

# Electro-Mechanical Control Systems Simulator (ECSS) With Multi-Language Support

HASAN ERDAL      VEPA HALLIYEV

Department of Electronics and Computer Education  
Faculty of Technical Education, Marmara University  
Goztepe Campus Kadikoy, Istanbul  
TURKEY

herdal@marmara.edu.tr      vepa\_hall@yahoo.com

*Abstract:* This paper describes a simulator for the electro-mechanical control systems. Electro-mechanical control systems mainly consist of contactors, time relays, electrical motors, switches, buttons and etc. Single or three phase power system that has high voltage and current is generally used in this kind of systems. Engineering students or technicians who are studying electro-mechanical control systems are always faced with a high voltage and current. For this reason a simulator is developed to establish a safety study environment. In this environment, students easily implement their designs or assignments to get familiar with the real industrial applications in the laboratory.

*Key-Words:* Electro-mechanical systems, Electrical motor control, Electrical control techniques simulator, Educational tool, Educational simulators.

## 1 Introduction

Education is a dynamical and complex area. Research in education increases year by year. This increase is an important factor in the development of new educational techniques such as using simulators and computers [1,2]. Simulators are the educational tools that make the experimental or applied studies easier and more fascinating [3-5]. They make possible systems to be tested and run in safety without using real system or elements [6,7]. The student can plan different experiments and obtain results quickly. Thus, it is possible to discuss and contrast the results with the ones obtained theoretically [8]. Studies or designs of a system based on a simulator allow students an in-depth understanding of the device and circuit operation, and link between theory and application [9]. There are a few commercial software packages including electro-mechanical systems such as FluidSim [10], and automation studio [11]. These software packages cover hydraulic, pneumatic, electrical, PLC and control technologies together. They have much more complicated structure for Electro-mechanical Control Systems (ECS). Learning of their usage is time consuming and they also might be costly for many students and instructors. Students should be able to learn the applications of the electromechanical systems without difficulty [12]. Electro-mechanical Control Systems Simulator (ECSS) is the first simulator written in Turkish and dedicated for electro-mechanical

systems [13]. The simulator has also user definable multi-language support feature. The students (or users) can easily convert the environment language to their own languages. The ECSS environment has presently four different languages: Turkish, English, Bulgarian and Persian. Bulgarian and Persian languages are added by users in 13.02.2006 (thanks to N.Delchev) and in 13.11.2007 (thanks to Hamid Reza) respectively. Also, the ECSS can be downloaded from the web address without charge [14, 15]. One of the other major differences between ECSS and the other similar simulators is that three electro-mechanical systems, two different gate systems and a basic elevator system are in the library of ECSS.

In this study, an educational simulator, ECSS, to teach ECSC has been presented for cost effective education and training. It helps students to easily design and testing the solution circuit for a given problem and it has a flexible structure and user-friendly interface.

## 2 The Content and Training Steps of the Typical ECS Course

The ECS course normally consists of theoretical and practical parts. The content of practical parts of the ECS course mainly covers the subjects [16-19]:

- General Principles of Electrical Motor Control
- Control Pilot Devices
  - Push buttons and Control situations
  - Contactors and Relays

- Timing relays
- Limit switches
- Control Circuits
  - Starting and Stopping of the Single and Three Phase Induction Motors
  - Push-Button Interlock of Induction Motors
  - Auxiliary Contact Interlock of Induction Motors
  - Star-Delta Starting of Three Phase Induction Motors
  - Dynamic Braking of AC and DC Motors
  - Multi-Speed Three Phase AC Motor Control
  - Automatic Sequence Control
- Jogging Control Circuits
- Control Circuits for Different Industrial Processes or Given Control Problems (Such as sliding gate control, mixing process etc.)

After giving a brief practical knowledge, a problem is given to the students. The students design and draw the solution circuit scheme of the given problem on a paper. After checking the circuit scheme by instructor, let the students to set the control circuit on the trainer board. The training steps of practical part of ECS course are generally conducted as seen in Figure1.

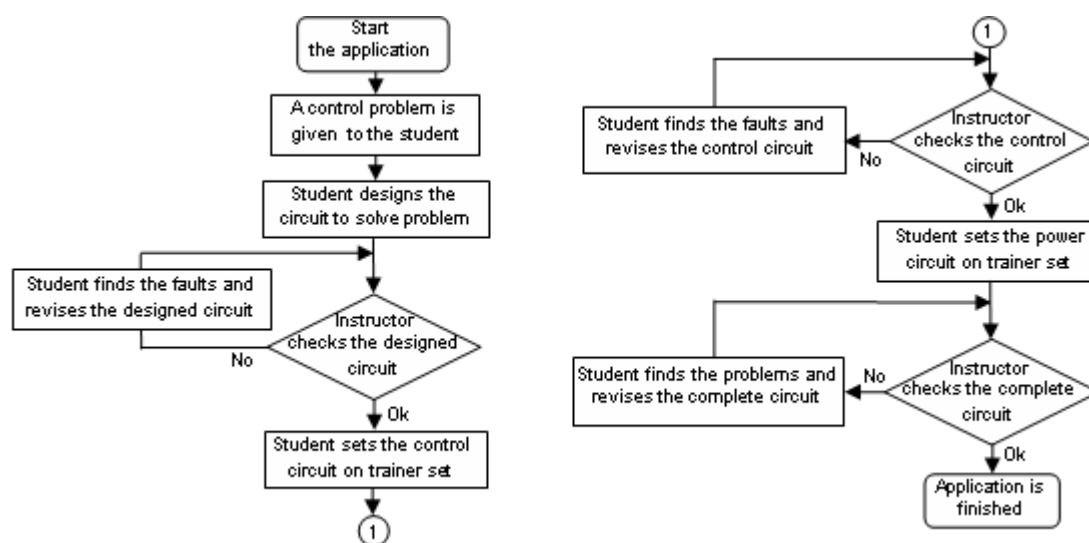


Fig.1 The training steps of practical part of the ECS course

As seen on Fig.1, the training steps of the applications of the ECS course require pretty long time. For this reasons in the laboratory hours one or two applications can be done. If the students can be able to set and to test their applications circuits before coming to laboratory, they can be done much more applications at the same time. As mentioned above, the applications circuits of ECS course include real industrial components such as contactors, time relays, buttons, and electrical motors, the students can not to set and to test their circuits. By using the ECSS, the students can be able to set and to test their circuits before coming to laboratory. This is the one of the major advantages of the ECTS.

Application circuits of the ECS course comprise two main parts: the control circuit and the power circuit. The control circuit includes the components such as contactors, time relays, buttons etc. It is the

logical part of the solution circuit and generally constituted in ladder diagram format. The operation sequence of application is implemented according to this part. The power circuit consists of electrical motors or systems such as sliding gate, mixing system, elevator system and etc [20-22].

The instructor supervises the whole activity for safety throughout the practice hour. As it is stated in the training steps, the power and control circuits are not set at the same time. One of the most important reasons is the power circuit that uses single/three phase high voltage. The other reason is, if the circuit doesn't operate as desired, the difficulty of finding the malfunction in the whole circuit. Because, setting of the two circuits at the same time causes a complex wiring structure.

### 3 The ECSS and Its Operational Procedure

The simulator, ECSS is developed in the environment of Microsoft C#.NET and is basically divided into three main sections, the “Work Sheet”, the “Tool Bar” and the “Library”. The electrical control and power circuits are designed in the Work Sheet by means of ladder diagram programming format. All the components, the systems, the power sources and the motors are within the Library. The icons of basic operations of files for opening,

saving, running, printing, etc. are located in the Tool Bar. The simulator has been designed to reinforce the training and enable participants of the course to quickly design and test new circuit before physical realization of the application. It will also increase self-confidence of the students and strengthen the interest to the course will consciously and willingly participate in laboratory and industrial studies. The start up window, the work environment and library window of the ECSS is shown in Fig. 2.

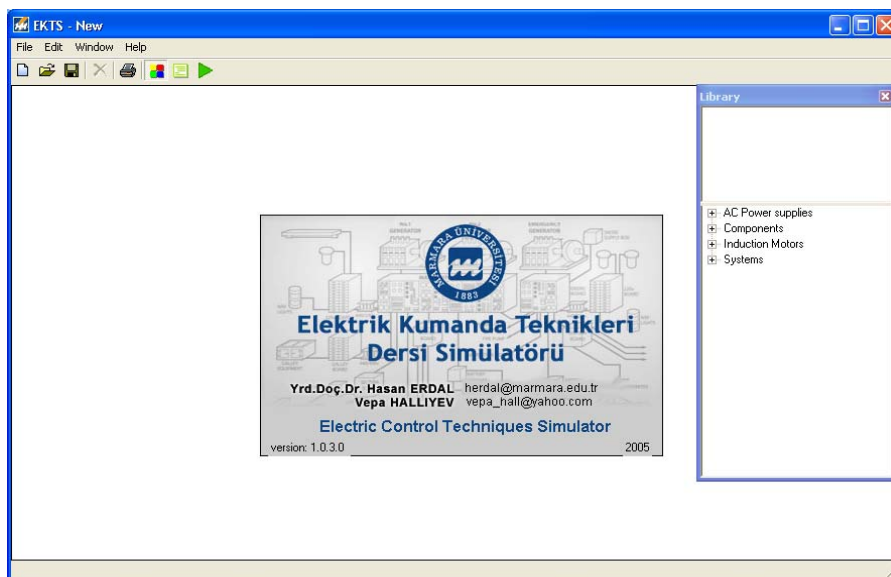


Fig. 2 The start up window, the work environment window of the ECSS

All of the components are in the library section. This section has four main parts as seen on Fig. 3.

- AC Power supplies
- Components
- Induction motors
- Systems

There are single and three phase ac supplies in the AC Power supplies menu. Contactor, time-relays, switches, buttons, open and closed contacts etc. are located in the Components menu. Single and three phase squirrel cage induction motors are under the Induction motors menu. Finally, a five-floor elevator and two kind of gate systems are in the Systems menu.

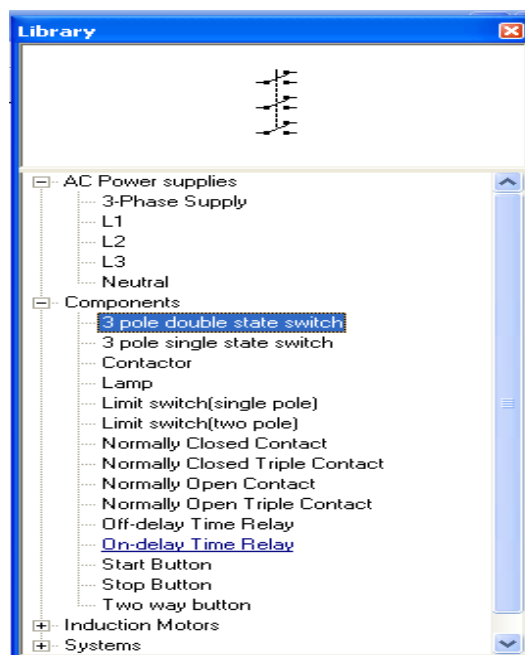


Fig. 3 The library section of the ECSS

The ECSS has also help menu as seen on Fig.4. Users can easily learn all information about the

simulator such as how to design a circuit on the simulator or how to use it and etc.

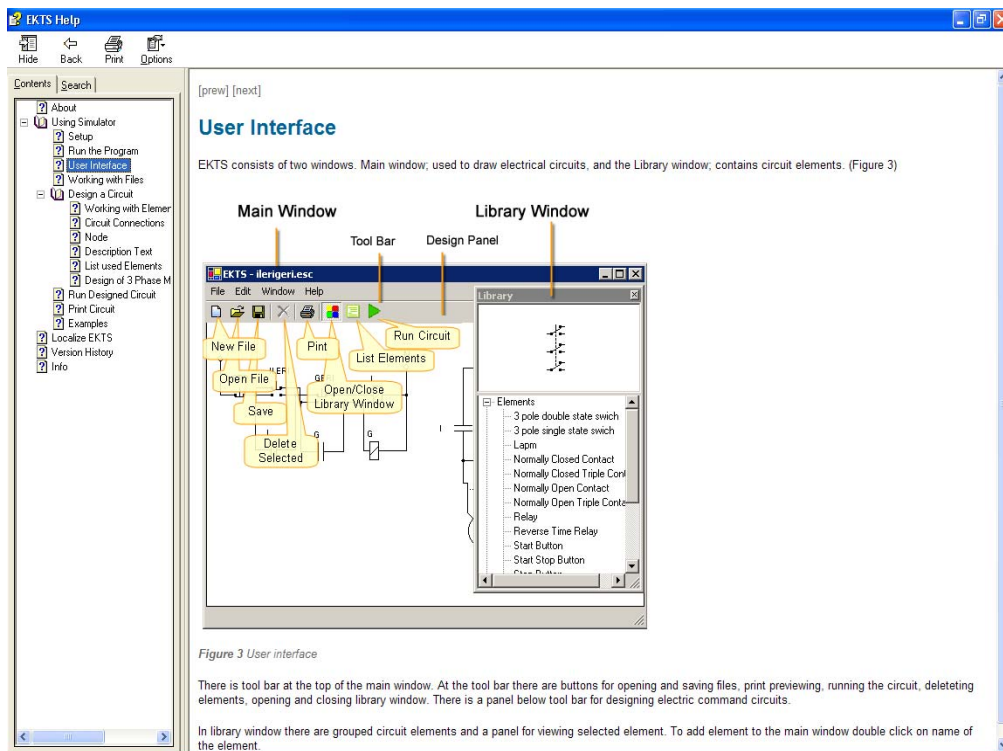


Fig. 4 The help menu

The basic control circuits of the induction motors can be drawn and simulate easily in ECSS. As an

example, Star-Delta starting of a three-phase induction motor circuit is shown in Fig. 5.

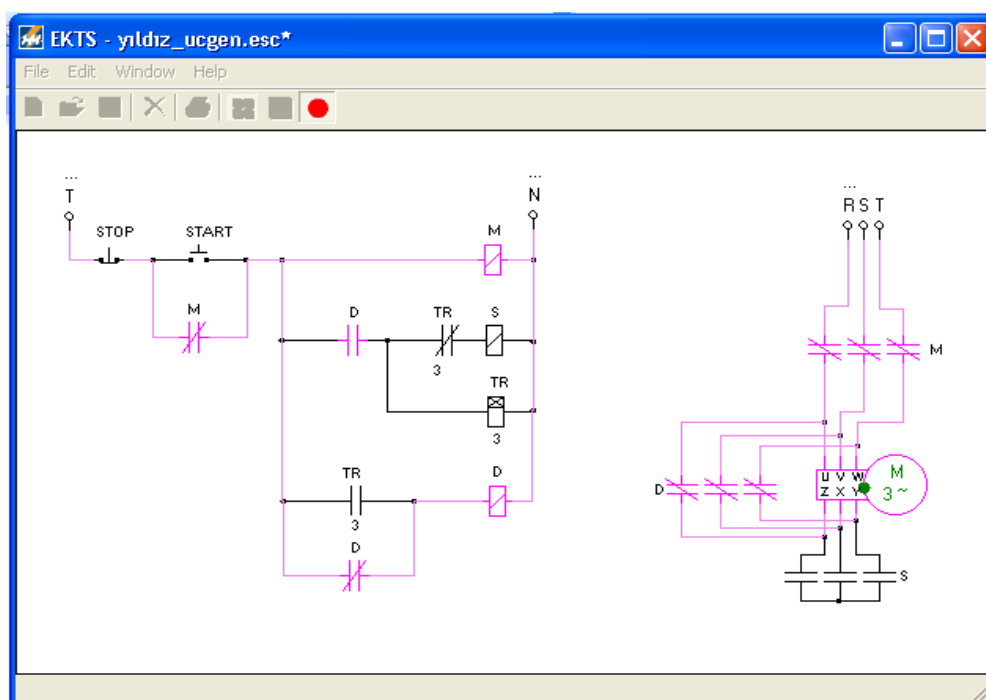


Fig. 5 Star-Delta starting of a three-phase induction motor in ECSS.

As seen in Fig. 5., colors of the energized components and lines are magenta. Also, there is a green circle on the motor symbol, which shows rotation and direction of the rotor when the motor is energized. Therefore, the user can easily comprehend and follow the circuit. The star-delta starting application is implemented in the lab

environment as shown in Fig.6. There are complex cable connections as shown in Fig.6. It takes too long time to set up this kind of circuit. On the other hand, after set up the experiment circuit, if it does not work, it is not easy to find where the faults or wrong connections are.

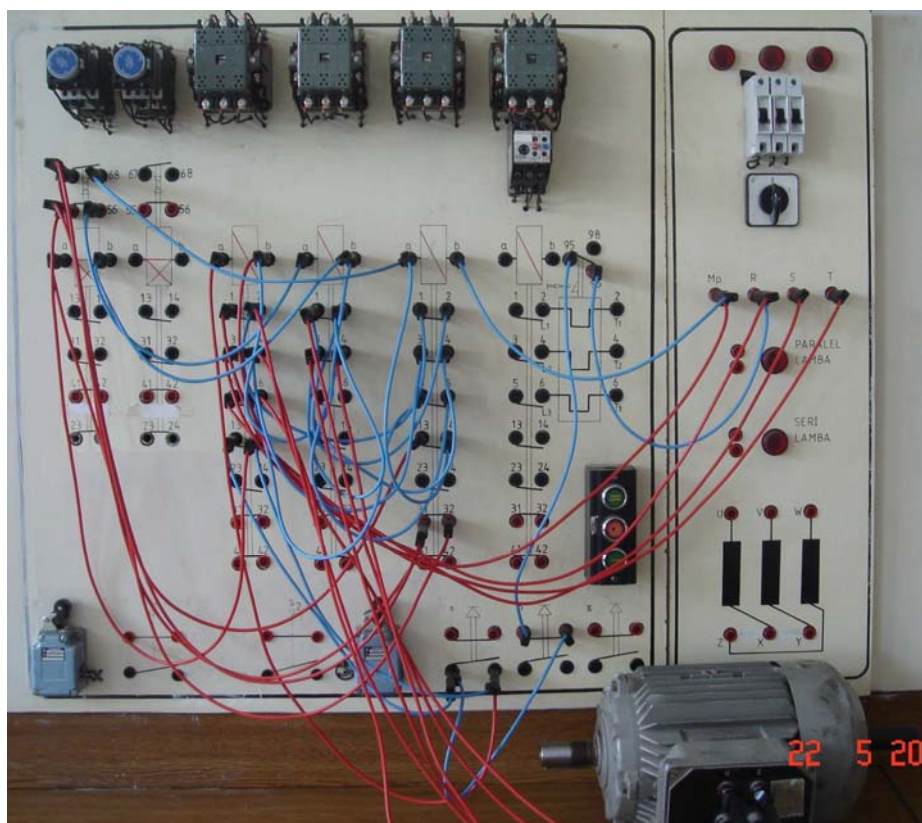


Fig. 6 Star-Delta starting of a three-phase induction motor in Laboratory experiment set.

In the ECSS, when a malfunction occurs during the run mode, such as wrong connections or short circuit, it is indicated on the error window. The scheme in Fig. 7 is belong to a single phase capacitor start induction motor control circuit. There is a wrong connection on motor circuit. This is a capacitor start single phase induction motor so

the auxiliary winding's energy must be cut-off after starting. This error is indicating on a small window and red-yellow flashing. This is a very important specialty for educational purpose. If there are some mistakes or wrong connections it can be seen easily and corrected by students or instructors.

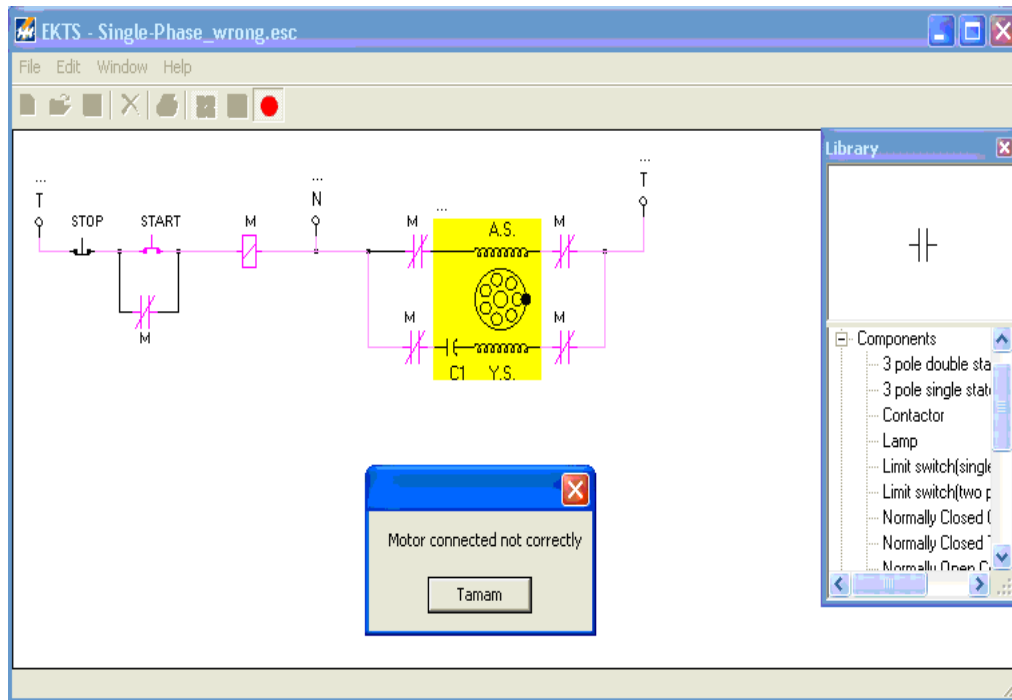


Fig. 7 Fault indicating window.

Otherwise ECSS can be used to design for more complicated control circuit such as in Fig.8. The control and power circuit a barrier type gate system can be designed by ECSS as shown in Fig.8.

Although this is a much complicated circuit, but students can understand and test it easily and in a very short time by using ECSS.

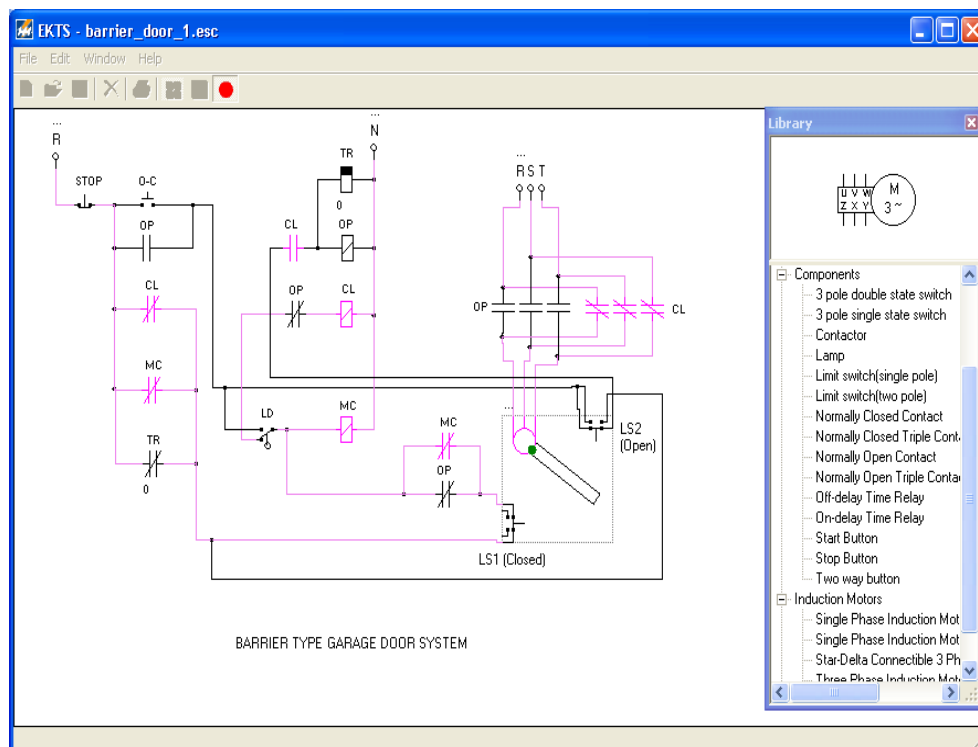


Fig. 8. A barrier-gate system that is designed in ECSS

In practice this kind of circuits mostly includes high voltage and in carelessness the electrical shock can be occurred. By using ECSS there is not any risk for electrical shock or other dangerous situations. Also when you want to make some modifications on designed circuit, it is very difficult and takes a long time in practice, but it is

too easy and takes a few second in ECSS. The other very useful and one of the essential specifications of the ECSS is the users can get the list of used components on the designed circuit. For example, the used components list of the circuit (in Fig. 8), is seen in Fig. 9.

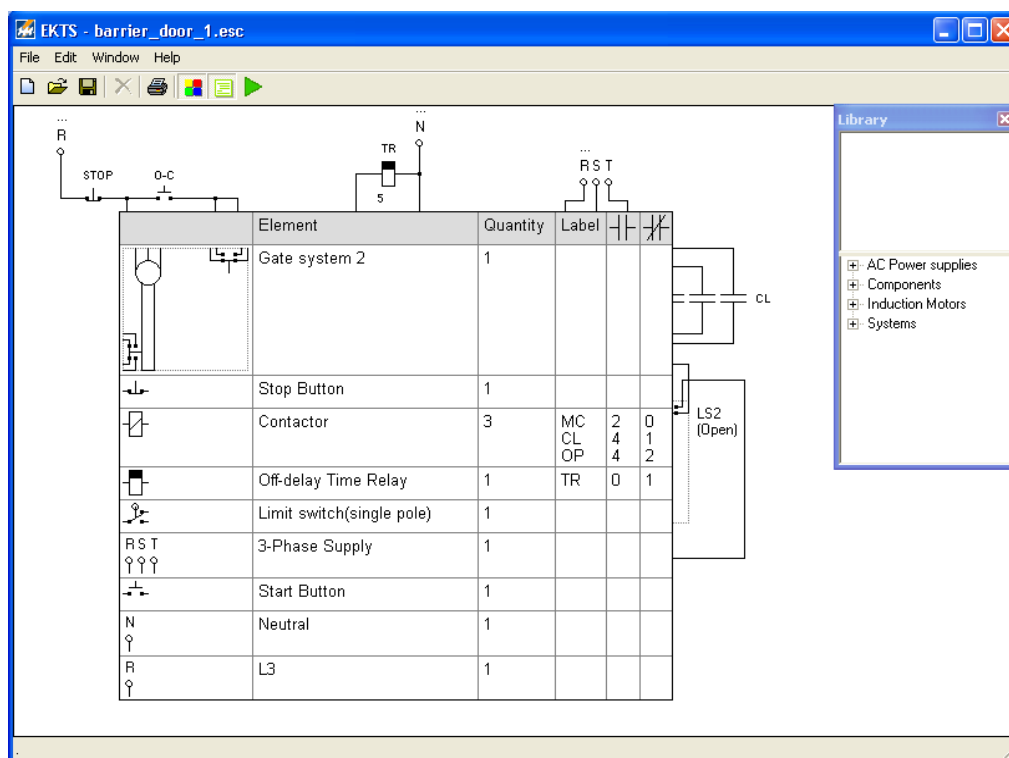
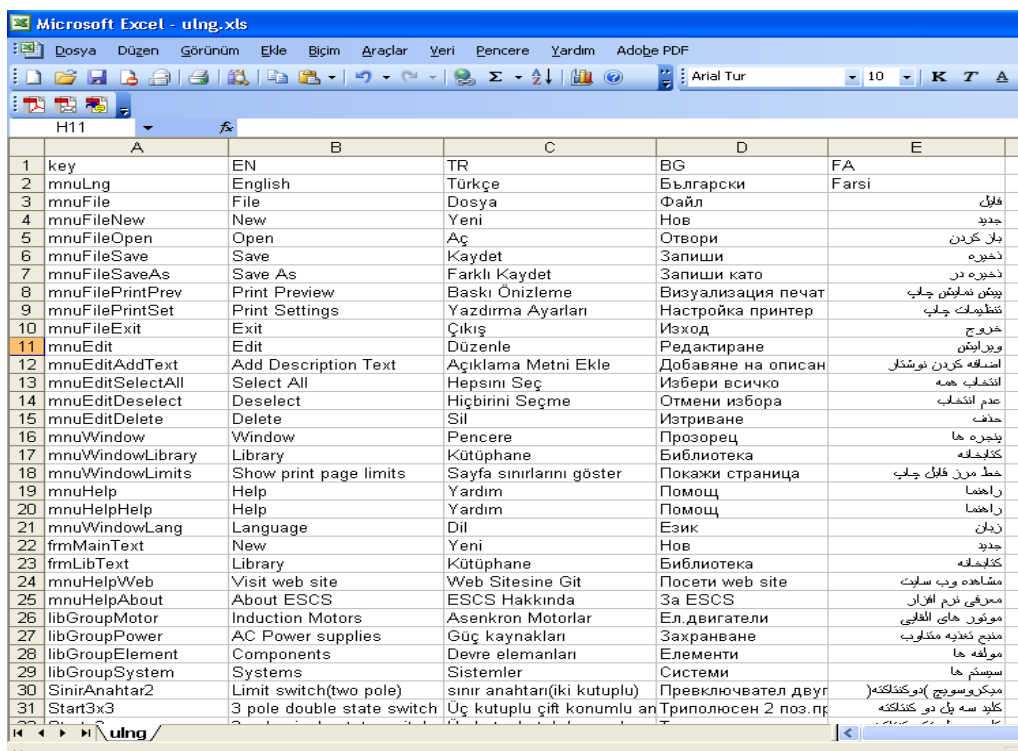


Fig. 9 The used components list of the circuit in Fig. 8.

As mentioned above, other important feature of the ECSS is user definable multi-language support. The users can easily change the menu and library texts

to their own language. The operations changing language can be easily realized by using excel file as shown in Fig.10.



	A	B	C	D	E
1	key	EN	TR	BG	FA
2	mnuLng	English	Türkçe	Български	Farsi
3	mnuFile	File	Dosya	Файл	فایل
4	mnuFileNew	New	Yeni	Нов	جدید
5	mnuFileOpen	Open	Aç	Отвори	باز کردن
6	mnuFileSave	Save	Kaydet	Запиши	ذخیره
7	mnuFileSaveAs	Save As	Farklı Kaydet	Запиши като	ذخیره در
8	mnuFilePrintPrev	Print Preview	Baskı Önizleme	Визуализация печат	پیش نمایش چاپ
9	mnuFilePrintSet	Print Settings	Yazdırma Ayarları	Настройка принтер	تنظیمات چاپ
10	mnuFileExit	Exit	Çıkış	Изход	خروج
11	mnuEdit	Edit	Düzenle	Редактиране	ویرایش
12	mnuEditAddText	Add Description Text	Açıklama Metni Ekle	Добавяне на описан	اضافه کردن نوشتار
13	mnuEditSelectAll	Select All	Hepsini Seç	Избери всичко	انتخاب همه
14	mnuEditDeselect	Deselect	Hiçbirini Seçme	Отмени избора	عدم انتخاب
15	mnuEditDelete	Delete	Sil	Изтриване	حذف
16	mnuWindow	Window	Pencere	Прозорец	پنجره ها
17	mnuWindowLibrary	Library	Kütüphane	Библиотека	کتابخانه
18	mnuWindowLimits	Show print page limits	Sayfa sınırlarını göster	Покажи страница	خط مرز فایل چاپ
19	mnuHelp	Help	Yardım	Помощ	راهنما
20	mnuHelpHelp	Help	Yardım	Помощ	راهنما
21	mnuWindowLang	Language	Dil	Език	زبان
22	frmMainText	New	Yeni	Нов	جدید
23	frmLibText	Library	Kütüphane	Библиотека	کتابخانه
24	mnuHelpWeb	Visit web site	Web Sitesine Git	Посети web site	مشاهده وب سایت
25	mnuHelpAbout	About ESCS	ESCS Hakkında	За ESCS	معرفی نرم افزار
26	libGroupMotor	Induction Motors	Asenkron Motorlar	Ел двигатели	موتور های القایی
27	libGroupPower	AC Power supplies	Güç kaynakları	Захранване	منبع تغذیه متناوب
28	libGroupElement	Components	Devre elemanları	Елементи	مولفه ها
29	libGroupSystem	Systems	Sistemler	Системи	سیستم ها
30	SinirAnahtar2	Limit switch(two pole)	sinir anahtarı(iki kutuplu)	Превключвател дву	میکروسویچ (دو کنتاکته)
31	Start3x3	3 pole double state switch	Üç kutuplu çift konumlu an	Триполюсен 2 поз.п	کلید سه پل دو کنتاکته

Fig. 10. Changing language by using excel file

### 3.1 The Evaluation of the ECSS

The ECSS is designed within a master thesis [10] and released on web [11, 12] freely to students and other users such as teachers, lecturers, instructors, teaching assistants, technicians and etc. During the two last years it is downloaded around 4000 times. The first impressions coming from the students, instructors, teachers and the technicians have shown that the ECSS was appreciated in a high rate. In their opinions the good features of ECSS are;

- Free of charge,
- Multi language interface and convertibility to own language,
- Easy usage,
- Help menu,
- Not complicated structure,
- Fault indicating,
- Rich library, gate and elevator systems,
- Can get the list of the used components of the circuit,
- Not require big size memory and specific technical features (for PC),

At the same time the users denote some failures of ECSS and express their expectations as follows;

- No copy-paste, zoom and catching feature,
- Printing feature is not much functional,

- It will be very nice if some other systems can be added such as mixing, heating or cooling
- Circuits can be drawn only ladder diagram format, other draw formats should be added.
- The other components such as thermostat, phase fault relay, proximity switches and etc. should be added.
- DC motors and other type of induction motors and electrical systems should be added.

Although the ECSS has some failures, the feedback from the students and users is very positive. Our studies continue to eliminate the failures and to improve the features of ECTS. The first year after the development of the ECTS, the half of the students of Computer-Control Education Program used the ECTS and the others did not. The scores of the laboratory assignments of the students who used ECTS were higher than others. The students, they use ECTS, were very successful especially to solve and designed complicated circuits.

## 4 Conclusions

In this study, a simulator as an educational tool to teach electro-mechanical control systems has been presented for cost effective education and training. The simulator helps the students improve their



learning and easily design and test the applications circuits of the ECS course. Through fault indicating feature, students can observe their mistake or wrong connections easily. ECSS has Multilanguage interface and every users can convert interface language to own language easily. Since single/three-phase power system is generally used in the applications of ECS course, students are always faced with a high voltage and current. By using ECSS students can design and test their circuit on a safety atmosphere without dangerous situations. Therewithal, after some improvements on ECSS it is planning to use this simulator for e-learning and remote access laboratory applications.

#### References:

- [1] C. E. Iglesias, A.G. Carbajo and M.A.S. Rosa, Interactive tools for Discrete Mathematics e-learning, WSEAS Transactions on Advances in Engineering Educations, Issue 2, Volume 5, February 2008.
- [2] S. Enache, A. Campeanu, M.A. Enache and S. Ivanov, E-learning Tools for Education in Asynchronous Machines, WSEAS Transactions on Advances in Engineering Education Issue 11, Volume 4, November 2007.
- [3] Ç. Elmas and M.A. Akcayol, PC based educational tool for a switched reluctance drive with fuzzy logic, International Journal of Electrical Engineering Education, Vol.40(4), 208-219 (2003).
- [4] A.A.B. Pritsker, Introduction to Simulation and SLAM II , John Wiley&Sons, New York (1995).
- [5] M. Gokbulut and A.Tekin, An Educational Tool for Neural Network Control of Brushless DC Motors, International Journal Of Engineering Education, Vol 22; Numb: 1, 197-204 (2006).
- [6] Ç. Elmas and M.A. Akcayol, Virtual electrical machinery laboratory: A fuzzy logic controller for induction motor drive, International Journal of Engineering Education, Vol.20, Issue 1, 226-233, 2004.
- [7] M.A. Akcayol, Ç. Elmas, O.A. Erdem and M. Kurt, An educational tool for fuzzy logic controller and classical controllers, Computer Applications in Engineering Education, Vol.12, Issue 2, 126-135, 2004.
- [8] J.A. Mendez, C. Lorenzo, L. Acosta, S. Torres and E. Gonzalez, A Web-Based Tool for Control Engineering Teaching, Computer Applications in Engineering Education, Volume 14, Issue 3 , 178-187, 2006.
- [9] E. Niculescu, D.M. Purcaru and M.C. Niculescu, Using Circuit Simulators to Sensitivity-Factor Analysis in Analog Circuits, WSEAS Transactions on Advances in Engineering Education, Issue 3, Volume 5, March 2008
- [10] <http://www.festo-didactic.com/int-en/learning-systems/software-e-learning/fluidsim/>
- [11] <http://www.automationstudio.com>
- [12] M.A. Akcayol, A. Çetin and Ç. Elmas, An educational tool for fuzzy logic controlled BDCM, IEEE Transactions on Education, Vol.45, Issue 1, 33-42, 2002.
- [13] V. Halliyev, Design of A Simulator for Usage in Electrical Control Techniques Course Applications, Master Thesis, Marmara University Institute for Graduate Studies in Pure and Applied Sciences, 2005.
- [14] <http://www.veppa.com/ekts/>
- [15] <http://mimoza.marmara.edu.tr/~herdal/>
- [16] <http://www.tef.gazi.edu.tr/elektrik/icerikler.htm>
- [17] <http://web.firat.edu.tr/elkegitimi/dersicerik>
- [18] <http://www.tef.marmara.edu.tr/elobil/icerik>
- [19] <http://tef.kou.edu.tr/elektrik>
- [20] W. N. Alerich, Electric Motor Control, Delmar Publishers Inc., New York, 1988.
- [21] C. S. Siskind, Electrical Control Systems in Industry, Mc Graw-Hill Publishers, Columbus, 1983.
- [22] J.T. Humpries, and L.P. Sheets, Industrial Electronics, Delmar Publishers Inc., New York, 1993.

respectively. He has been Assistant Professor in the Electronics and Computer Education Department, Control Main Field since March 1999. His research interests focus on control education, automatic control applications, control algorithms and intelligent control.

**Vepa Halliyev** was born in Turkmenistan, in 1980. He received B.Sc. degrees from the Marmara University Technical Education

**Hasan Erdal** was born in Samsun, Turkey, in 1963. He received B.Sc. degrees from the Marmara University Technical Education Faculty, Department of Electrical Education, Istanbul, and the M.Sc. and the Ph.D. degrees in Electrical Education from the Marmara University, Institute for Graduate Studies in Pure and Applied Sciences, in 1990 and 1998

Faculty, Department of Electronics-Computer Education, Istanbul, and the M.Sc. degrees from the Marmara University, Institute for

Graduate Studies in Pure and Applied Sciences, in 2005. He is still working as a freelancer in London.