

Message Protocol MuonLab III

With this protocol communication with the MuonLab III electronics can be made. The MuonLab III electronics can measure life-time of a muon and time difference between two signals.

At the same time the analog input signal on channel 1 can be digitized such as a digital oscilloscope.

This is controlled by writing setting- and selection bytes to the electronics.

Data from the selected measurement(s) is outputted via USB in the described data message structure beneath.

Each of the setting-, selection- or data messages have the same general structure and look like this:

General message structure

Header	Identifier	Data	End
99	1 byte	N bytes	66

Each message starts with a Header byte and is always 0x99 (hexadecimal) and ends with an End byte, which is always 0x66.

The second byte, after the header byte, is an Identifier byte and defines the kind of message, like a specific message for writing a certain setting or receiving specific data.

The bytes between the identifier byte and end byte are data bytes. This can be one or thousand bytes, depending on the type of message.

Setting messages

The MuonLab III electronics is controlled by the next messages. All setting messages have one data byte.

Identifier	Description
0x10	Offset voltage Channel 1
0x14	High voltage control for photomultiplier Channel 1
0x15	High voltage control for photomultiplier Channel 2
0x16	Threshold level hardware comparator Channel 1
0x17	Threshold level hardware comparator Channel 2
0x1A	Pre-trigger time Channel 1

For example:

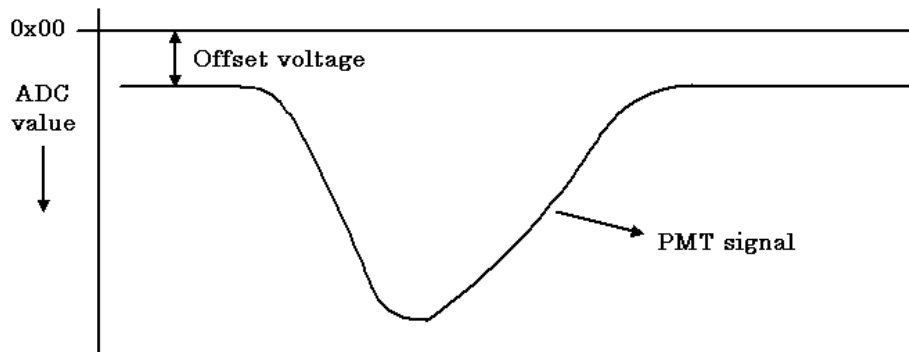
Sending 99 10 80 66 (hexadecimal) sets half of the apply able offset voltage to channel 1.

Explanation of setting parameters

Setting 1. Offset voltage.

The analog input signal of channel 1 (channel 1 only) is digitized by an Analog-to-Digital-Converter (ADC) and written to memory on a trigger. An offset voltage can be added to the input signal before it is digitized. This makes it possible to view the whole (noisy) baseline of the photomultiplier signal.

Note that the offset voltage is used only for the digitizing part and has no effect on the input signal to the comparators.

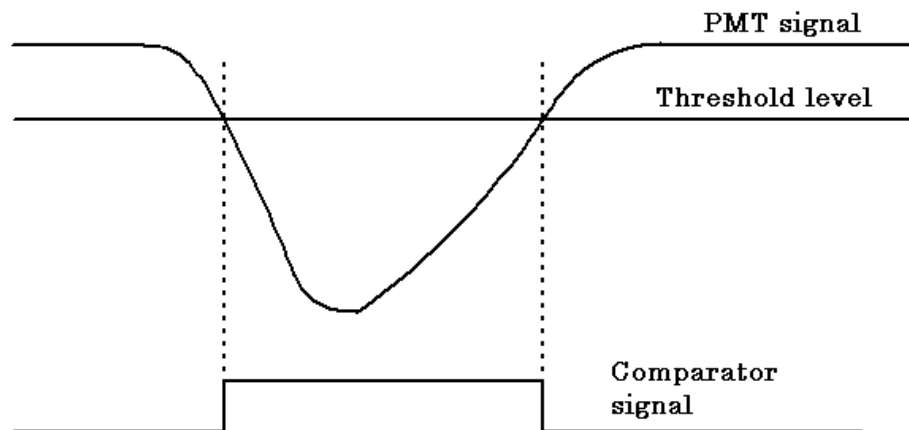


Setting 2. High voltage control for photomultiplier.

This setting controls the high voltage of a photomultiplier connected to a channel.

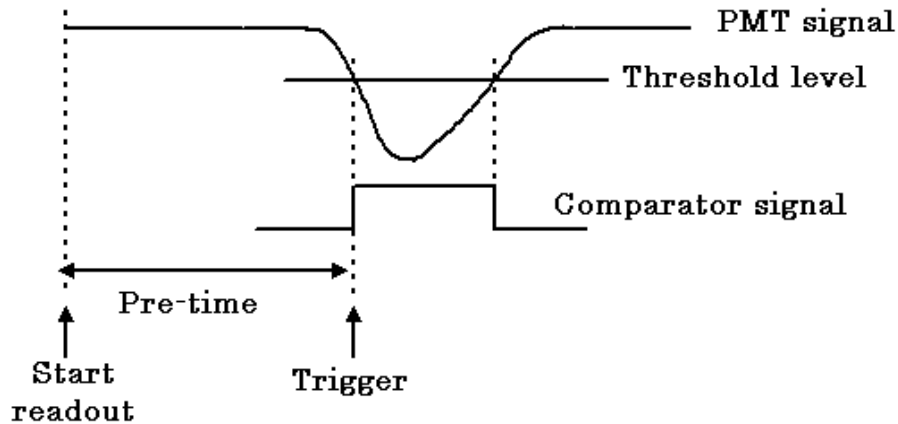
Setting 3. Threshold level hardware comparator.

Each channel has a hardware comparator to discriminate the analog input signal with a threshold voltage. The digital comparator output signal is used for lifetime and delta-time measurements and trigger signal of the digitizer/oscilloscope part.



Setting 4. Pre-trigger time.

Stored digitized input values from the ADC can be read out starting from a certain time before the trigger and makes it possible to view the leading edge of the input signal. The pre-trigger time can be set from 0 to 2550ns in 255 steps of 10ns.



Selection message

This message has identifier 0x20.

Header	Identifier	Data	End
99	20	1 bytes	66

There is only one data byte necessary to cover all possible selections. Selection is done by setting a unique bit within the byte. Bits are numbered from D7 (most significant bit) to D0 (least significant bit). All bits can be set independently to select more options simultaneously.

Bit	Description
D0	Select life-time measurement. Data will be outputted when this bit is set (high) and life-time is valid. Valid means, there must be two pulses on channel 1 within ~20us.
D1	Select delta-time measurement. Data will be outputted when this bit is set (high) and delta-time is valid. Valid means, there must be a pulse on channel 1 and channel 2 within ~1us.
D2	Digitized values of the analog input signal of channel 1 will be outputted when this bit is set (high)
D3	Enable USB
D4	Trigger select. Triggers on waveform on channel 1 when low. Triggers on coincidence of channel 1 and 2 when high.
D5	Not implemented
D6	Not implemented
D7	Not implemented

Data messages

Life-time data message

If life-time measurement is selected and a valid life-time is detected, MuonLab III electronics sends data in the following structure:

Header	Identifier	Data	End
99	A5	2 bytes [Byte 1] [Byte 2]	66

This message is characterized by identifier 0xA5. The 2 data bytes in the message contain 11 bits time data, whereby Byte 1 comes first and then Byte 2. The least significant time bit is the least significant bit of Byte 2.

Byte 1								Byte 2							
D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
Life-time data															
n.u.	n.u.	n.u.	n.u.	n.u.	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

n.u. = not used

Life-time is measured in steps of 10ns. With 11 data bits the maximum measured life-time is 20470ns or slightly more than 20 μ s.

Delta-time data message

If delta-time measurement is selected and a valid delta-time is detected, MuonLab III electronics sends data in the following structure:

Header	Identifier	Data	End
99	B5	2 bytes	66
	B7	[Byte 1] [Byte 2]	

This message is characterized by identifier 0xB5 or 0xB7. If the input signal on channel 1 comes sooner than the input signal on channel 2, the identifier is 0xB5. If channel 2 was hit first, the identifier is 0xB7.

The 2 data bytes in the message contain 11 bits time data, whereby Byte 1 comes first and then Byte 2. The least significant time bit is the least significant bit of Byte 2.

Byte 1								Byte 2							
D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
Delta-time data															
n.u.	n.u.	n.u.	n.u.	n.u.	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

n.u. = not used

Delta-time is measured in steps of 0.5ns. With 11 data bits the maximum measured delta-time is 1023.5ns or slightly more than 1 μ s.

Digitizer data message

If this message is selected for outputting digitizer data and a valid trigger is detected, MuonLab III electronics sends data in the following structure:

Header	Identifier	Data	End
99	C5	2000 bytes	66

This message is characterized by identifier 0xC5. The 2000 data bytes in the message contain amplitude values of the input signal every 5ns. Data is send out from a pre-time before the trigger, which is set by 0x1A for channel 1. The total sampled time in a message is 10us (2000 x 5ns).

Hits per second message

This message is send out every second and gives the amount of hits of both channels. MuonLab III electronics sends data in the following structure:

Header	Identifier	Data		End
99	35	2 bytes CH 2	2 bytes CH 1	66

This message is characterized by identifier 0x35. The first 2 data bytes in the message contain the amount of hits of channel 2 and the last 2 bytes the amount of hits of channel 1.

Coïncidence message

This message is send out when there is a hit on channel 1 and channel 2 within 100ns, regardless which hit comes first.

Header	Identifier	End
99	55	66

This message is characterized by identifier 0x55, and contains no data.

Specifications

Life-time

Maximum measurement time: 20470ns

Resolution: 10ns

Valid when channel 1 is hit twice within max. measurement time.

Delta-time

Maximum measurement time: 1023.5ns

Resolution: 0.5ns

Valid when channel 1 and channel 2 are hit within max. measurement time.

Digitizer

Y-axis:

Maximum digitized voltage (full scale): $\sim 2\text{V}$

Resolution: 8-bit, $\sim 2000\text{mV} / 255 = \sim 8\text{mV}$

X-axis:

Maximum fixed measurement time or time base: $10\mu\text{s}$

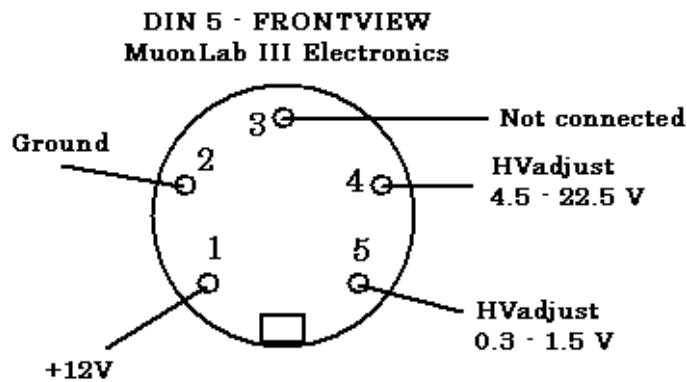
Resolution: 5ns

Triggered when an input signal on channel 1 is bigger than the threshold level of channel 1.

Note that input signal and threshold level are negative voltages.

Control plug to photomultiplier

The high voltage on the dynodes of a photomultiplier is controlled by the High Voltage Control setting. On the plug are two high voltage control voltages for two types of photomultiplier tubes. Each type is connected to another pin of the plug, therefore the user will not notice or bother with type is used.



Connections photomultipliers:

