



SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

PROJECT REQUIREMENTS AND SPECIFICATIONS DOCUMENT

# Peabody Energy Remote Substation Monitoring

***Project Team:***

*Curtis Plumb, Samuel Hinricher, Aaron Sherck, Brian Gallagher, and  
Trevor Rombough*

***Faculty Adviser:***

*Dr. Thomas Montoya*

**Sponsor:**

Peabody Energy

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## Revision History

Version	Date	Approved By	Comment
1.0	Oct. 5, 2017	<i>Samuel N. Hinricher</i>	Initial document release

# 1 Introduction

This document is meant to outline the requirements and the specifications that we will follow throughout our project. This will outline how we will be developing our project and gives a much more detailed breakdown that can be used to further our earned value analysis.

## 1.1 Document Purpose

The purpose of this document is to detail the requirements of our system design along with outlining the areas where we can explore and determine what will work best for the system. This document will outline where we have freedom to perform engineering studies and determine ourselves what is the best way to overcome obstacles. It also gives a detailed outline for us to follow to stay on track with the project.

## 1.2 Project Description

The creation of this project comes from the need to be able to remotely monitor currents, voltages, power fluctuations, and GPS locations of the numerous mobile substations throughout the mine site at the North Antelope Rochelle Mine. With this being the largest surface coal mine in the world, it is very difficult to monitor the integrity of the 37 substations mine wide. This project also stems from the need to be able to eventually remotely trip and close the circuit breakers of the substation. This is a major need as there is a high potential of an arc flash when closing the circuit breakers. This creates a risk for the technician who currently has to close these in manually. This is not going to be included in this project as we do not have the time nor resources to perform this research and development. This does however give us a requirement that when we design we must leave the ability to conduct these tasks later on after this project is completed.

## 1.3 Document Layout

The sections that follow provide a simplified project example based on our mini-project. Each requirement will be identified through the paragraph numbering structure of this document. The document structure shall be as follows:

1.w.x.y.z

Example tree structure is given below:

1 *level 1 item*

1.1 *level 2 item*

1.2 *level 2 item*

2 *level 1 item*

Requirements shall be contained in Section 2.1 of this document. The corresponding Specifications are contained in Section 2.2 of this document. The “1.w.x.y.z” numbering scheme shall identify the requirement and specification hierarchy.

## 2 Project Requirements and Specifications

### 2.1 Requirements

1 Power Monitoring System

Design a system that utilizes components that are in use at the mine to monitor the power distribution system of the pit substations.

2 Wireless Data Transmission

Design a wireless system that transmits data over the Rajant wireless mesh network.

3 Human Machine Interface

Design a human machine interface that allows for the operators at the mine to monitor currents voltages and positions of the substations remotely. This is in the form of some screen that displays these items upon the users request of substation number.

4 Global Positioning System

Design a system that allows the location of the substation to be relayed over the wireless network.

5 Documentation

Provide all documentation associated with this project.

## 2.2 Specifications

### 1 Power Monitoring System

- 1.1 Design a system to monitor voltages and currents of the substation through the existing Current Transformers and Potential Transformers
  - 1.1.1 Monitor Line voltages
  - 1.1.2 Monitor Line Currents
  - 1.1.3 Monitor Phase voltages
  - 1.1.4 Monitor Phase Currents
- 1.2 Following MSHA electrical codes, study and implement a ground fault monitoring system.
  - 1.2.1 Utilize a Ground Fault Resistor that is already on the substation
  - 1.2.2 Utilize the Ground Fault Relays that are being used now
  - 1.2.3 Wire and program the ground fault relays
- 1.3 Have indication lights to show what state the circuit breakers of the substation are in
  - 1.3.1 Have an LED light for the trip state of each set of circuit breakers
  - 1.3.2 Have an LED light for the Closed state of each set of circuit breakers
- 1.4 Use General Electric 750 Feeder Protection Relays to monitor the system
  - 1.4.1 Program the relay to monitor the voltages and currents specified above
  - 1.4.2 Program the relay to push the voltage and current data over the ether net port on the rear of the relay
  - 1.4.3 Create a document that explains how to change the settings within the relay
  - 1.4.4 Program the relay to trip the circuit breakers on an over-current
  - 1.4.5 Program the relay to trip the circuit breakers on phase imbalances
  - 1.4.6 Program the relay to trip the circuit breakers on voltage imbalances
  - 1.4.7 Program the relay to trip the circuit breakers on voltage drops and spikes

### 2 Wireless Data Transmission

- 2.1 Use Allen Bradley programmable logic controllers on the substation and in the office going to the HMI
  - 2.1.1 Use Allen Bradley ControlLogix 5000 PLC's
  - 2.1.2 Use Rockwell Collins RSLogix 5000 PLC's
  - 2.1.3 Use Modbus/TCP data communication protocol
  - 2.1.4 use cat 5 ether net cable for hardwired communication
- 2.2 Use the Rajant wireless network to transmit data
  - 2.2.1 Transmit Line voltages
  - 2.2.2 Transmit Line Currents
  - 2.2.3 Transmit Phase voltages
  - 2.2.4 Transmit Phase Currents
  - 2.2.5 Transmit GPS location

- 2.2.6 Transmit the trip/close state of the circuit breakers
- 2.2.7 Take an input signal from the PLC on the substation
- 2.2.8 Output a signal in the office where the PLC going to the HMI is located
- 3 Human Machine Interface
  - 3.1 Research and determine what type of HMI is the best option for our use
  - 3.2 Design a human machine interface that allows an operator to monitor the voltages and currents that were transmitted over the wireless system
    - 3.2.1 Display the substation number
    - 3.2.2 Display the substation GPS location
    - 3.2.3 Display the line currents
    - 3.2.4 Display the line voltages
    - 3.2.5 Display the phase currents
    - 3.2.6 Display the phase voltages
    - 3.2.7 Display the Current and Voltage waveforms
      - 3.2.7.1 Calculate and Display the current waveforms on a secondary screen displaying the substation number
      - 3.2.7.2 Calculate and Display the voltage waveforms on a secondary screen displaying the substation number
    - 3.2.8 Calculate and Display the power usage and power factor of the system
  - 3.3 Create documentation on how to add another feed from another substation
  - 3.4 Create a document explaining how to extend this HMI's usage to other substations around the mine
- 4 Global Positioning System
  - 4.1 Research what is the best way to determine the location of the substation within the mine site
  - 4.2 Develop a system that allows the location of the substation to be transmitted through a PLC configured for I/O data signals
  - 4.3 Develop the system to mark the location of the substation on a map of the mine site
  - 4.4 Mark the location of the substation to within one yard
- 5 Documentation
  - 5.1 Develop a documentation binder for all work associated with this project
    - 5.1.1 Include the Project Proposal
    - 5.1.2 Include all meeting notes
    - 5.1.3 Include all technical documents
    - 5.1.4 Include all documents that explain the system
    - 5.1.5 Include all documents that step technicians through daily activities
    - 5.1.6 Include the Requirements and Specifications Document
    - 5.1.7 Include the Preliminary Design Review documents
    - 5.1.8 Include the Critical Design Review documents

- 5.1.9 Include the final report
- 5.1.10 Include any other documentation that we determine fit
- 5.2 Develop a professionally constructed documentation binder that could be used to recreate our design