MINERvA Serial Protocol

Communication in MINERvA DAQ Upgrade

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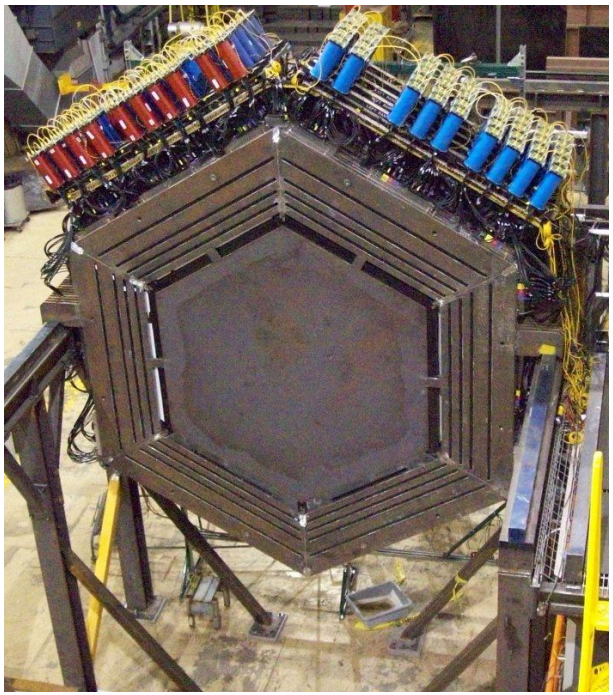
What is MINERvA experiment

MINERvA (Main Injector ExpeRiment v-A) is low-to-medium energy neutrino scattering experiment at Fermilab.

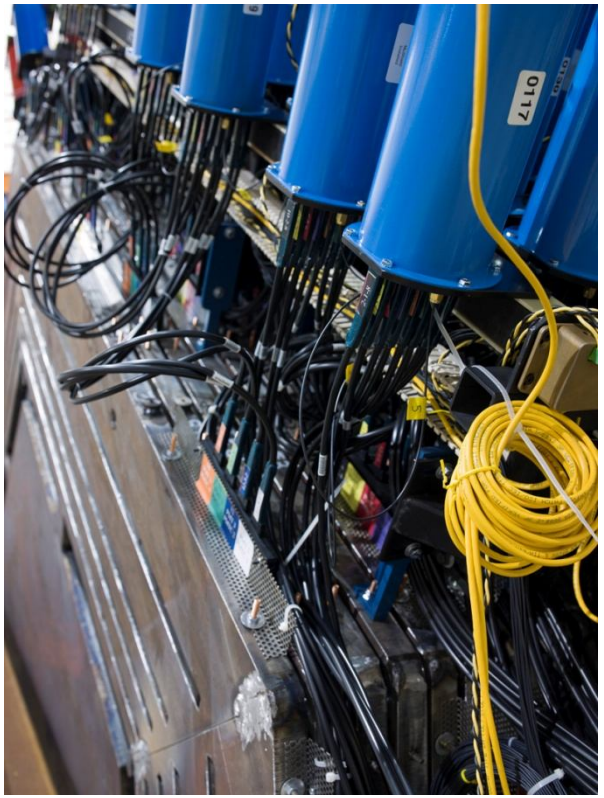
MINERvA seeks to measure low energy neutrino interactions.



MINERvA detector technology

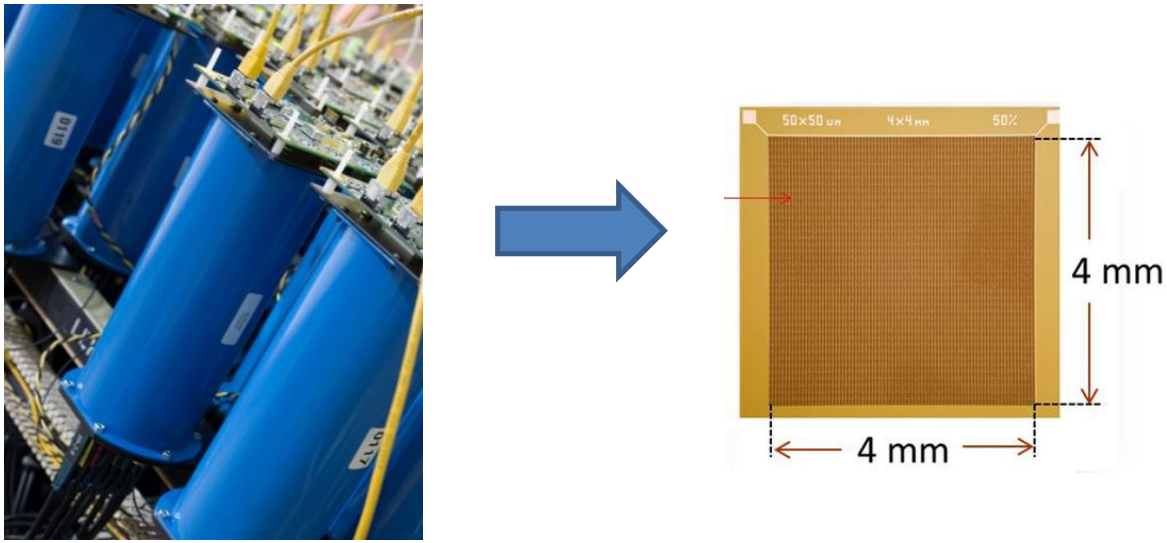
MINERvA utilizes plastic scintillator as detector technology.

Light is then delivered to Hamamatsu R7600 64-channel photomultiplier tubes through long fiber wires.



MINERvA Upgrade

PMTs are replaced by SiPMs

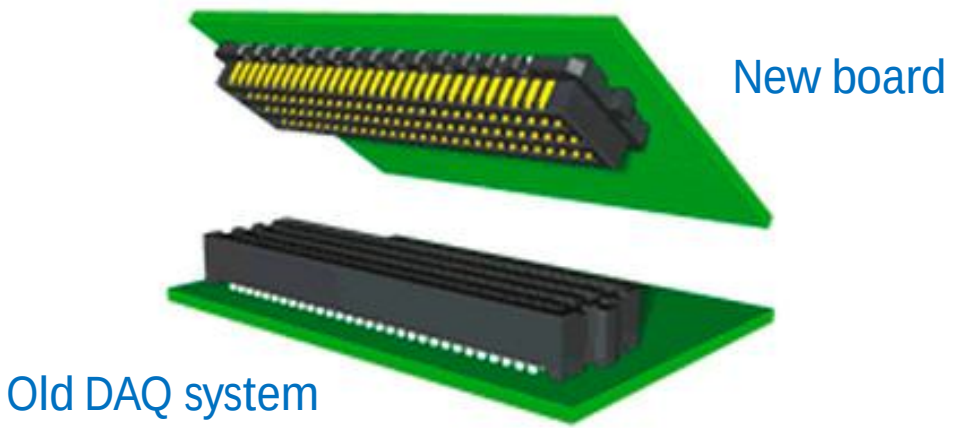


Reasons to upgrade :

- Reduced Crosstalk.
- Increased quantum efficiency.
- Increased light yield by getting rid of optical cables.

Why do we need communication?

Communication is needed to handle NEW TASKS. New detectors will mantain BACKWARD COMPATIBILITY with the DAQ. The board will be plugged into old connector of front end system.

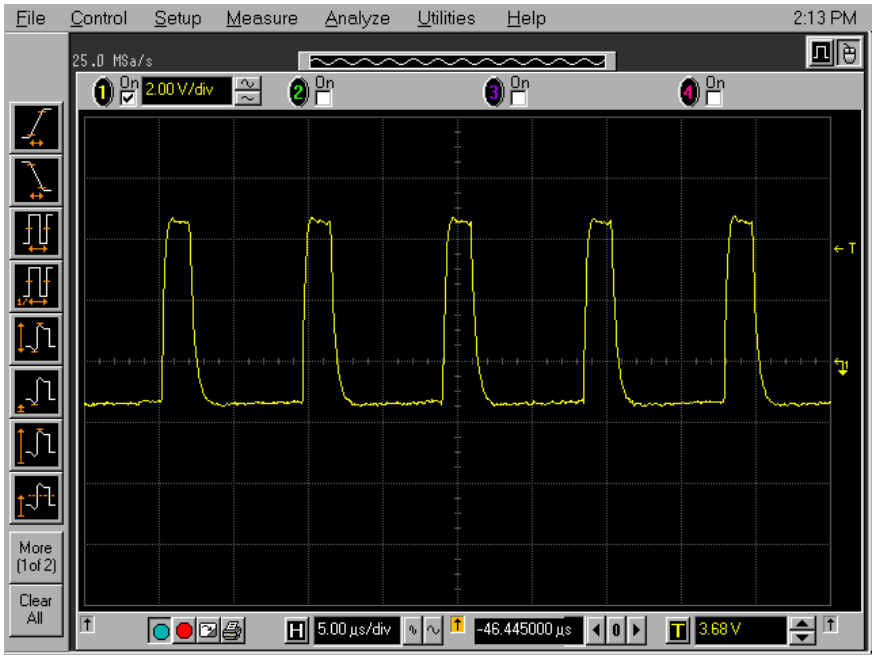


But new electronics requires control from the DAQ. Thus, there is a need for commands and data delivery. As old system was not meant to communicate to other electronics, we had to find a way to reuse hardware that is already on DAQ.

Communication

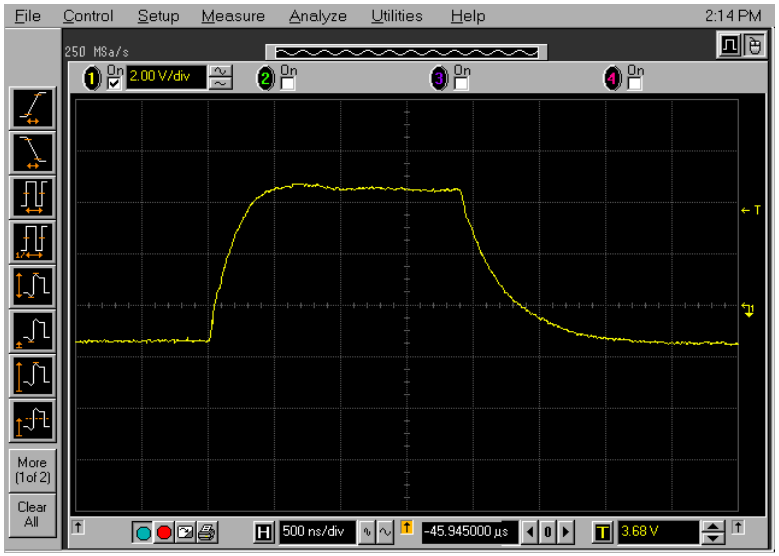
The only way to communicate with the external world is using an onboard transformer. It can produce bursts of pulses.

The diagram below shows a typical stream of pulses from the transformer terminated by 100 Ohms.



Limitations

The picture shows a typical pulse generated by transformer.



Very low reliability of the width of the pulse set a strong limitation and lead us to define a **proprietary communication protocol**.

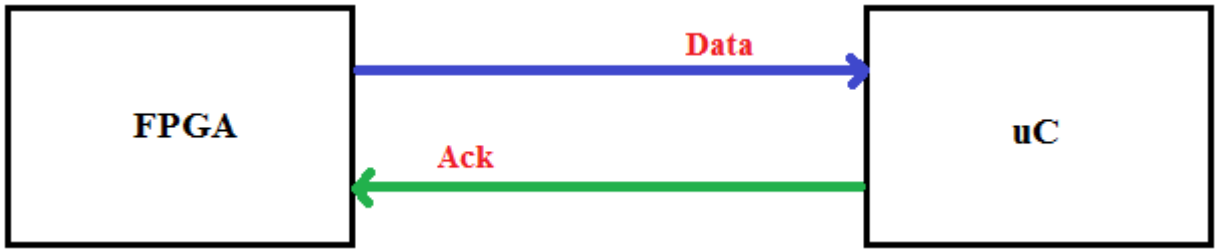
Design

MINERvA Serial Protocol has been designed to make an alphabet out of sequences of pulses and delays.

At the basis of the protocol there are three symbols : Reset, One and Zero.

Commands and data are combination of these symbols.

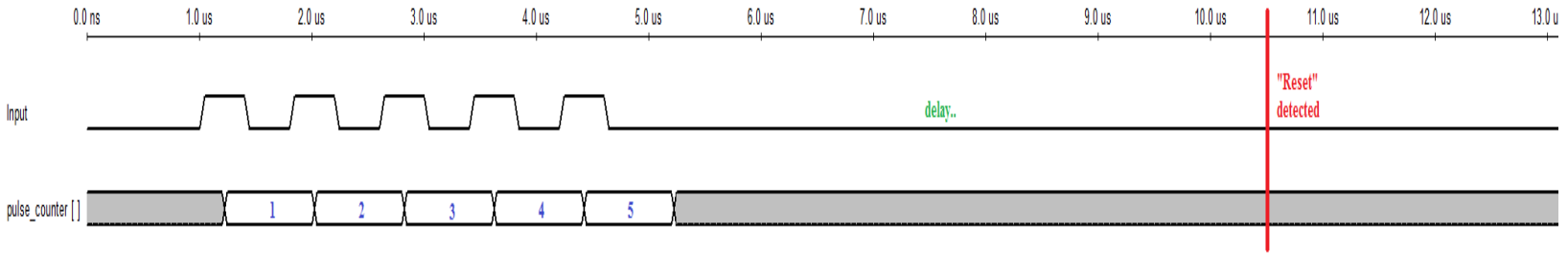
Communication is UNIDIRECTIONAL : the FPGA initiates and controls all activities on the physical link. The Microcontroller can only send Acknowledgement pulses back.



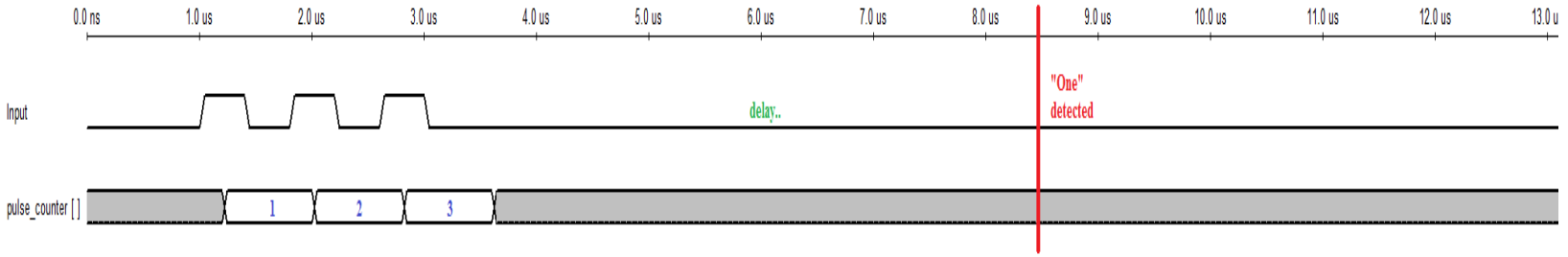
Symbols

Each symbol is a sequence of pulses and delays.

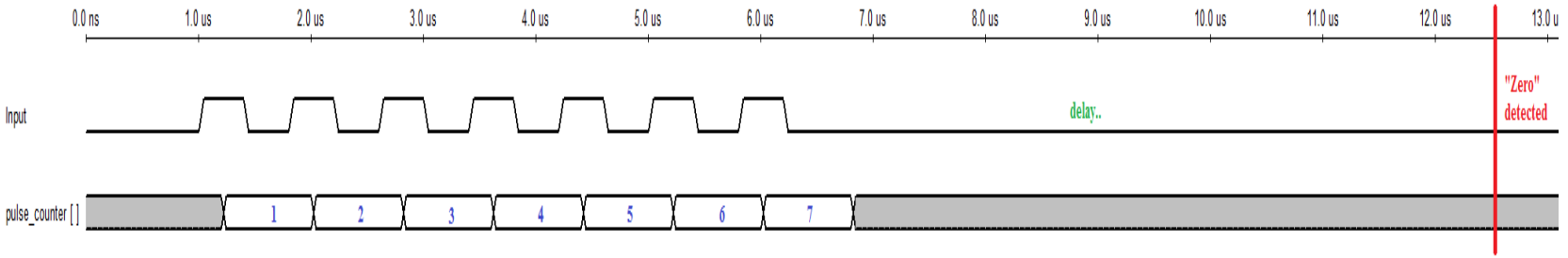
- Reset



- One



- Zero



Commands

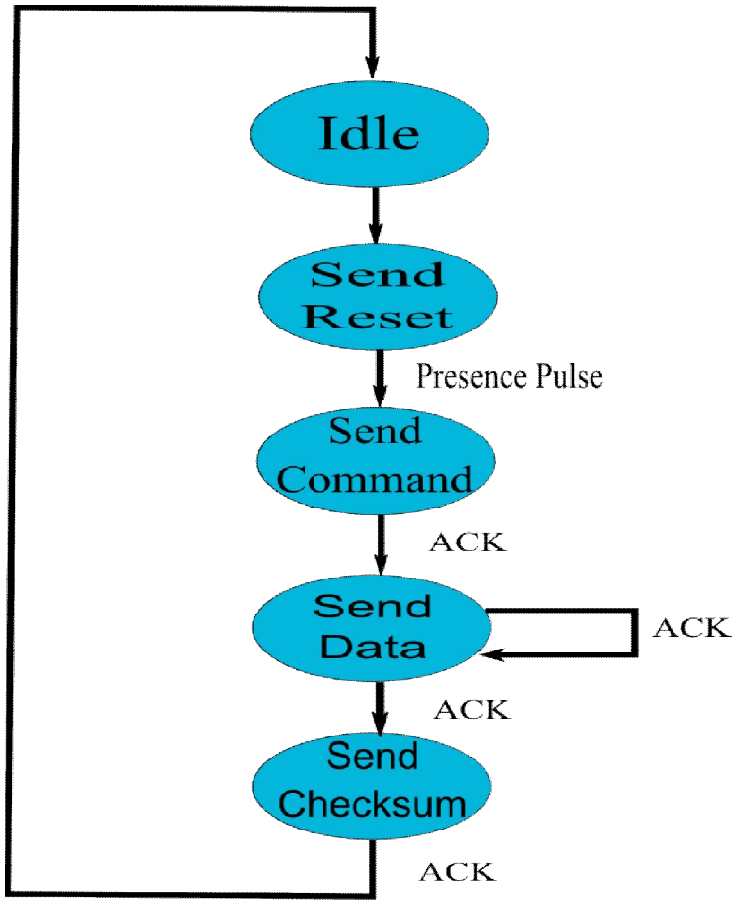
- Commands are meant to address different devices and specify the parameters to set, such as SiPM bias voltages, current gain of amplifier stages, temperature alert thresholds.

  Feature : parameters may be set either before start or modified at runtime.

- Commands are received by a microcontroller (Microchip PIC16F1503). They are transmitted to it by FPGA on the front end board across a transformer.

Theory of operation 1/2

Communication is performed by sending information wrapped into Frames



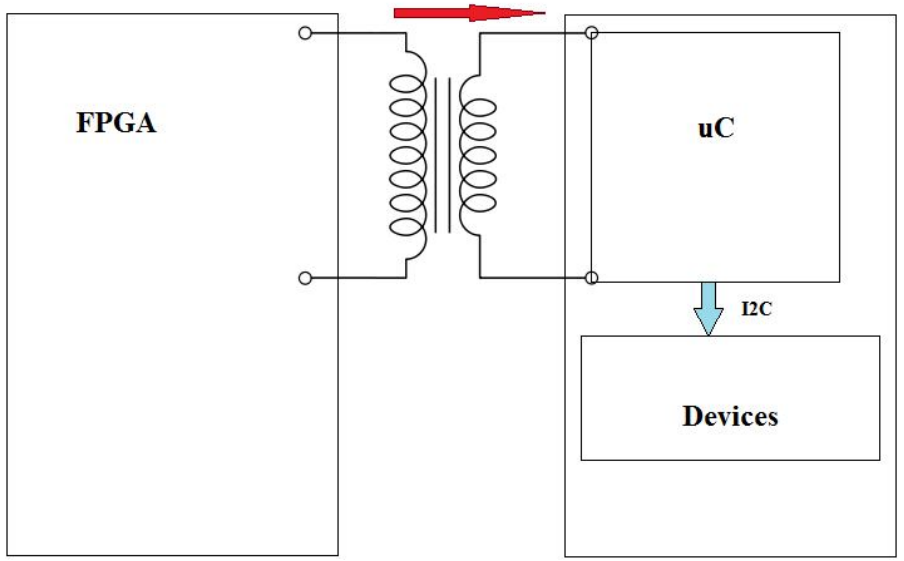
Frame Format :

- Reset
- Command
- Data
- Checksum

Theory of operation 2/2

- Microcontroller is responsible for command identification and translation of commands into a call to the proper routine.

- Communication between Microcontroller and devices is handled using I2C interface.



- For more details see online MINERvA Serial Protocol Specification

Prototype and Tools

Microchip F1 Evaluation Board, PICKIT 3

Summary

What has been done :

- Familiarizing with hardware and development tools.
- Design and partial implementation of MINERvA Serial Protocol.
- Protocol Specification.
- Development and testing of subroutines to handle I2C communication with Thermometer, Digital Potentiometer and DAC.
- Testing of subroutine to identify input symbols.
- Sample code working on Microchip F1 Evaluation Platform.
- Software documentation.

What needs to be done :

- Combine all the subroutines to produce the final version of the software.
- Test the software on the final board.