POWER PLANT – RELAY REPLACEMENT
DELIVERABLE
RELAY REPLACEMENT DOCUMENTATION

ISU Senior Design Group: Dec15-22

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1. SUMMARY

This project is part of the Power Plant – Relay Replacement senior design project. This document is to clearly demonstrate the required deliverables as stated in the Project Plan and Design Document.

Due to age and condition the existing power plant electro-mechanical relay equipment will be retired and new microprocessor based 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.

2. PROJECT BRIEF

The main objective of this part of the project is to replace four power plant electromechanical relays with microprocessor based Schweitzer Engineering Laboratories (SEL) relays. A full set of for-construction drawings will be competed 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 will be identified and described.

3. PROJECT REQUIREMENTS

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

3.1. SPRING SEMESTER 2015 DELIVERABLES

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

3.2. FALL SEMESTER 2015 DELIVERABLES

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

4. FOR CONSTRUCTION PACKAGE

The For Construction Package will follow CIPCO guidelines and contain the following:

- Project memo to the installation crew showing what is included in the construction package
- Bill of material for the equipment and material
- Drawing list
- All required drawings to complete the project

See Appendix A – For Construction Package

5. BILL OF MATERIAL

Bill of material is defined by Business Dictionary as "A list of raw materials, parts, intermediates, subassemblies, etc., (with their quantities and description) required to construct, overhaul, or repair something". This material list is particularly important for planning the project, estimating cost, and purchasing the material.

The table below shows what equipment and material will be required for the relay replacement.

Bill of Material
Power Plant - Relay Replacement

Required Material

Material Description	Manufacturer	Model	Qty
Microprocessor relay	SEL	351A	4
Test switch 10 position	ABB	129A501G01	4
Test switch 14 position	ABB	129A514G01-6C	4
6 Amp fuse, 600V, medium time lag	Littelfuse	G-Class	8
Fuse holder - 2 pole - panel mount	Square D	9080FB2	4
Fiber-Optic transceiver/modem	SEL	2800	8
Fiber-Optic cable	SEL		4x500'

Table 1: Bill of Material

6. COST ESTIMATES

A cost estimate should include all material, equipment, and labor to complete the project. Budgetary bids can be requested from vendors to get current material cost and lead times. Cost estimates and lead times can help with project budget planning and scheduling. Estimates can also help determine the most economical choice to fit budgets and project requirements.

The below cost estimate shows multiple options. This is to help weigh the benefits versus the cost of the addition equipment or labor cost. For instance, you could use fiber-optic cable instead of standard communication cable. There is an additional cost to the more expensive option, but if you have lots of electrical noise this could be a better option.

PROJECT COST ESTIMATE
Power Plant - Relay Replacement

Required Material					
Material Description	**Manufacturer**	**Model**	**Qty**	**Unit Cost**	**Total**
Microprocessor relay	SEL	351A	4	$2,380.00	$9,520.00
Test switch 10 position	ABB	129A501G01	4	$56.00	$224.00
Test switch 14 position	ABB	129A514G01-6C	4	$64.00	$256.00
6 Amp fuse, 600V, medium time lag	Littelfuse	G-Class	8	$7.00	$56.00
Fuse holder - 2 pole - panel mount	Square D	9080FB2	4	$12.00	$48.00
Communication cable	MonoPrice	CAT6	4x500'	$0.094	$188.000
				sub total	$10,292.00

Optional Equipment					
Fiber-Optic transceiver/modem	SEL	2800	8	$102.00	$816.00
Fiber-Optic cable	SEL		4x500'	$1.98	$3,960.00
(for communication line interference)				**sub total**	$4,776.00
Control switch with time delay	Electroswitch	TD-CSR	4	$1,573.00	$6,292.00
(Arc flash safety switch option)				**sub total**	$6,292.00

Installation Cost				
Labor Description	Hours per Unit	Hours for 4 units	Cost per Hour	Total Cost
Relay installation	8	32	$160.00	$5,120.00
Checkout and testing	3	12	$160.00	$1,920.00
			sub total	$7,040.00

Optional Equipment Installation Cost				
Control Switch with time delay	1	4	$160.00	$640.00
(Arc flash safety switch option)			**sub total**	$640.00

TOTAL COST	
Standard Equipment option - Total	**$17,332.00**
Fiber-Optic Cable option - Total	**$21,920.00**
Arc Flash and Fiber-Optic Cable option - Total	**$28,852.00**

Table 2: Project Cost Estimate

7. RELAY FUNCTIONS

In power systems, a protective relay is a device 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 and circuitry for detection of electrical faults.

Electromechanical relays were limited to the purpose and function they were created for. Microprocessor based relays are essentially limited by the software and programing. This allows the microprocessor relay to have many functions that were not available in electromechanical relays. The software uses inputs from the system such as line voltage and line current to determine unstable or unsafe electrical conditions. The following are functions that would be considered for this project:

- Overcurrent protection
  - Over current protection would guard against damage resulting from excessive current by opening the metalclad switchgear at a set level of current.
- Fault detection
  - An electrical fault is any abnormal electric current. Fault detection would be determined by use of the relays inputs and software calculations.
- Ground time-overcurrent elements
  - Ground time-overcurrent relays measure the summation of the currents from the current transformer devices. The summation should add up to zero unless under fault conditions. These use a set “pick up” value and the operating time is inversely related to the operating current which helps with protection coordination. This relay protection device helps protect equipment from ground faults.
- Over/under frequency elements
  - Either over or under electrical frequency can lead to equipment damage.
- Measure and record MW, MVAR, MWh, MVARh, Power Factor, instantaneous and/or peak demand
  - These items can be measured and recorded to help determine system and equipment loading.

8. DESIGN CHANGES

Very few design changes were made during the design and review process. One important change was made to account for the harsh operating environment. Due to the high probability of electrical noise between the relay and the communication processor, the connection will be made using fiber instead of cat6 communication copper wire. The electrical noise is fluctuation in the electrical signal. These fluctuations can happen in the power plant environment due to the high voltage equipment, large motors, switching gear, and high current sources. Noise on the communication cable could cause loss of signal between he equipment which is not a desired condition. This determination to go with fiber was made by CIPCO in hopes of preventing future communication problems and was a weighted cost verses benefit decision. The additional cost is shown in the project cost estimate.

9. CONCLUSION

This senior design project has helped me improve my knowledge significantly in the area of relay design and functionality. Combining electrical design with project management topics such as budgets and cost benefits has improved my overall understand of the requirements and the amount of detail that goes into engineering projects. The review process helped immensely. Having completed multiple reviews gave me a chance to ask questions and learn from the review comments. The review process was also setup to help catch mistakes before they were carried though out the design which help keep the project on schedule.

10. REFERENCES

Business Dictionary
https://www.businessdictionary.com
<http://www.businessdictionary.com/definition/bill-of-materials-BOM.html>

Understanding Microposcessor-based Technology Applied to Relaying, 2009
Power System Relaying Committee, Report of Working Group I-01 of Relaying Practices Subcommittee, <https://www.friends.edu/sites/default/files/pdf/ElectronicReference.pdf>

Grounding and Ground Fault Protection, 2004
Industry Applications, IEEE Transaction (Volume:40, Issue:1)
Pages 24-28

SEL 351 Information
Schweitzer Engineering Laboratories (SEL)
https://www.selinc.com
https://www.selinc.com/SEL-351/

Power System Protective Relaying: basic concepts, industrial-grade devices and communication mechanisms
Report # Smarts-Lab-2011-003
KTH Royal Institute of Technology
http://www.vanfretti.com

Metal-clad switchgear definition and information
Controlled Power, LLC
5kV and 15kV Metal-clad Switchgear, June 16, 1999
www.controlledpower.com/CPC5Kv15KvMetalClad.pdf