Virtual Semiconductor Devices Lab

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Abstract. The paper describes the developed virtual laboratory that makes possible to play and learn basic characteristics, parameters and important applications of semiconductor devices via standard web browser. Virtual lab is implemented as Java-based applets embedded in HTML pages. It permits student to arrange experiments and to obtain hands-on experience operating with virtual signal generator and dual channel oscilloscope

1. Introduction

The revolution in the sphere of information and communication technologies has speeded up the fundamental transformation from an industrial to an information society. Information society technologies increasingly pervade all industrial and societal activities and accelerate the globalisation of the world.

The technological development and the modern society continuously required more qualified and competent citizens. To maintain their innovative forces in the future, highly qualified experts with a multidisciplinary background, experimental skills and social attitude must be educated [1]. The ever growing importance of knowledge and greater numbers of people being educated and trained at a high level have increased the responsibility of educational institutions, particularly universities which are under strong pressure to change [2].

At the same time decreasing level of secondary school education and lack of student motivation, have led to great difficulties in the teaching situation and decline of exam results at the universities. Out-of-date laboratory equipment can't support students' skill obtaining and leads to financial problems for university budget. Another important point is the need to operate on the increasing competitive global education market. Obvious there is a need for change not only leading to better study results but also in finding a new infrastructure meeting the need for less expensive teaching localities.

To fulfil these requirements and cover a very wide range of fields effectively, the e-Learning tools should be developed and introduced into the educational scheme in general [3]. Their wide use and dissemination is enhanced by rapid growth and use of the Internet and WWW, which have become the inevitable base for all type of life long and/or distance learning.

2. e-Learning and Educational Transformation

e-Learning is the delivery of training and/or education via the Internet. e-Learning has been referred to as the Internet's "second wave." [4] Some of the more significant benefits that many institutions are realising through their use of e-

Learning are cost benefit, learning benefit, global benefit, continuity benefit. The added interactivity of e-Learning, the ability for students to set their own pace through a course, and the flexibility to review course material at any time, improves the retention levels of learners.

The Internet has enormous power to improve the educational process. By using the Internet, education can be personalized to each user, so that each student is given a targeted set of materials based on his or her specific educational goals and previous achievements. At the same time, the Internet allows material to be updated dynamically, which creates an up-to-date resource for students.

The Internet also allows for collaboration in a way that has not been possible before with technology-based learning – collaboration not only with the student at the next desk, but also with a student half a world away.

Finally, the ability to connect different kinds of resources so that they become a coherent whole is an opportunity to create an integrated curriculum out of an incredibly wide range of source material.

The net effect of all of this is that education is becoming increasingly targeted to the individual; it is going to be integrated more completely into our daily lives, generating a process of lifelong learning, and it is going to happen in real time.

e-Learning is a tool. It is a very powerful tool, but it is only a tool. The Internet is such a powerful medium that it is going to change the face of education. Whether that change is for good or ill depends on the talents and motivations of the people implementing it [5].

More of the tools already developed are text-based. Some includes animations to facilitate understanding. Especially for the students in engineering not only knowledge but also experimental skills are very important. Practical training can contribute considerably to obtaining hands-on experience essential for future engineers.

By applying new technology we aim to increase students' motivation and to enhance their qualification in using measurement devices. Our goal is to make learning interesting – to make it so relevant and exciting that student want to learn and to continue learning. We aim to give students ability to

- Arrange experiments and achieve qualification in setting appropriate input signals and analysing output signals;
- Obtain hands-on experience operating with virtual signal generator and dual-channel oscilloscope.

To address these issues, we have developed a virtual lab, which allows students to study *dc* and *ac* behaviour of semiconductor devices via standard web browser. We introduce more interactivity, helping students to obtain hands-on experiment working in virtual lab in a way they do this in the real lab.

3. Structure of the Virtual Lab

The virtual lab consists of two basic facilities – one for obtaining static characteristics of semiconductor devices and second concerning *ac* applications. Virtual lab is implemented as Java-based applets embedded in HTML (Hyper Text

Markup Languages) pages. Applets are designed as general tools permitting analysis of different semiconductor devices.

3.1 Static Characteristic Tool

Static characteristic applet contains schematic field, characteristics display area, and control panel.

Schematic field visualises the circuit required for measurement corresponding *dc* characteristics. For some devices, physical processes occurring inside the device can be observed in the same field.

Control panel permits students interactively to choose the device type, the characteristic type, to set appropriate voltage value, and to start simulation. Simple simulator calculates characteristics' points.

Family curves are automatically scaled and plotted in different colours in the applet's display area. The parameter value is also visualised.

Figure 1 shows result of using static characteristic tool for obtaining output curves of the enhancement mode MOSFET.

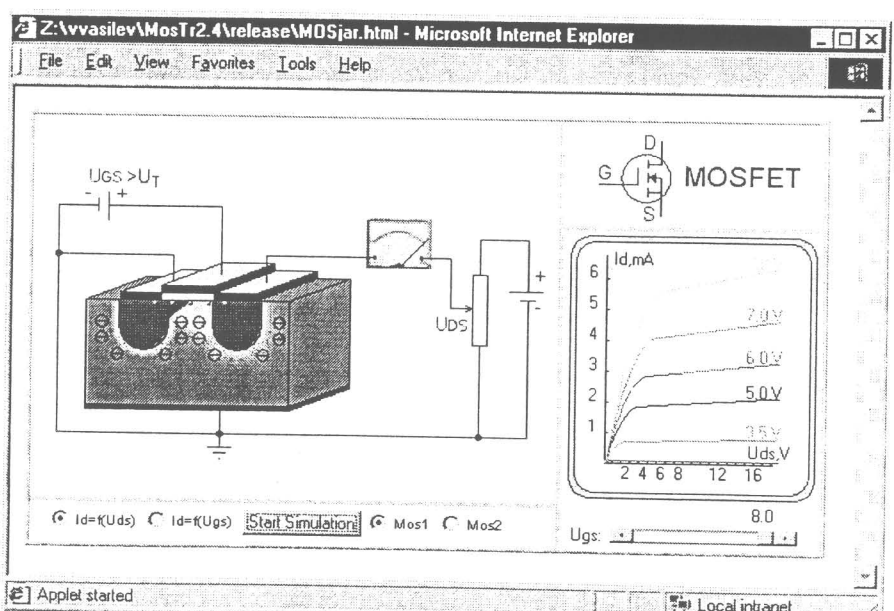

Figure 1. Interactive tool for VA characteristics – Output VA characteristics of a MOSFET

Using the same tool one also can obtain transfer characteristics of an enhancement mode or depletion mode MOSFET. Figure 2 shows transfer curves of the enhancement mode device.

Interactive web-based tools are developed as a part of e-Learning material dedicated to self-learning as well as a complementary material to regular training.

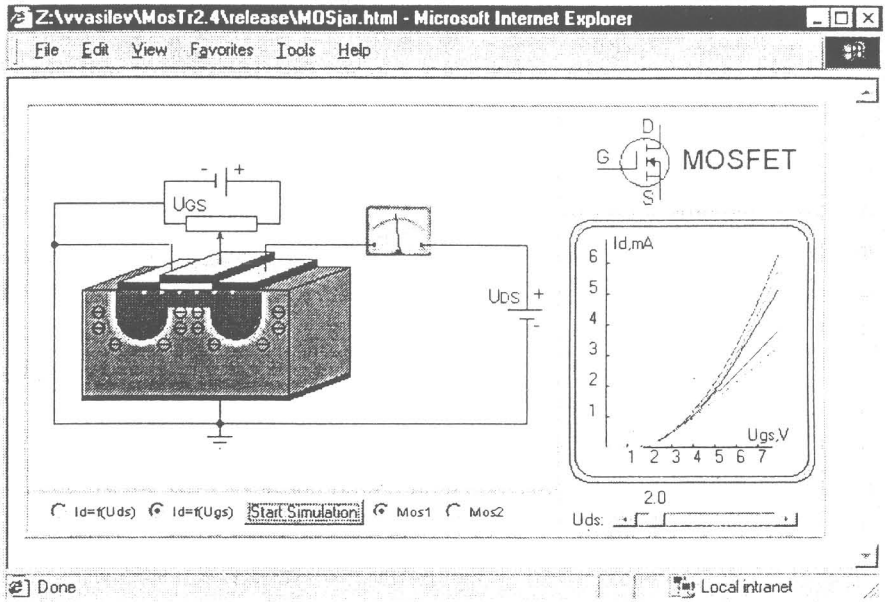

Figure 2. Interactive tool for VA characteristics – Transfer VA characteristics of a MOSFET

3.2 AC Semiconductor Device Behaviour Tool

AC device behaviour can be studied in virtual lab containing interactive dual channel oscilloscope and interactive signal generator. Both measuring devices, like in real life need first to be switched on before starting measurement.

The signal generator permits setting of different input signal types – sinusoidal, pulse or triangular. Students can choose voltage levels or frequency as well as pulse duty factor. Simple simulator calculates the output signal depending of current application.

Both input and output signals are displayed by dual channel oscilloscope. Students can manipulate these signals like in real oscilloscope – move in x or y direction, change voltage levels or frequency.

Figure 3 shows laboratory arrangement for analysing MOSFET amplifier. Observing simultaneously both *ac* input and output signals student can see differences in phase and voltage level between these signals. By using oscilloscope settings they can determine amplifier voltage gain.

4. Conclusions

We have developed a Web-based e-Learning tool, aimed to enhance practical training of the students. The developed virtual laboratory consists of Java based interactive modules, which permit students to arrange experiments and to study dc and ac behavior of the semiconductor devices. All these modules are directly ac-

cessible through the WWW browser.

Virtual lab can be used for studying VA characteristics, diode rectifiers, voltage limiters, bipolar, JFET and MOSFET amplifiers, CMOS inverters, multiplexers and other typical applications of basic semiconductor devices.

e-Learning allows university to start creating a better skilled, better performing workforce today. Practical training can contribute considerably to an easier and deeper understanding of learning material. These tools that can be used most effectively to leverage the teacher's time and energy, so that the teacher spends the most time doing those things that add the most value to the learning process. This way, faculty can harness the power in these tools for teaching and research.

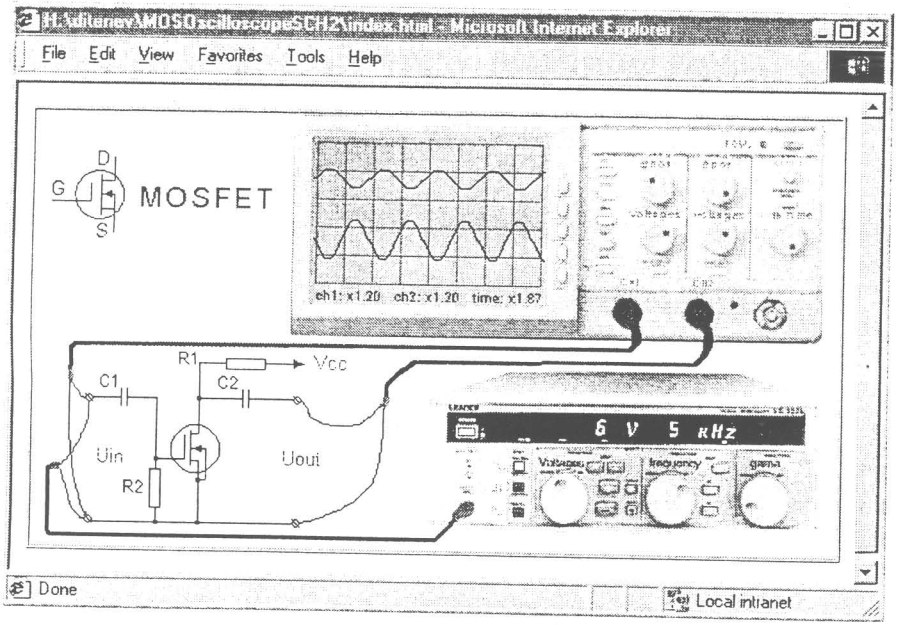

Figure 3. Virtual signal generator and dual-channel oscilloscope analysing MOSFET amplifier

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