A NEW UNDERGRADUATE ELECTRICAL POWER AND CONTROL ENGINEERING CURRICULUM

Asser Zaky, Ibrahim El-Mohr and Mohamed El-Faham
Arab Academy for Science and Technology
Alexandria, Egypt

Abstract

Because of the increasing complexity and advancements in all areas of the electrical power industry (generation, transmission, distribution, control, protection, reliability, economics, etc), there is a growing need for graduates to be specialists in the power field. To meet such needs the Arab Academy for Science and Technology (AAST) has developed a new department of Electrical and Control Engineering which combines electric power systems, electric drives and automatic control in one undergraduate B.Eng. degree program. This paper gives details of the AAST program, implemented in 1994, designed principally to meet the present day needs of industry and electrical utilities in developing and rapidly industrializing countries. In drawing up the curriculum the proposals of the IEEE Subcommittee on Power Engineering Curricula have been used as a guide and the degree plan is structured to meet requirements of the Supreme Council for Universities of Egypt and the ABET requirements.

I. Introduction

In the highly developed countries the past two decades has seen a decline in the power engineering content of EE curricula in favor of more financially viable topics such as electronics, communications, computing and software engineering. For reasons of prestige and world-wide recognition, developing countries have tended to follow suit without any regard for local requirements or the fact that, as pointed out by Bijker[1], technology does not always just equate to "global" and "identical" but relates to "regional" and "individual" requirements. In stressing the importance of electrical power engineering it is perhaps appropriate to quote what Philip Sporn , one of the great power engineers of this century – had to say about electrical power: " In the United-States a new industrial revolution evolved …. The development of electric power and its general availability thought the U.S has been an important factor in this revolution… As a direct consequence of this new industrial revolution, we have a standard of welfare unequaled in history"[2].

There is much evidence that in the Arab world and other developing countries in general there is a growing demand for electrical power and control engineers. Generation of electricity, its transmission and its distribution are of primary concern to all developing and rapidly industrializing countries. Since it is estimated that some 80% of generated power is used to drive motors, machines, electrical drives and power electronics form a very important part of electrical power engineering. With electrification projects forging ahead and peak demand forecast doubling every ten years, there is a pressing need for expert generation, transmission and distribution engineers. Also under study by Arab and African countries are projects for the formation of supergrids linking all nations from Iraq in the east to Morocco in the west and from North Africa across the continent to South Africa with eventual interconnection with Europe. The scope of electrical power engineering is thus very wide indeed and power engineers are required to be knowledgeable in both conventional and front-line topics. The nature of the jobs undertaken falls mainly in the areas of maintenance and servicing of existing electric power generation, transmission and distribution systems, design of new such systems, design of electrical drives and their control systems, design and installation of electrical distribution in industrial plants, power system control and automation, application of programmable logic controllers (PLCs), management and marketing.

II. Choice of curriculum

In drawing up a degree plan for a specific engineering discipline a number of issues have to be taken into consideration. Since the technological development of industry varies widely among countries, the objectives of the engineering educational system in developing countries are different from those of highly developed ones so that each country must decide for itself the type and nature of the engineering education which is best suited to its present phase of technological development. The Accreditation Board for Engineering and Technology (ABET) recognizes this fact [3]. Thus the first and foremost consideration is that the degree plan must be tailored to satisfy the requirements of local industry, national interests and the needs of the community at large. In order to achieve these goals educators have to make a number of crucial decisions the most important of which are the following:

i) Specialization or generalization? If specialization then at which semester level should it start.
ii) Which new topics should be included and which topics should be excluded?
iii) What should the depth and breadth of coverage be?

In addition to internal constraints, consideration must be given to the rapid development of technology and society and the role of engineers within it. Today there is a universal consensus that what engineers need most of all are:
i) interdisciplinary skills (management, economics, sociology, etc,…)
ii) written and oral communication skills.
In addition to the above considerations the degree plan must meet the requirements of the Supreme Council of Universities (in Egypt) as well as those of the Accreditation Board for Engineering and Technology (ABET)[3] . Also since students at the AAST come from the Arab world and Africa the demographics of the student body which will pursue the program of study have to be taken into consideration. In the drawing up of the degree plan presented here the IEEE Power Engineering Education Committees recommendations were used as a guide[4-6]. Throughout the Arab world the duration of study for engineering degrees is 5 years. The number of credit hours required for graduation may vary from one country to another but in Egypt the requirements (set by the SCU) is 180 credit hours. This means 18 credit hours per semester. The finalized degree plan (approved by SCU) and implemented in 1994 is

shown in Table I. Table II shows a comparison of the degree plan to the requirements of the ABET.

III. Objectives

The degree plan presented here has been prepared to meet the following objectives:

- To impart to students the type of technical and engineering knowledge which reflects the immediate technological needs and practical skills required to produce power and control engineers who are capable of making a positive contribution to their countries and their communities as soon as possible after graduation. This is particularly important in developing countries in order to satisfy the pressing need of the national industries (both governmental and private) and National Electricity Boards in both Arab and African countries for such engineers in the area of power system planning and operation, power generation, transmission, distribution, utilization and automatic control.

- To incorporate in the curricula the latest front-line topics such as reliability, neural networks, digital protection, digital control etc., together with the more classical topics. This will enable graduates to assimilate the rapid technological advancements incorporated in modern equipment as well as the advanced analytical techniques used for design and performance analysis.

-To satisfy the requirements of the Higher Council for Universities and the ABET.

- To provide a good foundation in applied mathematics.. The mathematics courses incorporated in the degree plan have been specially tailored to give the student the necessary mathematical tools which are a prerequisite for all courses in his field of specialization.

The computer has become such an important and ubiquitous learning tool that the use of computers and computer packages has become an essential and inseparable part of any engineering course. All courses therefore have a “built-in” computer component. Computer programs not only aid students in obtaining numerical results but allow them to focus on the significance of these results and examine how parameter changes can affect problem solutions.

The inclusion of humanities courses in engineering curricula has been strongly advocated by many eminent educationalists as well as by ABET. Such courses relieve the dryness and rather materialistic aspect of technology courses and enlighten the student on the effects which technology and industrialization have on the moral, aesthetic and social values, as well as on the environment. A recent survey [7] of electrical power engineering programs in Egyptian universities shows that these do not meet the ABET criteria regarding humanities and social science courses. Hopefully, the inclusion of such courses will help improve the interaction between engineers and the societies they serve.

Table I. Degree plan

(LC: Lecture, LT: Laboratory or Tutorial)

Semester 1

Course title	LC – LT - CR
English for Special Purposes(1)	1 - 3 - 2
Mathematics (1)	2 - 2 - 3
Physics (1)	2 - 2 - 3
Introduction to Computer	2 - 2 - 3
Eng. Drawing & Descriptive Geometry	0 - 6 - 2
Engineering Mechanics (1)	2 - 2 - 3
History of Science & Technology	2 - 0 - 2
	11 - 17 - 18

Semester 2

Course Title	LC – LT - CR
English for Special Purposes (2)	1 - 3 - 2
Mathematics (2)	2 - 2 - 3
Physics (2)	2 - 2 - 3
Structured Programming	2 - 2 - 3
Manufacturing Technology	1 - 3 - 2
Engineering Mechanics (2)	2 - 2 - 3
Chemistry	1 - 3 - 2
	11 - 17 - 18

Semester 3

Course title	LC – LT - CR
ESP (3)	2 - 2 - 3
Mathematics (3)	2 - 2 - 3
Electrical Circuits (1)	2 - 4 - 3
Digital Fundamentals	2 - 2 - 3
Materials Science	2 - 2 - 3
Programming Applications	2 - 4 - 3
	12 - 16 - 18

Semester 4

Course Title	LC – LT - CR
Mathematics (4)	2 - 2 - 3
Thermofluids	2 - 2 - 3
Electrical Circuits (2)	2 - 4 - 3
Electronics (1)	2 - 2 - 3
Electrical Measurements & Instrumentation (1)	2 - 4 - 3
Scientific Thinking	2 - 2 - 3
	12 - 16 - 18

Semester 5

Course title	LC – LýT - CR
Mathematics (5)	2 - 2 - 3
Electric and Magnetic Fields (1)	2 - 2 - 3
Electronics (2)	2 - 2 - 3
Electric Machines (1)	2 - 4 - 3
Introduction to Power Eng.	2 - 4 - 3
Network Analysis	2 - 2 - 3
	12 - 16 - 18

Semester 6

Course Title	LC – LT - CR
Statistics & Numerical Methods	2 - 2 - 3
Electric and Magnetic Fields (2)	2 - 2 - 3
Fundamentals of Control Eng.	2 - 2 - 3
Electrical Machines (2)	2 - 4 - 3
Power Systems (1)	2 - 4 - 3
Electrical Measurements & Instrumentation (2)	2 - 2 - 3
	12 - 16 - 18

Semester 7 | Semester 8

Course title	LC – LT - CR	Course Title	LC – LT - CR
Introduction to Microprocessors	2 - 2 - 3	Thermal Plant Engineering	2 - 2 - 3
Power Electronics (1)	2 - 4 - 3	Power Electronics	2 - 4 - 3
Power Systems (2)	2 - 2 - 3	Drives (1)	2 - 2 - 3
Control Systems (1)	2 - 4 - 3	Power systems Protection (1)	2 - 2 - 3
Electrical Machines (3)	2 - 2 - 3	Control Systems (2)	2 - 4 - 3
Economics & Law for Engineers	2 - 2 - 3	Aesthetic Education & Art Appreciation	2 - 2 - 3
	12 - 16 - 18		12 - 16 - 18

Semester 9 | Semester 10

Course title	LC – LT - CR	Course Title	LC – LT - CR
Project (1)	0 - 8 - 3	Project (2)	0 - 8 - 3
International Business & Management	2 - 2 - 3	Industrial Organization Management	2 - 2 - 3
Control Major	6 - 6 - 9	**Control Major**	6 - 6 - 9
3 Courses from group A	2 - 2 - 3	3 Courses from group A	2 - 2 - 3
1 Course from group B		1 Course from group B	
Power Major	6 - 6 - 9	**Power Major**	6 - 6 - 9
3 Courses form group B	2 - 2 - 3	3 Courses from group B	2 - 2 - 3
1 Course from group A		1 Course from group A	
	10 - 18 - 18		10 - 18 - 18

Course title	LC – LT - CR	Course Title	LC – LT - CR
Group A:		**Group B:**	
Discrete Control Systems	2 - 2 - 3	Power System Protection (2)	2 - 2 - 3
Automated Industrial Systems	2 - 2 - 3	Electrical Power Stations	2 - 2 - 3
Control Applications in Power Engineering	2 - 2 - 3	Electrical Power Distribution	2 - 2 - 3
Robotics	2 - 2 - 3	Special Electrical Machines	2 - 2 - 3
Computer Control of Dynamic Systems	2 - 2 - 3	Power Systems (3)	2 - 2 - 3
Modern Control Systems	2 - 2 - 3	High Voltage Engineering	2 - 2 - 3
Optimal and Adaptive Control	2 - 2 - 3	Electrical Engineering Materials	2 - 2 - 3
Automated Industrial Systems (2)	2 - 2 - 3	Utilization of Electrical Energy	2 - 2 - 3
Operations Research	2 - 2 - 3	Electrical Drives (2)	2 - 2 - 3
		Electromechanical Systems for Commercial Installations	2 - 2 - 3

Table II. Overall Accreditation Categories

	Credits	Program %	ABET %
Humanities and Social Sciences:			
English language	7		
Management	6		
Free Electives	11		

	24	13%	10 –15
Basic Sciences & Mathematics:			
Mathematics	18		
Physics	6		
Chemistry	2		
Thermofluids	3		
Material Science	3		
Computers & Programming	9		

	41	23%	20-30
Basic Engineering:			
Drawing	2		
Engineering Mechanics	6		
Workshop Technology	2		
Circuits	9		
Electronics	9		
Electric & Magnetic Fields	6		
Measurements	3		
Fundamentals of control Engineering	3		

	46	26%	25-35
Engineering Specialization:			
Rest of Program Courses	69	38%	30-40
Total Credits	180	100%	

In order to achieve the above objectives it is necessary to opt for early specialization. However, with a five-year degree program students can still be given a sufficiently broad-based electrical engineering foundation upon which they can continue to build their career.

IV. Degree requirements

To obtain a B.Eng. degree in Electrical and Control Engineering students must successfully complete 180 credit hours. The normal duration of study is 5 years (10 semesters). The first two semesters are common to all engineering disciplines. Specialization starts from the third semester. Semesters 3 to 8 are common to all students in the Electrical and Control Engineering department. In the final year students may choose to major either in Power and Machines or in Control : in each of the final semesters students select 3 courses in their chosen major plus one course from the other major (Table I). All students are required to complete a final year project in their chosen major.

The final year project is allocated 6 credit hours - 3 per semester. Each project is undertaken by 4-6 students and assessed by two academic supervisors throughout the year. The project provides an opportunity for students to synthesize the knowledge they have acquired and relate it to real-world engineering. It assists them in developing design, problem-solving and communication skills and provides a good opportunity for students to share their expertise. The emphasis is on design and the project must be realistic. Students can either engage in the design, construction, testing, evaluation etc, of a piece of apparatus (e.g. drives or control) or they can carry out an analytical study -which could include development of software- of a simple but modern problem in power system design. Students must submit their individual project report for initial evaluation; final evaluation is after an oral presentation and discussion before an examination board of faculty members and industry representatives.

Conclusion

The extent to which the degree plan will have met its objectives will become apparent when the first graduates will take up employment in September 1999.The courses, however, have been accepted enthusiastically by all faculty members of Egyptian and other Arab universities, external advisers to the department and by people in industry who have been consulted on the matter. However, one must realize that whatever the curriculum, engineering education cannot produce the complete professional in a particular engineering specialization within a prescribed time. What engineers do not learn in their undergraduate curriculum they must learn on the job, in graduate school or through continuing education courses and a sound undergraduate foundation should prepare them for this.

Bibliography

1. Bijker,W.E. Of bicycles, bakelites, and bulbs: towards a theory of sociotechnical change. MIT Press, Cambridge,MA, (1955).
2. Sporn,P. Vistas in Electric Power, Vol. 3. Pergammon Press, NY (1968).
3. Furgason,R.R. Quality assurance of US engineering education through assessment. Proc. 3rd World Congress on Engineering Education Training, Cairo, Egypt (1994)
4. IEEE Power Engineering Education Committee, Task Force Report on Electrical Power Engineering Curriculum, “A model undergraduate electric power engineering curriculum”. IEEE Trans. Power Apparatus and Systems, Vol.100,No 6 (1981).
5. IEEE Power Engineering Education Committee, Task Force Report on Electrical Power Engineering Curriculum, “A model advanced electric power engineering curriculum”. IEEE Trans. Power Apparatus and Systems, Vol.100, No 7 (1984)
6. IEEE Power Engineering Society, Subcommittee on Power Engineering Curricula, “Electric power engineering curricula content in the 21st century”. IEEE Trans. Power Apparatus and Systems, Vol 9, No 3, (1994).
7. El-Faham,M. & Khalil,A.E. Undergraduate electric power engineering programs in Egypt: A comparative assessment. ASEE 1996 Annual Conference Proceedings.

ASSER ZAKY

Dr. Zaky is currently Consulting Professor at the Arab Academy for Science and Technology at Alexandria. He received his B.Sc. in Electrical Engineering from the University of Alexandria,Egypt, a M.S. from the University of Illinois, Urbana , and a Ph.D. from the University of London, England. He served as UNESCO Expert at the University of Brasilia, Brazil and was Chairman of the Electrical Engineering Departments at the University of Alexandria, Egypt, King Fahd University at Riyadh, Saudi Arabia and Sultan Qaboos University at Muscat, Oman. He is a Life Fellow of the IEEE, Fellow of the IEE(UK) and of the Institute of Physics(UK).

IBRAHIM EL-MOHR

Dr. El-Mohr is Assistant President for Technology Transfer at the Arab Academy for Science and Technology at Alexandria. He received his B.Sc. degree in Electrical Engineering from the University of Alexandria, Egypt, a M.Sc. and D.Sc. from the George Washington University, USA. From 1991 to 1997 he was Chairman of the Electrical and Control Engineering Department at the AAST, Alexandria. He is a Senior Member of the IEEE.

MOHAMED EL-FAHAM

Dr, El-Faham is currently Dean of Graduate Studies at the Arab Academy for Science and Technology, Alexandria, Egypt. He received his B.Sc. degree in Electrical Engineering from the University of Alexandria, Egypt, and M.S and D.Sc. degrees from the George Washington University, USA. He was the founding chairman of the Department of Electrical and Control Engineering at AAST. He is an ASEE member and Senior Member of the IEEE.