

Base527 MODULE SERIES

DIGITAL MULTICHANNEL ANALYZER



USER MANUAL



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REVISION SHEET

Release No.	Date	Revision Description
Rev. 01	08/24/2018	First official revision
Rev. 02	12/14/2018	Added Chapter 11. Update Firmware
Rev. 03	02/12/2019	Revised Chapter 1.1 (safety) Revised Chapter 4 (Base socket pinout) Revised Chapter 5.1.1 (Hint for HV setting) Revised Chapter 6.2.9 (Baseline settings)
Rev. 04	02/21/2019	Revised Chapter 3.2.2 (Note RS485 powering) Revised Chapter 3.2.2.1 (RS485 wiring Vcc, GND) Revised Chapter 3.2.3 (Note USB Port)
Rev. 05	07/17/2020	Added Base527-SYNC, Chapter 3.4

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1. FOR YOUR SAFETY

1.1 SAFETY INSTRUCTIONS



1. Only skilled and or trained personnel should operate the Base527
2. Do not open the Base527! Risk of an (mild) electrical shock will be present!
3. Do not operate the device without plugged PMT/detector!
4. Do not pull off/ plug in PMT while HV is operating!
(This may damage the preamplifier)
5. Always make sure the PMT-connector is free of dust or dirt before plug in!
6. Do not place the product on heat-generating devices such as radiators or fans!

1.1.1 INTENDED USE

Use the Base527 only in its designated purpose as described in this User Manual, for example in [Chapter 2.1, "Product description"](#), on page 8.

Observe the operating conditions and performance limits stated in the "Technical Specifications" in [chapter 9](#) or in the respective datasheet on: <http://www.gbs-elektronik.de/downloads>

In general, the Base527 series have been developed for the measuring of gamma ray radiation in a laboratory environment with non-safety relevant applications with plugged photomultiplier /detector. Furthermore, it is not allowed to open the device in any case.

1.1.2 MAINTENANCE

The Base527 is completely maintenance-free. However, before every usage, check visually for proper condition, especially the PMT-connector must be free of dirt.

1.1.3 CLEANING

For cleaning the device and connector use only a lint-free and dry cloth!

2. INTRODUCTION

Thank you for buying GBS Elektronik' Base527 module.

This document is a User's Guide that describes the Base527 spectrometer series in hardware, digital signal processing and software parameter settings.

2.1 PRODUCT DESCRIPTION

Together with a detector, the Base527 Series are complete spectrometer with integrated bias supply and preamplifier for PMT based detectors. It was developed to be used for gamma-ray spectroscopy applications with NaI, LaBr, SrI2 or similar scintillation detectors.

The Base527 modules are suitable for detectors with 14-pin (standard version) or 12-pin photomultiplier tubes like the Hamamatsu R6231, R1306 (*Jedec B14*) or R9420, 9102B, XP2060B (*Jedec B12*).

Special socket options are available on request.

The Base527 series are categorized in their respective computer interfaces and comes either with μ USB- (*Base527*), Ethernet & USB- (*Base527E*) or with a RS485 (*Base527R*). The whole module is powered from the USB interface port, by "Power over Ethernet" or RS485 power lines.

Due to the integration of all hardware components for a gamma spectroscopy system in one package, there is only one cable necessary to connect the system to a computer or network switch. The Base527 can be operated with our free of charge software programs, available for the entire MCA527 product family, such as WinSpec or WinMCS.

KEY FEATURES

- *MCA-module with up to 4k channel resolution*
- *PMT optimized preamplifier*
- *Integrated high voltage supply*
- *Available with 14-pin or 12-pin-socket*
- *Special socket options on customer request*
- *Low weight and small outer dimensions*
- *Very low power consumption of 0.4W*
- *Fully digital signal processing*
- *Fixed cable versions on request*
- *Eloxed aluminum housing*

2.2 GENERAL INTRODUCTION INTO GAMMA SPECTROSCOPY

The main application of gamma spectroscopy is to measure the radiation emitted from decaying radionuclides and from this conclude on the type and quantity of isotopes present. In most cases, the gamma radiation is most suitable to distinguish between different radioisotopes. Gamma radiation consists of photons, similar as light. But whereas the typical photon energy for visible light is 1eV ($1.6 \cdot 10^{-19}$ Joule) the gamma photon energy from radioactive decay is much higher and typically between 3keV and 3MeV. For measuring this gamma radiation, a suitable detector is needed. This can be a semiconductor detector, which converts an absorbed photon directly into a small charge quantity. Or it can be a scintillation detector, which converts an absorbed photon into visible light, which is then converted by a photomultiplier into a charge. After the preamplifier, which is usually integrated within the detector, the charge appears as voltage step on the output signal.

The task of the multi-channel analyzer is now to measure the amplitude of these voltage steps with best possible accuracy and make a histogram of all measured amplitude values. This is called pulse height analysis (PHA) mode.

Another important operation mode is to record count rate in dependence of time, using defined time channels. This is called multichannel scaling (MCS) mode. Various other measurement modes are possible and described later in this manual.

3. HARDWARE

3.1 HARDWARE OVERVIEW BASE527E

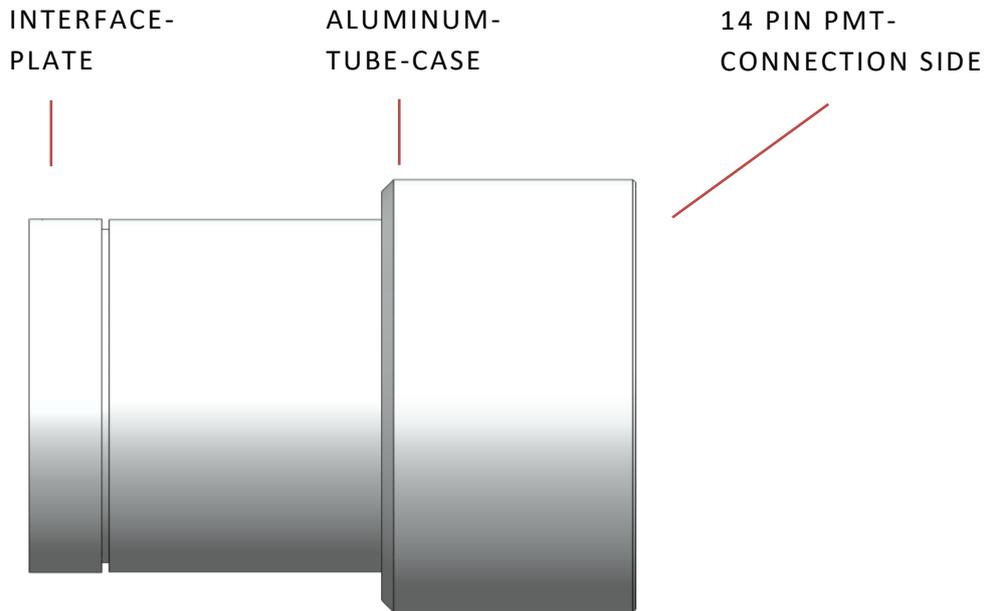


FIGURE 1: BASE527E SECTIONS (SIDE VIEW)

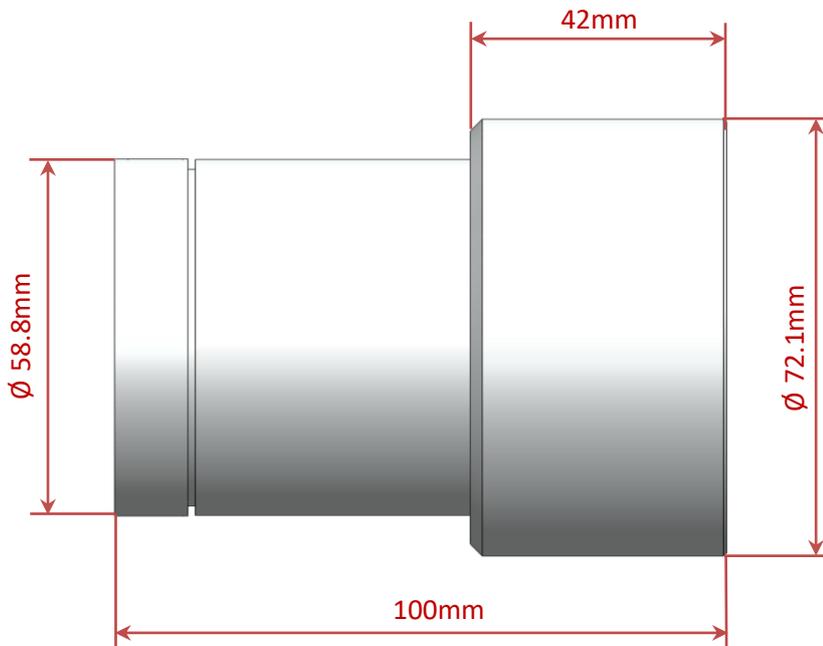


FIGURE 2: BASE527E OUTER DIMENSIONS (SIDE VIEW)

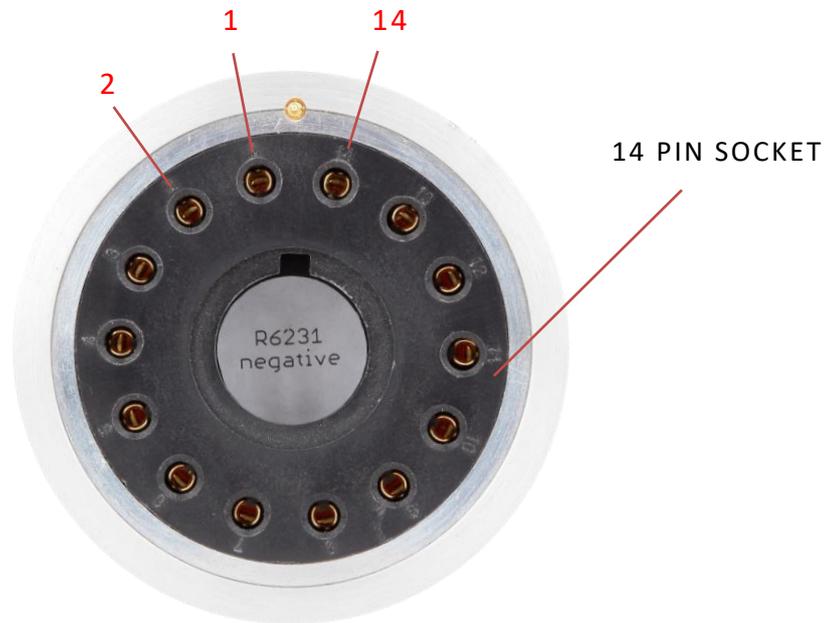


FIGURE 3: BASE527E PMT-DETECTOR CONNECTION (FRONT VIEW)

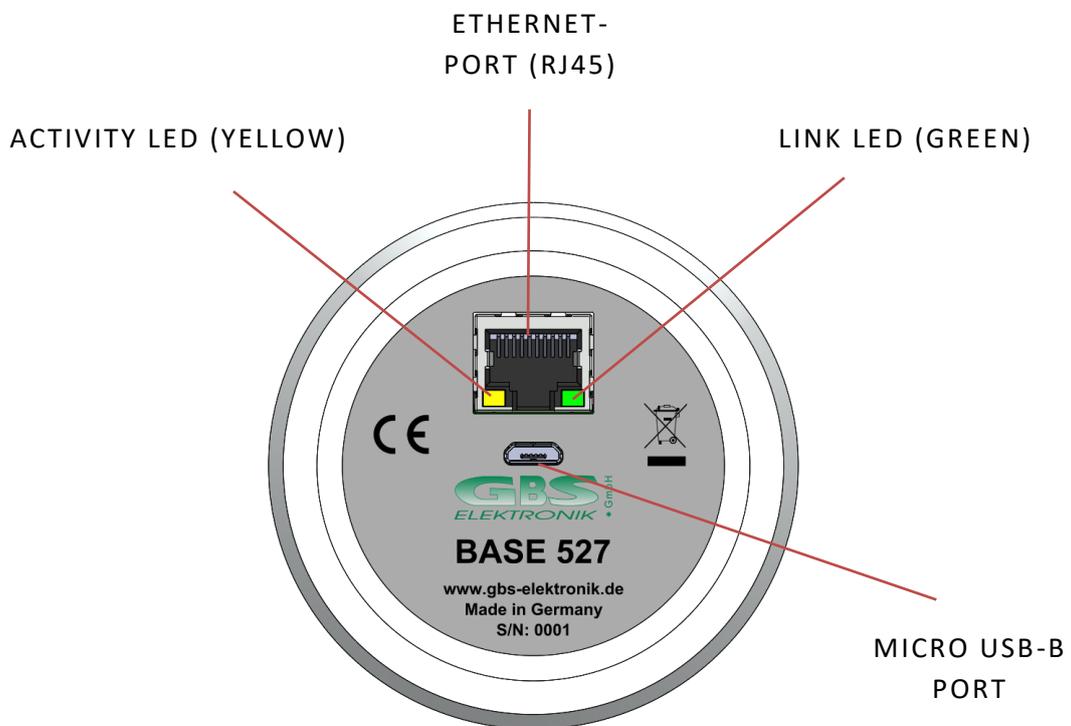


FIGURE 4: BASE527E INTERFACES (REAR VIEW)

3.1.1 BASE527E INTERFACES

3.1.2 ETHERNET PORT

The Ethernet interface supports 10/100Mbit/s. By default, it is configured to obtain the IP address automatically from a DHCP server or if not available, using Zero Configuration Networking (also named Automatic Private IP Addressing).

The maximum cable length between Base527E and switch can be up to 100 meters.

3.1.3 POWER-OVER-ETHERNET (POE)

Power over Ethernet is an extension of the IEEE802 Ethernet standard, which enables devices to be powered via a network. For this purpose, after a prescribed request between the terminal and the supplying device (for example a PoE switch), a voltage of nominal 48V feeds the cable. It is preferable to use the data lines or the four free wires of an 8-pin CAT5 cable. The Base527E can be powered over Ethernet in both ways.

Note: A normal Laptop or Desktop PC usually does not supply PoE.

3.1.4 MICRO-USB

The USB interface is USB2.0 compliant and allows to power the Base527E, and to communicate with the computer. It's also possible to power the device via USB and to communicate with Ethernet.

Note: A high power device USB port (500mA) must be present!

3.2 HARDWARE OVERVIEW BASE527R

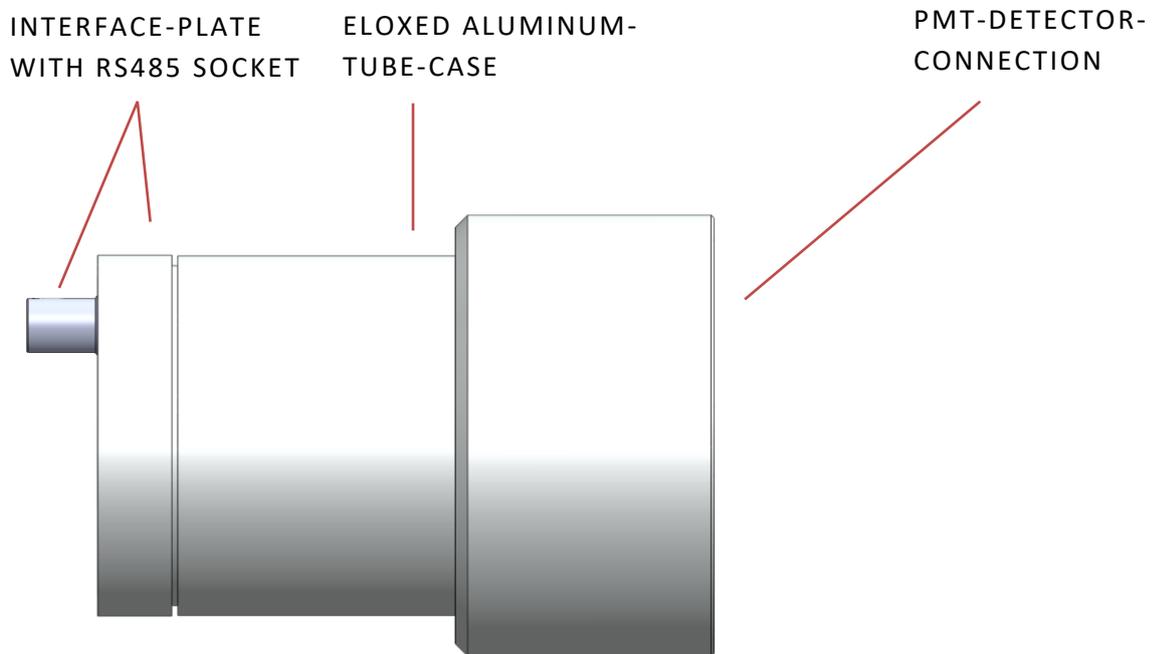


FIGURE 5: BASE527R SECTIONS (SIDE VIEW)

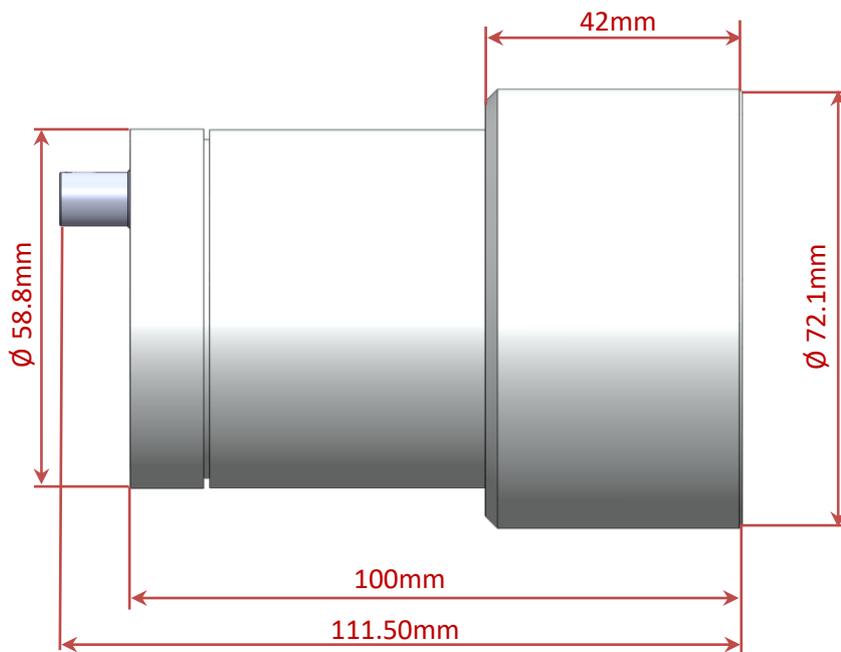


FIGURE 6: BASE527R OUTER DIMENSIONS (SIDE VIEW)

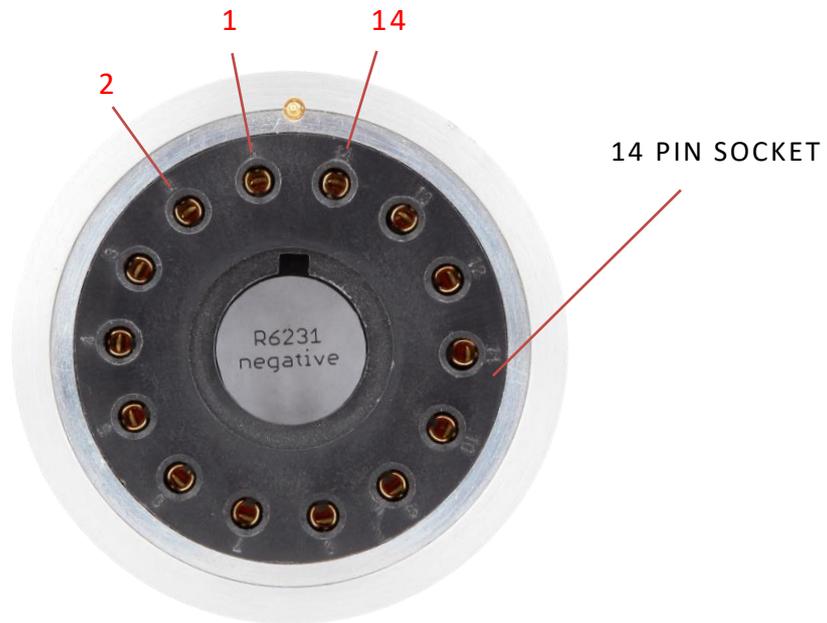


FIGURE 7: BASE527E PMT-DETECTOR CONNECTION (FRONT VIEW)

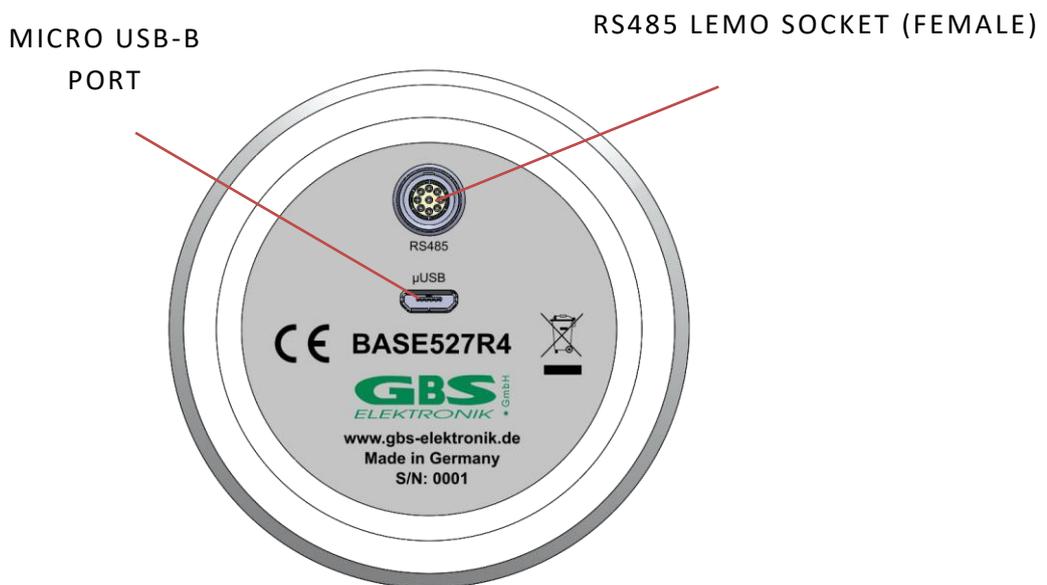


FIGURE 8: BASE527R INTERFACES (REAR VIEW)

3.2.1 BASE527R INTERFACES

3.2.2 RS485 INTERFACE

The RS485 interface has been developed for high-speed serial data transmission over long distances and is becoming popular in the industrial sector. The RS485 is designed as a bidirectional bus system. An RS485 bus can be set up as a half-duplex or full-duplex system.

3.2.2.1 Base527 RS485 CONFIGURATION

The Base527R interface can be operated in half- or full duplex mode. Power can be supplied either via a USB wall-adaptor or via Lemo socket pin 4(Vcc) and 5,9(GND).

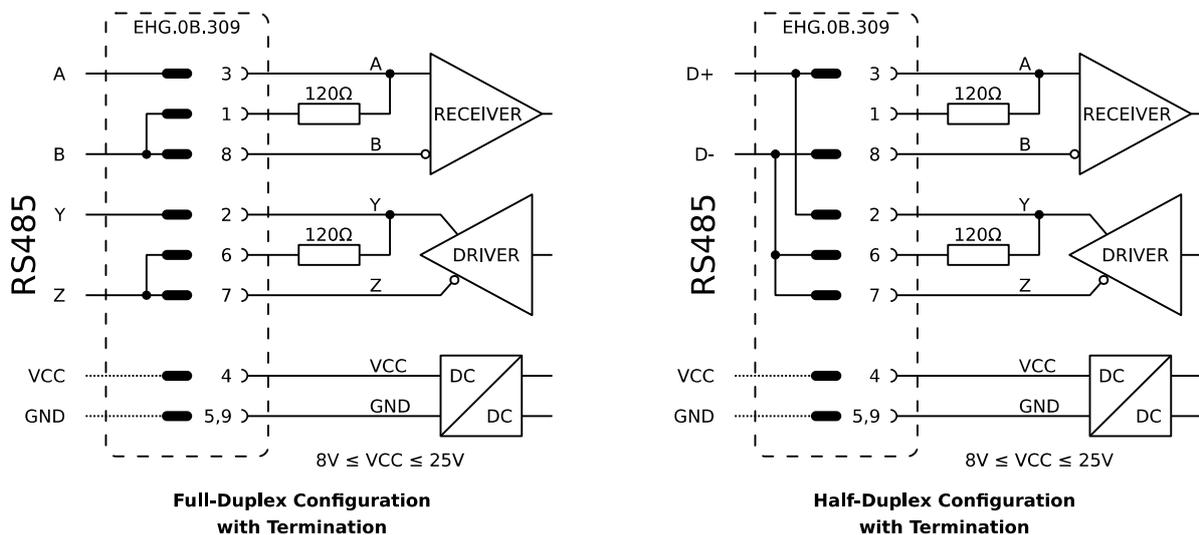


FIGURE 9: WIRING OF POSSIBLE CONFIGURATIONS WITH THE BASE527R

3.2.2.2 RS485 LEMO SOCKET PINOUT

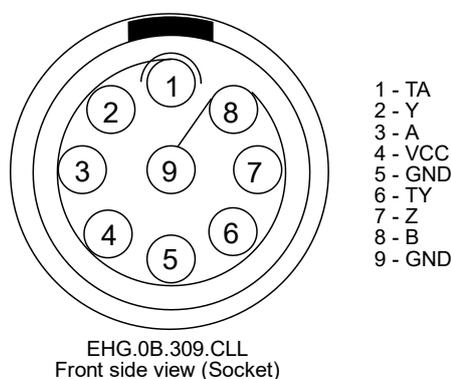


FIGURE 10: BASE527R RS485 PINOUT

3.2.3 MICRO-USB

The Base527R USB interface is USB2.0 compliant and allows to power and to communicate with the computer. For this, a high-power USB interface is needed.

Another possibility is to power the Base527R via an USB wall-adapter and to communicate with RS485.

3.3 HARDWARE OVERVIEW BASE527

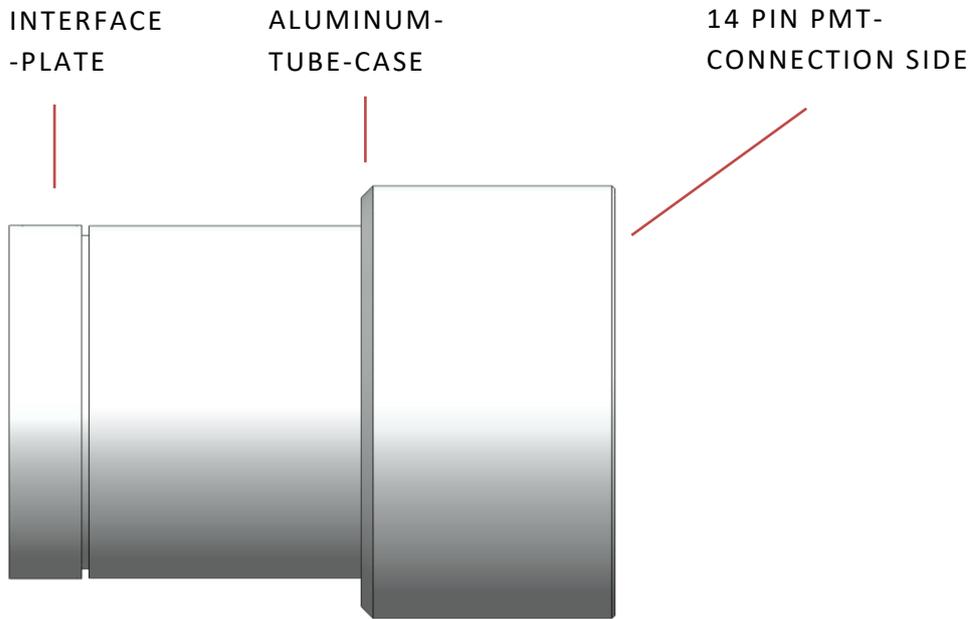


FIGURE 11: BASE527 SECTIONS (SIDE VIEW)

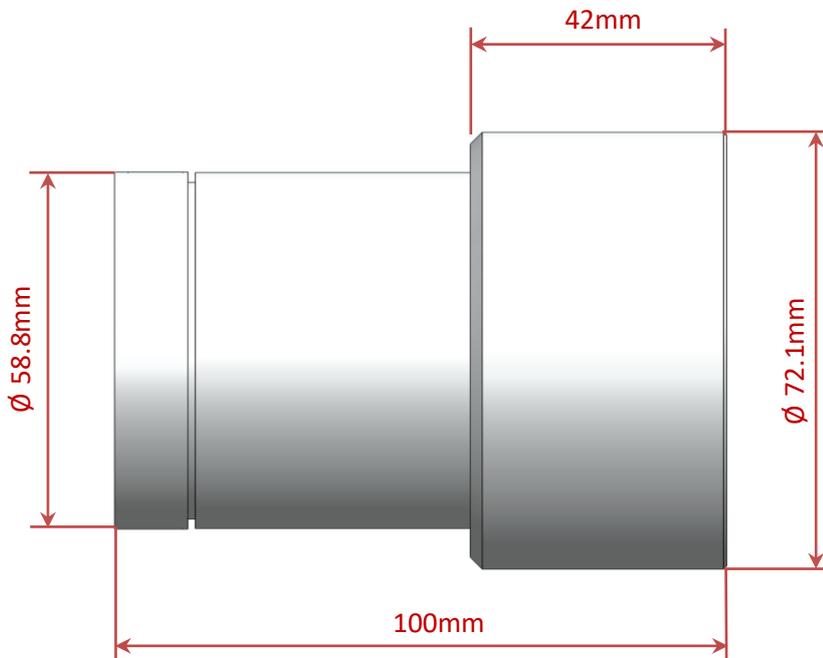


FIGURE 12: BASE527 OUTER DIMENSIONS (SIDE VIEW)

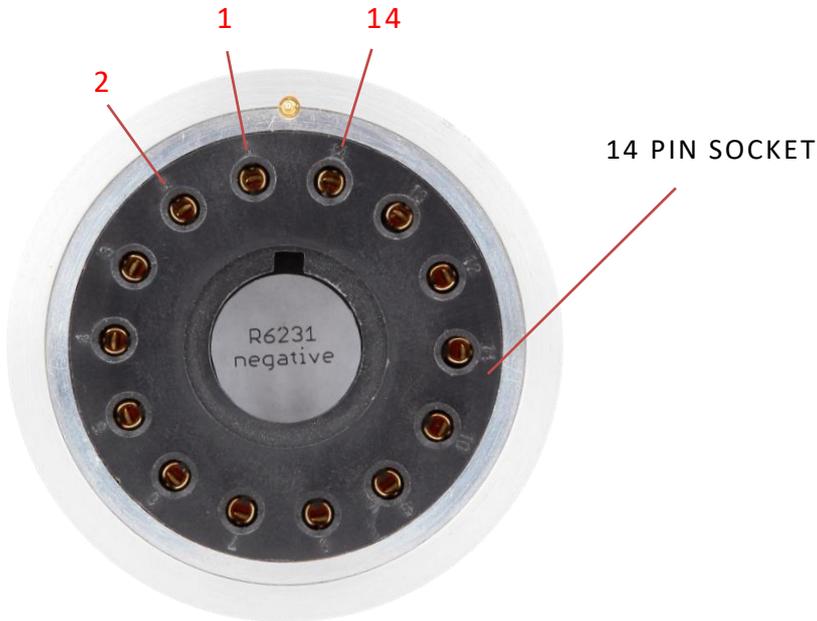


FIGURE 13: BASE527 PMT-DETECTOR CONNECTION (FRONT VIEW)

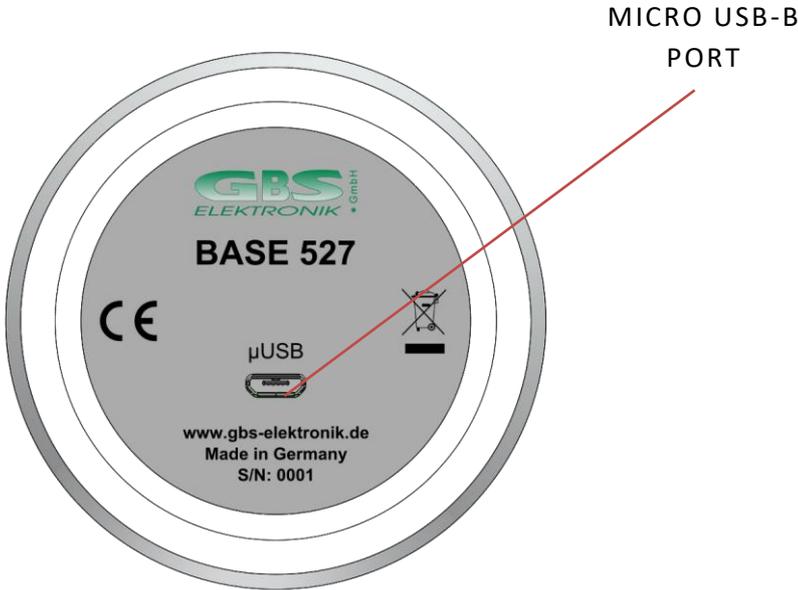


FIGURE 14: BASE527 INTERFACE (REAR VIEW)

3.3.1 BASE527 INTERFACES

3.3.2 MICRO USB

The USB interface is USB2.0 compliant and allows to power the Base527 and to communicate with the computer.

Note: A high power device USB port (500mA) must be present!

3.4 HARDWARE OVERVIEW BASE-SYNC

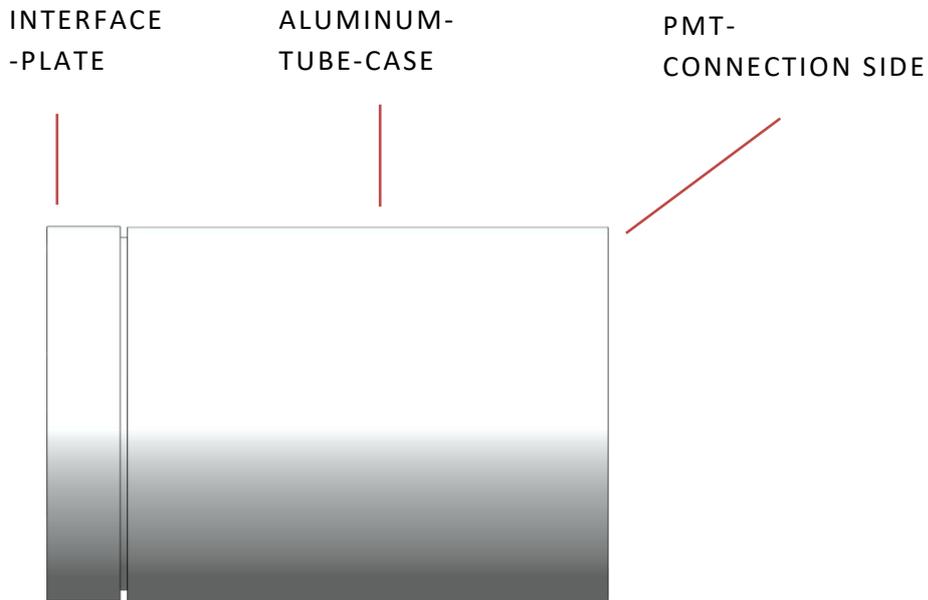


FIGURE 15: BASE527-SYNC SECTIONS (SIDE VIEW)

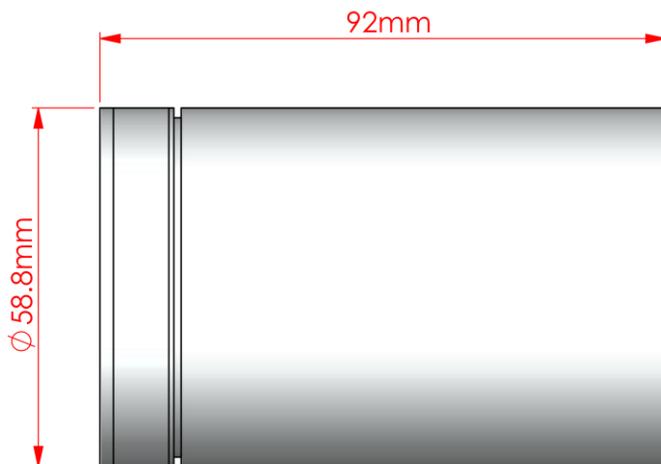


FIGURE 16: BASE527-SYNC OUTER DIMENSIONS (SIDE VIEW)

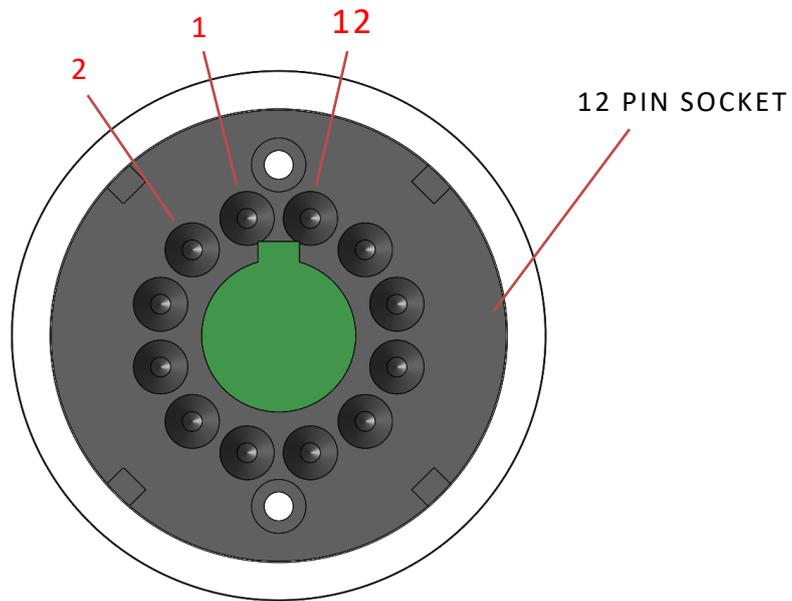


FIGURE 17: BASE527-SYNC PMT-DETECTOR CONNECTION (FRONT VIEW)

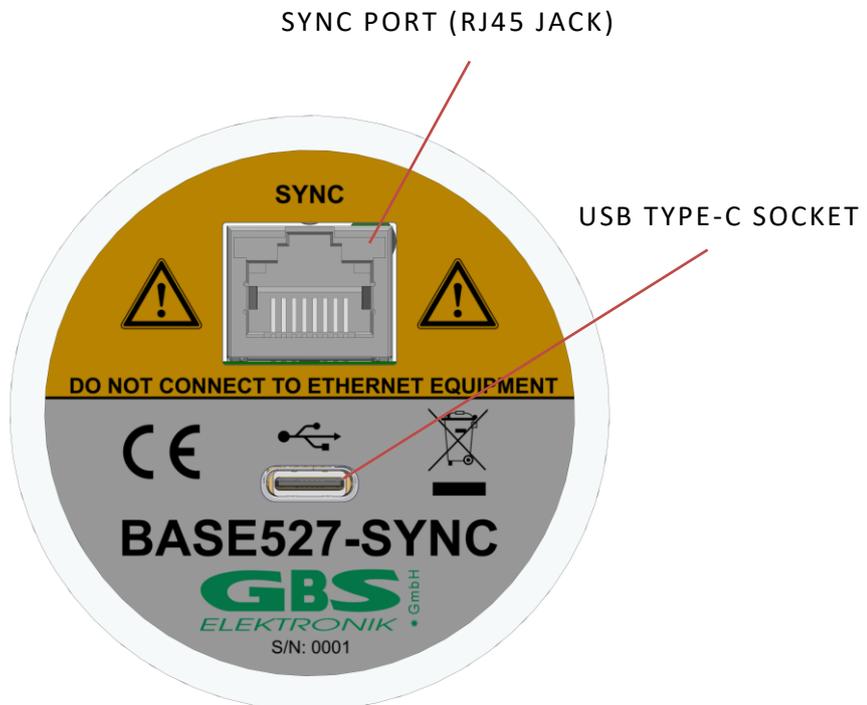


FIGURE 18: BASE527-SYNC INTERFACES (REAR VIEW)

3.4.1 BASE527-SYNC INTERFACES

3.4.2 USB TYPE C

The USB interface is USB2.0 compliant and allows to power the and to communicate with the computer.

Note: The USB connection must be able to deliver at least 500mA!

3.4.3 SYNC INPUT

The RJ45 jack is intended to feed a measurement clock and a synchronization signal into the device.

When no external measurement clock is applied, the system automatically uses the internal 40MHz clock source as reference clock for the ADC.

So, the Base527-SYNC may be used like each other Base527 when no external clock is applied. During power-up or when a software reset takes place the system measures the frequency of the input clock and adjusts the ADC clock divider to achieve a sample clock of 10MSps. While 10MSps is the standard sample rate, the user may change it to 20MSps (WinSPEC: Setup/Amplifier.../Advanced/Sampling rate). In this case the processor clock should be changed to 600MHz to avoid a leak of computation power. For proper operation, the MCA needs an input clock of 10MHz, 20MHz or 40MHz. It works with other frequencies too, but the results are wrong in this case. For a sample rate of 20MSps an input clock of 20MHz or 40MHz is required.



While the SYNC port (RJ45 jack) is mechanically compatible to standard Ethernet interfaces, the signals are not! To avoid damage to the device, it must be never connected to any Ethernet equipment!

3.4.4 SYNC FUNCTION

To synchronize the Base527-SYNC with other equipment, the SYNC port (RJ45 jack) may be used.

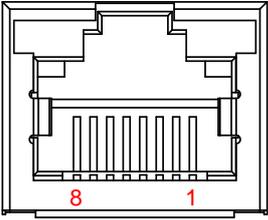
Table 1 shows the pinout and the signals of this port. It accepts LVDS signals for measurement clock (ACLK) and synchronization (SYNC). When a valid clock signal in the range of 10MHz to 40MHz is applied, the internal clock source is turned off and the external measurement clock is used as reference clock for the ADC.

Clock duty cycle must be 50% \pm 5%. When the clock source is changed during operation, a software reset (or power cycle) is required to force the MCA to readjust the ADCs clock divider. The clock detect circuit can be disabled by closing jumper JP1 (see figure 19). This may be useful to detect an external clock fault and to ensure that the system is running on the external clock and not the internal. When jumper JP1 is closed, a valid external clock must be applied. If no external clock is available, the ADC does not work.

The SYNC input may be used to trigger the start of a measurement. Minimum trigger pulse width is 20ns, the measurement is started at the positive-going edge. Because of the pipeline architecture of the ADC, the analog input data have a latency of 8 sample clock cycles.

Care should be taken to the cable length when multiple devices are triggered in a system. Cables of different lengths have different signal flight times. A difference of 1m results in a flight time difference of about 5ns.

Table 1 RJ45 jack pinout and signals

RJ45 jack (front view)	Pin	Signal	Description
	1	n.c.	not connected
	2	n.c.	not connected
	3	ACLK+	measurement clock input, LVDS positive node
	4	n.c.	not connected
	5	n.c.	not connected
	6	ACLK-	measurement clock input, LVDS negative node
	7	SYNC+	synchronization signal input, LVDS positive node
	8	SYNC-	synchronization signal input, LVDS negative node

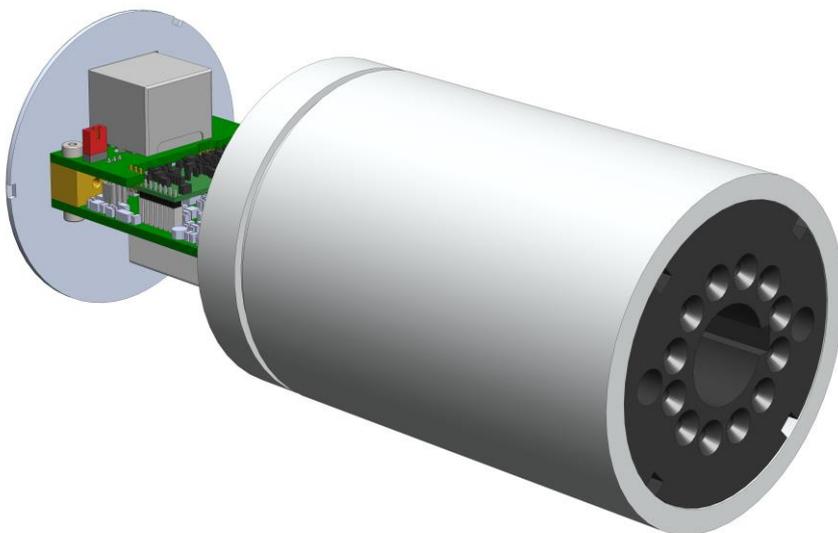


Figure 19 Location of the jumper JP1 (red)

3.4.5 SOFTWARE

WinSPEC is the recommended program to work with the Base527-SYNC. How the program works is described within the online help. The program can be downloaded for free from our internet page ([WinSPEC for Automation](#) or [WinSPEC for Inspectors](#)).

Within WinSPEC, the SYNC input is named as fast trigger.

3.5 BASE527 WITH 12 PIN SOCKET

All Base527 interface variants are also available with a 12pin socket

3.5.1 HARDWARE OVERVIEW 12 PIN SOCKET BASE527

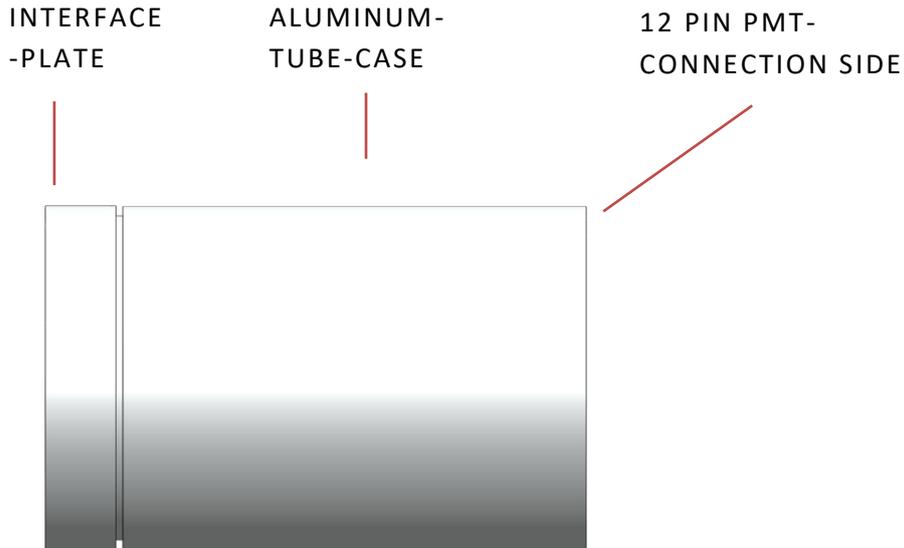


FIGURE 20: BASE527 12 PIN SOCKET VERSION SECTIONS (SIDE VIEW)

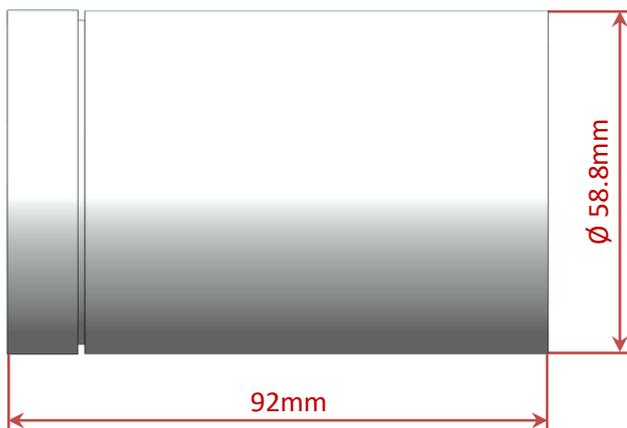


FIGURE 21: BASE527 12PIN SOCKET VERSION OUTER DIMENSIONS (SIDE VIEW)

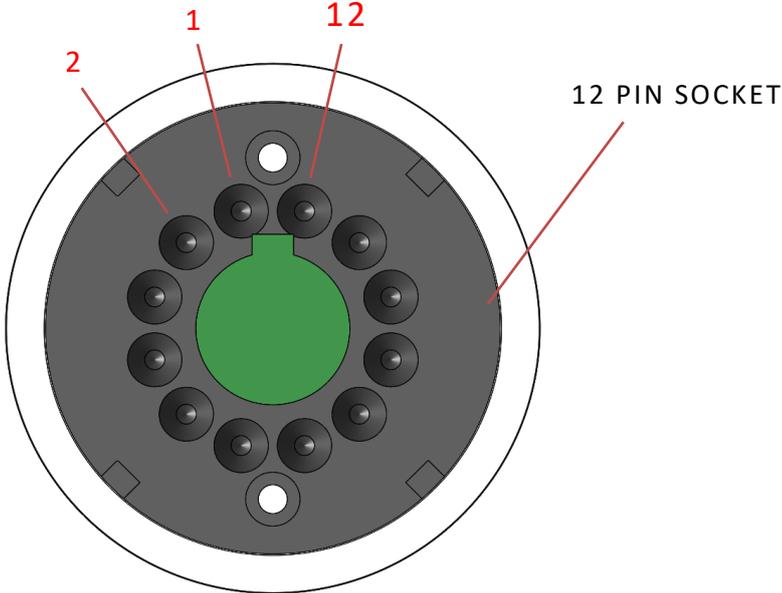


FIGURE 22: BASE527 PMT-DETECTOR CONNECTION (FRONT VIEW)

4. VARIANTS OF SOCKET CONNECTIONS

As there are different photomultipliers available there are different variants of the Base527 socket connection available. The following table shows some variations.

Other variants, upon request.

Variant name	R877p	C636A*	R1306p	R6231p	R6231-01p**	R9420	XP2060B	9102B	9102KSB
applicable PMTs	R877, 9305K, R6231-100, (R1306)	9305K	R1306, R1307	R6231, R6232	R6231-100-01, R6231-01	R9420	XP2060, 9102B	9102B	
socket / pin connection	B14	B14	B14	B14	B14	B12	B12	B12	B12A
K	14	14	14	14	14	12	12	12	12
G	13	-	13	13	1	-	-	-	-
D1	1	1	1	1	3	1	1	1	1
D2	2	2	2	3	4	11	11	11	11
D3	3	3	3	4	5	2	2	2	2
D4	4	4	4	5	6	10	10	10	10
D5	5	5	5	6	7	3	3	3	3
D6	6	6	6	7	8	9	9	9	9
D7	7	7	7	10	9	4	4	4	4
D8	8	8	8	11	10	8	8	8	8
D9	9	9	-	-	-	(5)	5	5	5
D10	10	10	-	-	-	(7)	7	7	7
A	11	11	11	12	11	6	6	6	6
component values									
R1	330k	330k	330k	680k	680k	1M	680k	680k	0
R2	330k	330k	330k	680k	680k	0	0	0	680k
R3	330k	330k	330k	330k	330k	330k	330k	330k	330k
R4	330k	330k	330k	330k	330k	330k	330k	330k	330k
R5	330k	330k	330k	330k	330k	220k	330k	330k	330k
R6	330k	330k	330k	330k	330k	220k	330k	330k	330k
R7	330k	330k	330k	330k	330k	220k	330k	330k	330k
R8	330k	330k	330k	330k	330k	220k	330k	330k	330k
R9	330k	330k	330k	330k	330k	220k	330k	680k	330k
3	330k	330k	330k	330k	330k	0	330k	1M	330k
R11	330k	330k	0	0	0	0	330k	1.3M	330k
R12	330k	330k	0	0	0	220k	330k	1M	330k
R13	1M	100k	330k	330k	330k	2.2M	2.2M	2.2M	2.2M
R14	10k	0	0	10k	10k	0	0	0	0
R15	1M	1M	1M	1M	1M	1M	1M	1M	1M
C1	-	-	10 nF	10 nF	10 nF	-	-	-	-
C2	-	-	10 nF	10 nF	10 nF	10 nF	10 nF	10 nF	10 nF
C3	10 nF	10 nF	10 nF	10 nF	10 nF	-	10 nF	10 nF	10 nF
C4	10 nF	10 nF	-	-	-	-	10 nF	10 nF	10 nF
C5	20 nF	10 nF	-	-	-	10 nF	10 nF	10 nF	10 nF
C6	4.7 nF	4.7 nF	4.7 nF	4.7 nF	4.7 nF	10 nF	10 nF	10 nF	10 nF
C7	4.7 nF	4.7 nF	4.7 nF	4.7 nF	4.7 nF	10 nF	10 nF	10 nF	10 nF

*depreciated, the variant R877p with pin13 connected is more universal and should replace it.

**The R6231-01 is a pinout variant of the R6231, used by Crismatec, the R1306p variant will also do.

Using a PMT with a wrong socket will normally not harm the PMT but may lead to no or too small signal output or deteriorated resolution.

For the B14 socket, the variant R877p may be the most universal one, as it will also work with the 9305k and the R6231, and possibly with a little bit increased voltage also with the R1306. The R6231/R6232 is incompatible with all others as it uses Pin 12 for output.

For the B12 socket, the XP2060B might be the most universal, but it might be inferior for 8 Dynode PMT's.

The list of PMT's on page22 is not comprehensive. For PMTs not mentioned here please request.

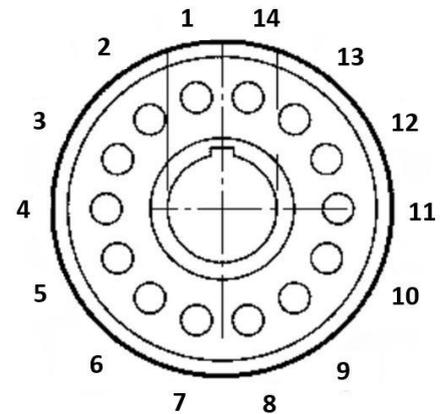


Figure23: Jedec B14 Pinout Base socket

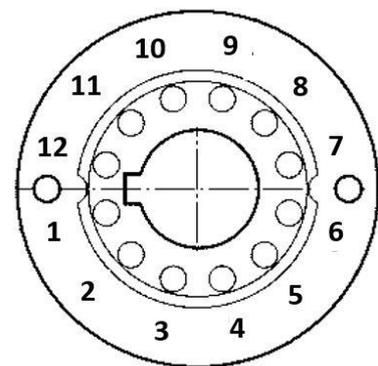


Figure 24: Jedec B12 Pinout Base socket

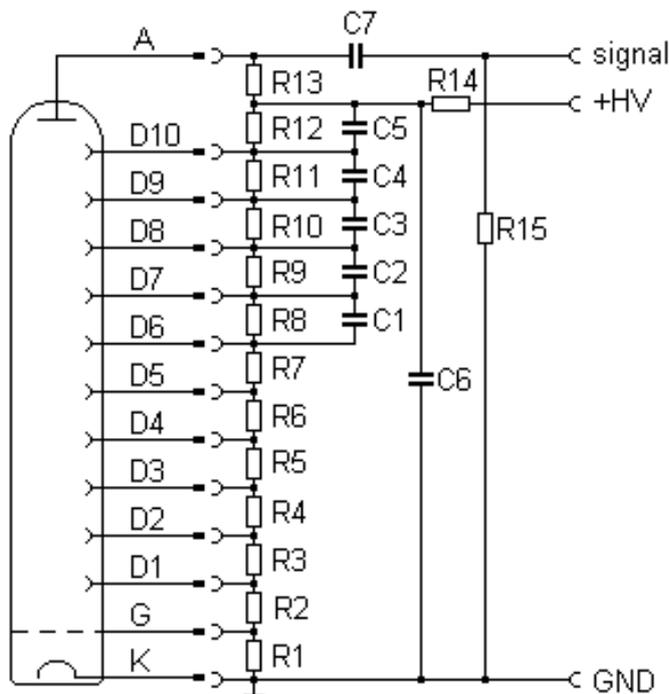
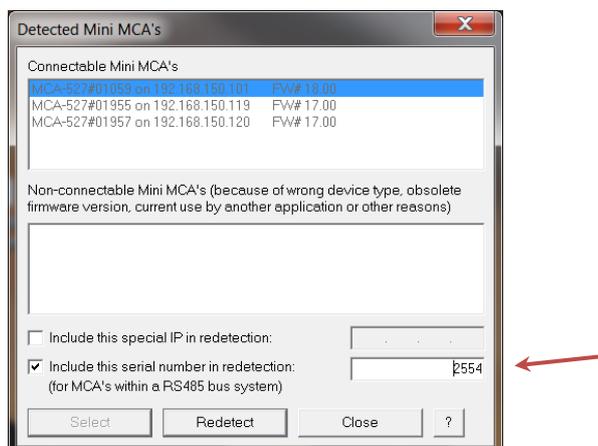


Figure 25: Schematic of the external 14-pin PMT wiring

5. GETTING QUICK STARTED

5.1 DETECTING BASE ON PC

1. **Install the WinSPEC software on your PC.** It is important to do this before the Base527 is connected with the PC, because required drivers being preinstalled during the software setup. The software is included in the delivery or can be downloaded from our homepage: www.gbs-elektronik.de.
2. Plug the **photomultiplier** into the Base527-module (if not done already)
3. **Connect the Base527 with your PC** and possibly with an external power supply. (see chapters 2.4 – 2.7)
4. **Start WinSpec**
The program starts with the detection of available MCAs. All detected MCAs are displayed in a list within the communication build up dialog. If your Base527 is listed, mark it and press "Select".
5. In case your Base527 is not listed, there can be several reasons for it.
 - If the Base527 is connected via Ethernet, it takes up to some minutes until the connection is ready to use. Wait and press "Redetect".
 - If the Base527 is configured for use within a RS485 bus system, the serial number must be included for the detection. Insert the serial number in the provided text box and press "Redetect".



**FIGURE 26: BASE527R WITHIN A BUS SYSTEM,
THE SERIAL NUMBER NEEDS TO BE ENTERED**

5.1.1 SETTING HIGH VOLTAGE

The high voltage must be adjusted according to the specifications of the detector manufacturer. To do so,

- Execute the menu command **"Setup" / "High Voltage"**.
- Insert the recommended value in the text box and press **"OK"**.

The high voltage can also be used to adjust the signal amplitude, if the signal does not fit to the ADC input range.

5.1.2 FURTHER PARAMETER SETTING

In the next steps, the configuration is adapted to the special characteristics of your PMT-detector, to your measuring sample and the task to be done.

- **Execute the "Setup"/"MCA ..." menu command.**
- **Select the channels number according to the resolution of your detector.** (It makes no sense to use a high channels number if the resolution of the detector does not yield that.) The other parameters of the dialog should remain unchanged.

- **Execute the "Setup"/"Amplifier ..." menu command.**

Note: To adjust the parameters of this dialog, you need a gamma reference source that is positioned in front of the detector.

First adjust the PZC (pole zero cancelation). For it,

- **Press "PZC adjustment" and subsequently press "Automatic PZC by offset minimization"** in the appearing dialog.

This starts a routine that tries to minimize the zero offset.

Now adjust the gain (represented by coarse and fine gain). The best way for the gain adjustment is to use:

- **"Visual amplifier adjustment ..."**.

Change the gain until the energy peak is on the intended position.

The other parameters of the amplifier setup should remain unchanged. The defaults guarantee a good measurement result. The measurement result can be optimized by changing the remaining parameters. To do so, **expert knowledge is needed**.

- **Execute the "Setup"/"Presets ..." menu command.**

The dialog allows presetting the stop condition for the measurement. If you want to use the ROI integral or area as stop condition, you must set a ROI within the spectrum diagram before. To set a ROI (Range of Interest), move the cursor (dotted line within the spectrum diagram) with the direction keys or the mouse pointer to the intended ROI begin. Press the shift key. Move the cursor to the intended ROI end. Release the shift key.

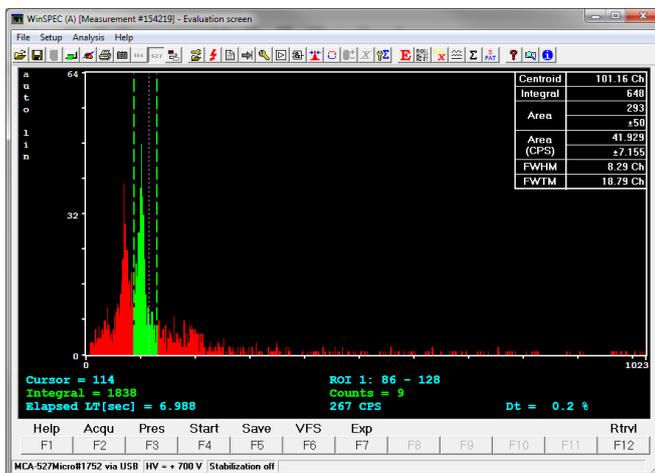


FIGURE 27: RANGE OF INTEREST MARKED IN GREEN WITH RELATED ROI VALUES IN THE UPPER RIGHT CORNER

- Optionally, the **"Setup"/"Stabilization ..."** menu command can be executed. Stabilization is useful for long measurements.

Read the online help of WinSpec for more information.

After you have completed the adjustment, the measurement can be started with the function key F4. Learn more by reading the online help of WinSpec and Chapter 6.

6. PULSE HEIGHT SPECTROSCOPICALLY MEASUREMENTS

6.1 INTRODUCTION IN TO DIGITAL SIGNAL PROCESSING

The main task of a multi-channel analyzer is to measure the height of voltage steps. In a conventional analog MCA, the voltage step is converted by a Gaussian bandpass filter into a pulse with several microseconds pulse width, a peak detector converts this to a DC voltage, which is then measured with a single conversion of an analog to digital converter (ADC). Typical there is also a fast channel, which converts the signal to very narrow pulses for counting, triggering, and rejecting events which are in too short time distance to be measured correctly (Pile up rejection, PUR).

In a digital MCA the input signal is digitized with a high sample rate, and the amplitude is calculated from a multitude of measurements. The Base527 samples the input signal with a 14-bit ADC and a rate of 10MS/s, this is one voltage measurement every 100ns.

Digital filtering with a finite impulse response (FIR) filter is now just multiplying the incoming train of measurement values with a fixed row of numbers and adding up all the results. This row of numbers is the digital filter. A signal processor is especially designed to perform such a task.

Also, with a digital MCA the signal processing is split up into a fast and a spectroscopical (slow) channel. A short trigger filter is applied to the incoming signal every 100ns, whereas the long spectroscopical filter is only applied if a valid event was found.

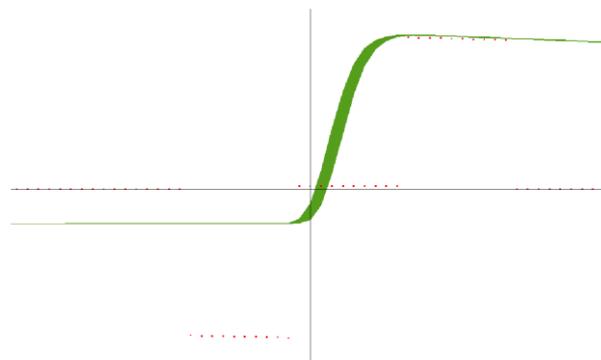


Figure 28: *Example of a digital filter applied to a voltage step.
Here: the flat top time $1\mu\text{s}$ ($10 \cdot 100\text{ns}$) and the shaping time $0.5\mu\text{s}$
($\approx 1\mu\text{s}$ rise time)*

The simplest method to measure the step voltage is to take one value before the step and one after the step and subtract them from each other. This would correspond to a digital filter looking like -1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1. But such a filter would be quite unusual as the accuracy of this would be rather bad compared to what is obtainable.

The main errors of an ADC are amplitude noise and timing error. So, for minimizing the errors, it is advisable to use more than one voltage value before and after the step for averaging, and to avoid using voltage values where the voltage is changing quickly. So typically, between 10 and 100 values before and after the rise are averaged.

This time over which the values are averaged is often found as rise time. This rise time is in effect comparable to the shaping time of an analog shaping amplifier, and comparable results are achieved if the rise time is twice the shaping time. For compatibility reasons, the Base527 uses still the term “shaping time” and the rise time is just twice as high as that.

Further the values near the voltage step are omitted from calculation. This parameter is called flattop. The above mentioned very simple filter would have a flattop of $0.8\mu\text{s}$ and a shaping time of $0.05\mu\text{s}$.

But there are more things to optimize a digital filter for and to be taken into account:

- A voltage step sitting on top of a previous step should be calculated to the same amplitude as if it was starting from the baseline. This correction is adjusted with the pole zero setting.
- The positioning of the filter has typically an accuracy not better than the sample rate, here 100ns. So, the filter should be adjusted such that the result is invariant to a shift of 100ns forward or backward. This correction is also derivate from the pole zero setting.

6.2 ADJUSTMENT AND SETTINGS

6.2.1 COARSE GAIN

For the Base527 Spectrometer series, there is one hardware-specific course gain level available. The adjustable levels in the software, for example Winspec, are created in the respective firmware. There are no real preamplifier levels present.

Which means, in case of an overflow, the reduction of the course gain level in the software won't have an effect.

6.2.2 FINE GAIN

The fine gain adjusts the gain and therefore the energy to channel ratio. This gain is just a mathematical factor used for calculation of the filter.

6.2.3 TRIGGER FILTER

The trigger filter is applied continuously to the incoming signal to check for events (voltage steps). The Base527 series have a double differential filter which is a very good compromise between good time resolution and sensitivity.

Trigger Filter Base527	Pulse Pair Resolution	Best Dynamic Range Possible	Lower Energy Cutoff in % of Full Scale
1, 0, -2, 0, 1	330ns	1:325	0.30%

6.2.4 TRIGGER LEVEL

The trigger level is normally automatically adjusted to 7 times the evaluated RMS noise level by default. This works fine for almost all tasks. However, a detector may exhibit non-Gaussian noise or there may be other high frequency disturbances around and therefore a reason to read just trigger level. Some software allows this.

Symptoms of too low trigger level are:

- There is an unusual high-count rate with some detector and no sources present
- Left of the normal spectrum cutoff there is a significant peak right at 0keV in the energy scale

If this noise count rate and the noise peak are annoyingly high, the trigger level may be increased. It may be increased just such high, that the noise peak disappears. Further increasing of the trigger level just increases the low energy cutoff unnecessary and impairs the ability to reject pile up with low energy events.

6.2.5 PILE-UP REJECTION

Pile-up rejection is to prevent the spectroscopical filter to be applied to events too close following each other to be evaluated properly. If there is another voltage step within the length of the filter, the energies are partially or fully added. Pile up is a problem getting increasingly worse with filter length and count rate. It can be easily seen as background right of a peak and sometimes as pile-up peak at exactly double energy.

Recognizing pile-up is task of the trigger logic. The ability to prevent pile-up depends very much on the time resolution, and therefore on the used trigger filter.

6.2.6 SHAPING TIME

The shaping time defines the length of the spectroscopical filter, or how many values before and after the voltage step are averaged to evaluate the pulse height. The shaping time is half the rise or integration time. So, for a shaping time of $1\mu\text{s}$ 20 values before and 20 values after voltage rise are averaged. Depending on the detector and its noise spectrum, very different values can be optimum for best resolution. A long shaping time eliminates a lot of high frequency noise but is more sensitive for low frequency noise.

The best shaping time to set depends also on expected count rate. For higher count rates a lower shaping time is useful, as pile-up probability and necessary processing power decreases with decreasing shaping time. Default value for shaping time is $1\mu\text{s}$.

6.2.7 FLAT TOP TIME

Flattop is a parameter introduced with digital multi-channel analyzers. Basically, this is adjusted to the rise time of the preamplifier in the detector module. Reason is that digitizing the amplitude can be done with quite high accuracy, down to 0.01% error. But the input bandwidth (3MHz) is rather high compared to the sample rate (10MHz), and so during the rise of the preamplifier signal, the value may change by 20% within 100ns and a timing jitter in this order may cause a significant error. Therefore, values where the signal is rapidly changing must not be used for evaluation.

This is adjusted with the flattop setting. As the signal to the ADC is bandwidth limited, there is a finite rise time of around 300ns even for infinitely fast rising signals, settling time may be twice as long.

If flattop setting is too high, the spectrum will become more sensitive to low frequency noise and resolution will degrade slowly. Below a certain setting, the spectrum will degrade very rapidly. Default value for flattop is 1.2 μ s.

6.2.8 POLE ZERO COMPENSATION

The pole zero correction is applied to make sure that a voltage step starting from the base line is evaluated with the same amplitude as signal sitting on the falling slope of a proceeding step. Without correction the slope is causing an error.

If the decay time constant of the signal is known, the slope can be easily calculated from the amplitude. In practical terms pole zero correction is achieved by adding a defined amount of DC from the input to the result. The pole zero value to be set is a value from 0...2499 It is reciprocal connected with the decay time constant by:

$$\tau = \frac{88650\mu\text{s}}{PZC}$$

For pole zero adjustment, go to the pole zero settings window of the software. There the spectroscopical filter is applied to the signal before and after a voltage step, but where the result should be zero. The difference between those both measurements is the pole zero offset and the results are averaged over 0.8s. The pole zero value has now to be adjusted such that the pole zero offset becomes zero.

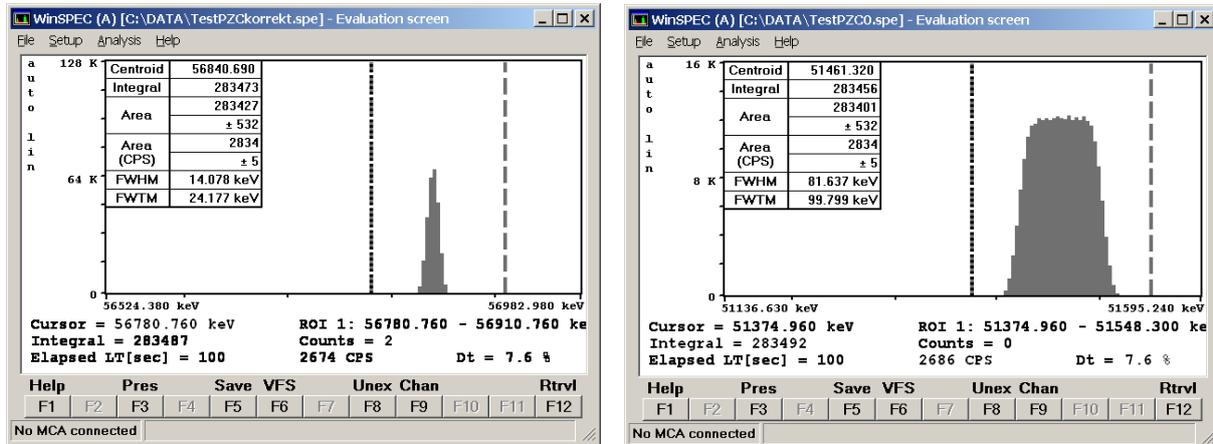


Figure 29: Measuring a periodic signal generator signal.

Left: Correct PZC setting and Jitter compensation.

Right: PCZ=0, no Jitter compensation, the jitter error gives a rectangular distribution.

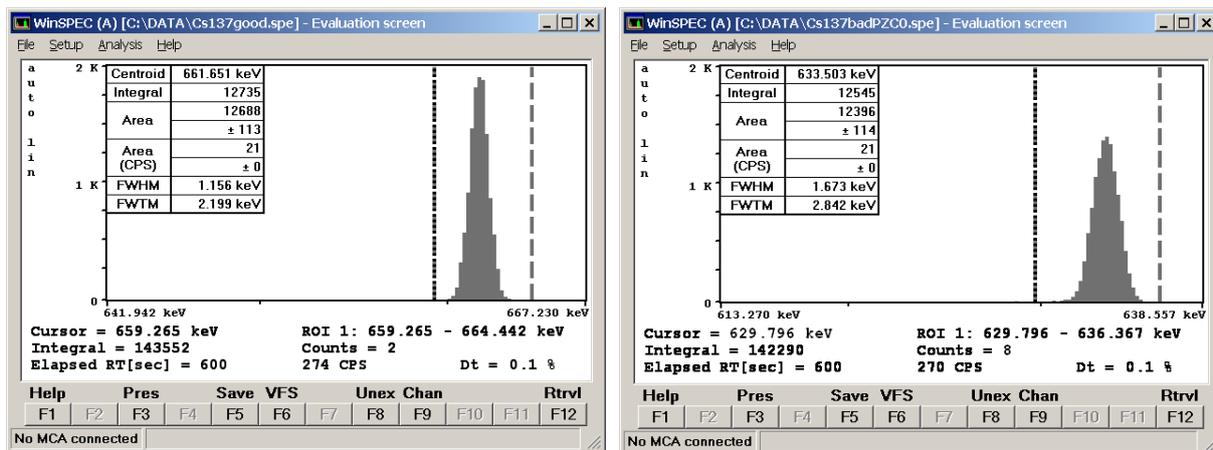


Figure 30: Measuring Cs137 with different PZC settings

Left: Measured Cs137 peak with correct settings. The calculated ratio of FWTM/FWHM is 1.91, which is reasonably close to the 1.82 expected from a gaussian distribution.

Right: Spectrum without jitter or PZC compensation. As the jitter error has a rectangle like distribution, the FWTM / FWHM ratio is significantly smaller here and resolution is generally worse. The wrong pole zero does not really affect as the count rate is very low.

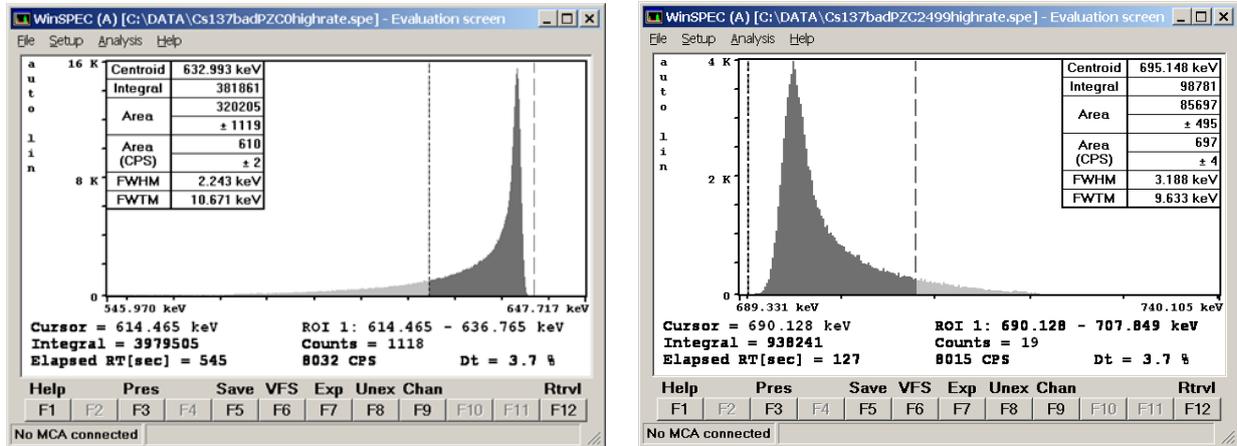


Figure 31: Measuring Cs137 with different PZC settings, jitter correction always on

Left: Wrong pole zero has the worst effect with higher count rates. Here the characteristic low energy tailing typical for under-pole-zero can be seen, and the count FWTM / FWHM ratio is very high.

Right: Too high pole zero setting causes tailing on the high energy side of the peak.

6.2.9 BASELINE RESTORING

A disadvantage of the conventional approach of pole zero compensation by adding a DC component is, that now the result becomes sensitive to DC and low frequency disturbances, Furthermore, it is desired that an energy of 0keV is found in channel 0 and the spectrum does not have an offset. This is corrected by the base line restorer. The baseline restorer applies the spectroscopically filter to the signal immediately before the event if possible, and this result for the baseline is subtracted from the evaluated value for the event. The disadvantage of this is that the baseline measurement has itself an error, which adds to the total error and leads to some peak broadening. As the baseline should not change too fast, it is possible to do averaging. At the Base modules the default value is fixed at 4.

6.2.10 NUMBER OF CHANNELS

The number of channels the spectrum is distributed to can be chosen between 128 and 4096 (4k). The setting depends mainly on the connected detector. If the setting is too low, details of peaks may not be seen, if the setting is too high, the statistics for a single channel is bad so the spectrum looks very noisy and of course storage of the spectra takes more space. Default is set to 1024

6.2.11 LLD / ULD

The LLD / ULD settings (lower level discriminator, upper level discriminator) determine, which part of the spectrum is counted. This setting is most useful in MCS mode for taking time dependent rate for a special part of the spectrum. In PHA mode, typically the full spectrum is counted.

Default setting for LLD is 0, for ULD it is the resolution - 1; e. g. for a 4k resolution this is 4095.

6.3 MEASUREMENTS WITH STABILIZATION

Stabilization is an option if the gain of a detector system is not fully stable. It allows to adjust fine gain during a measurement to keep a certain peak in the spectrum at its place.

Stabilization is mostly used with temperature sensitive detectors such as NaI and for long term or series measurements.

For stabilization, a peak must be selected from spectrum, which

- should be always present
- should be significant and not disturbed by other peaks
- is preferably in the upper part of the spectrum.

Typically, peaks used would be the K40 peak (1460.5keV) which is always present in background, Am241 peaks, (gamma or alpha) as Am241 as source is sometimes integrated with NaI detectors, or a peak generated by LED light pulses, as present in special NaI detectors.

For selecting a peak, a stabilization ROI must be selected, and a centroid to which to stabilize a peak.

The stabilization area defines the minimum counts in the stabilization peak collected in a stabilization cycle before the fine gain is readjusted. The optimum value depends on the peak FWHM, peak count rate and peak drift rate. If the drift rate is high, then a rather low stabilization area is good to adjust the fine gain frequently. If drift is rather low a high stabilization area is better as then the centroid is calculated more accurate. Practical values are between 1000 and 25000. A formula to estimate the optimum area N_{opt} setting is given here¹:

$$N_{opt} = \left(\frac{FWHM \cdot n}{2 \cdot 1460 \text{keV} \cdot 5 \cdot 10^{-6} \text{s}^{-1}} \right)^{\frac{2}{3}}$$

FWHM = expected width of the stabilization peak in keV

n = peak area count rate

E = energy of stabilization peak in keV

ϑ = expected drift rate for the energy calibration.

¹Jörg Brutscher, "Behavior of the MCA 166 at different Temperatures and Gain settings and limits of centroid accuracy", internal report 2001

6.4 MEASUREMENT TIME PRESETS

For non-infinite measurements, the Base527 offers 4 choices to limit the measurement time.

Real Time

The simplest method. The measurement will take as long as the time given. This is also the choice if doing repeat measurements.

Live Time

Often chosen if quantitative evaluation of the spectrum is done. Very similar to real time, only with high count rates live time measurements will take a bit longer than real time measurements, as live time is the real time with the dead time subtracted.

Integral

The measurement will continue until a certain number of counts in the spectrum or in a ROI are achieved. This is a choice if a certain statistic is needed in a spectrum.

Area

The measurement will continue until a certain net area of a peak is reached. This is a choice if the area of a distinct peak has to be measured with a defined accuracy.

6.4.1 DEAD TIME CALCULATION

Dead time calculation is a crucial task when doing high rate measurements and still expecting accurate quantitative measurement results.

Dead time with MCA527 has several components. At first there is the limited pulse pair resolution of the trigger filters. The pulse pair resolution (the minimum time distance between two subsequent events which is needed to count them separately) depends on trigger filter and must be found out experimentally.

Next is the time interval which corresponds to the length of the digital filter within which no other pulses are tolerated for correct calculation. Here different subsequent pulses can be distinguished but are rejected as pile-up.

Also, the time where the input signal is out of range must be considered as dead time. At last, also the time where the processor is busy with other tasks and cannot process events is dead time.

6.4.2 REPEAT MODE

Repeat mode is basically a feature realized by software. It comprises just starting a new measurement after the previous one has finished. Number of repetitive measurements are determined by application software.

A problem for some tasks however can be that the spectrum must be transferred to the computer before the next measurement is started. As this takes some time it may not be tolerable to some tasks, especially if measurement time is very short. For that, there exists the firmware repeat mode which allows to start immediately the next measurement while transferring the data of the previous spectrum simultaneously.

6.5 MULTICHANNEL SCALING (MCS)

This mode is for semi-automated measurements of time distributions. The software used for this is WinMCS.

It allows to measure a time distribution of count rates, and in case of a spectroscopical detector, measurement of an integral spectrum at the same time.

Input can be set to the following:

- Input rate (corresponds to the fast count rate of MCA measurements)
- LLD/ULD (corresponds to the content of a partial region of a spectrum, defined by the lower end LLD and the upper end ULD).

6.6 OSCILLOSCOPE MODE

Oscilloscope mode is in WinSPEC-A a sub-menu of the amplifier settings menu. Its main purpose is troubleshooting; so, without the necessity of an extra oscilloscope it can easily be seen, if there is a preamplifier signal present, and if it fits correctly to the MCA signal input. Compared to a regular oscilloscope, the bandwidth is with 3MHz and 10MSps rather limited, but the noise level is extremely low and measurements down to the μV level are possible.

6.7 INTERNAL TEMPERATURE

The Base527 spectrometer series have an onboard temperature sensor to log the operation temperature of the MCA. Main purpose of this is troubleshooting and quality control in case of remote measurements. This internal temperature is shown in the diagnostics menu and it is written in saved spectrum files. It is typically 9°C higher than the environmental temperature because of self-heating effects.

7 SOFTWARE

7.1 OVERVIEW

The following sections give a brief description of our applications. You can find more detailed information on the USB-stick delivered together with the device. You should also use the online help for each program.

7.2 WINSPEC

This program is the default program for measuring spectra. It supports semi-automated measurements of gamma ray spectra with the MCA. The spectra are stored on mass storage media on a computer. There are two variants of WinSPEC. WinSPEC-I (for Inspectors) was designed for standard use. WinSPEC-A (for Automation) was designed for unattended measurements. Special features of WinSPEC-A are:

- Automatic restart of the program after loss of mains power, program or operating system crash
- Writing zip files
- Data file retrieval to a flashcard
- Archiving of data files
- Writing a log file

7.3 WINMCS

This program supports semi-automated measurements of time distributions. There are two variants of WinMCS. WinMCS-I (for Inspectors) was designed for standard use. WinMCS-A (for Automation) was designed for unattended measurements. It contains the same special features as WinSPEC-A.

7.4 WinU235

These programs support stabilized U235 enrichment verification measurements. The algorithm bases on absolute intensity measurement of the 186keV photon energy. It also needs a two-point intensity calibration with two standards.

Reevaluation / recalibration using previously recorded spectra is possible. Verification results are documented in a report file, which is automatically saved with the extension *.rep.

7.5 WinUF6

SimilarWinU236. Only one intensity calibration measurement is necessary.

7.6 MCA Touch

Software made for safeguards purposes. The focus here is on usability and support of computers with small touchscreens and pocket computers.

7.7 AUXILIARY SOFTWARE FOR ANALYSIS, PRESENTATION AND MISCELLANEOUS FUNCTIONS

7.7.1 IDENTIFY

Identify is an intelligent, interactive software tool to evaluate spectra. It does peak search and nuclide identification. HPGe, CdZnTe and NaI detector gamma spectra are supported. For correct peak search a starting point for the detector resolution and efficiency is assumed based on detector type and size. Features are:

- includes full master library of gamma lines (derived from table of radioactive isotopes)
- editor for creating application specific evaluation libraries
- detector function is calculated from detector data sheet, no efficiency calibration needed
- automatic determination of FWHM of the peaks found in a spectrum as function of energy
- supports 1 to 3-point energy calibration
- linear, logarithmic, square root, and double log representation possible
- error estimations/confidence assessment for identified isotopes and visualization (by overlay of calculated spectrum for a certain isotope)
- switching between English and German languages
- interactive nuclide pattern identification
- nuclide assignment suggestions also for each single peak
- instant graphical comparison to simulated spectra by clicking on a nuclide
- Windows 3.1 version also available
- IDENTIFY is not included in the MCA price
- IDENTIFY routines are also available as library for MS Windows and Linux

7.7.2 MCA PLOT AND MCA PRINT

MCA Plot and MCA Print are programs to view and print spectra. Up to 32 spectra can be viewed at the same time and be printed on one page. Also, some evaluation functions are available. MCA Plot is not included in the MCA price. MCAPrint is a free downgraded version of MCA Plot.

7.7.3 MCA WAND

MCA Wand is a program for converting different file formats. Please note that there may be always a loss of information as not all kind of information about the spectrum is supported by every file format. The following information is converted:

- Channel Data
- Energy Calibration
- Energy Calibration points
- Live time, Real time
- Date and Time of measurement
- Spectrum Remark

The following file formats are supported for reading and writing:

Table 2: Supported file formats by MCAWAND

Source	Target
*.spe (MCA166 native)	*.spe (MCA166 native)
*.chn (Ortec)	*.chn (Ortec)
*.spe (Interwinner)	*.spe (Interwinner)
*.spc (Target)	
*.dat	*.dat (2 column: energy, channel content)
*.de1 (Canberra S100)	
*.dat (Silena Gamma 2000)	
*.spk (Röntgenanalytik)	
*.spa (Sarad)	
*.usf (URSA)	

7.8 MISCELLANEOUS

For communication and evaluation some libraries for MS Windows and Linux are available. This may help to make own application programs or to integrate the MCA527 into an existing system.

8. SOME OF THE MOST IMPORTANT PHOTON ENERGIES

ISOTOPE	HALF-LIFE	ENERGY (KEV)	BRANCHING RATIO (%)
Am241	432.2y	26.34/59.54	2.4/36
Cd109	462.6d	88.03	3.63
Bi214	19.9min, daughter of Ra226	609.31	46.09
Ce139	137.64d	165.86	79.87
Co60	5.271y	1173.23/1332.49	99.85/99.98
Co57	271.8d	14.4/122.06/136.47	9.16/85.6/10.68
Cs137	30.07y	661.66	85.1
Eu152	13.3y	121.77/344.28/778.91/ 964.11/1112.07/1408. 00	28.38/26.59/12.98/14.46/ 13.57/20.85
Hg203	46.61d	279.19	81.84
Mn54	312.2d	834.82	99.98
Pb214	26.8min, daughter of Ra226	241.91/295.09/351.86	7.46/19.17/37.06
Ra226	1600y	186.11	3.28
Sn113	115.09d	391.7	64.89
Sr85	64.84d	514.0	98.4
U235	7.04E8y	143.78/163.37/185.73/ 205.33	10.53/4.7/53.15/4.7
Y88	106.65	898.04	94
Pb fluorescence x-rays	-	74.96/72.79/84.99/ 87.34	

TABLE 3: PHOTON ENERGIES FOR DIFFERENT ISOTOPES

9. TECHNICAL SPECIFICATION

PHOTOMULTIPLIER TUBES	
<ul style="list-style-type: none"> ✓ All PMTs for the JEDEC B14A socket can be adapted (like the Hamamatsu R6231, R1306) ✓ 12 PIN socket 	
SPECTROMETRIC PERFORMANCE	
<i>Example:</i> Resolution: 2k channels measured with NaI Detector Size: 63mm x 63mm	(FWHM) @ 662keV <5.8 %
Throughput into memory (input rate 150kcps, 0.2µs shaping time)	>100.000cps
OPERATION MODES	
PHA (Pulse Height Analysis)	✓
MCS (Multichannel Scaling)	✓
Sample Mode (Transient Record)	✓
Oscilloscope Mode	✓
Firmware Repeat Mode	✓

DIGITAL SIGNAL PROCESSING	
Trigger Filter	double differential filtering
Differential non-linearity	<1% (for 2k, @ 1 μ s shaping time)
Pile Up Rejection	✓
Pulse Pair Resolution	~400ns
Trigger Threshold Adjustment	automatically / manually
Shaping Time	0 μ s to 2 μ s, step 0.1 μ s
Flat Top Time	0 μ s to 15 μ s, step 0.1 μ s
Fine Gain Adjustment	0.5 to 6.5, step 0.0001
Channel Splitting	128, 256, 512, 1024, 2048, 4096
Base Line Restorer	BLR with fixed averaging
Pole Zero Adjustment	Decay time down to 40 μ s can be compensated
Peak Stabilization Mode	✓
AMPLIFIER UNIT	
Amplifier Type	Charge sensitive preamplifier for photomultiplier tubes
Integrated bias supply	0V to +1000V, (negative polarity on request)
Gain Steps	10, 50
Input -and bias voltage monitoring	✓

ANALOG DIGITAL CONVERTER	
Sample Rate	10MS/s
Resolution	14bit
Integral non-linearity	≤ 0.05%
POWER SUPPLY	
Base527	- via USB PC-Port, ≤500mA
Base527E	- Power over Ethernet ≤ 2W - USB PC-Port ≤ 500mA - USB wall-adapter ≤ 500mA
Base527R	- LEMO ² Pin 4 → 8V ≤ VCC ≤ 25V Pin 5 → GND - via USB PC-Port, ≤500mA
Power consumption (device running, without detector, HV off)	0.4W* <small>*(depends on interface)</small>
COMPUTER INTERFACE	
Base527	USB 2.0 compliant
Base527E	- Ethernet 10/100Mbit, RJ45 - USB 2.0 compliant
Base527R	- RS485 up to 3Mbit/s (half or full duplex) - RS485 → USB adapter (on request) - USB 2.0 compliant
WEIGHT & DIMENSIONS (∅ x L)	
Base527	72.1 x 100mm ~400g
Base527E	72.1 x 100mm ~400g
Base527R	72.1 x 110mm ~400g
ENVIRONMENTAL CONDITIONS	
Operation Temperature Range	0°C – 50°C
Humidity	≤90%, non-condensing
IP Protection Class	IP20

² see LEMO pinout, Chapter 3.2.2.2

10. TROUBLESHOOTING

General Remark:

Before changing anything concerning the hardware, plugging or pulling cables etc. shut down the high voltage.

Soldering or manipulating with the SMD boards is strongly not recommended for users. We have specialists for that. If you have a problem which cannot be solved by the table below, contact us. If it is really a hardware fault, we repair this for a fair price.

1. Software tells "MCA not connected!"
 - Check cable between MCA and Computer. Cable may be loose or not connected. Connect cable correctly
 - Try another cable.
 - Try another interface

2. The threshold of the spectrum seems to be much higher than expected.
 - If the lower cutoff rises by itself, this is most probable caused by the auto threshold circuit which is responsible for detecting the noise level and adjusting the threshold to it. Check for excessive noise in the system.

3. The high energy part of the spectrum is reduced or even missing .
 - Check if the behavior changes if the pile up rejector is switched off. Check the signal from the preamplifier. If the preamplifier signal rise time is slower than 500ns, then there is the danger that regular pulses (especially the large ones) are misinterpreted as pile-up. The same may happen if the preamplifier signal exhibits overshoot or ringing.

4. Dead time shown is very high although the count rate is low.
 - Count rate may be extremely high so that the MCA is overloaded.
 - Electronic noise in the system.

5. While opening a spectrum, the MCA program tells "Wrong data format" or "data format error"
 - spectrum was created by another program or another program version. Check results just ignore.

6. Too high-count rate
 - Keep a bigger distance to radiation source.
 - Check for disturbances of switch mode power supplies etc.

11. FIRMWARE UPDATE

GBS Elektronik maintains the firmware of the MCA527 continually. We improve the performance, add new features and fix bugs that have been known. In order that all MCA527 users can participate in the improvements, we provide the newest releases of the firmware on our download page in the internet.

The firmware of the MCA527 can be changed easily by yourself.

You only need the GBS Firmware Loader and the firmware file that suits to your MCA527. Both can be download from our internet page.

There are different variants of the MCA527 (Full, Lite, OEM and Micro) with different hardware versions. If you are unsure about the variant and the hardware version of your MCA527, look for this information within the diagnostics dialog of, for example, WinSPEC.

When all preparations have been completed, start the GBS Firmware Loader. You will be prompted to load a suitable loader file. After the file has been loaded, the button "Select device ..." is enabled. Press this button to search for devices. If your MCA527 is within a RS485 bus system, you have to input the RS485 address. The next dialog lists all detected devices. If all working steps have been done correctly, your MCA527 should appear within the list of the applicable devices. Select your MCA527 and start the firmware upload. It is recommendable to check the "Verify uploaded firmware" option.

A MCA527 ALGORITHM, FORMULAS

This appendix lists the algorithms used by the MCA for the following functions:

- Area, Area uncertainty
- Centroid
- FWHM
- Smooth
- Strip
- Energy Calibration

The Area and the Area Uncertainty Function:

The area algorithm calculates the number of counts above the background in a ROI. The background area is determined by averaging 4 points on both sides of the peak (the ROI limit points and 3 outer points) and linear fit:

$$\text{Area} = \text{Integral} - \text{Background}$$

$$\text{Background} = \frac{ROI_{end} - ROI_{begin} + 1}{8} \left(\sum_{i=ROI_{begin}-3}^{ROI_{begin}} \text{Spectrum}_i + \sum_{i=ROI_{end}}^{ROI_{end}+3} \text{Spectrum}_i \right)$$

$$\text{Integral} = \sum_{i=ROI_{begin}}^{ROI_{end}} \text{Spectrum}_i$$

$$\text{Area Uncertainty} = \sqrt{\text{Integral} + \left(\left(\sum_{i=ROI_{begin}-3}^{ROI_{begin}} \text{Spectrum}_i + \sum_{i=ROI_{end}}^{ROI_{end}+3} \text{Spectrum}_i \right) \left(\frac{ROI_{end} - ROI_{begin} + 1}{8} \right)^2 \right)}$$

Where

- Spectrum_i = the absolute number of counts in channels i
 ROI_{begin} = the ROI's start channel
 ROI_{end} = the ROI's stop channel
 i = channel number

Centroid:

The peak centroid is the sum of the channel contents³ times the channel number divided by the sum of the channel contents in the range of the channels above the half maximum:

$$Centroid = \frac{\sum_{i=l}^h i \cdot Spectrum_i}{\sum_{i=l}^h Spectrum_i} \text{ where}$$

i = channel number

l = lowest channel above the half maximum

h = highest channel above the half maximum

$Spectrum_i$ = net contents of channel i

FWHM:

The Full Width at Half Maximum (FWHM) is the background corrected peak's width at one-half of its maximum amplitude. The algorithm first proceeds down one side of the peak until it finds a channel (e. g. 1203) whose counts fall below the half maximum channel. It is now made sure that the following channel (e. g. 1204) also falls below the half maximum channel. The same algorithm is applied for the other side of the peak. The left and the right FWHM points are the interpolated channels between the counts of the channel below and above the half maximum value.

Smooth:

Smooth averages the current spectrum (the original data will be overwritten) using a binomial formula:

3-point smoothing:

$$Spectrum'_i = \frac{Spectrum_{i-1} + 2 * Spectrum_i + Spectrum_{i+1}}{4}$$

5-point smoothing:

$$Spectrum'_i = \frac{Spectrum_{i-2} + 4 * Spectrum_{i-1} + 6 * Spectrum_i + 4 * Spectrum_{i+1} + Spectrum_{i+2}}{16} \text{ where}$$

$Spectrum_i$ = the original contents of channel i

$Spectrum'_i$ = the smoothed contents of channel i

³ background corrected

Strip:

Strip subtracts a specified fraction of the spectrum. The Strip factor can be “positive” or “negative” :

$$Spectrum'_y = Spectrum_y - F * Spectrum_x \text{ where}$$

$Spectrum'_y$ = Count content of channel i in the resulting spectrum

$Spectrum_y$ = Count content of channel i in the original spectrum

$Spectrum_x$ = Count content of channel i in the spectrum to be subtracted

F = Strip factor

E-calibration:

The Energy calibration allows to convert the x-axis channel numbers into energy values in KeV. The following formula is used:

$$E = S * Channel + O \text{ where}$$

S = slope

O = offset

$Channel$ = channel number

The coefficients can be set as numeric values or by linear fit of two energy channel/peak centroid pairs.

B FURTHER DOCUMENTS

The further documents are not intended for ordinary users but for developers and users which need more information about the MCA527. The further documents do not exclusively refer to the MCA527.

- MCA Spectral Data Format
MCA_Spectral_Data_Format_XXXX_XX_XX.pdf
- Description of the MCA527 Firmware Commands
MCA527_Firmware_Commands_XXXX_XX_XX.pdf
- Description of the MCA Communication DLL
MCA_Communication_DLL_XXXX_XX_XX.pdf
- Use of MCA User Data Memory by Specific Applications
MCA_User_Data_XXXX_XX_XX.pdf
- Description of the MCA527 Oscilloscope Mode
MCA527_Oscilloscope_Mode_XXXX_XX_XX.pdf
- MCA Binary Data Format
MCA_Binary_Data_Format_XXXX_XX_XX.pdf