Master's Thesis Engineering Technology

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Integration of a PI controller in a wireless control network

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Introduction

The use of a wireless network is becoming more and more attractive but what are the disadvantages of it? This paper focuses more on the integration of a specific control structure in which wireless communications are used and researches if using wireless technology can be used in an industrial setting. To get a full wireless control network, a PI controller was implemented in the network. To understand what the disadvantages are, we need to take a closer look at the communication problems and which impact the implementation of a PI controller has in the wireless network.

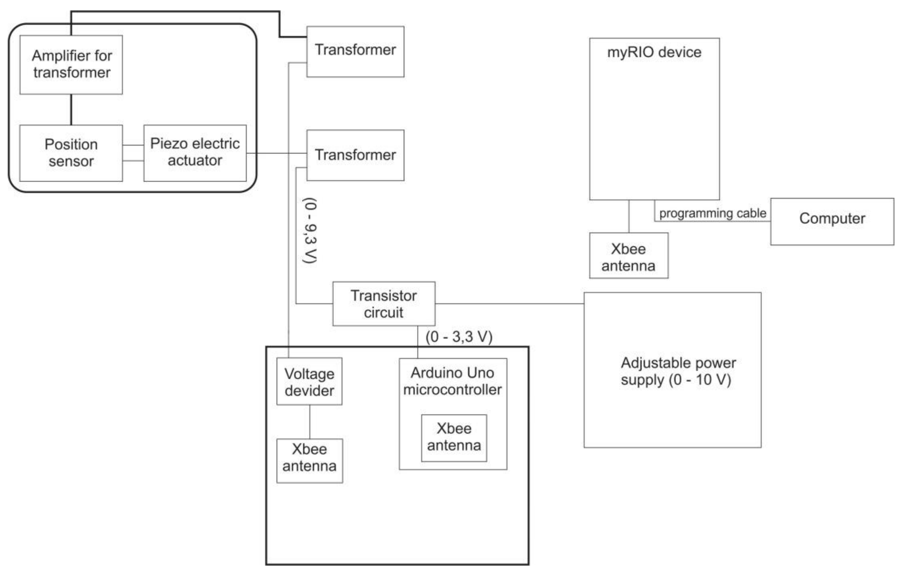

Figure 1 :Schematic overview of the total setup

To accomplish this wireless network XBee antennas are used, these transmit the data from the sensor to the myRIO and from the myRIO back to the actuator. An Arduino Uno microcontroller is used to interact with the physical world. Its primary use is to generate a PWM signal in order to control the end effector. In order to convert the PWM signal that is provided by the Arduino microcontroller a transistor circuit is built. This circuit will transform the PWM signal into an analog signal with a range of 0,7 V – 10 V. The PI controller will be configured within LabVIEW and will eventually be uploaded onto a myRIO device, with which it can run autonomously. The myRIO runs the LabVIEW program and saves the data that is obtained. The end effector used in this setup is a piezo electric actuator outfitted with a position sensor. This actuator is a good representation of an actual end effector used in industrial processes. The paper was separated in 2 main parts : Communication and Controller.

Controller

For the control algorithm a simple PI controller is used. This type of controller is chosen because it is simple to implement, simple to configure and is most commonly used in industrial processes. In order to configure the PI controller a MATLAB toolkit was used to determine sufficient parameters. This toolkit uses a series of data which we acquired through LabVIEW. Figure 2 consist of receiving and sending data without controlling. Figure 3 is a closed loop system with a PI controller.

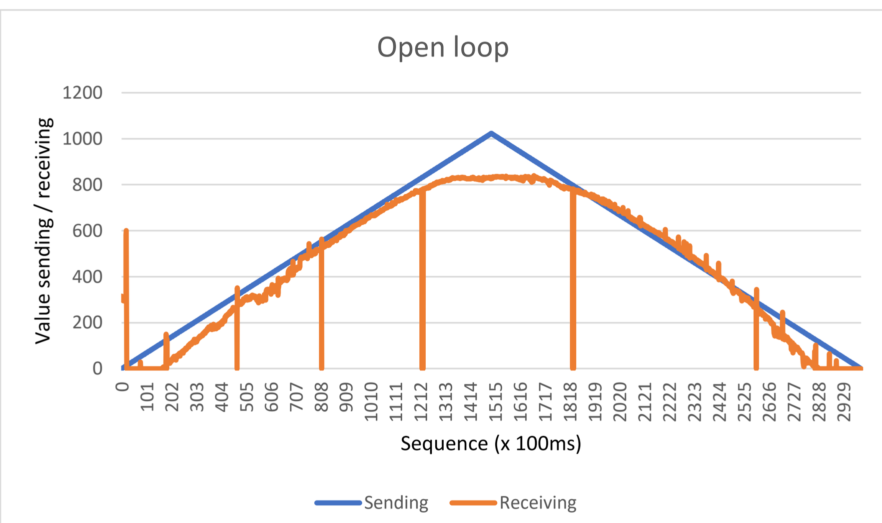

Figure 2 :Open loop test (sequence =100ms)

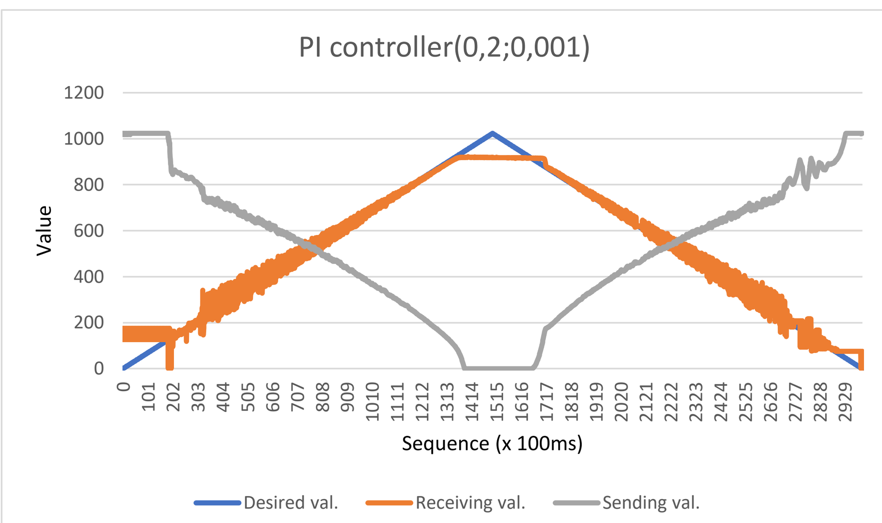

Figure 3 :Closed loop (PI controller, sequence=100ms)

Communication

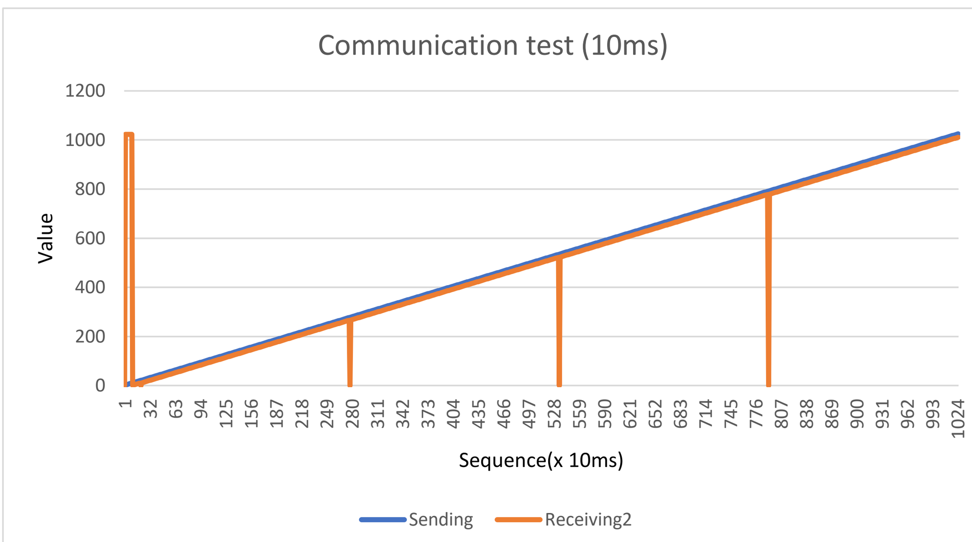

Figure 4 :Communication test (Lost samples)

Lost samples	Total samples	Start error	
3	1025	11 samples	
Percentage lost samples		Latency	
0,29585799 %		14 samples	= 140 ms

Table 1 :Communication errors (Lost samples,start error, Latency)

Only the myRIO controller and Arduino Uno microcontroller are used to test the communication. The principle behind these tests is to see how the frames are sent and received. Latency (Table 1) equals the starting error and increases with the amount of wrong frames.

The starting error is due to frames from the previous test remaining in the buffer.

The wrong frames occurred each time the data byte "0A" was sent. This problem was solved but the source of receiving the wrong frames was unknown.

Test Results

The PI will control the sending value depending on the received value and the PI parameters. All PI controllers are configured with the same parameters. The buffer error was solved by clearing the buffer in the beginning of every test.

When there is a fault in the checksum, the myRIO uses the previous frame and uses that data to control the system herby the problem of wrong frames is solved.

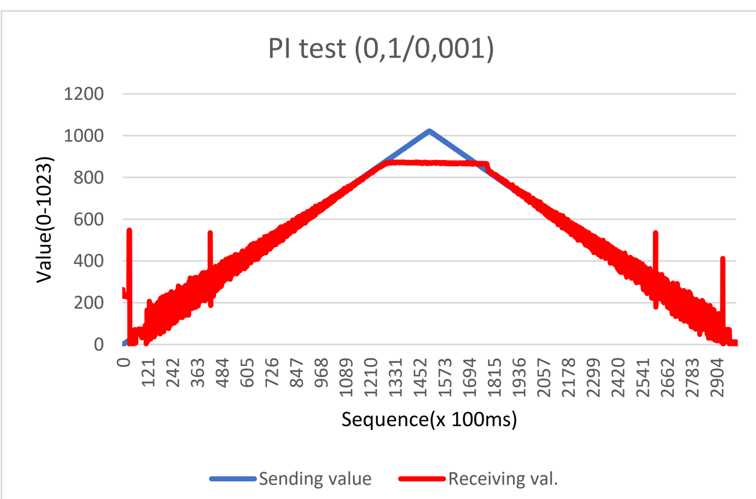

Figure 5 : PI Test (ramp, sequence = 100ms)

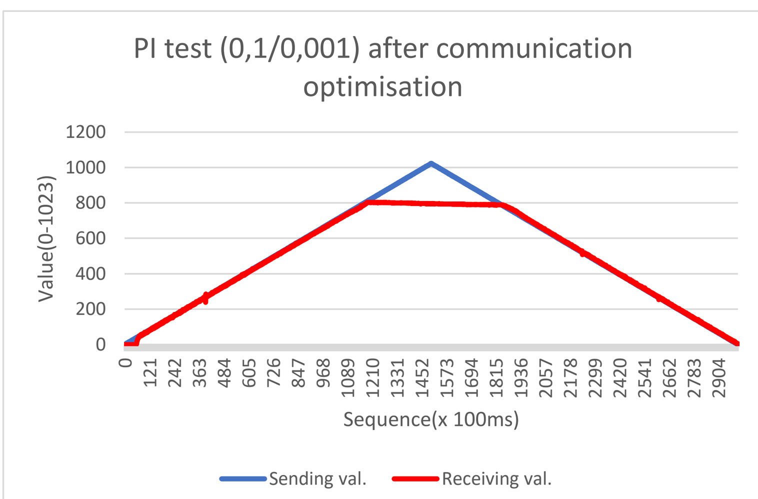

Figure 6 : PI Test after communication optimisation (ramp, sequence = 100ms)

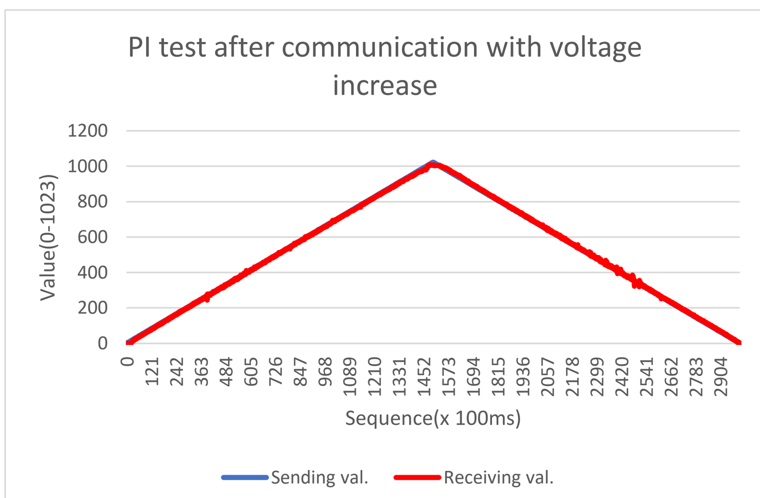

Figure 7 : PI Test after communication optimisation and increasing voltage (ramp, sequence = 100ms)

Conclusion

Some problems were encountered such as package losses and latency. These are characteristic to wireless systems but it was deemed necessary to further research these aspects in order to determine the validity of using wireless networks in a control structure. In the end we were still unsuccessful in finding the cause of this problem but at least a solution was found. There are a few problems inherent to the wireless transmission of data. For instance this should only be used with non-critical systems. Also for systems that require real time control, the response time of the wireless systems is just too slow. Overall we can conclude that the implementation of the PI was successful.

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