**ELEN 4240: Protection and Monitoring of Electric Energy Systems**

**Class Schedule:** 3 credits in 2 - 75 minute class periods

**Course Coordinator**: Nabeel A. O. Demerdash

**Course Materials:**

**Required:**

(1) Class Notes, by Course Instructor, Dr. N.A.O. Demerdash

(2) Power System Analysis, 2nd Ed., by Charles A. Gross, 1986

**Course Description:**

Principles of design of relay and sensor protection systems for detection of faulty operating conditions in electric generators, transformers, power transmission lines, motors and other loads in power systems. Symmetrical components, balanced and unbalanced faults include single and multiple unbalances. Design and hierarchical coordination of protection systems for interconnected generation, transmission and distribution facilities in power systems. This includes integrated generator-transformer busbar-transmission line-load protection and analysis of operation under fault conditions.

**Prerequisites:** ELEN 2020, ELEN 3110, and ELEN 3210

**Selected Elective** in Power and Energy Systems area.

**Contribution to Professional Component:** Engineering Science 40%

Engineering Design 60%

**Course Goals:**

Gives the student the background and skills to understand, design and analyze properly coordinated protection systems for generators, transformers, busbars, transmission lines, dynamic loads (motors), and static loads. These are the systems that help identify (sense) locate and isolate faulty equipment in a power system, to maintain system security and integrity to the maximum extent possible for guarantee of continuity of safe operation and continuity of energy supply. Thus students gain knowledge of maintaining power system integrity, and reliability.

**Course Objectives:**

*By the end of this course, the student should be able to...*

1. Analyze unbalanced/asymmetrical and balanced faults/short circuits in polyphase power systems and devices.
2. Analyze multiple unbalanced faults in polyphase power systems and devices.
3. Properly analyze and design/select the proper instrumentation transformers to detect and monitor all types of faults in polyphase power systems and devices.
4. Properly design, analyze and select the proper protection equipment to protect generators and motors in electric energy generation and energy utilization applications/systems.
5. Properly design, analyze and select the proper equipment and schemes for busbar fault protection
6. Properly design, analyze and select the proper equipment and schemes for transformer fault protection.
7. Properly design, analyze and select the proper equipment and schemes for transmission line and distribution line fault protection.
8. Properly design, analyze and select the proper equipment and schemes for load and dynamic load (motor) fault protection in industrial and domestic environments.
9. Properly design a coordinated fault protection scheme for complex systems containing generation, transmission, distribution and utilization of electric energy in polyphase and single phase electric energy systems.

In summary, this course should give the student the design experience in the proper choice of apparatus specifications and error analysis of current and potential transformers for electric energy system monitoring, instrumentation, and protection. Experience in the design of over-current, over-voltage, percentage differential, reverse power, and other protection systems for generators, transformers and busbar protection in electric energy systems. Design experience in the proper choice and coordination of directional distance/impedance protection of electric energy system transmission and subtransmission lines, as well as distribution feeders. Design experience in hierarchically coordinated electric energy system protection for improved electric energy system stability, in relation to generator-transmission line-major load networking. Design of protection systems for motors and large dynamic loads in electric energy systems. Design experience involving hierarchal coordination of transmission, subtransmission and distribution lines in localized regions of electric energy systems. Appropriate levels of computer-aided modeling and simulation are used at various stages of the course.

**Contribution to Program Objectives:** partial fulfillment of Criterion 3 objectives A, B, C, E, G, I, K

**Course Topics:**

1. Fault Classification in Electric Energy Systems.

2. Unbalanced/Asymmetrical Fault Analysis in Electric Energy Systems and Devices

3. Multiple Unbalanced/Asymmetrical Fault Analysis in Electric Energy Systems and Devices

4. Potential and Current Transformers in Electric Energy Systems

5. Generator Fault Detection and Protection Design

6. Busbar Fault Detection and Protection Design

7. Transformer Fault Detection and Protection Design

8. Transmission Line Fault Detection and Protection Design

9. Motor and Load Fault Detection and Protection Design

10. Energy Systems Fault Detection and Protection Design with Hierarchal Coordination

11. Advanced Concepts in Transients in Fault Monitoring, Protection and Modeling in Power System.