Work In Progress - Virtual Laboratory with a Remote Control Instrumentation Component

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Abstract - **The virtual laboratory of the Department of Electrical and Computer Engineering of the University of Calgary comprises all laboratory components of the department, with two locations already developed for long distance education: a remotely controlled instrumentation laboratory, SelfLab@Home, and a digital design experiments collection where the operation of the basic digital circuits is simulated with html applets. The students are invited to take a virtual visit of the laboratory rooms in which they will perform course required experiments in order to easier locate the devices to be used as well as operate them appropriately. The main objective of SelfLab@Home was to become a self-paced remotely accessed training site for the use of four basic laboratory devices: oscilloscope, waveform generator, DMM and a power supply. The digital devices experiments demonstrate the logic operation of digital circuits and a remotely controlled traffic light with its computer visual interface application.**

Index Terms - remote control, virtual experiments, distance education, instrumentation laboratory

PROJECT CONTEXT AND DESCRIPTION

The University of Calgary's Learning plan outlines that "learning technologies will be employed to enhance the campus experience and extend inquiry-based learning through the innovative use of on-line resources, collaborative learning opportunities and electronic communication among faculty and students" [1]. We are focusing on a virtual lab which in the near future will see added to its computer visual interface (CVI) component, a remotely controlled traffic light signal. The students will be able to run digital experiments, change input parameters and analyze the results remotely. These are current educational trends of the internet-based training by experimental work in the electrical, computer and software engineering curriculum.

VIRTUAL LABORATORY COMPONENTS

The virtual laboratory of the Department of Electrical and Computer Engineering of the University of Calgary comprises all laboratory components of the department (figure 1), with two locations already developed for long distance education: a remotely controlled instrumentation laboratory, SelfLab@Home, and a digital design experiments collection where the operation of the basic digital circuits is simulated

with html applets. The educational site integrates exercises with progressive degree of difficulty, from simple gates to digital controllers. It is shown that an interactive graphic simulation is an effective instructional tool for bridging the gap between booleans, logic and physical understanding of transistors. Flowcharts are presented for each intermediate sequential machine which is a logic part of the controller and students can modify them according to assigned questions given by the course instructors.
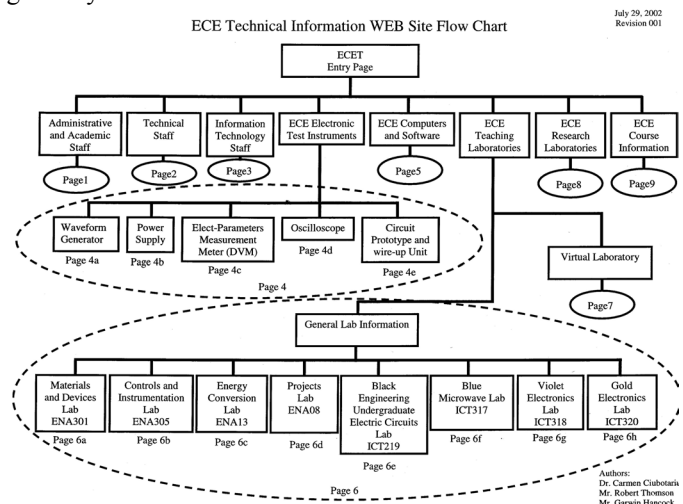

FIGURE 1
VIRTUAL ROOMS AND COMPONENTS OF THE DEPARTMENTAL COMPUTER ACCESSED LABORATORY

Additional features of our virtual digital design laboratory are the CVI for the traffic light controller, vending machine and complete descriptions of the learning cycles involved in simple digital design projects. For a beginner's level in digital circuitry the virtual labs are good to assimilate theory. The code for the CVI component is accessible and students can create their own version of a traffic light controller and check with the one proposed in the remotely controlled traffic light.

Students begin with traditional transistor-transistor logic-based projects containing a few gates and progress to designing a counter. Figure 2 illustrates an exercise which helps students understand the logic operation of a master/slave reset/set flip flop circuit. The students follow the evolution of each component of the logic circuit according to their selected input and the effect of the clock.

The virtual laboratory contains simple exercises which demonstrate gates operation based on logic functions and the CVI for the traffic light controller which operates presently as a laboratory experiment. Figure 3 illustrates the operation of a simple combination of gates and Figure 4 illustrates the CVI simulation for the traffic light controller with emergency buttons and counters of cars passing the intersection in both directions.
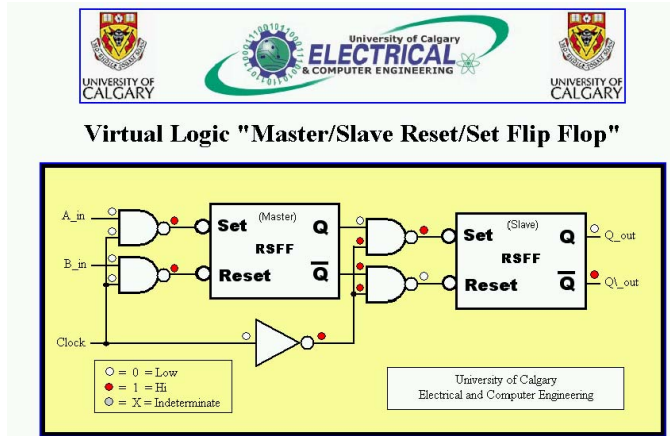

FIGURE 2
SCREEN SHOT OF SIMULATION EXERCISE FOR CLOCKED INPUT FLIP FLOP OPERATION

Two digital design projects are completely presented in the virtual digital design laboratory: one project demonstrates the operation of a street level traffic light controller and the other describes the design and the operation of a vending machine.
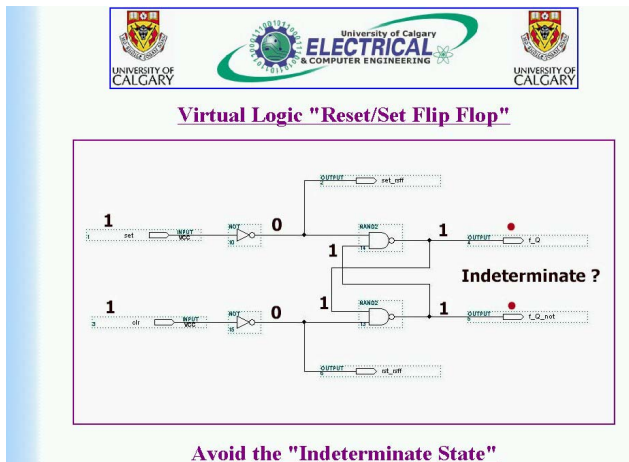

FIGURE 3
DETAILED INPUTS AND STATES OF A SIMPLE FLIP FLOP

The design programs are written using Max Plus II Software (Altera Corporation, 1997) in Altera High-level Description Language (AHDL). The designs incorporate Fundamental Mode State machine (FSM) circuits. The traffic light controller (TLC) design allows for flexible configuration of a typical traffic flow operation including pedestrian crossings and Day / Night operation. A logic training module (LTM) using ALTERA Complex Programmable Array Logic (CPLD) is developed for use within the ECE department.
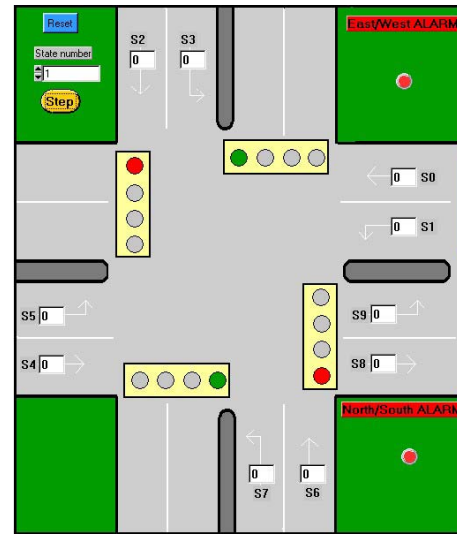

FIGURE 4
COMPUTER INTERFACE FOR THE TRAFFIC LIGHT CONTROLLER WITH FLASHING GREEN LIGHT, EMERGENCY BUTTONS AND CARS COUNTER

In an effort to appeal to the new generation of engineering students and increase motivation in undergraduate students, the virtual laboratory experiments are introduced. Before wiring up the digital circuitry on the home-built prototype units of the digital design laboratory, students are invited to check their theoretical knowledge with the virtual lab simulations for a "pre-lab study". There is a significant learning curve that must be overcome [2] when using a complicated commercial tool like Altera's MaxPlus II, in the introductory digital design laboratory. Sequential description tutorials have been added on-line, for the second year students only (password protected) to complete the teaching process and help students understand circuitry operation details. By introducing the students to a small subset of tools in a systematic, controlled manner, they are provided with a comfortable environment to quickly master the tools before concentrating on design concepts and theory. To the existing components of the educational virtual laboratory, the following features will be added: a remotely controlled traffic light signal with a more sophisticated light sequence and its corresponding CVI. The present CVI simulation is related to an already existing traffic light controller which does not provide the students with sufficient detail on the design and the construction of the controller.

REFERENCES

[1] Learning and Instructional development sub-committee (LIDS), "Institutional Learning plan", University of Calgary, March 2003

[2] R.T. Abler, H.L. Owen, G.F. Riley, "University methodology for internetworking principles and design projects", IEEE Transactions on Education, vol. 46, no. 2, May 2003, p. 218