High Voltage Engineering: A Supplemental Component for an Undergraduate Electrical Engineering Curriculum

Hassan El-Kishky, MIEEE
Department of Electrical Engineering
The University of Texas at Tyler
3900 University Blvd.
Tyler, TX 75799

Abstract

Inadequate preparation of electrical engineering graduates in the area of electric power and high voltage engineering is a major concern of the power industry. This paper highlights the problem and proposes a new undergraduate electrical engineering curriculum with balanced emphasis on major areas in the practice of electrical engineering. The problem has its roots in the universities. Loading undergraduate curriculum with many general education courses at the expense of more specialized engineering courses is a major factor contributing to the problem. This in turn limits the amount of course offerings in the area of electric power engineering and completely removes high voltage engineering from the map. Moreover, reducing the credit requirements of an undergraduate engineering degree to match that for a B.S. or a B.A. in liberal arts is another major factor that contributes to the problem. Finally, the telecommunication and information technology explosion has pushed many schools into completely washing away their electric power component, while other schools trimmed their power engineering offerings to a below minimum level. Yet, high voltage engineering and technology is still virtually out of the picture in an undergraduate electrical engineering curriculum. A new undergraduate electrical engineering curriculum with a comprehensive electric power and high voltage engineering components is proposed. In addition to the more common electromechanical energy conversion, power system analysis and control, and power electronics, basic knowledge of the fundamentals of the high voltage phenomena, high voltage generation, testing and measurement, dielectrics and electrical insulation as well as electric power equipment simulation, modeling, and design are believed to be necessary items in the electrical engineering package.

1. Introduction

Deregulation of the power industry has placed significant pressure on both energy utilities and power equipment manufacturers to enhance their functionality and reliability in order to stay competitive. One of the goals of the power industry in this new era of open energy market is to attract electrical engineering graduates with adequate background in the area electrical power and high voltage engineering. Yet, one of the challenges for the power industry is inadequate preparation of the electrical engineering graduates in electrical power engineering in general and in the area of high voltage engineering in particular. In the area of electric power distribution, the shortage of electrical engineers seems to be passing a critical point [1]. There is no apparent

Copyright © 2002, American Society for Engineering Education

supply of electrical engineers with reasonable background in that field to replace the retiring experts [1,2]. The supply problem is of extreme concern to industry but has its roots in the universities, where future engineers obtain their education [1-4]. Yet, the need to electric power engineers in both utility and industrial areas will not diminish despite lack or universal recognition [1,2]. It seems that lack of recognition of the problem from the university side may have its negative effect on solving the problem.

Traditionally, electric power education was limited to offerings in electromechanical energy conversion, power system analysis and control, and power electronics. However, basic knowledge of the high voltage phenomena, high voltage generation, testing and measurement, dielectrics and electrical insulation as well as electric power equipment simulation, modeling, and design are believed to be necessary items in the electrical engineering package. On the university side, the problem appears to spread in more than one dimension. Expanding towards the area of telecommunication and information technology at the expense of more traditional areas such power systems and engineering on the one hand, and squeezing an undergraduate electrical engineering curriculum that is already loaded with a substantial number of general education courses often mandated by the state or regional board of education on the other hand. Nonetheless, trimming undergraduate engineering curricula to match a national trend represents another big obstacle toward developing more comprehensive specialized majors.

This paper sheds some light on the industry need for electrical engineering graduates with reasonable background in electrical power and high voltage engineering. Salient deficiencies in existing electrical engineering curricula are pointed out. The extent of preparation of electrical engineering students in major areas and specialties is addressed. A modified curriculum structure that covers the fundamentals of high voltage and electric power engineering and yet takes into consideration the restrictions imposed by the cap on the total number of credit hours and the existence of a substantial general education component is proposed.

2. Problem Identification

There are two sides of that problem. The university, the supplier of future electrical engineers stands on one side and the electric power industry on the other side of the problem. From the electric power industry side, shortage of electrical engineering graduates with reasonable amount of knowledge in electric power and high voltage engineering is a major concern. However, it is worth mentioning that both utility and power industry share part of the responsibility for the situation by not providing enough funding to help build up-to-date electric power and high voltage engineering educational lab facilities in engineering schools. On the university side, the problem appears to spread in more than one dimension. Expanding towards the area of telecommunication and information technology at the expense of more traditional areas such power systems and engineering on the one hand, and squeezing undergraduate electrical engineering curriculum that is already loaded with a substantial number of general education courses, often mandated by the state or regional board of education on the other hand. Moreover, trimming undergraduate engineering curricula to match the requirements of a B.S or B.A in liberal arts will have its negative effects on plans to increase course offerings or to enhance specialization in electrical engineering.

Copyright © 2002, American Society for Engineering Education

Tables 1 and 2 show the number of electrical engineering faculty engaged in electric power teaching at some of the schools compiled by the IEEE Electric Power Engineering Education Resources Subcommittee [5-9]. The drop in the number of faculty members engaged in electric power education reflects shrinking of electric power programs in those schools.

Table 1: Faculty engaged in electric power teaching and research (Carnegie-Melon Research I Universities, 1994 edition)

Faculty Engaged in Electric Power Teaching / University	Year 1985-1986	Year 1987-1988	Year 1989-1990	Year 1991-1992	Year 1993-1994
Arizona State University	6	5	6	6	5
University of Alabama-Birmingham	3	3	3	3	3
University of California-Irvine	5				3
U of California-Los Angeles	2	1			
University of Colorado-Boulder	4			3	3
University of Connecticut	1	1	1	1	1
Georgia Institute of Technology	8		12		
University of Illinois-Urbana	8	8	6	6	6
Iowa State University	10	7	8		
University of Kentucky	4	4	3	3	4
Louisiana State University	5	3	3	3	4
Michigan State University	4	6	6	7	7
University of Wisconsin-Madison	11	10	10		
University of Washington	8	7	8	10	10
Texas A&M University			7	8	8
Virginia Poly Institute and State Univ.	13	7	9	7	7

Table 2: Faculty engaged in electric power teaching and research.

Faculty Engaged in Electric Power Teaching / University	Year 1985-1986	Year 1987-1988	Year 1989-1990	Year 1991-1992	Year 1993-1994
Clemson University	6	4	5	4	4
Rensselaer Polytechnic Institute	7	5	6	7	8
Florida International University	2	2	3	4	3
California Polytechnic State University	7	6		5	
Clarkson University	6		5	6	5
Illinois Institute of Technology	5	3		3	
Mississippi State University	4		4	4	4
University of Missouri-Rolla	15	12	6	7	7

Copyright © 2002, American Society for Engineering Education

Ohio State University	4	4	4	4	4
University of Southern California	10			9	
University of Texas at Arlington	8	3	4	4	4
Tulane University	2	4	3		

3. The Need for High Voltage Engineering

The need for a high voltage engineering component in the undergraduate electrical engineering curriculum stems from the fact there is a need for electrical power engineering graduates to be equipped with a reasonable background in high voltage engineering in order to be able to fill the position of retiring expert electric power engineers. Specific positions in the electric power industry require more depth in high voltage engineering than others. Research and development and electric power engineering consulting firms require more extensive understanding of high voltage engineering. Project engineers, design engineers and testing engineers are positions that need a reasonable background in high voltage engineering, and testing in particular.

Out of 88 universities responded to the survey by the IEEE Electric Power Engineering Education Subcommittee in the United States and Canada [9], nine universities offered a course in high voltage engineering/systems as a graduate elective course, and only one university offered a required graduate course, Table 3. Moreover, four universities offer a high voltage course as an elective for both graduate and undergraduate students, Table 3. Two universities offer a high voltage engineering course as an undergraduate elective and none of the schools responded to the survey offer any required high voltage engineering/systems on the undergraduate level, Table 3.

Table 3: A list of universities in USA and Canada offering high voltage courses.

University	Course Level					
	BR	BE	UR	UE	GR	GE
U of British Columbia						HV Eng
Arizona State University						HV Eng
Clarkson University						HV Mes
University of Connecticut						HV Eng
University of Florida		Lightning				
General Motors Institute				HV Eng		
Georgia Tech						HV Eng
Mississippi State University						HV Eng
University of Missouri-Rolla		HV Eng				
University of New Orleans					HV Eng	
Sunny-Buffalo		HV Eng				
Nova-Scotia Tech				HV Eng		
Ohio State University		HV Eng				
University of Tennessee						HV Sys

Copyright © 2002, American Society for Engineering Education

University of Texas-Arlington						HV Eng
Washington Sate University						HV Eng

Key to Table 3
BR: both graduate and undergraduate required
BE: both graduate and undergraduate elective
UR: undergraduate required
UE: undergraduate elective
GR: graduate required
GE: graduate elective
HV Eng: High Voltage Engineering
HV Sys: High Voltage Systems
HV Mes: High Voltage Measurement

A new undergraduate electrical engineering curriculum is proposed in Table 4. The new curriculum is based on the University of Texas at Tyler's undergraduate electrical engineering curriculum for the academic year 2001-2002. In the original curriculum, the two introductory freshman electrical engineering courses (ENGR 1200 - 2 credit hours, EENG 1201 – 2 credit hours) are eliminated and digital systems (EENG 3302 – 3 credit hours) is moved to the freshman year as the electrical engineering introductory course with a digital systems laboratory (1 credit hour) that meets for 3 hours a week. Two courses are added in the senior year, electric power systems (required) and high voltage engineering (elective).

The contents of the elective high voltage engineering course are outlined in the following:

- Introduction to high voltage systems
- Generation of high voltage
- Measurement of high voltage
- Gas dielectrics
- Liquid dielectrics
- Solid dielectrics
- High voltage cables
- High voltage testing

Table 5: Proposed undergraduate electrical engineering curriculum with a high voltage engineering supplemental component.

Freshman Year **First Semester**	**Freshman Year** **Second Semester**
General Chemistry Grammar and Composition I Calculus I Intro Political Science Freshman Seminar	University Physics I Grammar and Composition II Calculus II Digital Systems
Sophomore Year **First Semester**	**Sophomore Year** **Second Semester**

Copyright © 2002, American Society for Engineering Education

US History I Multivariate Calculus University Physics II Structured Programming Statics	US History II Differential Equations Economics Linear Circuits I Visual & Performing Arts (Elective)
Junior Year **First Semester**	**Junior Year** **Second Semester**
Theory of Probability Science/Math (Elective) Thermodynamics I Linear Circuits II Electronic Circuits I	American Government Design Methodology Electromagnetic Fields Electronic Circuits II Signals and Systems
Senior Year **First Semester**	**Senior Year** **Second Semester**
Senior Design I Automatic Controls Electric Power Systems Communication Theory World/European Liter (Elective) Engineering (Elective)	Senior Design II Senior Seminar Power System Analysis and Design Engineering (Elective) Engineering (Elective) Humanities (Elective)

Electric power engineering and high voltage engineering courses are offered as three credit hours elective courses during the first and second semester of the senior year. An introductory course in electromagnetic fields will serve as a prerequisite to the proposed high voltage engineering course.

4. Conclusions

The problem of inadequate preparation of electrical engineering graduates in the area of electric power and high voltage engineering is highlighted. The problem was discussed from the side of electric power industry as well as the university side. The need for electrical engineering graduate with reasonable preparation in electric power and high voltage engineering areas was presented. An undergraduate electrical engineering curriculum with supplemental components in electric power and high voltage engineering is proposed.

5. References

1. Robert Smith, Howard Hamilton, “Where Are the Industrial Engineers?”, IEEE Trans. on Industry Applications, vol. 24, no. 2, March/April 1988.

2. John A. Casazza, “ Effect of Electric Power Restructuring on R&D”, IEEE Electrical Insulation Magazine, Vol. 15, no. 1, 1999.

3. C. Fred, “Are Required Courses Meeting Industry Demand”, IEEE Potential, Vol. 20, no. 3, 2001.

Copyright © 2002, American Society for Engineering Education

4. M. L. Crow, **"**Comparing alternatives-power systems or energy conversion: which path students choose and why", IEEE Power Engineering Society Winter Meeting, Vol. 2, 2001.

5. S. K. Starret; M. M. Morcos, "Development of a power learning environment", Annual Frontiers in Education Conference, FIE '99, Volume: 1 , 1999.

6. IEEE Power Engineering Society Committee Report, "Electric Power Engineering Education Resources 1985-86", IEEE Trans. On Power Systems, vol. 3, no. 3, Aug. 1988.

7. IEEE Power Engineering Society Committee Report, "Electric Power Engineering Education Resources 1987-88", IEEE Trans. On Power Systems, vol. 6, no. 1, Feb. 1991.

8. IEEE Power Engineering Society Committee Report, "Electric Power Engineering Education Resources 1989-90", IEEE Trans. On Power Systems, vol. 7, no. 4, Nov 1992.

9. IEEE Power Engineering Society Committee Report, "Electric Power Engineering Education Resources 1991-92", IEEE Trans. On Power Systems, vol. 9, no. 3, Aug. 1994.

10. IEEE Power Engineering Society Committee Report, "Electric Power Engineering Education Resources 1993-94", IEEE Trans. On Power Systems, vol. 11, no. 3, Aug. 1996.

11. E Lakervi, J Partanen, "An Attractive Curriculum in Power Engineering", IEEE Trans. on Power Systems, vol. 7, no. 1, Feb. 1992.

Biography

Hassan El-Kishky is an Assistant Professor with the College of Engineering, University of Texas at Tyler. Before joining UT Tyler, Dr. El-Kishky was R&D manager at National Electric Coil, Inc., where he was responsible for the development of Insulation and corona suppression systems for high voltage machines. Dr. El-Kishky is engaged in teaching and research in high voltage and electric power engineering.

Copyright © 2002, American Society for Engineering Education