

WCES-2010

Remote accessible laboratory for error controlled coding techniques with the labview software

Berkay Erder^a *, Aynur Akar^a

^a*Technical Education Faculty, Marmara University, İstanbul, 34180, Turkey*

Received October 5, 2009; revised December 14, 2009; accepted January 4, 2010

Abstract

Whilst the laboratory works at faculties providing education on the field of electronics and communication support the technical knowledge of students, they also develop their implementation abilities. The fact that there is less equipment requiring advanced technologies in laboratories, enforces the students to group works and thus limits working time and their contribution to the experiments. Contemporary computer technology provides the possibility for establishing alternative laboratories, environments in which the students can perform implementations without the restrictions of location and time.

In this work, real time remote accessible experiment sets are prepared regarding coding techniques with error control. It is provided that the students can connect to the web based laboratory system via any computer on the LAN and make experiments. In this laboratory, the student will perform real time implementations without the restriction of location and time and strengthen their theoretical knowledge.

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Keywords: LabVIEW; Error Control Coding; Remote Accessible Laboratory; WEB Based Learning; Block Coding; Convolutional Coding; Turbo Coding.

1. Introduction

Technical education faculties hold an important place both at meeting the needs for teachers at technical high-schools in our country, as well as the needs for qualified personnel of the industry. At these faculties, along with theoretical lessons, also practical laboratory works are performed. These laboratory works support the theoretical knowledge of the students and develop their implementation abilities. As the laboratory equipment means make it necessary that the students make some applications in groups, alternative methods, which provide support to the laboratory works, are developed. With the increase of the importance of remote education day by day, remote accessible and controllable environments are needed. Thus, students will be able to access the laboratory facilities without the restriction of location and time. Remote accessible laboratories are applications at which the students connect to laboratory equipment remote and perform experiments and get the results of such experiments as feedback information (Cmug, 2006). The basic need in order to obtain reliable information on the end of the receiver in communication systems is to apply error controlled coding techniques. For this purpose, techniques like block

* Berkay Erder. Tel.: 0555 6710396

E-mail address: berkayerder@hotmail.com

coding, convolutional coding, turbo coding are used (Grant, 1999). The real time applications of the error controlled coding techniques in this work are prepared by the LabVIEW software and a remote accessible laboratory is established. So the students will strengthen their theoretical knowledge by real time applications they will make in the remote accessible laboratory without being restricted by the location and time.

In Part 2, information regarding the equipment structure of the established remote accessible laboratory is given. In Part 3, information regarding the block coder, convolutional coder and turbo coder experiment sets, designed with the LabVIEW software, is given. It is explained how the students will access the experiments via the web-site and the ways to be followed while making the experiments. And in Part 4, it is dealt about the obtained results and evaluations at the end of the work.

2. Hardware Structure

The hardware setup of real time tests regarding error control coding techniques is given in Figure 1. The server computer in the system provides the control of the Agilent 33220A signal generator and the NIDAQ 8.6 data acquisition card in the system via its USB ports. The server provides transfer of the application into the intranet and internet environment via an ethernet card. The Agilent 33220A signal generator is used to generate the data signals to be applied to the inputs of the coders in the performed applications. The signal generator generates random values via the block structure, designed with the LabVIEW software. These random values of the signal generator are transferred into the computer environment via the NIDAQ 8.6 data acquisition card. The signal generator and the data acquisition card, used in the application, are devices with USB interfaces. They are connected via USB cables to the USB ports on the server. The devices receive commands sending by the LabVIEW software and perform necessary processes.

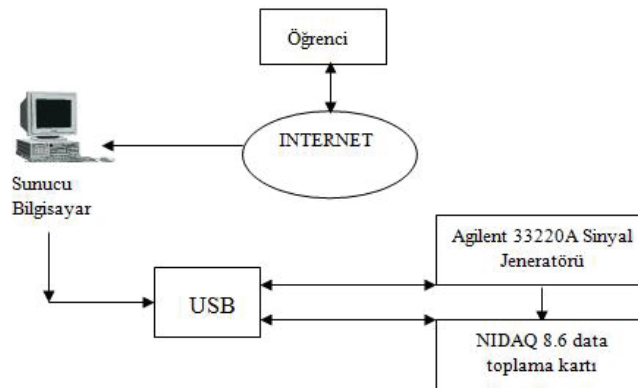


Figure 1. Hardware structure of the application

2.1. Control of the signal generator

The driver of the signal generator is installed on the server computer in order to provide the control of the Agilent 33220A signal generator in the system and the communication with the server computer. The port address, which the signal generator is connected to, is determined by creating a block structure in LabVIEW, provided that it generates values between 0-1 Volts.

2.2. Control of the data acquisition card

A NIDAQ 8.6 data acquisition card is used in order to transfer random values of the signal generator to the server computer. The driver of the data acquisition card in the system is installed on the server computer in order to provide communication of the server computer with the data acquisition card. The DAQ Assistant among the functions is used in order to transfer the values, read by the data acquisition card, into LabVIEW environment. The DAQ Assistant, added to the diagram panel of the LabVIEW block structure is reset. After this process, purposes of

the data acquisition card are selected in the opened window. As the 0-1 Volt random values in the applications are supposed to be read by the data acquisition card, after the analog input is selected for the data collection card it is adjusted relatively to the voltage. In the new opened window, it is selected at which input of the data acquisition card values will be read. Later, the limit ranges of the data from the data collection card and the number of digit are adjusted.

3. LabVIEW Software of the Application

In the real time applications of the error control coding techniques (block coder, convolutional coder, and turbo coder) experiments are prepared. The real time control of the data source at the remote access of the student to the laboratory can be performed with the Agilent 33220A signal generator. The VIs (Virtual Instruments), created with the LabVIEW software, are published on the internet using the Web Publishing Tool.

3.1. Generation of the data-bits to be applied to the coder input

The binary data, applied to the inputs of each error controlled coders, is obtained by conversion of random values among 0-1 Volt generated by the signal generator into binary sequences. For this purpose, an analog-digital converter (ADC) block structure diagram is created by using the VIs of the LabVIEW software. The random values among 0-1 Volt, obtained from the data output of the DAQ Assistant are measured by Amplitude and Levels VI. An analog signal is generated in relation to the values determined by the Square Waveform VI. This generated analog signal is applied to the input of the Analog to Digital Waveform VI and converted to a digital signal. The parameters of the Analog to Digital Waveform VI are adjusted and the 8 bit or 4 bit output sequence in relation to the 0-1 Volt input signals is created. This parallel data sequence is serialized with an algorithm, created in the Formula Node function. So the data sequence to be applied to the coder input is obtained.

3.2. Block coder experiment-set design

Block codes are generated by adding the $(n-k)$ parity bits to the k data bits and are indicated as (n, k) . Due to bit errors during digital transmission on noisy channels and the easiness of the coding, it is widely used particularly to detect errors (Yıldız, 2004). By adding 3 parity bits to the 4 bit data sequence, applied to the coder input with hamming code, modelled on the test-set of which the front panel can be seen in Figure 2, a coded output sequence of 7 bits is obtained from the coder output. At the setup of the test-set, first the front panel, at which the test related parameters can be adjusted, the coder output and error detection process can be observed, is established. The student will be able to perform the coder test in relation to the random values between 0-1 Volts from the Agilent 33220A signal generator at the front panel in real time. A vectoral matrix process is performed for the generator matrix, constituted by 4 rows and 7 columns created on the block structure established in LabVIEW, and the 4 bit data sequence at the ADC output. The student observes 7 bit coded output sequence, constituted by the 4 bit data sequence, generated by multiplication, and the 3 parity bits, on the front panel. The 7 bit coded output sequence, obtained from the coder output, is applied to the parity-control matrix in order to provide the student to observe the error detection. The Null vector is obtained by applying a vectoral matrix process for the transpose of the parity-control matrix, constituted by 3 rows and 7 columns in the block structure, and the 7 bit coded output sequence. The error detection process is performed in relation to the obtained Null vector. The student observes whether there are any errors at the 7 bit coded output sequence by comparing the columns of the parity-control matrix and the Null vector.

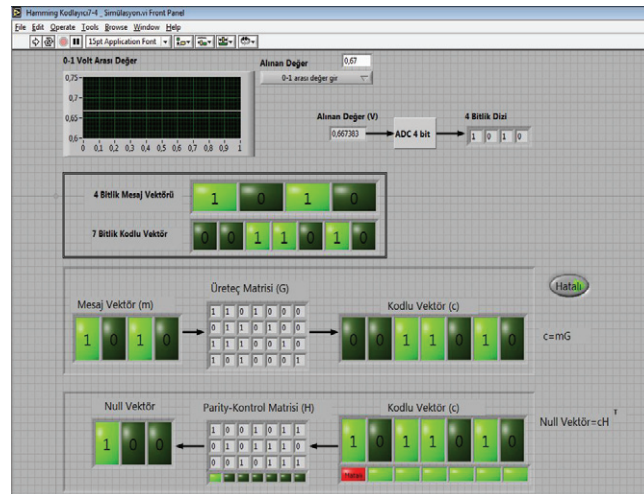


Figure 2. The front panel display of experiment set for the block coder

3.3. Convolutional coder experiment-set design

There are block codes and convolutional codes used in order to detect and correct errors in digital transmission. As the block codes are without memory, the output code word is dependant to the input message at that moment only. But the output codeword of the convolutional coder is dependant to the previous input bit along with the input at that moment. One (n, k, m) convolutional code can be realized consecutive circuit with m memory, k input and n output (Haykin, 2000). For the convolutional coder experiments, realized by using the LabVIEW software, first the front panel, at which the test related parameters can be adjusted, the coder output and the state diagram can be observed. Later, the block structures are created in order to perform these experiments. Regarding the $(2,1,2)$ convolutional coder, $(3,2,2)$ convolutional coder, $(3,1,2)$ systematic convolutional coder, $(2,1,3)$ systematic convolutional coder with feedback, the student performs real time experiments for these convolutional coders with different structures by using the random values between 0-1 Volt obtained from the Agilent 33220A signal generator. Tracks the state diagram of the coder registers by observing the input and output bits of the coder.

E.g. the $(2,1,2)$ convolutional experiment set belongs to a convolutional coder constituted by a 1 bit input, 2 bit output and 2 shift register. The front panel of the experiment-set can be seen in Figure 3. The student applies each bit of the 8 bit sequence at the ADC output in order to the coder input. He/She observes the 2 bit coder outputs depending on the input bit and the actual condition of the D1-D0 registers. The coder outputs in the block structure, created in LabVIEW, are obtained in relation to generator sequences. As the coder outputs $\check{C}0$ - $\check{C}1$ are two bits, the coder has two generator sequences. Of the generator sequences, $g^{(1)}$ determines the $\check{C}0$ bit, and $g^{(2)}$ the $\check{C}1$ bit. These generator sequences define the inputs of the mod2 collectors. E.g. the $g^{(1)}$ generator sequence indicates that the U input bit and the content of the D1-D0 registers are applied as inputs to the TOP1 collector, and the $g^{(2)}$ indicates that the U input bit and the content of the D0 register are applied as inputs to the TOP2 collector. As the outputs of the coder are not only dependant to the input at that time, but also to the previous inputs, the changes in the content of the D1-D0 registers are important. Due to that there are 2 registers in this coder; there are 4 different constellations as 00, 01, 10, 11 to be achieved by the D1-D0 recorders. In relation to this situations and the U input bit of the coder, the below given state diagram is created. As the U input bit, applied to the coder input, is one bit, there are 2 different branches at the transition from the actual register states to the following register states. The student tracks step by step the actual states of the D1-D0 registers and their next transition states for each on the coder input applied bit. There are different experiment-sets established for the above mentioned different structured convolutional coders. The students perform experiments for each coder and can observe the coder outputs obtained in relation to the coder structures and the register states transitions.

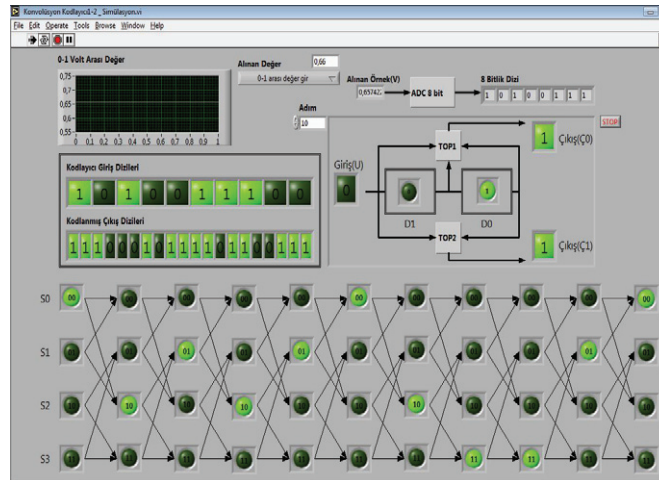


Figure 3. The front panel display of experiment set for the (2,1,2) convolutional coder

3.4. Turbo coder experiment-set design

Turbo codes provide the correction of errors due to parity bits, which are sending along with source bits, and noisy transmission channels. The turbo coder is constituted by an interleaver and by two systematic convolutional (RSC) coders, which in general of the same structure. Whilst the first of these coders obtains the input data unchanged, the second obtains the new sequence, generated after the interleaver process, which provides that the turbo codes seem to be random (Osman, 2006). At the turbo coder experiment-set, the student obtains from the Agilent 33220A signal generator a value between 0-1 Volts. Converts this obtained value to an 8 bit sequence at the analog-digital converter. Performs the turbo coder experiments by applying the 8 bit sequence of the ADC output on the coder. The 4 states turbo coder with $R=1/3$, of which the front panel can be seen in Figure 4, consists of 2 systematic (RSC) convolutional coders with feedback and 1 block interleaver. For each bit, applied on the input of the turbo coder, 3 bit coded outputs are obtained at the coder output. The $\check{C}0$, $\check{C}1$ bits are obtained at the output of the 1st RSC coder and the $\check{C}2$ bit at the output of the 2nd RSC coder. The $g^{(1)}$ of the 1st RSC coder generator sequences determines the $\check{C}0$ bit and $g^{(2)}$ the $\check{C}1$ bit. According to the $g^{(1)}$ generator sequence, created in block structure on LabVIEW, the $\check{C}0$ bit is identical with the U input bit. And according to the $g^{(2)}$ generator sequence, the U input bit and the feedback from the D1-D0 registers is applied on the input of the TOP1 collector. The bit at the output of the TOP1 collector and the content of the D0 collector are applied to the input of the TOP2 collector and so the $\check{C}1$ bit is obtained. The U input bit is applied on the block interleaver first in order to obtain the $\check{C}2$ bit. The 8 bit sequence is placed onto a 3X3 matrix in the block interleaver and read column by column.

E.g. as when the 10110011 sequence is applied on the block interleaver, the elements of this matrix at the interleaver output will be read column by column and sending to the output, first the elements of the 1st column, then the elements of the 2nd column and finally the elements of the 3rd column are sending to the output. This means that the sequence 11100110 will be obtained at the interleaver output. By applying this sequence at the interleaver output to the input of the 2nd RSC coder, the $\check{C}2$ bit is obtained. The generator sequence, determining the $\check{C}2$ bit is identical with the $g^{(2)}$ generator sequence at the 1st RSC coder. As D1-D0, there are 2 registers at the RSC coders used at this turbo coder. These registers constitute 4 different states as 00, 01, 10, and 11. As the U input bit, applied to the coder input, is 1 bit, there are 2 different branches at the transition from the actual register states to the following register states. The students perform experiments for each coder and can observe the coder outputs obtained in relation to the coder structures and the register states transitions. The student tracks the register states transitions and the 3 bit coder outputs on the state diagram, established in relation to this situations and the U input bit applied to the coder input, step by step.

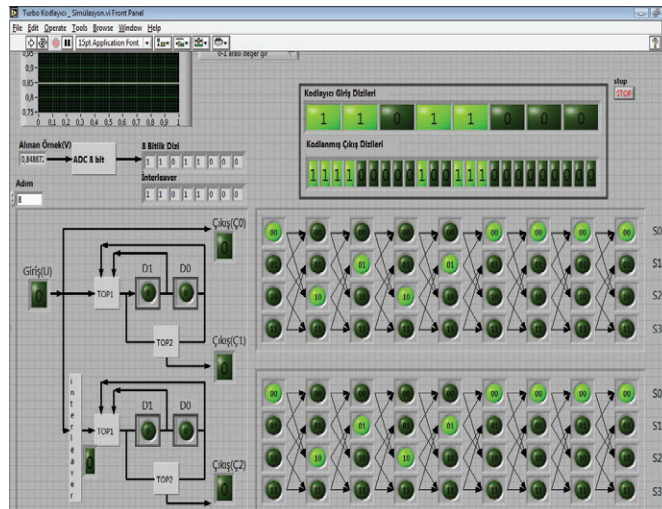


Figure 4. The front panel display of experiment set for the turbo coder

3.5. The WEB site regarding the access on the experiments

The prepared real time experiment-sets are accessed via Internet by the student. The student, who is connected to the site via any computer in the local network, can select the desired coder model test from the part “Experiments” on the site. He/She can perform the experiment by applying the experiment stages in the WEB site and can also easily access the theoretical information regarding the issue.

4. Conclusion and Recommendation

In this work, a remote accessible real time laboratory regarding coding techniques with error control is established. In this laboratory, there are experiment sets regarding block coders, convolutional coders and turbo coders. The experiment sets are prepared with the graphical programming language with LabVIEW (Laboratory Virtual Instruments for Engineering Workbench) of the company National Instruments. The real time experiments sets are prepared in accordance to the theoretical structure. The students will make their related experiments error controlled coding techniques in the established remote accessible laboratory and strengthen their theoretical knowledge. That the student makes one-to-one experiments with the experiment sets converts the education into a student-focussed one. The real time laboratory experiment sets, prepared with computer support, are of modular structure. This means that also regarding other error controlled coding techniques real time experiment sets can be designed by utilizing similar methods. Beside this, laboratory systems can be developed by controlling devices with an USB interface (ADC, CODEC circuits etc.) via a computer.

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