Supervisory Control and Data Acquisition for A DHDS Substation

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ABSTRACT: This paper presents the design of a Supervisory Control and Data acquisition (SCADA) based automation system in DHDS plant. SCADA is a system which is used to monitor and control the circuit breakers, equipments etc from a remote site. SCADA system includes a user interface usually called Human Machine Interface (HMI). Electromagnetic relays are replaced by numerical relays since numerical relays can handle complexity. A substation automation system comprises of numerical relays and meters at feeder level interfaced to Device interfaced Processor (DIP). The DIP's are connected to central server on LAN. The numerical relays used are SIPROTEC 7SJ61 and 7SJ63. The process visualization software HMI is installed on this central server. Desired parameters such as voltage, current, power factor, MVA, MVAR, KWh etc of Remote Terminal Units (RTU) can be controlled and monitored by connecting the system to SCADA. The SCADA is implemented in nearly all industries because automation increases the efficiency and anything that increases efficiency helps to reduce the cost. The proposed SCADA system can find wide application in controlling and monitoring of the system distributed over extensive geographical area with fast reaction for cost reducing management.

KEYWORDS: SCADA automation, DHDS plant automation

I.INTRODUCTION

  A supervisory control and Data acquisition (SCADA) system consists of one or more computers with appropriate applications software (Master Stations) connected by a communication system (wire, radio, power line carrier or fiber optics) to a number of remote terminal units (RTU) placed at various locations to collect data and for remote control and to perform intelligent autonomous (local) control of a system and report results back to the remote masters. SCADA system includes hardware and software component. The hardware gathers and feed data in to a computer that has SCADA software installed. The computer then processes this data and presents it in a timely manner.

 SCADA warns when conditions become hazardous by sounding alarms. SCADA allows safe and reliable operation to control the complete network from a central control room through various plant overviews. The substation automation system comprises of numerical relay and meters at feeder level interface to Device interfaced Processor (DIP). DIP's are connected to central server on LAN. The process visualization software (HMI) is installed on this central server. The operating system of HMI is SIEMENS WINCC. The electromagnetic relays are replaced by numerical relays since it can handle complexity. Thus, SCADA allows the utility operator to monitor and control processes that are distributed along various remote sites.

II. SCADA SYSTEM

SCADA stands for Supervisory Control And Data acquisition. This is an industrial measurement of control system. The existing system consists of
1. Numerical relays and meters at the feeder level interfaced to Sicam PCC (PC Control) device interfaced processor (DIP) on IEC-103 and PROFIBUS DP protocols respectively in the three 11 KV substations namely MRS,CPP and CDU.
2. Three DIP/Data concentrators at different substation are connected to a Sicam PCC central server (HMI PC) placed in MRS substation by a fiber optic TCP/IP network LAN. The central server is the main data base for the entire system, which has the configuration and operational data.
3. The process visualization software Simatic Win PCC is installed on the HMI PC. The control and monitoring is possible from HMI (Human Machine Interface).

4.   1At MRS substation, there are two machines available. One will be used an operator console (OC) and other one as engineering console (Eng. PC). Generally, OC shall be used for HMI operator and Engg. Console for operating engineering operations like relay settings, fault analysis etc only in case of failure of OC, Engineering console should be used for HMI operations additionally.
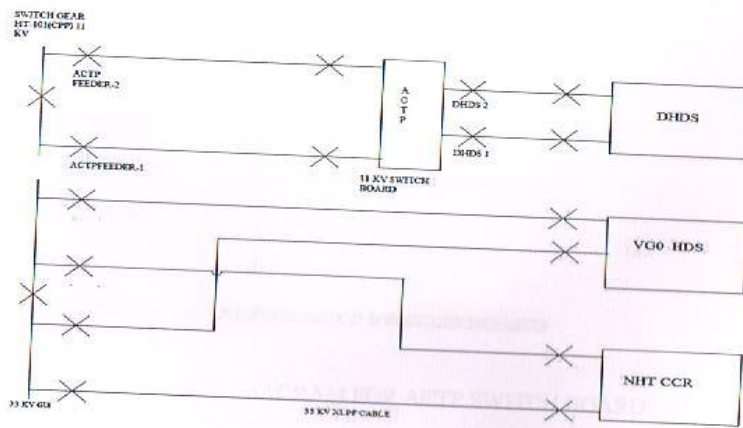
DHDS area- Single line diagram

Fig 1. DHDS area-single line diagram

 This is an environmental project. This has been set up in order to decrease sulphur in high speed to less that 0.25 wt% in the first stage. In the second stage, the sulphur content is reduced to 0.05 wt%. The major processing units in DHDS are Hydrogen generation unit, diesel hydro sulphurisation unit, and sulphur recovery unit.

A. Hydrogen generation unit (Design capacity: 25000 N M3/hr)

Hydrogen of 99.9 % purity is provided by steam reforming of naphtha and purification by pressure swing adsorption. The source naphtha from the tank is desulphurised in the pre –desulphurisation section, where the sulphur content is reduced to < 10 ppm. The PDS consists of a reactor system, a stripper section to strip off the H_2S in the liquid naphtha and a recycle gas system. The system consists of a hydrodesulphurisation reactor with H_2 from the makeup gas compressor followed by a reactor. The desulphurised naphtha is fed to the steam reformer and is fed to a HT shift reactor, where Co further reacts with steam to produce H_2 and CO_2 .The hydrogen rich gas in the shift reactor is then converted to pure hydrogen.

B. Diesel hydro sulphurisation unit

The sour HSD from tanks are pumped to the DHDS feed surge drum through the feeder filler. The feed is mixed with recycle H_2 and preheated before entering the first reactor. There are two reactors in series having three and one bed respectively. The effluent from the first reactor is fed to the second reactor. This is cooled in the feed preheat and is collected in the cold separator. One part of the gas phase from the cold separator goes to the HP amine absorber where H_2S is removed by washing with DEA and goes to recycle gas KOD. The other part bypasses the HP amine absorbed and routed to the recycle gas KOD for maintaining a constant H_2S content. Fresh H_2S is made up from the makeup gas compressor, which is fed from the H_2 plant.

C. Sulphur recovery unit

This is designed to produce 120 TPH of sulphur from hydrogen sulphide rich gases generated from the amine regeneration unit. The hydrogen sulphide rich gases are burnt in the presence of air and reacted over an alumina catalyst to produce liquid sulphur. The liquid sulphur thus produced is solidified as pellets in the pelletiser units.
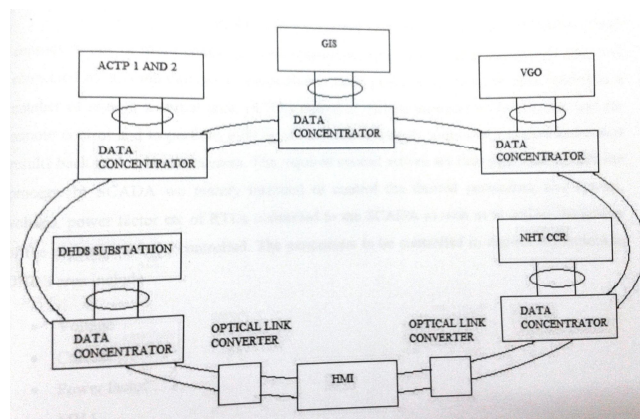
III. PROPOSED SCADA SYSTEM

Fig 2.   Proposed SCADA system

In the proposed SCADA system, for DHDS area, the master station is situated in the captive power plant (CPP). The main unit of master station unit is the Human Machine Interface (HMI) unit in CPP. The different RTU's consist of ACTP 1 and 2, GIS, VG0 HDS, NHT CCR, and DHDS substation. The parameters to be controlled, i.e, current, voltage, MVA, MVAR, power factor, KWh etc are obtained from the data concentrators connected to each RTU in DHDS area. The data concentrator is interfaced with the numerical relay by means of the output ports. The data concentrator of various RTU's are networked together by means of optic fiber cable (OFC). It is this OFC which conveys the information from various RTU's to HMI by means of optical link converter.

Operation:

The proposed SCADA for DHDS area will collect all the parameters to be controlled. The DHDS substation now contains electromechanical type relays. In this system, this electromechanical relays are replaced by numerical relays. The numerical relay used is SIEMENS SIPROTEC 7SJ61. The replacement of electromechanical relay is because of the fact that, we cannot network the electromechanical relay directly to the SCADA system. In order to interface electromechanical system to the SCADA system, transducers and other control circuits are to be used. It is not a good practice to use transducers as they are not reliable and economical.

Different RTU's like ACTP 1 and 2, GIS, VG0 HDS, NHT CCR, and DHDS substation are connected to individual data concentrator by means of input/ output ports available in the numerical relays. Each data concentrator unit is networked to the main station by means of OFC. The OFC's are used as they posses high reliability and efficiency to carry the signals. There is a photo signal booster in order to avoid the attenuation caused due to the transmission of signals in long optic fiber cables.

The network of RTU's for the SCADA in DHDS area forms a closed fiber loop system which enables the network to avoid the transmitter data even when failure occurs. When a failure occurs in one point in OFC, the system is capable to communicate with the main station through another closed loop. There is an optic link converter provided at each terminating point of OFC to the HMI. The purpose of using the optic link converter is such that the signal in the OFC is

in the form of photo signals which is to be converted to digital form that the computer understands. It serves another function such as to convert the signal to an appropriate level of 4 to 20 milli ammeter.

HMI is the centre where the desired parameters are accessed and monitored. It consists of a computer monitor which graphically represents all the parameters to be controlled and monitored. The different methods of operation of HMI are can be represented schematically in the monitor. This is made possible by giving the address or tag of the port in which the particular data is collected in the data concentrator. The addressed data signal is received in the HMI and thus we get the graphical representation. It is from the HMI, we could get the graphical representation of single line diagram of the connected systems and networks. The faults in the network is detected and and we should get the graphical representation of the fault like over current, earth fault, and frequency collapse. They are commonly known as grid faults.

From the HMI, we should get an awareness about the breakers and bus couplers in operation ie, ON or OFF position. It also gives a graphical representation of which the connected loads are islanded and load shedding actuated. The ECS SCADA provides graphical HMI for the electrical network. ECS SCADA is configured in client-server architecture. In a client-server architecture, clients automatically reroutes to project specific master server system. The operator workstations as clients are, connected to both redundant servers through Ethernet switch. The communication between the clients and server is via standard Ethernet TCP/IP connection. The process connections as well as all permanently required functions such as process image, alarm processing, historic records and data processing shall be run on server computers.

ECS SCADA is based on SISOG^{CIS} EDM software (SIMATIC WinCC V6.2) and runs on Microsoft Windows Operating System. SIMATIC WinCC offers standard function modules for the supervisory control and monitoring, real time indication of status, alarm processing archiving and logging.

For an efficient real time monitoring a large amount of information are required to be displayed. This is done in the process visualization system SIMATIC WinCC, which allows the distributed architecture to achieve required smooth processing of real time monitoring of large process data. Its powerful process interfaces shall be configured for operator control, monitoring system for visualizing and operating processes status. The various displays include,

   i.   SLD of the electrical network for overview of the process, monitor the status of various devices, and present the information of various electrical devices normal working condition, current state etc and control of the electrical network.

   ii. Trends display for graphical representation of analog parameters.

   iii. Alarm display.

   iv. Annunciation.

   v.   Event display.

   vi. Legend display.

   vii. Report display

Overview display:

In this display, given in fig 3, single line diagram of individual substation shall be displayed. Circuit breaker status, isolator status, active power and reactive power of feeders, bus voltage and frequency shall be displayed. Control of circuit breakers, isolators, OLTC and generators shall be possible from this display.

In the system overview display, single line diagram of the whole electrical network shall be displayed in brief. In this display, circuit breaker status, isolator status of 33KV, 6.6KV incomers/bus couplers and active power of generators shall be shown. Controls of circuit breakers, isolators, OLTC and generators shall not be provided in this display. Navigation to different individual substation overviews can be done by clicking on the bus bars.
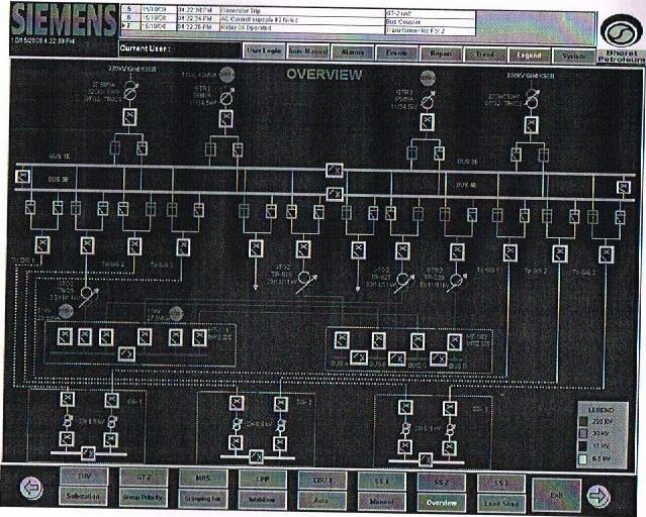
Fig3. overview display

Substation overview display:

In this display, the interconnectivity of ECS system shall be displayed. The display shall include various equipments of the ECS SCADA like workstation PCs, servers, printers, GPS receiver, and their interconnectivity. Status of workstation shall be shown in two colours. i.e, Green for working condition and Red for faulty condition. Status of SISOG EDM servers shall be shown in three colours. i.e, green for working and master condition, Yellow for working and stand by condition and Red for faulty condition.
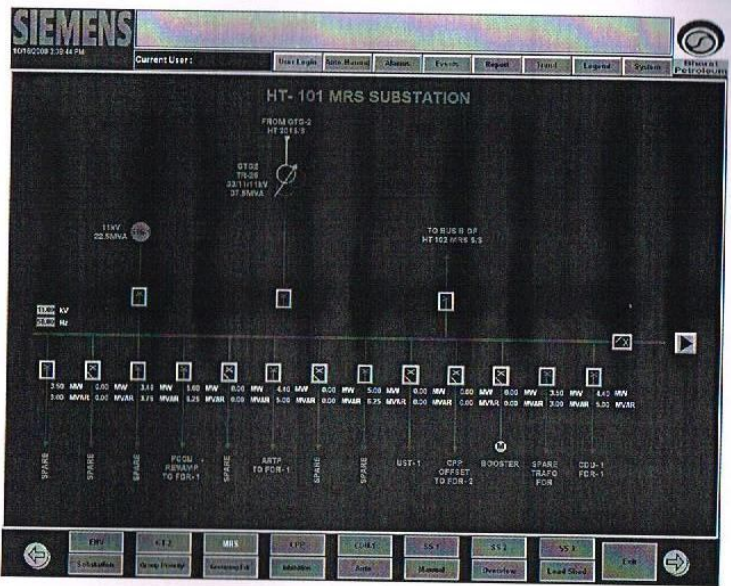

Fig4. Substation overview display

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The working status of the controllers shall be shown in this display. Remote I/O modules and gateways at individual substations shall be shown in separate displays, which can be navigated from the buttons shown in the system overview display. These displays shall show the different remote I/O modules (ET200M), gateway and their connections with IEDs and meters.

IV. CIRCUIT BREAKER CONTROL

By giving a control signal from the main station, we can ON or OFF the desired circuit breakers connected to the different plants. The CB control shall handle all the activities and interlocks relating to a Cb operation. This will include iinterlock status, control , Alarm status, Maintenance condition, operation count. Following details relating to the signals shall be considered for the circuit breaker control, which will be present on CB face plate.

- Close feedback- The close feedback from the CB shown in red colour.

- Open feedback- The open feedback from the CB shown in green colour

- Alarm signals- Alarm signals like Trip circuit faulty, lockout operated, feedback error, breaker unhealthy, fail to open, fail to close from the corresponding CB.

- Interlock bypass option- This option shall be provided for bypassing 4 numbers of least priority close interlock conditions.

- Breaker Close command- Close command from HMI

- Breaker Open command- Open command from HMI

- Interlock status- shows the interlock conditions for open and close operation.

- IO fault- Shows whether there is any input /output fault in the IO card.

The breaker graphics provided shall be used to control and monitor the breakers in the electrical system from the ECS. Control graphic dialogue box shall appear upon selecting the circuit breaker for any control action. The status for the circuit breaker dialog is as follows.

Circuit breaker faceplate is divided in to three sections; Main, Status and Alarms. Main section shall contain information like P value, Q value, currents, CB status (open/close). Status section shall contain information related to close and open interlock conditions. Alarm section shall display the important alarm status of the breaker.
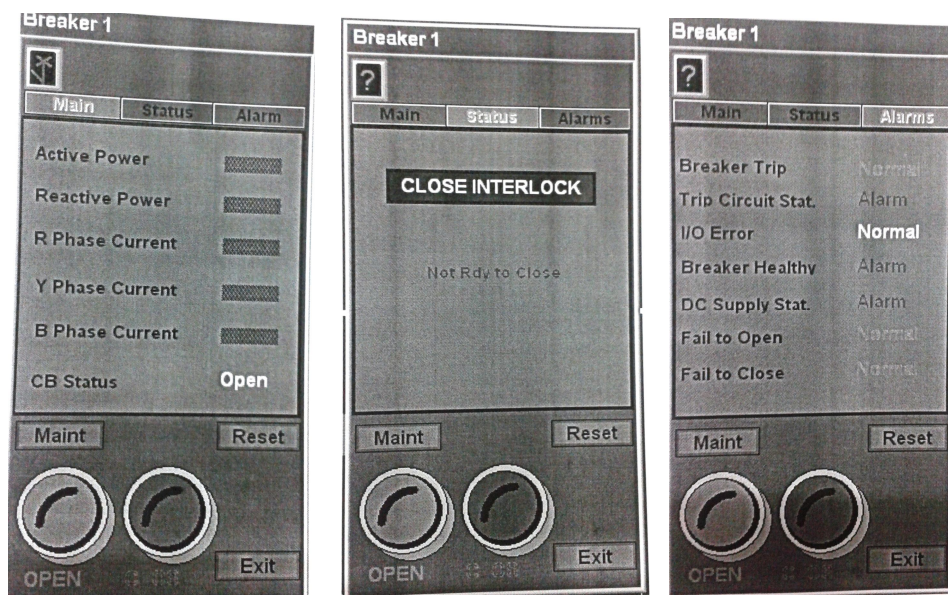

Fig 5. Circuit breaker Faceplate windows Main, Status, and alarms

Circuit breaker face plate shall have command operations like , (i) Open command for opening the breaker, (ii) Close command for closing the breaker,(iii) Maint command for assigning the maintenance tag to the breaker, and (iv) Exit command for closing the breaker face plate.

Required operation can be carried out by clicking on the Open or Close button. After clicking a pop-up for confirming the operation shall appear. The operator has to click on "Yes" to complete the operation, or "No" to cancel the operation.

V. RESULTS

From the HMI of the SCADA system , we could get an easy awareness about the indication on which loads are connected or which breakers are ON or OFF.

i.   Trip Indication:

It is a graphical representation on which breaker is tripped. Tripping commands shall be issued to the load feeders based on the pre assigned priorities. Load feeders up to the required priority are shed inorder to achieve power balance in the system. There shall be provision for the operators to reset the load shed commands. Load shed command shall be high unless the operator resets it.

ii.   Transformer Tap Indication:

Gives awareness about the tap position in HT side on which the transformer works.

iii.   Metering :

Through the appropriate signals, we can measure the control parameters like voltage, current, power factor, KVA, KVAR, KWh etc.

iv.   Temperature Control:

It gives the transformer oil temperature and winding temperature.

v.   Alarm Setting:

It is able to generate alarms when the control parameters are above or below the desired range. ECS SCADA has extensive alarm processing capabilities. The alarm list displays the station alarms in a separate list. Each alarm shall be presented with real time stamp (date and time) , feeder name, an alarm text and alarm status. The alarm in alarm list appear in chronological order.

vi.   Fault Recording:

It gives a record of the type of the fault and when it occurs with continuous diagrams.

vii.   Report Generation:

The report generation means, the data about energy consumption, fault recording etc with accurate time and continuous diagrams. Various report displays are provided in the ECS system. They reports can be shift report, daily report, and monthly report.

viii.   Event Display:

Gives a continuous monitoring and thereby obtaining a particular component's operating history. The event list presents the process events from the controlled and monitored process in chronological order. Each event shall be normally presented by displaying apredefined event text line, which describes event in the process. Each event shall be presented with timestamp (date and time), feeder name, an event text and status.

Fig 6 Event display

VI.CONCLUSION

This paper presents the possibilities of SCADA system in the fields of Engineering and Technology for supervision, control and automation. A complex power system requires a system which presents all network data to allow safe and reliable operation to control the complete network from a central control room through various plant overviews. For obtaining a stable plant operation inspite of instability in grid supply real time , load automation is required and that is why SCADA system is introduced.

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