MTM-16

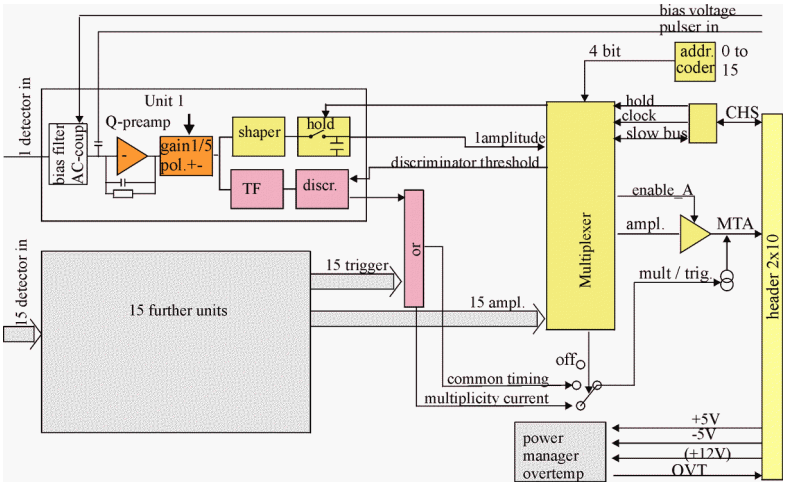
(Data sheet V2.3_01)

Multiplexed high quality readout for large numbers of channels for charged particle detectors

More and more experiments in nuclear and particle physics require detectors with higher position resolution and increased size. This means that more amplifier channels, filter stages and ADCs providing high signal quality are needed at lower cost per channel. The most effective approach to reduce costs is early multiplexing within a front end electronics which is situated near the detector. From analog signal processing requirements, the earliest stage for time multiplexing is directly behind the shaping amplifiers.

One method of time multiplexing is to store the individual amplitudes as a charge in a capacitor, switch it to a bus line one channel after the other and digitize it with an ADC in a CAMAC or VME module. Several 100 channels can be digitized this way with a minimum of cabling and only one ADC. Many approaches have been made with monolithic integrated circuits, but for many applications the signal quality (amplitude resolution, linearity, offset, offset drift, low noise at high input capacity) and the flexibility (missing features like: good timing, self triggering or adapted energy range) are not sufficient. Also the available digitizers will not provide high resolution with low differential non linearity (sliding scale ADCs) which is necessary for spectroscopy applications.

The implemented preamplifiers should be low power for vacuum operation and a special version should be suitable also for high capacity detectors up to 2 nF (typical for large and thin energy loss detectors). It will provide excellent timing and some types will allows to create multiplicity selective triggers.



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16 channel front end electronics

It includes charge sensitive preamplifiers, variable gain and polarity stage, a timing branch with filter amplifier and discriminators, and a slow branch with spectroscopy amplifiers followed by a track & hold stage. Up to 16 MTM-16 (= 256 channels) can be connected to one readout bus, allowing to reduce cabling and hardware costs. All parameters can be set and controlled via integrated slow bus, allowing easy operation of the units in vacuum or enclosed environments.

Common settings for all channels

Preamp gain, polarity

(via control bus or coder)

Discriminator threshold

(Potentiometer / control bus)

Digital multiplexer output signals

CHS signal

includes "hold" and "slow bus" as positive pulse, "clk" as negative pulse.

hold for a l us shaping time the hold signal must go active 2 us after the timing trigger output. It is reseted automatically after readout.

control bus is a bidirectional bus, which allows to set thresholds, gains, polarity, modes and also to get information from the MTM-16. It can be handled directly via MDI-2 with VME commands.

clock is a 50 ns negative signal. It is used as a time base for shifting out the analog amplitudes from the hold stages. Each module must have a unique address given by a coder on the board.

MTA signal

includes a negative trigger signal from discriminators (optional also multiplicity) and the amplitude signal with synchronisation marks.

trigger signal

If hold or readout is not active all MTM-16 can add digital trigger pulses to the line.
They are converted to a trigger signal by the MDI-2 module.

amplitude signal (max ±1.3 V)

For **sequential mode** (standard) the multiplexer unit waits for the MTA-module ready marks of the preceeding module to determine its time slot for sending the amplitude information.

Detector bias supply

Lemo input, maximum ±400 V. Provides high voltage to the detector. AC-coupling and filtering of the bias voltage is provided.
For SHC type max ±40 V is allowed.

Pulser input

Lemo input, tail pulse required.

Type 100/500 MeV	LP: 110 MeV/V
Type 7/35 MeV	LP: 15 MeV/V
Type 5/25 MeV	HC/SHC: 15 MeV/V

Power

(supplied via MDI-2) (+12 V / +5 V / –5 V)

Type 100/500 MeV LP:
(40 mA / 110 mA / –30 mA)
Total Power: 1.2 W

Type 20/100 MeV LP:
(40 mA / 110 mA / –30 mA)
Total Power: 1.2 W

Type 7/35 MeV LP:
(40 mA / 110 mA / –30 mA)
Total Power: 1.2 W

Type 5/25 MeV HC:
(60 mA / 140 mA / –20 mA)
Total Power: 1.5 W

Type 5/25 MeV SHC:
(140 mA / 140 mA / –20 mA)
Total Power: 2.5 W

Functional units of MTM-16

Gain/polarity stage

allows to add an amplification of 5 and to adapt to input signal polarity. Related coder settings are:

0: gain = 1, input polarity = pos
1: gain = 5, input polarity = pos
E: gain = 1, input polarity = neg
F: gain = 5, input polarity = neg

Gain/Polarity can also be set via remote control.

Shaper

A shaping time of 1 us (2.3 us FWHM) .
CR $(RC)^3$ gaussean shaper.

Stretcher stage

holds the actual shaper signal at the maximum within the gate signal created by MDI-2.

TF

A timing filter amplifier: differentiation and integration to filter the fast timing signals.

Discriminator

Fast discriminator with variable threshold for sub nanosecond timing. 4 timing signals of neighbouring channels are added and then discriminated. The threshold can be adjusted by trim potentiometer and can be measured at the sense point. 2V corresponds to single channel maximum range. Threshold can also be controlled via remote control (RC).

Or

Makes a logical or from the 4 timing signals for common timing output.

Multiplexer

readout time estimates
(trigger to readout start is about 2 us):
For LP-devices: further reduction to 0.95 W will be possible in next revision

Clock frequency

Max 10 MHz
(at 10 MHz 2.5 % of crosstalk to the following channel in the readout chain has to be expected: channel 0 → 8 , 1 → 9 ....)
For lower readout frequencies crosstalk is negligible.

Serial mode

(useful if many channels respond simultaneously, no threshold or self trigger needed)
Readout time with 10 MHz clock: 1700 ns per MTM-16 in the chain.
example:
128 channels = 8x MTM-16 → 15.8 us readout time from trigger to ready for new trigger.

Overheat shutdown

not implemented in the current revision.

Cooling under vacuum conditions

For not too densely packed low power devices (100 pF type) in vacuum and for operation outside vacuum, cooling is not necessary. The high power devices (for high detector capacity) can be operated in vacuum without cooling if their distance is more than 100 mm. For densely packed devices in vacuum a liquid cooling is necessary. It can be designed in collaboration with the customer.

Size of the units

16 channel unit: 100 x 160 x 6 mm^3

Setting the gate

Parameters which have to be written into the MDI2 module are:

- hold_delay0/1 = 1000
- hold_width0/1 = 34

Sequencing

17 clocks needed per module. Set MDI-2 register "seq0_cct_ seq1_cct"
The maximum clock frequency of 10 MHz is allowed. (reg seq_clk_freq0/1 = 3)

Data output format

Data wich are found in the MDI-Buffer are interlaces. This means:

event 0 represents channel 0
event 1 represents channel 8
event 2 represents channel 1
event 3 represents channel 9 ….

Remote Control via MDI-2 and VME

MTM-16 commands: (the MTM-16 can be initialised with 2 write commands)
The MDI-2 allows to send the format: busnumber, id, opcode, address, data

Data at Address 0

4	3	2	1	0
Set rc-status 1 = set	rc_status (1 = on)	not used	polarity 0 = neg. input 1 = pos input	gain 0 = high gain 1 = low gain

Data at Address 1

set common threshold
dat[11:0] → dac (0xfff = 50 % of single channel range)

The data are immediately read back from the module and can be checked at register 0x6086 and 0x6088.
Explicit reading with opcode 18 is not supported for present MTM-16.

Send time is 400 us. Wait that fixed time before reading response or sending new data.
Also polling at 0x608A for bit 0 is possible. For details see MDI-2 data sheet.

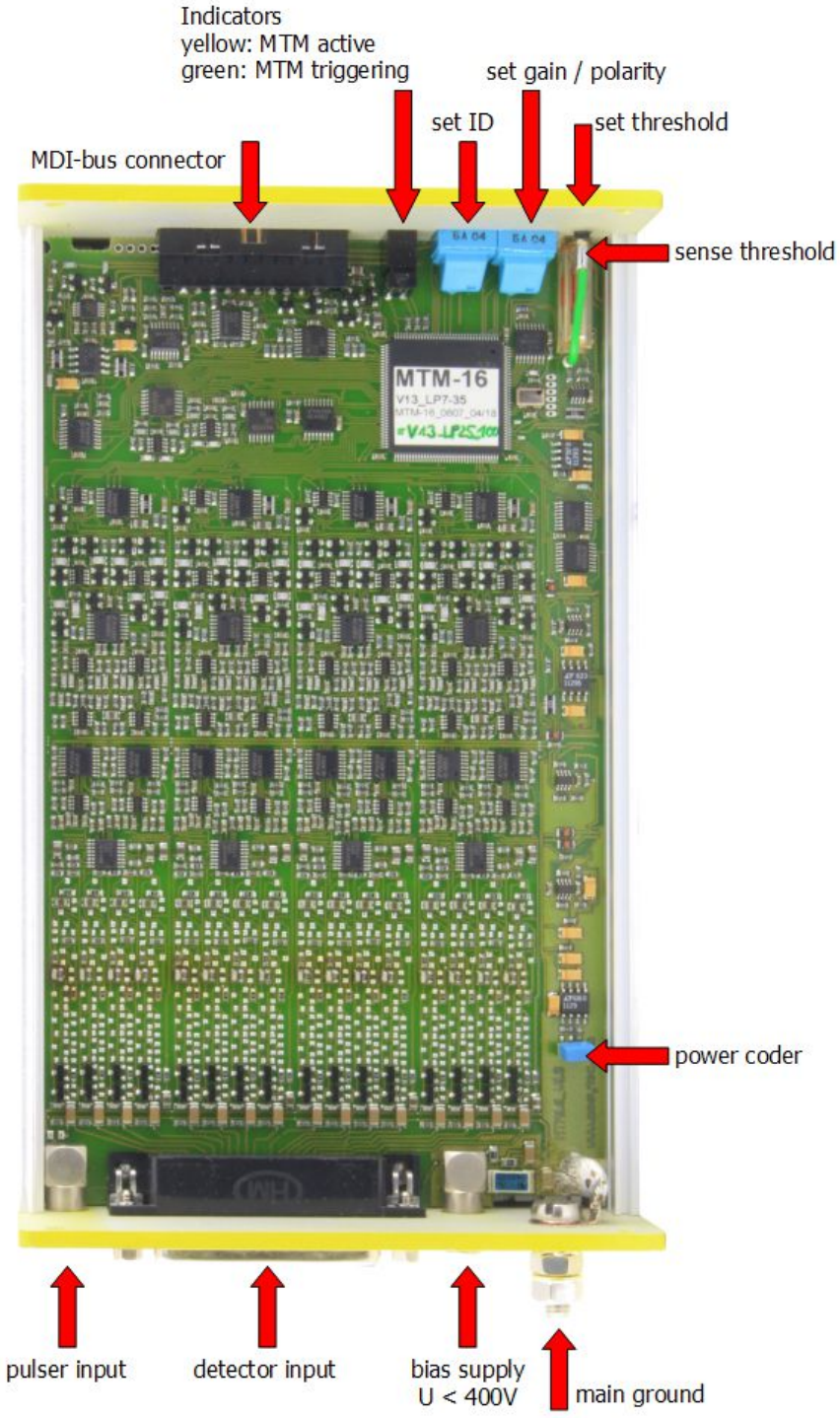
Input connector

- Input connector(s). SubD 25 female connector (for a 16 channel unit)
- Pin assignment:

Function	connector	Funktion	connector
Sig-gnd	1, 2, 7, 12, 13, 14, 15, 25	Cha 8	19
Cha 0	11	Cha 9	6
Cha 1	23	Cha 10	18
Cha 2	10	Cha 11	5
Cha 3	22	Cha 12	17
Cha 4	9	Cha 13	4
Cha 5	21	Cha 14	16
Cha 6	8	Cha 15	3
Cha 7	20	guardring	24

The guardring output (24) is connected via R-C-R filter (100 kΩ, 10 nF, 100 kΩ)
to the common detector bias input.

MTM-16 PCB overview



Set ID

The MTMs on a bus must have unique IDs in consecutive order, starting with ID 0.
So for one MTM-16 on the bus the ID has to be 0.

Set gain / polarity

0: gain = 1, polarity = pos
1: gain = 5, polarity = pos
E: gain = 1, polarity = neg
F: gain = 5, polarity = neg

Set threshold

A single channel has a maximum amplitude of 2 V per channel.
The threshold is applied to the sum signal of four neighbouring channels.
(0 to 3 / 4 to 7 / 8 to 11 / 12 to 15).

Power Coder

has only a function on high power devices. When jumpered the power consumption is reduced and preamplifier noise is increased.

Main GND

for multi MTM-16 setups, the PCBs have to be connected very well with this ground connection.

Bias supply

Input for detector bias. A T-filter is implemented with a common 1MΩ bias input resistor followed by a 10 nF filter capacitor.
The filtered bias is distributed by 16 individual 10 MΩ resistor to the preamplifier inputs.

Pulser input

expects a tail pulse with fast rise time (typ 10...20 ns) and slow decay time (typ 100 us).
All channels respond simultaneously.