuracy
- different accuracy in one range for different values of parameter (for example AC voltage function, range 2 – 20 V can have different accuracy for various frequencies.

Priority of set accuracy is described in chapter 2.3.4.



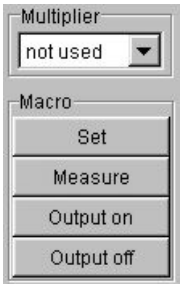
Description of accuracy may consist of max. three parts. The first and second ones „% of reading“ and „% of range“ are in percents, „Absolute error“ must be set in standard units of selected range, like V, A, Ohm… Exponential format is allowed. At minimum one of accuracy fields must be filled in.

Note: In fact when new Instrument card is created or already created one is edited, no specification field must be directly typed. You

can save Instrument card with "no specification". But if such Instrument card is used in Calibration procedure and specification is not described, error is signalised during calibration.

Multiplier. It enables to set value during reading from (or sending to) the instrument in another decimal units than in basic SI. Normally it is set "not used", but every decimal prefix from the range 1e-18 to 1e+12 can be set. Atto, fempto, pico, nano, micro, milli, kilo, mega, giga, tera multipliers are predefined.

Correct item of the "Multiplier" must be set up, when the instrument is used with remote control either GPIB or RS-232. Normally the commands for instrument remote control doesn't require any special setting of the multiplier have to be done. For example if voltage 200 mV is to be set on calibrator M-140, value of voltage is expressed in basic units, i.e. "0.2" here. But some simple instruments do not use basic units as parameter. For example, to set voltage 200 mV, value in mV must be sent to the instrument, i.e. "200". In this case parameter of the Multiplier "milli" must be selected. If they are such settings necessary to match commands to the standard language, on all functions and all ranges the item of Multiplier have to be checked.



When used the instrument in manual mode (without GPIB or RS-232 remote control), selected item in Multiplier field depends on the user only. If "not used" item is selected, it means that manually entered values (readings) must be expressed in basic units (volts, amps, etc.) during calibration. If "milli" item is selected, it means that manually entered values (readings) must be expressed in "milli" units (millivolts, milliamps, etc.) during calibration.

Note: *Different prefix can be used in instrument card on the same function and range, but for different methods of control.*

Meaning of buttons under the field MULTIPLIER depends on way of control/scanning. For GPIB, RS-232 or GPIB+RS232 possibilities, four buttons Set, Measure, Output on, Output off with headline MACRO will appear. For manual method of control/scanning the same buttons but without headline MACRO will appear. If camera module is used for display scanning, no function and no macro are need.

Macro is list of commands for instrument remote control via RS-232 or GPIB bus. Four types of macro are available for instrument – source. Macros „Set" and „Measure" can be created for remotely controlled instruments. Macro "Set" enables to set the instrument (source) to the desired predefined configuration when in remote control. Macro "Measure" enables to request confirmation if the source was set to the required configuration.

Macro „Output on" a „Output off" is for remotely controlled sources only. It is used for switching output terminals on and off.

See chapter “Macro creating” for more details.

Note: If instrument is not equipped with RS-232 or GPIB interface, macros cannot be created. Instrument can be used in manual mode only.

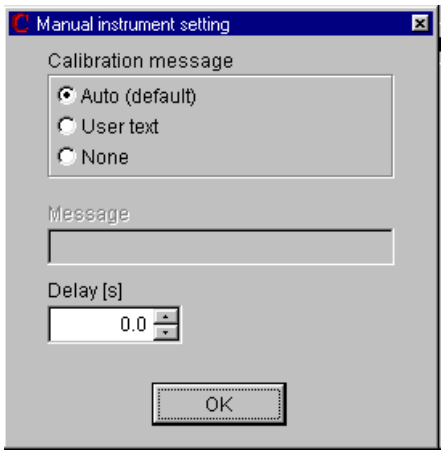
Manual control function consists of four items:

- Set
- Measure
- Output on
- Output off

These functions determine, what warnings (requests, notes) are displayed on the screen during calibration. They are used to inform user, that new output value must be manually set, determine which value is standard value, if to switch output terminals on or off. These function are not macros.

Set

Function SET allows to include warnings into calibration procedure, when output value of the instrument-source have to be changed for next calibration point performing.
After pushing the button SET following form will appear:



Auto is default item. It means that in each calibration point where output value is to be changed, default warning will be displayed.
User text means that in the bellow field written text will be displayed, when output value of the instrument-source is to be changed
None means that no warning is displayed in this case.
Delay(s) field specifies time between confirmation of warning and continuing calibration procedure.
Choose suitable item and confirm by OK.

Note: The most common is item AUTO. When NONE is chosen, no interruption will occur between two next calibration points.

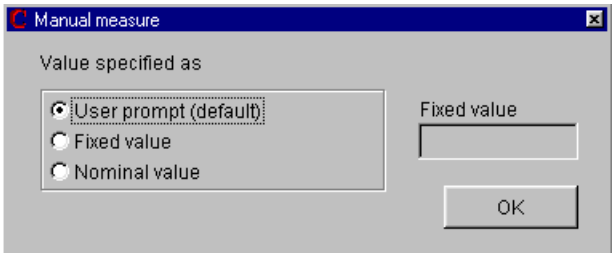
Note: Calibration points and their order in calibration procedure is determined in Calibration procedure.

Measure

In similar way function MEASURE define which value is taken by program as correct value of instrument-source in calibration point.

Note: Instrument source can be either SU (i.e. calibrator, when multimetr as UUT is calibrated) or UUT (i.e. calibrator as UUT is calibrated with more accurate standard multimeter. Both types of calibration can be performed with CALIBER.

One of following possibilities have to be chosen:



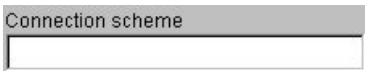
User prompt is default item. It means that in each calibration point you are asked to type manually standard (or UUT) value, i.e. actual output value of the instrument-source.
Fixed value means that in the "Fixed value" field written value is taken as standard (or UUT) value in the calibration point.
Nominal value means that nominal value of output signal is taken as standard (or UUT) value.
Choose suitable item and confirm by OK.

Output on / Output off

Functions OUTPUT ON and OUTPUT OFF are of the same meaning and using as function SET with the difference, that warnings are displayed, when output signal of the instrument-source will be switched on or off.

Note: If item NONE is chosen, output signal is not switching on (off) during moving between two next calibration points.

Connection scheme is text description, which output terminals will be used during calibration procedure. Normally calibrators use different terminals for voltage output, current output, etc.



Short text like Hu,Lu or H,L for voltage terminals and +I,-I for current terminals is recommended.

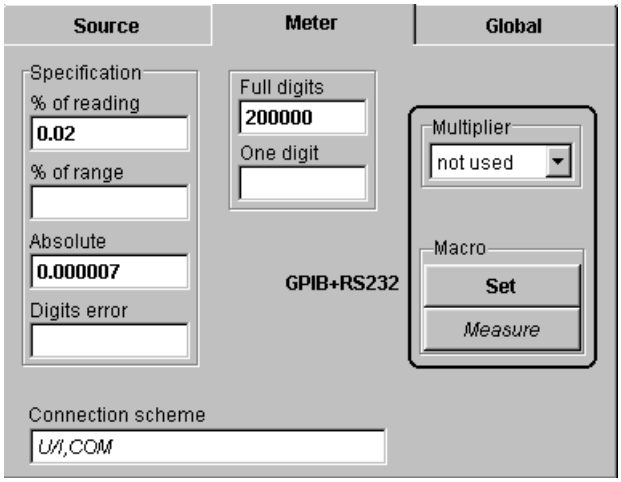
Text in this field influences warnings, which are displayed during calibration on the screen and which warn user that change of cable connection is necessary before continuing the calibration.

If you use for example symbols "Hu,Lu" for voltage terminals, use exactly the same symbols for all functions, where these terminals are used as output terminals.

2.3.2 Card of meter

Meter card describes features of the instrument, when it is used as meter. Specification, commands for remote control and connection of output terminals is written here. Meter card must be filled in, when the instrument is either standard meter or UUT (multimeter, V-meter, Ohm-meter, etc.). Meter card is not normally filled in, when the instrument is a source (calibrator, resistance decade, etc).

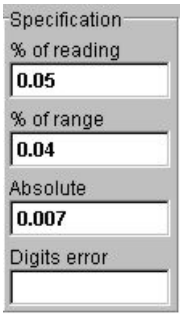
After clicking on Meter folder following form will appear:



Specification field enables setting of accuracy of the instrument. Specification can be written on one in following levels:

- one accuracy for the whole instrument, i.e. accuracy here set is valid for all functions, ranges, etc.
- various accuracy for functions, i.e. accuracy here set is valid for all ranges in one function
- various accuracy for ranges, i.e. each range can have different accuracy

Priority of set accuracy is described in chapter 2.3.4.



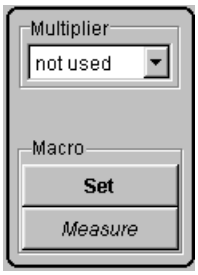
Form of accuracy may consist of max. four parts. The first and second ones „% of reading“ and „% of range“ are in percents, „Absolute error“ must be written in standard quantities of selected range (exponential format is allowed) and „Digits error“ must be written in number of digits. At minimum one of accuracy fields must be filled in.

Note: *In fact when new Instrument card is created or already created one is edited, no specification field must be directly typed. You can save Instrument card with “no specification”. But if such Instrument card is used in Calibration procedure and specification is not described, error is signalised during calibration.*

Fields “Full digits” and “One digit” represent resolution of the instrument-meter, expressed in two different ways. One of them should be set only.

Full digits (for meters only) represents resolution in term of maximal length of the display of the meter.
One digit represents resolution of the meter expressed by least significant digit. It have to be set in units of measured value.

Multiplier. It enables to set value during reading from (or sending to) the instrument in another decimal units than standard. Normally it is set “not used”, but every decimal value from the range 1e-18 to 1e+12 can be set. Atto, fempto, pico, nano, micro, milli, kilo, mega, giga, tera multipliers are predefined.



Correct item of the “Multiplier” must be set up, when the instrument is used with remote control (either GPIB or RS-232). For example if measured voltage 200 mV is red from the multimeter, value of voltage is expressed in basic units, i.e. “0.2” here. But some simple instruments do not use basic unit as parameter. For example, to set voltage 200 mV, value in mV must be sent to the instrument, i.e. “200”. In this case parameter of the Multiplier “milli” must be selected. If there are such settings necessary to match commands to the standard language, the “Multiplier” have to be checked on all functions and all ranges.

When used the instrument with Camera module, also appropriate prefix have to be set up on each function and each range. For example if measuring range of hand-held multimeter (as UUT) is 200 mV and on the display values in mV are displayed, i.e. “200.0”, prefix “milli” have to be set on this range in the UUT instrument card, while switch of way of control is set to “Camera”.

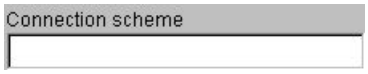
When used the instrument in manual mode without GPIB or RS-232 remote control, selected item in Multiplier field depends on the user only. If “not used” item is selected, it means that manually entered values (readings) must be expressed in basic units (volts, amps, etc.) during calibration. If “milli” item is selected, it means that manually entered values (readings) must be expressed in “milli” units (millivolts, milliamps, etc.) during calibration.

Note: *Different prefix can be used in instrument card on the same function and range but for different method of control.*

Similar to the source card, meaning of buttons under the field MULTIPLIER depends on way of control/scanning. For GPIB, RS-232 or GPIB+RS232 possibilities two buttons Set, Measure with headline MACRO will appear. For manual method of control/scanning only button Measure without headline MACRO is displayed. If camera module is used for display scanning, no function and no macro are need.

Macro is list of commands for instrument remote control via RS-232 or GPIB bus. Two types of macro are available for instrument – meter. Macros „Set“ and „Measure“ must be created for remotely controlled instruments. Macro “Set” enables to set the instrument (meter) to the desired predefined configuration when is used in remote mode. Macro “Measure” enables to transfer reading of the meter to the computer. See chapter “Macro creating” for more details.

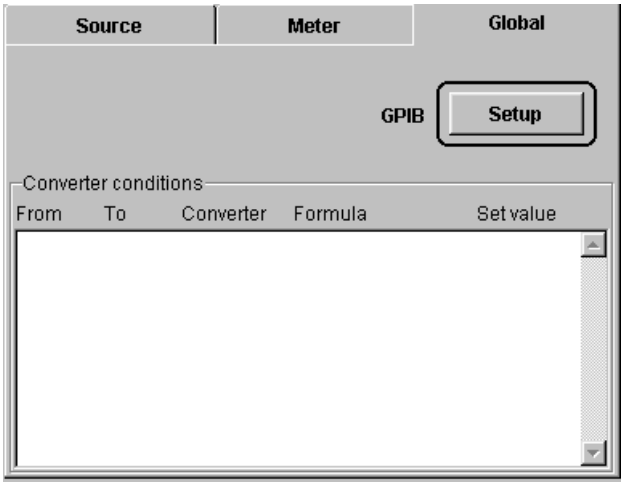
Manual control function consists of item SET only, where displaying of warning message during calibration procedure between two next calibration points can be set. The rules are the same as at appropriate function in SOURCE CARD.



Connection scheme is text description, which output terminals will be used during calibration procedure. Some meters use different terminals for voltage input, current input, etc. Short text like Hu,Lu or +I,-I is suitable. The rules are the same as for appropriate function in SOURCE CARD.

2.3.3. Global settings

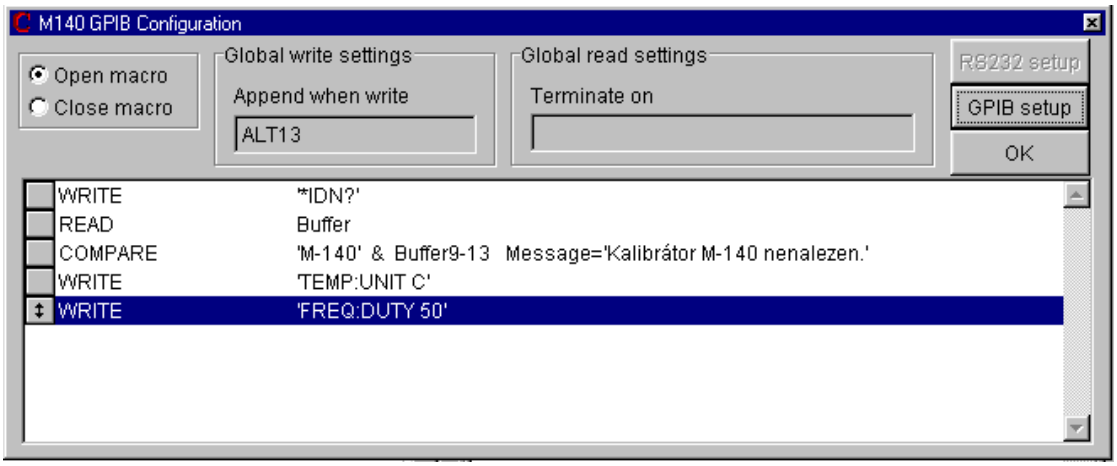
Folder Global enables to set parameters of interfaces, camera module (if used) and parameters of converters.



Set-up function is active for instruments with declared remote method of control/scanning, i.e.RS-232, GPIB or when Camera module is used for display scanning of the instrument. The function define parameters and features of remote control and scanning. With the function macros for opening/closing instruments and parameters of interface bus can be created (see chapter "Macro creation").

Set-up function is not available for manual control and scanning. No settings is need in this case. Also for combination of both GPIB and RS-232 control set-up function is not available. In this case parameters of GPIB and RS-232 have to be set separately.

After set-up button pushing following form will appear:



Depending on chosen method of remote control (GPIB, RS-232) either GPIB set-up button or RS-232 button is enabled. All other fields belongs to the Macro facility, see chapters 2.3.5, 2.3.6.

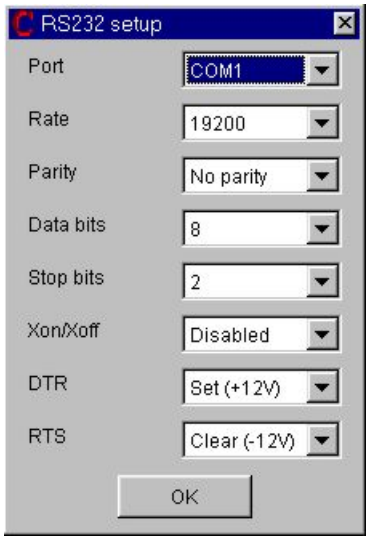
GPIB bus

When GPIB interface is selected as interface for remote control and set-up function is activated following form will appear.

In this case GPIB card must be installed in the PC. Only address of the instrument can be set here. Allowed range is from 1 to 30, address 0 is reserved for PC. All other parameters of GPIB bus have to be set during GPIB card in PC installation.

RS-232 line

When GPIB interface is selected as interface for remote control and set-up function is activated following form will appear.



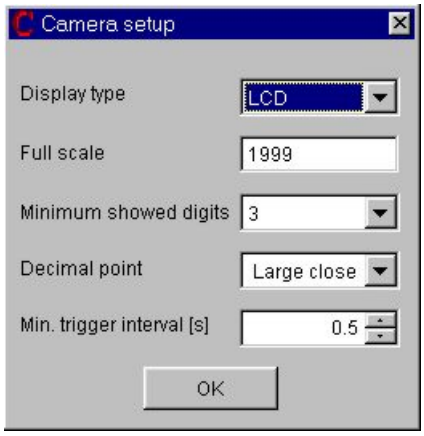
Free port RS-232 must be available in this case in PC. Number of Com port, communication rate, parity, number of data bits, number of stop bits, Xon/Xoff and meaning of signals DTR a RTS in static status. The last mentioned parameter is important for communication with some older types of instruments, which use this signals for interface supplying.

OK button

After pushing the button, update of global setting is saved and program will return to the Instrument card basic form.

Camera

Let us go back to the Global settings. If Camera option is chosen for remote scanning of UUT display, after *SETUP* button pushing form for setting of camera parameters is displayed.



Measured values of instrument (usually UUT) are scanned through camera. Camera module CAM-OCR must be installed in PC. Camera module enables only scanning of the instrument display and transferring value to the PC. It cannot be used for controlling of an instrument. Following parameters can be set for camera scanning :

Display type – LCD (dark numbers on light background) or LED (light numbers on dark background)

Full scale – it is the highest number, which can be displayed on the instrument, i.e. max. length of display (decimal point is not considered)

Minimum shown digits – this information makes better condition for sub-program which transfer live image of camera module to the number.
Note: to recognise this number, switch UUT on and read number of digits on the display. Don't connect input terminals.

Decimal point – one of following types have to be selected:

- No instrument doesn't use decimal point
- Small close size of decimal point is approx. half of segment width
- Small far small decimal point located from segment more than half segment width
- Large close size of decimal point is approx. the same as segment width
- Large far large decimal point located from segment more than half segment width

Both minimum shown digits and decimal point are important for reliable reading of camera module and recognising displayed number. These information makes better condition for sub-program which transfer live image of camera module to the number.

Min. trigger interval [s] – speed of reading rate of the instrument. Approximately in this interval camera scans display of instrument.

Manual

There is no special setting for manual way of control/scanning.

Converter conditions

Some of instruments can be used as converters. It means that they can convert one function to other. Typical application is resistance shunt. It is used for high current ranges calibration of UUT. Current from the current source is led into UUT (set on current range) through resistance shunt. Exact value of current is measured as voltage across the voltage terminals of resistance shunt. In fact source of standard (true) value is both voltmeter measuring voltage on the shunt and resistance value of this shunt. From calibration system point of view, resistance shunt is converter current to voltage. This feature must be described in its instrument card, in "Converter conditions" window.

There are two basic group of converters:

- **Virtual converter**

Virtual converter is not real instrument. It is intended for converting of function. It does not influence calibration uncertainty, it matches only function of UUT and SU as they are defined in their Instrument cards.

Example: *it is requested to calibrate resistance standard (UUT) with nominal value 100 Ohm with standard multimeter HP 3458A (SU). Resistance standard is two terminal type, i.e. RDC-2W function is defined in its Instrument card. 4-wire method of connection is preferred here.*

Under normal condition Wizard for calibration procedure generation supposes, that two-wire technique will be used. To change it to 4-wire method you have to use virtual converter, which converts RDC-2W function of UUT to RDC-4W. In this case Wizard generates calibration procedure based on 4-wire measuring (both UUT and SU are equipped with RDC-4W function now).

- **Real converter**

Real converter is for example resistance shunt, which can transform current to voltage. Resistance shut has two meanings:

- it is source of resistance and it can be used as SU for resistance meter calibration
- it is converter and involves to measure high current as voltage drop on it.

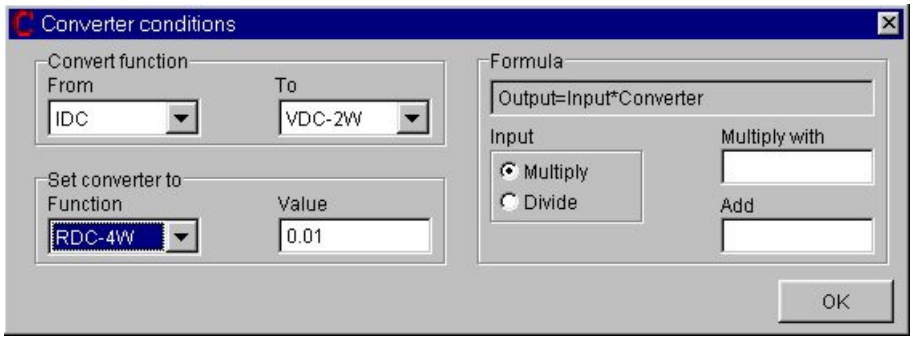
Window of Converter conditions is a part of basic form of Instrument card. To create or edit Converter conditions click right mouse button while mouse pointer is located in the window "Converter conditions". Menu with following items will appear:

Add enables to add new converter function

Modify can be used for editing still existed converter function.

Delete deletes existing converter function.

To modify or delete item from the window, put mouse pointer on the desired line and click with right mouse button. To add function click right mouse button while mouse pointer is located in the window "Converter conditions". Choose from menu "Add". Following window will appear.



There are shown here all converter functions, which the instrument (=converter) can convert. During calibration, program automatically select suitable function according to the input and output function.

In the figure above configuration for 10 mOhm resistance shunt is shown. Following fields are available to describe shunt as converter function:

Convert function

From select input function of the converter (in case of resistance shunt it is IDC or IAC)

To select output (target) function of the converter (in case of resistance shunt it is VDC-2W or VDC-4W or VAC-2W or VAC-4W).

Note: *all functions can be added, it depends on mean of use of the instrument as converter.*

Set converter to

Function select the basic function of the instrument. It means function to which it must be set to convert input function to the output function In case of resistance shunt it is simple, RDC-2W or RDC-4W or RAC-2W or RAC-4W. When virtual converter is created, use item "Void" in this field, which denotes virtual converter.

Value type nominal value of instrument-converter, to which it is requested to set to convert input function to the output function. In case of resistance shunt type its nominal value.

Exact value of real converter, which is used in calibration procedure, must be defined in Instrument card of the converter (folder Source, button Measure)

If virtual converter is created, value is not necessary to fill in. For virtual converter must exist its own Instrument card. In the instrument card, functions, ranges and accuracy are not obligatory.

Formula displays formula of conversion. It is created automatically by setting values in fields "Multiply with" or "Add" and changing position of switch "Input". It can not be edited directly.

Input

Multiply input function is multiplied with here set out coefficient (see line Formula)

Divide input function is divided with here set out coefficient (see line Formula)

Multiply with fix constant for Multiply/Divide function

Add fix additive constant

2.3.4 Rules of item displaying

Specification, terminal connection and method of control/scanning can be set in any level in hierarchy: instrument – function – range. Any of these items set in higher level is valid in lower levels too. If any of these items is set in several levels, parameter in the lowest level is valid for calibration point. To make orientation easier, various types of letters are used:

a) Normal item is not set yet

b) **Bold** item is set on currently displayed level.

c) *Cursive* item was set in higher level and in currently displayed level is valid too.

Specification, terminal connection and method of control/scanning must be set before starting calibration procedure. If this condition is not fulfilled, error message will appear during calibration procedure.

2.3.5 Types of Macro

To control instruments remotely via GPIB or RS-232 interface, a control commands have to be sent to the interface bus. Macros consists of list of such commands, which are sent to the instrument when remotely controlled. Macros make remote operation easier. Knowledge of programming is not need. Operation manual of the instrument with commands for remote control is enough.

Six basic macros are available:

- ***Open*** open communication on interface bus (GPIB or RS-232)
- ***Close*** close communication on interface bus (GPIB or RS-232)
- ***Set*** enables to set configuration of the instrument. It send string for setting.
- ***Measure*** enables to transfer reading of the instrument to the PC.
- ***Output terminals on*** It switches output terminals on
- ***Output terminals off*** It switches output terminals off

Macro OPEN and CLOSE are part of GLOBAL SETTING. Macro SET and MEASURE are available in METER CARD and SOURCE CARD. Macro OUTPUT ON and OUTPUT OFF are available in METER CARD only.

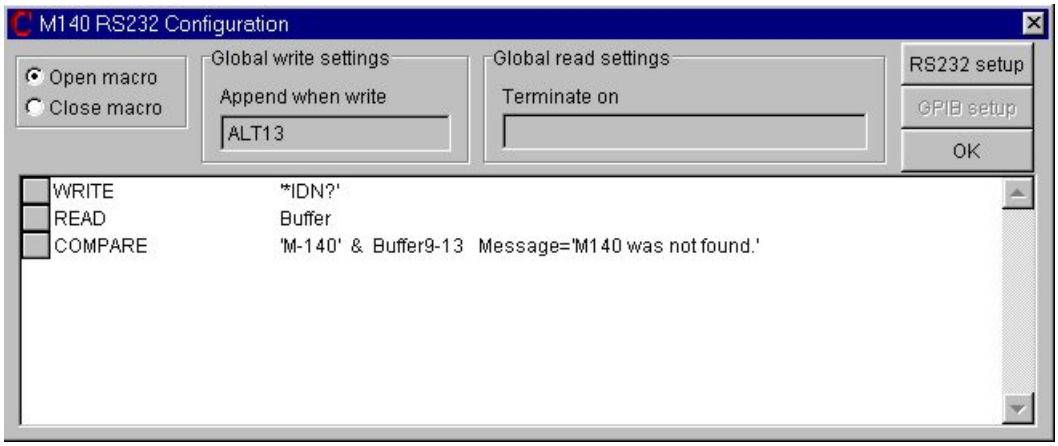
Every item (row in the macro form) in macro consists of three parts. The first part is key word, like WRITE, COMPARE, etc. Key word specify what kind of operation is to be perform. Key word is followed by its parameter, the second part. In the figure bellow parameter of the first command in macro OPEN is command WRITE with parameter “IDN?”. Parameter specify what the instrument exactly performs (set function, range, send back type number, etc.). Every command with its parameter is normally ended by character CR, this is the third part of a command. Character CR means, that the instrument performs command with its parameter after receiving character CR. The instrument always waits for this CR, before it change setting, send reading, … CR character is confirmation, that command with parameter is valid for the instrument.

The most common CR character are “ALT13”, “ALT10”, “,” and others. M-140 calibrator uses in its interface structure ALT13 as CR character. Type of CR character is described in operation manual of the instrument.

Note: some simpler instruments doesn’t request to send CR character.

See also chapter 2.3.7.

Macro OPEN



It can be defined for GPIB a RS232 interfaces. Macro for opening communication interface of the calibrator M-140 is shown on the screen above. In window “Global write settings“ string is displayed, which is sent to the instrument after command “WRITE”. This string (ALT13) is identical to the end string CR in M-140 calibrator. Window “Global read settings“ contains string with meaning “End of message”. Reading can be terminated also after certain predefined number of characters. If both possibilities are chosen (termination both after receiving the string “End of message” and predefined number of characters), reading is terminated if any of these conditions occur. Window “Global read settings” is normally not used. It is aimed for some older instruments with RS-232, where reading synchronisation is not possible.

Macro can be saved by pushing the button OK. In the picture above following commands are used:

WRITE – it sends string „*IDN?“ into the instrument. The string is followed by character CR (ALT13) for M-140 calibrator.

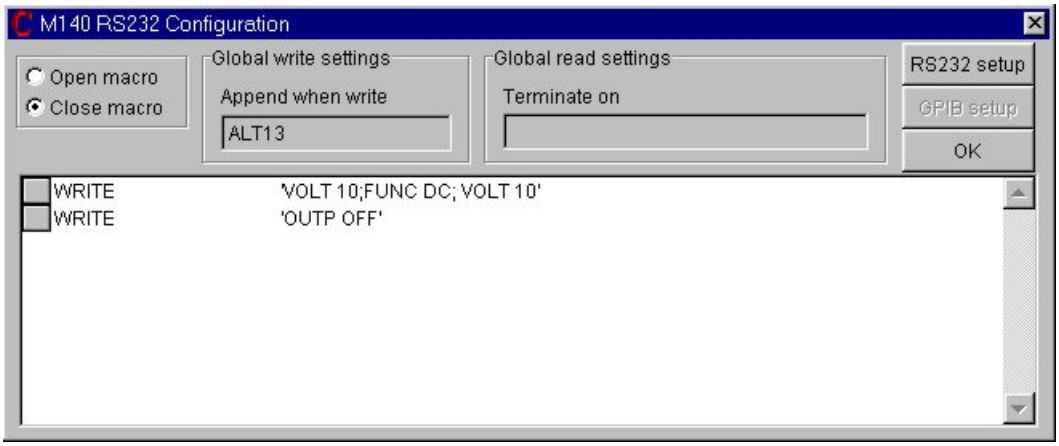
READ – read response from the instrument and saves it into the variable BUFFER.

COMPARE – compare string „M-140“ with in buffer saved characters 9-13. When there is difference between both strings, program will display message „Instrument M-140 not found“. Calibration is interrupted.

Macro OPEN is valid for both source and meter. If the instrument is equipped with both RS-232 and GPIB, macros must be defined for both interfaces separately. See chapter “Creating macro”.

Macro CLOSE

It can be defined for GPIB a RS232 interfaces. Macro for closing communication interface of the calibrator M-140 is shown on the screen above. Meaning of windows „Global write



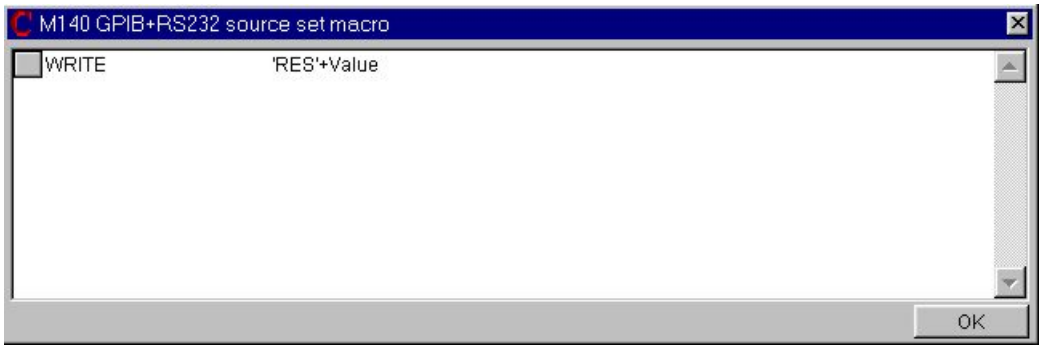
settings", „Global read settings" are described in section Macro OPEN above. Macro can be saved by pushing the button OK. In the picture above following commands are used:

WRITE – send string „VOLT 10;FUNC DC;VOLT 10" followed by character in "Append when write" field (CR=ALT13 is valid for M-140 calibrator) into the instrument (calibrator).

WRITE – send string „OUTP OFF" followed by character in "Append when write" field (CR=ALT13 is valid for M-140 calibrator) into the instrument (calibrator).

Macro CLOSE is valid for both source and meter. If the instrument is equipped with both RS-232 and GPIB, macros must be defined for both interfaces separately. See chapter "Creating macro".

Macro SET

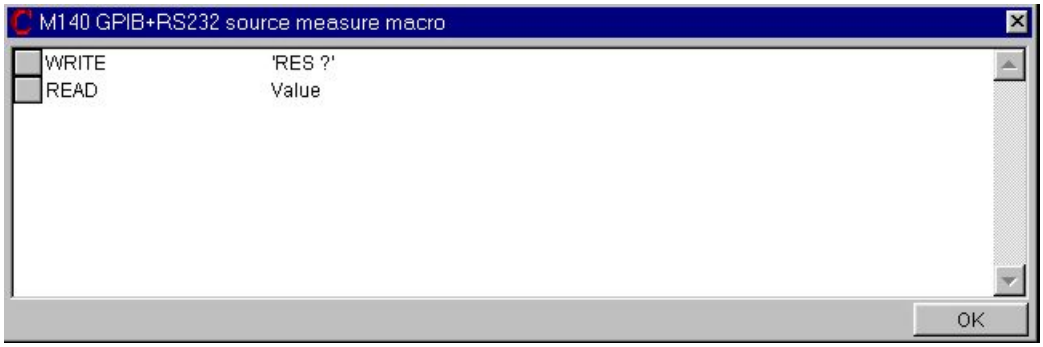


It can be defined for GPIB a RS232 interfaces. In the picture above macro for M-140 calibrator setting to the mode R-2W (source of two-wire resistance) is shown. Following commands are used:

WRITE – send string „RES" into the calibrator, followed by nominal value of calibration point. To the command is appended character in "Append when write" field (CR=ALT13 is valid for M-140 calibrator).

Macro SET can be the same for both RS-232 and GPIB. Independent macros can be created for instrument-source (source card) and instrument-meter (meter card). In SOURCE CARD macro SET set up function, range and value of calibration point. In METER CARD set function and range. See chapter “Creating macro” for more details.

Macro MEASURE



Above displayed sample of macro MEASURE is valid for M-140 calibrator. It can be used for communication on GPIB and RS-232 too (See the line above window). The macro is macro of instrument-source. It send query to the instrument.

Following commands are used:

WRITE – send string „RES ?“ into the calibrator. To the command is automatically appended character defined in macro OPEN/CLOSE (i.e. CR=ALT13 for M-140 calibrator).

READ – read response from the instrument and saves it into variable VALUE.

Macro MEASURE can be the same for both RS-232 and GPIB. Independent macros can be created for instrument-source (source card) and instrument-meter (meter card).

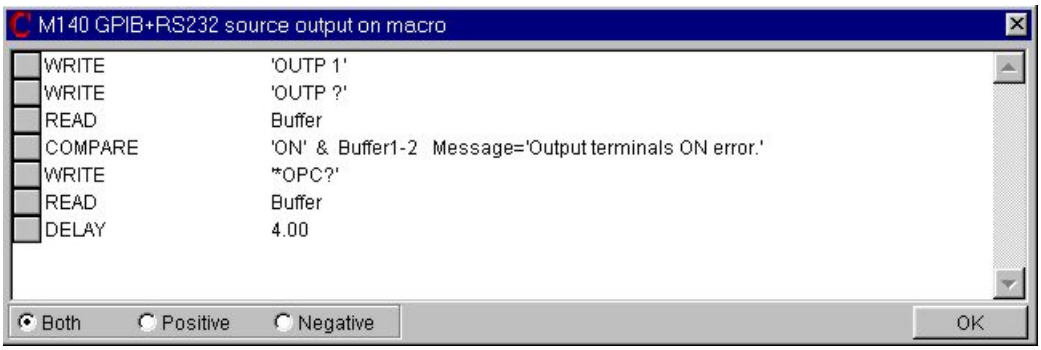
In SOURCE CARD macro MEASURE read previously set up value of the instrument-source. One reading is always taken from the instrument.

In METER CARD macro MEASURE takes one reading from the instrument-meter, i.e. on the instrument actually displayed value is transferred to the PC. See chapter “Creating macro” for more details.

Macro OUTPUT ON

It can be defined for GPIB a RS232 interfaces. In the picture above macro for M-140 calibrator setting of output terminals ON is shown. Following commands are used:

WRITE – send string „OUTP 1“ followed by nominal value of calibration point. Command is



ended with character defined in macro OPEN/CLOSE (i.e. CR=ALT13 for M-140 calibrator).

WRITE – send string „OUTP ?“. Command is ended with character defined in macro OPEN/CLOSE (i.e. CR=ALT13 for M-140 calibrator).

READ – read response from the instrument and saves it into the variable BUFFER.

COMPARE – compare string „ON“ with in buffer saved characters 1-2. When there is difference between both strings, program will display message „Output terminals cannot be switched ON”. Calibration is interrupted.

WRITE – send string „*OPC?“. Command is ended with character defined in macro OPEN/CLOSE (i.e. CR=ALT13 for M-140 calibrator).

READ – read response from the instrument and saves it into the variable BUFFER.

DELAY – waits 4 sec to settle output value.

In the bottom line switch „Both“, „Positive“ and „Negative“ is displayed. When the instrument-source uses the same command for positive and negative polarity of output signal switching on, one macro is enough. Set the switch to the position “Both”.

Some sources uses different commands for positive and negative signals. In this case different macros should be defined for negative and positive polarity.

Macro OUTPUT ON can be the same for RS-232 and GPIB interfaces. It is available for instrument-sources only. See chapter “Creating macro” for more details.

Macro OUTPUT OFF

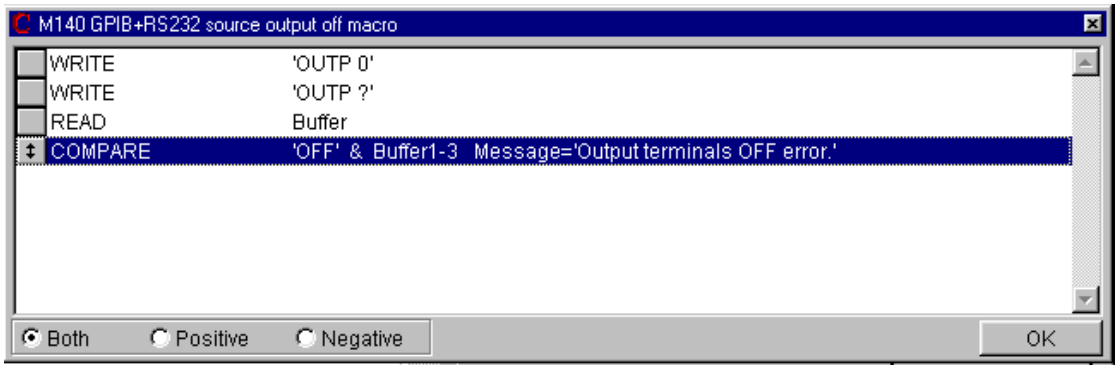
It can be defined for GPIB a RS232 interfaces. In the picture above macro for M-140 calibrator setting of output terminals OFF is shown. Following commands are used:

WRITE – send string „OUTP 0“. Command is ended with character defined in macro OPEN/CLOSE, i.e. CR (ALT13 for M-140 calibrator).

WRITE – send string „OUTP ?“. Command is ended with character defined in macro OPEN/CLOSE, i.e. CR (ALT13 for M-140 calibrator).

READ – read response from the instrument and saves it into the variable BUFFER.

COMPARE – compare string „OFF“ with in buffer saved characters 1-3. When there is difference between both strings, program will display message „Output terminals cannot be switched OFF”. Calibration is interrupted.



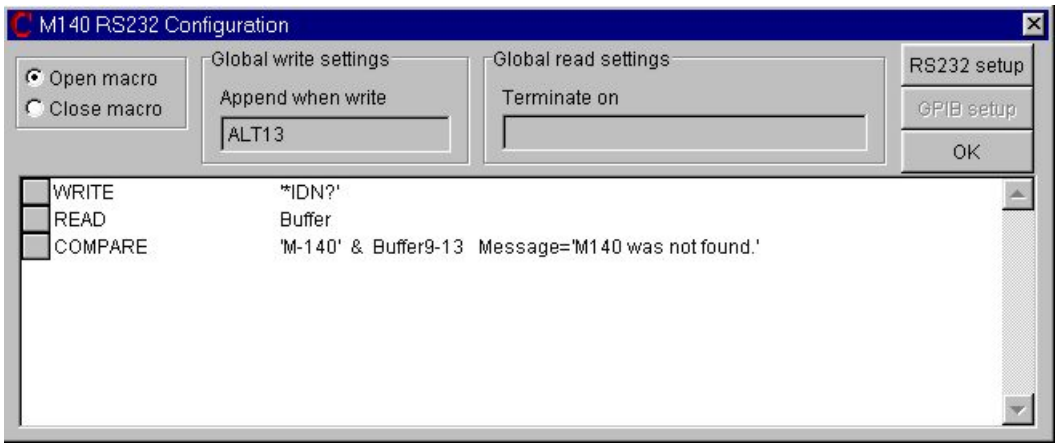
In the bottom line switch „Both“, „Positive“ and „Negative“ is displayed. When the instrument-source uses the same command for positive and negative polarity of output signal switching on, one macro is enough. Set the switch to the position “Both”.

Some sources uses different commands for positive and negative signals. In this case different macros should be defined for negative and positive polarity.

Macro OUTPUT OFF can be the same for RS-232 and GPIB interfaces. It is available for instrument-sources only. See chapter “Creating macro” for more details.

2.3.6 Creating macro

OPEN and CLOSE macro is aimed for open and close communication on RS-232 or GPIB interfaces. They can be created only in folder GENERAL SETTINGS. Item RS-232 or



GPIB must be chosen in this folder. After pushing the button SETUP following form will appear:

Choose appropriate item (Open macro or Close macro). You can edit already existed macro or you can create new one.

SET and MEASURE macro are available in folder SOURCE CARD and METER CARD too. Any of RS-232 or GPIB or RS-232+GPIB must be chosen in this folder. If RS-232 is chosen, macros SET and MEASURE work when instrument is in remote control mode via RS-232. If GPIB is chosen, macros SET and MEASURE work when instrument is in remote control mode via GPIB. If GPIB+RS-232 is chosen, macros SET and MEASURE work when instrument is in remote control mode via either RS-232 or GPIB. The same commands are sent to the instrument interface (RS-232, GPIB). Push appropriate button SET or MEASURE. Form for creating and editing macro will appear.

OUTPUT ON and OUTPUT OFF macros are available in folder SOURCE CARD only. Any of RS-232 or GPIB or GPIB+RS-232 must be chosen in this folder. If RS-232 is chosen, macros SET and MEASURE work when instrument is in remote control mode via RS-232. If GPIB is chosen, macros SET and MEASURE work when instrument is in remote control mode via GPIB. If GPIB+RS-232 is chosen, macros SET and MEASURE work when instrument is in remote control mode via either RS-232 or GPIB. The same commands are sent to the instrument interface (RS-232, GPIB). Push appropriate button SET or MEASURE. Form for creating and editing macro will appear.

Note: *Type of letters of the labels in the macro buttons depend on fact, if already exists a macro for current level of instrument (i.e. instrument – function – range). Current level is level for which macro is created/edited. If fact, for each calibrating point its own macro can be generated. The most common is to create one macro of each type for whole instrument. See chapter 2.3.4.*

Every macro consists of one or more rows with commands and their parameters.

2.3.7 Macro commands

After entering to the form for a type of macro creating/editing, click the right mouse button. Menu with available commands for macro creating will appear:

Modify – opens window for modifying already existing macro.

Add Write – opens window for adding new command WRITE.

Add Read – opens window for adding new command READ.

Add Delay – opens window for adding new command DELAY.

Add Message – opens window for adding new command MESSAGE.

Add Compare – opens window for adding new command COMPARE

Add Numeric compare – opens window for adding new command NUMERIC COMPARE

Delete – deletes current row.

Delete All – deletes all rows.

Macro can work with one of following objects:

a) **Text** – it is created with row of standard ASCII characters (code 32 …255). Control codes 0 .. 31 are not allowed here.

b) **Alternative code** – one ASCII character (0 .. 255). It enables to write any single ASCII character including control codes 0 .. 31.

c) **Variable** – macros use as parameter two numeric variable and one text variable. Numeric values are:

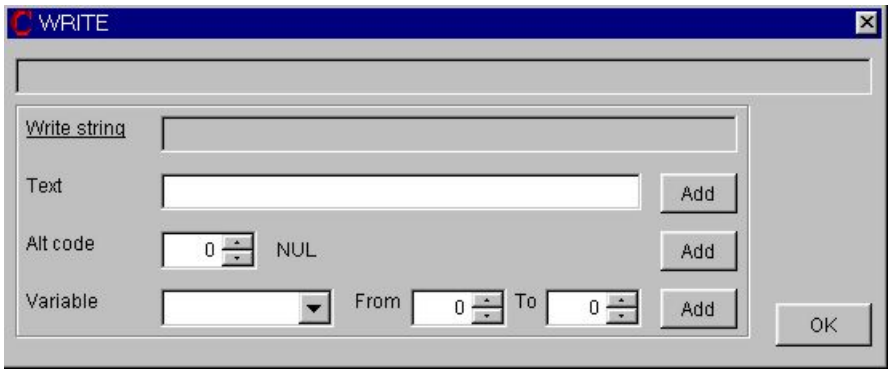
- „Value“ for instrument-source it represents normally value, which is set on the instrument. It is obviously main nominal value of the calibration point, like 10 (V), 19 (V), etc. (macro SOURCE) and this value will be . For instrument-meter it represents variable, to which is saved reading from the meter (macro READ).
- „Parameter“ it represents value of next parameter in calibration point. It can be for example value of frequency, when AC voltage/current ranges are calibrated.

Text variable is:

- Text variable “Buffer” has general use. In this variable saved string can be used as one part for comparing of two strings, for example to compare string received from the instrument with awaiting string. Typical application is identification of an instrument.

2.3.7.2 Add/edit command WRITE

Command WRITE enables sending to the instrument a string containing constants and



variables. Created string is written in the field “Write string”. This field cannot be directly edited. The string may obtain „Text“, „Alternative code“ and „Variable“. All three types of

string can be written to the appropriate field and added by pushing the button “Add”. In “Variable” field also only selected part (from - to) can be added into the string.

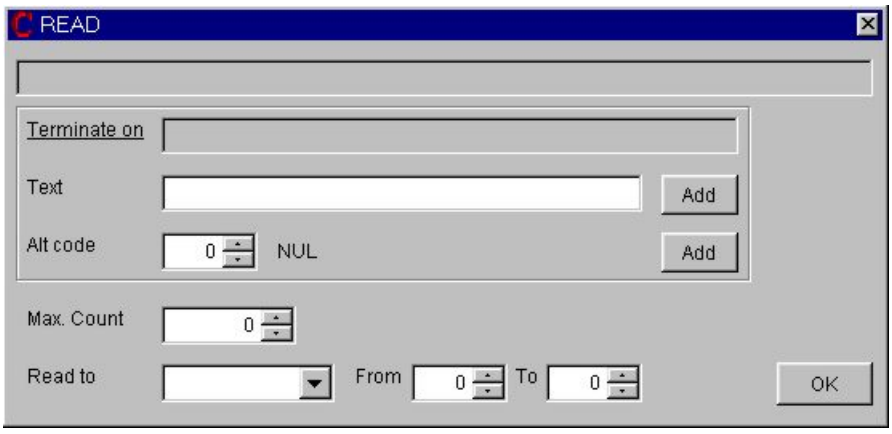
To create new text simply write the text into field “Text” and click on the button Add. To create new alternative code write it into field “Alt code” (or use increment arrows) and click on the button. To add variable choose from the menu in the field “Variable” and click on the button Add.

To edit Text, Alt code or Variable simply click on the item which is to be edited. Edited characters will appear in appropriate field and at the same time edited characters in field “Write string” change colour from black to red. Now you can change in appropriate field content of the string. The change is automatically moved to the “Write string”. While editing the string, you can delete editing string by pushing the mouse right button over the edited string in “Write string” field.

Note: *for instrument-source and instrument-meter meaning of WRITE command is similar. It set the instrument configuration.*

2.3.7.3. Add/edit command READ

Command READ enables reading a string containing constant or/and variable from the instrument. String from the instrument is written into variable “Value” when the received string is numerical, i.e. number displayed on the display. String from the instrument is written into variable “Buffer” when the received string is text string, i.e. for example string for further calculation (comparison of strings, etc.)

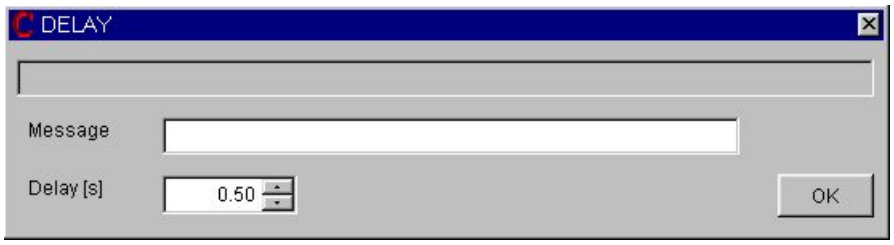


For creating/editing the same rules as for command WRITE are valid. Result form of the command is shown in the top field. In the field “Terminate on” symbol for stop reading is shown. Contain of this field cannot be changed here.

Note: *for instrument-source and instrument-meter meaning of READ is a little bit different. For meter, current reading is requested with this command normally. For source, with READ command actually set up value is asked.*

2.3.7.4. Add/edit command DELAY

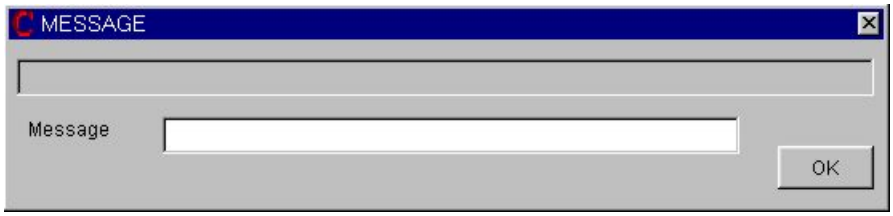
The command interrupts calibration procedure for time pre-set in window “Delay”. Allowed range of time is 0 to 999 s. During interrupting message written into the field “Message” is displayed on the screen.



Note: command DELAY can be used with advantage for creating and compiling newly created macro. Insert command DELAY before each command in the macro. When running of macro is stopped during compiling it is easy to learn, which command causes error.

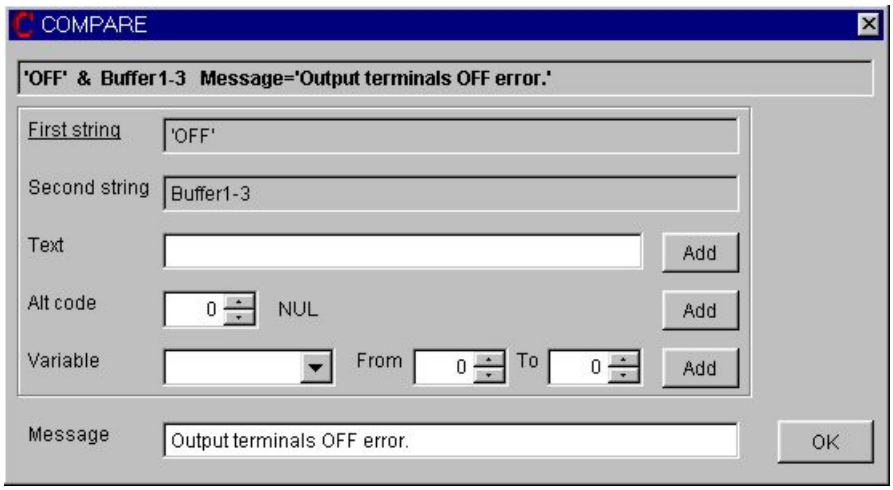
2.3.7.5. Add/edit command MESSAGE

The command interrupts running of calibration procedure and display text written in the field “Message”. To continue in calibration procedure press key ENTER. Command is suitable to inform user about an action, which cannot be perform automatically.



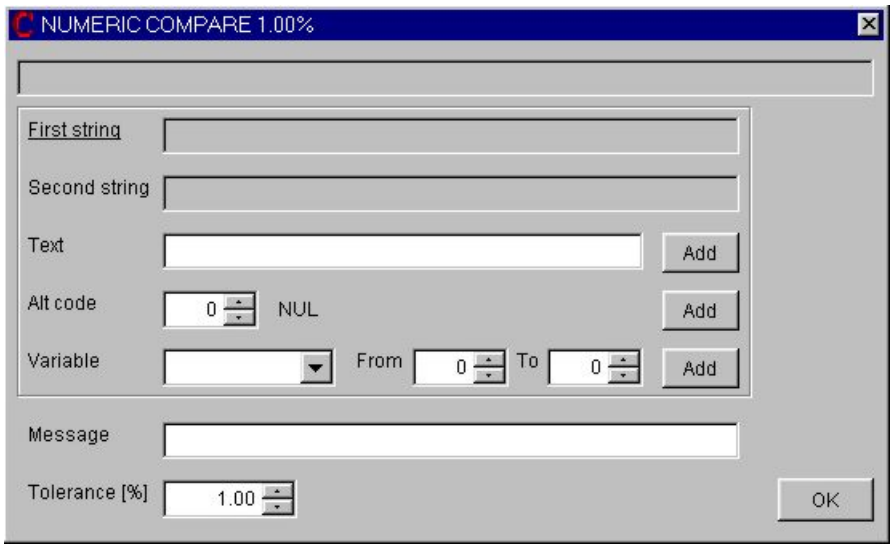
2.3.7.6. Add/edit command COMPARE

Command compares two text strings. If they are not equal, calibration procedure is interrupted and text written in the field “Message” is displayed on the screen. In most frequent cases content of variable “Buffer” is compared with fix string. Content of “Buffer” variable is determined by command READ. In the figure bellow comparison of two firsts characters from variable “Buffer with fix text “OFF” is set. If the comparison is fail, calibration procedure is terminated and error message “Output terminals OFF error” is displayed on the screen. For creating/editing the same rules as for command WRITE/READ are valid. Result form of the command is shown in the top line.



2.3.7.7. Add/edit command NUMERIC COMPARE

Command compares two numeric or strings. If they are different more percent than written in the field “Tolerance”, calibration procedure is interrupted and text written in the field “Message” is displayed on the screen. For creating/editing the same rules as for command WRITE/READ are valid. Result form of the command is shown in the top line.



Note: *also text strings can be compared with this command. In this case the first text strings are converted into number. Both numbers are after that compared.*

2.4 User functions

For calibration of any instrument appropriate Instrument cards, Calibration procedure and Functions must exist. Item Instrument card defines features of the instruments, Calibration procedure defines methodology of calibration and relations between instruments. Module Functions is internally used for automatic matching of the SU and UUT functions. Only in this program module defined functions can be used during calibration. After installation of program CALIBER, set of **basic** measuring functions described in the file "Default.fce" is automatically loaded into the list of function. If a function of UUT is to be calibrated, which is not in the list of basic functions, it must be define the first. Definition of new

Basic sorting of measuring function is following:

- **absolute functions**

  If selected function is considered as absolute, it starts from any fix point (-200 ^{o}C) and ends in another fix point (850 ^{o}C). Absolute function is for example temperature scale of a multimeter, thermometer, etc.

- **relative functions**

  If selected function is considered as relative, it starts from zero or nearly zero (0 V) and ends in fix point (1000 V). Usually it cover several decades of quantity. Relative function is for example voltage range of meter.

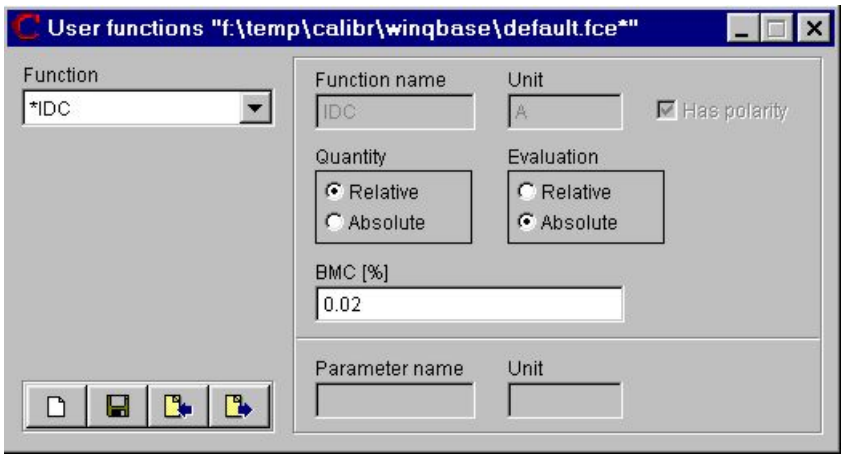
In User's function module, way of UUT deviation and calibration uncertainty evaluation. If it is set up as absolute, all deviations and uncertainties will be expressed in units of function, i.e. in volts, amps, Ohms, etc. If it is set up as relative, all deviations and uncertainties will be relatively expressed, i.e. in "%".

Bellow list of basic functions is set out.

*VDC-2W	two – wire DC voltage
*VAC-2W	two – wire AC voltage
*IDC	DC current
*IAC	AC current
*RDC-2W	two - wire DC resistance
*RDC-4W	four - wire DC resistance
*C-2W	two - wire capacity
*FREQ1	Frequency
*FREQ2	frequency with amplitude as parameter
*RAC-2W	two – wire AC resistance with frequency as parameter
*RAC-4W	four – wire AC resistance with frequency as parameter
*VDC-4W	four – wire DC voltage
*VAC-4W	four – wire AC voltage with frequency as parameter
*C-4W	four – wire capacity
*P100 D90	Pt 100 temperature sensor, ISO standard, ITS90
*P100 U90	Pt 100 temperature sensor, US standard, ITS90
*P100 D68	Pt 100 temperature sensor, ISO standard, PTS68
*P100 U68	Pt 100 temperature sensor, US standard, PTS68
*P200 D90	Pt 200 temperature sensor, ISO standard, ITS90

*P200 U90	Pt 200 temperature sensor, US standard, ITS90
*P200 D68	Pt 200 temperature sensor, ISO standard, PTS68
*P200 U68	Pt 200 temperature sensor, US standard, PTS68
*P500 D90	Pt 500 temperature sensor, ISO standard, ITS90
*P500 U90	Pt 500 temperature sensor, US standard, ITS90
*P500 D68	Pt 500 temperature sensor, ISO standard, PTS68
*P500 U68	Pt 500 temperature sensor, US standard, PTS68
*P1000 D90	Pt 1000 temperature sensor, ISO standard, ITS90
*P1000 U90	Pt 1000 temperature sensor, US standard, ITS90
*P1000 D68	Pt 1000 temperature sensor, ISO standard, PTS68
*P1000 U68	Pt 1000 temperature sensor, US standard, PTS68
*N100 S90	Ni 100 temperature sensor, ITS90
*N100 S68	Ni 100 temperature sensor, PTS68
*N1000 S90	Ni 1000 temperature sensor, ITS90
*N1000 S68	Ni 1000 temperature sensor, PTS68
*TC R S90	TC temperature sensor type R, ITS90
*TC R S68	TC temperature sensor type R, PTS68
*TC S S90	TC temperature sensor type S, ITS90
*TC S S68	TC temperature sensor type S, PTS68
*TC B S90	TC temperature sensor type B, ITS90
*TC B S68	TC temperature sensor type B, PTS68
*TC J S90	TC temperature sensor type J, ITS90
*TC J S68	TC temperature sensor type J, PTS68
*TC T S90	TC temperature sensor type T, ITS90
*TC T S68	TC temperature sensor type T, PTS68
*TC E S90	TC temperature sensor type E, ITS90
*TC E S68	TC temperature sensor type E, PTS68
*TC K S90	TC temperature sensor type K, ITS90
*TC K S68	TC temperature sensor type K, PTS68
*TC N S90	TC temperature sensor type N, ITS90
*TC N S68	TC temperature sensor type N, PTS68

Program module “User function” was designed for defining new **user’s measuring functions**. With this feature measuring function definition can be created and edited. To create or modify already existed users function select program module “User functions” in main menu in the top line on the screen. Following form is shown.



Normally default file with default functions is opened.

In the field “Function” you can select any function and look at its setting. Every function is defined with following parameters:

Function – name of the function. Max. length is 10 characters.

Unit – basic unit of the function like A, V, Ohm, K, Pa, etc. Max. length is 4 characters. Prefix are automatically added to the basic unit in order to create partials and multiples of basic unit (kilo, mega, milli, etc.).

Has polarity – tick the field, when the function allows both positive and negative setting.

Note: When field “Has polarity“ is ticked and range is 20 to 200 V, it means that both voltages from the range +20 to +200 V and from the range –20 to –200 V can be set. When field “Has polarity“ isn’t ticked and range is 20 to 200 V, it means that only voltages from the range +20 to +200 V can be set.

Quantity – with this switch main feature of the range can be set.

Setting here influences method of generation of calibration points during calibration procedure creating. For temperature range with “absolute quantity”, calibration points with equal and linear distances **in one range** are generated For voltage range with “relative quantity” several points on each range are generated.

According to the set switch “Quantity”, also BMC should be type either in % or in measured units.

Evaluation – setting of the parameter influence only method of UUT deviation calculating. It determines if allowed deviation of UUT, measured deviation of UUT and calibration uncertainty are calculated as absolute or relative. This evaluation is added into test report of calibration.

Note: after installation, evaluation default setting is set to absolute.

BMC – means “best measurement capability” of cal lab. Every user should fill in this information, although it is not necessary. Meaning of this information is in correct evaluating of calibration uncertainty. Calibration uncertainty is calculated according to the valid standards from standard value source uncertainty, number of repeating readings, etc.(see chapter 2.6). But if the evaluated calibration uncertainty is lower than uncertainty in the field “BMC”, BMC value is written to the calibration test report instead evaluated uncertainty. BMC can be typed either relative or absolute depending on setting the switch “Quantity”

Parameter name – text string can be typed here. Max. length is ten characters. Item is not compulsory. It is used in case when next parameter should be specified (for example for AC voltage/current ranges frequency have to be defined, i.e. “Frequency”).

Unit – text string can be typed here. Max. length is ten characters. Item is not compulsory. It is used in case when next parameter should be specified (for example for AC voltage/current ranges frequency have to be defined, i.e. “Hz”).

In the bottom side normally used keys are shown:

 **New** – add new user defined function.

 **Save** – saves newly created/edited list of functions into the file.

 **Import** – imports functions created formerly in this program module and exported via button Export (format *.fce). During import, existing already created function in database against new function is checked. List of functions is append with new functions with new definitions only.

 **Export** – exports function in format *.fce. Format is suitable for transferring functions among more users.

Export and import are not very often used function. List of instrument functions is saved in calibration procedure of every instrument (format *.pre). It is aimed for transferring among users.

Note: *Basic function can be edited too. From the parameters, BMC and Evaluation can be changed. Editing of all the rest parameters is not allowed. In the list of functions basic functions are marked with symbol “*”.*

User’s defined functions can be edited in all items.

2.5 Wizard rules

2.5.1 Basic features

Program module is aimed for creating and editing wizard rules. Wizard rules are important for automatic calibration procedure generation. These rules are used in module “Calibration procedure”, see chapter 2.2.2. CALIBER program involves to define more than one “Wizard rules” and to save them under their own names. When new Calibration procedure is created, you can choose according to which rules calibration points will be generated. It is very convenient to have different rules for calibration points generating for calibrating of meters and of sources.

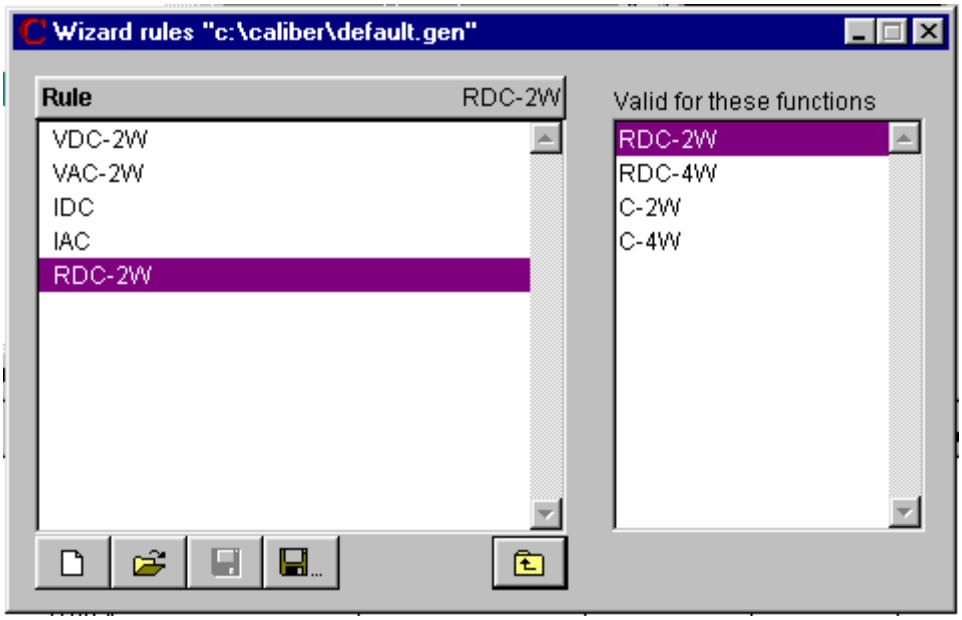
As default Wizard rules “default.gen” file is available as basic rule file for calibration points generation. File default.gen is located in current directory . /CALIBER. Default Wizard rules contains rules for following functions:

- rule VDC-2W for functions DC voltage with 2W or 4W connection
- rule VAC-2W for functions AC voltage with 2W or 4W connection
- rule IDC for functions DC current and frequency
- rule IAC for functions AC current
- rule RDC-2W for functions DC resistance with 2W and 4W connection, capacitance with 2W and 4W connection

4W means four-wire connection and for normal calibration of middle accurate meters it is used very seldom.

Note: *Calibration procedure cannot be generated without use of “Wizard rules”.*

Choose item “Wizard rules” in main menu in the top line on the screen. Following form is displayed:



Status window is displayed on the left side. In the status window structure of wizard rules is shown. Following levels are available: Rule – Scale – Range type – Value. To move among them, double click on selected line to go down, click on button “Back” to go up. In the right part, window with list of functions which the rule is valid for is displayed.

Standard functions are available in bottom line:

New – creates new file of rules..

Open – opens already created file with rules.

Save – saves edited file.

Save as – saves created/edited file with rules under new name.

Back – it is used for moving from lower level to the higher level in hierarchy procedure – function – range – point. Moving down (from higher level to lower level) can be performed with click of mouse pointer on chosen item.

Valid for these functions – list of UUT functions which the rule is valid for.

2.5.2 Calibration points generation wizard rules

Calibration points generation wizard rules are aimed for easy automatic calibration point generation during calibration procedure creating.

Status window has following structure:

Rule – name of rule is obviously the same as name of a function. One rule can be valid for more functions.

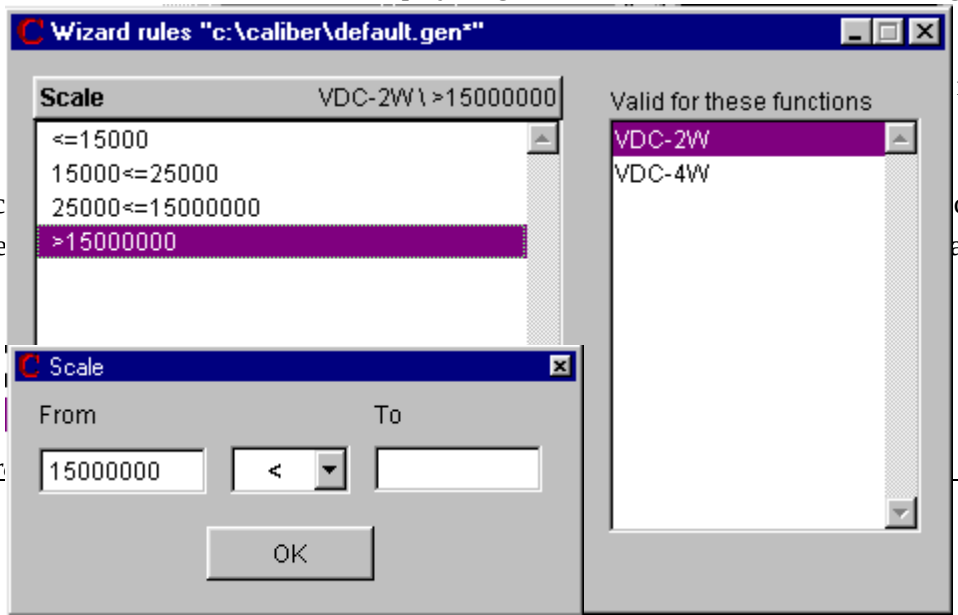
Double click on any name in "Rule" window. Scale as one step lower level of Wizard rules will appear.

Scale – describes length of the UUT scale (maximal displayed value). Instrument-sources have not normally set length of scale in Instrument card. For them length 2000 is taken into account. Any rules for "scale" can be defined for different functions.

According to the standards which are recommended for calibration procedures creating, for instrument (digital multimeter) with higher resolution is designed calibration procedure with more calibration points, see guideline EA-10/15.

In the form bellow, you can see scales for rule with name VDC-2W. This rule is valid for functions VDC-2W and VDC-4W. Following digital scales are defined:

- <= 15000, scale with display length lower than 15 000 digit (31/2 digit meters)
- 15000<=25000, scale for display length between 15 000 and 25 000 digits (41/2 digit meters)
- 25000<=15000000, scale for display length between 25 000 and 15 000 000 digits (51/2
- meters)



By c cale, any
scale ar :

Following syntax is used:

- =< means the first point of the scale is “From” (i.e. left side border point is included), the last point is “To” –1 digit (right side border point is excluded).
- <= means the first point of the scale is “From”+1 digit (i.e. left side border point is excluded), the last point is “To” (right side border point is included)
- < means the first point of the scale is “From”+1 digit (i.e. left side border point is excluded), the last point is “To” –1 digit (right side border point is excluded too).

Double click on any scale in “Scale” window. Type range as two steps lower level of Wizard rules will appear.

Range type – describes type of range from its position among all other ranges. The type of range influences number of calibration points generating by Wizard, when new calibration procedure is created.

Following types of range are available:

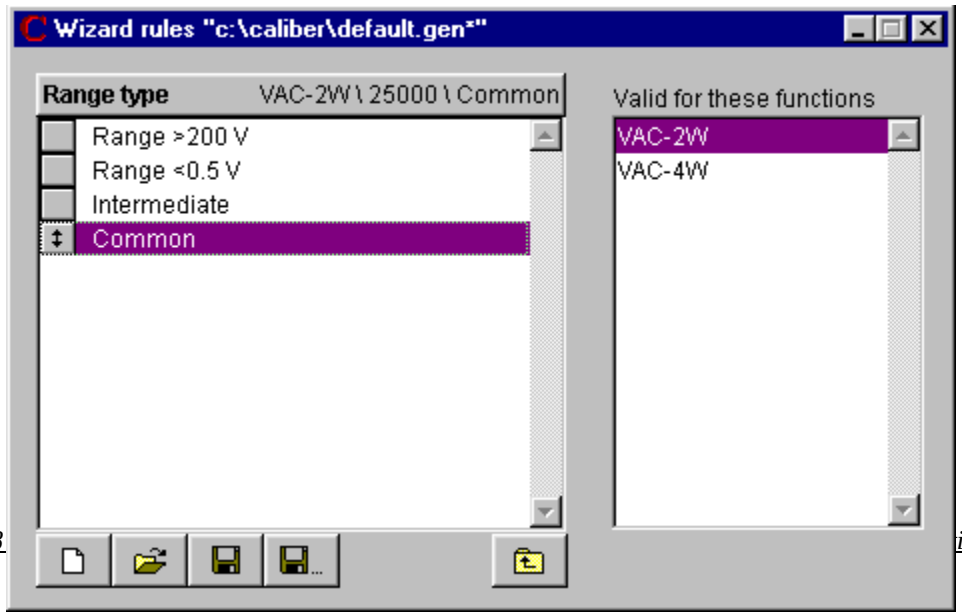
Highest – the highest range for chosen function. In multimeters mostly the highest range on VDC-2W function range 1000V is.

Lowest – the lowest range for chosen function.

Intermediate – middle and basic range of UUT (for voltage function it is usually range 20V). If number of ranges is even, as intermediate range is chosen higher of two middle ranges.

Specific – range which is determined by fix interval of calibrated value. For example “higher than 100 V” or “lower than 200 V”. Also limitation from both sides is allowed (for example 30 V to 150 V).

Common – all other ranges.



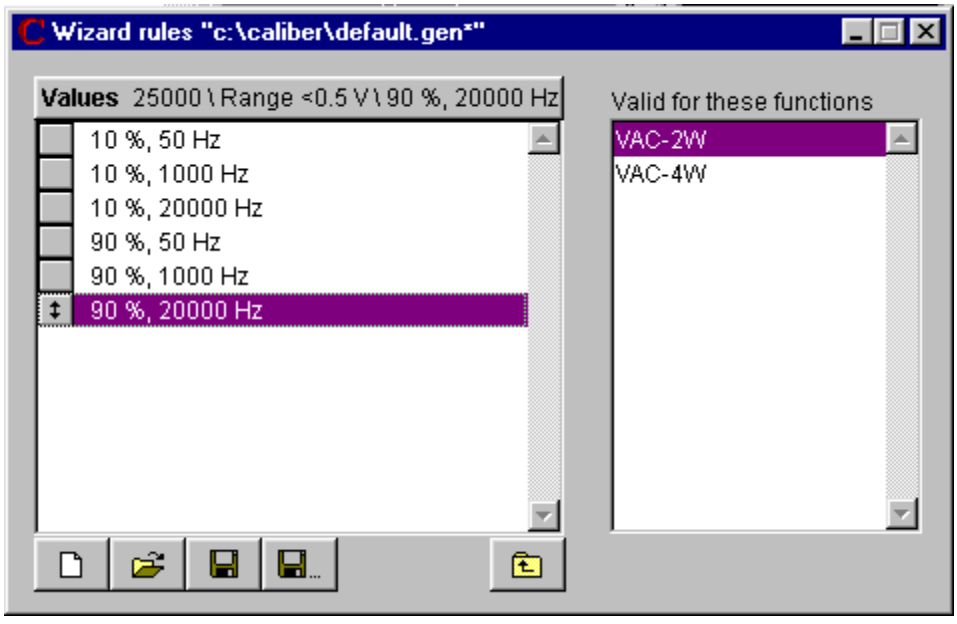
In the form above 4 Range types are defined, all for functions VAC-2W (VAC-4W) and for meter with display length up to 25 000 digits. The first two Range types are of special type, the first type will be used for ranges of UUT above 200 V, the second type will be used for ranges of UUT bellow 500 mV. The third Range type is intermediate type (usually used for calibration of the most important UUT range). The fourth Range type is common, i.e. this rule will be used for calibration points generation for common ranges, without any special feature.

During calibration procedure generation, program model “Procedures” goes step by step through all defined UUT ranges and their functions. It compares every UUT range with appropriate range in “Wizard rules” and searches, which “Range type” correspond to this range (common, intermediate, etc.). From calibration procedure generation point of view, the range if UUT is considered as “Range type” according to the “Wizard rules”. When two or more possibilities for the range are defined in Wizard rules, the “ Range type”, which is higher in order is used. If actually valid order of “type of range” for some range should be changed, you can do it very simply in “Wizard rules”, level “Range type”. Place mouse cursor on the field with double arrow, push left mouse button and move up or down.

According to the “ Range type”, appropriate calibration points are generated .

Double click on any range in “Range type” window. Value window as three steps lower level of Wizard rules will appear.

Values – defines way of creating of calibration points for each range. Calibration points are included into calibration procedure in here defined order. To change the order click with left mouse button on the field with double arrow in desired line, hold the mouse button and move it with the pointer up or down.



In the form above 6 calibration points are defined for UUT with display length to 25 000 digits for VAC-2W (VAC-4W) function and for ranges bellow 0.5 V. Calibration points will be generated for 10 % and 90 % of range on three frequencies 50, 1000, 20000 Hz.

To create, edit or delete wizard rules following tools are available:

- Rule. New rule can be created. Existing rule can be deleted. Put mouse pointer on a rule and click right mouse button. From the menu “Add rule” or “Delete” can be chosen.
- Scale. New scale can be created or existing scale can be deleted or existing scale can be changed. Put mouse pointer on a scale and click right mouse button. From the menu “Add scale…” or “Modify…” or “Delete” can be chosen.
- Range type. New range type can be created or existing range type can be deleted or existing range type can be changed. Put mouse pointer on a range type and click right mouse button. From the menu “Add range type…” or “Modify…” or “Delete” can be chosen. When one of the first two items is chosen, list of available ranges is offered.

Values. New value can be created or existing value can be deleted or existing value can be changed. Put mouse pointer on a rule and click right mouse button. From the menu “Add value…” or “Modify…” or “Delete” can be chosen. When one of the first two items is chosen, form with field “Value” is shown to type new value. In case of functions with parameter also field of this parameter is displayed (for example “Frequency” for AC ranges).

Following calibration point definitions are used in the „Default.gen“ file:

- Calibration points 10%, 50%, 90%, -10%, -90% for intermediate range and 10%, 90%, -90% for common ranges are generated when this wizard rule is used for calibration points generation for multimeters with display length up to 15000 digits.
- Calibration points 10%, 30%, 50%, 70%, 90%, -10%, -90% for intermediate range and 10%, 90%, -90% for common ranges are generated when this wizard rule is used for calibration points generation for multimeters with display length from 15000 to 25000digits.
- Calibration points 10%, 30%, 50%, 70%, 90%, -10%, -90% for intermediate range, calibration points 10%, 50%, 90%, -90% on ranges > 200V and points 10%, 90%, -90% for common ranges are generated when this wizard rule is used for calibration points generation for multimeters with display length from 25000 to 15 000000 digits.
- For multimeters with display length over 15 000000 digits on range > 200V calibration points 10%, 50%, 90%, -90% are generated, on intermediate range points 10%, 30%, 50%, 70%, 90%, -10%, -90% are generated and for common ranges points 10%, 50%, 90%, -90% are generated.

2.6 Evaluation of deviation and calibration uncertainty

2.6.1. Structure of the calibration in one point

The procedure of calibration in each calibration point consists of following steps:

a) Setting of functions and ranges of all instrument-meters, which take part in calibration procedure.

b) Setting of functions and ranges of all instrument-sources, which take part in calibration procedure.

c) Switching output terminals of instrument-source on (if it is equipped with this function).

d) Reading of standard value from SU. When instrument-source is used as SU, one reading is performed (normally it is nominal set up value). When instrument-meter is used as SU, program perform set of readings.

Note: *In case if manual control, half of repeated readings are performed from total sum in "No. of standard measurement" field set out. If number of total repeated readings is odd, half of this readings rounded up is performed.*

In case of remote control, one more reading is performed as first reading, This first reading is not used for further calculation.

e) Reading of value from UUT. When instrument-source is UUT, one reading is performed (normally it is set nominal value). When instrument-meter is UUT, program performs a set of readings.

Note: *In case if manual control whole set of repeated readings is performed. Number of readings is taken from "No. of UUT measurement" field.*

In case of remote control, one more reading is performed as first reading, This first reading is not used for further calculation.

f) Set of new readings from SU is performed, when instrument-meter is used as SU.

Note: *For all ways of control, half of repeated readings are performed from total sum in "No. of standard measurement" field set out. If number of total repeated readings is odd, half of this readings rounded down is performed.*

g) Program calculates average value, root mean square value, calibration uncertainty, etc. Program compares evaluated values with criteria for course error. If course error seems to arise during calibration, procedure according to the items a) to d) is repeated.

h) Switching off the output terminals of instrument-source (if it is equipped with this function).

If during calibration course error is identified (measured deviation to nominal value is five times greater than allowed deviation of UUT), program is either interrupted or continue in

calibration process. Program will be interrupted, if the item “Stop on” – “Deviation error” is ticked, see chapter 2.2.1. Repeating of calibration in this point is offered. If item “Stop on” – “Deviation error” is not ticked, program will ignore course error and continue to the next calibration point.

2.6.2. Evaluation of deviations

Structure of deviation calculation is fixed in program and it cannot be changed. Evaluated deviation represents absolute deviation, when function of UUT, with - in Users function absolute evaluation definition - is calibrated. Evaluated deviation represents relative deviation, when function of UUT, with - in Users function relative evaluation definition - is calibrated.

Calibration points with value less than 1 % of range, with absolute evaluation, are the only exceptions. Here deviations are related to the range of UUT (row in test report is characterised with symbol “R” in test report).

2.6.2.1. Maximal allowed deviation of UUT

One of the firsts steps of calibration evaluating is calculation of maximal allowed deviation of UUT. This value is calculated from data, which describe accuracy of UUT. Program takes this data from UUT Instrument card. Method of maximal allowed deviation calculation depends on definition of measuring function. According to basic sorting of functions, following cases can appear:

- ***Allowed deviation of UUT for absolutely defined function with absolute evaluation*** is determine for each range and function according to the following formula:

  $$t_M = \text{¡Error!} * |X| + \text{¡Error!¡Error!} * MHR + \text{¡Error!} L_3 + diga * L_4$$

  Typical example is function of temperature in simple multimeter. This function is defined as absolute. Calculation of UUT deviation in any calibration point is required in ^{o}C, i.e. evaluation in absolute terms must be done usually.

- ***Allowed deviation for relatively defined functions with absolute evaluation*** is determine for each range and function with following formula:

  $$t_M = \text{¡Error!} * |X| + \text{¡Error!¡Error!} * MHR + \text{¡Error!} L_3 + \text{¡Error!} * L_4$$

  An example is function of DC voltage in a multimeter. This function is defined as relative. Calculation of UUT deviation in any calibration point is required in absolute units, i.e. in V (or mV, uV).

- ***Allowed deviation for relatively defined functions with relative evaluation*** is determine for each range and function with following formula:

  $$t_M = L_1 + \text{¡Error!} * L_2 + \text{¡Error!} * L_3 + \text{¡Error!} * L_4 \quad [\%]$$

or for calibration point under 0.01*MHR (1% of UUT measuring range)

$$t_M = \text{¡Error!} * L_1 + L_2 + \text{¡Error!} * L_3 + \text{¡Error!} * L_4 \quad [\%]$$

An example is function of DC voltage in a multimeter. This function is defined as relative. Calculation of UUT deviation in any calibration point is required in relative units, i.e. in %.

Symbols in above formulas have following meaning:

L_1 - accuracy of value (see operation manual of UUT) [%]

L_2 - accuracy of range (see operation manual of UUT) [%]

L_3 - absolute accuracy in units of the function (see operation manual of UUT)

L4 - absolute accuracy in digits (see operation manual of UUT)

X - value indicated by UUT in calibration point

E - standard value (value of SU)

digr - number of UUT digits, in fact UUT resolution (see operation manual of UUT)

diga - resolution of one UUT digit in terms of measuring value units (see operation manual of UUT)

MHR – maximal value of UUT range in terms of measuring value units (see operation manual of UUT)

2.6.2.2. UUT deviation

UUT deviation for function with absolute evaluation is calculated from the following formula :

$$d = X - E$$

For calibrated instrument-source, UUT measured value (X) is equal to the, on the instrument set value. For calibrated instrument-meter, UUT measured value (X) is calculated as average from i readings

$$X = \text{¡Error!}$$

Number of readings is defined in “No. of UUT measurement” field, see chapter 2.2.1.

UUT deviation for function with relative evaluation is calculated from the formula:

$$d = (\text{¡Error!} - 1) * 100 \quad [\%]$$

or for calibration point under 0.01*MHR (1% of UUT measuring range)

$$d = (\text{¡Error!}) * 100 \quad [\%]$$

Course error identification is done according to the relation:

$$|a_i - X| > 2.5 * z_{ai}$$

where z is root mean square

$$z_{ai} = \text{¡Error!}$$

If above described relation is fulfilled for any single reading ai (i.e. course error occurs), calibration procedure is repeated in this calibration point. If the set of values doesn't meet criteria for course error excluding for third time, the last readings are used, but remark „~" not stable on the end of appropriate row in the test report is written.

2.6.2.3. Standard value

Standard value (E) is equal to the set value for standard instrument-source. Standard value **(E)** is equal to the average value calculated from j readings for standard instrument-meter.

$$E = \text{¡Error!}$$

Number of readings is defined in "No. of Standard measurement" field.

Course error identification is done according to the relation:

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

where z is root mean square

$$z_{aj} = \text{¡Error!}$$

If above described relation is fulfilled for any single reading aj (i.e. course error occurs), calibration procedure is repeated in this calibration point. If the set of values doesn't meet criteria for course error excluding for third time, the last readings are used, but remark „~" not stable on the end of appropriate row in the test report is written.

2.6.3. Calibration uncertainty

Calibration uncertainty calculation is determined according to the standard EA-4/02. Structure of calibration uncertainty evaluation cannot be changed but values of some partial uncertainties can be modified by user according to the real uncertainties in measuring circuit. In compare with rules described in above mentioned guideline, CALIBER method of calibration uncertainty evaluation enables to modify way of calibration. For example, it allows to calibrate UUT in one calibration point without necessity to perform repeated readings. If this parameter is set to 1 or 2, uncertainty of type A should be inserted manually – if it is

known (see chapter 2.2.1) If more than 3 repeated readings are set, uncertainty of type A is automatically calculated.

The most used number of repeated measurements is 10 readings. CALIBER calculates appropriate root mean square (u_a) and average values also for lower or higher numbers of repeated readings. If number of repeated readings is not equal to 10, uncertainty of type A is evaluated for this number of readings, according to bellow set out formulas. This values are used in basic formula for combined standard uncertainty u_c without any other coefficients.

Relative uncertainty related to the measured value (i.e. UUT indicated value) is calculated for functions with relative defined accuracy. Absolute uncertainty related to the measured value (i.e. UUT indicated value) is calculated for functions with absolute defined accuracy. Calibration points with value less than 1 % of range are the only exceptions. Here deviations are related to the range of UUT (line is characterised by symbol "R" in test report).

When calculated UUT deviation lays inside interval "UUT accuracy +/- calibration uncertainty", appropriate line is characterised with symbol „?" in test report. It means that you cannot judge if the UUT is OK in calibration point or not.

In module Procedures character „?" can be changed with any other one. To change it run program module Procedures and load the calibration procedure where change is to be perform. Click with right mouse button on the row with name of calibration procedure. Choose from menu item "Global settings" and in the form change the character in field Failed in band.

2.6.3.1. Calibration uncertainty for functions with absolute evaluation

Standard distributed uncertainty is calculated for every calibration point. Both uncertainty and all its components are expressed in measured value units.

$$\mathbf{U = k_u * u_c}$$

where

$\mathbf{k_u}$ - extension coefficient. It is determined in calibration procedure, (normally k_u=2).

$\mathbf{u_c}$ - combined standard uncertainty. It is calculated from the formula

$$\mathbf{u_c = \sqrt{u_a^2 + u_b^2 + u_d^2 + u_{de}^2 + u_e^2 + u_m^2 + u_r^2 + u_p^2}}$$

$\mathbf{u_a}$ - additional uncertainty of type A. Its value can be set up individually depending on sources of A uncertainty in calibration circuit. Normally is used value 0.0.

$\mathbf{u_b}$ - additional uncertainty of type B. Its value can be set up individually depending on sources of A uncertainty in calibration circuit. Normally is used value 0.0

Note: *Coefficient $\boldsymbol{k_u}$ and uncertainties $\boldsymbol{u_a}$, $\boldsymbol{u_b}$ can be set on level of function, range or calibration point. To change it, run program module Procedures and load the*

calibration procedure where change is to be perform. Click with right mouse button on the row with name of calibration procedure. Choose from the menu item "Uncertainty…" and in the form change appropriate value.

u_d - uncertainty due to the limited resolution of UUT (when UUT is source u_d equals 0)

u_d = 0.29 * diga

diga - least digit resolution of UUT in terms of measured value unit

u_{de} - least digit resolution of SU in terms of measured value unit (when SU is source u_{de} equals 0)

u_{de} = 0.29 * digea

digea - resolution of SU one digit in terms of measured value

u_e - uncertainty due to the uncertainty of standard unit

u_e = ¡Error!

d_{max} - accuracy of standard value in calibration point in terms of measured value unit

u_m - uncertainty type A, determined from i repeated measurements a_i of UUT (for i >= 3)

u_m = ¡Error!

X = ¡Error!

u_r - uncertainty type A, determined from j repeated measurements a_j of SU (for j >= 3)

u_r = ¡Error! [%]

E = ¡Error!

u_p - uncertainty coursed of accuracy of standard value converter (if used)

u_p = ¡Error!

d_{pmax} - converter accuracy in calibration point in terms of measured value unit

2.6.3.1. Calibration uncertainty for functions with relative evaluation

Standard distributed uncertainty is calculated for every calibration point. Both uncertainty and all its components are expressed in %.

$U = k_u * u_c$ [%]

where

k_u - extension coefficient. It is determined in calibration procedure, (normally k_u=2).

u_c [%] - combined standard uncertainty, evaluated from the formula

$$u_c = \sqrt{u_a^2 + u_b^2 + u_d^2 + u_{de}^2 + u_e^2 + u_m^2 + u_r^2 + u_p^2} \quad [\%]$$

u_a [%] - uncertainty of type A. Its value can individually set up by user depending on sources of A uncertainty in calibration circuit. Normally is used value 0.0

u_b [%] - uncertainty of type B. Its value can individually set up by user depending on sources of A uncertainty in calibration circuit. Normally is used value 0.0

u_d [%] - uncertainty due to the limited resolution of UUT (when UUT is source u_d equels 0)

$$u_d = 0.29 * \text{¡Error!} * 100 \quad [\%]$$

or for calibration point bellow than 0.01*MHR:

$$u_d = \text{¡Error!} * 100 \quad [\%]$$

MHR - maximal value of UUT range
E - reading of SU
digr - number of UUT digits. It is taken from Instrument card.

u_{de} [%] - uncertainty due to the limited resolution of SU

$$u_{de} = 0.29 * \text{¡Error!} * 100 \quad [\%]$$

or for calibration point bellow than 0.01*MHR:

$$u_{de} = \text{¡Error!} * 100 \quad [\%]$$

MHRe - maximal value of SU range
E - reading of SU
diger - number of SU digits. Information is taken from Instrument card of the instrument.

u_e [%] - uncertainty due to the SU accuracy

$$u_e = \text{¡Error!} * \text{¡Error!} \ [\%]$$

or for calibration point bellow than 0.01*MHR:

$$u_e = \text{¡Error!} * \text{¡Error!} \ [\%]$$

d_{max} - SU accuracy in calibration point
E - SU reading
MHR - maximal value of UUT range

u_m [%] - uncertainty of type A evaluated from i readings ai of UUT (for i >= 3)

$$u_m = \text{¡Error!} * 100\ [\%]$$

or for calibration point bellow than 0.01*MHR:

$$u_m = \text{¡Error!} * 100\ [\%]$$

$$X = \text{¡Error!}$$

E - SU reading

u_r [%] - uncertainty type A evaluated from j readings aj of SU (for j >= 3)

$$u_r = \text{¡Error!} * 100\ [\%]$$

or for calibration point bellow than 0.01*MHR:

$$u_r = \text{¡Error!} * 100\ [\%]$$

$$E = \text{¡Error!}$$

u_p [%] - uncertainty due to the accuracy of converter (if used)

$$u_p = \text{¡Error!} * \text{¡Error!}\ [\%]$$

or for calibration point bellow than 0.01*MHR:

$$u_p = \text{¡Error!} * \text{¡Error!}\ [\%]$$

d_{pmax} - converter accuracy in calibration point in terms of measured value unit

E - SU reading

MHR - maximal value of UUT range

2.7 Test report

Result of calibration procedure is test report. It contains main information and calculated values for each calibration point. Structure of test report form including headline is fixed and cannot be edited. In each line calibration uncertainty and summary result is appended. Normally, major part of calibration uncertainty creates uncertainty of SU (standard value uncertainty = master unit uncertainty). Exact procedure of uncertainty evaluation was described in chapter 2.6. On the end of each row in test report following characters can appear:

* - means that UUT measured deviation is greater than UUT allowed deviation.

~ - means that measured value is not stable (see chapter 2.6)

R - all deviations are related to the range

? - calculated deviation lays inside interval “UUT accuracy +/- calibration uncertainty”. It means it cannot be judged if the UUT is OK in calibration point or not.

In module Procedures characters „?“ and “*” can be changed with any other one. To change it run program module Procedures and load the calibration procedure where change is to be perform. Click with right mouse button on the row with name of calibration procedure. Choose from menu item “Global settings” and in the form change the character in field “Failed in band” or in field “Failed”.

ok - UUT is in calibration point OK

Example of test report:

Function	Range	Standard	UUT	Deviation	%spe	Allowed	Uncertainty
VDC-2W	300 mV	30.00 mV	30.01 mV	12.6 uV	38	33.0 uV	6.0 uV ok
VDC-2W	300 mV	270.00 mV	269.97 mV	-26.0 uV	-46	57.0 uV	7.3 uV ok
VDC-2W	300 mV	-30.00 mV	-29.99 mV	12.6 uV	38	33.0 uV	5.9 uV ok
VDC-2W	3 V	-2.7000 V	-2.7000 V	-0.013 mV	-2	0.570 mV	0.069 mV ok
VAC-2W	20 V	10.0001 V; 1 kHz	10.0000 V	-0.1 mV	-3	3.5 mV	1.2 mV ok
VAC-2W	20 V	18.999 V; 50 kHz	19.000 V	1 mV	5	16 mV	12 mV ok
RDC-2W	100 Ohm	10.00020 Ohm	10.00000 Ohm	-0.20 mOhm	-2	13.00 mOhm	0.27 mOhm ok
C-2W	10 nF	10.0200 nF	10.0000 nF	-20.0 pF	-36	55.0 pF	5.7 pF ok
IDC	200 mA	100.0024 mA	100.0000 mA	-2.4 uA	-15	16.0 uA	9.3 uA ok
IAC	200 mA	100.031 mA; 120 Hz	100.000 mA	-31 uA	-52	60 uA	21 uA ok
IAC	200 mA	190.056 mA; 120 Hz	190.000 mA	-56 uA	-54	105 uA	46 uA ok
IAC	200 mA	190.056 mA; 1 kHz	190.000 mA	-56 uA	-53	105 uA	97 uA ?

Meanings of titles are as follows:

Function calibrated function (VDC-2W, VAC-2W, IDC, ...).

Range calibrated range of UUT. When range is over 1000 or bellow 1, prefix is added.

Standard calibration point (its standard value) with next parameter (if used). Units with prefix are determined according to the calibrated range. When range of auxiliary parameter is over 1000 or bellow 1, prefix is added. Number of printed places is limited through calibration uncertainty. For example if

uncertainty is presented with resolution 10 mV, also standard value is printed either with the same resolution or with resolution of UUT display, what is lower.

UUT UUT reading (average value if repeated readings are set). Units with appropriate prefixes are determined according to the calibrated range. Number of printed places is limited through calibration uncertainty. For example if uncertainty is presented with resolution 10 mV, also standard value is printed either with the same resolution or with resolution of UUT display, what is lower.

Deviation UUT deviation (see chapter 2.5). Number of printed places is determined by calibration uncertainty. If evaluation in absolute form is set, units are one prefix less (if measured value is in V, deviation is in mV).

% spe gathered percent of specification (Deviation / Allowed * 100 %). Value is displayed with 1 % resolution. Maximum value is 999 %.

Allowed maximal UUT allowed deviation. Number of printed places is determined by calibration uncertainty. If evaluation in absolute form is set, units are one prefix less (if measured value is in V, deviation is in mV).

Uncertainty extended standard deviation for extended coefficient ku = xxx (see chapter 2.5). Number of printed places is two. If evaluation in absolute form is set, units are one prefix less (if measured value is in V, deviation is in mV).

2.8 Test procedure

Test procedure “TEST” is a part of software. The procedure allows to check correct function of all important program modules of CALIBER. To the tested functions belong correct evaluation of deviations, calibration uncertainty, form of calibration procedure, etc. Test procedure is virtual type and it doesn’t require any instrument.

To use Test procedure follow the instructions:

1. Find program module “Procedures” and import from directory ../CALIBER calibration procedure “Test. pro”. Push the button “Start calibration”. Follow messages of the test procedure. When procedure requires a reading, write values in the table bellow, according to the function.:

Function, calibration point	**Set value**
V-DC, 10.0 V	**10.01**
A-AC, 1.0 A	**0.98**
O-2W, 100 Ω	**100.0**

Test procedure run automatically. Result of the test procedure is test report with following contain:

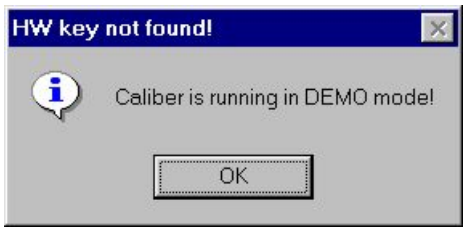
```
Funkction|  Range |            Standard|           UUT|   Deviation|%spe|    Allowed| Uncertainty
-------------------------------------------------------------------------------------------------
 VDC-2W  |    20 V|            10.000 V|      10.010 V|       10 mV|  50|      20 mV|       12 mV ?
    IAC  |     2 A|     1.0000 A; 60 Hz|      0.9800 A|    -20.0 mA|-999|     2.0 mA|      1.2 mA *
 RDC-2W  | 200 Ohm|          100.00 Ohm|    100.00 Ohm|      0 mOhm|   0|   200 mOhm|   127 mOhm ok

    * ... fail
    ? ... deviation in interval allowed deviation ± calibration uncertainty
```

Compare generated test report with above shown example. Contain of both test should be the same. If required, reports of test procedures can be saved.

2.9 DEMO version

DEMO version is automatically started, if no hardlock was found on PC parallel port.



DEMO version is fully working, except saving and printing of test report.

2.10 Launching CALIBER from WinQbase

In chapters 2.1. to 2.9. you could find description of program CALIBER, when it is used as alone standing program.

CALIBER can be easily used with database system WinQbase as well. When it is used together with WinQbase, there are some differences in handling, especially when CALIBER is started and ended.

Creating of Calibration procedure

To create new procedure, select in WinQbase main menu item “Calibration procedures”, continue with “+” button (it means add new procedure) and from next menu select “Generator”. Procedure wizard in CALIBER is started. Go through all five steps and finish new procedure. Close CALIBER, use “cross” button. When CALIBER is closed, in the form “Procedures” you can see new procedure in text form. You can add a comment and you must enter name of the procedure before saving. After pushing the button with icon “Diskette”, new procedure is saved in database of procedures under previously typed name.

Creating of Instrument card, User’s function and Wizard rules

To create new records of Instrument card, Users function and Wizard rules follow similar procedure. Select in WinQbase main menu item “Calibration procedures”, continue with “+” button (it means add new procedure) and from next menu select “Generator”. Procedure wizard in CALIBER is started. Cancel it with button “Cancel”. Now you are in basic CALIBER mode. You can select any of items from CALIBER main menu. including Instrument card, Users function and Wizard rules.

Execution of calibration

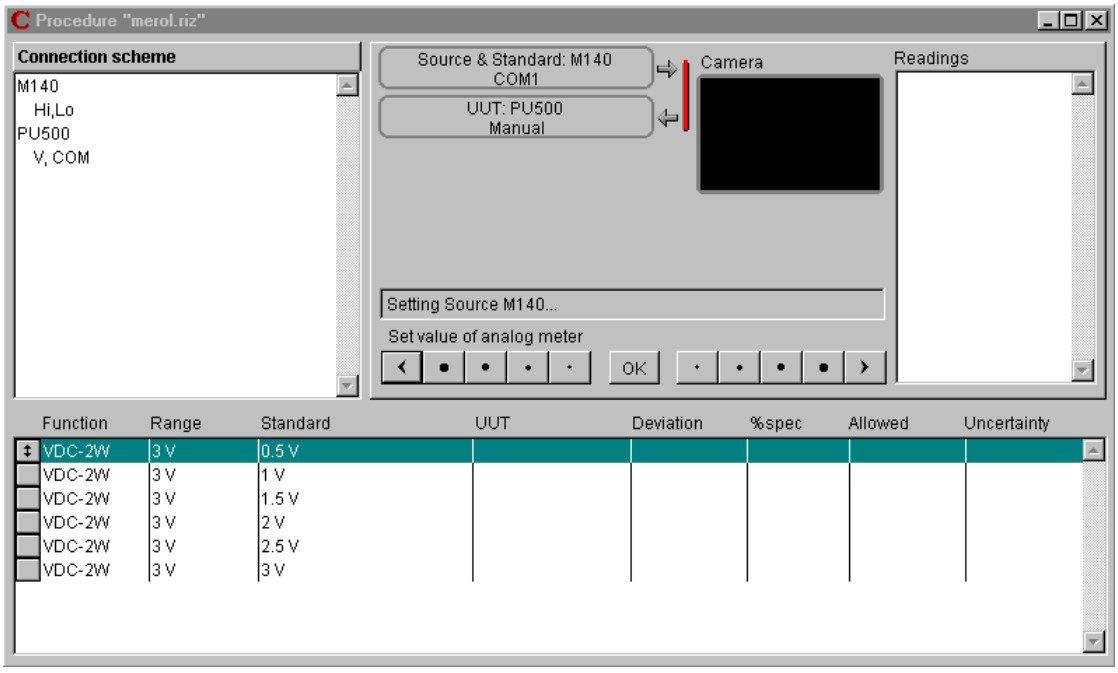
CALIBER program is automatically launched, when calibration procedure and method of calibration certificate creation are selected. Panel with “Procedures” is opened and calibration procedure is loaded. According to features of CALIBER, you can move with starting point down and up or start calibration. You can change some parameters of calibration, but after changing you cannot save modified procedure. Also any other calibration procedure is not allowed to open here.

The name of loaded procedure is always “Merol.riz”. It has only symbolic meaning. It cannot be changed.

2.11 Analogue meters

Starting with Release 1.11 program Caliber can be used for analogue meters calibration. For this type of calibration standard source of appropriate electric quantity with sufficient resolution to reach fluently calibration point on the analogue meter under test is requested. E.g. analogue ohmmeter cannot be calibrated with fix resistance standards, but with resistance decade only.

During calibration procedure program involves to set fluently level of output signal on standard unit to reach exactly calibration point on meter under test (analogue meter pointer covers exactly pre-defined calibration point). Course and fine setting of output signal level can be performed with eleven program buttons in central window. Five buttons leftside allow to decrease output value, the same buttons rightside can increase output value. Individual buttons in the groups have different sensitivity. The highest step have outer buttons, the finest resolution have inner buttons. Ratio of sensitivity of two beside placing buttons is 1 to 4. Clicking on the appropriate button can be reach exactly desired value of output signal for the calibration point.



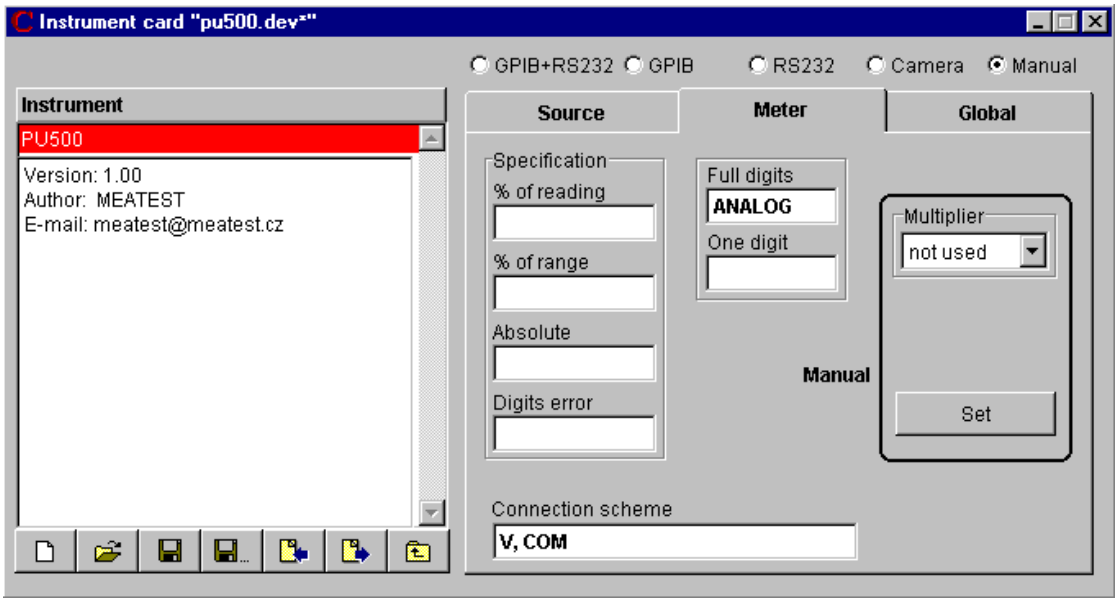
After final setting, validity of actual value must be confirmed by pressing the button OK. On standard unit set value is used for evaluating of deviation of meter under test.

New part of uncertainty of type A is added into calculation of **calibration uncertainty** (see chapter 2.6), which is coursed of uncertainty due to the limited resolution of reading on analogue meter. This part of calibration uncertainty is determined automatically as 10 % from analogue meter accuracy in the calibration point. If another way of uncertainty of type A creating or its modifying is requested, it can be done directly in calibration procedure, see chapter 2.2.1.

Calibration points for analogue meters have to be designed individually, according to the model of meter under test, its scale length, resolution, linearity, etc. It is recommended to

use only those calibration points, which correspond on meter under test scale numerical labels to. After new calibration procedure automatic creation in program module “Procedure” all nominal values should be manually checked and modified if necessary.

When new **instrument card** for analogue meter is created, fix text “ANALOG” must be entered in folder “Meter” in field “Full digits”. This value identifies, that new meter is an



analogue meter and above described method of standard output signal setting will be used in all calibration points.

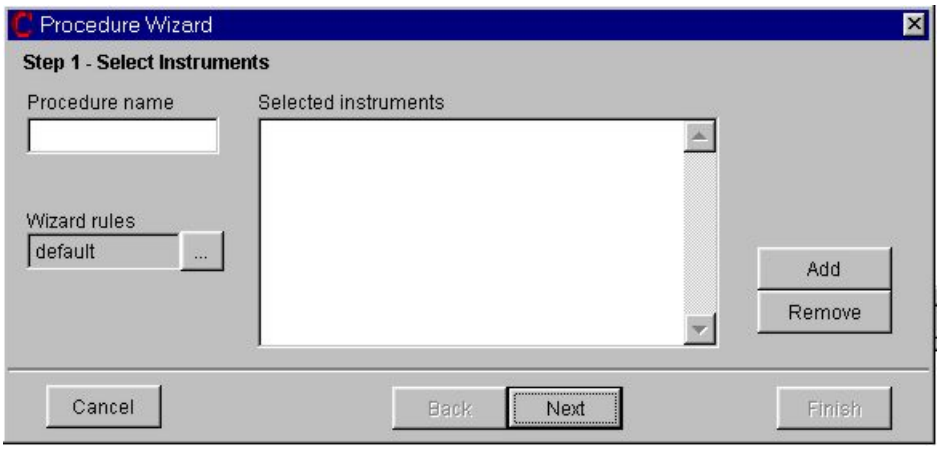
3. Examples

3.1 Calibration procedure creating

Create new calibration procedure for calibration of 31/2 digit hand-held multimeter model Metex 3800. Use manual calibration without camera module. Use M-140 calibrator as standard.

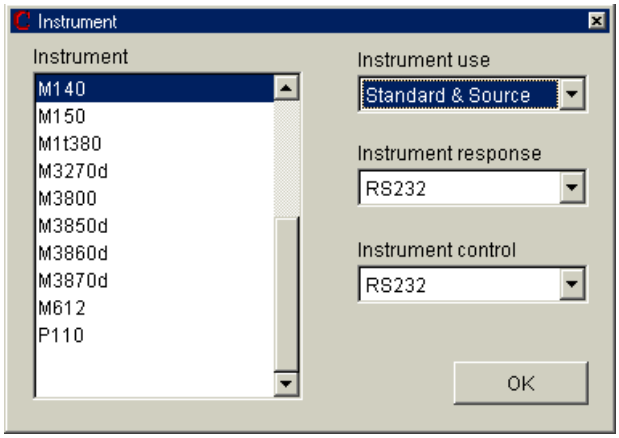
Procedure

- Run program CALIBER, choose program module „Procedures“. In bottom line click on icon “New”. Wizard for calibration procedure creating is run.



Step 1 – Select instrument

- Write name of new calibration procedure to the field “Procedure name”, for example M3800x.
- Choose Wizard rules for automatic creating of calibration points. Use Default.gen file, if no other has been created.
- Choose instruments which will take part in calibration. Push the button “Add”. List of existing Instrument cards is displayed.



- Choose M3800 as calibrated instrument from the list. Define its position. Click on Instrument use and choose item UUT (M3800 is unit under test). Click on "Instrument response" and choose Manual (it means, readings will be manually written through keyboard. Click on "Instrument control" and select Manual (UUT is not equipped with remote control).
- Choose M140 as standard instrument from the list. Define its position. Click on Instrument use and choose item Standard&Source.

  Note: M140 is here source of quantity – voltage, current, resistance, capacitance, frequency. M140 is here standard instrument too. It is source of standard value. Its output value is considered as "true" value.

  Click on "Instrument response" and select GPIB (if GPIB bus is used for communication with PC) or RS-232 (if RS-232 is used for communication with PC). Click on "Instrument control" and select the same interface.
- Click on Next. Window for function selection will appear.

Step 2 – Select functions

- In the right field "Selected functions" list of all functions of UUT is displayed. Types of functions are determined by Instrument card of UUT (M3800). Number of functions which are to be calibrated can be decreased, but not increased. To remove a function from the list of Selected functions mark appropriate function and use buttons in the middle to remove it. Removed function is displayed in left field "Available functions".
- Click on Next. Window for ranges selection will appear.

Step 3 – Select ranges

Wizard will display in the field "Function" the first function (VDC-2W, it means DC voltage with two-wire connection). In the field "Selected ranges" all available ranges for function DCV-2W are displayed. If you want, you can all ranges leave as "Selected ranges" (i.e. UUT will be calibrated in all shown ranges) or remove any one or more ranges. Use middle buttons again. Types of ranges are defined in Instrument card and cannot be changed here. Type of ranges are determined according to the Instrument card and used Wizard rules.

Note: range signed with red star is in Instrument card defined as intermediate range.

- Go through all functions and set ranges, where calibration is to be done.
- Click on Next. Window for calibration points selection will appear.

Step 4 – Select values

- Wizard automatically generates calibration points for all functions and all ranges. List of created calibration points is shown in window "selected values".

- Any value can be removed or added. Mark selected value and use buttons “Remove” or “Add” perform operation.
- Click on Next. Window for inapplicable points will appear.

Step 5 – Confirm inapplicable values

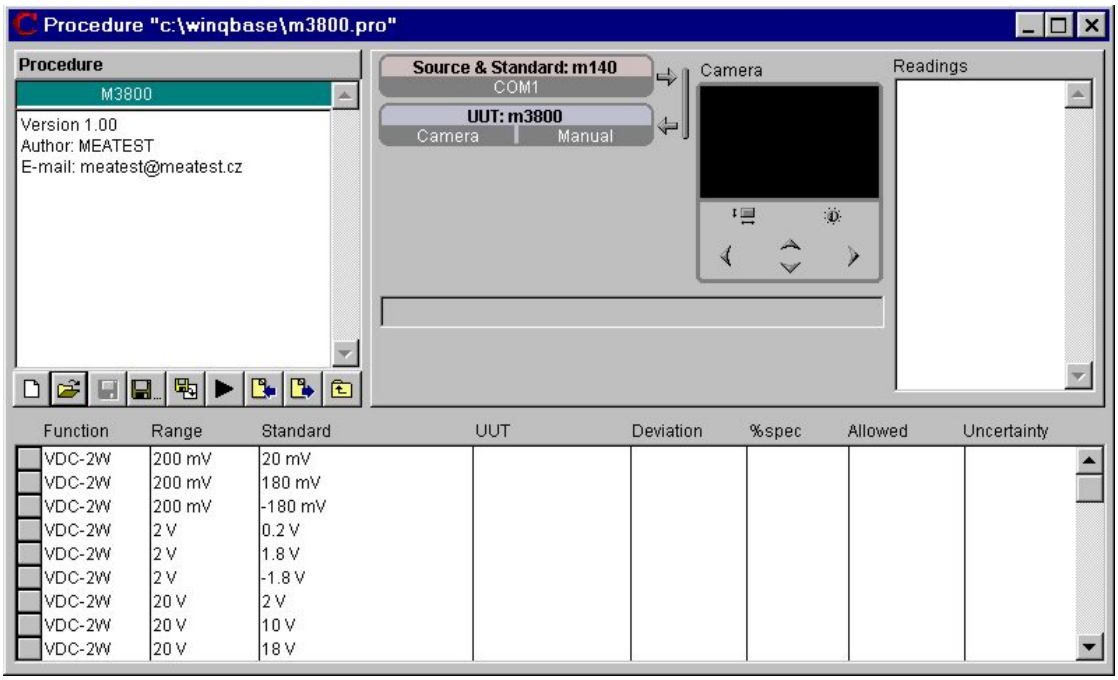
- In the form list of non-correct calibration points is displayed. Non-correct calibration point is point, which is out of range of SU.
- If the list is not empty, use button “Back” to go one step back. In form “Select values” non-correct values can be removed or changed.
- Click of “Finish” button to finish calibration procedure.
- Form of Calibration procedure is displayed with loaded newly created calibration procedure. Save it by pushing the button with icon “Save” or “Save as”.

3.2 Calibration of UUT

Calibrate hand-held multimeter model METEX 3800. Use calibration procedure M3800 with M-140 calibrator as standard.

Procedure

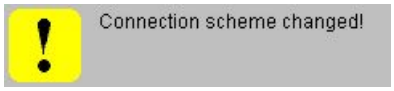
- Run program CALIBER, select program module “Procedures“.
- Push the button with icon “Open” and select calibration procedure M3800.pro.



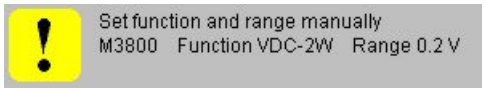
- Connect instruments displayed in the window of active instruments. On the picture above, M-140 calibrator have to be connected to PC over RS-232 line on port COM1. Display of UUT can be scanned via camera module or reading can be typed manually through PC keyboard.
- If camera module is not used for UUT display scanning, configuration of UUT have to be appropriately set. To do it push the right mouse button while the mouse pointer is on blue field with label UUT:M3800. Menu will appear.
- Select “Configure instrument” and change the item in the field “Instrument response” to Manual. Confirm OK.
- In the main window list of all calibration points in calibration procedure M3800 is displayed. You can start with calibration. Select calibration point which calibration should start from (normally it is the first point in the list, any one can be selected). Push the button with icon “Start” (blue arrow).

Note: also here you can still change order of calibration points. Simply put mouse pointer on the small field with double arrow left side in line which order you want to change. Move with it. Order of selected point is changed.

- Calibration is starting.
- The first program displays message about output/input terminals connection and opens communication on interface bus.



- Calibration is performed automatically “point by point”
- Always when change of terminal connection is required, message is displayed on the screen. Program waits for confirmation.



Note: If camera module is not used for scanning, manual set of UUT readings through keyboard must be performed.

Normally for full automated calibration, repeated (multiple) measurement of ten readings is pre-set. Number of repeated readings can be changed. To change it stop calibration with button ESC. In status window select level for which the change is requested. If you chose level Function, the change will be further valid for whole function. If you chose level Range (Value), the change will be valid for selected range (calibration point) only. Push right mouse button while its pointer is located in status window on line with requested function (range, value). Menu will appear. Select item “Uncertainty” and change value in the field “No of UUT measurements”.

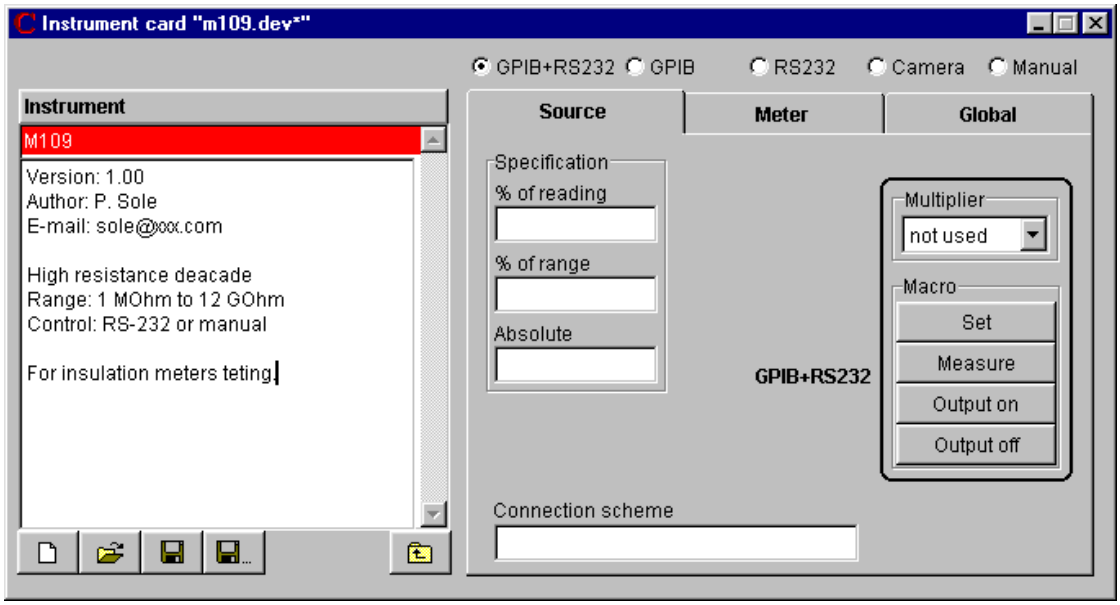
- Calibration procedure can be terminated anywhere. Use the button ESC on the keyboard. To go on, push the button “Start” on the screen.
- Calibration can be terminated and run again from any calibration point. If a calibration point was already checked and new calibration in this point is started again, old values are overwritten with recent ones.
- When program CALIBER is used with database WinQbase, test report is after finishing automatically saved in database of calibrations. If program CALIBER is used alone, test report must be manually saved. Use button with icon “Export” to save it. If test report is not exported and saved, it is deleted after exiting the program.

3.3 Instrument card of resistance decade M-109

Create Instrument card for M-109 High resistance decade.

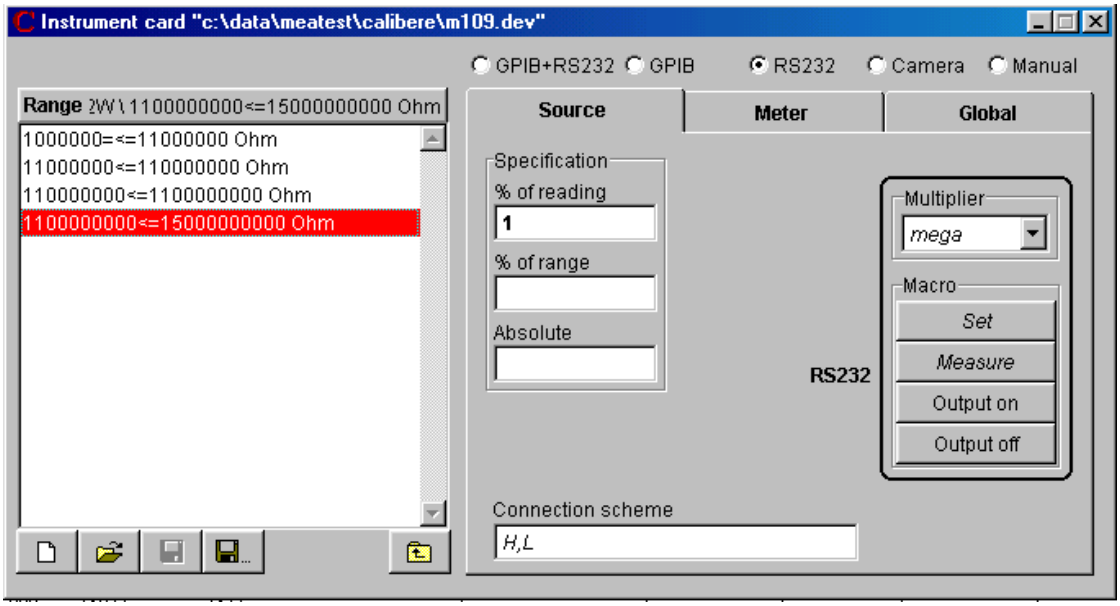
Procedure

- Run program CALIBER, find program module “Instrument card” and start it.
- Push the button with icon “New”. Type name of instrument card into the field, for example M109 and confirm by ENTER. In status window of new Instrument card identification is displayed.



- Add name of author. If you want any remarks can be written here (see figure above).
- Set mouse pointer on the red strip with instrument name and click twice. Window for definition of function will appear.
- Click with right mouse button and select “Add function” from the menu. Select RDC-2W function for M-109 decade (two-wire DC resistance). Name of function is written into Function window.
- Click twice on the name of function. Window for range creating is displayed.
- Click with right mouse button and select “Add range”. Type all ranges of the instrument into the field. In case of M-109 decade following ranges should be set:
  1 MOhm =<= 10 MOhm
  10 MOhm <= 100 MOhm
  100 MOhm <= 1 GOhm
  1 GOhm <= 12 GOhm

- Type ranges step by step, fill in the field with accuracy (% reading, % range, absolute). On each range select also prefix “Multiplier”, which is to be used (for example for range 1 MOhm to 10 MOhm set prefix “mega”, for range 1 GOhm to 12 GOhm set prefix “giga”.



It is not necessary to set the prefix, but it will make easier to enter requested values of the decade (in MOhm and GOhm, not in Ohm).

Note: ranges are not allowed to be over each other. Each value set on the instrument must belong to one range only. Notice relation operators between end points of each range in the window “Range”.

- Use “back” button to return to the first level in Instrument card. Add symbols for terminal connection (H,L is suitable, for example).

Basic parameters (functions, ranges, accuracy) are included into the Instrument card now. Still method of control or scanning must be defined in the card.

- Because M-109 is equipped with RS-232 interface, set the switch of way of control to the position RS-232. If Instrument card for only manually controlled decade is created, switch way of control to “Manual”.

Decade with RS-232 control

- All next setting have to be performed in the highest level, i.e. level “Instrument” (see status window left side. It means that all setting is valid for the instrument on all ranges, all points.
- Set multiplier to mega. This prefix (MOhm) uses M-109 decade for communication on RS-232.
- Create Macro “Set”. This is macro for remote setting of value on the decade.

Macro consists of:

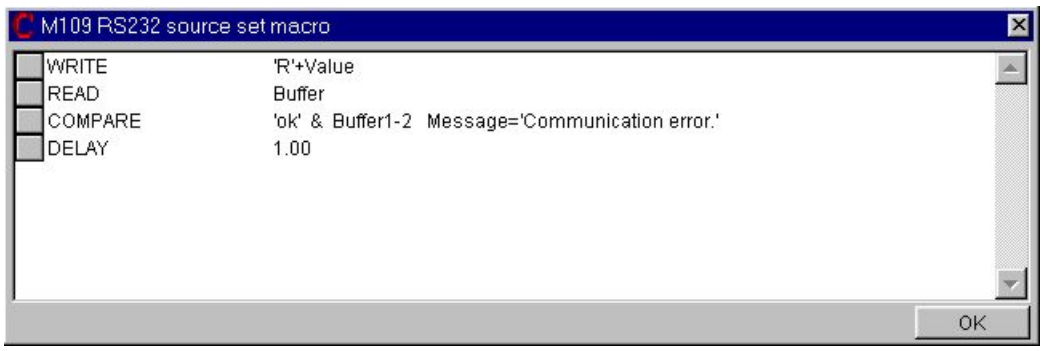
a. WRITE command for setting value. As parameter of the command set “R+xxx”, where xxx is new value (for example R500 means 500 MOhm. This information can be found in operation manual of M-109 decade.

b. READ command to read response from decade. Use standard variable Buffer for caching the response.

c. COMPARE two commands/words/strings. It compares, if response from decade equals to “ok”. In operation manual of M-109 decade can be find, that “ok” is symbol which instrument sends to PC after receiving query and after executing the command.

d. DELAY command, for waiting 1 s after overswitching the decade. Parameter is 1.00

In fact, macro sets new value on the decade and checks if decade understands the



command immediately. After overswitching, program is waiting for 1 s to stabilise output signal, before it goes on. If decade doesn’t understand the commands, error message “Communication error” is displayed on the screen.

- Set Macro “Measure”. This is macro for query, what value is actually set on decade. Macro consists of:

a. WRITE command for sending query to the decade. Form of command is letter “V” (see operation manual of M-109 decade).

b. READ command for caching the response from the decade. Parameter is variable “Value”. In this variable actually value set on decade is

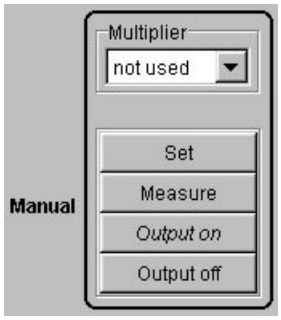
saved.

- Macro “Output on” and “Output off” are not necessary to create. M-109 is not source of active electric quantity like voltage, current, etc.

Decade with manual control

If decade is not equipped with remote control, switch should be switched to the position “Manual” in top level (i.e. Instrument status panel is displayed left side).

- All next setting have to be performed in the highest level, i.e. level “Instrument” (see status window left side. It means that all setting is valid for the instrument on all ranges, all points.
- Set Multiplier to “mega”. It is not necessary in manual operation. But if you set this prefix, you will enter value in Mohm instead of Ohm



- Activate function “Set”. Leave setting “Auto”. It means, that during calibration, when new calibration point is to be set on decade, message “Set new value on the instrument” is displayed on the screen. You have to switch decade over manually. Here also delay period between new setting and going calibration procedure on can be set (field “Delay”).
- Activate function “Measure”. Set item “Nominal value”. It means, that nominal value is considered as “true” (standard) value in calibration process.
- Function “Output on” and “Output off” to “None”. There is no reason to control in a special way switching output on and off.
- Save new instrument card. Use screen button “Save” or “Save as”.

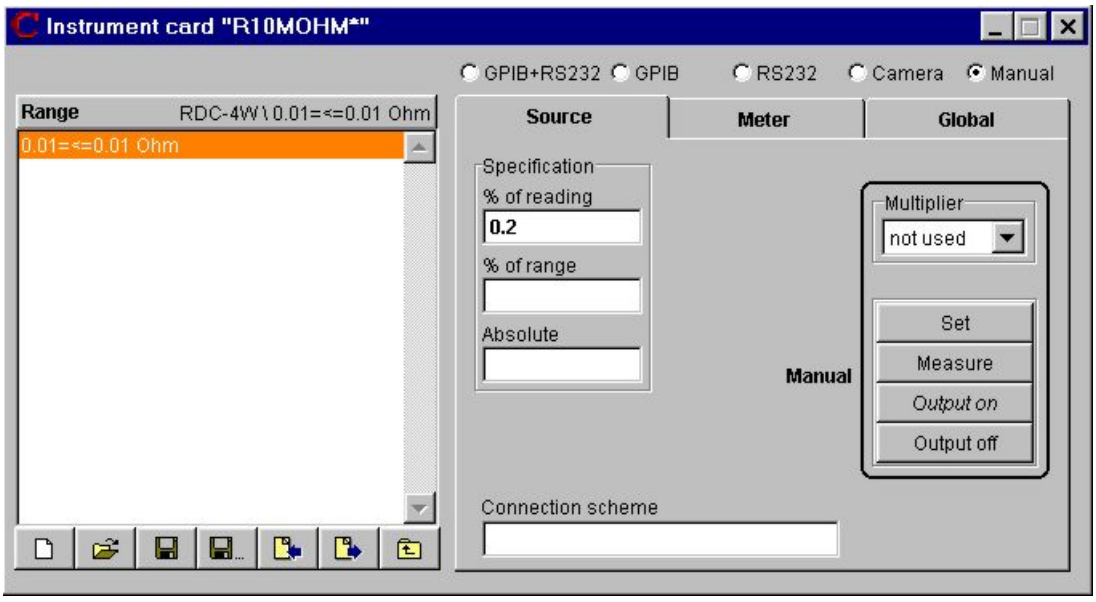
3.4 Instrument card of resistance shunt 10 mΩ

Create Instrument card resistance shunt 10 mOhm.

Note: this simple resistance standard be used in two ways. Either it is used as standard of low resistance for UUT low resistance range, or it is used as converter current/voltage for high currents measuring (for example 100 A). In this case converter constant is 0.01 Ohm. Both features can be described in its Instrument card.

Procedure

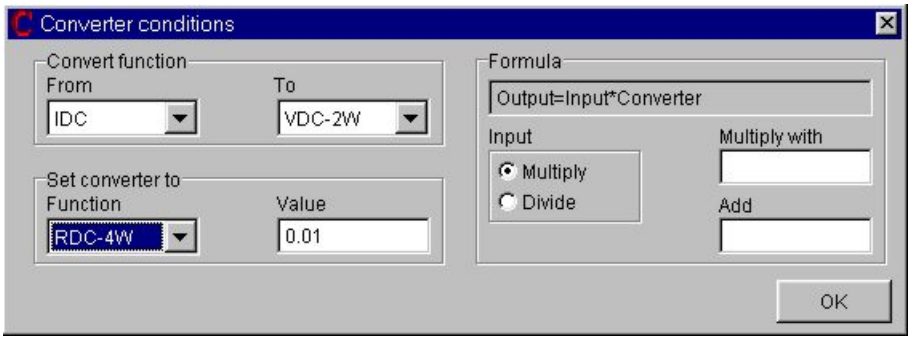
- Run program CALIBER, find program module “Instrument card” and start it. Push the button with icon “New”. Type name of instrument card into the field, for example R10mOhm. Add a comment into the status field.
- Click with right mouse button and select “Add function” from the menu. Select RDC-4W (four-wire source of resistance) or RDC-2W (two-wire source of resistance). If AC parameters of resistance decade are known too, it can be used for AC resistance ranges of UUTs. Add in this case RAC-4W or RAC-2W.
- Click twice on the name of the first function. Window for range creating is displayed.
- Click with right mouse button and select “Add range”. Type values 0.01 =<= 0.01 into the field. It means that the range of the resistance shunt is only one value, i.e. 10 mOhm.
- If RAC-2W or RAC-4W function was selected too, place mouse pointer on line of range (value) and double click. Status window for setting frequency range will appear. Use right mouse button, select “Add frequency” and specify frequency range for AC resistance shunt calibration (for example 20 Hz to 120 Hz).



- Set accuracy of the resistance shunt. If both RAC and RDC functions are pre-set, set accuracy for both functions.
- Set type of terminals in the highest level to the field “Connection scheme” (for example Hi, Hu, Lu, Li.
- Set switch for method of control to the position “Manual”.
- Set function “Set” to “None” (no special message is need).
- Set function “Measure” to “Fixed value” and write calibration value of resistance shunt into the field “Fixed value” and confirm OK.
- Functions “Output on” and “Output off” leave in position “None”.

Now Instrument card related to the resistance shunt 10 mOhm as source of “true” value for calibrating of UUT resistance ranges is ready. Still features of resistance shunt as converter for high current measuring should be included into the card to be able to use it for high current ranges calibration of UUT.

- Activate folder “Global”. In right part window for converter specification is displayed.
- Push right mouse button while mouse pointer is in window “Converter conditions”. From menu select “Add…”
- Window for converter conditions will appear. Set function which is converted from into field “From” (i.e. IDC or IAC, shunt converts current going through it to the voltage). Set function which is converted to into the field “To” (VDC-2W).



- Select item RDC-4W for field “Set converter to” from the list of functions. This is shunt´s own function (4W resistance)
- Type nominal value 0.01 Ohm of the shunt to the field “Value”.
- Set switch “Input” to the position “Multiply”. In the field “Formula”, formula for calculating of output value of converter is displayed. In the figure above is “Output=Input*Converter”. It means, that output value equals input value times value in field “Converter. This explanation is not quite accurate. In fact, instead of nominal value program takes calibration data of the resistance shut. Calibration data are part of Instrument card.

4. Terminology

In the chapter special metrological terminology in the operation manual used is explained.

Caliber – SW program system aimed for calibration of measuring instruments. It consists of several program modules. The result of CALIBER is "Test report" when used alone or "Calibration certificate" when used with database WinQbase. A part of test report (Calibration certificate) are UUT deviations and calibration uncertainty. All instruments can be controlled either manually or remotely.

Test report – it is result of UUT calibration. Test reports is created by CALIBER program after calibration automatically. Test report has form of table with fix number of columns with fix predefined meaning. Each calibration point presents one row. Among columns belongs: calibrated function, calibrated range, calibration point, reading of UUT, deviation of UUT, gathering % of UUT deviation, allowed UUT deviation, calibration uncertainty.

Calibration certificate – it is result of UUT calibration. Calibration certificate is created by WinQbase program after calibration automatically. Calibration certificate consists of several pages. The first page contains information about calibration laboratory, UUT, conditions of calibration, etc. A part of the first page picture can be too (for example logo of calibration laboratory). The second page contains text part of calibration. This page can be left out. As next pages Test report is appended. Test report is generated by CALIBER program after calibration. It will be automatically transferred into WinQbase database, if CALIBER is launched from WinQbase.

Standard – (SU – Standard Unit) standard instrument which is source of "true" (standard) value of a quantity. SU can be either source or meter.

UUT (Unit Under Test) – instrument to be calibrated. Both source and meter can create UUT.

GPIB – (General-Purpose Interface Bus) is standardised parallel interface bus for remote control of measuring devices. It enables to remote control up to 16 instruments connected to the GPIB bus. Instruments must be defined on different addresses. To use GPIB interface with program CALIBER, GPIB card must be installed in PC.

RS-232 – serial standardised interface. It enables remote control of those instruments. Only one instrument can be connected to each serial port in PC.

Function – function of UUT or SU. Function can be either real function of instrument (AC voltage, DC current, Capacitance, Frequency, etc.) or virtual transfer function of converter (transfer two-wire connection to four-wire connection). As a part of installation file "Default.fce" of type Users function is available.
In CALIBER program, there is basic sorting of measuring functions between absolute and relative functions. For absolute functions, resolution of one digit and BMC parameter are entered in absolute units (^{o}C, etc.). For relative functions, length of display, i.e. number of

digits like 2000, 4000, etc. is expressed in digits (without decimal point). BMC parameter for relative functions must be entered in "%".
Independently on kind of function (absolute or relative as above described), absolute or relative expression of deviations, calibration uncertainties, etc. can be set. For relative functions (like voltage) you can set both absolute and relative expression of results. When absolute expression is selected, calculated values will be expressed in V (mV, uV). When relative expression is selected, calculated values will be expressed in "%". For absolute functions (like temperature) evaluation in absolute units is allowed only (deviation and calibration uncertainty cannot be expressed in "%", but in ^{o}C only).

Program module – it is any of items from Window menu in basic form in CALIBER. Four program module are available: Procedures, Instrument cards, User functions, Wizard rules.

Calibration procedure – file where exact calibration procedure for calibration of known UUT with known SU is described. In the file, types of instruments and calibration points are recorded. Calibration procedures files are located in current directory ../CALIBER. Its extension is always *.pro. For export and import of calibration procedures form the database another format *.pre is used. For creating and editing of calibration procedures, program module "Procedures" is aimed. Without existing and correct Calibration procedure, calibration cannot be performed.

Instrument card – files contain description of all features of an instrument UUT and SU. Metrology specification-accuracy, functions, ranges, output/input terminals connection and method of control/scanning (GPIB, RS-232, camera, manual) as well are saved here. Without existing and correct Instrument cards of all instruments which takes part in a calibration procedure, calibration cannot be performed. For creating and editing of Instrument cards, program module "Instrument card" is aimed.

Module „User functions" – program module for creating and editing of measuring functions of the instruments. As a part of installation file "Default.fce" of type Users function is available.

Module „Wizard rules" – program module for creating and editing rules for automatic calibration points generating. Rules are saved in the file with extension *.gen in current directory ../CALIBER. As a part of installation file "Default.gen" of type Wizard rules is available.

Parameter of calibration point – it describes next (minor) value of a calibration point. Typical example is calibration of AC ranges, where main value is voltage/current and frequency have to be specified as parameter. Other example is calibration of frequency ranges, where main value is frequency and its parameter is amplitude of output voltage.

WinQbase – database software MEATEST. It is aimed for managing inventory of instruments, generating calibration certificates and others. In software hierarchy here described WinQbase is on the top level. When calibration is to be perform in database WinQbase, program CALIBER is called.