

Experiment teaching of digital electronic technology using Multisim 12.0

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ABSTRACT: The application of Multisim 12.0 as part of the reform of digital electronic technology teaching by experiments is discussed. First, experiments used in the teaching of digital electronic technology are analysed. Second, the feasibility of teaching experiments using Multisim 12.0 is explored. Finally, examples of the use of Multisim 12.0 in validation experiments, extensible experiments and comprehensive design experiments are provided. Practice shows that the application of Multisim 12.0 in digital electronic technology experiments can greatly improve the teaching. Its use solves problems in teaching experiments, e.g. shortage of equipment. The analysis and design and practical abilities of students are cultivated. Therefore, the application of Multisim 12.0 to digital electronic technology experiment teaching should be encouraged.

INTRODUCTION

Quality education that actively cultivates the innovative abilities of students is the goal of higher education, and is also at the heart of the reform of teaching based on experiments. With the rapid development of electronic and computer technology, the importance of digital electronic technology experiment teaching is increasing. Through digital electronic experiments, students can deepen their understanding of the basic theories and concepts of digital electronic technology. As well, the student's interest in learning is stimulated. Through experiments, students receive rigorous, fundamental and systematic training as they master the basic methods and skills required by the experiments. Moreover, the student's innovative spirit is cultivated. In addition, the student's rigorous scientific thinking, the ability to integrate theory with practice, and the ability to analyse and solve problems are greatly improved. Therefore, existing experiment teaching methods and means should be changed to reflect the importance of teaching by digital electronic technology experiments. Digital electronic teaching, using Multisim 12.0, has improved the experiments, and cultivates students innovative ability to analyse and solve problems.

STATUS OF DIGITAL ELECTRONIC TECHNOLOGY TEACHING BY EXPERIMENTS

There are outstanding issues in the teaching of digital electronic technology by experiments. For example, teaching methods for the experiments are simple and although close attention is paid to the results, the underlying processes are ignored. The contents of experiments are obsolete. They are only validation experiments and are not extensible or design experiments. In this way, students' thinking is tightly confined within the scope of theoretical knowledge. Students can only passively understand basic concepts and theoretical knowledge, and their abilities to innovate are not developed. The equipment is inadequate and has a single function [1]. Experiments requiring a variety of instruments and fully functional instruments cannot be supported. Hence, teaching by experiment is seriously hindered.

FEASIBILITY OF MULTISIM 12.0 APPLIED TO THE TEACHING OF DIGITAL ELECTRONICS BY EXPERIMENT

The simulation software Multisim 12.0 is the latest version developed by the American National Instrument company. It provides a large database, a variety of virtual instruments, a powerful function for analysing circuits and a friendly user interface. Multisim 12.0 software can simulate the multimeter, oscilloscope, signal generator, frequency meter, logic analyser, digital signal generator, logic converter equipment and various electronic components. It can support each of the digital electronic technology experiments. If Multisim 12.0 is used for the teaching experiments of digital electronic technology, it not only can take the place of a variety of traditional instruments in the laboratory, but also can realise a virtual laboratory. As long as there is a computer, students can use it whenever and wherever to study various circuit simulations [2]. Experiments that require lots of expensive instruments and which could not be done in the past, can now be easily realised using Multisim 12.0. Multisim 12.0 plays an important role in improving students' practical, analysis and innovative abilities [3].

Multisim 12.0 is applied to validation teaching experiments: in digital electronic technology experiments, the goal of validation experiments is to validate the basic theory of electronic technology and the basic functions of commonly used digital circuits. This deepens students' understanding of basic knowledge, and cultivates their basic practical ability, as well as the ability to analyse a question and produce an answer. The experiment of validating the basic logic functions of a TTL (transistor-transistor logic) inverter is used as an example to introduce the application of Multisim 12.0 to validation experiments. The experiment requires students to master the basic structure, working principle and basic logic functions of a TTL inverter circuit, and to observe its static characteristics.

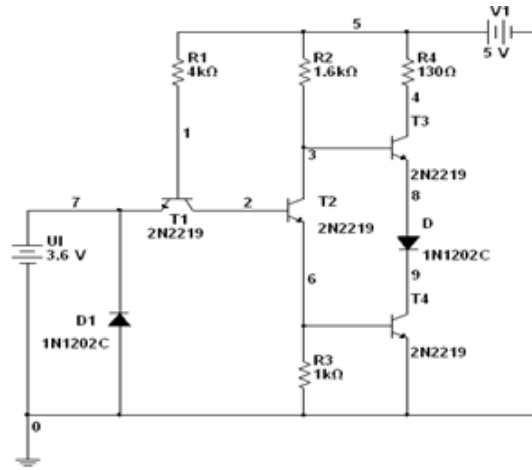


Figure 1: TTL inverter of high level input.

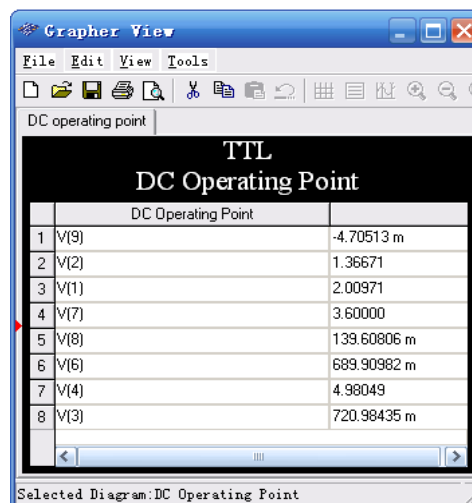


Figure 2: Voltage of each node of high level input.

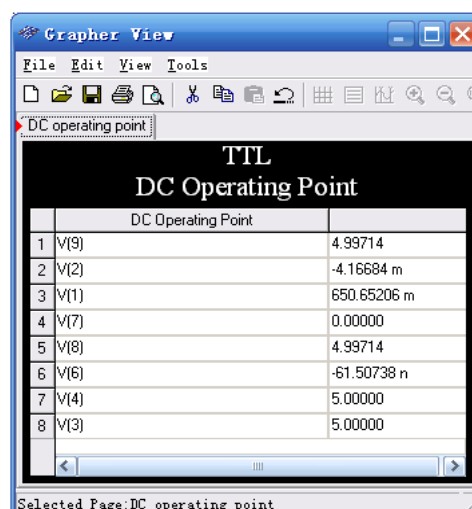


Figure 3: Voltage of each node at low level input.

In Multisim 12.0 environments, the experimental circuit of the TTL inverter is drawn by selecting DC power supplies, transistors, diodes, resistors and other components. The simulated circuit of high level input is shown in Figure 1. The circuit of low level input can be simulated by modifying the input [4]. Click Simulate/Analyses/DC Operating Point Analysis, selecting all the nodes as the simulation object and, then, click the button to run. When the input voltage is high, the voltage of each node is shown in Figure 2. When the input voltage is low, the voltage of each node is shown in Figure 3.

Select a voltage source as the input signal, set up the value of voltage source (between 0V and 3V), click Simulate/Analyses/DC Sweep, select Node 9 as the simulation object and, then, click the button to run. This produces the transfer characteristic curve of voltage, as shown in Figure 4.

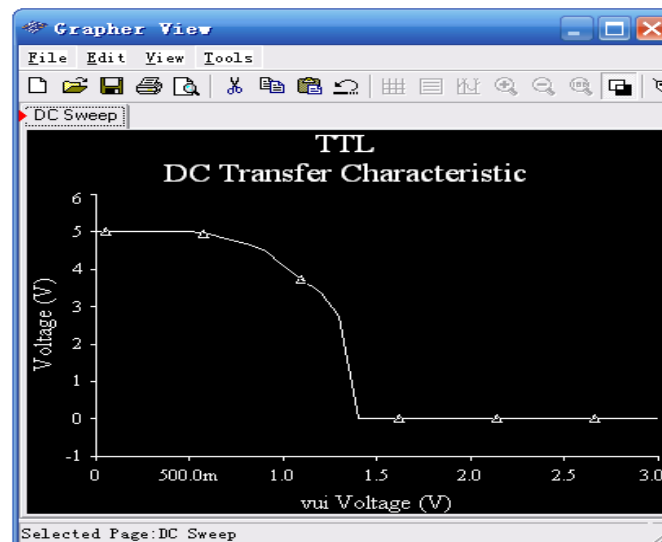


Figure 4: Transfer characteristic curve of voltage.

Simulated results and the transfer characteristic curve of voltage show that the experimental results and theoretical analysis results are consistent. The TTL inverter experiment can be done well by Multisim 12.0.

Multisim 12.0 is applied to extensible teaching experiments: the purpose of extensible experiments is to cultivate students' aptitude for inquiry and innovation, and to further improve their knowledge of circuits and practical skills. For example, 74160 is an integrated decimal counter with asynchronous reset and synchronisation loading. It can be used to design any binary counter [4]. As an example, consider the design of a six binary counter using the functions of asynchronous reset and NAND. Figure 5 is from the working window of Multisim 12.0 and shows the circuit for the six binary counter. The counting process of the counter can be observed by the logic analyser [5]. The output waveform of the logic analyser is shown in Figure 6.

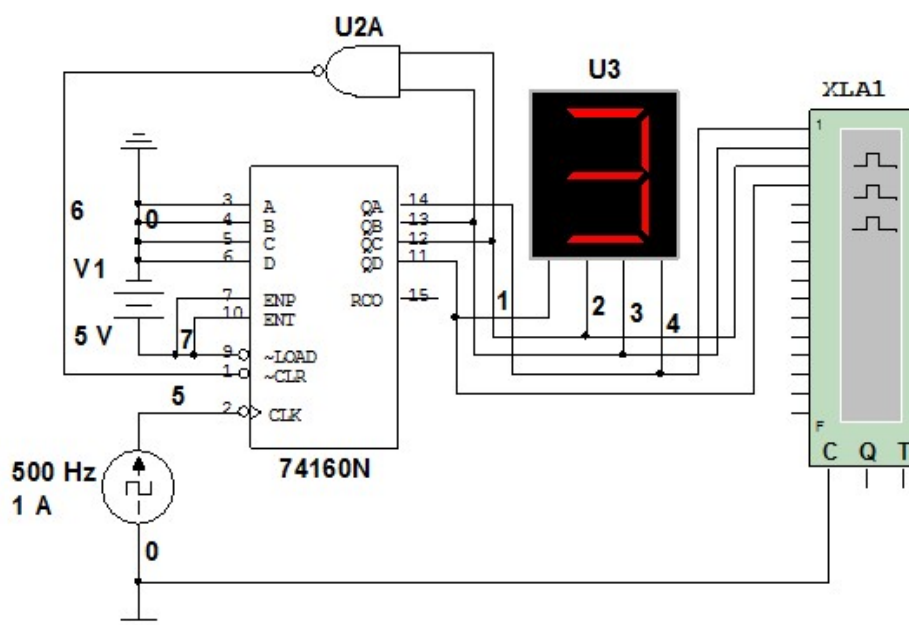


Figure 5: Circuit of the six binary counter.

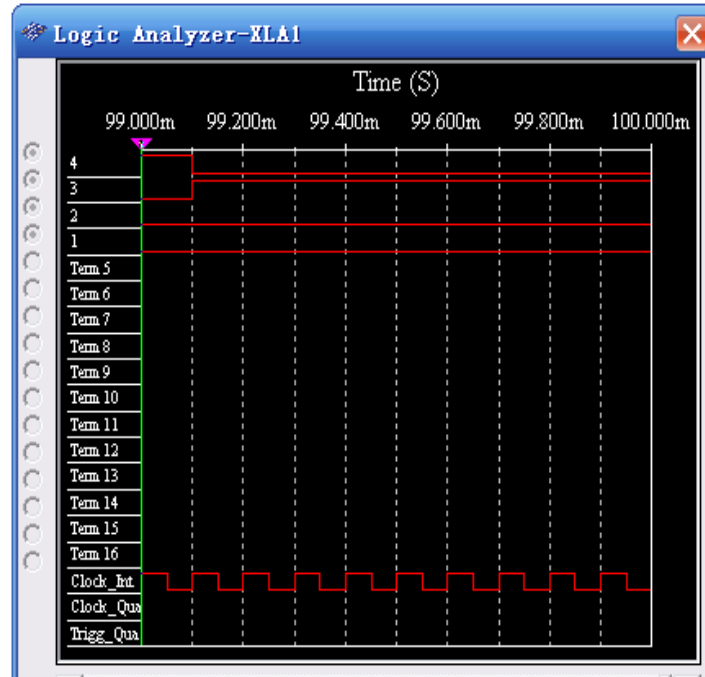


Figure 6: Output waveform of the logic analyser.

Multisim 12.0 is applied to comprehensive design experiments: the aim of comprehensive design experiments is to design and make practical circuits by using electronic technology, in order to cultivate students' practical ability, requiring the comprehensive application of knowledge. For example, a signal generator with adjustable frequency is to be designed using a 555 timer and other components. The signal generator has functions of reset and signal indication.

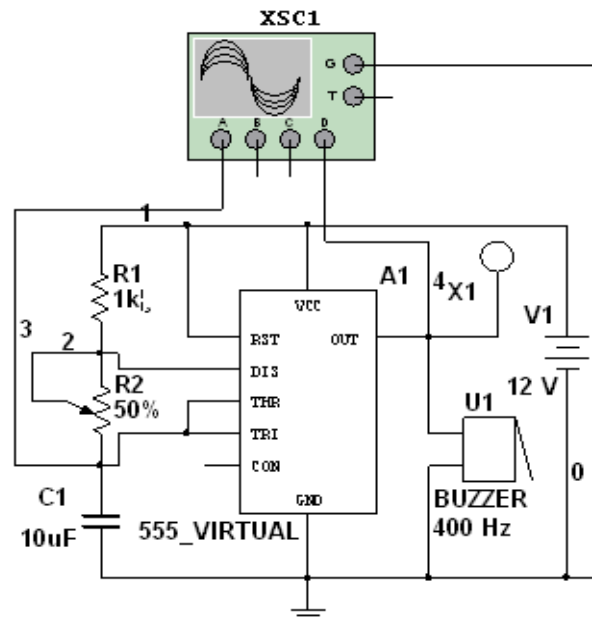


Figure 7: Circuit of the signal generator.

The circuit of the signal generator was drawn using Multisim 12.0, and is shown in Figure 7. The frequency of the signal is given by Equation (1):

$$f = \frac{1.43}{(R1 + 2 \times R2) \times C1} \quad (1)$$

From the equation, the frequency is related to resistors R_1 , R_2 and capacitor C_1 [6], R_2 is an adjustable resistor, so that the 555 timer can output signals with adjustable frequency. The output waveform can be observed by a virtual oscilloscope, as shown in Figure 8. At the same time, the frequency and amplitude of the oscillation signal can be read [5].

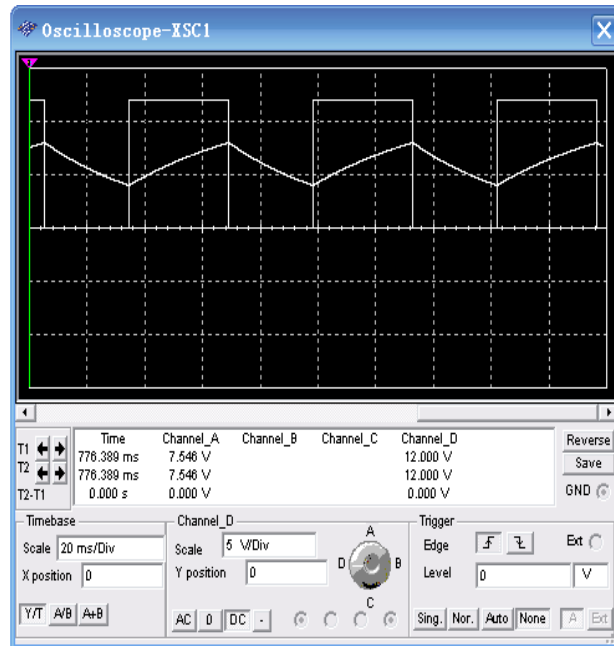


Figure 8: Output waveform of the virtual oscilloscope.

TEACHING EFFECT OF APPLYING MULTISIM 12.0 TO TEACHING EXPERIMENTS FOR DIGITAL ELECTRONIC TECHNOLOGY

Multisim 12.0 has been applied effectively to teaching experiments of digital electronic technology. Compared with the previous experiment teaching methods, Multisim 12.0 is visual, economical and usable. From 2009, there have been remarkable achievements in experiment teaching using Multisim 12.0. The application of Multisim 12.0 stimulates students' interest and curiosity in experiments.

Students better combine theory and practice, their design ability has improved, the pass rate of the theoretical course has gradually increased and students' abilities to analyse and solve problems have improved significantly. The method has effectively promoted the reform of practice teaching, and the PubMed rate has improved, as shown in Table 1. Multisim 12.0 could be used in experiments for other curricula.

Table 1: The effect of applying Multisim 12.0.

Time (Year)	Class atmosphere	Design ability of students	Pass rate of the theoretical course %	PubMed rate %
2007	Inactive	Poor	45	10
2008	Inactive	Poor	37	7
2009	Active	Medium	55	15
2010	Active	Good	70	20
2011	Active	Excellent	80	27
2012	Active	Excellent	90	38
2013	Active	Excellent	98	57

CONCLUSIONS

The application of Multisim 12.0 to digital electronic technology experiments plays an important role as a bridge between theory and practice, and is an important innovation in teaching experiments. It overcomes the problems of a shortage of laboratory equipment and limited funds for experiments. Students learn to think about problems from multiple angles and, then, propose different solutions. Students' ability to solve practical problems has improved.

Realistic simulations greatly improve students' interest in learning. The combination of computer simulation and physical experiments enables students to master basic theory. It also encourages initiative, improves students' practical ability and cultivates their innovative ability.

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