

# THE COMPACT, MICROCONTROLLER BASED DATA ACQUISITION SYSTEM FOR RELIABLE OPERATION UNDER THUNDERSTORM CONDITIONS

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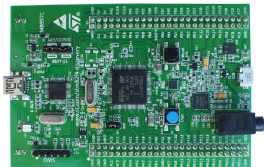
2016

## Technical requirements

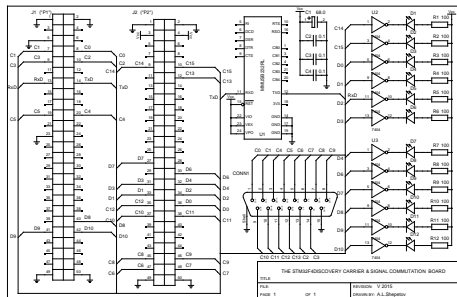
- ▶ up to 10–16 input informational channels;
- ▶ the high measurements rate with periodicity up to 2-5  $\mu\text{s}$ ;
- ▶ up to 5000-10000 succeeding signal readings in every registered time series;
- ▶ synchronization of the measured signal intensity histories with external control signal (the trigger);
- ▶ alternative autonomous synchronization possibility by a trigger generated internally on the basis of current stream of input signals;
- ▶ possibility of an on-the-fly change of operation settings in dialog regime just in the time of measurement run;
- ▶ low power consumption and possibility of prolonged operation with an autonomous (accumulator-based) power source.

# The universal MCU carrier board for signal registration

- ▶ The *STM4Discovery* type evaluation board



- ▶ Schematic



- ▶ Basic features of the signal registration system:

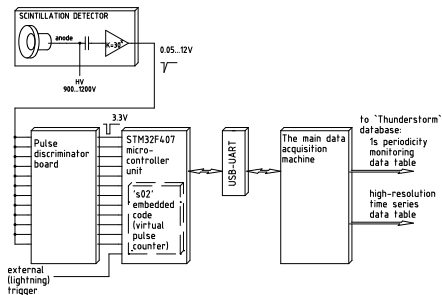
- \* it's used for connection of up to 16 external signals to I/O pins of the *STM32F407* microcontroller unit (MCU) installed on a *STM4Discovery* evaluation board of *ST Technologies* production;
- \* it ensures bi-directional information exchange with the main control computer by sequential line via a  $UART \leftrightarrow USB$  interface converter on a *MMusb232RL* type chip (with communication rate up to 2 Mbaud);
- \* the MCU runs under the control of *s02* (pulse counting) of *s03* (ADC measurements) embedded programs of the local Tien-Shan station's design which fulfill above requirements to data acquisition.

# The seance of data registration

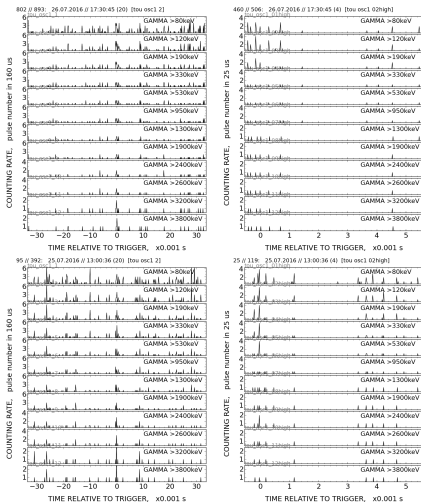
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# V05: THE PULSE INTENSITY REGISTRATION PROGRAM
# TO WORK WITH A 'ST' MICROCONTROLLER UNIT BASED
# DATA ACQUISITION SYSTEM RUNNING THE 'S02' TYPE
# EMBEDDED CODE (THE BASIC VARIATION-LIKE
# MEASUREMENTS ORIENTED FLAVOUR)
#
# ----- 19 / 11 2015 -----
# ----- IV -V 2015 -----
# ----- IX-X 2015 -----
#
# Online diagnostics output enabled into '/dev/shm/q'.
# Exposition length is set to 10s.
# Asynchronous trigger events registration is OFF.
#
{
(*) - immutable ones:
button_enabled: 0
conti_flash_pass: 1
conti_flash_timeout: 100
counter_channels(*): 12
expo: 0
extics_count(*): 12
generator_freq: 0
multi_channels(*): 6
multi_enabled: 0
multi_gate_length: 800
nchan: 6
tisca_auou: 0
tisca_deadtime: 0
tisca_nfirst: 20
tisca_nint: 1504
tisca_nlength: 50
tisca_on: 0
tisca_trichans: 1 2 3 4 5 6
tisca_triest: 0
tisca_trigate: 10
tisca_trithre: 50
uati_echo: 1
uati_iosize(*): 50K
uati_speed: 115200
units_number: 1
units_number_max(*): 1
}
# Entering into the loop;
# hit 'Ctrl/C' to terminate...
#
# Initial measurement dropped...
#
22.09.16 18:22:24
['c', '1', '>', '21', '22', '13', '23', '27', '30', '<']
22.09.16 18:22:34
['c', '1', '>', '15', '20', '16', '23', '32', '26', '<']
```

- ▶ any communication with embedded microcontroller code succeeds in a simple textual form through the virtual sequential port of control computer;
- ▶ all the necessary internal parameters which define the mode of microcontroller operation can be set at any moment (typically, at the start of the data acquisition program);
- ▶ the data collected are stored in general database of the Tien Shan mountain station for further off-line analysis.

# Use case: remote gamma-detector (3750 m a.s.l.)

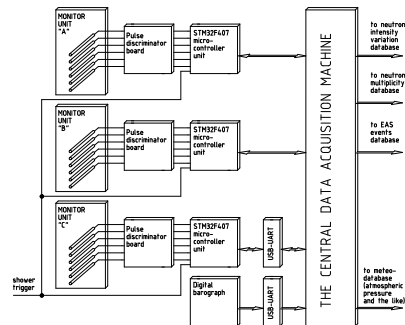


The remote detector point in vicinity of a mountain peak (400 m above the level of Tien Shan station; 3750 m a.s.l.), electromagnetically shielded scintillation gamma-ray detector with autonomous powering installed in this point, and its compact, microprocessor based data acquisition system.

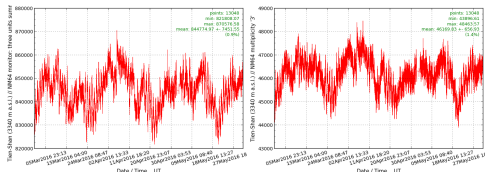


A sample of the events registered at remote detector point: time series of gamma-ray intensity written with a  $160\mu\text{s}$  and  $25\mu\text{s}$  resolution around the moment of nearby lightning discharge (at  $T = 0$ ).

# Use case: the Tien Shan NM64 neutron supermonitor

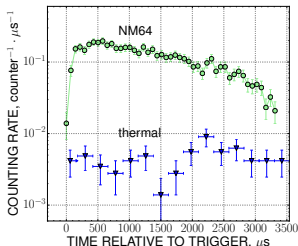


- ▶ the neutron intensity monitoring with a 1 min periodicity (simultaneously on three 6-counter monitor units);
- ▶ internal generation and intensity monitoring of the neutron multiplicity signals;



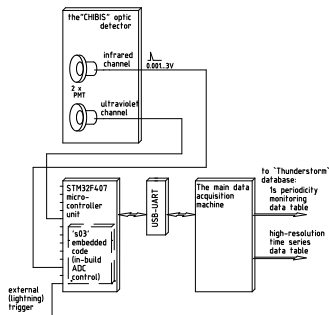
Neutron intensity and triple multiplicity signal variation during the Spring 2016.

- ▶ measurement of the neutron intensity time series with a  $40 \mu\text{s}$  resolution and synchronization both from internal and external (typically, caused by a close extensive air shower (EAS) passage) trigger types.

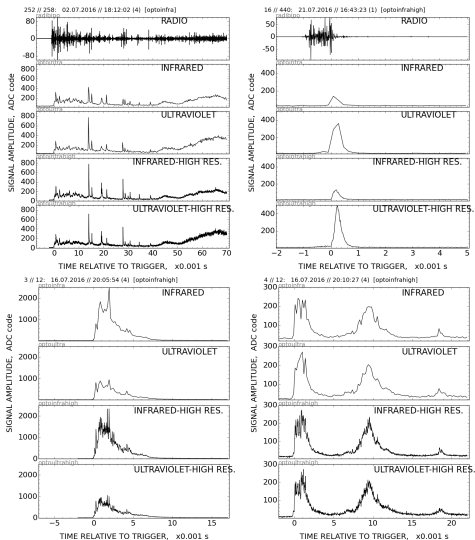


High-resolution time series of neutron signal after a  $10^{17}$  EAS core passage through the neutron monitor.

# Use case: analogue signal of the optic lightning emission



- ▶ registration of distant lightning emission during the night time in infrared and ultraviolet diapasons;
- ▶ synchronization either with internal or external (lightning) trigger;
- ▶ simultaneous registration of input signal intensity with a low ( $190\mu\text{s}$ ) and high ( $20\mu\text{s}$ ) time resolution.



Time series of lighting emission measured simultaneously with a  $190\mu\text{s}$  and  $20\mu\text{s}$  (*HIGH RES*) time resolutions. Development of lightning discharge can be traced by intensity of its attendant radio-signal (*RADIO* panels,  $10\mu\text{s}$  resolution).

# CONCLUSION

- ▶ the universal MCU based data acquisition system for registration of the particle detector signals was designed at the Tien Shan mountain cosmic ray station which is aimed especially for reliable operation in the vicinity of lightning discharges at thunderstorm time;
- ▶ effective application of the system newly designed was checked in a number of practical experiments held at Tien Shan in 2015–2016 years.