The Need for Electrical/Electronic Graphics in Engineering and Related Curricula

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Abstract *– This paper documents the applicability of electrical and electronics graphics to introductory general engineering graphics curricula. It includes an overview of the architectural, mechanical, and electrical/electronic graphics language.*

The electrical/electronic field is the largest branch of engineering and continues to grow. This dynamically changing field interfaces with architectural, civil, mechanical, industrial, computer, and the many other disciplines of engineering. A common, seamless, and interrelated graphics language is used to prepare drawings and diagrams by engineering design groups.

Electrical/electronic graphics is frequently overlooked in introductory engineering graphics courses and texts. Electrical and electronic graphics is part of the universal engineering graphic language used to prepare, read, and interpret plans, and should be included in engineering and related curricula. This paper describes how electrical/electronic graphics can be incorporated to effectively introduce students to design, creative thinking, visualization, and the understanding of the widely used graphics language.

Introduction

Engineering graphics is a fundamental communication medium used by technically trained people worldwide to design, construct, and operate structures, machines, or products. The registered professional engineer assumes a working and legal responsibility for the technical correctness of a device or design as represented by the engineering graphic language. Engineering graphics cannot be described in English nor visualized in math. It is a unique language which is indispensable in generating, forming, reading, and transmitting ideas. Graphics is a universal technical language without equal: a vocabulary of engineering with its own alphabet, symbols, abbreviations, slang, terms, idioms,.grammar, and conventions. The design effort is hampered by the inability of engineers to read their design plans or to read the interfacing plans of the other engineering disciplines. Graphic illiteracy creates a schism in engineering not only between applied and research engineers but also between engineers of different disciplines. Industry readiness requires a working knowledge of the engineering graphics language. Graphic illiteracy should not be tolerated in the Information Age.

The Disciplines of Engineering Graphics

The three main disciplines of engineering graphics are architectural, mechanical, and electrical/ electronic graphics.

Architectural graphics is generally used in the representation of large-scale structures, machines, or products. Examples include: buildings, bridges, towers, ships, aircraft, pipe, vent, and cable systems. Architectural graphics has been used since ancient times, and is more widely used in modern times as structures become larger and more complex. The methods of architectural representation include orthographic (plans and elevations) with associated sections and details, axonometric, and perspective.

Mechanical graphics is generally used to represent objects at or near full size – for example: half or double size. Major mechanical drawing methods include detail and assembly drawings. Methods of pictorial representation include orthographic, axonometric, and oblique drawings with associated details, sections, and developments. Mechanical graphics has become more highly developed and widely used during the Industrial Revolution. Mechanical graphics is frequently taught as the **only** "engineering graphics", with architectural and electrical/electronic graphics omitted.

Electrical/electronic graphics represents the largest of engineering disciplines, surpassing all others in the 1970's. This is the newest form or dialect of engineering graphics with most of its growth occurring in the twentieth century. Electrical/electronic graphics differs markedly from the more closely related architectural and mechanical graphics. Electrical and electronic symbology and drawings are not drawn to scale unless required by a structure (printed-circuit board) or machine interface. The electrical and electronic engineering drawings include block, line, schematic, wiring, terminal, and logic diagrams. Architectural and mechanical based electrical/electronic drawings include: contracts, guidance, arrangement, and installation drawings.

Description of Electrical/Electronic Graphics

The electrical/electronic graphics language functions as a common interface between the major engineering disciplines and is in common usage throughout industry worldwide. For instructional purposes, the presentation of electrical/electronic graphics to first-year students may be divided into two divisions.

The parent division, electrical graphics, may be taught as the generation, transmission, and distribution of electrical power for residential, commercial, and industrial users. Industrial users include lighting, heating, ventilation, and air conditioning (HVAC), and most types of equipment operation. All engineering graphics students should know basic electrical graphical symbols including receptacles, switches, batteries, fuses, and circuit breakers. Cable and wiring drawings, including their color coding, and wire connectors should also be presented. Student design projects might include basic power riser diagrams, circuit mapping, transmission diagrams, and substation layouts.

The electronics graphics division is far larger than the electrical graphics. Electronics graphics may be taught as the processing and control of electrical energy in small amounts. Electronics includes: computers, circuitry of appliances, guidance and control systems, and communications networks. Electronics symbols include many discrete components from integrated circuits to the power vacuum tube. Students should recognize basic electronic symbols such as transistors, diodes, resistors, inductors, capacitors, relays and solid-state circuitry including a variety of internal descriptive and external interconnection symbols. Student design projects include the application and interconnection of power tubes, transistors, solid-state and integrated circuits as applied to alarms, radios, televisions, and computers.

Suggestions for Curriculum Delivery

The electrical/electronic education model includes emphasis on visualization, training in form and arrangement, rapid and accurate sketching techniques [1] and electrical/electronic based computer software packages such as AutoCad® for printed-circuit wiring. The widespread use of freehand sketching and electrical/electronic-based computer software within the industrial application of electrical/electronic graphics documents the need for its instruction. Presentation of curriculum material may evolve towards competency-based instruction. The curriculum material may be delivered, taught, and evaluated Just-In-Time so that the preceding and following knowledge is linked. Examples are presented in the authors' recent paper [3].

The electrical/electronics engineering graphics is incorporated into an introductory engineering course. It is delivered under the following four topics:

1. Drafting Practices

- Diagram Titles states the type of diagram or component.
- Drawing Size and Format, specified by ANSI Y14.1, describes drawing sheet size and layouts.
- ANSI Line Weight Conventions are used for electrical and electronic diagrams.
- Lettering is size and font is specified.

2. Symbols

- Graphic Symbols (ANSI Y32.2) describe how combinatorial symbols can be drawn and explained on the drawing.
- Graphical Symbols include geometrical design representing an electrical or electronic device or component.

3. Diagrams

- Power Riser Diagrams may be the most frequently used diagrams on electrical working drawings. They show the required components and how these components are interconnected.
- Circuit Mapping uses numbers and electrical symbols that describe the working drawing of the electrical system.
- Block Diagrams are similar to flow charts. They typically consist of interconnected single lines and rectangular blocks that indicate major functions of component parts of a circuit or system.
- Line Diagrams consist of single lines and graphic symbols. They are typically used to indicate the course of the circuit or system with principal circuit connections.
- Schematic Diagrams are elementary diagrams that consist of single lines, graphic symbols that show circuit connections and functions without showing the physical size, shape, or location of devices. They are used in performing design calculations, selecting components, and troubleshooting the circuit.
- Wiring Diagrams or Connection Diagrams are used to show the connections of component devices which form the circuit. They show the general physical arrangement of components and the internal and/or external connections.
- Terminal Diagrams are used to show the internal circuits of a unit or device and its relationship to the terminal configuration, locating the terminal with respect to the shape or outline of the device.
- Logic Diagrams contain logic symbols and notes, and the details of signal flow and control.

4. Standards

- ANSI Y32.9-1972 (Reaffirmed 1989) American National Standard Graphic Symbols for Electrical Wiring and Layout Diagrams Used in Architecture and Building Construction
- IEEE Std 815-1975 (Reaffirmed 1989) Standard Graphical Symbols for Electrical and Electronics Diagrams (ANSI/DoD approved)
- IEEE Std 815A-1986 Supplement to Standard Graphical Symbols for Electrical and Electronics Diagrams (ANSI/DoD approved)
- Z10.1 – Abbreviation for Scientific Engineering Terms
- IEEE STD 200-1975 (Reaffirmed 1988) Standard Reference Designations for Electrical and Electronics Parts and Equipment (ANSI/DoD approved)

Students should become familiar with selected Institute of Electrical and Electronics Engineer (IEEE) standards, American National Standard Institute (ANSI) standards, and International Standards Organization (ISO) standards, National Fire Protection Association (NFPA) standards, and Electronic Industry of America (EIA) standards, as well as general specifications (GEN SPECS) and military specifications (MIL SPECS). Students should understand how, where, and when to apply governing standards to electrical and electronic design.

FUTURE CURRICULUM DEVELOPMENT

For several years, the IEEE and ANSI have worked with the ISO Secretariat to devise a set of international standards for Documentation and Graphical Symbols. These will include four subsets of graphical documents:

- Graphical Symbols for Diagrams that will contain rules for symbol elements, basic or general symbols, qualifying or additional symbols, conceptual symbols, and rules for different forms and orientations of symbols.
- Documentation that will contain graphical symbols for use in documentation and for use on equipment; general rules for preparing technical documentation of a device, equipment, system, or plant, including diagrams, charts, and other descriptions; definition and coordination of the information required to plan, develop, describe, install, maintain, and operate a device, equipment, system, or plant, taking into account all facilities of information processing systems, their data handling and system independent data exchange formats.
- Graphical Symbols for Use on Equipment that will contain standards for the creation of graphical symbols; the graphical symbols themselves, and graphical symbols for use on equipment
- Data Sets for Libraries of Electric Component Data that will contain standards for data sets suitable for inclusion in libraries of data (in human-readable and machine-readable and processible form) on electric components, including electronic and electromechanical components to be used in computer-aided design, manufacturing, and testing; including technical data elements, geometrical shapes, graphical symbols, and models for simulation of the function.

The following is a list of available IEEE standards categories for which documents have been developed. In establishing curriculum topics for graphics, the asterisked (*) categories are suggested for inclusion in graphics course(s).

Table 1: IEEE Standards Categories

Aerospace Electronics
Antennas & Propagation
Circuits & Systems*
Communications*
Information Technology*
Abbreviated Test Language for all Systems (ATLAS)™
Bus Architectures & Microprocessors/Microcomputers
Computer Glossaries
Design Automation
Local & Metropolitan Area Networks (LAN/MAN)(802's)
Portable Applications (POSIX)
Software Engineering
Test Technology
Electrical Insulation
Electricity Metering
Electromagnetics
Electron Devices*
Instrumentation & Measurement
MagneticsMedical Device Communications
National Electric Code®
National Electrical Safety Code®*
Nuclear Engineering
Power Electronics*
Power & Energy*
Cement Industry Applications
Dispersed Power Generation
Electric Machinery
Insulated Conductors
Insulation Coordination
Marine Transportation
Petroleum & Chemical
Pole Line Hardware

Power Capacitors
Power Dielectrics & Insulation
Power Distribution & Regulating Transformers
Power Generation
Power Systems
Protective Relaying
Roadway Lighting
Static Power Converters
Substation & Switchgear
Surge-Protective Devices
Transmission Line Construction
Transmission & Distribution
Ultrasonics, Ferroelectrics, & Frequency Control
Symbols, Designations, & Units*
Students should at least be aware of the above categories and their general content. They will learn the details on the job.

Conclusion

An industrial strength graphics program based on a balanced architectural, mechanical, and electrical/electronic graphics will prepare students for upper-level courses and employment in the engineering field. A deficiency in graphics education creates a vertical weakness in the engineering curriculum as it impacts the design process in future courses. Student enhancement of electrical/electronic graphics material is necessary so they can read and prepare design drawings, communicate creative design effectively, and visualize the entire engineering project. Graphic literacy across the engineering spectrum creates a common base among applied and research engineering, engineering technology, designers, drafters, and technically trained people worldwide. Enhancement and enrichment of electrical/electronic graphics is vital to all engineering and technical disciplines.

References

1. Hansberry, Eric W., "Sketching in the Graphics Curriculum", Proceedings of ASEE-EDGD 1989 Mid-Year Meeting

2. Hansberry, Eric W., "The Need for Architectural Graphics in the General Engineering Curriculum", ASEE 1990 Annual Conference

3. Hulbert, Thomas E., Hansberry, Eric W., and Angus, Robert B., Just-In-Time Education©: An Idea Whose Time is Overdue, Proceedings of ASEE 1995 Annual Conference