1 SAFETY PRECAUTIONS

- Carefully read these operating instructions before operating this instrument. This is necessary to avoid damage to it, as well as for user-safety.
- Check that your mains supply voltage corresponds to that given on the type plate fixed to the instrument.
- Install the instrument so that the on/off switch and the mains connecting plug are easily accessible.
- Do not cover the ventilation slots.
- Take care that no liquids or objects enter in through the ventilation slots.
- Only use the instrument in dry rooms in which there is no risk of explosion.
- Do not start up this instrument should there be visible signs of damage to it or to the line cord.
- Only use the instrument for the purpose for which it was designed.

2 PURPOSE AND CHARACTERISTICS

The Multichannel analyser (see Fig.1), named MCA in the following, is part of an instrumental system for the generation of energy spectra of radioactive substances. This instrumental system has been specifically designed to meet demonstration and practical work requirements in the teaching of Natural Science (see Fig. 2).

The MCA classifies incoming voltage pulses according to pulse height. The connection between the pulse height and the energy of the radiation quantum is effected by the particular input amplifier and detector used.

The MCA assigns a value interval to the pulse height of a channel. The channel content of a given channel corresponds to the number of voltage signals recorded whose pulse height lies within the value interval. The recording of one further voltage pulse whose pulse height lies within the considered value interval therefore increases the channel content by 1. The spectra result from the plotting of channel contents against the channels. The MCA allows voltage pulses with pulse heights from 0 to 4 V to be processed.

The MCA is controlled by a connected computer and the Phywe Systeme GmbH "MCA module" MEASURE software (14452.61).

Alongside the function of multichannel analysis, the MCA also makes operating and bias voltages available to the input amplifier connected ahead. The operating and bias voltages can be taken or set directly at the instrument.
Fig. 2: Diagram of the experimental set-up.

Fig. 3: Logic structure of the Multichannel analyser.
3 FUNCTIONAL AND OPERATING ELEMENTS

The instrument is enclosed in a shock-resistant plastic housing. A holding grip is fixed to the sides of the housing which can be folded down and so serve to hold the instrument at an inclined position. Four rubber feet ensure non-slippage and stability. The instrument can be stacked on other instruments having the same type of housing, whereby the rubber feet fit in corresponding hollows in the lower housing as a further guard against slippage.

Connections, operating elements; detailed information

Gamma-Detector
Connection via BNC cable from the signal output of gamma detector 09101.00 to input (1) of the MCA. (The gamma detector is separately supplied with high-voltage from the operating unit 09101.93). The MCA input also accepts pulses from other gamma detectors commonly used in nuclear physics. Calibration is slightly dependent on the length of the signal cable.

Alpha-Detector
Connection via BNC cable from the output of the $\alpha$ - input amplifier 09100.10 to input (1) of the MCA. The ±12 V operating voltage for input amplifier 09100.10 can be taken from the 5-pole socket (4) with the help of connecting cable (supplied with 09100.10); a smoothed 12 V voltage is then fed to the $\alpha$-detector from the input amplifier. When the $\alpha$-detector is to be used with higher voltages (for full utilization of the resolving power), then a negative bias voltage, selected from -33 V, -66 V and -99 V, can be taken from the BNC socket (5) and be led to the $\alpha$-detector, also via the $\alpha$-input amplifier. Rotary switch (6) serves to switch between the choice of bias voltages.

Oscilloscope
Connect the analog output (2) of the MCA to the oscilloscope input with a BNC cable.

Oscilloscope settings:
- Triggering on positive pulse
- Amplitude range 0.1 to 10 volts
- Time-base deflection 10 to 100 µs/cm

With the help of the oscilloscope, the individual voltage pulses of the measurement signal can be analysed according to pulse shaping and amplification and be optimized if appropriate.

Coincidence conditions
The feed of TTL signals into the Disable socket (see 3) allows coincidence conditions to be set. With the Multichannel analyser under coincidence conditions, only those voltage pulses of the measurement signal are taken into account with which a TTL signal high (momentary direct voltage of value between 2 and 5 V) simultaneously lies on the Disable socket. When the Disable socket is open, all voltage pulses of the measurement signal are classified by the Multichannel analyser.

Computer
Two interfaces are available for the connection of a measuring computer to the MCA. A USB cable can be connected to the MCA at the USB interface (7) and an RS 232 cable 14602.00 at the serial interface (8).

Function and operating elements on the front (see Fig. 1)

1 Input
BNC Socket at which the measurement signal from the input amplifier, or direct from a detector, is fed into the measuring instrument.

2 Output
BNC Socket from which the analog measurement signal is taken, after pulse shaping and amplification, and can be fed into a further measuring instrument (e.g. an oscilloscope).

3 Disable
BNC Socket at which TTL pulses can be fed in. Coincidence conditions are set on the feeding in of TTL pulses.

4 Socket +/- 12 V
5-Pole socket for the supply voltage of input amplifier 09100.10, or for 12 V operating voltage for an $\alpha$-detector (optionally positive or negative). An appropriate cable is provided with 09100.10.

5 Bias
BNC Socket which supplies the bias voltage for a detector. The bias voltage can be switched between -33 V, -66 V and -99 V (see 6) and can be fed in via input amplifier 09100.10.

6 Switch
Switch for switching over between -33 V, -66 V and -99 V (see 5).

7 USB
USB Interface for connection of a computer.

8 RS 232
RS 232 Interface for connection of a computer.

9 Power
Green light-emitting diode that shows the operating mode of the MCA (on/off).
4 HANDLING
When the MCA is connected to the detector on one side and to a measuring computer on the other, spectra of radioactive substances can be recorded. For this, first call the MEASURE measurement programme from the measuring computer. Under the Measuring instruments menu choice, call the Multichannel analyser module. Following the call, a menu window (see Fig. 4) opens with the following menu options:

- Spectra recording
- Single channel analyser
- Integration measurement
- Settings and Calibration

These menu options are described in the following:

**Multichannel Analyser**

![Multichannel Analyser](image)

**Please select the measurement mode**

- Spectra recording
- Single channel analyser
- Integration measurement
- Settings and Calibration

**Description**

Allows to record spectra using the multichannel mode. The recorded spectra can then be transferred to the measure software for post processing.

**Fig. 4: Surface of the MEASURE Multichannel analyser module**

**Spectra recording**

Calling the Spectra recording menu choice opens the appropriate surface for the control of the MCA and the recording and presentation of spectra. The Spectra recording menu choice has the following control functions for the MCA and data acquisition:

**Control**

The Start/Stop button allows the recording of a spectrum to be started or stopped. After stopping, the spectra continues to be displayed. By again starting, the new measurement signals are added to the spectrum that already exists. The Reset button under the Start/Stop button serves to erase a spectrum. The Reset function can be utilized both during the recording of a spectrum and also at the end of data acquisition.

**MCA Settings**

The Gain button serves for adjustment of the amplification of the main amplifier in the MCA. Three amplification stages are available. These amplification stages correspond to gain factors of roughly 6, 12 and 24. At a higher amplification factor, the (physically) same line lies at higher channel numbers ("further right") in the spectrum than at lower ones. To be able to set a suitable amplification factor, this can be changed during a measurement. In this case, the spectrum remains gray and as a background spectrum before the amplification factor is changed. The signal recorded after the amplification factor is changed generates a new spectrum. This spectrum is red and in front of the background of the spectrum that was recorded with the original amplification factor. This method of presentation makes the influence of the change in the amplification factor immediately visible.

The Offset button serves for the suppression of noise. Noise leads to non-physical (not caused by the sample but by the electronics) counting rates or channel contents at small channel numbers. The percentage value of the Offset relates to 4 V (100% corresponds to 4 V). A voltage corresponding to the percentage Offset is subtracted (after pulse shaping and amplification in the pulse height analyser) from the incoming measurement signal. Signals whose maximum value is negative after subtraction of the Offset are no longer taken into account in the multichannel analysis and, therefore, do not contribute to the spectrum.

Offset can also be used to have a wanted section of a spectrum represented, as the signals are sorted into lower channels corresponding to the subtracted voltage values. In combination with the settings of the amplification, the 4,000 channels that are available enable an optimal display of the relevant section of the spectrum.

Offset can also be changed within a measurement. The spectrum generated after changing Offset is presented in red. The spectrum recorded before the change in Offset remains is still to be seen, gray and in the background.

As the subtraction of a voltage value also changes the position of the lines in a spectrum, energy calibration of the spectrum can only be carried out at a fixed offset. Should the Offset or the amplification factor be changed following an energy calibration, then the energy calibration is no longer usable.

**Histogram**

With the help of the x-Data record button, the presentation of the channel contents can be selectively made according to channel number or (should an energy calibration have been carried out) according to the energy. The Interval width button allows the summation of the channel contents of neighbouring channels. The sum is then assigned to all channels whose channel content was summed up.

**Accept data**

The accept data button enables a measured spectrum to be taken over by the MEASURE programme from the Multichannel analyser module. The measured spectrum can then be worked on or analysed by use of functions of the MEASURE programme. The Multichannel analyser software module is automatically closed in this process and the user is returned to the MEASURE programme. The Multichannel analyser module can be recalled from the MEASURE programme, however, complete with the last used settings (in particular, the energy calibration). The button marked with a red point on the MEASURE surface (upper left) serves for the recalling.
momentarily observed section of the spectrum. The section of the spectrum, i.e. the selected range of the x-axis, remains hereby unchanged. On selection of manual scaling, a window opens in which the user can enter the lower and upper limits of the wanted section on the x-axis and y-axis. The marking of appropriate segments can also be made with the button and the mouse (see above). The button can be used to position one or two vertical marking lines in the spectrum. The marking lines can be shifted to any required position of the displayed section of the spectrum with the mouse. The channel number gives the position of a marked line. When two marked lines are in the spectrum, then the corresponding difference in the two channel numbers is additionally given. After having been shifted, the marking lines can be brought back to their initial position with the Reset option.

The total number of the pulses recorded in the actual measurement, the pulse rate per second and the calibration used are shown below the spectrum.

Fig. 5: Surface of the menu option Spectra recording
**Single channel analyser**

On selection of the *Single channel analyser* menu choice, the function of the Multichannel analyser is limited to that of a single channel analyser. In single channel analysis, the spectrum is measured stepwise. At each step, a certain energy interval or, should energy calibration not have been carried out, a certain channel interval is observed. The interval or window is determined by its upper and lower limits, whereby the distance between the limits is the same for all intervals. During a step, the MCA records the number of signal pulses whose energy or height lies within the observed interval and a certain time period. The number obtained is the interval content. When a step has been finished, the upper and lower limits of the intervals are each shifted by the same step width, i.e. a certain energy difference or number of channels, to the right. This gives the interval that belongs to the next step. In the first step, the energy zero point or the first channel coincides with the lower limit of the interval.

For the presentation of the spectrum, the channel contents are formed by summation via interval contents. In the summation, an interval content only contributes to a channel content when the channel in question lies in the interval associated with the interval content. This approach allows the selection of an interval width which is both larger and smaller than the step width. In the first case the interval can overlap, i.e. the same channel belongs to different intervals. In the second case, there are channels to which no interval has been assigned and that therefore do not contribute to the analysis. It is recommended to select equal interval widths and step widths, as then not only is an overlap of the interval prevented but also all channels are considered in the analysis.

The following operating elements for the MCA are given under the *Single channel analyser* menu option.

**Window width**
The entry in the *window width* panel determines the interval width.

**Step width**
The entry in the *step width* panel determines the step width.

**Recording time**
The entry in the *recording time* panel determines the time period for the determination of the interval content.

**Start/Stop**
Single channel analysis is started or stopped by means of the *Start/Stop* button.

**Accept data / Cancel**
The functions of the *Accept data* button and the *Cancel* button have already been described above under *Spectra recording*.

The buttons that lie beneath the area for presenting spectra are described under *Spectra recording*.

The total number of pulses for the actual measurement, the number of pulses in the actual channel, the remaining time of measurement, the actual pulse rate per second, the actual recording time and the detector calibration are given below the spectrum.

![Fig. 6: Surface of the menu option Single channel analyser](image-url)
Integration measurement

An integration measurement can be considered to be a manually controlled single channel analysis. A single integration measurement corresponds to one stage of a single channel analysis. The parameters for the integration measurement are in each case to be determined by the user. This allows the number of pulses whose energy or pulse height lies within a certain interval to be determined by the MCA. The measurement interval, or window, is fixed by the entries for the upper and lower limits. In addition, the period over which recorded pulses are to be measured is to be fixed. An integration measurement can be repeatedly carried out for different parametrizations of the window and the time of measurement. The results of the different integration measurements are displayed in a graph of the consecutive numbers of the integration measurements. In addition, a Table of the data is prepared.

The Integration measurement menu prompt presents the following operating elements for the MCA (see Fig. 7):

Control

Selection of Reduce window allows the manual determination of the upper and lower limits of the interval, as well as the measurement time. When Reduce window is not selected, then the MCA records all pulses measured between the start and end of measurement, which are to be manually entered.

The entries in the Lower limit/Upper limit panel determine the upper/lower limits of the interval. The measurement time is determined by the entry in the Recording time panel.

The Measure (Cancel measurement) buttons serve to start or stop an integration measurement. A measurement can be manually stopped before the measurement time has elapsed, even when a measurement time has been set. Measurement automatically stops when the set measurement time has elapsed.

Operation of the Delete data button causes erasure of the actual and all previous integration measurements.

MCA Settings

The MCA Settings panel is described above under Spectra recording.

x-Data

The x-Data record panel allows the free indexing of the individual integration measurements. The entry in the Title panel determines the description of the integration measurement. The default description is “number”. A Symbol can be determined by entry in the Symbol panel. The default entry is the running number of the integration measurement. The unit for the dimension can be entered in the Unit panel.

Accept data / Cancel

The Accept data and Cancel panels are described under Spectra recording.

The panels below the graphical presentation are described in the description of the Record spectra menu choice.

The total number of pulses recorded, the number of pulses from the actual integration measurement, the actual pulse rate per second, the remaining time of measurement for the actual integration measurement and detector calibration are shown under the graphical presentation.

Fig. 7: Surface of the menu option Integration measurement
Settings and Calibration

The Settings and Calibration menu window enables the user to carry out a two or three point calibration between channels and energy.

On being called, the Settings window first opens. It is divided into two areas, Detector calibration and Device information (see Fig. 8).

In the Detector calibration area, selection can first be made in the Detector/Calibration areas between User calibration and calibrations that have already been filed. The User calibration option leads to the carrying out of a new calibration. Filed calibrations are shown in the selection area under the name that was used to store them.

Parameter assignments of the actual calibration are shown below the selection area. Information on the calibration selected is given in the Comment panel, should this to be stored with the calibration. The Mode panel informs if the selected calibration is a two point or three point calibration. The Gain panel shows the amplification setting and the offset with which the selected calibration is to be carried out. Finally, in the Equation panel, the equation used for the calibration is shown. The parameters of the equation can also be read off there.

The Calibrate, Save and Delete buttons following the panels that show the parameter assignment of the actual calibration. On selection of the Calibrate button, the calibration window opens (see above) and a new calibration can be carried out. The Save button allows storage of the actual calibration and its parameters. A window opens for this in which the user can enter the name for the calibration and remarks on it. The Delete button allows already stored calibrations to be erased. It is therefore only active when an already filed calibration has been selected with the Detector/Calibration selection face.

The Instrument information face serves to balance the MCA and is only to be used after consultation with Phywe Systeme GmbH & Co. KG.

The Close button in the Settings window lies outside of the Detector calibration and Device information faces. On operating this button, the actual calibration is acquired and the user returns to the start window of the Multichannel analyser MEASURE module. Should now one of the other three menu options be called, then the calibration is acquired for these menu options.

As described above, the Calibration window is reached by operating the Calibration button in the Settings window. The surface of the Calibration window is constructed similarly to the window of the Spectra recording menu option (see Fig. 9).

The MCA Settings face has the same function as is under the Record spectra menu option. The description of this face is therefore given in the description of the Spectra recording menu option.

The Calibration face serves for the assignment of parameters to the calibration. With the Mode selection surface, a choice can be made between two or three point calibration. The setting of the unit (keV or MeV) that is related to the calibration is made with the Unit selection face. With input, an input face with a two-column Table structure is screened. For a two point calibration the Table has two columns and for a three point calibration three. Channel numbers are given in the column on the right and the corresponding energy values in the column on the left. On the one hand, a manual input of the channel numbers and the corresponding energy values in the Table is possible, on the other hand the cursor can be used to enter the channel numbers. For this, marking lines in the spectrum are shifted with the cursor on the lines to known transitions in the spectrum. The channel number of the marking line is then automatically read in in the Table. Each line of the Table represents a marking line. The marking lines are assigned to the lines in the Table with the help of different colours.

Finally, the depicted spectrum can be erased with the Clear Diagram button.

Still further buttons are to be found in the Calibration window, the Apply and Cancel buttons. When Apply is selected the Calibration window is closed and the parameters of the calibration that was carried out are acquired. The user is returned to the Settings window when the Calibration window is closed.

On operating the Cancel button the Calibration window is closed without acquirement of the parameters. The user is again returned to the Settings window.

The buttons beneath the spectrum are explained in the description of the Spectra recording menu item.
Fig. 8: Surface settings for menu option Settings and calibration

Fig. 9: Surface calibration for menu option Settings and calibration
5 NOTES ON OPERATION
This high-quality instrument fulfills all of the technical requirements that are compiled in current EC guidelines. The characteristics of this product qualify it for the CE mark.
This instrument is only to be put into operation under specialist supervision in a controlled electromagnetic environment in research, educational and training facilities (schools, universities, institutes and laboratories).
This means that in such an environment, no mobile phones etc. are to be used in the immediate vicinity. The individual connecting leads are each not to be longer than 2 m.

The instrument can be so influenced by electrostatic charges and other electromagnetic phenomena that it no longer functions within the given technical specifications. The following measures reduce or do away with disturbances:
- Avoid fitted carpets; ensure potential equalization; carry out experiments on a conductive, earthed surface, use screened cables, do not operate high-frequency emitters (radios, mobile phones) in the immediate vicinity. After a total blackout, carry out a “Reset” (new start) of the complete system.

This instrument corresponds to Class A, Group 1 of the EN 55011 Standard and can only be operated without limitation outside of residential areas. Should electromagnetic disturbances occur in surrounding residential areas although operation is limited to the technical room of a school or other training facility, then it can be demanded of the operator that he carries out adequate measures (e.g. screening, greater distance, reduction in the operating time) at his own cost.

6 LIST OF EQUIPMENT
For use in connection with the MCA:
- Alpha-Detector 09100.00
- Pre-amplifier for Alpha-detector 09100.10
- Gamma-Detector 09101.00
- Operating unit f. Gamma detector 09101.93
- Container f. nuclear phys.experiments 09103.00

7 TECHNICAL SPECIFICATIONS (typical for 25°C)
Operating temperature range 5...40°C
Relative humidity < 80%

Mains supply
Protection class I
Connecting voltage 110...240 V
Mains frequency 50/60 Hz
Power consumption 20 VA
Mains fuse see type plate

Housing dimensions (mm) 205 x 155 x 135 (W, H, D)
Weight approx. 1.37 kg

Signal input (for negative pulses)
Impedance: 3.3 kΩ || 150 pF, maximum level at 1.2 V
For short pulses of 0.2 to 4 µs the input works integral; maximum level at 2.4 nAs. For longer pulses (above 8 µs with a minimum build-up time of 0.7 µs), the input works differential.

Amplification
Total amplification in three stages, approx. 6, 12 and 24 digital settable
Limitation of the pulse height at 4 V
Length of the formed pulse approx. 15 µs
Maximum pulse rate of 1000 s⁻¹

8 GUARANTEE
We guarantee the instrument supplied by us for a period of 24 months within the EU, or for 12 months outside of the EU.
This guarantee does not cover natural wear nor damage resulting from improper handling.
The manufacturer can only be held responsible for the function and technical safety characteristics of the instrument, when maintenance, repairs and changes to the instrument are only carried out by the manufacturer or by personnel who have been explicitly authorized by him to do so.

9 WASTE DISPOSAL
The packaging consists predominately of environmental compatible materials that can be passed on for disposal by the local recycling service.

Should you no longer require this product, do not dispose of it with the household refuse. Please return it to the address below for proper waste disposal.

PHYWE Systeme GmbH & Co. KG
Abteilung Kundendienst
Robert-Bosch-Breite 10
D-37079 Göttingen

Phone +49 (0) 551 604-274
Fax +49 (0) 551 604-246
USB-DRIVER INSTALLATION WINDOWS 2000

You require a Measure CD (version 4.2 release 1 on) for installation. To carry out installation, place the original CD in the appropriate drive. Should the Measure installation programme start on its own accord, stop the installation programme. The USB-driver is to be found in the Driver\USB-VCP Driver\Win98&me&2K&Xp directory.

Now connect the USB-device to the PC by means of the USB connecting cable provided and switch the device on.

The PC recognizes that a USB-device is connected and shows this as follows:

![Found New Hardware](image)

The Installation Assistant subsequently starts automatically.

![Found New Hardware Wizard](image)

Please select the entry **Search for a suitable driver for my device (recommended)** and operate the **Next>** key.
Please select here the **Specify a location** entry and confirm it with "**Next**". A new window now opens.

Enter the installation path (Driver\USB-VCP Driver\Win98&me&2K&Xp) here. Should you not be sure of the position of the driver, operate the **Browse**.. key. Following this, enter the directory of the Measure CD given above (Driver\USB-VCP Driver\Win98&me&2K&Xp).

Select the FTDIBUS.INF file, then click first on **Open**, then on **OK**.
The driver will now be loaded.

Click on **Next >**, then on **Finish**.

The PC again reports after a short time that the new hardware has been found.

Following this, the Installation Assistant re-starts. Please now again carry out installation as described above.

After you have brought the Installation Assistant to an end with **Finish**, the driver is completely installed.
You require a Measure CD (version 4.2 release 1 on) for installation. To carry out installation, place the original CD in the appropriate drive. Should the Measure installation programme start on its own accord, stop the installation programme. The USB-driver is to be found in the Driver\USB-VCP Driver\Win98&me&2K&Xp directory.

Now connect the USB-device to the PC by means of the USB connecting cable provided and switch the device on.

The PC recognizes that a USB-device is connected and automatically starts the Installation-Assistant:

Select the selection choice "Automatically install software", check that the Measure CD is mounted and confirm with the Further> key.

The PC now searches for suitable drivers and starts the installation. During this process a window belonging to the Windows Logo testing opens. Ignore these test and select the (Continue anyway) button.
The driver will now be installed. After successful installation, a further driver is installed. The Hardware-Assistant reports back on this.

Please now again carry out installation as described above.

After you have brought the Installation Assistant to an end with Finish, the driver is completely installed.