Combining Research and Teaching in Order to Attract More Students

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Abstract

This paper shows how to explore research experience, including industrial projects, to enrich the lectures by adding practical demonstrations to theoretical parts of engineering courses. We do not have scheduled regular laboratory sessions for these graduate courses. During the lectures some selected and more interesting parts of experiments based on our research are demonstrated. The focus is to organize the class room lectures and industrial or/and theoretical research to increase the understanding of the various topics and increase the interest in the practical application of the various theoretical topics. It has been observed over the last several years that a large number of students have chosen several elective graduate courses because of the existence of the class room research demonstrations that help them understand connections between theory and practice.

1. Introduction

The teaching and research attract each other and they could not be completely separated one from the other in Electrical and Computer Engineering topics. The technology is changing fast and the research is driving the technology. The theory that is normally taught in a class room can be explained better using the latest research and demonstration of experiments or simulations with technology along with the theory.

The relationships between research and teaching depend strongly upon the areas of education. In this paper electronic and electrical engineering are considered. We present here about linking the improvements in lecture presentations to support theories and to show limitations of existing theoretical explanations. Some experimental findings could be used to expand theoretical boundaries. In addition to regular book, article, handout materials the graduate courses include short projects, which cover additional topics or enhanced course topics. Most of our students work in local industry and they use available resources in their work places though most of the instruments and equipment are available at the Universities.

Some professors feel that "courses taught by those at the cutting edge of research will necessarily be of higher quality than those taught by those merely using the research results of others – whatever the apparent quality of their style of delivery" [1, 2]. Hattie and Marsh [3] found no significant relationship between research productivity and teaching. "There is clear evidence from a range of studies in different types of institutions of students valuing learning in a research-based environment" [4, 5].

Research is rewarded more than teaching at most of the universities. Some professors at major universities spend most of their time in writing proposals to do advanced research and find grants for research. But, these professors bring in their research experience and industry experience and provide a good rounded education to students.

We need to realize that doing world-class research is a full time job and doing an excellent teaching is also a full time activity. Effective teaching involves developing new and creative methods, updating the teaching material constantly, introducing lively discussions in the class room, motivating the students, providing students ability to do life-long learning and others .

2. Demonstrations in the Class

In this paper we observe the following in graduate classes:

1. Most of our graduate students work for local industry,
2. Creation of regular laboratory with a decent number of laboratory stations to support advanced graduate courses takes a lot of time and money.
3. We introduce some demo experiments during the lectures to help illustrate presented theory and show the test setup.
4. Involving all students in the class in observing and in partial measurements and extension of measurements by simulations of some experiments, etc provide a huge learning opportunity for students.

Over the last 15 years the authors have observed an increased interest of students to attend graduate elective courses that have materials related to the results of faculty research. The research topics have been mostly supported by local industry. Due to the limited laboratory space, equipment and timing, these courses could not be directly supported by regular laboratory sessions, but the classroom demonstrations and short student team projects have created a lot of interest to our students.

The examples of courses discussed are [6-10]: High Frequency Electronics (ECE 527), Validation and Verification of Embedded Systems (ECE 573), and Electromagnetic Compatibility (ECE 546), Measurement and Instrumentation (ECE 525) – electronic instrumentation part (oscilloscope, spectrum analyzer, sine and pulse generators, Line Impedance Stabilization Network (LISN), spark generator are used in these presentations and antennas. Some of the experiments developed to support these courses could be also demonstrated to undergraduate students attending the introductory course of electromagnetics (such as ECE 345 at OU). Some parts of experiments could be also supported by computer simulations (PSPICE, MATLAB).

In Instrumentation and Measurement course (ECE 525) and other courses we introduced experiments/demonstrations in the class to show basic measurement methods, limitations of instruments (Scope calibration, scope rise time, scope bandwidth, scope probes, SA (spectrum analyzer) frequency span, SA frequency resolution, SA bandwidth limitations), Standing wave patterns in transmission lines – sinusoidal signals are applied to observe signals along the coaxial cable. Pulse reflections in transmission lines, TDR (time-domain reflectometry) to identify and locate the transmission line loads, and their characters. Transmission line radiation and immunity, and Conducted immunity (LISN) with effects of environmental noise are demonstrated and also conducted immunity when the interfering signal from the noise generator is radiated. We demonstrate also conducted immunity when the interfering signals of the spike generator are observed and radiated immunity in all above situations.

Practical experiments related to Daimler-Chrysler grants (Minivan body grounding, student projects, CAN (Controller Area Network) protocol system hardware tests, especially twisted pair, including TP transceivers) led to acquaintance with broader issues of EMC and preparation of EMC course – the course attracted many students, especially from automotive industry. Simulation results and modelling of lines and transceivers also attracted interest of Michigan Automotive Consortium.

Recent automotive industry research is related to investigation of EMC (electromagnetic compatibility) performance of unshielded and shielded twisted pair transmission lines, in order to find limitations of both categories. As one of the results, a practical demonstration was prepared to be shown during our EMC lecture – three trays: with UTP (unshielded twisted pair), STP (shielded twisted pair) and coaxial cable, coupled with single conducting wires used to inject interfering signals were set up to show how interfering signals can get from the single wire to transmission lines as common mode and differential mode signals. In addition, it could be observed how effective the process of shielding is when coaxial cable has various grounding connections. Interesting observation could be made when the interfering signals are observed on the shield of coax when both ends of the screen are grounded – to show effectiveness of shield grounding. The research led to some publications and to preparation of some experiments later demonstrated to students. Simulations used to supplement experimental results, and to make some predictions were later simplified and introduced to support lectures.

Figure 1 shows the equipment to demonstrate most of the above experiments. They include transmission line, pulse generator, a four-channel oscilloscope. The image on the scope shows various points along the line, and clearly reveals the pulse delay due to the length of the line.

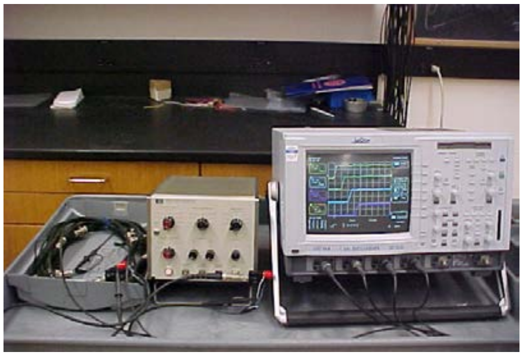


Fig. 1: The equipment necessary for the demonstration.

Figure 2 shows the radiation from a twisted pair, single wire, and untwisted pair wire by modeling. Figure 3 shows CAN calculator done to find the sources of emission (TP, IC, grounds), determine the most significant sources, and this provides input to industry to make improvements to their design.

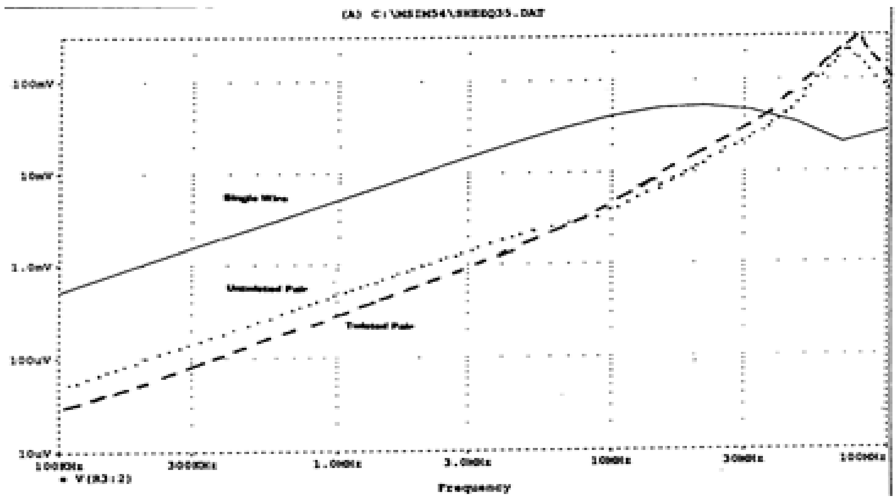


Figure 2. Radiation curves for single-wire, untwisted pair and twisted pair transmission lines.

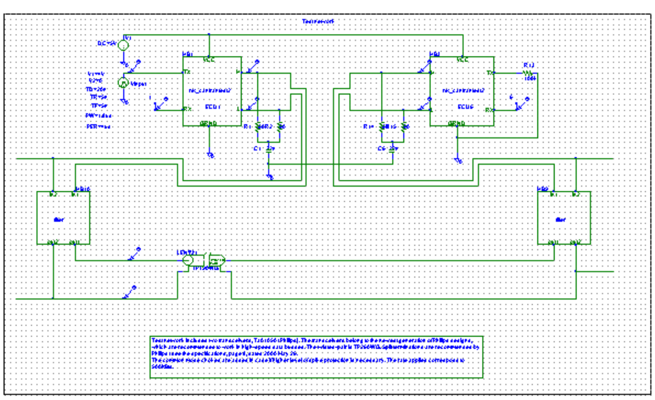


Figure 3. Circuit for CAN Modelling

3. Simulation of transceivers

Two-transceiver circuit with common-mode filters and twisted pair applied to test basic parameters of the models

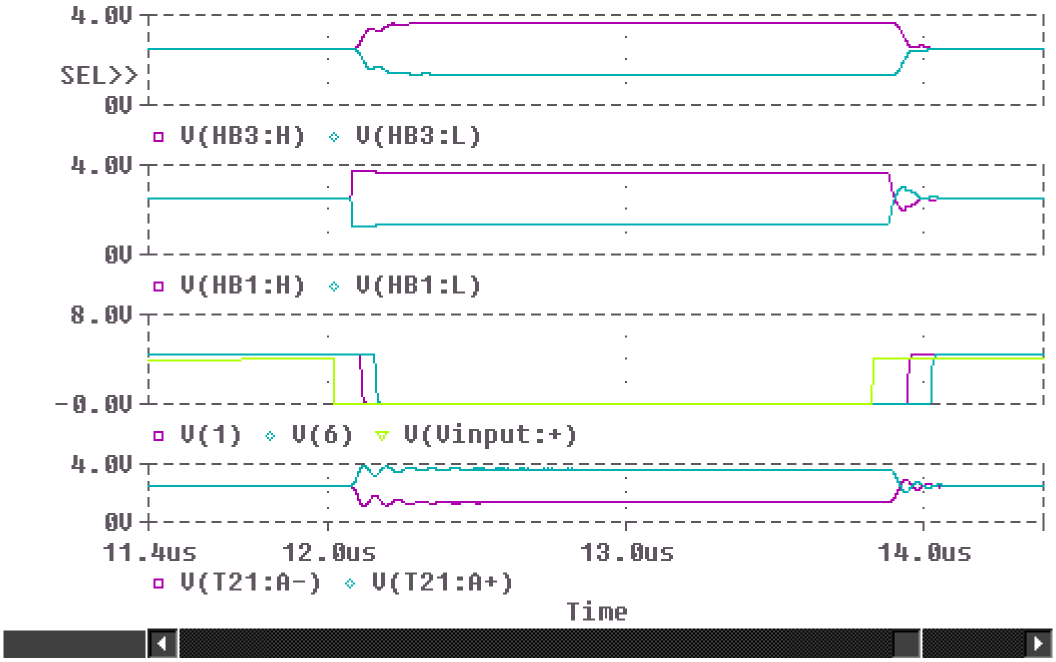


Figure 4. Transceiver simulation results

Simulated waves are shown in the circuit of Fig. 4. Waves V(HB1:H) and V(HB1:L) are the transmitted bus signals from the left transceiver of Fig. 4 (before the common-mode filter). Waves V(T21:A+) and V(T21:A-) are the bus signals entering the twisted pair (after the filter). Signals V(HB3:H) and V(HB:L) are the bus signals received by the second transceiver. Signals V(Vinput:+), V(1), and V(6) are the first transceiver input, first transceiver output, and second transceiver output voltages respectively.

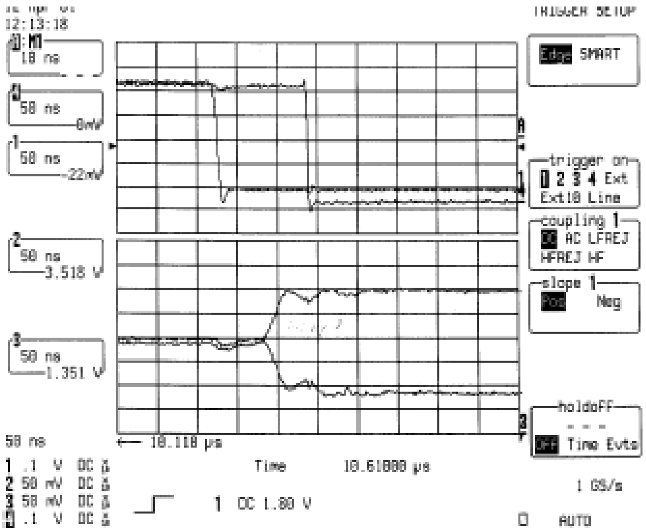
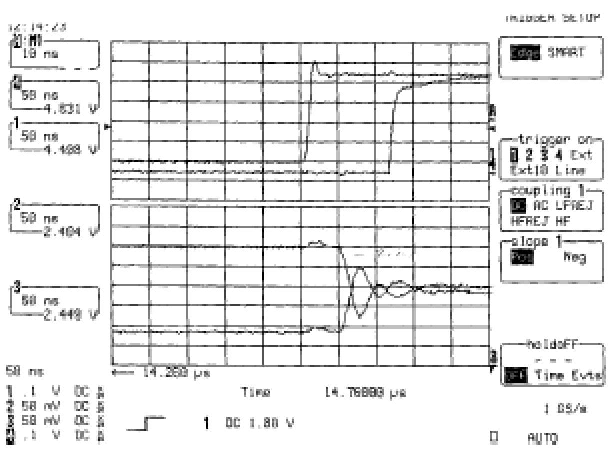


Figure 5 and 6 Transceiver input and output signal

Measured waves for a circuit are shown in figures 5 , 6. Upper channel shows transceiver input signal (left), and receiver output signal. Lower channel shows recessive-to-dominant bus transitions.



Measured waves for the circuit of Fig. 7. Upper channel shows transceiver input signal (left), and receiver output signal. Lower channel shows dominant-to-recessive bus transitions.

Figure 7: Transceiver input and output signals.

4. Simulations for Time Domain Reflectometry

Simulation provides unparalleled ability to explain the dynamics underlying, Time-Domain

Reflectometry, TDR. The line length used to reproduce the waveforms for all of the figures shown here is 14 meters; the unit delay is 23.3 cm/ns. Figure 8a shows a PSpice/ MultiSim simulation circuit for a matched source. Figure 8b shows the temporal simulation result. Figure 8c provides an oscilloscope screen picture of the waveforms affiliated with an open ended transmission line input. In Figure 8c the input – Channel 2 (upper curve) shows the incident step and reflected step. The time between the incident and reflected step is the delay time introduced by signal as it passes through length of the line and then returns the length of the line—a doubled TL delay. The "Output – Channel 4" signal, (the lower curve), shows the doubled incident wave level with a long pulse applied by the source, delayed about 60 ns due to the length of the line. The distance between steps of Channel 2 is double the transmission line delay time.

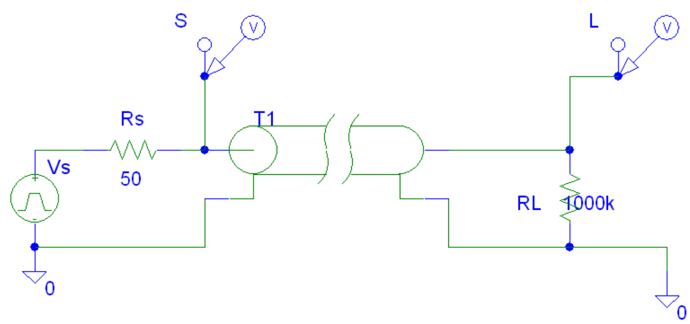


Figure 8a: PSpice/MultiSim model of an open ended transmission line (TL) with a long pulse applied. The source is matched.

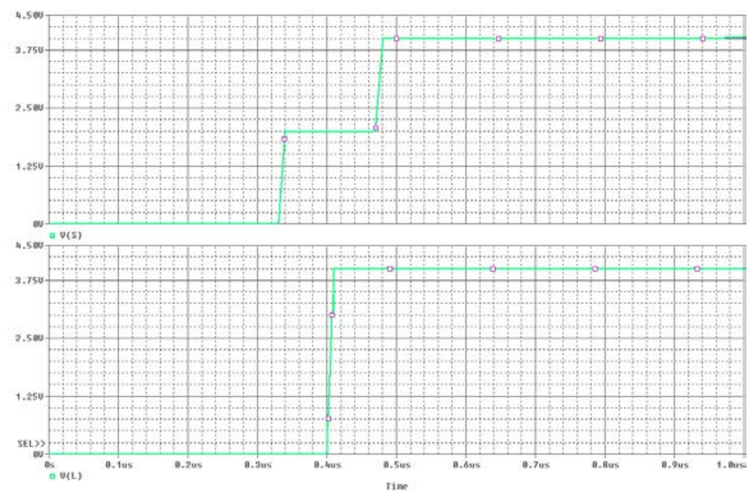


Figure 8b: PSpice/Multisim simulation results for the circuit shown in Figure 2a.

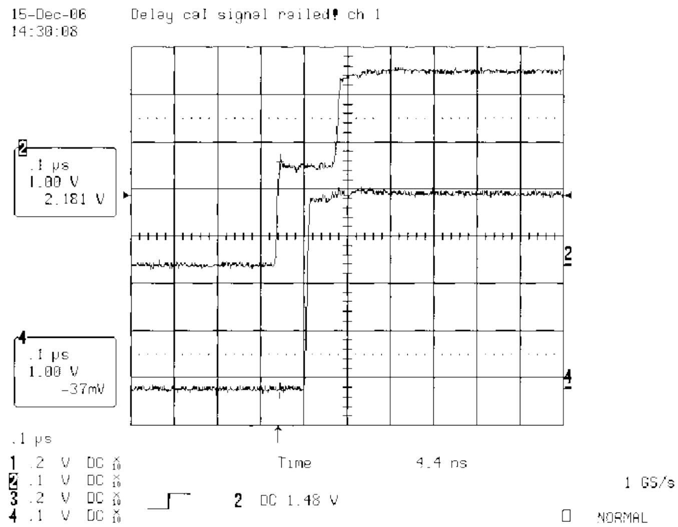


Figure 8c: Oscilloscope scope screen shot of voltage waves affiliated with an open-ended transmission line with a matched source.

5. Demonstrations done in Validation and Verification graduate course

This graduate course does not have a laboratory component and it is a new evolving course. During the class lecture we did simulation and analysis using CAN communication simulation, Matlab, PSpice, CodeWarrior for HC12 system, Live Devices: Real time architect software and Simplorer multi Domain simulation software tool.
Some of them are described briefly below. These tools were used for various industry research projects and we use that experience to teach them in the course.

1. CAN network: We demo the CAN simulation & analysis tools from Vector CAN Tech. This helps them to understand how to debug problems in the nodes, CAN interface or CAN bus.
2. Mat lab tool: We model a simple engine controller and learn how to analyze the design. They also download the code generated by Matlab autocode generator to a HCS12 micro board and do a hardware-in the loop testing. They use the (Real time) RT tool box.
3. Lab view: We model a simple behavior and engine controller. This allows us to demo a model-in the loop testing of their controller design.
4. PSpice: We use Pspice tool to simulate the effect of temperature on op-amp, look at the characteristics. In the model, we vary the resistance values with a given tolerance (to max and min values) and study the output behavior.
5. Simplorer: We use the Simplorer to study electronic circuit simulation.
6. Real time software development tools ASCET and INTECRIO from ETAS[21]. We use this software tool to schedule a few Real time tasks, run them in real time on a HCS12 board. Then check schedulability of various tasks within deadline using the software tool.

5.1 FMEA application in circuit design:

Failure mode and effective analysis (FMEA) evaluates the potential failure of a product and its effects, identifies actions to reduce the failures, and documents the process/ design to satisfy the requirement. System level FMEA design analysis of one of the automotive electronic circuit and board is done.

5.2 WCCA and design-for-six-sigma:

Worst case analysis methods are: Extreme value analysis, root sum square analysis and Monte-Carlo method. Worst case analysis estimates circuit's worst case performance. Root sum square method provides realistic worst case performance. For some auto parts Monte-Carlo method is used for WCCA to validate the designs. WCCA aligns with zero defects and the design becomes overly conservative and leads to high production costs. By using statistical analysis based on six-sigma, a more reasonable understanding of the design specifications and how parts will be assembled is demonstrated.

6. Two Graduate Course Descriptions

As an example, two graduate courses where we tried this approach is described below.

High Frequency Electronics Course Contents: (ECE 525)

1. Passive lumped components at high frequencies
2. Transmission lines with sinusoidal and pulse excitation
3. Active devices operating at high frequencies
4. Pulse operation of active devices
5. High frequency amplifiers
6. High frequency oscillators
7. High frequency communication circuits
8. Introduction to high frequency measurements and instrumentation
9. Software Applied: PSPICE, Serenade, MATLAB, SMITH 191, APPCAD

Electromagnetic Compatibility High Frequency Electronics Course Contents: (ECE 546)

1. Overview of EMC
2. EMC Requirements
3. Review of Electromagnetic Principles
4. Distributed and Lumped Components
5. Signal Spectra and Spectrum Measurements
6. Introduction to EMC Pre-compliance and Compliance Tests, Component and System Level Measurements
7. Radiated Emissions and Susceptibility
8. Conducted Emissions and Susceptibility
9. Crosstalk
10. Shielding and Guarding

11. Electrostatic Discharge

7. Conclusion

In this paper we discussed the relation between research and teaching graduate courses. We introduced demonstration of research projects in the graduate classes during the lecture. From the course evaluations we find that this approach increased the student's interest in the course material and increased their understanding.

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