POWER PLANT – RELAY REPLACEMENT PROJECT PLAN

ISU Senior Design Group: Dec15-22

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Project Web Site:

http://dec1522.sd.ece.iastate.edu/

Project Sponsor: CIPCO

Project Advisor: Professor Mani Mina

Revised: 4/25/15

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1. PROBLEM STATEMENT

There are three main parts to this project. First, due to age and condition the existing power plant electro-mechanical protective relay equipment will be retired and new microprocessor based protective relaying equipment will be installed. The senior design project will be responsible for the complete design of the relay replacement which includes all required schematics and wiring diagrams.

Second, the senior design project will complete arc flash calculations and analysis for the existing metal clad switch gear. Metal clad switch gear has been known in the industry to have a high potential for arc flash issues. Determining the potential of these issues allows the operator to be aware of the proper amount of precaution and personal protective equipment.

Third, the senior design project will provide engineering solutions to operate the switch gear safely. By analyzing the potential arc flash, engineering solutions shall be provided to advise in choosing the proper safety precautions during operations.

2. GOALS

The goal of this project is to complete the following activities to completion:

- For-construction drawing set to complete the replacement of four power plant electromechanical relays with microprocessor based SEL relays.
- Arc flash calculations and analysis for the existing metal clad switch gear.
- Two engineering solutions to operate the switch gear safely.

All goals are to be completed on time, under budget, and with emphasis on Central Iowa Power Cooperative (CIPCO) cultural priorities of safety, reliability, and compliance.

3. PROJECT SCOPE

3.1. RELAY REPLACEMENT

The primary goal of this project is to replace four power plant electromechanical relays with microprocessor based SEL relays. A full set of for-construction drawings will be completed showing the removal and addition of equipment and wiring, including communication equipment. The drawings will be completed using existing drawings while following CIPCO drafting standards and design templates. Relay functions for this situation will be identified and described.

3.2. ARC FLASH CALULATIONS AND ANALYSIS

The second part of this project is to complete arc flash calculations and analysis. These will be used to show the potential of an arc flash on metal clad switch gears which are controlled by the relay equipment that will be replaced.

3.3. SAFE OPERATION OF METAL CLAD SWITCH GEAR

Metal clad switch gear have an industry history of arc flash safety problems during operation. The third part of this project will be to identify two engineering solutions to operate the metal clad switch gear and relay equipment safely. Cost estimates and benefits of both solutions will be reviewed.

4. EXCLUDED FROM PROJECT

4.1. DESIGN SIMULATION AND TESTING

While all due diligence will be given during the design of this project, simulation and testing will not be completed as part of this project. Verification of design documentation will be completed during design review meetings with CIPCO.

4.2. RELAY SETTINGS

Relay settings will not be included as part of the relay replacement. Identification of suggested relay functions will be included.

4.3. RELAY TESTING

Microprocessor based relays require very precise testing due to the amount of features and internal programming. Relay tests or system check out procedure will not be provided as part of this senior design project.

5. PROJECT REQUIREMENTS

The following list of requirements was established with CIPCO and in accordance with CIPCO document “Project Scope” included under section design documents. The template for the CIPCO Project Scope was provided by CIPCO.

5.1. SPRING SEMESTER 2015 DELIVERABLES

5.1.1. RELAY REPLACMENT DESIGN

- Relay one line diagram
- Elementary diagram / current schematic
- Control schematic
- Panel wiring
- Communication processor wiring
- Drafting and review

5.1.2. ARC FLASH CALCUATION

- Calculation per O.S.H.A. (Occupational Safety & Health Administration)

5.1.3. SAFE OPERATION OF METAL CLAD SWITCH GEAR

- Research and identify two possible engineering solutions
- Evaluation both solutions

5.2. FALL SEMESTER 2015 DELIVERABLES

5.2.1. RELAY REPLACEMENT DESIGN

- For construction package
- Bill of material
- Cost estimates
- Relay functions

5.2.2. ARC FLASH ANALYSIS

- Calculation analysis
- Compliance regulations

5.2.3. SAFETY OPERATION SOLUTIONS

- Compliance regulation
- Cost estimates
- Operation guides

5.3. DESIGN ALTERNATIVES

There are limited design alternatives for potions of this project due to the strict standards, regulations, and requirements the project will be held to. Alternatively, two viable solutions will be required for the safe operation of metal clad switch gear portion of this project.

5.4. FUNCTIONAL REQUIREMENTS

Due to the properties of this project, there will be no physical deliverables to test the functionality. The project will be designed to meet the main project requirements while adhering to CIPCO and regulatory standards. That being said, the reviews completed by the project sponsor will help insure that the designer is working towards producing a proper design that will function as required after implementation. Therefore, the following are considered functional requirements of this design project:

- Development of engineering for construction drawing package in AutoCAD format for relay replacement including the following:
  - Relay one line diagram
  - Elementary diagram / current schematic
  - Control schematic
  - Panel wiring
  - Communication processor wiring

  - All required drafting
  - Proposed relay functions
  - Bill of material
  - Cost estimates
- Arc flash calculations and analysis
  - Per OSHA standard 29 CFR 1910.269
  - Calculation analysis and safety recommendations
- Safe operation of metal clad switch gear
  - Two possible engineering solutions to safely operated switchgear
  - Analysis of compliance regulation
  - Cost estimates
  - Operations guides for solutions

5.5. NON-FUNCTIONAL REQUIREMENTS

Due to this project being a design without implementation, there are no non-functional requirements. This is primarily due to the project exceptions of relay modeling and testing. The project will be designed to meet all standards to insure the equipment will function as required when installed and tested. The functionality and relay settings will be tested at installation and is out of scope for this project.

6. ASSESMENT OF PROPOSED SOLUTION

The solution to the proposed requirements will be a team effort between CIPCO and the design team. Strengths, weakness, and tradeoffs will be identified for each part of the project.

6.1. RELAY REPLACEMENT

The relay replacement must follow strict guild lines and compliance standards limiting the diversity of design solutions.

6.2. ARC FLASH

Similarly, the arc flash calculation and analysis must follow strict guidelines and compliance standards limiting the diversity of design solutions.

6.3. SAFETY OPERATION

The safety operation solutions allows for creativity while adhering to safety and compliance standards.

7. VALIDATION & ACCEPTANCE TEST

During the design process all drawings, calculations, and solutions will be reviewed by CIPCO engineering for accuracy and correct implementation. Design documentation will be

revised per CIPCO feedback and revised until the documentation is correct per CIPCO standards and expectations and ready for implementation.

8. TECHNICAL APPROACH

8.1. DESIGN SPECIFICATIONS

As stated, the existing electro-mechanical relays are being replaced due to age and condition. The new SEL 351 relays are microprocessor based and which has many benefits over electro-mechanical style relays, such as the following:

- Higher level of flexibility of protection schemes
- More inputs and outputs for greater control and room for expansion
- Faster and more precise relay testing
- Communication to monitor and gather data

The new SEL relays give overall flexibility and room to grow as protection needs and technology change.

8.1.1. OPERATING ENVIRONMENT

The operating environment will be considered for each part of the project due to the harsh power plant environment. The environment can have large temperature changes along with dust, vibration, audio and electrical noise. These, among other operating constraints, will be considered during the design of this project.

8.1.2. COMPLIANCE STANDARDS

Compliance standards play a large part in all aspects of the electric utility business and operation. These compliance standards will be present in all aspects of this project

8.1.2.1. OSHA

Occupational Safety and Health Administration (OSHA) standard 29 CFR Parts 1910 & 1920 Electric Power Generation, Transmission, and Distribution. This standard helps setup rules and standards to promote safety in the electric utility industry.

8.1.2.2. NERC

North American Electric Reliability Corporation (NERC) standards are in place to help protect the reliability of the electric system. These standards are highly important and full compliance is required.

8.1.3. STANDARDS

8.1.3.1. DESIGN AND CAD STANDARDS

CIPCO design and CAD standards will be followed during the design of this project. These design standards are in place to insure the equipment is designed properly, and to help prevent field installation problems, and ease of design and checkout.

9. PROCESS DETAILS

The electromechanical relays to be replaced are on four different units, controlling four different switch gear, and powering different power plant equipment.

9.1. SYSTEM INPUT/OUTPUT ANALYSIS

9.1.1. SYSTEM INPUTS

The inputs to the new relay equipment will be very similar to the existing relays. AC line currents, AC bus voltages, 125VDC to power the relay, alarms, and breaker status will be brought into the SEL relay. The relay will use its programming to determine multiple functions and actions including tripping or closing the switchgear.

9.1.2. SYSTEM OUTPUTS

The outputs are similar to the relay inputs in that they will remain similar to the existing relay equipment's outputs. The outputs will be switchgear trip and close, relay alarm, and communications.

9.2. USER INTERFACE SPECIFICATIONS

The primary software used for this project is AutoCAD. The CAD files will work as specified in the CIPCO CAD standard. These will be saved as .dwg file types and printed to .pdf. Fonts, layering, colors, title blocks, and additional items are covered in the CAD standard. The design review will cover both the electrical design as well as the drafting details.

9.3. HARDWARE/SOFTWARE SPECIFICATIONS

This project is software based, in that no physical product will be delivered. The project will be primarily designed in AutoCAD software. Other software used will be Microsoft products and Adobe Acrobat. No specialized software will be required and all CIPCO CAD standards will be followed.

9.4. SIMULATIONS AND MODELING

All design drawings will be completed in AutoCAD and printed to pdf for review and for final construction drawings. These reviews will act as our testing grounds to produce a theoretical functioning design that meets industry standards. Arc

flash calculations will be completed in Excel for ease of use and repeatability. Simulations and relay testing are out of scope for this project.

9.5. IMPLEMENTATION CHALLENGES

There are many challenges to this project. Some are based on lack of experience with this type of equipment and the environment that it is operated in. Other challenges can be schedule conflicts and meeting required deadlines. Other challenges could be to balance cost versus benefit of the particular solution. All challenges will be met with a tenacious determination and a willingness to learn.

9.6. TESTING, PROCEDURES, AND SPECIFICATIONS

No formal testing or simulations will be completed during this project and are considered out of scope. This design will be heavily reviewed to ensure all industry standards, and regulations will be met and followed.

10. TEST PLAN

As stated previously, no formal testing or simulations will be completed during this project and are considered out of scope. This design will be heavily reviewed to insure all industry standards, and regulations will be met and followed.

Each step has a review process with the Terry Fett, the Project Sponsor from CIPCO and the Supervisor of the Engineering Department, to insure the right approach has been taken with the design. During the review process, drawings will be delivered to Terry Fett. He will review and comment on the drawings. The drawings will then be delivered back to the designer for corrections. This process continues until Terry has deemed the design correct and then the designer can move on to the next step. This early and often approach prevents mistakes from being carried throughout the project making corrections far more complicated, time consuming, and costly. This review process follows closely how CIPCO operates with internal and external design consultants.

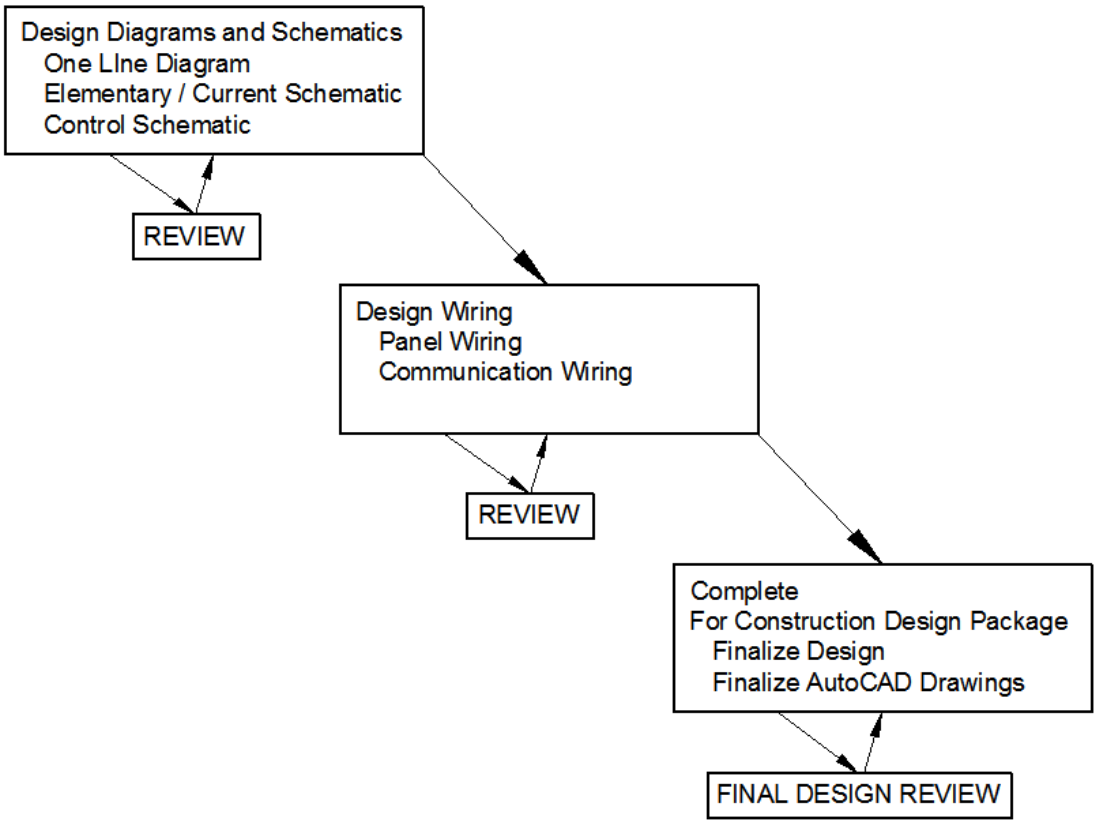

Figure 1: REVIEW PROCESS BLOCK DIAGRAM

11. PROJECT SCHEDULE

Power Plant - Relay Replacement

Iowa State EE Senior Design - December 2015
Group: Dec15-22
Dan Dye - 4/25/15

Key Activities	Weeks - Spring 2015														
Spring	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Develop Project Scope															
Develop Project Plan															
Develop Man-hour Budget															
Gantt Chart															
Design Relay One Line Diagram															
Design Elementary Diagram / Current Schematic															
Design Control Schematic															
Design Panel Wiring															
Design Communication processor Wiring															
Design Review															
Arc Flash Calculation															
Arc Flash Design Review															
Safe Operation Engineering Solutions															
Safe Operation Engineering Solutions Design Review															
Compleation of Project Report															
Presentation Practice / Presentation															

Key Activities	Weeks - Fall 2015														
Fall	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Design Elementary Diagram / Current Schematic															
Design Control Schematic															
Design Panel Wiring															
Design Review															
Relay Replacement Deisgn Construction Package															
Relay Replacement Deisgn Function															
Arc Flash Calcuation Analysis															
Arc Flash Calcuation Compliance Regulations															
Arc Flash Analysis Review															
Safety Operation Solutions Compliance Regulations															
Safety Operation Solutions Cost Estimates															
Safety Operation Solutions Operation Guild															
Safety Operation Review															
Compleation of Final Project Report															
Design of Project Poster															
Presentation Practice															
Presentation															

Table 1: PROJECT SCHEDULE GANTT CHART

12. RISK / FEASIBILITY ASSESSMENT

12.1. S.W.O.T. ANALYSIS

A S.W.O.T analysis was completed to help identify key areas of strengths, weaknesses, opportunities, and threats. Below are the key concepts.

Strengths • Industry experience • Strong professional support	**Weaknesses** • Relay experience • Schedule • Harsh environment
Opportunities • Improved reliability • Improved testing • Improved communication • Gain knowledge of equipment	**Threats** • Outages • Safety • Compliance

Table 2: S.W.O.T. ANALYSIS TABLE

12.2. RISK ITEMS

This project involves many areas of risk. While designing this project the designer will have to take into account these risks and design around them. Some of these areas of risk are operating environment, complying with compliance standards, budgetary constraints, and meeting project deadlines. During the design, the designer will need to build in protection from these risks.

12.3. FEASIBLITY ASSESSMENT

A feasibility study will not be completed at part of this project. The technical feasibility of the project is high. This high assessment is due to the experience and knowledge of Terry Fett the project sponsor. His guidance and coaching will most likely lead to positive results.

13. COST CONDSIDERATION

The cost considerations are an important part of this project. Material and equipment acquisition will be completed at a later date, but overall cost will be considered. The main cost of this project will be labor associated with research, design, and design review. Additionally computer resources and a full seat of AutoCAD will be required. A

bill of material and cost estimates will be completed for the relay replacement and safety operation solutions.

14. MARKET/LITERATURE SURVEY

This project will require research to gain background knowledge on equipment, compliance standards, and current practices and technology. This research will help determine the best approach for design and equipment specification.

15. CONCLUSION

This senior design project has helped me improve my knowledge significantly while working on the relay replacement, arc flash calculation and analysis, and safe solutions for operating switchgear. I have a far better understanding of relay protection, power equipment, and the detail involved in the engineering and design process.

16. DEFINITIONS

16.1. METAL-CLAD SWITCHGEAR

Metal-clad switchgear is a combination of electrical disconnect switches and circuit breakers enclosed in a grounded metal compartment. These are often used in conjunction with protective relays. Metal-clad switchgear are used in electric power systems to control, protect and isolate electrical equipment. These are used to both de-energize equipment to allow work to be completed and to clear faults downstream. The proper use of this type of equipment is directly linked to the reliability of the electric system.

16.2. PROTECTIVE RELAY

In power systems, a protective relay is a device to designed to trip a circuit breaker, or in our case a Metal-clad switchgear, when a fault or other undesirable operating conditions are detected. The original protective relays were electromechanical devices that relied on coils and moving parts to provide detection of abnormal operating conditions. Microprocessor-based protective relays use software base protection algorithms for detection of electrical faults.

17. REFERENCES

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