INCREASING BANDWIDTH OF DATA ACQUISITION SYSTEMS ON IBR-2 REACTOR SPECTROMETERS IN FLNP

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The present paper considers variants of using a high-speed interface USB 3.0 for the data acquisition system based on MPD [0] and De-Li-DAQ-2D [0] modules developed earlier in FLNP and widely used at present on IBR-2 reactor neutron spectrometers. To connect the modules to a computer for this system, a fiber optic adapter with a USB2.0 interface was originally developed. Modern trends towards increasing the number detector channels and volume of registered and accumulated data in real time in experiments on IBR-2 reactor spectrometers of FLNP require increasing the bandwidth of data acquisition systems. Modern detector systems with point detector elements currently used on and being developed for FLNP spectrometers can be connected to data acquisition systems based on MPD-240 and De-Li-DAQ 2D modules, respectively. The MPD-240 module enables data acquisition from a maximum of 240 elements with a maximum load of up to 8 mega events per second. This requires the bandwidth of computer communication channels of up to 50 MB/s, which is impossible with the USB 2.0 interface.

1. Hardware

As a part of the task of increasing the bandwidth of data acquisition systems, the following options of further USB 3.0 using are considered:

The first option assumes development of the new MPD and De-Li-DAQ units with an inbuilt USB 3.0 interface and their connection to a computer via an optical fiber extender of the USB 3.0 interface (fig. 1). This option has become feasible due to emergence on the market of USB 3.0 to Fiber Optical Extenders (fig. 2). Such extenders allow operation of the USB 3.0 interface in the super speed mode with a length of the fiber of up to 250 meters.

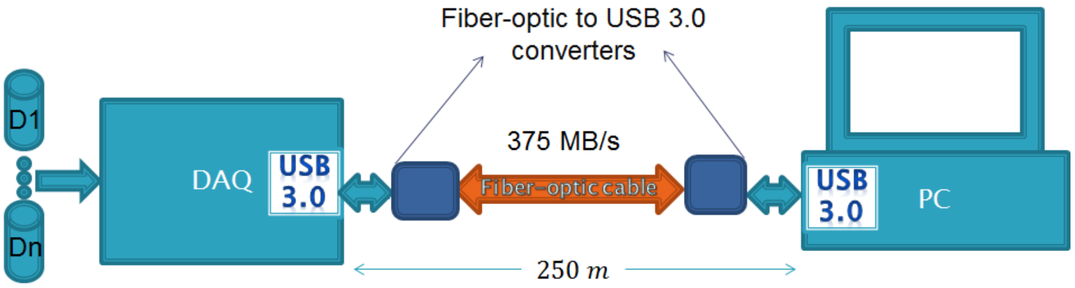

Figure 1. Scheme of data transmission with direct connection

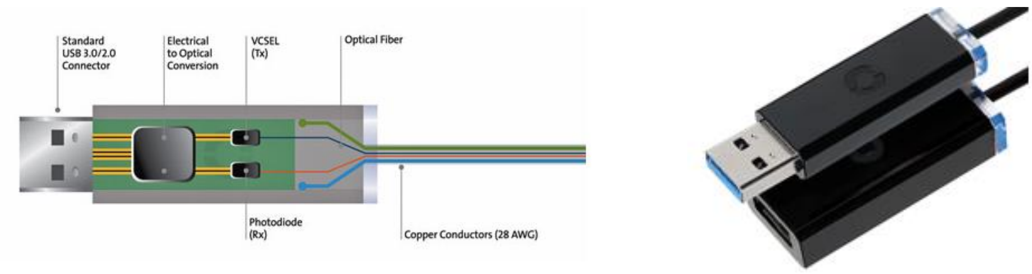

Figure 2. Built-in signal converter

Development of new blocks with USB 3.0 interface is more promising. This permits increasing the data transmission bandwidth up to 375 MB/s preserving the possibility of remote connection as required for FLNP spectrometers. In developing the new blocks there will be taken into account new requirements for characteristics of the existing data acquisition systems that arose in the process of their operation as well as to meet the requirements of the newly developed projects.

The second option assumes development of the new fiber adapter FLINK USB 3.0 (fig. 3). This will allow us to use a maximum data transmission speed of the fiber interface of old blocks and will increase 10 times the bandwidth of the data transmission channel.

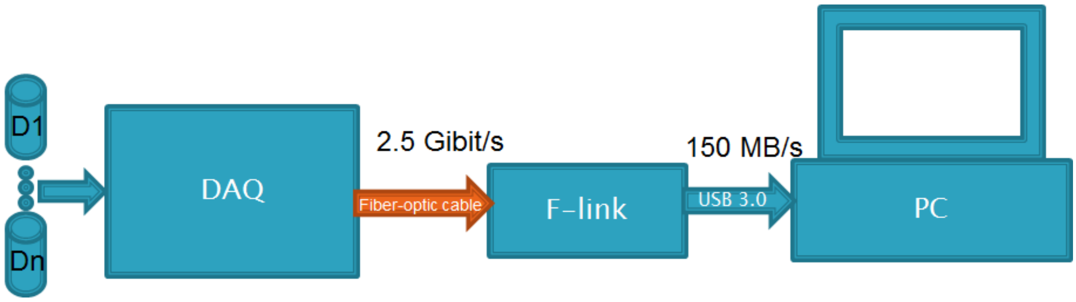

Figure 3. Scheme of data transmission with new module

The first option allows increasing the data transmission rate and simplifying the architecture. However, development of new modules of data acquisition systems with a new interface is much resource and time consuming.

The second option allows increasing the data transmission rate by developing just one module, which allows more effective use of all the modules already installed on the spectrometers.

In the framework of solving this problem the architecture of the new module consisting of three main integrated units has been developed (fig. 4):

- TLK 2501 for synchronization of the optical interface with USB 3.0 at 100 MHz;
- Modern FPGA Cyclone IV EP4CE6E22C8N;
- New chip USB 3.0 FT 600 produced by FTDI.

Also, for increasing the bandwidth the optical interface Serializer/ Deserializer TLK1501 was replaced with TLK 2501 with a maximum rate of the data transmission channel of 2 Gibit/s.

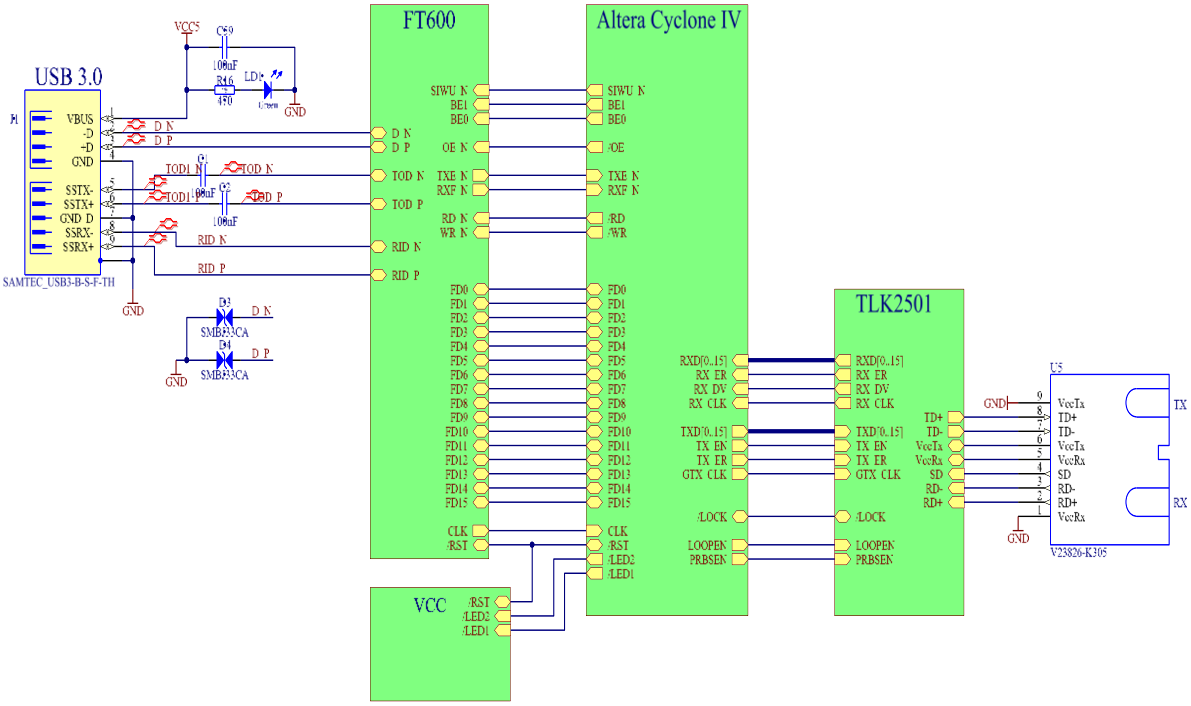

Figure 4. Architecture of new module FLINK USB 3.0

To date, first five samples of FLINK-USB 3.0 converters have been manufactured (fig. 5).

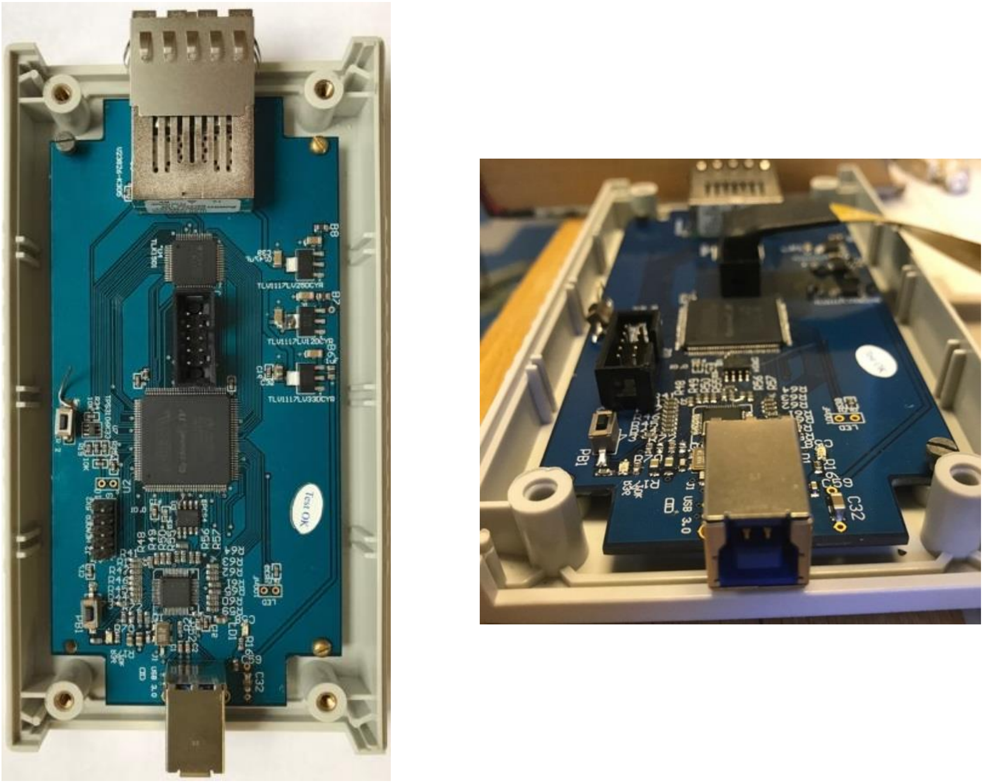

Figure 5. FLINK USB 3.0 module

2. Firmware

In FPGA project design data exchange is realized over two bidirectional 16-bit channels FIFO which use four End Points of the USB interface FT600 (fig. 6).

When the data is recorded to the internal memory and commands are transmitted, the data transmission channel is specified by the USB interface of the application_program which realizes the link protocol with DAQ modules.

In the course of transmitting commands and data from the computer the packet is written to an appropriate transmission buffer with a volume of 2 Kb. At the same time, FPGA reads and checks the transmitted packets using package start ID and check sum according to the format of the packets transmitted by the application program. If there are no errors, a ready-signal is generated and the packet is transmitted to the input of the TLK2501 chip. The Ser/Des_wr module is synchronized with TLK2501 by the acknowledge signal. If TLK2501 is not ready to receive the packet, the application program transmitted error via the Acknowledge_packet.

In the Ser/Des_rd module the type of received data is also determined by package start ID. After synchronization the packet of data is written to an appropriate FIFO buffer. On checking for the error and receiving the acknowledge signal, the packet of data is written to pre_fet module for determining the read channel. The packets of data are further transmitted through the end points 0x82 and 0x83 to FT600.

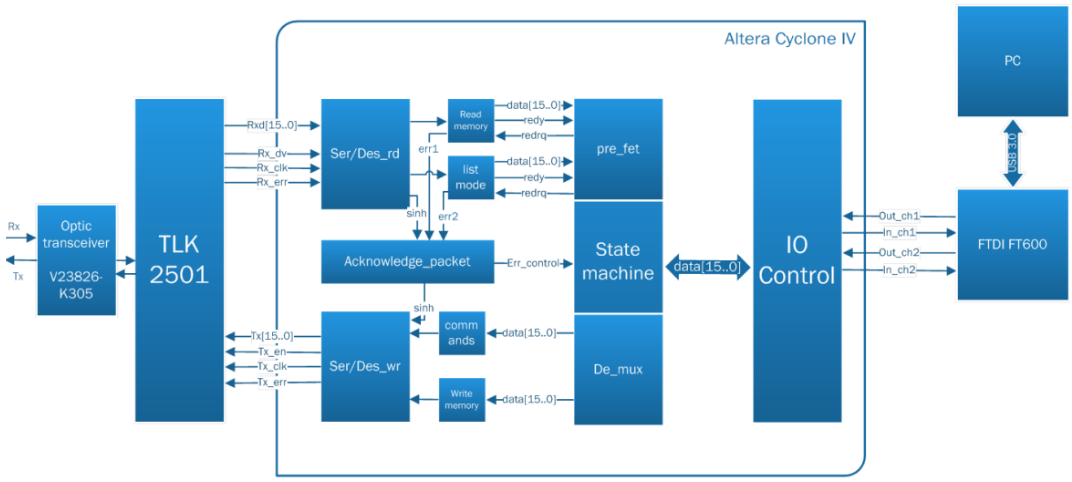

Figure 6. Design of the firmware FLINK USB 3.0

For developing the FPGA firmware a test kit based on the FTDI UMFT600A debugging set, Cyclone V debugging set and the optical interface module earlier manufactured in FLNP, are used.

In the course of testing the reading of data in the Loop Back mode by the optical cable through the TLK1501 the maximum data rate 156 MB/ s is achieved (fig. 7). This speed is a maximum feasible one in transmitting data through TLK1501.

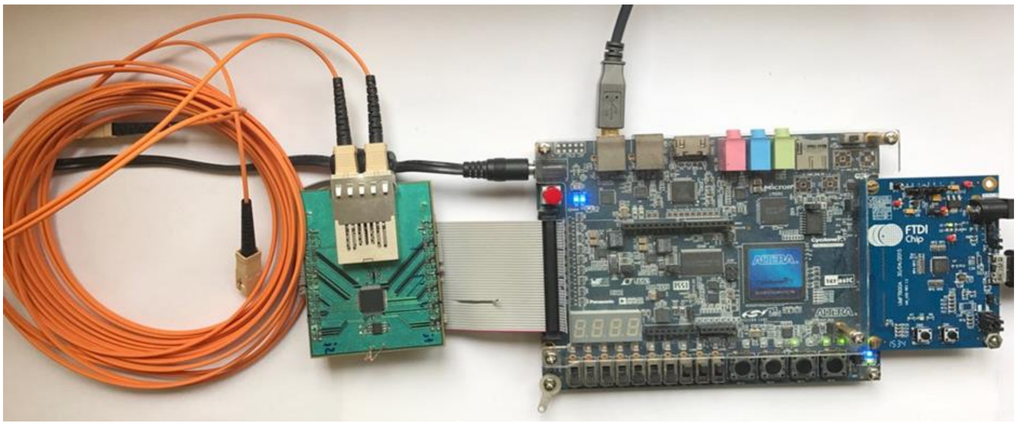

Figure 7. Loop Back test on test layout

To date, the manufactured module FLINK USB 3.0 has been successfully tested in the loop back mode (fig. 8). As a result of the test the speed of data reading 140 MB/s has been achieved.

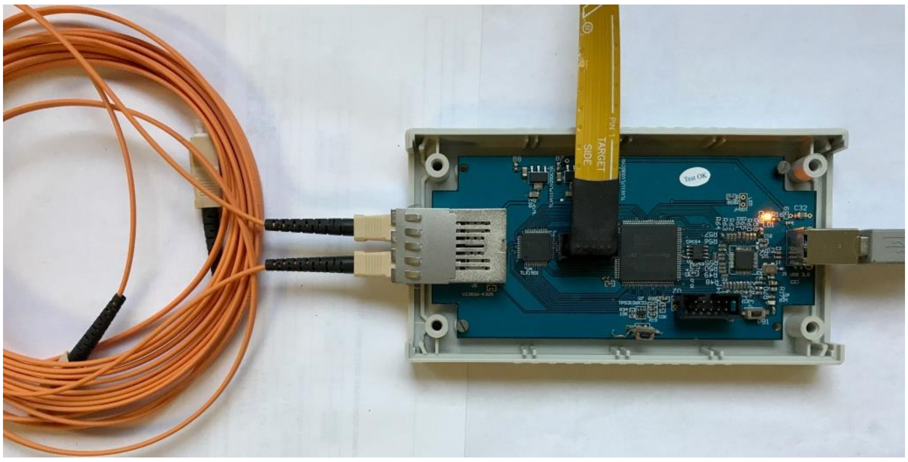

Figure 8. Loop Back test on FLINK USB 3.0

3. Future plans

Work to increase the bandwidth of data acquisition systems will continue. A new MPD-16 module with USB 3.0 interface has already been designed (fig. 9). Developing of the new MPD and De-Li-DAQ-2D modules with USB 3.0 interface together with using a USB 3.0 to Fiber Optical Extender allows increasing the bandwidth of the data transmission channel of data acquisition systems up to 350 MB/ s.

Work on developing the firmware for MPD-240 and De-Li-DAQ modules is also under way today.

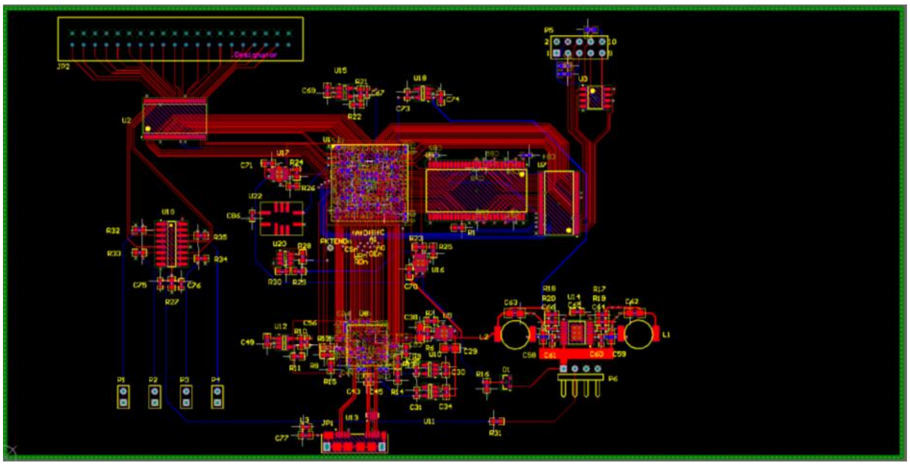

Figure 9. Layout of new module MPD 16

4. Conclusion

Today manufactured module FLINK USB 3.0 has been successfully tested. At first cycle of reactor working is planning to continue testing the system on the spectrometers of the IBR-2 reactor in real experimental conditions.

References

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[2] F.V. Levchanovskiy, S.M. Murashkevich. *De-Li-DAQ-2D – a New Data Acquisition System for Position-Sensitive Neutron Detectors with Delay-Line Readout*. /ISSN 1547-4771, Physics of Particles and Nuclei Letters, 2016, Vol. 13, o. 5, pp. 591–594.