Application of Virtual Simulation technology in Electrical Engineering Experiment Teaching

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***Abstract*—Virtual simulation experiment teaching is a good supplement of electrical engineer traditional experiment, especially in some dangerous situation, such as some instrument with high voltage. With virtual simulation experiment, not only some knowledge could be test and verify that couldn't test in traditional before, but also stimulate the interesting of students.**

Keywords-Virtual Simulation; Electrical Engineering; power elctronics; Experiment teaching

I. INTRODUCTION

At the present stage, electrical engineer is developed quickly, and the electric power plays an important role in many fields. The future development trend of electric power grid is smart grid, which include such features as flexible, clean, secure, economic, friendly and so on[1].

Because of the environment of the power system and power industry is high-voltage, high risk, high energy consumption, the cost of real experiment is high and dangerous[2].

The virtual simulation experiment teaching is an important application of the information technology in higher education and becomes an important part of educational informatization [3].

II. APPLICATION IN POWER ELECTRONICS

Power electronics refers to control and conversion of electrical power by power semiconductor devices where in these devices operate as switches[4].

PSIM is one of the fastest simulators for power electronics simulation. It achieves fast simulation while retaining excellent simulation accuracy. It can helps students to simulation electrical control, the top of circuit, and helps students to analysis the results, enrich the teaching contents, deepen students' understanding of power electronics.

For example, in a single-phase full-bridge inverter. If bipolar modulation PWM switching scheme is used. Vd=300V, ma=0.8, If unipolar modulation bipolar modulation is adapted, which one can achieve lower DC current ripple?

The first step, students need to use the power electronics knowledge to analysis this question, and make there conclusion. The second step, students need to use PISM to draw the unipolar and bipolar modulation, then simulate and compare the result and analysis the deferent.

A single-phase full-bridge inverter is shown in Fig.I, and unipolar modulation PWM switching scheme is used.

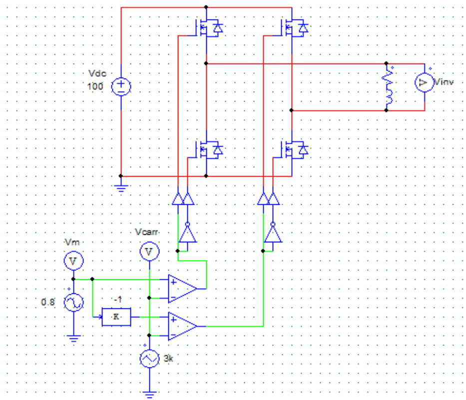

FIGURE I. UNIPOLAR MODULATION INVERTER

The waveform of output voltage and the waveform of unipolar modulation PWM are shown in Fig.II.

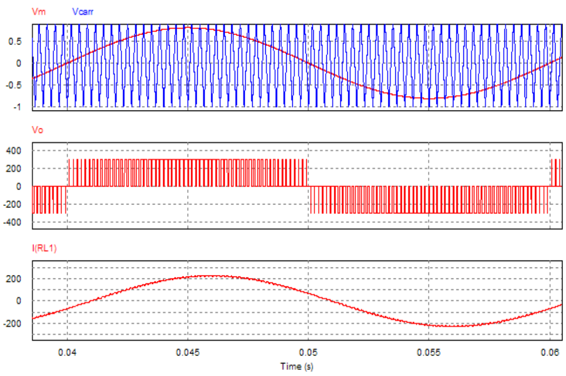

FIGURE II. WAVEFORM OF UNIPOLAR MODULATION INVERTER

The same single-phase full-bridge inverter is also shown in Fig.III, but unipolar modulation PWM switching scheme changes to the bipolar modulation PWM switching scheme.

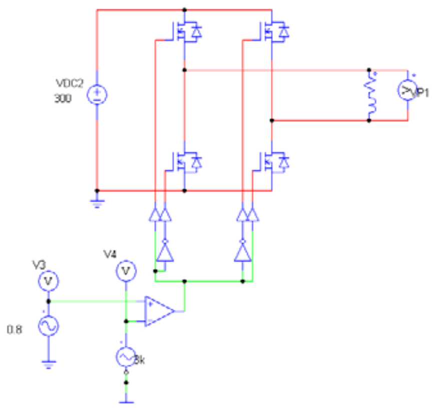

FIGURE III. BIPOLAR MODULATION INVERTER

The waveforms of output voltage and the unipolar modulation PWM is shown in Fig.IV.

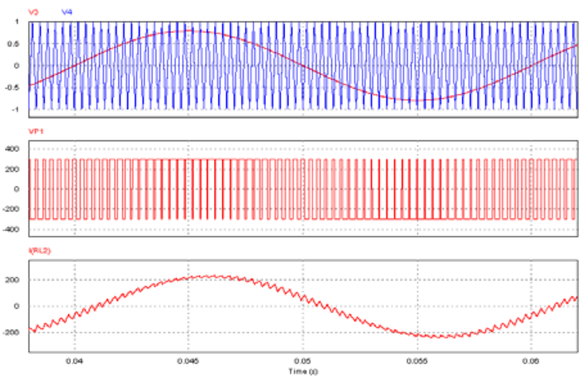

FIGURE IV. WAVEFORM OF BIPOLAR MODULATION SIMULATION

Compare the waveforms of the output of unipolar modulation inverter and bipolar modulation inverter, it is easy to find that the PWM with unipolar voltage switching can achieve lower DC current ripple.

III. APPLICATION IN ELECTRIC DRIVE

Electric drive include the principle of motor, electromagnetics, the technology of automatic control system for electric drive, dynamics of machinery etc.

The traditional experiment of electric drive course includes some defects, such as experimental process abstraction, experiment difficult and high cost [5].

MATLAB(Matrix Laboratory) is a scientific, mathematical and engineering software package for numerical computation, visualization and application development.

With MATALAB, students could practice in another way, the safe, convenient experiment. This method will activate the motivation of the students.

For example, the mechanical character of three-phase induction motor is describe as equation (1) , it is an important formulae in learning motor.

$$T = \frac{P_{em}}{\Omega_1} = \frac{3I_2'^2 r_2' / s}{\frac{2\pi f_1}{p}} = \frac{3pU_1^2 r_2' / s}{2\pi f_1[(r_1 + r_2'/s)^2 + (x_1 + x_2')^2]} \quad (1)$$

Where Pem is the electromagnetic power, Ω1 is the angular velocity, I2' is the current of rotor, r_2' is the resistance of rotor, x_2' is the rotor inductances, r_1 is the resistance of stator, f1 is the frequency of source, s is slip, p is number of pole pairs. All quantities are referred to the stator.

This mechanical character can be simulate by MATLAB, use M file, the character curve is shown in Fig. V.

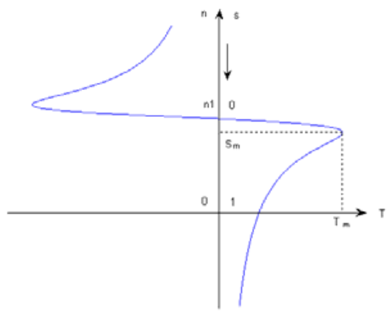

FIGURE V. MECHANICAL CHARACTER OF MOTOR

When the parameter of motor is changed, the mechanical character will changed too. This change can be simulate by MATLAB, use M file, the character curve that the parameter is changed is shown in Fig. VI.

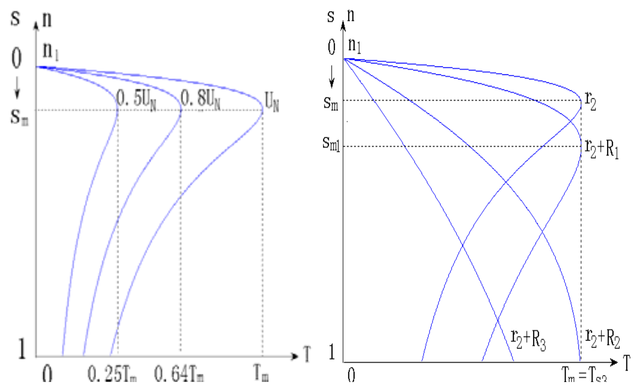

FIGURE VI. MECHANICAL CHARACTER OF MOTOR

The cures in Fig. V. and Fig. VI. show when the voltage of the stator is reduced, the maximum slip is unaltered. But with the voltage of the stator is reduced, the maximum electromagnetic torque will reduced, as well as the start electromagnetic torque.

There is the three-phase asynchronous machine in MATALAB library, that can be dragged into a model, specify the parameters of the model , to simulate the properties of the motor or control the speed of the motor.

It is helpful to use the demo, such as the power_pwm demo, it illustrates the use of the Asynchronous Machine block in motor mode. It consists of an asynchronous machine in an open-loop speed control system. The students can modify the demo, change the control technique, then test and verify the control system.

IV. APPLICATION IN POWER SYSTEMS ANALYSIS

The interconnected power system is usually referred to as the largest and most complex machine build by humankind. Include power system steady-state analysis and Dynamic Analysis.

Power system consists of generation, power transformers, transmission lines, loads, capacitors, reactors and protection devices.

Because the power system is a complex system, the voltage is high, include high transmission voltages and the lower distribution system voltages. It is impossible to structure a real system to do experiment, for the cost is enormous, and it is dangerous to do the test with high voltage for students.

There are some soft ware to analysis the power system, such as PSASP (Power System Analysis Software Package), EMTP-ATP (Alternative Transients Program）, PSSE (Power System Simulator for Engineering) , PSCAD /EMTDC (Power System Computer Aided Design/Electromagnetic Transients Program including Direct Current), EMTP(Electromagnetic Transients Program) etc..

PSCAD is a Powerful and flexible graphical user interface to EMTDC, electromagnetic transient simulation engine. With PSCAD, students could schematically construct a circuit, run a simulation, analyses the results, and manage the data in a completely integrated, graphical environment, and alter system parameters during a simulation run, and thereby view the effects while the simulation is in progress.

For example, to analysis short circuit fault of the transmission line, compare the changes of current and voltage.

There are many common models in the PSCAD master library, Resistors, inductors, capacitors, Mutually coupled windings, such as transformers, Frequency dependent transmission lines and cables ,Current and voltage sources, Switches and breakers, Protection and relaying, Diodes, thyristors and GTOs, Analog and digital control functions, AC and DC machines, exciters, governors, stabilizers and inertial models, Meters and measuring functions, Generic DC and AC controls, HVDC, SVC, and other FACTS controllers, and Wind source, turbines and governors.

Use the master library to construct the circuit, shown in Fig.V.

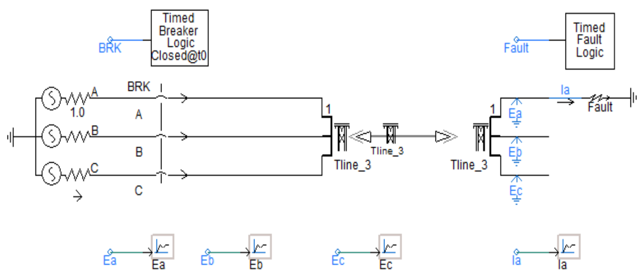

FIGURE VII. SINGLE-PHASE-TO-GROUND FAULT CIRCUIT

In Fig.VII. The Single-Phase Fault is controlled through a named input signal (Fault), where the fault logic is:0 = Cleared,1 = Faulted. by using the Timed Fault Logic component, the fault signal is configured automaticallyor, in this circuit, fault on resistance equal 0.01 ohm, fault off resistance equal 1x106ohm. The timed fault logic is configured, time to apply fault is 0.2s, duration of fault is 0.1s.

The Overhead Line is configured to the Bergeron model, it is is based on a distributed LC parameter travelling wave line model, with lumped resistance. Then enter transmission data by manual data entry component, Resistance (R), Inductive and Capacitive Reactance and so on. The parameter is shown in Fig. Ⅷ.

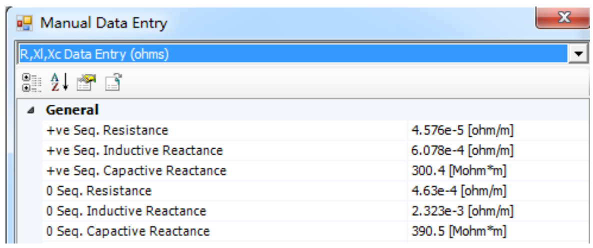

FIGURE VIII. SINGLE-PHASE-TO-GROUND FAULT CIRCUIT

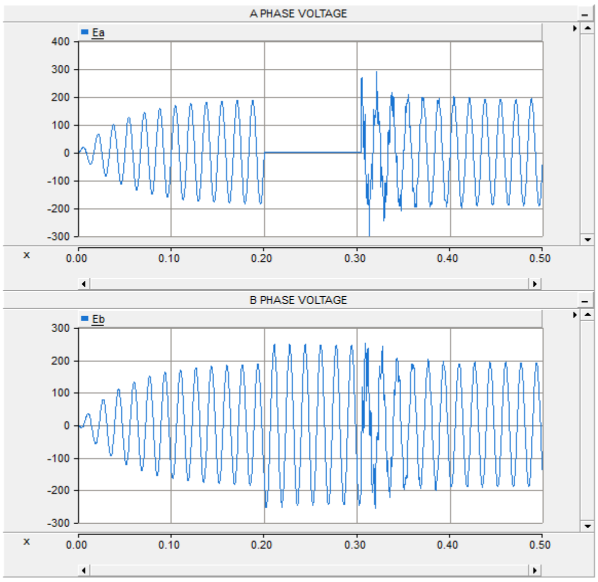

FIGURE IX. WAVEFORM OF A PHASE AND B PHASE VOLTAGET

Simulat this circuit , the A phase voltage and Bphase voltage is shown in the graph in the Fig. Ⅸ. The Waveform of A phase voltaget and current is shown in the Fig.X.

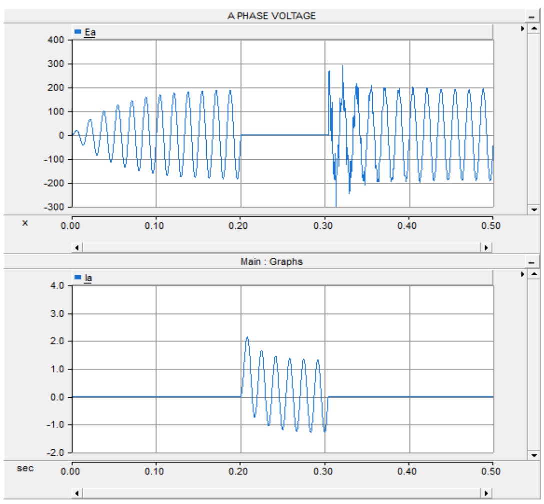

FIGURE X. WAVEFORM OF A PHASE VOLTAGET AND CURRENT

From Fig. Ⅸ. , it is easy to find the difrent betwent A phase and B phase voltage. When the fault occur, the voltage of A phase drop to zero but the voltage of A phase raise to a higer amplitude.

From Fig. X. , When the fault occur, the curent of A phase increase rapidly.

V. CONCLUSION

With Virtual simulation experiment, students have more chance to test their design, the technique that is hard to understand, Virtual simulation experiment teaching is a good supplement of electrical engineer traditional experiment. It is cheaper, convenient, safe, interesting and efficieny, especially in some dangerous situation, such as some place with high voltage. With virtual simulation experiment, not only some knowledge could be test and verify that couldn't test in traditional before, but also stimulate the interesting of students. It plays a positive role in the student's scientific study and training. The good results of teaching and learning are achieved.

REFERENCES

[1] Zhang Wenliang,Liu Zhuangzhi,Wang Mingjun,Yang Xusheng. "Research Status and Development Trend of Smart Grid". Power System Technology. Vol. 33 No. 13, pp1-10, Jul. 2009.

[2] Zhai Yongjie, Ji Pengbo, Wang Xiumei, Ma Jin, Ma Liangyu. Construction of virtual simulation experimental teaching center of whole electric power industrial proces.Experimental Technology and Management.Vol.31 No.8, pp5-8, Aug.2014.

[3] LI Ping, MAO Chang-jie, XU Jin. Construction of the National Virtual Simulation Experiment Teaching Centers, Improving the Experimental Teaching Informatization in Higher Education. Research and Explor Ationin Laboratory. Vol.32 No. 11, pp5-8, Nov.2013.

[4] Ned Mohan. Power Electronics: Converters, Application, and Design(Third Edition). Peaking: Higher Education Press

[5] Zhang Jing-nan , Zhang Qiang. Teaching Reform in the Simulation Experiment System of Electric Drive Course. JOURNAL OF EEE, Vol.36 No. 2, pp88-90, Apr. 2014.