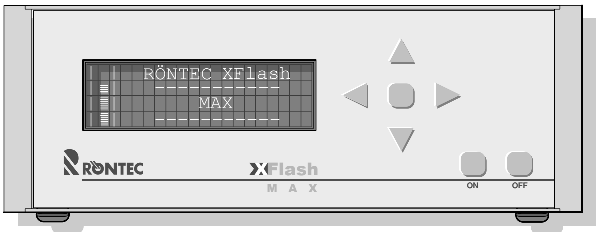
RÖNTEC MAX
Spectrometer

Operator's Manual



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Contents

1. Overview

The RÖNTEC MAX Spectrometer Unit complements the detectors of the RÖNTEC XFlash® Series to provide complete X-ray spectrometers. The MAX Spectrometer Unit comprises

- *the supply circuits for detector and preamplifier,*
- *a display and control unit for detector cooling (thermostat),*
- *a spectroscopy amplifier,*
- *a fast analog-digital converter (ADC),*
- *a spectra or data memory with signal processor (MCA),*
- *rate counters and timers, as well as*
- *a serial command and data interface.*

The built-in spectroscopy amplifier shapes and filters the output pulse signals of the energy-dispersive detector. The digital values supplied by the ADC are combined to spectra (MCA function) or made available through a buffer memory for further processing. A number of additional functions like timers and rate counters support analysis data acquisition. The acquired spectra, count rates, and other data can be queried via a standard interface (RS232/V24) or the proprietary RÖNTEC MegaLink.

The acquisition process and operating modes can be controlled through this interface as well. The flexible command syntax and the powerful device functions facilitate inclusion in user-own program systems. An optional Windows-software is available, which manages spectra acquisition and storage as well as a number of control functions, using dialog elements and the DDE interface.

The components of the RÖNTEC MAX Spectrometer Unit are contained in a small standard electronics case. The rear panel of the unit carries connectors for detector, interface, power supply, and others, as well as a number of controls. Many settings and operations can be carried out directly on the device, using the built-in display and the front-panel keypad. This is especially useful if the spectrometer unit and the data acquisition system are separate and far apart, or if the acquisition program used does not provide appropriate control elements.

The MAX Spectrometer (including detector) can be supplied by a low voltage DC supply (e.g. for mobile use) or by any common local mains, using the universal power supply adapter provided.

2. Principle of Operation

2.1 Detector Supply

The detector supply circuit is designed for operating a detector of the RÖNTEC XFlash® Series. The detector is connected through the rear panel 15-pin DSUB connector. The detector connectors are common to all RÖNTEC XFlash® products. Nevertheless, there are differences in the detector supply voltages (±15 V ... ±24 V) and in the permissible current for the Peltier cooler (typically 0.8 ... 1.6 A).

The RÖNTEC MAX Spectrometers provide a detector supply voltage of ±19 V. This permits operation of all newer XFlash® detector types (for older versions see section 3.1). The maximum cooler current can be set between 0 and 2 A through an internal control.

> **Caution!!** *It is a stringent necessity that the selected settings are in agreement with the data on the detector label.*

The cooler current supply circuit permits automatic detector temperature control (thermostat operation). The desired detector temperature can be set via the according rear panel control. The detector chip temperature reported by the detector unit and the momentary cooler current are shown on the device display. The operational principle of the detector cooling and the adjustment procedures are described in detail in the according detector reference manual.

An auxiliary voltage (12 V, connector FAN) is provided for detectors with fan-forced cooling.

2.2 Spectroscopy Amplifier

The spectroscopy amplifier further amplifies and processes the already preamplified detector output signals.

A fast event detector triggers on all incoming pulses and starts a control sequence as well as a rate counter (input rate counter). The shaping amplifier with Gaussian shaping and pole-zero-compensation (PZC) filters the detector and preamplifier noise off as much as possible and feeds the shaped signal to a spectroscopy grade analog-to-digital converter (ADC). One of four different measurement ranges (conversion ranges of the ADC) can be selected.

A gated base-line restorer (BLR) stabilizes the baseline of the shaping amplifier output. A so-called pile-up rejector (PUR) is employed to exclude superimposed or otherwise distorted signals from further processing. The pulse processing is also gated off for a set protection period (reset dead time) after a detector reset is detected, in case a detector with pulsed charge-reset is used.

The accepted pulses digitized by the ADC are passed on to the digital signal processor that - for example - accumulates the individual values to spectra.

The number of accepted pulses for spectra acquisition in a given time forms the usable count rate, which is measured by the output count rate meter. The current dead time shown on the display is calculated from the difference between output and input count rate.

Test connectors allow checking of the input signal (detector signal), the shaper output signal, and a number of control signals using an oscilloscope. The rear panel controls can be used to adjust gain and offset of the acquired spectrum. Additional controls permit setting of trigger thresholds, internal processing times, and compensation factors. The factory settings are optimized for the XFlash® Detector. In case that additional adjustment should be required, a special reference manual for the spectroscopy amplifier can be provided at request.

☞ **Note:** *Changes to these settings should only be done by experienced users or by service personnel provided with according testing equipment.*

2.3 MCA

The multi-channel analyzer (MCA) integrated in the digital signal processor acquires spectra in 4,096 channels with 32-bit depth each. As an option, the MCA memory can also be used as a buffer memory (FIFO), in which data are stored in the order of their occurrence. A display similar to that of an oscilloscope can be achieved in combination with the zero peak generator (see Appendix D). This is useful for many testing purposes (e.g. examination of interfering signals).

The acquisition process is controlled either via command interface or through the device's front panel keypad. Counters and timers permit an acquisition-time or pulse-count pre-selection. The acquired spectra or data can be read in different modes via the data interface.

2.4 Rate Counters

Two rate counters, which measure the input and output count rate, have been implemented. An additional counter (total output counter) provides the total number of data events acquired during the acquisition time. The current dead time is calculated from the difference between the counter values (for details refer to Appendix D).

The input count rate and the dead time are shown on the display (the latter in units of percentage of real time). The current values of the input and output rate counters can be queried through the interface.

Input and output rate counters use a common gate time, which can be adjusted per command or front panel keypad.

2.5 Multi-purpose Interface

The multi-purpose interface can be used to output control signals for driving signal lamps, shutters, or similar, and for the input of switching signals. The output signals can be set and the input signals can be queried via command, at any time. The signals are additionally shown on the display and can be toggled through the device keys.

2.6 Flash-EPROM

The RÖNTEC MAX Spectrometer is equipped with a non-volatile memory (Flash-EPROM), which can be used to store all current device settings permanently. These settings are reloaded automatically after the device is powered on again. The updating of the Flash-EPROM can be invoked through either command or key operation.

A free memory area of the Flash-EPROM can be used to store arbitrary data (e.g. calibrations, acquisition parameters, correction factors) permanently via the interface.

2.7 Data and Command Interface

All functions can be controlled through an uniform serial interface. This interface is also used to query the acquired spectra or data.

The serial standard interface can be operated with baud rates up to 230 kBaud, providing sufficiently fast spectra transfer for many purposes. Selection of an appropriate transfer mode and spectra compression features help reducing transfer time even further.

The device always defaults to 38,400 Bd after power on. The baud rate can be switched per command after the communication has been established. The optional RÖNTEC MegaLink interface has a fixed baud rate of 20 MBaud and features – apart from the very high speed - complete decoupling of the ground voltages of the measuring system and the connected computer.

2.8 Console

The console consists of an alphanumeric display and a group of front panel keys. The display shows current settings and operating conditions (count rates, dead time, etc.). This display can be browsed and a number of entries can be made using the keys.

3. Starting-up

3.1 Connecting the Detector

Beware!! *Only RÖNTEC XFlash® series detectors can be operated on this detector interface. Connecting a RÖNTEC Si(Li)-Detector can lead to serious damage.*

The detector is connected through the rear-panel DSUB-15 connector. Connection cables are available in lengths of 1.5 m or 5 m, respectively.

Beware!! *Connecting or disconnecting the detector must only be done with the device switched off. Allow at least 1 min after switching off for discharge.*

The supply voltage for the detector is ±19 V. Older XFlash® Detectors in ±15V-technology cannot be run with the MAX Spectrometer (but can be upgraded accordingly by RÖNTEC). The factory setting for the maximum cooler current (in most cases 0.8 A) is stated on the device rear panel. This value should be compared to that on the detector label.

The fan connector found on detectors with fan-forced cooling is to be connected to the socket FAN on the device rear panel, using the LEMO-cable shipped with the detector. (Note: The XFlash® Detectors‘ fan coolers are temperature controlled and may start only after a longer Peltier cooler operating period .)

3.2 Voltage Supply

The RÖNTEC MAX Spectrometer is run from a 24 V DC supply (approx. 20 W, including detector and cooling). The supply voltage is to be applied to the coaxial standard connector on the device rear panel (center pin connects to the positive pole). The universal power supply adapter included in the shipment can be used to run the device on all common local AC mains supplies (100 ... 240 V AC).

Note: The power supply adapter provided does not ground the spectrometer. If the detector is mounted insulated (recommended) and the interface connection provides no grounding either (for instance if connected to a laptop computer) interference or electrostatic damage due to the floating ground condition may occur. In order to prevent this, connect the device to a suitable grounding point (measuring earth conductor, installation chassis ground, etc.), using the rear panel grounding connector, if no other grounding is provided.

Unfavorable grounding conditions (e.g. ground loops) may affect the energy resolution adversely.

3.3 Interface Connection

The serial control and data interface meets the RS232 (V24)-Standard and is compatible to the serial interfaces on all modern personal computers. The socket layout is of the 9-pin modem-type. A common serial modem cable (*no* null modem cable) can be used for connecting the PC and the RÖNTEC MAX Spectrometer.

The optional RÖNTEC-MegaLink interface requires an according RÖNTEC MegaLink plug in card to be inserted into one of the expansion slots of the computer. Connections over distances of up to 30 m can be made using a standard Cat. 5 network cable.

4. Operation

4.1 Interface Operation

All measurement functions and settings can be controlled through the serial control and data interface, which is also used to transfer the acquired data. The RÖNTEC WinShell software is available for use on Windows-PCs. It can be used stand-alone or in connection with other programs through library functions (DLL).

Device operation and data acquisition can also be integrated directly in user-specific program packages. The RÖNTEC MAX Spectrometer provides a large number of commands and functions that relieve the user's computer from complicated calculations and time-critical tasks. The command functions and the syntax used are described in detail in the "MAX/MultiMax External Interface" reference manual.

A number of settings can be done per command as well as by using the front panel keypad. Both options are equivalent. Entries on the front panel are signaled to a connected evaluation program via the interface.

4.2 Display and Front Panel Keys

The key device functions can be controlled directly using the device's keypad. This includes the current count rate and dead time, the setting of the spectroscopy amplifier and MCA, as well as the function of the cooling system.

The RÖNTEC MAX Spectrometer Unit is equipped with a 4-line alphanumeric display that shows a number of parameters simultaneously. All parameters are distributed over two "pages". These pages can be browsed through repeated use of the "Up" and "Down" arrow keys (⮝, ⮟). When moving through the pages with these keys, one parameter at a time is selected (flashes). The current parameter value can be altered by pressing the keys of the middle row (⮜, ■, ⮞) on the keypad.

The meaning of the displayed values and the entry options are described in more detail in the following sections. The appendices contain a summary.

Note: The settings made on the device front panel can be overwritten by commands from the connected PC. Of course, on the other hand front panel entries influence a currently running acquisition. Check the according software manual for the front-panel entries that are permissible while the evaluation program is running.

4.3 Setting the Energy Range

Four different measurement ranges (normally 10, 20, 40, and 80 keV) can be selected through the front panel keypad or according commands.

Use the keys ⮝ and ⮟ to activate the energy range display (`(..keV)` flashes) and press the ⮜ or ⮞ key to choose the measurement range. The selected value can be stored in the Flash-EPROM as a startup default (see below).

The rear panel control "GAIN" may be used to fine-adjust the measurement range upper limit (energy calibration), the displayed nominal value remains unchanged, however. The lower energy range limit (typically 0.5 keV) is independent of the range selection and can be changed within limits by using the lower threshold control ("THR").

A digital offset of approx. 96 channels is applied to the spectra, in order to allow display of the zero peak (see Appendix D). The exact offset value can be adjusted using the "Offs." Control.

☞ *The rear panel controls not mentioned here control internal functions. They should not be adjusted without according experience and proper measuring equipment.*

4.4 Setting Detector Cooling Mode

The detector cooling is normally operated in thermostat mode. In certain cases it may be suitable to work with constant cooling current (maximum cooling). Detector cooling can be switched off in breaks between measurements to prevent unnecessary heating of the detector case.

The cooler operating mode can be set per command as well as through the front panel keypad.

Use the ⮝ and ⮟ keys to activate the cooler mode display (`off`/`on`/`max` flashes) and press one of the keys ⮜, ■, or ⮞ to switch the cooler off, thermostat mode on, or maximum cooling mode on, respectively. The selected setting can be stored in the Flash-EPROM as a startup default (see below). The desired detector temperature is set through the according rear panel control; the maximum permissible cooler current is preset internally. Advice on the correct settings is contained in the according detector reference manual.

Beware!! *Exceeding the maximum permissible cooler current may destroy the detector.*

4.5 Starting and Stopping an Acquisition

Starting and stopping spectra accumulation or data storage is normally accomplished through the connected data acquisition device. In certain cases it may be desirable to control the acquisition process directly from the RÖNTEC MAX Spectrometer. As the command and data interface allows monitoring the acquisition progress as well as querying front panel user actions, this can in turn be used to control spectra acquisition and processing remotely.

Activate the acquisition status display (`run/stop` flashes) using the ⮝ and ⮟ keys and press one of the keys ⮜, ■, or ⮞ to stop the running accumulation, start it anew, or continue a paused acquisition, respectively.

4.6 Setting Gate Times

The built-in rate counters (count rate display, dead-time display) use a common, adjustable gate time. A short gate time leads to a fast display response but also to relatively large statistical fluctuations; longer gate times provide a more stable display.

Use the keys ⮝ and ⮟ to activate the gate time display (`CT=...` flashes) and press one of the keys ⮜, ■, or ⮞ respectively to select one of the three predefined values 0.1 s, 0.3 s, and 1 s. The selected value can be stored in the Flash-EPROM as a startup default (see below).

4.7 Switching Signals

The switching signals on the multi-purpose interface are intended for remote control of the measurement setup or for experiment automation. They will therefore be mainly used through special program functions of the user software. The bit combination on the inputs and outputs is shown on the device display for information purposes.

To toggle the output signals one by one use the ⮝ and ⮟ keys to activate the output status display (`OUT=...`). The current bit position flashes; the desired position can be chosen with the ⮜ and ⮞ keys. The ■ key toggles the corresponding output line. The selected setting can be stored in the Flash-EPROM as a startup default (see below).

4.8 Changing the Startup Settings (Flash-EPROM)

If one or more of the settings described above were changed, the uppermost line of the first display page shows a character (♦), which hints that (most probably) the current settings are no longer identical to the startup defaults stored in the Flash-EPROM. Activate this character using the ⮝ and ⮟ keys (♦ flashes) and then press the key ■ to store the current settings in the Flash-EPROM.

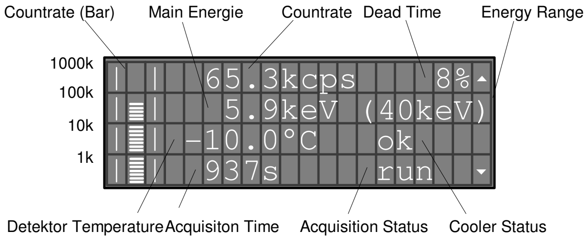
Storing the settings to the Flash-EPROM can also be invoked through the according command. Settings changed per command can only be stored per command (the ♦ character is not displayed in this case).

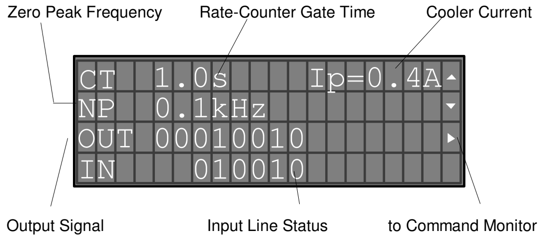
Appendices

A. Technical Data

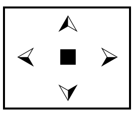
Detector connection	Supply voltage	+/- 19V (±5%), 300 mA
	Cooler current	0 ... 2A, maximum value adjustable
	Cooler operation modes	Thermostat, constant current
	Auxiliary voltage (fan cooler)	12V (±5%), 500 mA
	Signal input	Differential signal, 5 mV/keV, 50 ... 100 ns rise, 50µs decay (opt. ∞)
Spectroscopy Amplifier	Shaping	Gaussian; 0.22 µs (opt. 0.15 ... 1 µs)
	Max. pulse throughput	275 kcps (opt. 60 ... 400 kcps)
	Energy ranges	0.5 ... 10/20/40/80 keV, selectable
	Base-line restorer	Active, gated
	Pile-Up rejection	Internal, ca. 150 ns resolution
	Rise-time discriminator	150 ... 250 ns (energy dependent)
	Reset protection period	0.1 ... 50 µs (adjustable)
MCA	Number of channels	4,096 (internal)
	Counting depth	32 bit /channel
	Acquisition period	Start/Stop, real time pre-selection, event count pre-selection
	Evaluation	Mean values, range sums, spectra reduction (e.g. to 1,024 channels)
FIFO	Organization	Closed loop
	Storage depth	8,192 measurement values (16 bit each)
Counters and timers	Input and output rate	32 bit, 0.001 ... 65 s measurement time
	Total count number	32 bit
	Count pre-selection	1 ... 4 $*10^9$ counts
	Acquisition time pre-selection	0.001 ... 4* 10^6 s
Standard interface	Type	Serial, RS232 (V24)
	Baud rate	38,400 Bd (600 ... 230,400 Bd)
	Protocol	Hardware, (RTS/CTS)
	Data format	8 bit, no parity
Röntec MegaLink	Type	Serial, RS422
	Baud rate	20 MBd
	Protocol	none
	Data format	13 bit, no parity
Mains supply	DC operating voltage	18 ... 27 V, 2 A
	DC power consumption	ca. 20 W (incl. detector)
	Mains adapter	100 ... 240V, 50/60Hz
Environmental conditions (does not apply to the detector)	Temperature (operation)	0 ... 40 °C
	Temperature (storage)	-10 ... +70 °C
	Max. humidity	90 % RH
	Protective class (Adapter)	II (protective insulation)
	Protection degree	IP 20
Case	Dimensions (W x H x D)	236 x 90 x 245 mm
	Mass	Ca. 3.2 kg

B. Display Functions and Keys





Count rate	Input count rate; the count rate registered by the event detector. The bar display is scaled logarithmically and covers 4 decades. A full bar represents approx. 1,000 kcps.
Main energy	The energy value registered most often within the current period (= maximum of the partial spectrum). The period matches the gate time mentioned below.
Dead time	Reduction of the number of actually registered events compared to the number of incoming counts from the detector expressed in percent of real time. The dead time rises with increasing input count rate; the count rate loss due to the dead time effect outweighs the rise in incoming counts at above approx. 60% dead time. A further increase in input count rate even leads to a decrease in the number of usable events.
Energy range	Nominal upper limit of the measurement range (at 5mV/keV nominal input signal gain).
Detector temperature	The chip temperature as measured by the detector's temperature sensor; used for checking the thermostat setting (device rear panel) and the cooler function.
Acquisition period	Elapsed time of the current spectra accumulation.
Acquisition status	Information whether the measurement data acquisition (spectra accumulation, FIFO) is running or stopped. The rate counters and energy meters are independent hereof.
Cooler status	Status of the detector cooling. If the cooling is switched off ”`off`” is displayed, in maximum cooling mode the display reads ”`max`”. In thermostat mode ”`ok`” is displayed if the preset temperature is attained, if it is not (yet) reached the display shows ”`on`”.
Gate time	Period within which the count rates, dead time, and main energy are determined.
Cooler current	Momentary cooler current; allows checking of the maximum setting, or shows the available regulation reserve, respectively.
Zero peak frequency	The integrated zero peak generator's setting = frequency of the zero strobe (electronic peak).
Line status	The current bit combination at the RÖNTEC MAX Spectrometer's multi-purpose interface (input and output). Every bit position represents a signal line (0=low 1=high).
Command monitor	Data stream at the serial interface input; displayed on an extra page.



▲	Select previous value
▼	Select next value

	◀	■	▶
EPROM flag	-	Store	-
Energy range	Next smaller	20 keV	Next higher
Cooling	Off	Thermostat	Maximum
Acquisition process	Stop	Restart	Continue
Gate time	0.1 s	0.3 s	1 s
Multi-purpose interface	Higher bit-position	Switch	Lower bit-position

C. Connector Pin Assignments

A	Detector Connector (DSUB 15 female)
1	SIGNAL+
2	SIGNAL -
3, 6, 11, 12, 14	GND
4, 15	+19V
5, 7	- 19V
10	Peltier+
11	Peltier - (GND)
13	Temperature Signal
8, 9	Not used

B	DC Input (hollow connector2,5 mm)
inner	+18 ... +27V
outer	Ground

C	FAN (LEMO socket, 2 pole)
1	+12 V
2	Ground

D	Testing Connectors
IN (LEMO)	Input signal
OUT (LEMO)	Output signal (filter)
BUSY (PIN)	Processing time
VVR "	Protection time detector reset
TRIGGER "	Event signal (input counts)
STROBE "	Strobe signal (output counts)

E	Multi-I/O (DSUB 15 HD female)		
1	Channel 1	9	GND
2	Channel 2	10	GND
3	Channel 3	11	GND
4	Channel 4	12	GND
5	Channel 5	13	GND
6	Channel 6	14	GND
7	Channel 7	15	GND
8	Channel 8		

D. Dead Time and Zero Peak

Because of the time required for filtering, digitizing, and storing incoming pulses there is a short time after each pulse, in which no further pulses can be processed. In case of statistically occurring input pulses a mean dead time[1] results, which is stated as a value in percent. According to the laws of Poisson's distribution this can be expressed (in the most simple case) as

$$T\% = 100 * (1- \exp(-f_i * t_v))$$

(T%=dead time expressed in percent of the real time, f_i= input count rate, t_v= pulse processing time).

The dead time in percent increases with the input count rate. The useable count rate (output rate, pulse throughput) reaches a maximum at around 60% dead time; if the input count rate is further increased the dead-time effect overweighs. The maximum pulse throughput is a characteristic for the spectroscopic channel (filter and signal processor).

The reduction of the output count rate compared to the input count rate can be seen as a reduction of the effective acquisition time (live time) compared to the actual time elapsed (real time):

$$t_l = t_r * (1- T\%/100)$$

(t_l = live time, t_r = real time).

In order to estimate the dead time, the input count rate registered by a fast channel (with a much shorter shaping time than the main channel), that is incorporated in the pile-up rejector, is related to the output rate of the main channel. (For this purpose rate counters for the input and the output count rate have been integrated). The precision is mainly limited by the fast channel's time resolution and through the effect that the trigger level of the input rate counter has to be set slightly above that of the output rate counter, due to the different shaping times. The additional event rate produced by the zero peak generator (which is seen by the output rate counter, but not by the input rate counter) is taken into consideration by calculation:

$$T\%' = 100* (1- f_n/(f_b+f_g))$$

(f_n=output count rate, f_b= input count rate, f_g=zero generator frequency). The value calculated through this equation is displayed as current dead time and updated in rate-counter gate-time-intervals.

As an accurate means for determining the effective acquisition time (live time) a test-pulse generator (zero peak generator) is implemented that produces virtual events with ”zero energy” using electronic circuitry. A so-called zero peak appears in the spectra around the zero energy mark, which is therefore digitally shifted to the right. It is separated from the acquired spectra area by the lower threshold of the event detector (approx. 0.5 keV). As the virtual zero energy events are subject to dead-time effects in the same way as real events, the total number of counts in the zero peak area divided by the known generator frequency to provide the exact value of the effective acquisition time. This value can be taken into account during spectra evaluation to correct for the dead time effects (live-time correction). Another common approach is to pre-select the live time instead of the real time for spectra acquisition (i.e. prolonging the acquisition time accordingly), which is accomplished by the feature of event-count pre-selection for a specified spectra region (in this case set to the region around the zero peak).

Additionally, the zero peak informs on the exact zero position and the electronic resolution (noise) of the system.

[1] The signal-dependent dead time is the governing factor, apart from the energy-dependent detector quantum-efficiency that reduces the number of events registered (stored) in the spectrum compared to the number of incoming photons. Additional effects are e.g. incomplete charge-carrier collection, or ballistic deficits, as determined by the detector physics.