Simulation Software for Online Teaching of ECE Courses

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<u>ABSTRACT</u>

Online learning, also known as e-learning, has become an increasingly common choice for many students pursuing an education. Online learning requires the student to participate and learn virtually via computer, as opposed to the traditional classroom environment. Although online learning is not for everyone, it's important for prospective students to determine whether or not it's something they would like to pursue. The following are advantages and disadvantages for online learning:

Advantages
-Online learning provides flexibility because students are able to work when it's convenient for them. Students can do all the homework from any location as long as they have access to a computer.
-A student can learn at his or her own pace.
-Degrees can be completed in less time compared to traditional universities.
-Students have fewer distractions, and it can be less intimidating to participate in the discussions.
-Students have the opportunity to connect with and work alongside students from other locations.

Disadvantages
-Students who have trouble managing their time may find it difficult.
-Lack of interaction personally with other students and the instructor.
-Technology and/or technology issues may be a barrier for some students.

This paper discusses the required simulation software for online teaching of Electrical and Computer Engineering courses. This author has taught these courses for more than three decades using traditional onsite and online method of teaching. With today's trend of teaching courses online, especially with the challenges of teaching technical courses, the need to formulate an efficient online method of teaching technical courses and to replace physical interaction has a high priority. In this paper, the result of the authors' finding in this field, new requirements and recommendations for teaching the technical courses online will be discussed. Different courses

such as electronics, digital circuits, microprocessors, data communication, digital signal processing, and mechatronics are considered. Different techniques such as web conferencing and group interviewing are employed in the senior project course to replace physical interaction.

1-INTRODUCTION

Online learning requires the student to participate and learn virtually via computer, as opposed to in a traditional classroom environment. Though online learning is not for everyone, it's important for prospective students to determine whether or not it's something they would like to pursue. Online learning has become an increasingly common choice for many people pursuing education [4, 7, 8, 9, 10]. The following are advantages and disadvantages for online learning:

Advantages

-Online learning provides flexibility because students are able to work when it's convenient for them. Students can do all the homework from any location as long as they have access to computer.
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2-SUGGESTED SOFTWARE TOOLS

In this section different software tools for different courses will be explained. Student version of several of these software are available free for download. Specifically Multisim, Proteus are available for free download.

(a)- Proteus Design Suite

The Proteus Design Suite is a Windows application for schematic capture, microcontroller

simulation, 3D verification and PCB (printed Circuit board. The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in areas such as motor control, temperature control, and user interface design. It also finds use in the general hobbyist community and, since no hardware is required, is convenient to use as a training or teaching tool. Support is available for co-simulation of the following controllers:

Microchip Technologies PIC10, PIC12, PIC16, PIC18, PIC24, dsPIC33 Microcontrollers.

Atmel AVR (and Arduino), 8051 and ARM Cortex-M3 Microcontrollers

NXP 8051, ARM7, ARM Cortex-M0 and ARM Cortex-M3 Microcontrollers.

Texas Instruments MSP430, PICCOLO DSP and ARM Cortex-M3 Microcontrollers.

Parallax Basic Stamp, Freescale HC11, 8086 Microcontrollers.

(b)-Matlab

Matlab was designed at the University of New Mexico by Cleve Moler in the late 1970s. It soon spread to other universities and found a strong audience within the applied mathematics community. Later, Jack Little, a Stanford University engineer, recognized its commercial potential and founded Mathworks in 1983. Matlab is a commercial numerical computing environment and programming language. It has a lot of advanced toolboxes and functions, and they are oriented to circuit analysis, signal processing, financial analysis, economics, business, statistics, and optimization .These functions are well documented and developed. However they are proprietary and you cannot see the code of most of the algorithms you are using. The proprietary nature also makes it difficult for third parties to extend the functionality of this language. Matlab is not an open source language and you have to buy a license. However it is easier for beginners, because the package includes all you need for Digital Signal processing (DSP) courses[1,3,6].

(c)-Python Language

For Embedding programming, Microprocessors, and Senior Project courses Python could be used. Python is a high-level object-oriented programming language. It is designed to be easy to program. Guido van Rossum started the design of Python in 1980. Over the years, Python has gained popularity in a broad range of fields from web development, games, scripting language, science, and engineering. Python is an open source software, and can thus be distributed freely, even for commercial use. This openness makes that Python plays well with the other languages and is easily

expandable. Python is a general purpose language, which means that many things are made easy. Examples are string processing, reading/writing files, sockets, websites, and databases. This is why it has been adopted by so many universities. The ease of use for general tasks makes Python very suitable for education. For science this is also an advantage, as scientist often need to load data, visualize it, and maybe control it via a user interface. For commercial applications this means that many things work out of the box, saving time and money. Many users recommend Python as the best beginner language because of its simplicity yet great capabilities. The code is easy to read and enforces good programming style In Python, you can spend most of your time focusing on problem decomposition and data type design. These are important components of programming in any language. Python's large standard library allows students to create functional programs almost immediately. Python's interactive interpreter allows you to test features while programming. Python's popularity is also rising quickly today because of its adoption on popular websites like Instagram.

(d)- C/C++ Language
For embedding programming and senior project courses C/C++ could be used. C language was developed in 1969 by AT&T, it is also considered a general-purpose programming language. Unlike Python, however, it is not a dynamic language easily adapted to script programming. C/C++ remains the most widely used programming language and it has seen much standardization and improvement throughout the years. Applications for Apple are written C/C++. The static nature of this programming language helps prevent unintended operations. The drawback is that as a new programmer, you may find it difficult to master quickly. It is still used extensively in operating system architecture. Systems including UNIX (and Linux derivatives) rely on C/C++ for many functions.

(e)-Multisim
For digital, and electronics courses such as DC, AC, and Devices, MultiSim software could be used. Simulators are software packages used to virtually test a circuit's operation to verify the design. Simulation is necessary to avoid costly mistakes in the design and fabrication of circuits. Typically, circuits do not work as designed. A period of troubleshooting is usually required to find and correct errors. If this is done with physical labor, hardware, time, and money are lost since changes require reworking of the circuit. A preferred method is to simulate the circuit using software to identify problems and then simulate the corrected circuit until most errors are fixed. No simulation is perfect, so testing of the final hardware is still necessary, but simulation can find

many of the errors.

(f)-LabVIEW

For digital courses LabVIEW [2] could be used. LabVIEW is an acronym name for Laboratory Virtual Instrumentation Engineering Workbench. It is a graphical developments system designed by National Instruments. It is used in many industries. It can be used for data acquisition, machine control, instrument, and a wide variety of other applications. The use of LabVIEW reduces development time for a design. LabVIEW provides engineers with the tools needed to create and deploy measurement and control systems. You can use LabVIEW to simulate the program and compare the outcomes to the expected results. Once the program simulates correctly, you can download the program to the hardware and test its functionality. LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitates physical instruments, such as oscilloscopes and Multi-meters. LabVIEW contains a comprehensive set of tools for acquiring, analyzing, displaying, and storing data, as well as tools to help troubleshoot codes. LabVIEW can be used with IO interfaces such as GPIB, PXI, VXI, RS-232, and RS-484. It also has built-in features for connecting your application to the web using a web server and software standards such as TCP/IP networking and ActiveX. You also can create stand-alone executables and shared libraries, such as DLLs. It is also designed to be extendible. You can add modules through various means. A manufacturer of an interface card or an instrument may provide you with a driver which appears as a VI representing the card and its functionality in the LabVIEW environment. You can also write a module and save it as VIs (Virtual Instruments) to be used in other programs. You can also write modules which interface with LabVIEW in other languages such as C and C++. These are known as "sub-VIs" and are no different from VIs except that the interface has been defined to the next level. Sub-VIs in C or C++ is very useful if you have a complex numerical procedure to perform on the data which is not covered in a standard LabVIEW routine. LabVIEW contains three palettes called tools, controls, and functions. To create, modify, and debug a VI, tools palette are used. The controls palette is used to place objects on the front panel. The palette consists of top-level icons representing sub-palettes. The functions palette is used to place objects on the block diagram. The palette consists of top-level icons representing sub- palettes. Functions are grouped in sub-palettes based on the type of function. Boolean controls provide True/False input into a VI. Numeric controls provide numeric data input into a VI. Numeric indicators provide a numeric output from a VI. Each time a control or indicator is placed on the front panel, a corresponding terminal is placed in the block diagram. Some controls can be changed to indicators. Also, some

indicators can be changed to controls.

(g)-Wireshark

For Data Communication courses Wireshark could be used. Wireshark is a network packet analyzer. A network packet analyzer will try to capture network packets and tries to display that packet data as detailed as possible. It is basically a tool for seeing the bits and bytes flowing through a network in human readable form. Without it, understanding a network communication exchange would be practically impossible. As you may know, network protocol is broken down into 7-layers. The part that WireShark deals with is layer 2 up to 7. Most well know protocols can be decoded by WireShark. The purposes of Wireshark are:

-Network administrators use it to troubleshoot network problems.

-Network security engineers use it to examine security problems.

-Developers use it to debug protocol implementations.

(h) -Logixpro

For control and mechatronics courses Logixpro, and PLC could be used. Logixpro is the ideal tool for learning the fundamentals of ladder logic programming.

(i)-VHDL

For digital courses FPGA, and VHDL could be used. VHDL is a programming language that allows an individual to define how a piece of hardware behaves. This language was developed first by US military and became IEEE standard in 1987. It was updated in 1993 and is known today as "IEEE standard 1076 1993". The complexity of ASIC and FPGA designs has caused an increase in the use of hardware description languages such as VHDL. As a result, students must learn the advance features of this language. Companies like Xilinx, Altera, and Cadence have designed proper hardware interface for the use of this language. Recently, most chip manufacturers start on VHDL (or Verilog) before the company goes to actual production of a design. There are two aspects to modeling hardware that any hardware description language facilitates: true abstract behavior and hardware structure. VHDL has three parts: Library, Entity, and Architecture [5].

(j)- **TIMS is a telecommunications modeling system.**

TIMS uses modules to represent sub systems of a communication system. Different modules can be interconnected to form a particular system or operation in a communication system.

TIMS modules are available in hardware as well as software. Tutor TIMS is the software equivalent of the hardware modules. While you set up a communication system using Tutor TIMS modules and perform an operation, actual operation on the hardware modules takes place somewhere in a remote location.
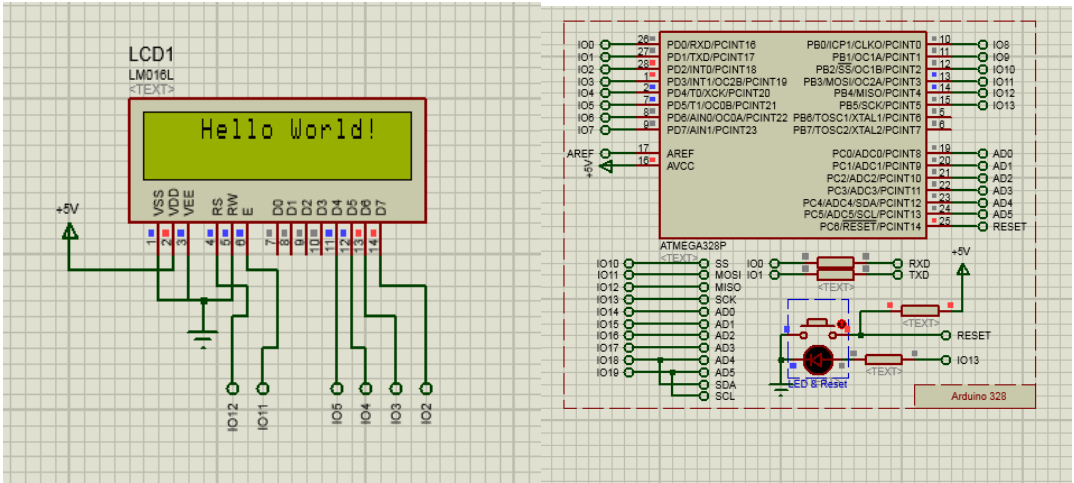
3- EXAMPLES OF ONLINE TEACHING OF COURSES

In this section, application of online tools for several courses will be explained. Student version of several of these software are available free for download. Specifically Multisim, Proteus are available for free download.

(a)-Microprocessor and peripherals

Proteus Design Suite, Python, C/C++, and LabVIEW could be used in the microprocessor and computer architecture courses. For example, LabVIEW has a module called Elemental IO. With the use of this module and a microcontroller, several concepts in the microprocessors course could be implemented. In one of the homework students asked to write a program in LabVIEW to implement Etch-a-Sketch on ARM processor.

Proteus Design Suite could be used for teaching peripherals such as LCD, Keypad, Interrupt, Timer, and ADC. In the following, students were asked to connect LCD to Arduino microcontroller in the microcontroller/peripheral course.

Figure 1. Example of Proteus in the Microprocessor course.

(b)-Electronics Courses

All lab experiments in the online teaching of electronics courses have three parts:

Theoretical Analysis:

Example: Calculate the Bipolar Junction Transistor (BJT) voltage-divider biased DC parameters.

MultiSim Simulation:

Example: Using MultiSim, Design a low pass filter circuit with a given cut-off frequency.

Breadboard Construction:

Example**:** Construct band-pass filter on a breadboard.

(c)-Online Senior Project Model

In online teaching of the senior projects course, the instructor defines a project for the entire class. This project has many sections and every student will contribute to at least one of the sections. Some students might contribute to several sections. The instructor or students can check other designs through a common Graphic User Interface. At the end of the term, based on a prepared job description for someone who will be hired by a company to do such a project, students will be interviewed by peers and the instructor. All students will participate in a mock interview. Every student is responsible for writing at least one chapter of the final document (book).

Example:

The following project might be one possible choice for the students with Electrical and Computer Engineering major:

Name of the project: Automation of the appliances in a house. This project controls appliances such as: Radio, TV, Garage door, Shower, Coffee maker, Microwave, Telephone, Refrigerator, etc.

Main Hardware: ZigBee or WiFi, IP gateway, Microcontroller.

Main Software: Graphic User Interface (GUI) was written using a high level language (JAVA, C++, C#, VBNET).

Every student will select one of the appliances for controlling. Through the internet, students can communicate with an IP gateway and then connect to their interface design for controlling an appliance. The entire class has access to main GUI and can select a particular device for control.

Action Items :

Each student will design his or her section and make it ready for the day of the interview. Along with the project, a student should write a job description for someone who represents a company that might hire someone to do such a project. All students should participate in a mock interview. As an interviewer when a student is not interviewed, he or she can ask questions on job description, about a company, and about the project. Students will be interviewed by peers and the

instructor. The class website should have capability to use different software for web conferencing similar to WebEX, Elluminate, or Adobe Connect for implementing this interview.

Grading of the senior projects:

Grading for each student in the engineering class is based on the following items:

Design

The instructor can check design and status of each section through a common GUI, which is linked to an IP gateway and the device. Grading for this portion is based on completeness, cost, efficiency, and timeliness

Job description

Assuming a company needs someone to do such a project, a student should write a job description that contains the following:

■Must be specific about the job description.

■Degree and major requirement.

■Is it Digital or Analog?

■Is it firmware? Driver? GUI?

■Description must be written for a good company.

Objective is to look for the best ▪people.

 Mock interview

At the time of interview students should consider the following:

■Job descriptions for someone who wants to do this project for a company.

■Student will be interviewed for those positions.

■Student has to justify why they should hire applicant.

■Student should demonstrate that applicant is well prepared.

■Student should demonstrate that applicant is a team player

■Student should demonstrate that applicant is professional.

Weekly message board activities

Writing one chapter of the final book

Format for the Final Book

There is only one final book for the entire class. Class jointly will come up with one outline. Each student assigned at least one chapter to write. One or two students should also be assigned for editing the book. Following are the key points:

■One final book for the entire class.

■Students jointly will come up with one outline.

■Each student assigned a chapter to write.

■Students should know the interface to the other sections.

■Students should read each other's document and ask questions.

(d)- Digital courses

Multisim, VHDL, FPGA, and LabVIEW could be used to enhance the teaching of digital courses. For example, LabVIEW is very helpful in explaining many important topics such as: Binary to decimal, decimal to binary, decoders, multiplexors, RS flip flop oscillations, and many other digital topics.

Figure 2 is an example by LabVIEW to demonstrate a decimal to binary convertor. Similar examples could be used for converting a number from other bases such as octal or hexadecimal.
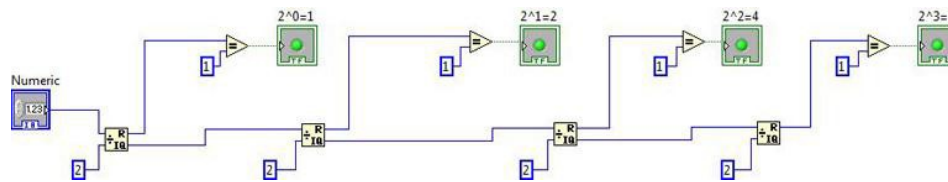
Figure 2. Example of LabVIEW in the Digital course.

(e)- Data Communications courses

LabVIEW, MatLab, and Wireshark could be used to enhance online teaching of communication courses. LabVIEW is very helpful in explaining many important topics such as: AM, FM, and PSK, and many other communication topics.

Example: Design AM modulation with LabVIEW. Use the following formula:

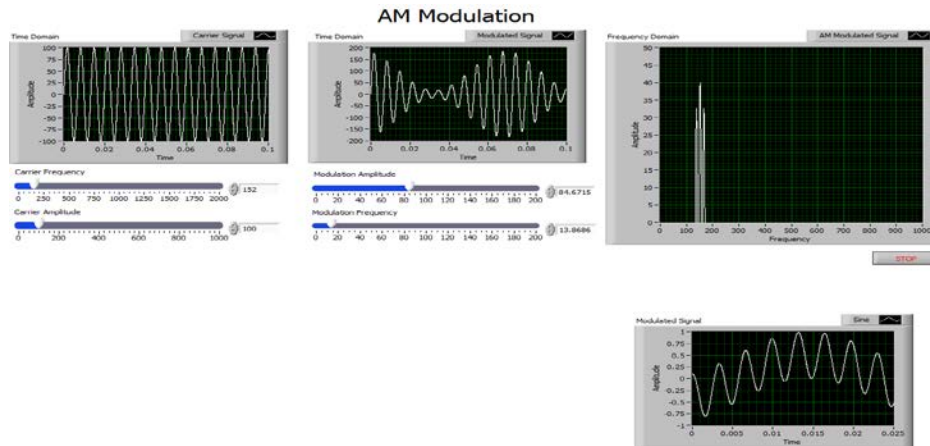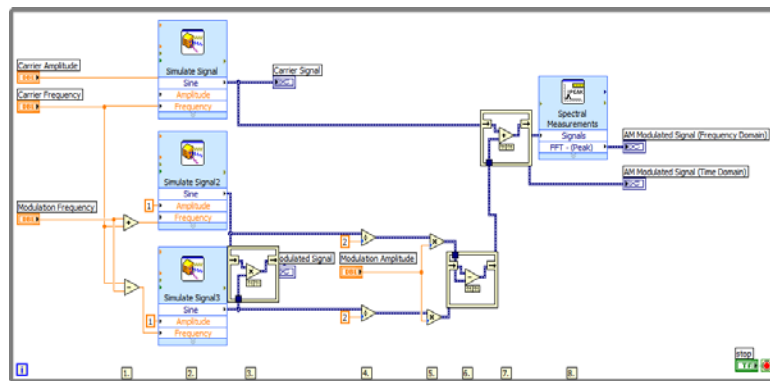Figures 3a and 3b are the Front and block diagram of this example.

Figure 3a. Example of LabVIEW in the Data Communication course.

$$y(t) = C\sin(\omega_c t) + M\frac{\cos(\phi - (\omega_m - \omega_c)t)}{2} - M\frac{\cos(\phi + (\omega_m + \omega_c)t)}{2}$$

Figure 3b. Example of LabVIEW in the Data Communication course.

Similar example could be used for teaching Shannon's Theorem and the channel capacity.

(f) Mechatronics

PLC and Logixpro software could be used to teach Ladder logic.

(g)- Digital Signal Processing courses

Matlab, and LabVIEW could be used in DSP courses. LabVIEW has a DSP Module and could be used to run DSP graphical codes directly on a DSP target board without performing any C programming. In the DSP course author asked the students to implement the following waveform generation and digital filtering on a microcontroller. Figure 4 is an example of LabVIEW in the Signal Processing course.
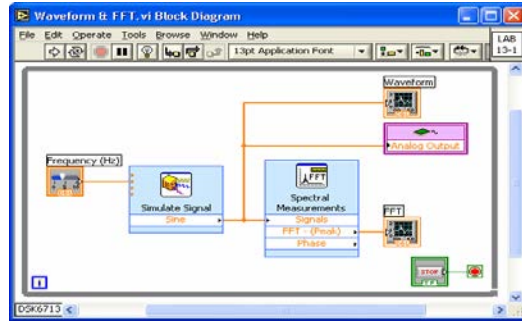
Figure 4. Example of LabVIEW in the Signal Processing course.

Similar example could be used by Matlab for drawing Bode Diagram for Low pass filter.
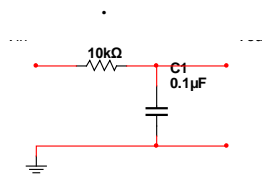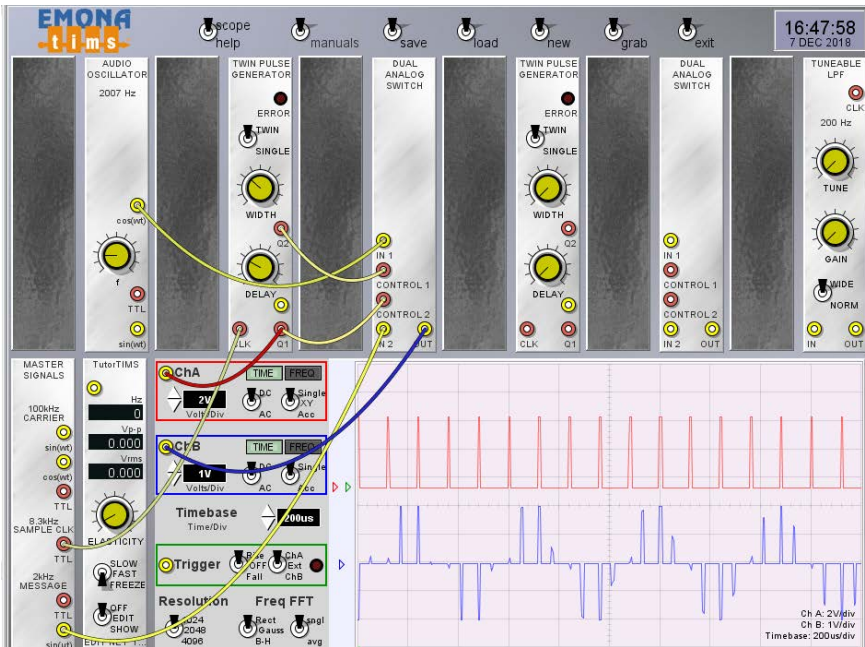

Figure 5. Example of Matlab in the Control course.

$$\frac{1}{RCs+1} * \frac{\frac{1}{RC}}{\frac{1}{RC}} = \frac{\frac{1}{RC}}{s+\frac{1}{RC}} = \frac{\frac{1}{10k\Omega * 0.1\mu F}}{s+\frac{1}{10k\Omega * 0.1\mu F}} = \boxed{\frac{1000}{s+1000}}$$

The following four lines of code can be used to find the Bode plot:

```
num = [1000];
den = [1, 1000];
TF = tf(num,den)
bode(TF)
1000
--------
s + 1000
```

(h) – For analog communication Tutor TIMS software could be used. The following is an example of one of the experiments in my communication course.

Figure 6. Example of TIMS in the Data Communication course.

4- SUMMARY

This paper discussed software tools for online teaching for Electrical and Computer Engineering courses. Students can find some of the mentioned software online for free. These include Multisim, VHDL, and Proteus. Online learning has become an increasingly common choice for many students pursuing a higher education. It requires the student to participate and learn virtually via computer, as opposed to the traditional classroom environment. It is important for prospective students to determine whether they will thrive in this type of environment. Most ECE courses that utilize lab experiments are more challenging to teach. There are different approaches to replacing physical interaction in ECE courses. This paper considered software tools for online teaching of ECE courses.

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