# Course Syllabus – University of Arkansas

**ELEG 587V Power System Reliability & Protection**

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| **Course Coordinator:** | Muthanna Al-Sarray, Ph.D. |
| **Catalog Description:** | Analysis and design of reliability and protection of power systems with considering NERC reliability standards and focusing on modeling, control and protection systems |
| Credit Hours | 3 |
| Course Level | Graduate |
| Prerequisite(s) by course | Introductory course in electric power systems |
| Prerequisite by topics | Power System Design and Analysis, techniques for sinusoidal steady-state analysis of three phase systems, power-flow and short-circuit analysis |
| Textbook | *Power System Protection*, P. M. Anderson, C. Henville, R. Rifaat, B. Johnson, S. Meliopoulos IEEE Press Series on Power and Energy Sys., Ed. 2, John Wiley & Sons, 2022 |
| Other Materials | Class content will be posted on class management system (BB or Canvas). |

**Learning Outcomes:**

Students who successfully complete this course will be able to:

1. Identify power plant types and design and fundamental components, Transmission and distribution substation design, the components of power systems from generation level to distribution level to consumers, and power flow.
2. Describe roles of protection systems and circuit breakers under various circumstances and emphasize the aims of protective systems including relays and circuit breakers (generation, transmission, and distribution levels).
3. Properly interpret the risks and challenges of operating electric power systems, especially issues associated with the use of renewable generating resources such as interconnections and operational configurations, cost and economic evaluations with concepts, and fundamentals of reliability in power systems.
4. Apply NERC reliability indicators in power systems to evaluate power systems reliability in terms of NERC requirements.
5. List and specify the impacts of application of risk evaluation to generation and transmission levels.
6. Describe the roles of recent technologies like synchrophasor in improving reliability of power systems via different applications such as Wide Area Management System and Control (WAMS).
7. Identify the impacts of cyber security on power system reliability and study Supervisory control and data acquisition (SCADA) in control centers of power systems.

# Course Topics:

1. Power plant types and design and fundamental components
2. Transmission and distribution substation design.
3. Protection system
4. Circuit breakers
5. Power flow
6. Reliability concepts
7. Outage models and risk evaluation techniques for components of power systems
8. NERC reliability indicators
9. Synchrophasor measurement methods and digital communications
10. Supervisory control and data acquisition and control centers
11. Cybersecurity attacks in power systems

# Course Contribution to Program Outcomes:

ELEG 587V contributes to an achievement of:

1. Outcome 1: An ability to identify, formulate, and solve complex engineering problems related to reliability and protection in power systems by applying principles of engineering, science, and mathematics
2. Outcome 2: An ability to apply electrical protective system design to produce solutions that meet specified needs with consideration of safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. Outcome 3. An ability to understand and contribute to the challenges of a rapidly changing society and function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives, especially with the power systems field.

# Course Delivery

1. Student-to- Module-Instructor Interaction: Students will listen/view lectures online (voice-over PowerPoint) and interact with the module instructor through discussion board and emails. Module Coordinators and/or Instructors will post weekly prompt(s) and respond to student postings. The instructor will post weekly announcements, provide individual feedback to students, and hold online office hours.
2. Student to Content Interaction: Students will engage with course content by completing reading assignments, listening/viewing Module Instructor presentations, writing discussion boards postings, and completing homework assignments.
3. This course uses synchronous student discussion via an online class management system (Blackboard). Methods to be used include live lectures and discussions, voice-over PowerPoint presentations, and written assignments.

# Technology Requirements

Basic online technology skills are needed for this course, as well as a capability to learn and use All work in this course must be completed and submitted online. Therefore, students MUST have consistent and reliable access to a computer and the internet. Before starting this course, students must feel comfortable doing at least the following:

* 1. Create, organize, and save electronic files,
  2. Download and upload documents to a classroom management system.
  3. Learn to build and operate a system model in a grid simulation tool. The course will use the following two simulation packages:
     1. PowerWorld Simulator (free student edition)

# Textbooks and References

* Roy Billinton, and Ronald Allan, “Reliability Evaluation of Power Systems” Springer.
* 2020 State of Reliability, an Assessment of 2019 Bulk Power System Performance,” North American Electric Reliability Corporation, 2020.

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# Course Assessment

Homework will normally be assigned every week. Problem solutions must show a clear and systematic method for arriving at the correct solution for full credit. Grading criteria, in the form of a rubric, will be provided for each assignment.

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|  | Percentage |
| Homework | 20% |
| Final Exam | 20% |
| Project | 60% |

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| **Final Grade** | **Semester Average** |
| A | 100 ≥ S.A. ≥ 91 |
| B | 90 ≥ S.A. ≥ 81 |
| C | 80 ≥ S.A. ≥ 71 |
| D | 70 ≥ S.A. ≥ 61 |
| F | 60 ≥ S.A. ≥ 00 |

**Course Outline/Schedule**

Topics for each class meeting are listed below. Circumstances may call for a departure from this schedule. Any changes to the schedule will be clearly announced via the online class management system. Homework assignments will be made at least one week prior to the due date.

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| **Date** | **Topic** | | **Videos, Lectures,**  **Reading, HWs** | **Learning**  **Minutes** | **Learning**  **Minutes per**  **Week** |
| Week 1 | Power plant types and design and fundamental components, Transmission  and distribution substation design, Power flow | | Video Module 1 | 60 | 450 |
| Reading 1 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| HW 1 | 145 |
| Week 2 | Protection systems and circuit breakers | | Video Module 2 | 60 | 450 |
| Reading 2 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| HW 2 & Begin Case Study | 145 |
| Week 3 | Reliability concepts, outage models of power system components, risk evaluation techniques for power systems | | Video Module 3 | 60 | 450 |
| Reading 3 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| Exam#1 | 145 |
| Week 4 | NERC reliability indicators | | Video Module 4 | 60 | 450 |
| Reading 4 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| Case Study Paper Due | 145 |
| Week 5 | Application of risk evaluation to generation and transmission levels and Special Protection Scheme | | Video Module 5 | 60 | 450 |
| Reading 5 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| HW 3 | 145 |
| Week 6 | Synchropahsor technique and its role in reliability and protection targets | | Video Module 6 | 60 | 450 |
| Reading 6 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| HW 4 & Begin Design Project | 145 |
| Week 7 | Supervisory control and data acquisition and control centers | | Video Module 7 | 60 | 450 |
| Reading 7 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| Exam2 | 145 |
| Week 8 | Cybersecurity attacks in power systems |  | Video Module 9 | 60 | 450 |
| Reading 9 | 145 |
| Online discussion | 50 |
| Class discussion | 50 |
| Design Project Due | 145 |
| Final Project | | | | | 900 |
| Total Learning Minutes | | | | | 4500 |