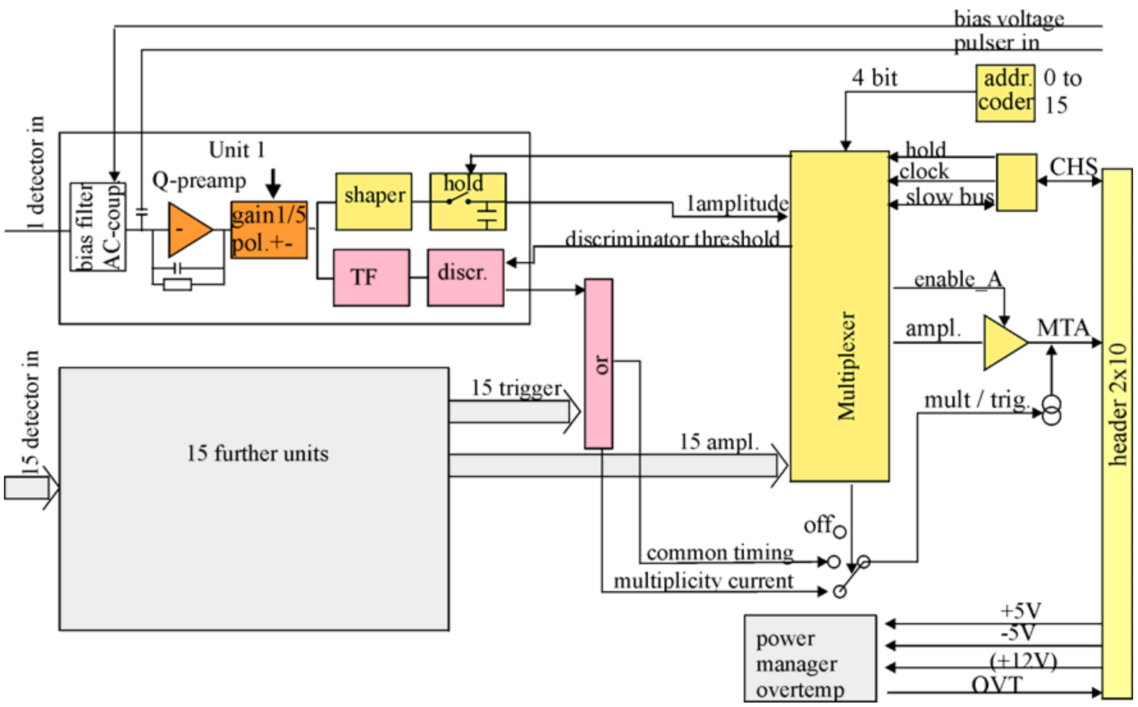
More and more experiments in nuclear and particle physics require detectors with higher position resolution and increased size.
This means that more amplifier channels, filter stages and ADCs providing high signal quality are needed at lower cost per channel. The most effective approach to reduce costs 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.
A drawback of simple time multiplexing is a relatively long conversion time for digitizing all channels connected to one bus. The proposal described here implements the simple time multiplexing. In addition a zero suppression mode will be implemented to overcome the long conversion time by adding zero suppression in the front end electronics. In zero suppression mode not only the amplitude but also an address of the responding channels are transmitted.
The implemented preamplifiers should be low power for vacuum operation and a special version should be suitable also for high capacity detectors up to 2nF (typical for large and thin energy loss detectors).
It will provide excellent timing and some types will allows to create multiplicity selective triggers.



MTM16: 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. The amplitude values can be read out sequentially or in a zero suppression mode.
Up to 16 MTM16 (= 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 1us shaping time the hold signal must go active 2us after the timing trigger output. It is resetted automatically after readout.

control bus is a bidirectional bus, which allows to set thresholds, gains, polarity, modes and also to get information from the MTM16. It can be handled directly via MDI2 with VME commands.

clock is a 50ns 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 MTM16 can add digital trigger pulses to the line. They are converted to a trigger signal by the MDI2 module

amplitude signal (max +-1.3V)
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 +- 400V. Provides high voltage to the detector. AC-coupling and filtering of the bias voltage is provided.
For SHC type max +- 40V is allowed

Pulser input,

Lemo input, tail pulse required.
Type 100/500MeV LP: 110MeV/V
Type 7/35MeV LP: 15MeV/V
Type 5/25MeV HC/SHC: 15MeV/V

Power (supplied via MDI2) (+12V / +5V / -5V)

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

Type 7/35MeV LP: 15MeV/V
(40mA / 110mA / -30mA)
Total Power: 1.2W

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

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

For LP-devices: further reduction to 0.95W will be possible in next revision

Functional units of MTM16

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

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

Gain/Polarity can also be set via remote control.

Shaper
A shaping time of 1us (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 MDI2.

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 controled 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):

Clock frequency:
Max 10MHz

Serial mode
(useful if many channels respond simultaneously, no threshold or self trigger needed)
Readout time with 10 MHz clock: 1700 ns per MTM16 in the chain
example:
128 channels = 8x MTM 16 -> 15.8 us readout time from trigger to ready for new trigger.

Zero suppression mode (OPTION, will be studied)
Only values above the threshold are transmitted, together with their 4 bit address (within the MTM16 address-space).
Readout time for 10 MHz clock: 100 ns per MTM16 + 200 ns per responding channel
example 128 channels = 8 x MTM16, two channels above threshold -> 2us+1.2 us+0.2us reset = 3.4us 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 capacity devices (100pF type) in vacuum and for operation outside vacuum, cooling is not necessary.
The high capacity devices can be operated in vacuum without cooling if their distance is more than 100mm.
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 160x 6mm3

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 are needed per module. Set MDI2 register "seq0_cct, seq1_cct"
The maximum clock frequency of 10MHz is allowed. (reg seq_clk_freq0/1 = 3)

Data output format

Data which are found in the MDI-Buffer are interlaced. 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 MDI2 and VME

MTM16 commands: (the MTM16 can be initialised with 2 write commands)
The MDI2 allows to send the format: busnumber, id, opcode, address, data

Data at Address 0:

4	**3**	**2**	**1**	**0**
set rc-satus 1= set	rc_satus (1= on)	deact. trigger	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 MTM16.

Send time is 400us. Wait that fixed time before reading response or sending new data. Also polling at 0x608A for bit 0 is possible
For details see MDI2 data sheet.

Input connector

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

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

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

MTM16 PCB overview

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SET ID:

The MTMs on a bus have to have an unique ID starting with ID 0.
So for one MTM16 on the bus the ID has to be 0

SET GAIN / POLARITY:

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

SET THRESHOLD:

A single channel has a maximum amplitude of 2V.
The threshold can be sensed at the "SENSE THRESHOLD" point vs ground

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 MTM16 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 1MOhm bias input resistor followed by a 10nF filter capacitor. The filtered bias is distributed by 16 individual 10MOhm resistors to the preamplifier inputs.

PULSER INPUT

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