TOMSK POLYTECHNIC UNIVERSITY

TPU – NPI Monthly seminar

«Software design for a PIN detector of ionizing radiation»

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27th February 2017

Presentation overview

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2. Microtron MT25
3. Ionizing Radiation Detector
4. PIN photodiode
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Aim of diploma thesis

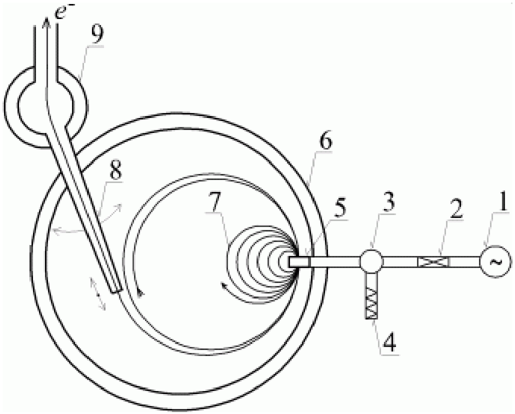
The aim of diploma thesis is to create software for a new type of spectrometric detector of ionizing radiation that work as a **personal dosimeter** for aircraft crew members.

Detector test will be made in the **Microtron laboratory**.

Ultra-low-power **ARM Cortex-M0+** processor is used for data acquisition and processing.

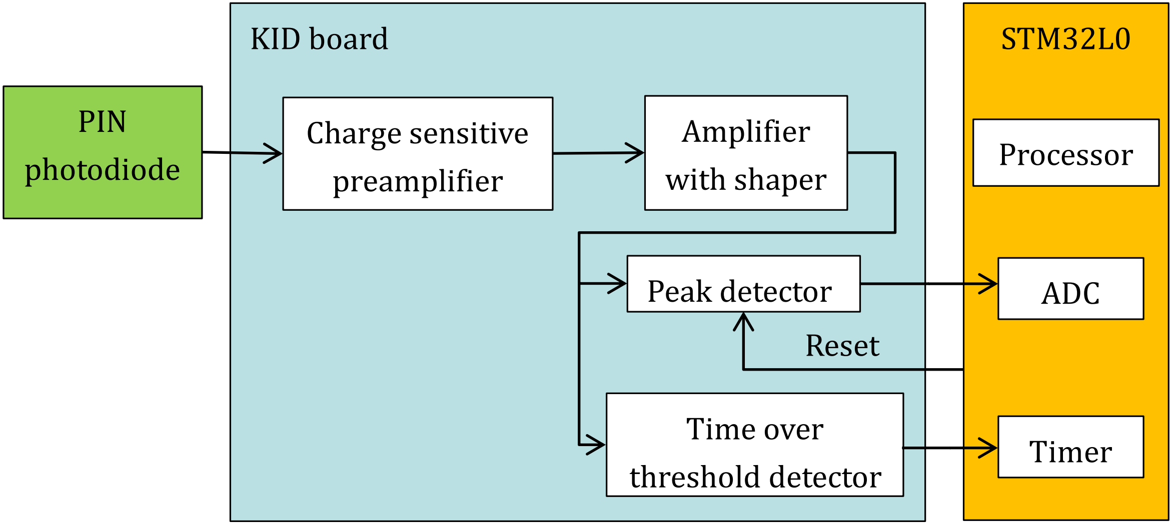
STM32 L0

Microtron MT25

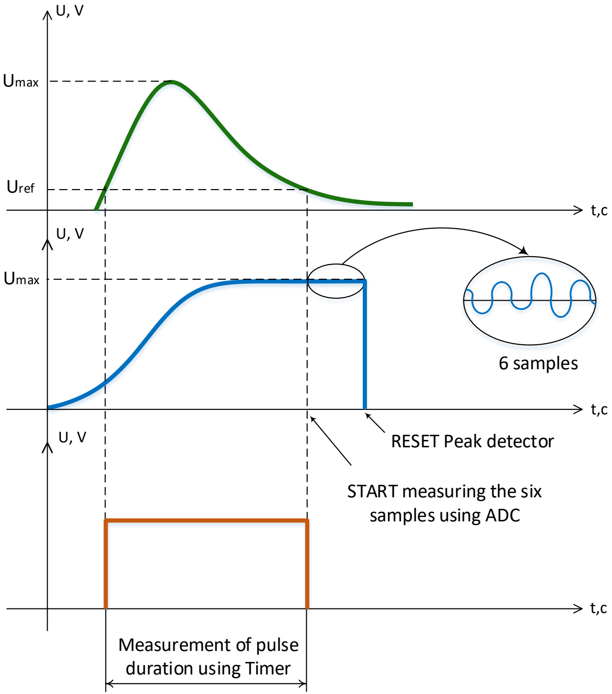


Schematic layout of the MT25 microtron: 1 – magnetron, 2 – phase shifter, 3 – circulator, 4 – water load, 5 – accelerating cavity, 6 – main magnet (vacuum chamber), 7 – electron trajectories, 8 – adjustable beam extractor, 9 – first deflector

Ionizing Radiation Detector



Ionizing Radiation Detector



1. Voltage pulse
(charged particle)

2. Positive Peak Detector
(extremum of the voltage signal measurement)

3. Time Over Threshold Detector
(pulse duration measurement)

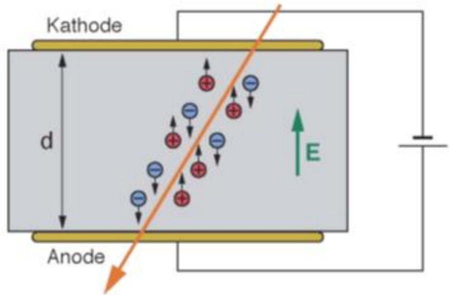
Ionizing Radiation Detector

Advantages of the developed detector:

- ✓ Low-power mode
- ✓ Availability of false signals filtration
- ✓ Orientation on aircraft (continuous measurement)
- ✓ Open sources (all schemes, the method of measurement and microcontroller program are available in the public domain)
- ✓ Universality (it is possible to change the measurement method)

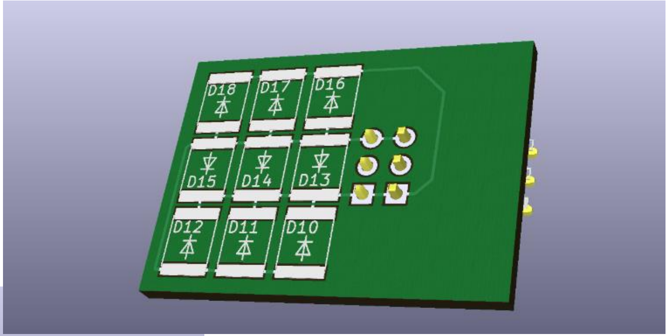
PIN photodiode

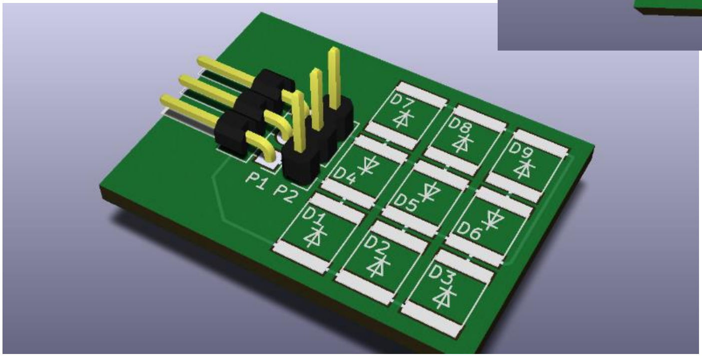
PIN-photodiode consists of p-type, n-type Si semiconductors and intrinsic conductivity portion disposed therebetween.



PIN photodiode detects individual particle of radiation (gamma or charge particle). When a particle strikes a depletion region created by reverse bias on the photodiode, it produces a small amount of charge in proportion to the photon's energy.

PIN photodiode

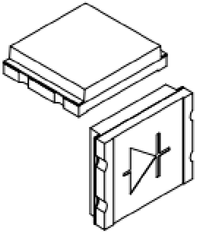


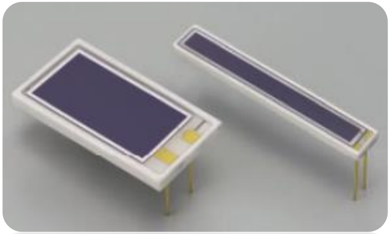


PIN photodiode

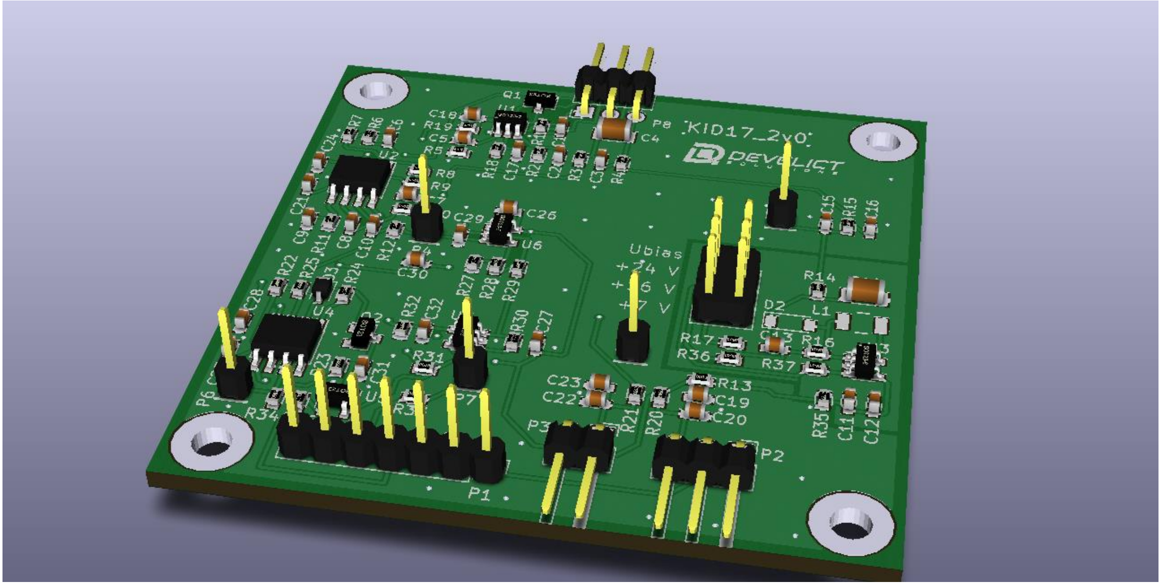
FEATURES

TEMD5080X01	S2744-09
Sensitive area: 7.7 mm^2	Sensitive area : 200 mm^2
Depletion layer thickness: 0.4 mm	Depletion layer thickness: 0.3 mm
Reverse voltage (max): V_R = 25 V	Reverse voltage (max): V_R = 100 V
Spectral response range: 350 to 1100 nm	Spectral response range : 340 to 1100 nm





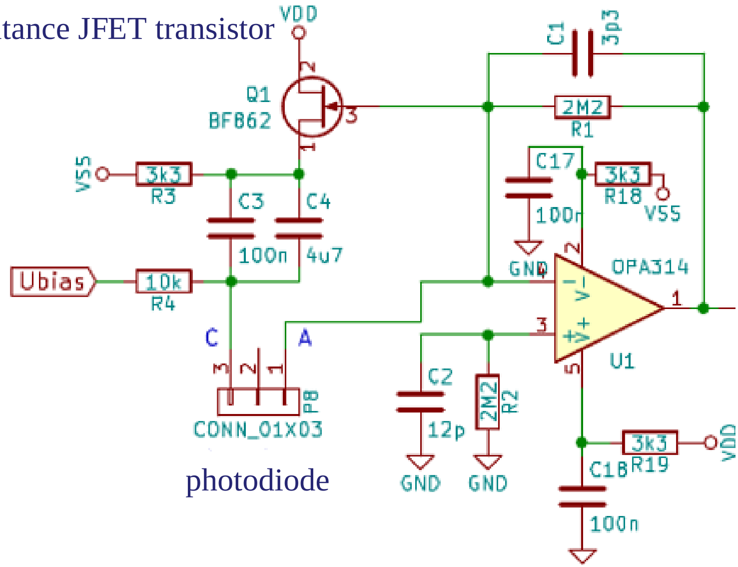
KID board



KID board: Charge sensitive preamplifier

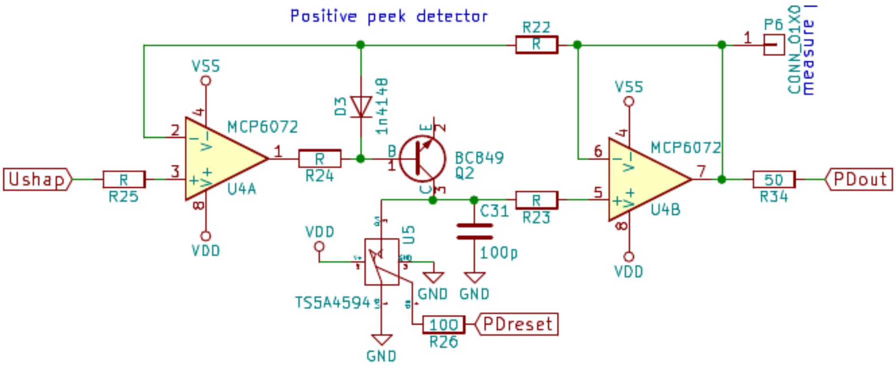
low noise and low capacitance JFET transistor

charge sensitive preamplifier



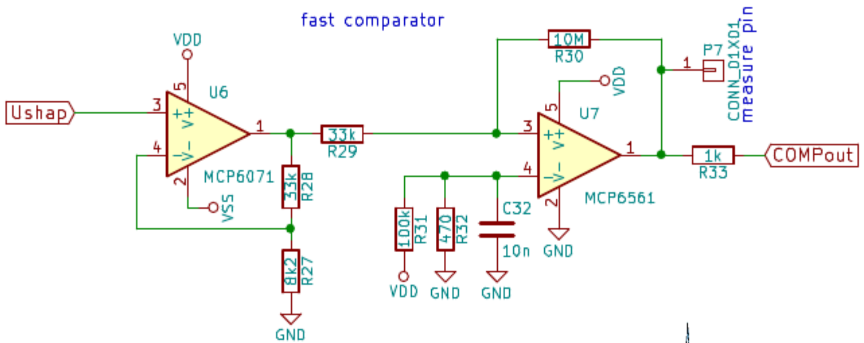
photodiode

KID board: Positive peak detector

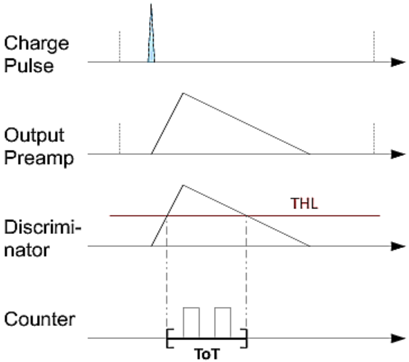


- ➢ Peak detectors capture the extremum of the voltage signal at its input.
- ➢ Output voltage is directly proportional to the energy deposited in detection diode.

KID board: Time over threshold detector

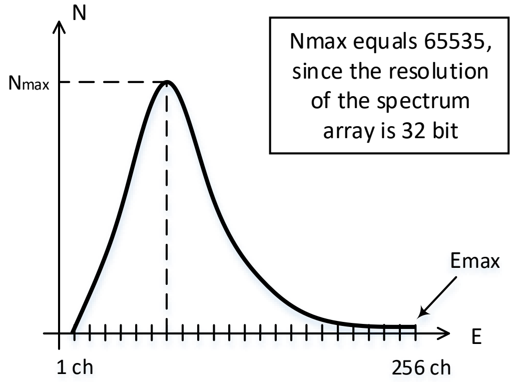


- The time-over-threshold is the number of clock counts in the time interval of the pulse above the threshold.
- The time interval is proportional to the energy deposited in detection diode.



Collecting data: obtaining the energy spectrum

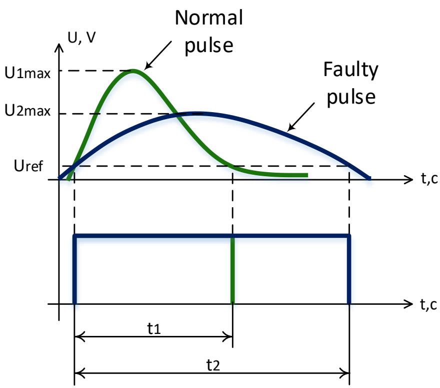
- Detection system feeds microprocessor by signals proportional deposited energy in Si photodiode.
- Processor has to store the data as energy spectrum. Spectrum has 256 channels in which is recorded the number of events (detected particles) in the given energy range.

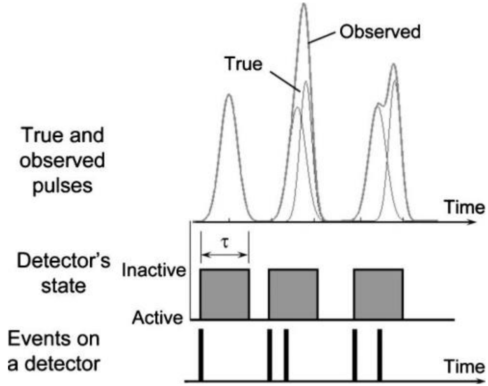


- After calibration, the data will be converted to dose equivalent.

Collecting data: filtration

- After loading inputs we can compare the two detectors (peek detectors and time over threshold detector). If the signals from these detectors significantly different, the event is labeled as faulty and signal is not processed (the electronic collimation of the diode).
- Filtration eliminates the overly wide pulses and Pile-Up effect.





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Processor ARM Cortex M0+ (STM32L053 Discovery board)

Flexible board power supply Through USB or external source

Integrated ST-Link/V2-1 (for programming and debugging)

Direct access to all MCU I/Os

2.04” E-paper display (172x72 pixels)

2 push buttons, 2 color LEDs

One linear touch sensor or four touch keys

Tasks of diploma thesis

a) Collection events from peak detector in microprocessor and calculating energy deposition (read ADC measurements and reset peak detector)

b) Collection events from time over threshold detector and calculating energy deposition (read TTL signal by timer)

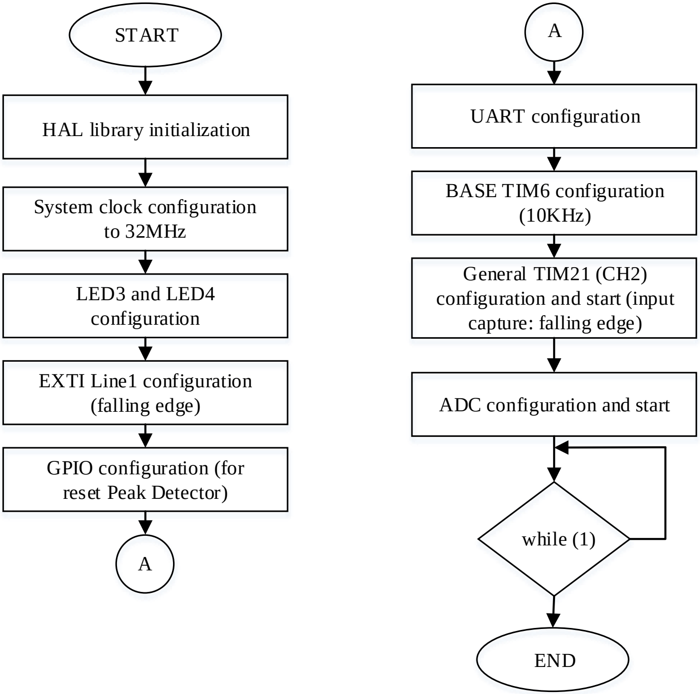
c) Comparison of both methods (both methods work in one processor)

d) Detection and filtering faulty signals (by comparing values from both detectors)

e) Detector calibration (photons from ^{60}Co or α-particles – Department of radiation dosimetry, protons – Tandetron lab)

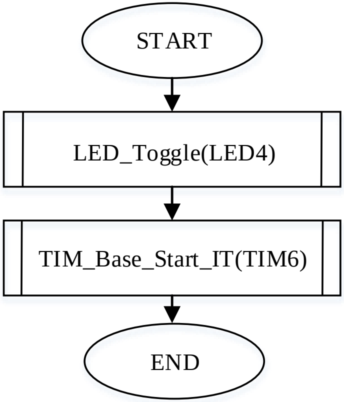
f) Detector test (photons and electrons – Microtron lab)

My first results (1)



Program: Main()

My first results (2)



Program: EXTI_callback()

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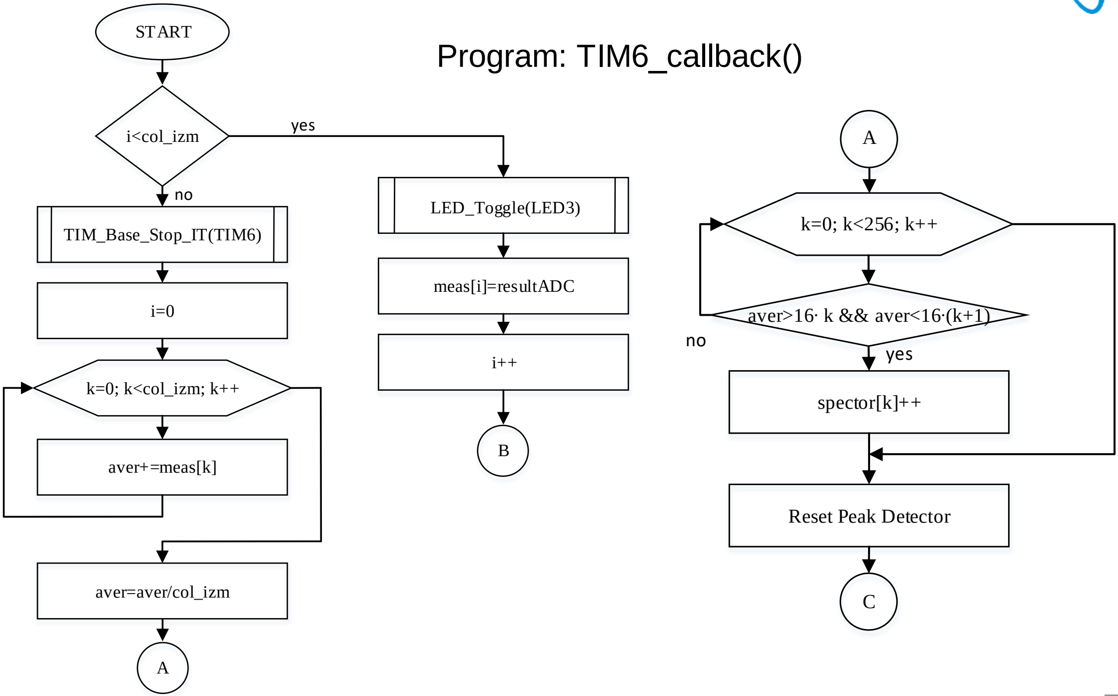
My first results (3)

Program: TIM6_callback()



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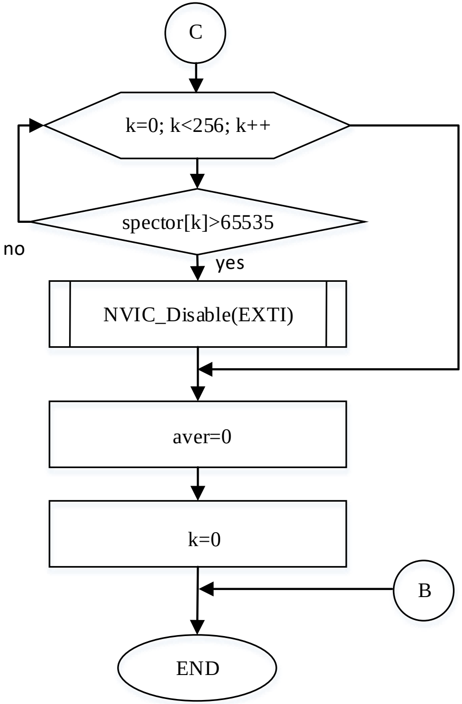
My first results (3)



Continuation of the program:

TIM6_callback()

Conclusion

Progress (from 9 to 25 Feb.):

- ✓ I visited microtron MT25
- ✓ I completed the STM32L0 training in Prague
- ✓ I programmed the first measurement method (for a peak detector)

Next steps:

- ➢ To program the second measurement method (for a time over threshold detector)
- ➢ To compare both methods
- ➢ To realize detection and filtering faulty signals
- ➢ To calibrate detector and make first experiment in Microtron laboratory

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Certificate

Certificate of accomplishment

This is to certify that

Kseniia Larina

has successfully completed the

STM32L0 training

Instructors

S.Panecki

A.Barata

Between **2017-02-22** and **2017-02-23**

ST Prague