Recent Advances in SCADA alarm System

Rajeev Kumar
Assistant Professor
Department of Instrumentation and Control Engineering
Galgotias College of Engineering Greater Noida-201306, India
E-mail: rajeevchr@hotmail.com

Abstract

SCADA stands for supervisory control and data acquisition- any application that gets data about a system in order to control that system is a SCADA. Some sensors detect conditions"on" or an "off". That "on" or an "off" originate as an on/off, Such as a valve sensor or it can represent an analog value that crosses a threshold value. Other sensors measure more complex situations where exact measurement is required. So we have developed a system in which SCADA system may be able to gets the more alarm details than a single discrete alarm point can provide in real time.

Keywords: *SCADA, Analog, Discrete, threshold RTU.*

1. Introduction

Supervisory control and data acquisition (SCADA) refer to the overall set of process control system systems that remotely monitor and measure remote sensors from a centralized location. These sensors also typically possess some type of automated response capability when certain criteria are met.

Systems that manage systems over very large geographic areas are typically referred to as Supervisory Control and Data Acquisition systems or SCADA systems. SCADA systems make up the critical infrastructure associated with electric utilities, water and sewage treatment plants, and large-scale transportation systems like interstate rail.

The basic structure of SCADA systems is made up of a wide range of components and several different communication protocols. The operation of such a large and diverse infrastructure requires an extensive network of electronic devices, communications, and control and monitoring systems, such as:

- Field Devices
    - Remote Terminal Units (RTU)
    - Programmable Logic Controllers (PLC)
    - Intelligent Electronic Devices (IED)
    - Programmable Automation Controller (PAC)
- Management systems to monitor and control field equipment
    - Human Machine Interface (HMI)
    - SCADA Controller or Real Time Processor
    - Historian
- Communications
    - Ethernet, Wireless, Serial
    - Modbus, DNP3 [4]

At the lowest level, the field devices are proprietary devices running embedded operating systems. These devices originally used serial communications to report to the centralized control center utilizing field bus protocols like Modbus and DNP3.Given the low bandwidth connections, these devices reported on a polling basis or a report-by-exception basis to minimize network traffic. The SCADA controller is responsible for managing all of these communications, analyzing the data, and displaying the alerts and events on the HMI systems.

In this paper we focus on analog sensors used in Steam Turbine System (STS).the Steam temperature, Pressure, and moisture are the three measure analog parameters in a steam turbine. Analog monitoring is highly valuable because it conveys specific value of the parameters. Near real time readings of these continuous values provide a much clear picture of the STS system than we can achieve with discrete alarm points alone.

2. Sensors and Transducers

The transducers that convert the mechanical input signals into electrical output signals are called as electrical transducers. The output obtained from the electrical transducers can be read by the humans or it can give as input to the controllers.

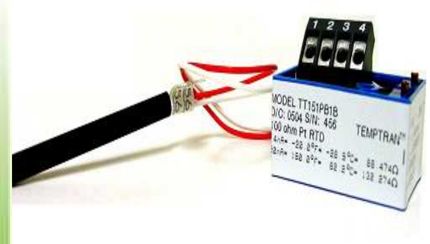
Transducers are the mechanical, electrical, electronic, or electromechanical devices that convert one form of the energy or the property that cannot be measured directly into the other form of energy or property that can be measured easily. The signal given to the transducers is called as input; this is the parameter that is to be measured but cannot be measured directly. The signal obtained from the transducer is called as output, which can be measured easily.

The transducer selected for the measuring system is such that the output obtained is proportional to the input. Since the output can be measured easily by the available instruments, the scale can be calibrated between the values of the output and the input. From this calibration, for all the values of the output the input value i.e. the parameter or physical quantity to be measured can be obtained easily.

The transducers are used for various applications, but here we are considering transducers used for the measurement of the physical quantities like temperature, pressure, Moisture etc.

Thermometer

The liquid have the property "liquids tend to get expanded when heated and get contracted when cooled". This property of the liquids is used to measure the temperature in thermometers, which is type of transducer.



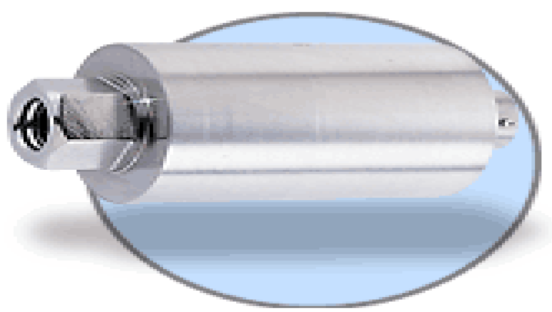
Temperature Sensor with Probe

In thermometers there is thin capillary tubing and small bulb at the bottom, which is filled with highly temperature sensitive liquid called mercury. When the temperature of the bulb of the thermometer increases, the mercury tends to expand and fill the capillary tube to certain level depending on the temperature. The thermal expansion of mercury is proportional to the temperature of the mercury, so more is the bulb temperature more is expansion of the fluid. Thus if the bulb temperature is higher, mercury will expand to higher levels in the capillary and if its temperature is lesser, the rise in level will also be lesser. [5]

Pressure Transducer

A pressure transducer is a transducer that converts pressure into an analog electrical signal. Although there are various types of pressure transducers, one of the most common is the strain-gage base transducer. The conversion of pressure into an electrical signal is achieved by the physical deformation of strain gages which are bonded into the diaphragm of the pressure transducer and wired into a Wheatstone bridge configuration. Pressure applied to the pressure transducer produces a deflection of the diaphragm which introduces strain to the gages. The strain will produce an electrical resistance change proportional to the pressure. This transducer provides a 4-20mA signal. This is also least affected by electrical noise and resistance in the signal wires because the 4-20mA signal.

High Stability/High Accuracy Pressure Transducers: Most pressure transducers feature an accuracy of 0.25% of full scale or higher. High stability and high accuracy pressure transducers can offer errors as low as 0.05% of full scale, depending on model. Although more expensive than general purpose transducers, they may be the only option if high precision is required. [5]



PX01 High Stability / High Accuracy Transducer

Humidity Sensor

Humidity is the most effective parameter in the steam turbine. So it is one of the key environmental alarms to monitor in unmanned remote site. Looking at both internal and external humidity ranges, it is very important to monitor what conditions of turbine revenue-generating equipment is operating in.

Temperature / Humidity Sensor with -48 VDC to -12 VDC Converter

If the turbine control unit failed and we did not have adequate monitoring of the humidity in the turbine, we would be completely unaware of the damage and would be too late in preventing equipment failure. Humidity can be monitored with both discrete and analog sensors much like temperature. But we are required the clear picture of the humidity in the steam turbine so we chose the analog senor.

As far as device configuration and condition monitoring, the on-line system has provided a completely different way of approaching items such as valve maintenance. We now have remote diagnostics and programming capability which saves us lots of time, effort and running around. Our daily routine is much more planned and efficient. Travel deviation on the valve positioned is the item that we watch most closely. Each day we check the status monitor for any problems. We get a warning at 2% travel deviation and an alarm at 4% deviation. But that doesn't mean we have to run out immediately. The key thing we look for is a worsening trend, which indicates a potentially serious problem."

Our inherently reliable metal and soft seated ball and butterfly valve solution assure increased risk reduction and provide long lasting tight shut-off with fast and safe operation together reduced fugitive emission for your safety applications.

In this paper as we have discussed above temperature, Dryness fraction factor or humidity, steam pressure are the measure parameter which effect the energy transformation as well as the maintenance of the steam turbine plant. So the picture of temperature, Dryness fraction factor or humidity, steam pressure in the steam turbine must be clear to for to improve the efficiency as well as to minimize the accidents in the steam turbine plant.

Some sensors detect conditions that are reported as an "ON" or an "OFF" called a discrete input or digital input. That "ON" and "OFF" originate as an ON/OFF, such as a valve sensor can represent an analog value that crosses a threshold. But in a steam turbine we have to measure the more complex situations or we required exact measurement. Not every alarm condition can be represented by an "ON" and "OFF".

Analog provide the ability to monitor environmental factors like temperature, Dryness fraction factor or humidity, steam pressure that affect the steam turbine operation. These inputs can answer the question of "how much" temperature, Dryness fraction factor or humidity, steam pressure. By knowing when these factors cross critical thresholds and by seeing their rate of change, Engineer/operator can take action before these conditions affect our system. As an example, operator might increase the temperature if the dryness fraction is low.

In this steam turbine system, operator ideally wants to keep the value between a bottom and top level. For example, operator wants the steam temperature in the turbine 50 and 73 degree Fahrenheit. If the temperature goes above or below this range, operator or system engineer need to be notified.

3. Establish critical thresholds

SCADA system is support to custom "safe zone" and alert operator automatically if the sensor detects conditions outside of that range. To make this system more advance we have specified six threshold alarm for all three measuring parameters i.e. temperature, Dryness fraction factor or humidity, steam pressure analog sensors, Low, minor Low, major Low, High, minor High and major High alarms as shown in Figure.1. These user defined values will help him/her to distinguish the severity of alarms by the indicating of alarms by indicating when a monitored analog has passed a certain value, such as a major Temperature high that threatens the equipment. Nominal range as shown in Figure.1 is the range of temperature which is specified by the system administrator.

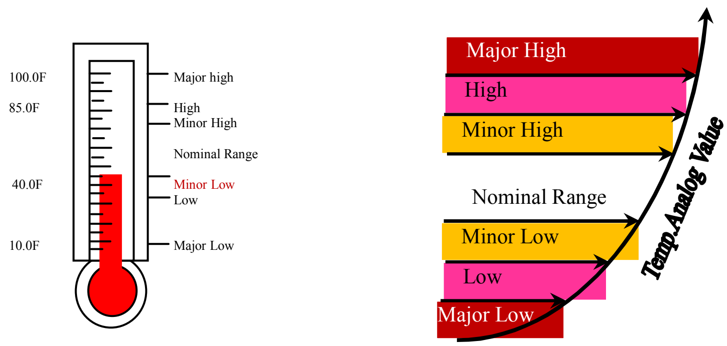


Figure 1. Set-Up of threshold values

Basic SCADA almost never include analog inputs, so we are never be able to measure exact values. Analog sensors Support gives us the key advantages of the complete visibility. As shown in Fig.1 we have set-up six different threshold values for a temperature sensor:

When the temperature is less than 10.0 degree Fahrenheit, page a technician and notify the network operation with a "Major Low" alarm. This low value might indicate that the heater is not working from long time.

When the temperature is less then 35 degree Fahrenheit, page a technician and notify the network operation with a Low alarm.

When the temperature is less then 45 degree Fahrenheit, page a technician and notify the network operation with a "Low" alarm. This low value might indicate that the heater is not functioning at full capacity.

When the temperature is more then 75 degree Fahrenheit, page a technician and notify the network operation with a "Minor High" alarm. This High value might indicate that the Cooling system is not working properly.

When the temperature is more then 85 degree Fahrenheit, page a technician and notify the network operation with a "High" alarm. This High value might indicate that the Cooling system is not functioning at full capacity.

When the temperature is more then 100 degree Fahrenheit, page a technician and notify the network operation with a "Major High" alarm. This High value might indicate that the Cooling system has failed.

Similarly we have also defined six-six thresh hold values for the pressure as well as moisture sensor to give the exact picture of pressure and humidity in the steam turbine to automatic control the system. It means we have defined 6 threshold values for each sensor or we can say that we define 6×3=18 threshold values to show the exact internal picture of the steam turbine. To control and monitor these 18 values we have used an advance remote terminal unit (Net Guardian 832A G5).

4. Advance Remote Terminal Unit

The advance remote terminal units (Net Guardian 832A G5) may include the following features:

1. **All Inclusive Sensor Platform**

Collect all the discrete and analog data we need at a single on-site RTU. The Net Guardian 832A G5 in the Steam turbine for temperature above has 8 inputs for analog sensor data, as well as 48 discrete alarm inputs for discrete sensors. Sensors attached to the RTU input their

"ON" / "OFF" data (discrete) or actual measured values (analog). Data is processed at the RTU and transported via LAN. RTUs like the Net Guardian 832A G5 can send 24/7 email and pager notifications to techs, based on the information provided from sensors.

2. Derived alarms and controls

Derived alarms are software-based alarms that occur whenever a user-defined combination of events occurs. Commercial power failure at an enclosure might be a minor alarm. Low battery at an enclosure might be a minor alarm. But the combination of a power failure and a low battery should be reported as a critical alarm, and derived controls allow us to do just that. Derived controls take this concept one step further. They are automatic responses to alarm combinations. Here we have setup a simultaneous power failure and low battery to automatically latch a control relay tied to a backup generator. This kind of advanced automation corrects network threats within seconds, protecting mission-critical equipment.

3. Hardened, industrial grade units

The Site climate is an important issue for SCADA system. If remote sites run the risk of being snowed in then the humidity in location reach extreme highs. The Rugged engineering allows advanced remotes to perform in the harshest conditions. The RTU for SCADA system should be built to withstand extreme high and low temperatures, as well as humidity and other factors that are relevant in your region. The Net Guardian 216 has industrial temperature ratings. This highly durable RTU withstands extreme hot and cold conditions, thanks to rugged engineering and brutal product testing. The Net Guardian 216 operates at temperatures between 32 and 140 degrees Fahrenheit.

4. Non-Proprietary Sensors - (+/-5V)

Using non- proprietary sensors gives a wider variety of vendors to choose from. An advanced RTU will give this freedom by accepting the standard +/- 5V input from analog sensors. This will prevent us from being "locked" into a single vendor because of compatibility issues.

5. Analog Value Scaling

In the event of an alarm set off by one of sensors, we can know the severity of the situation immediately. Use sensor calibration with analog value scaling on a modern RTU to program a translation from meaningless voltage output to useful sensor readings. For example, an alarm goes off at a remote site, and the sensor is reading 4.2v. The advanced RTU would hide the voltage and display "110 degrees Fahrenheit". Now any one would instantly recognize the danger. [9]

5. Evaluation of SCADA Master Stations

We have developed a SCADA system in which an engineer may be able to monitor all the systems like temperature, Pressure, and Moisture in the steam turbine from a central location. In this system all the three parameter like Temperature, pressure and moisture may be maintain in a user specified range automatically. The real SCADA do not communicates with just electrical system; either SCADA Data is enclosed in protocol format. But all the temperature sensor, moisture sensor and pressure sensor and relays are electrical devices that can not generate or interpret protocol communication. But remote terminal unit (RTU) encodes the sensor inputs into protocol format and forward then to the SCADA master and receives control commands in protocol format from master. So all the turbine system sensors are interface to SCADA by a remote terminal unit as shown in Fig.2.

The SCADA master also performs data processing on the information's gather from the temperature, pressure and moisture sensor and sends the control commands in protocol format. It also maintains report logs and summarizes historical trends.

The SCADA master presents a comprehensive view of the entire system and also presents more detail in response to user request. It monitors all the sensors and also alert to the operator if there is any alarm. As shown in Figure.2 the temperature is minor low.

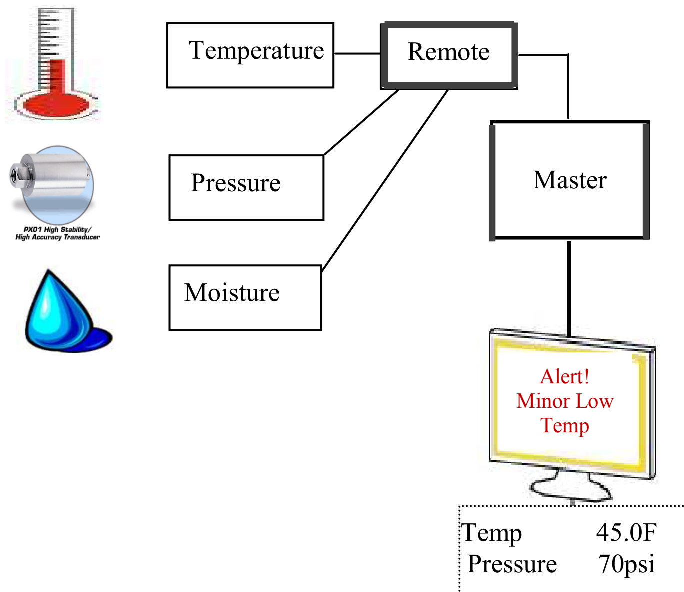


Figure 2. SCADA Master Station

To transport all the data collected from the Temperature, Moisture and pressure Sensors and control commands we set up an Ethernet and IP. To make our system more secure we kept our SCADA System on closed LANs without exposing sensitive data to the open internet.

6. Conclusion

Basic SCADA almost never include analog inputs, so we are never be able to measure exact values. So the stabilization of more number of threshold values (six threshold values) for each parameter we are able to show the complete visibility of the exact internal picture of the turbine as well as the system controlling may be also more effective.

Here as the number threshold values increase i.e. the number of sensor inputs increase but the use of advance Remote terminal unit (Net Guardian 832A G5) increase the ability of the system to more number of sensor inputs communication. It means in the cost of the system may be minor increase.

References

[1]. "Environmental Sensors for Monitoring Temperature, Humidity, Battery Levels and Building Alarms", DPS Telecom 4955 East Yale Avenue, Fresno, California 93727.

[2]. D.S.Kumar, "Mechanical Measurements and control", fourth Revised & enlarged edition-2006, Metropolitan book Co. Pvt.Ltd.1, Netaji Subhash Marg, New Delhi-110002.

[3]. Bob Berry, "A Fast Introduction to SCADA Fundamentals and Implementation". DPS Telecom 4955 East Yale Avenue, Fresno, California 93727.
[4]. "A Strategic Approach to Protecting SCADA and Process Control Systems" IBM Internet Security Systems, Inc. (2007)
[5]. www.brighthb.com/engineering/mechanical/articles/41926.aspx
[6]. Robert McMillan, "Hackers Break into Water System Network", InfoWorld (IDG News Service) Nov. 1, 2006; www.infoworld.com
[7]. Rune GUSTAVSSON, "Sustainable Virtual Utilities based on Micro grids" School of Engineering, Blekinge Institute of Technology Ronneby, SE-372 25, Sweden.
[8]. R.S.Khurmi, J.K.Gupta, "A text book of thermal engineering" S.Chand & Company Ltd, Ram Nagar, New Delhi-110055. ISBN-81-219-2573-8. (2007)
[9]. Bob Berry, "Unleash the power of your SCADA System with Advanced Sensors" DPS Telecom 4955 East Yale Avenue, Fresno, California 93727.version 1.0 February 3, 2009.
[10]. De Marco, C. and Braden, Y. "Threats to Electric Power Grid Security through Hacking of Networked Generation Control" In *Proceedings of CRIS Third International Conference on Critical Infrastructures*, Alexandria, VA. (2006)
[11]. Gustavsson, R. and Fredriksson M. Process algebras as support for sustainable systems of services. Invited paper to a special issue on *Applicable Algebra in Engineering, Communication and Computing* named *Algebraic Approaches for Multi-Agent Systems*. (2005)
[12]. Gustavsson, R., Mellstrand, P., and Törnqvist, B, "Information *Security Models and Their Economics"* CRISP Deliverable D1.6, BTH. (2005a)
[13]. Gustavsson, R. (2006a). Ensuring dependability in service oriented computing. In *Proceedings of The 2006 International Conference on Security & Management (SAM'06)* at The 2006 World Congress in Computer Science, Computer Engineering, and Applied Computing, Las Vegas, 2006.
[14]. Gustavsson, R. and Mellstrand, P. (2007) Ensuring Quality of Service in Service Oriented Critical Infrastructures. In special issue of the *International Journal of Critical Infrastructures (IJCIS)*, Indersciemce, 2007.
[15]. Handschin, E., Krause, O., Wedde, H. F., and Lehnhoff S. (2006) the Emerging Communication Architecture in Electrical Energy Supply and its Implications. In *Proceedings of the CRIS Workshop 2006. Influence of Distributed and Renewable Generation on Power System Security*. Res Electricae Magdeburgenses, MAFO Band 13, 2006.
[16]. Lewis, T. *Critical Infrastructures Protection in Homeland Security. Defending a Networked Nation*. Wiley-Interscience, ISBN-13: 978-0-471-78628-3. (2006)
[17]. Mellstrand, P. *Protecting Software Execution by Dynamic Environment Hardening*. BTH licentiate dissertation series no. 2005:12. (2005)
[18]. Mellstrand, P. *Informed System Protection*, BTH Doctoral Dissertation Series No. 2007:10. School of Engineering. Blekinge Institute of Technology (BTH). (2007)
[19]. Mellstrand, P. and Gustavsson, R. (2006a) An Experiment Driven Approach Towards Dependable and Sustainable Future Energy Systems. In *Proceedings of CRIS Third International Conference on Critical Infrastructures*, Alexandria, VA, September 2006.
[20]. Rahman, H.A., Beznosov, K., and Marti, J.R. Identification of sources of failures and their propagation in critical infrastructures from 12 years of public failure reports. In *Proceedings of CRIS Third International Conference on Critical Infrastructures*, Alexandria, VA. (2006)
[21]. Schreiber, G, et.Al. (1999) Knowledge Engineering and Management. The CommonKADS Methodology. MIT Press, ISBN 0-262-19300-0. (1999)
[22]. Schaeffer, G.J., Warmer, C., Kamphuis, R., Hammelberg, M., and Kok, K. (2006) Field Tests Applying Multi-Agent Technology for Distributed Control: Virtual Power Plants and Wind Energy. In Proceedings of the CRIS Workshop 2006. Influence of Distributed and Renewable Generation on Power System Security. Res Electricae Magdeburgenses, MAFO Band 13, 2006.

Author profile

Rajeev Kumar graduated in Electrical from Institutions of Engineers (India) in 2007 and received his Master's Degree in Instrumentation and Control Engineering from Dr. B.R. Ambedkar National Institute of Technology Jalandhar, Punjab, India in 2009. He is currently working as an Assistant Professor in Department of Instrumentation and Control Engineering in Galgotias College of Engineering and Technology, Greater Noida, India. He is the Member of the reviewer board of Engineering Letters, International Association of Engineers (IAENG) Hong Kong. His current Research Interest includes SCADA and Renewable Energy Resources.

E-Mail : rajeevchr_nitj@yahoomail.com