CONTINUOUS DATA ACQUISITION BY MYRIO USED FOR MEASUREMENT OF POLARIZATION TRANSIENT EFFECTS

Petr Dejdar
Doctoral Degree Programme (2), FEEC BUT
E-mail: xdejda00@stud.feec.vutbr.cz

Supervised by: Petr Münster
E-mail: munster@feec.vutbr.cz

Abstract: The paper describes the design and development of a universal software for communication with the myRIO device, which is used for data acquisition from the optical fiber sensing system detects vibrations. Specifically, it is a system using polarized light passing through an optical fiber and the subsequent calculation of the rotation change of the polarization of light. The device from National Instruments myRIO is used to obtain values from four photodetectors of polarimeter. This is a cost-effective system for analysing fast polarization rotation changes from four photodetectors. Finally, the paper deals with the use of a liquid crystal based polarization controller to set the initial polarization of the laser and use the component for measurement of polarization in time.

Keywords: data acquisition, GUI, NI myRIO, optical fiber, photodetector, polarimeter

1 INTRODUCTION

There are two ways to measure the optical polarization of optical fibers. The first is non-destructive measurement using in-line polarimeters. For example, applying a polarimeter using blazed fiber gratings [1]. The second option for measuring is to use an in-line polarimeter based on discrete optical components, namely several semi-transparent mirrors, or it is possible to use a subwavelength antenna array to generate four (or more) scattered beams [2]. Another option for in-line measurement is the use of Faraday rotations [3]. The second option is an impermeable polarimeter. In most cases, these polarimeters are based on Stokes polarimetry. Whether it's commercial polarimeters like Thorlabs PAX1000VIS/M [4], or non-commercial [5].

In the paper the use of polarimeter with four photodetectors for the measurement of polarization rotation is described. Furthermore, there is a design for the possibility of adjusting the polarization of the source using the Liquid Crystal Based Polarization Controller. It consists of four static liquid crystal retarders, which have the same function as rotating plates, in a polarizer using technology with rotating plates. The selected polarizer operates in the C-band and is connected to the FC/APC connector with a pigtail length of 1 m. The National Instruments myRio board, which has twelve input channels and a maximum sampling rate of 500 kS/s, is used for data acquisition from the photodetectors. Thorlabs PAX1000 polarimeter was used to check the polarization rotation measurement. The original connection of the experiment is described in the paper Measurement of Polarization Transient Effects Caused by Mechanical Stress on Optical Fiber [6], where Red Pitaya with two input channels is used for data acquisition from the balanced detector.

The goal is to create a system that can monitor and analyze fast polarization changes. There are also ready-to-use solutions with up to 1 MS/s sampling rate, such as the Photonics in-line polarimeter [7]. The polarimeter we have created could achieve a sample rate of hundreds of kS/s, which is slower but significantly more cost-effective than commercial solutions.

2 METHODOLOGY

A low noise Laser LD101 with a wavelength of 1550 nm and 5 MHz spectral width was used to test the photodetectors as a polarimeter. Using a polarization beam splitter, light is connected to the four photodetectors, from which the signal is then connected via the low noise, rail to rail operational amplifier to the analog inputs myRIO. These analog inputs are labeled AI0–AI3 in Figure 1. Other used pins from myRIO are DI0 and DI1, which are used to control transistors that change signal amplification.

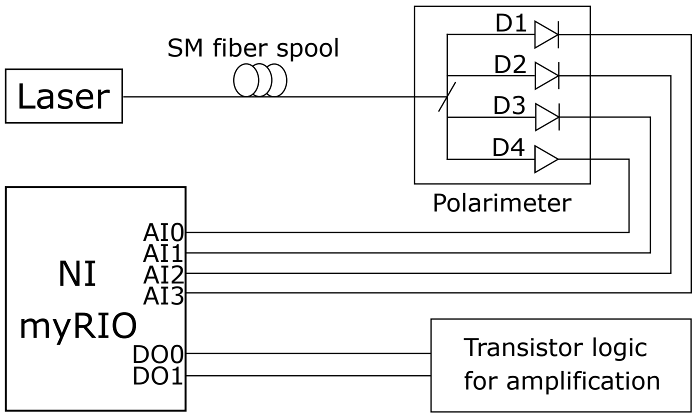

Figure 1: The scheme of the workplace.

3 DATA ACQUISITION

The detection unit consists of four detectors, so for data acquisition, it was necessary to use a device that has at least four analog inputs and at least two outputs for the possibility to change the gain. MyRIO board from National Instruments is used for the data acquisition. It can acquire up to 12 channels at 500 kS/s using one channel. If a user wants to use more than one channel the sampling rate is decreasing. In the simplest program when myRIO reads data from four channels and sends data over Transmission Control Protocol (TCP) protocol, the maximum frequency is 29 kS/s. For more complicated calculations, the sampling frequency then is decreasing again.

For detectors, it is also possible to change the gain. Two digital outputs are used for this purpose, where four gain values (10×, 5×, 1× and 0.9×) can be set using logical levels. This option is implemented in the Graphical User Interface (GUI) and by using network variables it is possible to change this gain before measurement. Another parameter that the GUI should be able to set is the sample rate. Because the sample rate is set using the frequency limitations while loop as shown at Figure 2, this operation also decreases the sample rate. Therefore it is possible to create a GUI for maximum sampling rate, i.e. 29 kS/s and especially a GUI with the possibility of setting the sample rate, where a maximum value of 6.5 kS/s is reached. To change all parameters, network variables are used, which are specially designed for communication with myRIO devices over TCP protocol.

Lastly, an infinite while loop is implemented in myRIO. Because of this, the program starts as soon as the device connects to the electrical network and runs until disconnected. If the operation PC is not connected, only the TCP listener is started on myRIO. The infinite while loop can be terminated by the integrated manufacturer's button.

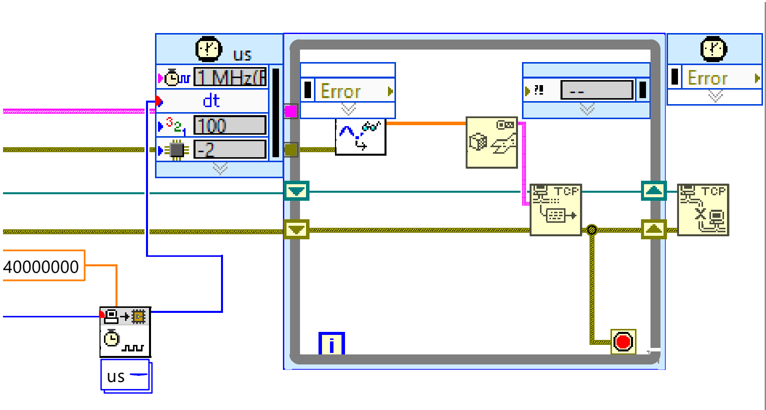

Figure 2: Block diagram of sampling rate setting.

4 GUI FOR OPERATION PC

For connected PC GUI in LabVIEW was created in Figure 4, where the user can set main parameters. First, the user is able to set the target time. It is set in seconds and is unlimited. The second parameter is Amplification, which switches the network variable for gain. The third parameter is the sample rate, which can be set from 1 to 6500 S/s because of the maximal sampling rate. And the last parameter is file length which defines files and data. For example, the target time is set to 60 seconds and file length to 10 seconds, then it creates 10 files, each with 10 seconds of data. This was created for extra long measurements to further process the data.

The data is saved in Technical Data Management Streaming (TDMS) format because it is the official bit stream format in LabVIEW and can be read in Microsoft Excel. The data can be further processed in both LabVIEW and Matlab. Of course, it is possible to capture data other than using the GUI, so in the GUI IP address is written and port for connecting any computer and the possibility of using other programs. Data is in big-endian, network order format.

The timestamp is generated using the computer's real-time converted to epoch time in Figure 3. This time is only generated when creating a new file. The calculation in each cycle also would slow down the program. At the same time, knowing the sample rate and the start time, it is possible to calculate the epoch time to display the timeline retrospectively.

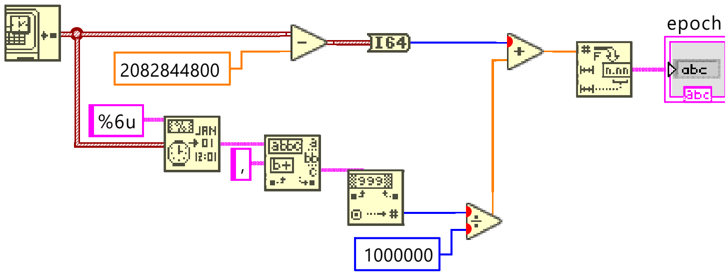

Figure 3: Diagram of calculation epoch time.

The main function of the program is reading data from TCP and saving it into newly generated files. These main functions are running in two parallel while loops to increase program speed. In the first loop, the TCP port 6486 is opened and the data is continuously read from this port and saved to the current file. The second while loop watches the set file length and when the time is exceeded the TDMS file is closed, the next file name is generated and this file is created. Based on the local variable, the file name is overwritten in the while loop that stores the data, and this loop then writes the data to the newly created file.

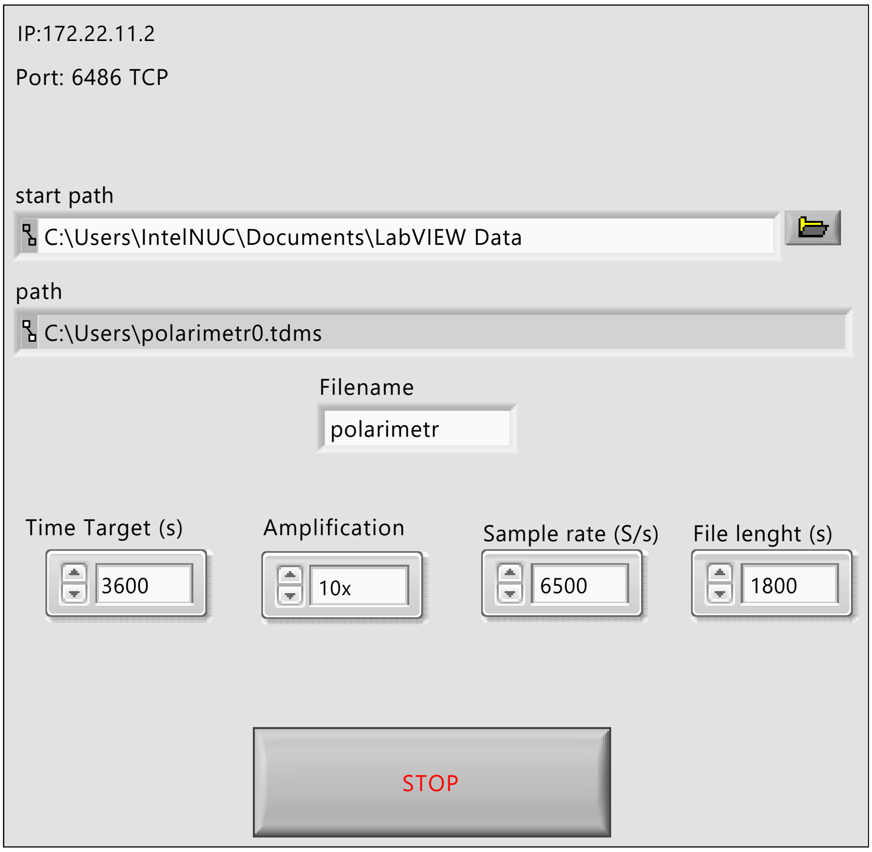

Figure 4: GUI for measurement of polarization's data.

5 POSSIBILITY OF USING LIQUID CRYSTAL BASED POLARIZATION CONTROLLER

To build a polarization rotation measurement system, it is necessary to polarize the input light signal. The design of the system must, therefore, be extended by a liquid crystal based polarization controller with a driver. This controller must then be set up.

The polarizer setting must be checked in time with a polarimeter. Thus, it is assumed that the polarization controller is directly connected to the polarimeter. Ideally, a long-term measurement is necessary to verify the correct function of the controller, to detect the change in polarization over time, or what deviation occurs. After adjustment, it is then possible to disconnect the polarimeter and connect the measured fiber. The original scheme of Figure 1 will, therefore, be complemented by a combination of a laser connected to a liquid crystal based polarization controller and then to the fiber spool. This is a configuration for measuring the input light polarization. Subsequently, the fiber spool should be replaced by a real path where the change in polarization rotation will be measured and the changes in the fiber should be determined.

6 CONCLUSION

The first chapter of the paper discusses the theory of polarimeters, some types, commercial polarimeters, and differences between destructive and non-destructive polarimeters. In the following section, the schema of the workplace is shown and the function of each component is explained. The myRIO device used for data acquisition and its program is described below. The fourth chapter describes the GUI, which is used to set up the device and is running on the connected computer. And in the last part, there is a design for using liquid crystal based polarization controller for the initial setting of light polarization.

After commissioning, the device was connected to a real testing trace. Both short-term and long-term (even multi-day) data acquisition were tested. The program for the connected PC was modified over time and the errors that occurred mainly in long measurements were eliminated.

In the future, it is planned to extend laser with the liquid crystal based polarization controller, which should set the initial light polarization and test its function. This system should be used to detect vibrations using a single mode fiber based on a change in the rotation of polarized light.

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