Department of Electrical & Computer Engineering

Requirements document for

Wireless Power Monitoring and Control System

Submitted to:

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Executive Summary

Currently, only large power utilities can use computerized systems to monitor and control substations and downstream devices. These systems allow live reporting and control capabilities, as well as automated switching capabilities in most cases. Unfortunately, these systems usually have an installed cost from several thousand dollars up to one million dollars or more[10,5], and require such exotic equipment such as fiber optic modems and land-lease lines for dedicated communications[9]. While these allow for a fast reliable system, the price makes it prohibitive for smaller utilities and cooperatives[5].

Our design will allow reporting and control capabilities, but with a cost in the thirty-five thousand dollar range and with a wireless implementation between the host & location, and the location center and individual devices[4]. All this will be done while keeping latency at a minimum to make the new system respond nearly as quickly as the existing systems. Our design will add newly desired features such as web interface and a centralized server based SQL database system. These features will create a product that works more efficiently with existing software, as well as removes platform dependencies.

We will use Scientific Atlanta's LLEOS (Little Low Earth Orbit Satellite) Transponder to communicate between the host and the site via satellite. A wireless communication system will be bought to allow communication between the transponder and the individual devices to control and/or monitor. The implementation of this now affordable technology will significantly reduce cost[9]. We are going to build an I/O board that will monitor and report the status of any device that supports analog and discrete data points. The I/O board will also be able to control discrete outputs. Software will be written to allow for a simple interface to control and monitor the devices. Software will be written to run on the transponder to interpret data received from the I/O board.

This design will allow for an inexpensive alternative to existing systems, while allowing most currently available features[1]. This design should also allow for easier system maintenance and upgrades, which are the biggest problems facing some of the larger systems [5]. This system should be simple enough that anyone familiar with electric utility operations should be able to operate it, unlike current systems that need dedicated and trained technicians to monitor and control the systems at all times. These features should make this system more appealing to smaller electric utilities that need automation technology but don't have the budget to accommodate larger systems or extra employees [5].

Beyond this project, the software and technology could easily be expanded to accommodate more services such as agriculture, offshore oil rigs, and any other application that involves machinery that could be remotely controlled or monitored via dry contacts. Several other industries and businesses need inexpensive ways to monitor and control devices in remote locations such as breakers, pumps, and generators, and this system would be ideal for these situations. Also, the technology could be further extended to decrease the latency with the satellite communications, and the wireless communications system could be improved to allow longer range. All of these would further increase the usefulness and capabilities of the system.

1. Problem

Large electric utilities frequently use automated systems to monitor and control devices in the field and in substations[1]. These allow switching routines and minor maintenance to be performed in much shorter time than any human could accomplish by eliminating the time required to drive to and from the site. They also save money by not requiring as many people to be on call[5].

These systems reduce error, downtime, and costs by reducing the amount of human intervention required[6]. By enabling a single computer to automatically initiate long complicated sequences of actions upon a certain occurrence, they reduce the time needed for a human to notice and respond to the occurrence and the possibility of error [4].

Unfortunately, these automation systems are usually only used by very large utilities because of the cost required to purchase, install, and maintain them [1]. For example, Harris and GE's SCADA requires nearly $75,000 in basic equipment to wire up a single substation. This doesn't include costs in wiring, installation time, and software configuration, which must be purchased separately for another hefty sum [5].

Most systems also have such exotic requirements as fiber optic lines running to all devices and dedicated landlines to each device [3]. While this is fine for large utilities and dense areas, this is cost-prohibitive for monitoring only a single device. Large systems also are frequently extremely complicated. They require specially trained personnel to control the devices. While trained personnel is probably a good idea in most cases, smaller utilities do not have the necessary funds to hire these rare highly trained professionals.

An inexpensive system is needed to accommodate the needs of smaller utilities and the needs of companies with more remote locations [5]. By using new innovations in communications, all of the dedicated phone line and fiber optic cables should be replaceable with newer and cheaper wireless alternatives. A less complicated system is also needed [5]. By creating a system that is easily expandable, while maintaining some of the most frequently used features of the existing systems, smaller utilities would be free to use them with almost no training. Basic computer knowledge and minimal training would be the only requirements to operate the system.

If such an implementation could be found, then almost all of the US's electric grid (and possibly the world) could be automatically controlled via computer. Utilities would save money by reducing the costs of maintenance crews. It would also make deregulation of electric utilities a much easier thing to implement [6]. Automating back-feeding and switching procedures would significantly reduce downtime, which is becoming an increasingly significant problem in today's "wired" world [5].

2. Objectives

1. **Speed**: Our system will send commands and receive results from the targeted devices within 11 minutes.

2. **Range**: The range of the new system will allow a single transponder to monitor all devices located within the substation up to 400 feet.

3. **Data integrity:** All devices will retain data during any and all power outages.

4. **Cost:** The entire system must have an all-inclusive installed cost below $35,000 per substation [9].

5. **Accuracy:** Our system should be able to receive at least 95% of all commands.

6. **Weatherproof:** All hardware must be capable of withstanding normal weather temperatures and be capable of handling rain, snow, and heavy winds.

7. **User Configurable:** All hardware should be easily user-configurable with no special tools other than the hardware itself and the designed software. All software should be easily understood by anyone familiar with electric utility operation and minimal training [8].

8. **Modularity:** The system should be easily to install and upgrade. All hardware should be replaceable with little or no configuration [8].

9. **Safety:** The device will conform to all known FCC regulations regarding radio transmissions, and all NEC regulations regarding power equipment. Also, the hardware should have safety parameters to protect servicemen working on remotely controlled equipment.

2.1. Improved Performance through Wireless

Using wireless communications should allow the following[7]:

1. Easier installation
2. Easier maintenance
3. Greater reliability
4. Lower Cost

Easier installation and maintenance should come from removing the dependencies on cables. Wired systems take much longer (hence much more money) to install and maintain, because cables must be run from the control house to every device the user wishes to monitor or control, and frequently these cables are run underground to reduce breakage[3]. These cables are also frequently expensive because of the speed and data integrity requirements. A wireless system will be much easier and faster to install and maintain without the requirement for cables[4]. Also, it will be much more reliable because it removes the possibility of a cable being severed or defective. A wireless system should significantly reduce costs by eliminating any cable costs, and reducing installation time[7].

2.2 Design of Wireless Communication Units

There are 4 main considerations in the design of the wireless units.

1. Packaging
2. Safety
3. Power loss
4. Speed

Of these, Safety and power loss are the most important.

Packaging must be able to withstand heavy wind, rain, extreme heat, and extreme cold. Also, it must be aesthetically pleasing. In the event of maintenance, it should be simple enough to open and quickly modify any hardware-based operating parameters.

There should be an easy way to discontinue remote control of devices so that serviceman, with no risk of anyone remotely activating the device, may perform routine maintenance. This is commonly called a “supervisory switch” and most new devices already have these. Several older devices, including most analog devices, do not have any form of remote protection. These devices will need an external supervisory switch built into the monitoring system.

All units should remain “stable” through a power loss. This means that the user should not have to perform the installation procedure after each power loss. Some parameters will have to be stored in some type of memory, so that when power is restored they can simply return to operating status.

The entire system should be able to retrieve monitored information within 5 minutes, and able to transmit control sequences within 10 minutes. These times, however, will have to be an average time. There will be instances where it could take much longer to retrieve or transmit data due to several factors beyond our control such as satellite availability, network control center loads, and message length.

2.3 Devices Being Monitored by the System

Cooper 4C Reclosure:

Open/close – if can’t stay close after three tries it will have to be manually closed; Current; Voltage; Phases

Cooper Voltage Regulator

Read tap position; Set tap position; Current / voltage; Max/min voltage; Current through device

Fuse

Good/Bad

2.4. Design of Software

The PC software should be both easy to configure and easy to use. It should provide monitoring and logging of data, along with basic control features. Graphics should be descriptive of devices and conditions, and should require minimal knowledge of computers for use. [8]

The transponder software should also be easy to configure. It will have to be bug free to maintain reliability, and also obey the limitations of the transponder. It must be able to detect a communications error and correct or report it, depending on the severity. When power is restored after an outage, it must be able to quickly restart the program with no loss of data, and return to an operating state. [5,8]

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Figure 2.1 "Equipment involved in the overall process."