

## Interactive Web-Based Laboratories in Digital Electronics

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### ABSTRACT

Web-based laboratory has become a useful tool in Engineering and Science education. Many educational institutions now days use web-based laboratory technology to conduct laboratory experiments for their students. This paper discusses the implementation of interactive Digital Electronics laboratories designed and implemented at University of Dar es Salaam. Particularly, the implementation of Decoder Encoder experiment using interactive web-based laboratories. The LabView 8.6 is used on the NI ELVIS platform. The use of web-based laboratory came after realizing the difficulties imposed by the traditional laboratories. Web-based laboratories allow students and educators to interact with real laboratory equipment located anywhere in the world at anytime. The Decoder Encoder experiment is one of the four digital experiments designed and deployed using web-based technology at university of Dar es Salaam.

**Keywords:** Interactive iLab Shared Architecture, Client, Lab Server, NI ELVIS, Service Broker.

### 1. INTRODUCTION

The modern network technologies allow creating practical education for engineering and science subjects online. This means that real processes can be carried out online. Contrary to simulations, which rely on mathematical models, online laboratories deal with real signals. Laboratory experiments provide students with practical experience that help them better understanding the theory taught in classes. However, traditional laboratory instruments are usually expensive such that many educational institutions cannot afford the instruments they require for their students. Sometimes students are overcrowded in laboratory sessions. In addition, laboratory personnel need to be hired to operate the facilities, thus imposing additional costs.

The goal of the web-based is to eliminate the problems imposed by the traditional systems and give hands-on experiences in real hardware, in real time. Web-based laboratories enable the students and educators to access experiments any time from anywhere through the internet. By providing remote access to laboratory to students, the problem of costly traditional laboratories can be overcome by using the few laboratory resources available at that institution. In addition, web-based labs will increase the range of experiments available at institution as not only the students will use the experiments at their institutions but they will be able to share the experiments with other educational institutions. Moreover, web-based laboratories will be suitable to open universities and other distance learners to enable them to get the hands-on, real-time experiences. Furthermore, students will experiment with freedom at their own time and have relevant experience. Developments of such laboratories are useful in developing countries where funds for education resources are hardly available.

The web-based laboratories existing over the decade now, but many of educational institutions use expensive equipment which is difficult for the developing country to deploy. In addition, many of available online laboratories are ad hoc systems and tailored for certain laboratory devices [1].

This paper describes the implementation of interactive web-based laboratory of Decode Encoder experiment. The objective of this experiment is to enable students to perform this experiment and learn the techniques used in data transmission. The National Instruments (NI) provided the affordable Educational Laboratory Virtual Instrumentation Suite (ELVIS) kit which interfaces the different components with the web server. Graphical User Interface (GUI) developed using LabView facilitates the on-line access and control of experiment parameters. The architecture used is known as iLab (internet laboratories) developed by Massachusetts Institute of Technology.

## 2. SYSTEM ARCHITECTURE

The architecture used is client-server architecture consists of Lab Server, service broker and client. **Lab Server** has the connection to the real laboratory device. **Service Broker** is responsible for authentication, authorization and forward the communication between Client and Lab Server as well stores students experiment specification and results under its account. It offers user interface for administration task (for example setting permission or adding new Lab servers to the system) and it is the first place where student comes to require permission to a lab. The **Client**, provides user interface for student to specify parameters for running experiments.

The interactive architecture permits students to observe the progress of the experiment and to interact with the experiment in ways that can change the experiment's parameters while the experiment is running. Contrary to the batched architecture, where user defines all parameters at a time for lab device before running, in an interactive architecture, user can specify parameters of the experiment on the fly to the Lab device. Such labs typically require more time to execute than batched experiments because they proceed in human not machine time. Because users control the lab equipment, they usually require limited access to it, asking users to queue for their turn to use the lab. In addition, there is a maximum allowable time, set by the lecturer or tutor for each experiment. Hence most interactive experiments require a scheduling application that allows the users to sign up in advance for time on a particular experiment. The scheduling can be looked at from two perspectives. From the lab server perspective, the scheduling application coordinates reservation to use a lab from multiple campuses. The scheduling server is also a process that holds the information to wake up a lab server to perform required action before a scheduled experiment. The second perspective is user's perspective; the scheduling application must accept authorizations to schedule from user's ilab service broker and must record reservation in the way that can be associated with individual users. Therefore, there are two categories of scheduling applications, the Lab-Side Scheduling (LSS) and User-Side Scheduling (USS). The LSS and USS scheduling communicate using web service protocol.

The interactive architecture requires that and independent Experiment Storage Service (ESS) be exposed as a web service. LabView Web Server is used to publish the front panel on the web. For displaying the front panel on the web, the VIs must be in the memory of the client computer. After they have been accessed, they can be controlled remotely via internet.

## 3. IMPLEMENTATION OF DECODER ENCODER

The 3x8 decoder encoder experiment is constructed in NI ELVIS prototyping board together with LabView 8.6. For data acquisition the PC 6251 Data Acquisition Card (DAQ) is used. The decoder encoder is designed to provide an interactive real-time experiment to students via internet. In the paper presented, the student will be prompted to enter the decimal number to be decoded and that number will be converted into binary form by LabView and then sent to the circuit for decoding. Then, the student will get the results of decoder and if he/she wants those output of the decoder to be encoded, it can be done as the output of the decoder will be inputs to the encoder.

### The Decoder

The decoder is a logic circuit that accepts a set of inputs that represents binary number and activates only the output corresponding to that number and other outputs remain inactive. The decoder can simply be defined as a multiple output combination logic networks with  $n$  inputs and  $2^n$  outputs. An  $n$  to  $2^n$  decoder is called binary decoder which is used when only one output is to be activated at a time. In the presented experiment, the 3 inputs are considered and hence the output is  $2^3$  which are 8 outputs. The decoder enable input must be asserted for a decoder to perform its function. Figure 1 is the experimental setup of decoder. Students are able to change the binary input at any time and obtain the results in real-time.

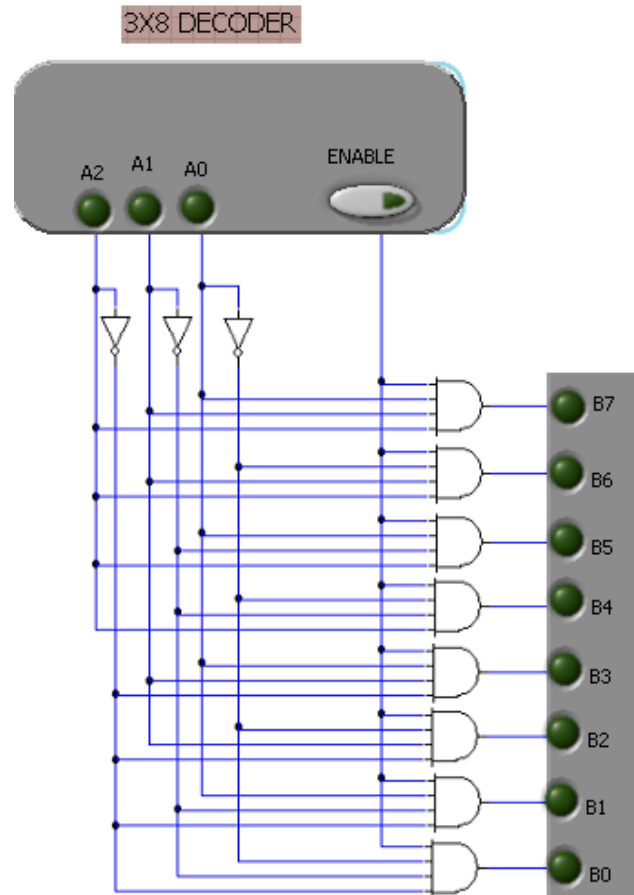


Figure 1: The 3x8 Decoder

### The Encoder

The Encoder is a logic circuit that translates a set of inputs into binary representation of ones or zeros. Encoder has less output as compared to the inputs. In order for the encoder to take place only one input must be active at a time. In this experiment, the binary encoder accepts  $2^n$  input and produces  $n$  output, in this case,  $n$  is 3. Hence, the 8 outputs from the decoder will be inputs to the encoder which in turn produce 3 output equivalents to the decoder's input. Here the 8 inputs have to be encoded by a unique binary sequence. Figure 2 is the experimental setup of the encoder.

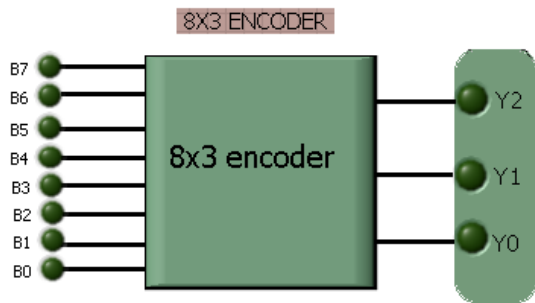


Figure 2: The 8x3 Encoder

To create the experiment setup to the interactive ilab architecture, the circuit is created in NI ELVIS prototyping board. The through the DAQ, the NI ELVIS can communicate with the computer/server. Then the LabView is configured to make a student/user to interactive with the decoder encoder circuit built in the prototyping board. The activities involve in LabView are the creation of the block diagram (programming part), front panel (user interface part) and the activation of the LabView Web Server to enable the publication of decoder encoder front panel on the web.

## LabView

The decoder encoder in LabView has two main parts:

**Block diagram:** This is the programming part where the computer is communicating with the hardware hosting the decoder encoder circuit. Figure 3 shows the block diagram of decoder encoder in LabView.

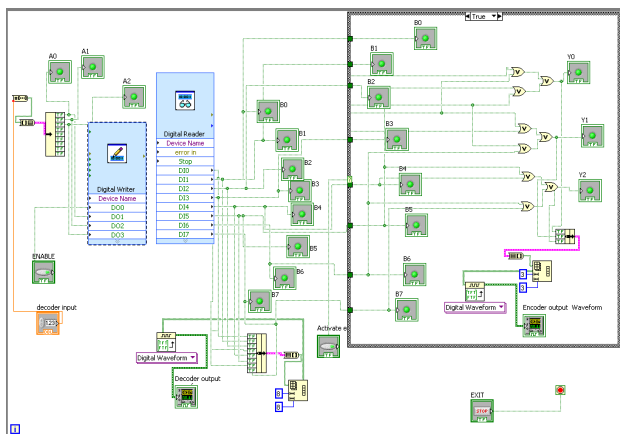


Figure 3: Decoder Encoder.Vi in LabView block diagram

**Front panel:** This is an interactive user interface of a Virtual Instrument (VI). VI named so because it simulates the front panel of a physical instrument. This is the part where the user/student interacts with the hardware in real time. Student can change the experiment parameters while the experiment is running. Figures 4 through 8 shows how the student can change the input parameters and get the output in real time, in this case 0, 1, 3, 5 and 7 are chosen and their outputs are shown. This implies that the information is decoded, transmitted and then encoded to the origin or transmitted information.

When the binary input is 000, the line B0 is activated, then in the encoder part, B0 is the input and the binary representation is 000, which is the original information.



Figure 4: Decoder Encoder when the input is 000

When the binary input is 001, the line B1 is activated. In the encoder part, B1 is the input i.e the activated input is 1 and the binary representation is 001.



Figure 5: Decoder Encoder when the input is 001.

When the binary input is 3, the line B3 is activated, then in the encoder part, B3 is the input and the binary representation is 011.



Figure 6: Decoder Encoder when the input is 011

When the binary input is 5, the line B5 is activated, then in the encoder part, B5 is the input and the binary representation is 101.

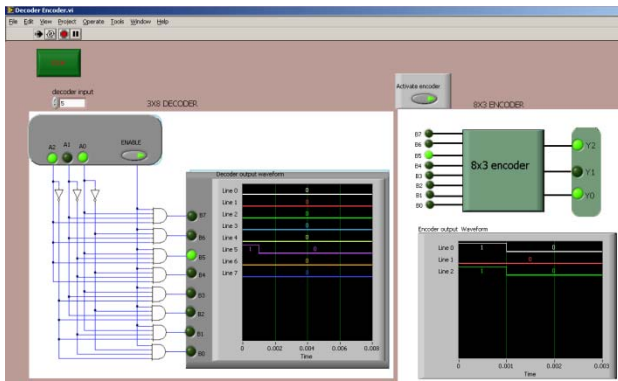


Figure 7: Decoder Encoder when the input is 101.

When the binary input is 7, the line B7 is activated, then in the encoder part, B7 is the input and the binary representation is 111.

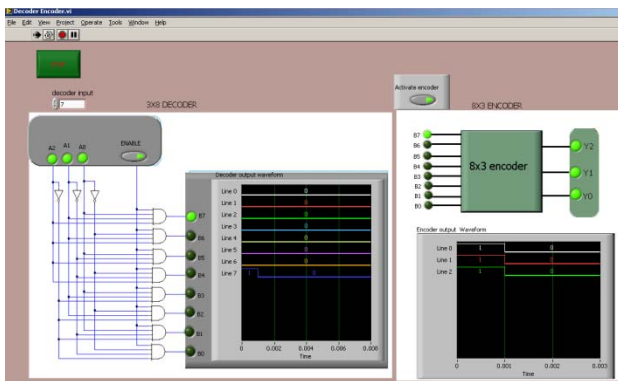


Figure 8: Decoder Encoder when the input is 111.

respectively.

**Table 1: The truth table of Decoder**

INPUTS			OUTPUTS							
$A_2$	$A_1$	$A_0$	$B_7$	$B_6$	$B_5$	$B_4$	$B_3$	$B_2$	$B_1$	$B_0$
0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	0	1	0	0
0	1	1	0	0	0	0	1	0	0	0
1	0	0	0	0	0	1	0	0	0	0
1	0	1	0	0	1	0	0	0	0	0
1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0

**Table 2: The truth Table of Encoder**

INPUTS								OUTPUTS		
$B_7$	$B_6$	$B_5$	$B_4$	$B_3$	$B_2$	$B_1$	$B_0$	$Y_2$	$Y_1$	$Y_0$
0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	1	0	0	0	1	0
0	0	0	0	1	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	0
0	0	1	0	0	0	0	0	1	0	1
0	1	0	0	0	0	0	0	1	1	0
1	0	0	0	0	0	0	0	1	1	1

#### 4. CONCLUSION

As many educational institutions have difficulties in providing hands-on experiments to their students due to many limitations imposed by traditional laboratories, the presented web-based laboratory is designed to provide students with the same interaction to real hardware as traditional ones. The presented paper is an effort to explore the capabilities of web-based laboratories in science and engineering education. The aim is to make students to get the same quality of education using advanced features of internet technology. As the digital electronics is vital to engineering, science and computing education, the designed experiment is intended to be used by ilab collaborating universities and other educational instructional if they want to. Other digital experiments which are ready to be deployed in interactive iLab architecture are 4-bit shift register, 4-bit BCD to Gray Converter and Analog –to-Digital conversion. Currently, at university of Dar es Salaam both analogue and digital experiments can be deployed using interactive remote laboratories.

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