

SGS-4

**Stabilized scintillation gamma spectrometer with embedded multichannel
mössbauer accumulation system.**

TECHNICAL DESCRIPTION AND MANUAL.

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PURPOSE

SGS-4 - stabilized scintillation gamma-ray spectrometer with a single-channel differential amplitude discriminator and a built-in accumulator mössbauer spectra used for X-ray and gamma-ray energy range from 3 to 30keV, and the accumulation of the mössbauer spectra. Required discrimination thresholds are set with the computer. The synchronization of the SGS-4 and the Mössbauer Doppler Modulator is carrying out by start and channel advance pulses. The connection between spectrometer and computer realized via a standard serial interface RS-232. The spectrometer can be used in mössbauer spectroscopy and related fields.

ENVIRONMENT

- Temperature +15...+35 °C
- Relative air humidity, less than 80%
- Atmospheric pressure from 460 mm Hg to 800 mm Hg

ATTENTION: Strictly forbidden to use the spectrometer in scattered magnetic field from high power equipment.

TECHNICAL DATA

Gamma quanta registration efficiency

Iron-57, E = 14.4 keV	≥ 75%
Tin-119, E = 23.8 keV	≥ 85%
Dead time of amplitude discriminator	≤ 0.65 μs

Strobe output

Signal type	+5V (standard direct TTL)
Load resistance	50 Ohm ¹

Spectrum output

Signal polarity	Bipolar
Working half-wave	Positive
Maximum distortion-free output	+5V
Load resistance	≥1000 Ohm

Start and Channel inputs

Input signal type	Standard direct TTL
Working half-wave	Negative

Memory

Number of channels	1024
Channel capacity	2 ³²

Power supply	+12V
Power consumption, less than	6W
Overall dimensions, mm	182 x 66 x 90
Weight, g, less than	1000

DELIVERY SET

SGS-4	1 piece
Cable for external registration unit	1 piece
Spectrometer-to-Modulator driver cable	2 pieces

¹ If the connection cable more than 2 meters long then it is necessary to connect 50 Ohm load resistance on the other end of the cable.

Combined PC and power connection cable	1 piece
Device passport	1 piece
Technical description and manual	1 piece

DESIGN AND FUNCTIONAL CONCEPT.

Structurally SGS-4 performed in compact metal case (Fig. 1). The inside of the device consists of printed-circuit boards (1), photomultiplier tube (2) and scintillation crystal NaI(Tl) (3). On the bottom there are two mounting holes (4) for the bench.

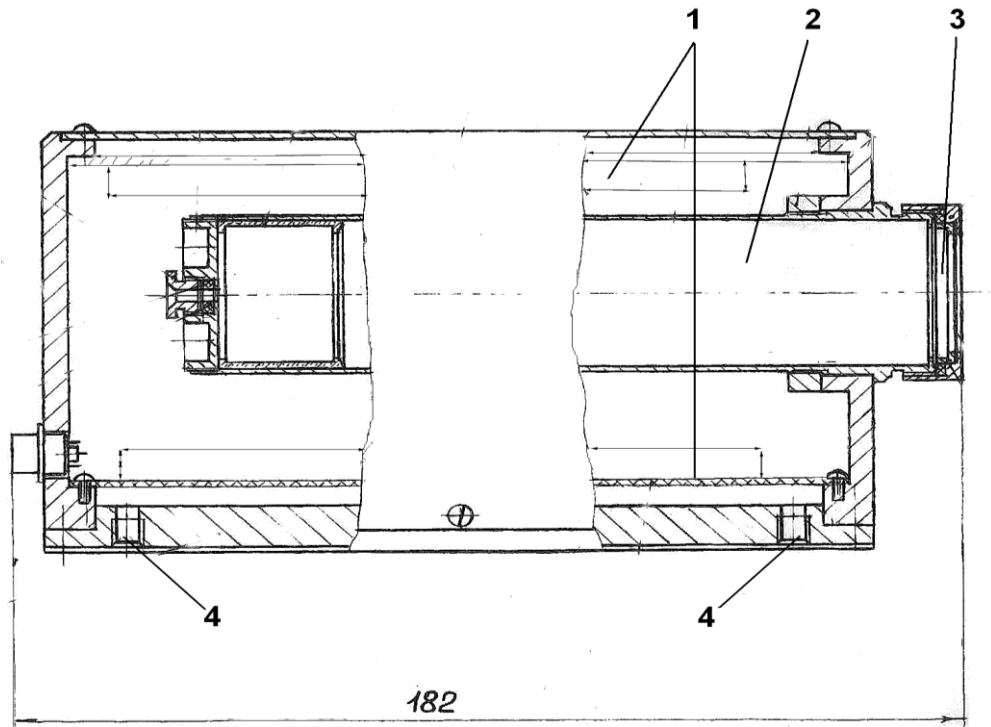


Figure 1. Spectrometer design

All connection slots are on the back panel.

Connection slots:

- «Strobe» - differential discriminator output;
- «Spectrum» - spectral output analog signal;
- «Start» - start advance pulse from modulation driver;
- «Channel» - channel advance pulse from modulation driver;
- «PC link» - slot for PC and power supply connection.

SGS-4 uses scintillation detector which register gamma radiation and reemit absorbed energy in the form of light. This light is registered by the photocathode of photomultiplier tube (PMT). PTM converts and multiply the incoming light impulses into electronic impulses and send them to electronic system of the spectrometer. The software transforms signals from detector to apparent spectra on the display of the computer.

The scintillator used in the spectrometer is scintillation crystal NaI activated with Thallium with thickness 0.1 - 0.15 mm. The use of "thin" crystals provides high-efficiency registration of gamma-rays from energy range under research along with low-efficiency detection of the hard X-ray and gamma-ray from the source.

FUNCTIONAL DIAGRAM

Functional diagram of SGS-4 is shown in Fig.2.

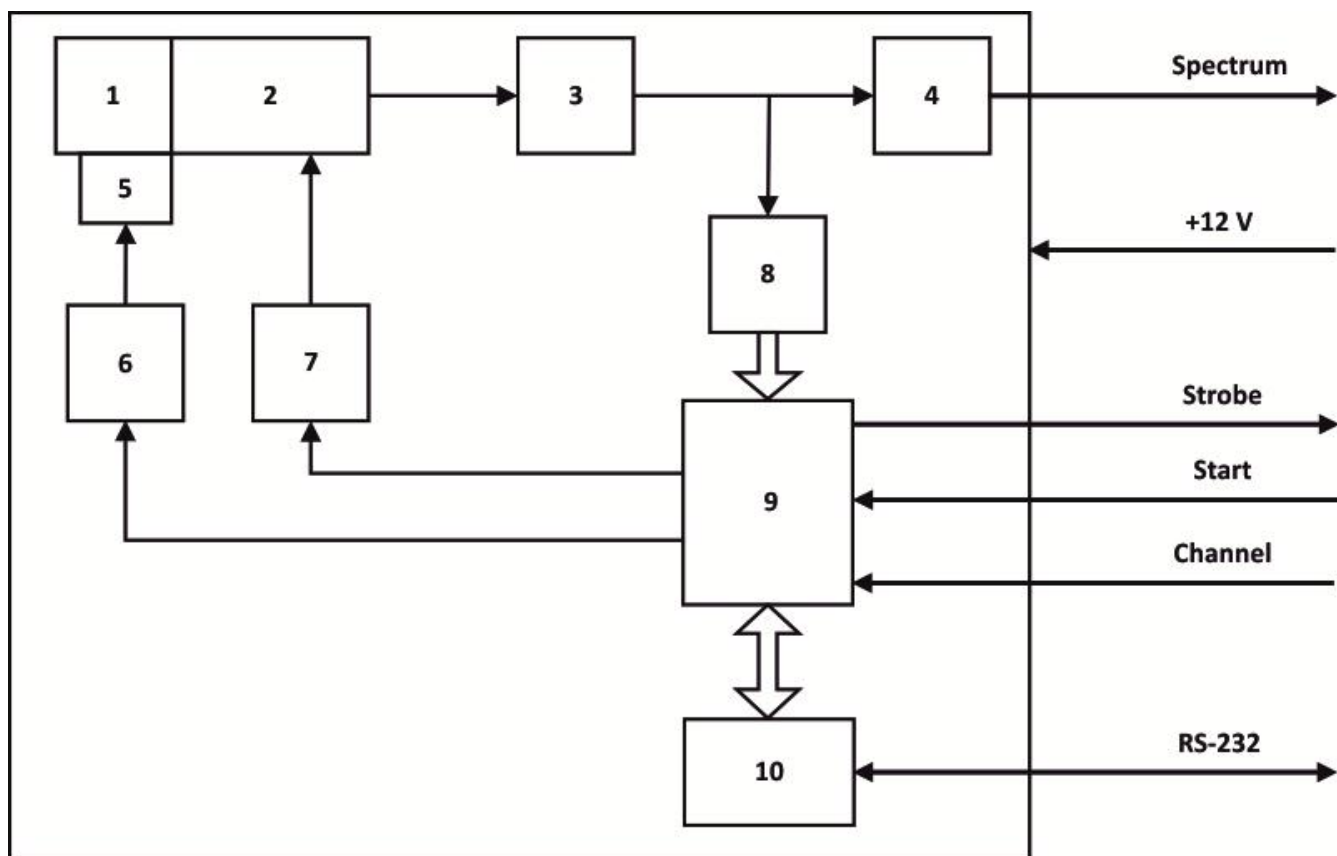


Figure 2. Functional diagram of SGS-4

1 – NaJ(Tl) Scintillation Detector
2 – Photomultiplier tube (PMT).
3 – Preamplifier
4 – Signal amplifier
5 – LED

6 – LED impulse generator
7 – High voltage power supply
8 – Analog-digital converter (ADC)
9 – Field-programmable gate array (FPGA)
10 – Processing unit

Absorption of gamma-quanta in the sensitive volume of the scintillation detector (1) produces visible light photons. Photomultiplier tube (2), optically coupled with the detector, converts the light pulses into electric impulses and then send them to preamplifier (3).

After preamplifier the signal goes to the ADC (8) and to the spectrometric amplifier (4). Being amplified the signal goes to the slot «Spectrum».

Analog signals, digitized in the fast parallel ADC (8), go to the input of programmable logic device (FPGA) (9), where occur different digital conversions: DC compensation, discrimination with operational thresholds and calculation of signal amplitude by digital integration. Also FPGA (9) implements the algorithm of differential amplitude discriminator, which output connected to slot «Strobe»

Depending on the mode of operation of the spectrometer, in the buffer RAM, also organized on the basis of programmable logic device, there is an accumulation of the amplitude spectra or time mössbauer spectra synchronized by external advance pulses "start" and "channel".

The PC provides controlling of various modes of the spectrometer and setting discrimination thresholds via protocol RS-232.

The entire signal path, including PMT, is included into a feedback loop system ensuring stability over time, and excellent measurement reproducibility. Light pulse from high stability LED (5), managed by LED impulse generator (6) is used as an etalon for stabilization circuit. The LED retains its output parameters under factors of influence destabilizing the signal processing section.

If a change in LED signal on signal amplifier output is detected, stabilization circuit corrects the signal processing section output by altering output voltage of high voltage power supply (7), thus changing its multiplication rate.

The digital stabilization algorithm implemented by processing unit (10), which also receives control commands and transfers accumulated information in the form of amplitude and mössbauer spectra to the PC via RS-232.

Differential amplitude discriminator levels are set based on the digital spectrum view.

SOFTWARE

General information

Software package for the spectrometer consists of spectra acquisition and processing program (**SGS4.exe**), intended for use with SGS-4.

Program SGS4 is built as a single executable module (**SGS4.exe**)

SGS4 software is a 32-bit application with graphic user interface, working in Microsoft® Windows XP environment (Windows XP™ or higher). The software is developed for PC-compatible platforms.

Features

SGS4 software allows:

- Automatic reading of spectral data from detector module to PC memory
- Discriminator levels setting from PC
- Switching between amplitude and mössbauer spectra
- Spectra viewing and analysis via user graphic interface
- Choosing number of channels for mössbauer spectra

Program execution

Installation is not required. Executable module (**SGS4.exe**) may be run from any media and location. Executable file is run with no additional keys by launching **SGS4.exe** through any OS or other software (file manager etc.) resources.

Input data

During the regular use of the program input data is a stream of bytes received via RS-232.

Running the program

Program launching by opening **SGS4.exe**. Program shutdown is done by «Close» button in the system menu. In case of abnormal operation, termination by OS Task Manager is permissible. Changing system date/time or desktop parameters, launching other applications are not allowed when SGS4 software is running.

User interface

Main window is performed in form of window for amplitude spectra accumulation. (Fig.3).

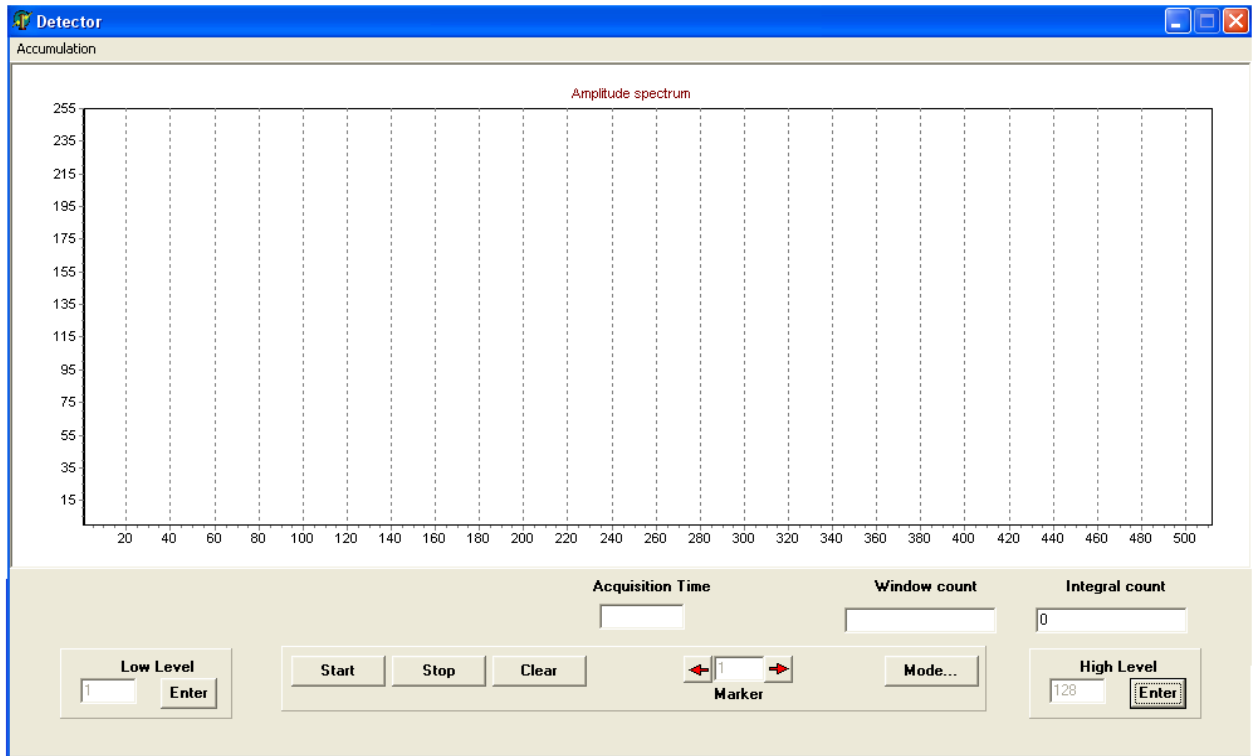


Figure 3. Main program window

Spectrum display area is located in the upper part of interface screen. Control and indication elements are found below

«Low level» panel

Features current low discriminator level position indicator and new level Enter button. Default low level value is 1.

«High Level» panel

Features current high discriminator level position indicator and new level Enter button. Default high level value is 128.

«Acquisition Time» Indicator

Shows elapsed acquisition time in seconds

«Marker» Indicator

Displays marker position. Left-clicking the mouse on left and right arrows on either side of the indicator move the marker 1 channel left or right. Hold down right mouse button on the arrows to continuously move the marker in desired direction. Initial marker position is channel 1.

«Start» Button

Clicking the **«Start»** button in main program window launches data acquisition process. During the acquisition process, spectrum window is auto-refreshed. Data acquisition stops when predefined time acquisition is reached, or when **«Stop»** button is pushed.

«Stop» Button

Interrupts the data acquisition process.

«Clear» Button

Clears memory buffer and spectrum window.

«Mode» Button

Clicking this button brings up a dialog window (see Fig. 4), allowing user to set serial port number to connect the Module to, and data acquisition time (1 to 1000 seconds).

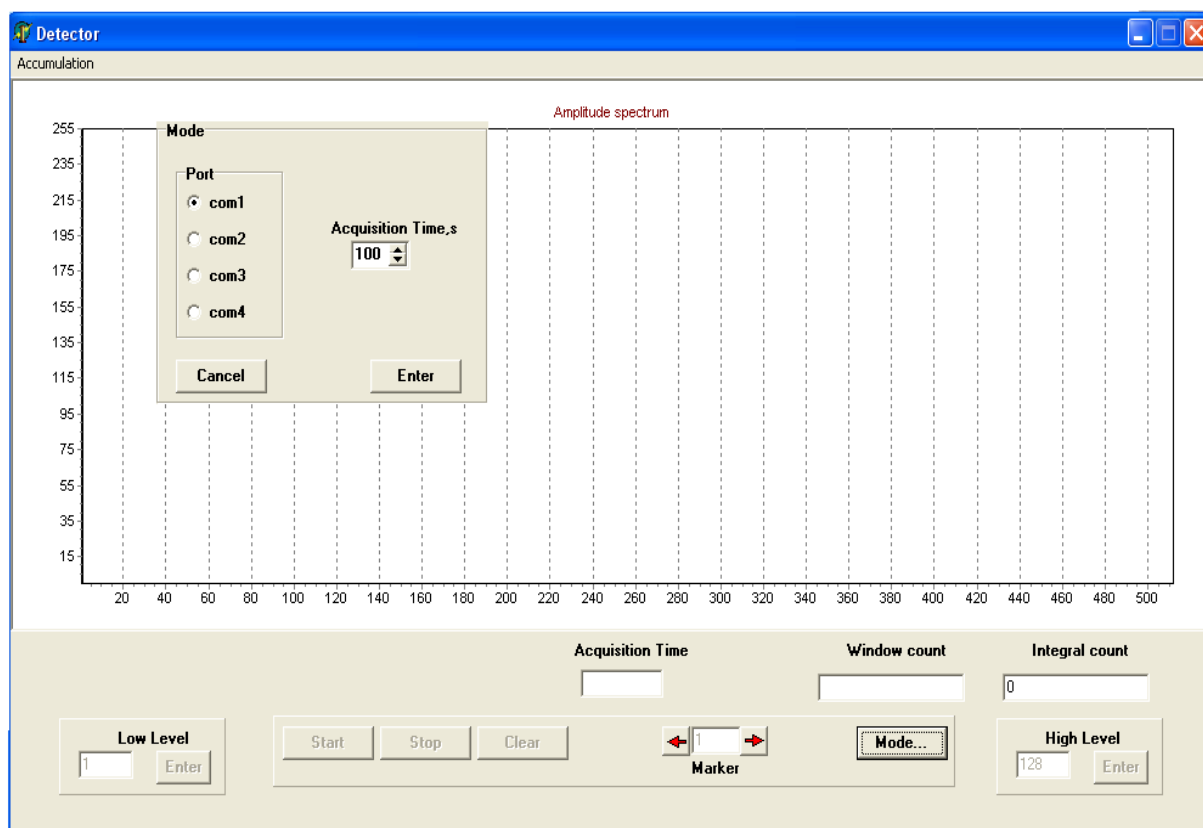


Figure 4. Mode setting dialog

Spectrum analysis

Hitting the “U” key on the keyboard stretches the spectrum in vertical direction.

Hitting the “A” key spectrum view returns to initial setting. Scale is selected automatically.

Discriminator levels setting.

Placing the screen marker to selected position and clicking «Enter» on either of the Level Setting panels sets the appropriate level. Corresponding level indicator will move to the new position. Part of the spectrum within the discriminator window is displayed in gray; rest of the spectrum is displayed in black.

Program shutdown

Clicking «Close» button in system menu exits the program and frees all system resources used by the program.

Mössbauer spectra

Mössbauer spectra accumulation mode (Fig. 5) is launching by choosing «Accumulation» in top menu.

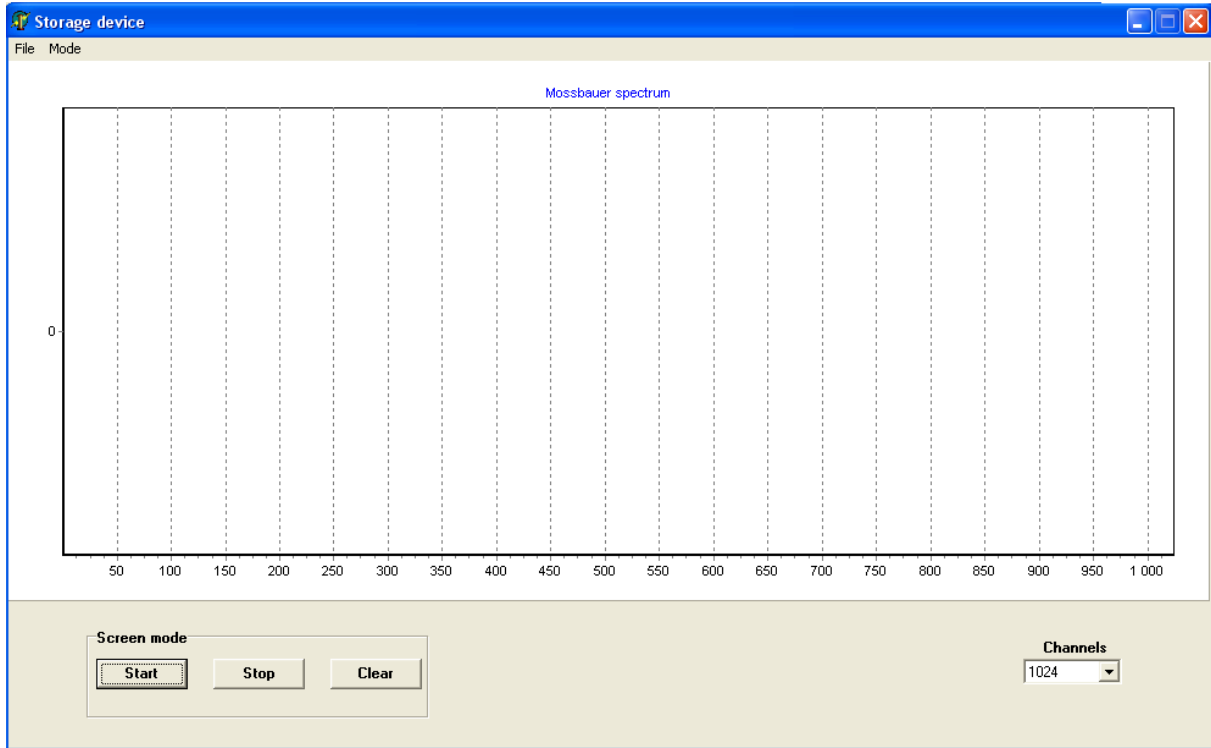


Figure 5. Mössbauer spectra window

Spectrum display area is located in the upper part of interface screen. Control and indication elements are found below

Top menu / «Mode»

Switches between screen and autonomous modes of accumulation. In screen mode view of spectrum updated every five seconds. In autonomous mode data accumulated in internal memory of spectrometer and loaded to PC by pressing «Stop» button.

Top menu / «File».

Opens standard windows dialog for saving spectra files. Basically program creates three files:

- Name.txt – full spectrum for all range of channels (e.g. 1 - 1024)
- Name_1.txt – spectrum from the first half (e.g. 1 - 512)
- Name_2.txt – spectrum from the second half (e.g. 513 – 1024)

It is convenient when vehicle function is triangle-shaped with forward and reverse stroke.

«Start» button.

Launches accumulation process.

«Clear» button.

Clears buffer memory and spectra window.

«Channels» indicator.

Allows to choose the number of channels for mössbauer spectra. Default value is 1024

Closing the program.

To close the whole program stop the accumulation, and press the default window button for closing windows first on mössbauer spectra window, then on amplitude spectra window.

DEVICE OPERATION

Device installation.

Using the cables supplied with the Device, connect all the signal cables and power supply according to the scheme (Fig. 6)

Note: When using in a Mössbauer system, install the Device onto your analytic bench, ensuring rigid, vibration-free connection between the Device and the bench.

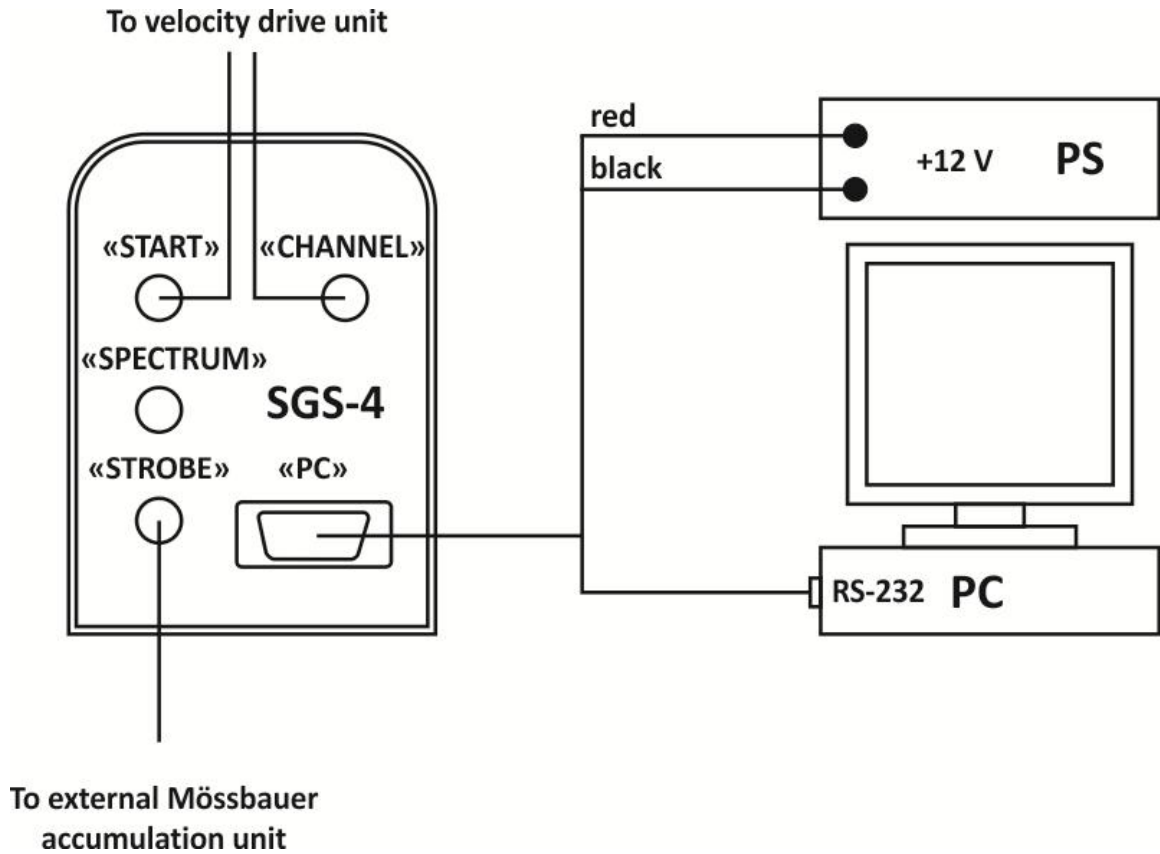


Figure 6. Connection scheme

Operation

Install the module in accordance with description written above. Turn on the power supply. Launch SGS4 program. Set acquisition time and com-port of your PC connected to the detector module in Mode dialog box. In case of wrong COM-port the message box will be shown. Click the «Start» button in main program window to start data acquisition. During data acquisition, the program window should look similar to that shown in Fig. 7.

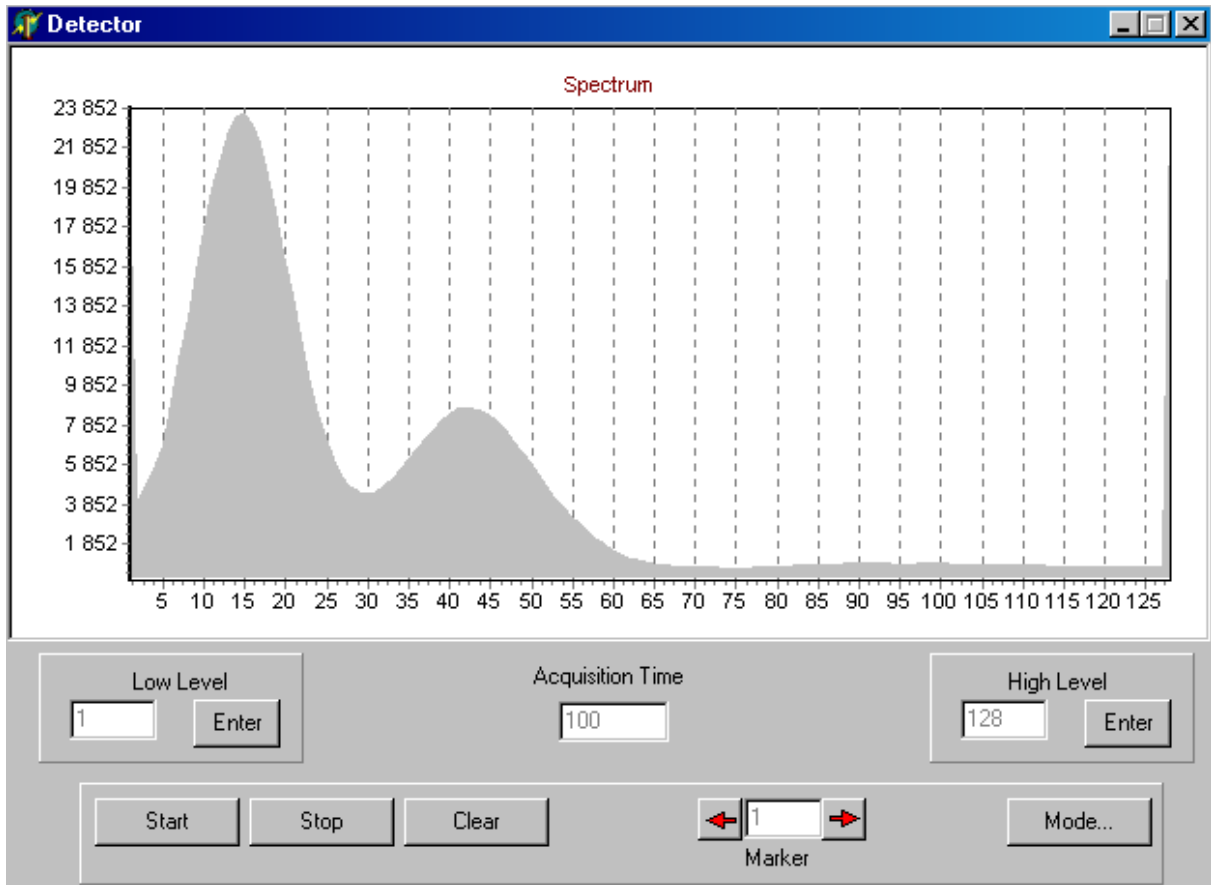


Figure 7. Co-57 amplitude spectrum

When acquisition ends, set discriminator levels using marker control. Delete the data collected by clicking «Clear» button. Spectrum sections located beyond the discriminator window will now be displayed in black during acquisition (Fig. 8).

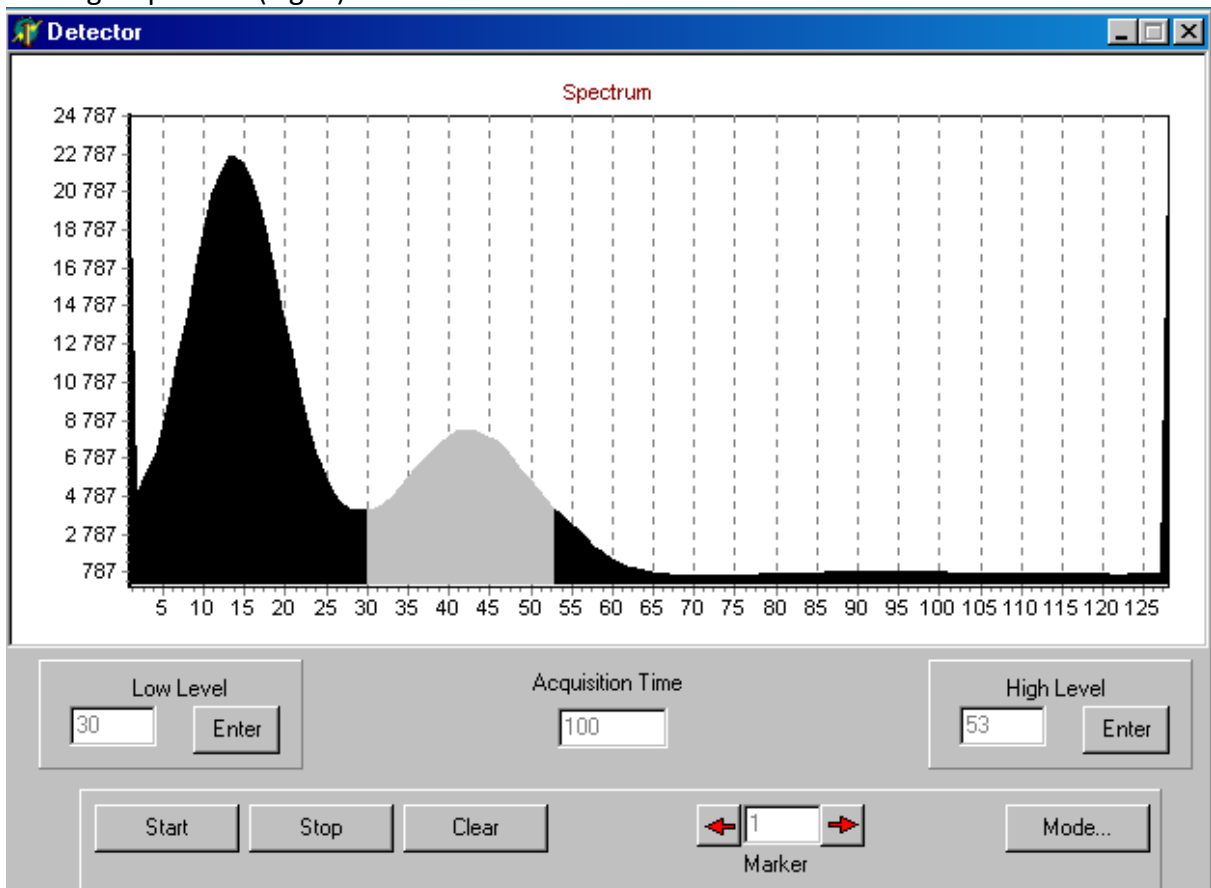


Figure 8. Co-57 amplitude spectrum with set discrimination levels

When an external mössbauer accumulation system is used, after setting the discrimination thresholds SGS-4, if necessary, can be disconnected from the computer and work autonomously.

When using the internal drive, you must use «Accumulation» in the top menu to open the window for mössbauer spectra acquisition. To choose the screen or autonomous modes of accumulation press «Mode» in the top menu. Set the number of channels by pressing on the «Channels» indicator. Press the «Start» button to start data acquisition. When the screen mode is active view of the spectrum will be updated every five seconds, in the autonomous mode the message box «Accumulation in progress» will appear on the display. The typical spectrum is shown in Fig. 9.

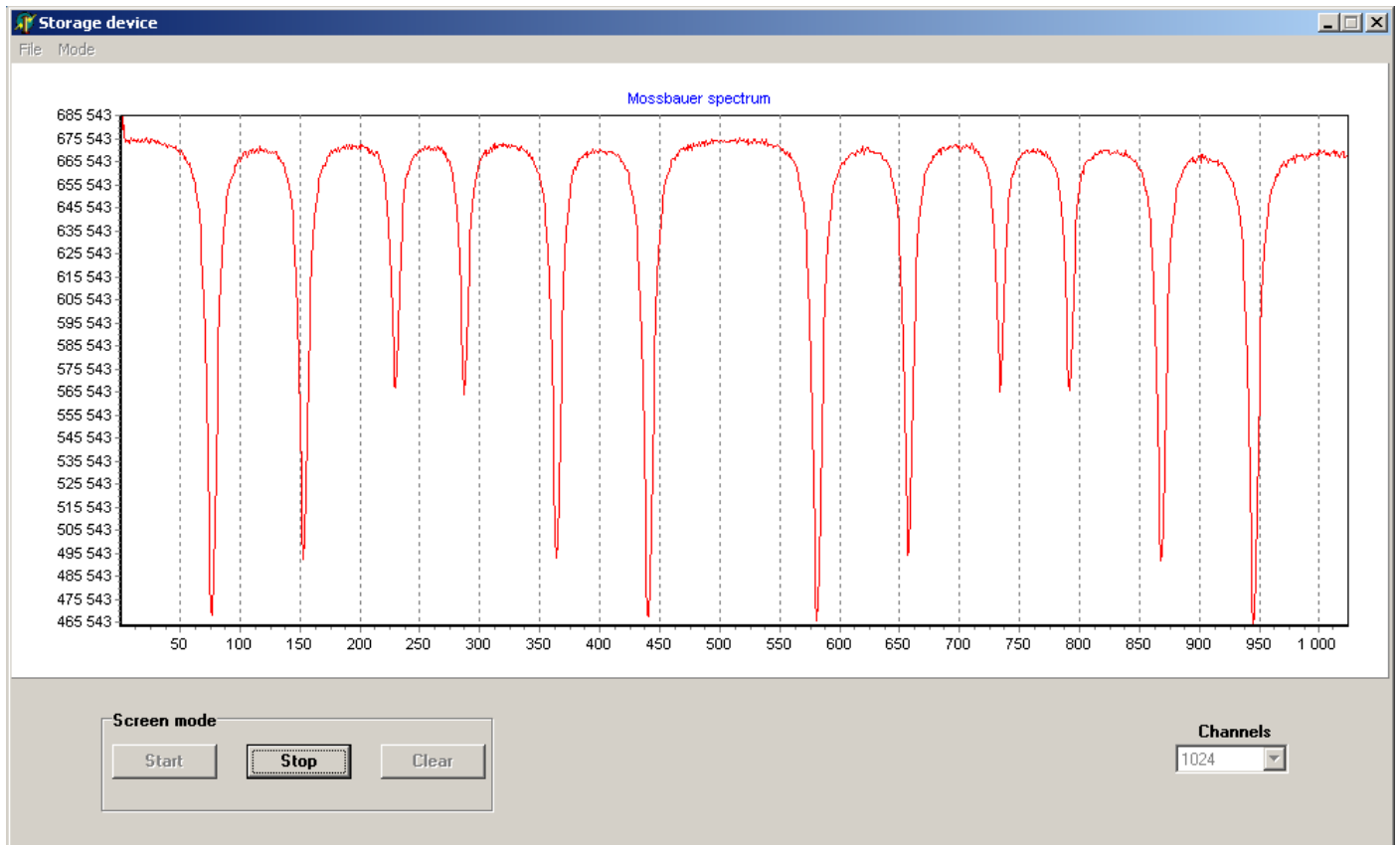


Figure 9. Mössbauer spectra (source Co-57, absorber alpha-Fe)

In the autonomous mode the computer can be disconnected from the device or shut down. After the reconnection or turning on the computer, press the «Stop» button and all the data will be transferred from the device memory to the computer.

To save the spectrum press «File / Save as». Program creates three files:

Name.txt – full spectrum for all range of channels (e.g. 1 - 1024)

Name_1.txt – spectrum from the first half (e.g. 1 - 512)

Name_2.txt – spectrum from the second half (e.g. 513 – 1024)

PRECAUTIONS

Do not turn on the module with removed external case. Parts of the device are operated under high voltage.

SERVICE

SGS-4 module don't requires any service or periodic maintenance.

STORAGE CONDITIONS

Long-term storage conditions are:

Temperature +5 to +40 °C,

Relative humidity up to 80% without dew formation.

TRANSPORTATION

The device may be shipped by any means of transport, except non-hermetic compartments of aircraft. Protection from direct atmospheric precipitation and dust is necessary. The device is supplied in non-returnable packaging.