Enhancement of ABET outcome 3b: Alternate designs and simulations

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***Abstract*—The paper presents enhancement of ABET criteria 3B through alternate designs and simulations. This also gives the analysis of the effectiveness of these activities. The objective is to enhance the course learning, beyond the traditional mode of conducting the experiments. In traditional mode of experiment: design, conduct and assessment provide less scope for in-depth learning of the course. Outcome Based Education (OBE) is an effort to overcome the limitations of traditional mode of course delivery. Progressive pedagogical models are used for the enhancement of ABET outcome 3b, in OBE. To meet this objective the experiments of Digital Communication laboratory are categorized as demonstration, exercise, structured enquiry. This is in comparison to the previous procedural based conduction of the same laboratory. In the proposed approach of laboratory conduction, the active learning provides more opportunities to explore alternate solutions, select the best suited solution with justifications and implement the same. Effectiveness of this activity is assessed through well-designed rubrics. In OBE framework the process of dividing outcomes into Outcome Elements (OE) and further into Performance Indicator (PI) allows enhancement of ABET outcome 3b.**

Keywords— Digital communication laboratory, alternate design, ABET, OBE, laboratory categorization

I. INTRODUCTION

The paper address in-depth learning in a set of laboratory courses using alternate designs and simulation activates as a pedagogical tool in Electronics and Communication engineering program. A graduating student should have an ability to design and conduct experiments, as well as to analyze and interpret data [2]. In the traditional laboratory course design and delivery, students were given the designed circuit and expected to rig up and conduct the experiment. The student's performance was evaluated based on laboratory records. However these activities did not provide any scope to explore the alternate design of the experiments and failed to enhance their design skills. The traditional methods may not provide sufficient resolution at the course level for the curriculum improvement. These methods provide less scope for conducting and assessing the extent of in-depth learning in the laboratory course. This limits the attainment of ABET criteria 3b i.e. design, conduct of experiments, interpret and analyze data. OBE is an effort to overcome limitations of traditional mode to conduct by using many progressive pedagogical models to meet 3b. The experiment categorization in laboratory including alternate designs, simulation, interpretation and analysis of data provides scope for enhancement of the design skills. The paper demonstrates:

- In-depth learning in digital communications laboratory course using pedagogical tool.
- Effectiveness of activity adopted by assessment of attainment of Program Indicators.
- Attainment may be used for continuous improvement and curriculum modifications.

The rest of the paper is organized as follows. Accreditation framework is discussed in section 2. The frame work of Enhancement of ABET outcome 3b is discussed in Section 3. Conclusions are provided in Section 4.

II. ACCREDITATION FRAMEWORK

The ABET Program Outcomes (POs) are statements that describe what students are both expected to know and to apply at the time of graduation [2]. Instructional techniques in meeting evaluation criteria for the various Pos are discussed in [3, 1]. In [4, 5] some general strategies for PO assessment are discussed. Paper [6] discusses meeting PO 3b from a Mechanical and Aeronautical Engineering perspective. Review of the literature revealed the following common features of rubrics: each focus on a stated objective, each use a range of evaluative scores to rate performance, and each contain a list of specific performance indicators [2].

To arrive at assessment of Program Educational Objectives (PEO), the programme has to begin with course level assessment and use this data to assess attainment of POs. The attainment of POs ensures the achievement of PEOs. Laboratory assessment rubrics have been used in assessing the attainment of PO-3b. The measurement of attainment of POs is challenging as outcomes are comprehensive and difficult to assess. A new approach to outcomes assessment that is based on the concept of "Outcome Elements" is used by the college to overcome this challenge. After detailed analysis, Outcome Elements (OEs) are developed for each of the Programme Outcomes. These OEs represent the different abilities specified in a single outcome that would generally require

different assessment measures. Furthermore, for each Outcome Element we have developed Performance Indicators, i.e. student actions that explicitly demonstrate mastery of abilities specified in an OE. The process of dividing outcomes into OEs and further into Performance Indicator allows sufficient resolution in assessment of an outcome.

III. Framework For Enhancement Of ABET Outcome 3B

The primary objective of lab categorization is to enhance the design skill as well as analyze and interpret data. In 2013, Electronics and Communication department redesigned curriculum structure. The experiments were categorized in digital communication lab for VI semester students. Figure 1 shows the framework of digital communication laboratory.

The basic concepts, applications and the mathematical modeling are covered in classroom teaching. For the given experiment in the lab the student will survey the different techniques which cater the same solution. Some of these surveyed techniques are tested using simulation tools and results are analyzed. Out of these techniques one of the techniques is going to be implemented on hardware platform and the results are verified with the simulated ones. This enhances the depth of learning

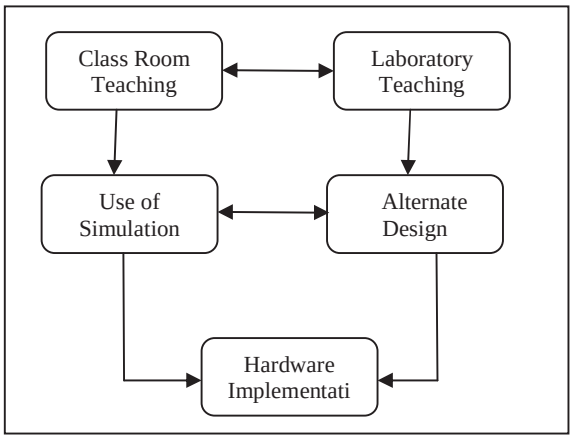

Fig. 1. Framework of digital communication lab

A. *Experiment Categorization in Digital Communication Laboratory*

The primary objective of the experiment categorization is to enhance the understanding of the design skills in laboratory. The experiments are categorized as: demonstration, exercise, and structured enquiry. In 2013, Electronics and Communication Engineering department redesigned curriculum structure and experiment categorization in laboratory was offered. Depending on the categorization of experiments the rubrics to evaluate student outcomes are identified. This paper discusses the experiment categorization in digital communication laboratory for VI semester. Continuous evaluation of the laboratory is carried out by the respective course instructor. The evaluation is done based on the defined rubrics. The review process in the continuous evaluation measures the student learning using defined rubrics.

Earlier most of the experiments in laboratories were focused on 'conduct of experiments' and to some extent analysis of data. At institutional level a comprehensive reform process was undertaken to enhance the laboratory experience. The laboratory experiments primarily meet outcome (b) and also outcomes (k). But, the extent to which the laboratory experience meets each element of the outcome depends upon the judicious choice of the experiments. The outcome (b) has three elements. The ECE department adopted the following categorization for laboratory experiments:

1. Demo experiments
2. Exercise experiments
3. Structured enquiry experiments

Demo Experiments: Set of demonstration experiments are introduced to provide an exposure of usage of tool, kit or equipment.
Exercise Experiments: Set of exercise experiments are given to provide experiential learning to the students in basic working of modules, components and small systems where the input, output and methodology is provided.
Structured enquiry experiments: Set of structured enquiry experiments are given to provide an exposure to identify solution to given problem, existence of alternate solutions and to choose optimal solution depending on the criteria.

Table I shows the categorization of few of the experiments in digital communication laboratory. 11% of the experiments are of demonstration category. 66% of the experiments are of exercise category. 23% of the experiments are of structured enquiry category.

TABLE I. Categorization Of Experiments In Digital Communication Laboratory

Category: Demonstration **Total Weightage: 10 %** **No. of lab sessions: 1**		
Expt. No.	**Experiment Details**	**Marks/ Experiment**
1	Title: **QPSK/DQPSK:** Demonstrate the carrier modulation and using ADCL-0 and ADCL-03 kits. Learning Objectives : The students should be able to: 1. Compare the Quadrature and Differential Quadrature PSK modulation techniques w.r.t. waveforms and circuit complexity.	80
Category: Exercise **Total Weightage: 40 %** **No. of lab sessions: 6**		
Expt. No.	**Experiment Details**	**Marks/ Experiment**
1.	Title: **Sampling Theorem:** Verify the sampling theorem using flat top sampler for various sampling rates, demonstrate and analyze the effect of ISI using eye diagram. Learning Objectives : The students should be able to: 1. Identify the sampling frequency for Nyquist criteria without aliasing.	80

	2. Analyze the effect of ISI by changing the sampling rates, using eye diagram.	
2.	Title: **Uniform Quantization using midrise or mid-tread quantizer.** Implement midrise and midtread quantizer using PCM kit and analyze the quantization error Learning Objectives : The students should be able to: 1. Identify the need for quantization and differentiate them. 2. Analyze the Quantization error by changing the step size.	80
Category: Structured Enquiry **Total Weightage: 50 %** **No. of lab sessions:4**		
Expt. No.	**Experiment Details**	**Marks/ Experiment**
1.	Title: **TDM using PAM signals**: Design and implement transceiver to transmit the signals of different frequencies through single channel using TDM system Learning Objectives : The students should be able to: 1. Identify the need for multiplexing. 2. Identify the necessity of synchronization between transmitter and receiver.	80
2.	Title: **BFSK Modulation and demodulation:** Design and implement BFSK Modulator / demodulator for pair of mark frequency and space frequencies given the bandwidth. Learning Objectives : The students should be able to: 1. Select the Mark, space and carrier frequencies 2. Analyze the circuit complexity associated with BFSK. 3.Give the applications of application of BFSK	80

B. Evaluation of experiment categorization in laboratorys

The Table II gives the Outcome Elements and Performance Indicators for Programme Outcome 'b'**.** Evaluation rubrics are used to assess outcomes elements through performance indicators. Table III shows the evaluation rubrics for digital communication laboratory.

The basic purpose is to assess the student competencies in understanding the problem definition, identifying the alternate solution and the selection of optimal solution. More specifically to assess the student's individual contribution, to establish the level of understanding of basic theoretical knowledge, relevant to the course.

The evaluation of CIE is carried out for each laboratory by the course instructor. The course instructor has the responsibility of educating the students about the criteria/standards being used for laboratory. The course instructor adopts a clear and consistent pattern of asking questions from general to specific aspects of the laboratory

The objectives of

1. Demonstration experiments are to enhance the ability to explain experimental procedure.

TABLE II. OUTCOMES ELEMENTS AND PERFORMANCE INDICATORS FOR OUTCOME B

ECPO(b) **Ability to design and conduct experiments in VLSI, Embedded and Communication systems using appropriate procedure to analyze and interpret data.**		
OE(b)-1	**Outcome Elements**	**Ability to design experiments**
	Performance Indicators	
OE(b)-1A	Ability to explain experimental procedure.	
OE(b)-1B	Ability to consider the variables.	
OE(b)-1C	Ability to identify the constraints and assumptions for the experiment	
OE(b)-1D	Ability to select appropriate equipment, test apparatus, model, etc. for measurements.	
OE(b)-1E	Ability to apply theoretical concept to design an experiment	
OE(b)-2	**Outcome Elements**	**Ability to conduct experiments**
	Performance Indicators	
OE(b)-2A	Ability to conduct a laboratory procedure with minimal supervision	
OE(b)-2B	Demonstrate ability to determine performance parameters.	
OE(b)-2C	Ability to select an appropriate EDA tool to solve problem	
OE(b)-3	**Outcome Elements**	**Ability to analyze and interpret data**
	Performance Indicators	
OE(b)-3A	Ability to analyze the observed tabulated data	
OE(b)-3B	Ability to Interpret the results using relevant theoretical background	
OE(b)-3C	Ability to Verify and conclude experimental results	

2. Exercise experiments are to design experiments with specifications using required formulae and perform simulation using appropriate tools.
3. Structured enquiry experiments are to identify multiple solutions, select the best suited solution with justifications and implement, Interpret the results using relevant theoretical background, to verify and conclude experimental results.

The above said objectives are set to meet few of the performance indicators like OE(b)-1A, OE(b)--1D, OE(b)--1E, OE(b)--2C, OE(b)--3B, OE(b)--3C through digital communication lab.

C. Illustrative example

This section explains alternate designs and simulation for digital communication laboratory considering BFSK Modulation and demodulation for illustration. This experiment is conducted in two parts, modulator and demodulator. The alternative approaches to carry out the experiment are,

- PLL (phase locked loop)
- XR-2206 and XR2211
- Switch and frequency generators etc.

Prior to implementing on the hardware platform, the alternate solutions are simulated in Matlab /Simulink/open source tools.

TABLE III. EVALUATION RUBRICS FOR DIGITAL COMMUNICATION LABORATORY

Evaluation criteria		
Demonstration Experiments	**Outcome Elements**	**Max Marks**
• **Explain experimental procedure** to set up the connections as per the instructions given for carrier modulation techniques. Using ADCL-02 and ADCL-03 kits. • Compare the Quadrature and Differential Quadrature PSK modulation techniques with respect to, waveforms and circuit complexity • Observing the input and output waveform	OE(b)-1A OE(b)-3A OE(b)-3C	**30** **30** **20**
Exercise Experiments		
• Identify the signal frequency and carrier frequency • **Design with specifications using required formulae.** • Select appropriate components as per the design. • Perform **simulation using appropriate tools.** • Analyze the performance of modulator and demodulator • Observing and interpreting the results • Demonstrate ability to determine performance parameters. • Verify and conclude experimental results.	OE(b)-1B OE(b)-1E OE(b)-1D OE(b)-2C OE(b)-3A OE(b)-3B OE(b)-2B OE(b)-3C	**10** **10** **10** **10** **10** **10** **10** **10**
Structured enquiry Experiments		
• Select the number of inputs signals. • Select the frequency of the identified signals. • Select the criteria for the identified signal. • **Identifying multiple solutions** • **Selecting the best suited solution with justifications, and implement** • Demonstrate ability to determine performance parameters. • **Ability to Interpret the results using relevant theoretical background** • **Ability to Verify and conclude experimental results**	OE(b)-1B OE(b)-1C OE(b)-1D OE(b)-1D OE(b)-1D OE(b)-2B OE(b)-3B OE(b)-3C	**10** **10** **10** **10** **10** **10** **10** **10**

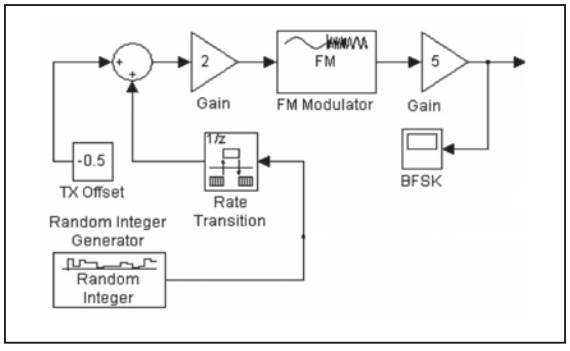

Fig. 3. Implementation of BFSK using matlab-simulimk tool

Figure 3 shows the simulation of BFSK signal using simulink. The student can tune different parameters and observe the corresponding changes in the output. This helps the students in better understanding of the experiment. One of the alternate designs is simulated using available opensource EDA tools. Fig. 4 shows the usage of switchs and transistors to generate the BFSK waveforms.This helps the students to explore and use different available tools.

The hardware was realized for the best suited design. Fig. 5 and Fig. 6 shows the circuits for the realization of BFSK .

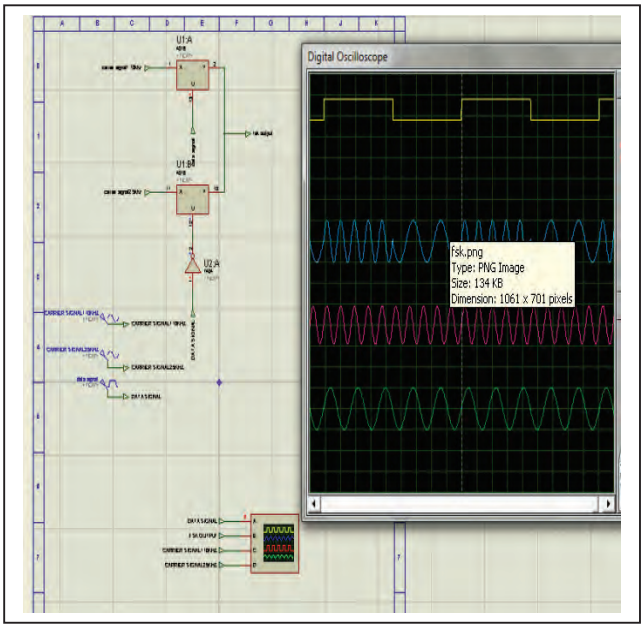

Fig 4. A snapshot of a circuit of BFSK using switches

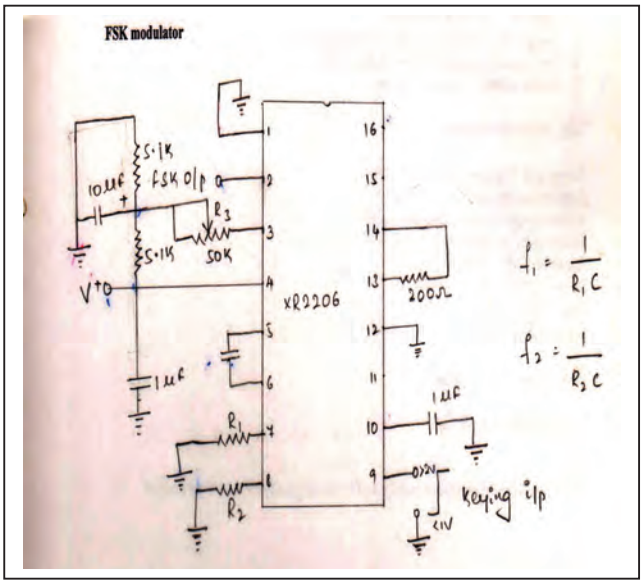

Fig. 5. A snapshot of a circuit of BFSK using XR2206 for modulator

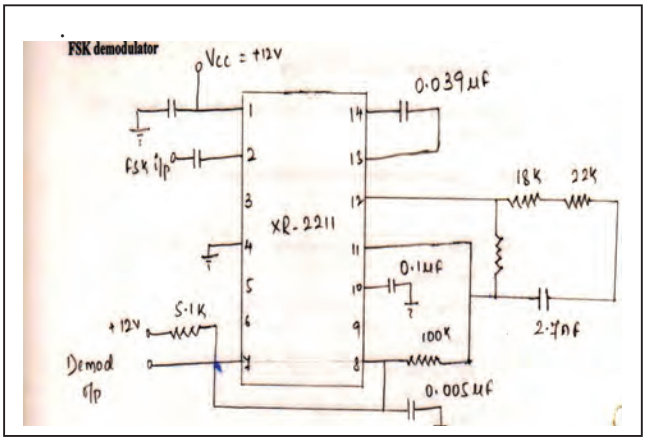

Fig. 6. Snapshot of a circuit of BFSK using XR2206 for demodulator

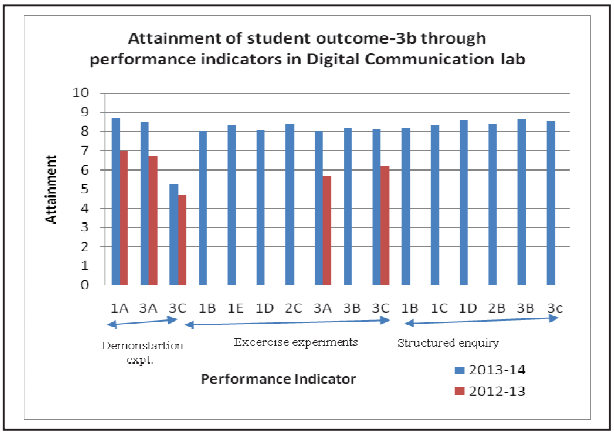

Fig.7. Attainment of student outcome-3b through performance indicators

D. Evaluation of student outcomes

Evaluation rubrics are used to assess student outcomes. The review process in the continuous evaluation measures the student learning against the student outcomes as per the a-k program outcomes of ABET. The student's performance is assessed by course instructor using the assessment rubrics and average score for each of the outcomes is normalized on a scale of 1-10.

Figure 7 demonstrates the attainment of student outcomes - 3b through performance indicators. In traditional mode of conduct (ex: for the academic year 2012-2013) most of the experiments in the digital communication were done in demonstration and exercise type. It was possible to attain OE (b)–1A, OE (b)–3A, OE(b)–3C of ABET. With the paradigm shift in the OBE (ex. for the academic year 2013-2014), the experiments are categorized and we could attain higher level student outcomes. The objective of the demonstration type of experiments is to enhance the learning of experimental procedures, i.e. OE (b)–1A, along with this OE(b)–3A, comparison of different PSK circuits is also attained. The attainment for OE (b)–3C, observing waveform is less, as it is a group demonstration for the academic year 2013-2014 activity for 15 students. The objective of the exercise type experiment is to design an experiment with specifications using required formulae, OE(b)–1E and simulation using appropriate tools, OE(b)–2C, along with these the performance indicators, OE(b)–1B, OE(b)–1D, OE(b)–3A, OE(b)–3B and OE(b)–3C are also attained. The focus of the structured enquiry type of theoretical background OE (b)–3B, to verify and conclude experimental results OE(b)-3C. Through structured enquiry OE(b)–1B, OE(b)–1C, and OE(b)–2B are also attained. The attainment of OE(b)-3C in demonstration type of experiments can be improved by reducing the student group size to 5. experiments are to identify multiple solutions OE(b)–1D, select the best suited solution with justifications and implement OE(b)–1D, interpret the results using relevant theoretical background OE(b)-3B, to verify and conclude experimental results OE(b)-3C. Through structured enquiry OE(b)-1B, OE(b)-1C, and OE(b)-2B are also attained. The attainment of OE(b)-3C in demonstration type of experiments can be improved by reducing the student group size to 5.

IV. Conclusion

The paper demonstrated the enhancement of ABET criteria 3b through alternate designs and simulations. This also gave the analysis of the effectiveness of these activities. The design of Digital Communication laboratory experiments are categorized as demonstration, exercise and structured enquiry. This active learning approach has provided the students with more opportunities to explore and solve a given problem in a team and devising their own experimental procedure. Laboratory assessment rubrics have been used in assessing the attainment of Programme Outcome-b. The process of dividing outcomes into OEs and further into PIs allowed sufficient resolution in enhancement of an outcome 3b.

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