Upgradation of SCADA System at SLDC, Bhopal

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***Abstract*- Supervisory Control and Data Acquisition and Programmable Logic Controller are presently the most effective automotive systems used around the world for both establishing communication and monitoring the process along with supervision and recording information at from various data location scattered either at remote or in vicinity plant locations. Recent technological shift had find its suitability in Power plant *like, Thermal, Gas, Hydro, Wind, Solar and other* electricity generation sources. It is mainly effective in monitoring the electrical parameters *(like voltage, current, power factor, Power etc)* & controlling any fault occurs in electrical distribution system. This paper attempts to analyze the existing network of Regional LDC, *for example WRLDC* that are mainly under responsibility of POSCO which is under ownership of PGCIL.**

Main & Backup Control Centers WRLDC are located at MPPTCL, GETCO, CSPTCL and GSED along with SCADA Systems at Union territories of Daman Diu (DDED) & Dadra Nagar Haveli (DNHED) and are able to perform all the functions of the Main control Centre except DTS and DDS. The system has been designed for meeting identified expansion requirements of present and future capacity calculated from archived data.

***Keywords:* SCADA, Distribution System, Fault identification, Back up of Control units, Data exchange and communication**

I. INTRODUCTION

The Indian power sector is organized in five electrical regions for operation *namely North, South, East, West and North-east*. And except south all the regions are synchronized as single block.

The exchange of power among these synchronized regions takes place through 765/400/220KV transmission lines and HVDC interconnections where as the power exchange with southern region is through HVDC interconnections.

The operation of the each regional grid is managed by the Regional Load Dispatch Centre (RLDC) with underlying State Load Dispatch Centre (SLDCs) and Sub-LDCs. At National levels, National Load Dispatch Centre located at New Delhi are under supervision of RLDCs and monitors inter-regional power exchanges. All SLDCs, RLDCs and NLDC control Centers are well- equipped with SCADA/EMS systems. The statutory functions of RLDCs and NLDC are discharged under applicable provisions of Indian Electricity Act.

Amongst other regions, Madhya Pradesh is in Western Region and its regional Load Dispatch Center (WRLDC) is located at Mumbai, managed by POSOCO. The POWERGRID has set up a subsidiary company named Power System Operation Corporation Ltd. (POSOCO) in March 2009.

The other Constituents of Western Region are MSETCL of Maharashtra, MPPTCL of Madhya Pradesh, GETCO of Gujarat, CSPTCL of Chhattisgarh and GSEB of Goa. Their existing SLDCs are located at Mumbai, Jabalpur, Gotri, Raipur and Panji respectively.

Hierarchy of WRLDC is depicted below (refer Fig:1) :-

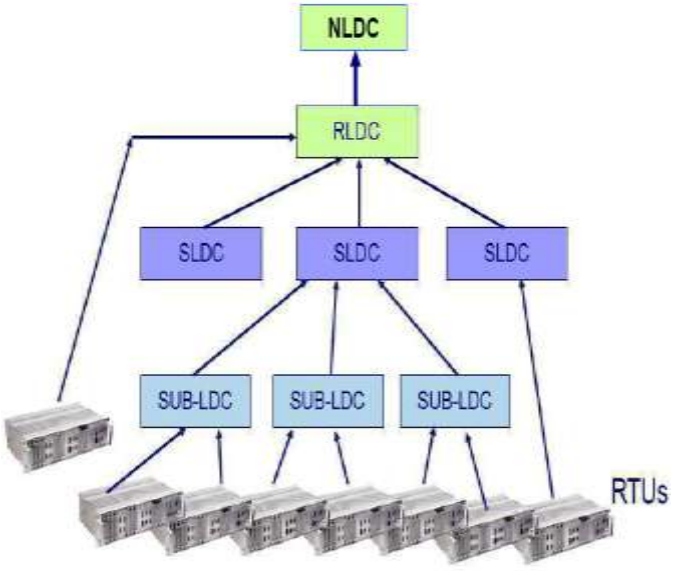


Figure 1: Agencies in coordination with WRLDC

1.1. Previous SCADA/EMS Systems at WRLDCS

Following subsystems are included in existing SCADA/EMS system of Western Region except of MSETCL:-

- SCADA/EMS servers- To Support the functions of SCADA, Real-time Dispatching, Power System Analysis functions.
- Communication Front-Ends (CFEs) that drives the serial communication lines connected to the RTUs.
- ICCP (Inter-Control Centres Communications Protocol) servers that support inter-site data exchanges between Control Centres.
- ISR server for Information Storage and Retrieval functions & is used for retrieval of stored data and Creation of Reports.
- DTS (Dispatcher Training Simulator) server and its associated DTS operator consoles that provide the dispatcher training capability. This is being used for the training purpose.

- Development Server is used to develop and maintain the SCADA/EMS software, displays and databases.
- Operator consoles and Video Projection System that handle the man-machine interface for system control and supervision operations.
- Network Management Console that provides the Configuration management, fault management and performance monitoring capabilities.
- WAN routers, in a redundant configuration, those allow several connections between Control Centres and with the Remote VDU (Video Display Unit).
- Peripheral equipment such as printers, satellite time receiver system, CD/ROM systems.

1.2. Upgraded SCADA/EMS Systems at WRLDC

The upgraded SCADA/EMS system changes with respect to previous system are as following:-

- Installation of SCADA/EMS system at Main & Backup Control Centers of WRLDC, MPPTCL, GETCO, CSPTCL and GSED. And SCADA Systems at Union territories of Daman Diu (DDED) & Dadra Nagar Haveli (DNHED).
- Existing RTU is integrated with new RTUs and is provided with Main & Backup Control Centers along with Installation of DCPCs.
- Not modification where required while integrating existing RTUs and Control Centers with new system.
- Change of setting by user or Auto adjustments specified in the specification didn't require or result in any short of downtime/unavailability of that system to the users.
- SCADA/EMS systems of MSETCL are integrated with Main & backup control centers of WRLDC.
- Wide area measurement system (WAMS)/Phasor Data concentrator (PDC) are integrated with Main and Backup Control Centers.
- Integration included Renewable Energy Control Centers with Main and Backup Control Centers.
- Installation of Auxiliary Power supply system for Main and backup control.

1.3. System Details

Each SCADA/EMS at the main & backup control centers of WRLDC, MPPTCL, GETCO, CSPTCL, GSED, DDED & DNHED have been enabled to serve as a backup to the other system. In normal course, Main Control Centre performs all the functions of Main Control Centre and Backup Control Centre functions as standby to Main Control.

Main Control Centre updates the Backup Control Centre automatically and based on availability the Main Control Centre acts as primary Control Centre for operations at all times (24x7 at 365 days).

The update/backup, periodicity of data at Backup Control Center from Main Control Center is as following:-

- Real time data is updated in every 10 seconds.
- ISR data is updated every hour.

In case of failure of the Main Control Centre, the Backup Control Centre takes over operations and functions of Main Control Centre. And when Main Control Centre recovers from failure, Backup Control Centre updates all data, including ISR data, at Main Control Centre. The takeover of main Control Center functions by Backup Control Center requires manual intervention.

II. LITERATURE REVIEW

SCADA[1] find most extensive use in increasing the reliability and efficiency of power plant and remotely monitoring the parameters of transmission and distribution. The beauty of this system is that the programme can be implemented in various languages.

The basic SCADA architecture begins with programmable logic controllers (PLCs) or remote terminal units (RTUs). PLCs and RTUs are microcomputers that communicate with an array of objects such as factory machines, HMIs, sensors, and end devices, and then route the information from those objects to computers with SCADA software. The SCADA software processes, distributes, and displays the data, helping operators and other employees analyze the data and make important decisions.

We have also referred the findings and observations of 'SCADA applications in thermal power plants' (M. N. Lakhoua), that helped in supporting the objective of this paper.It shows interests of the use of a SCADA system and up-gradation to newer technology for making operations effective and useful for power plants along with transmission & distribution .

Further inferences of 'A SCADA Based Power Plant Monitoring and Management System' was very informative as it highlighted that the data needed for more effective process management is often already available from the installed instrumentation; much of this however will remain unutilized. The approach taken in this work was to investigate whether non-time critical, low data frequency methodologies could be engineered which would be suitable for application using the processing power of the existing SCADA system.

III. OPERATION MECHANISM

3.1 SCADA System Functions

The SCADA system is provided with the IEC 60870-5-104 protocol and IEC 60870- 5-101 protocol. The Control centre supports all features of the IEC 60870-5-104 and the IEC 60870-5-101 unbalanced protocol. Besides this, Real-time

[1] *SCADA is a category of software application program for process control, the gathering of data in real time from remote locations in order to control equipment and conditions.*

data is collected from Remote Terminal Units (RTUs) located at various Substations and Power Plants. It is capable in collecting data *like momentary change detection inputs, phase angle, wind speed, wind direction, temperature, rainfall, humidity etc.*

Generally, the SCADA/EMS System functions are classified as Critical or Non-critical function. So at control centre every critical function is supported by sufficient hardware and software which ensures that no single hardware failure would interrupt the availability of the functions during the period exceeding the failover time.

Classification of Critical functions is as following:-

Table 1

a) SCADA functions	b) EMS functions
c) ISR	d) User Interface Requirements
e) Network Management system	f) Web and Scheduling Applications

On other hand, the non-critical function is not supported by hardware and in case of non-availability of corresponding hardware it can be suspended.

Classification of Critical functions is as following:-

Table 2

a) Database modification and generation	b) Display modification and generation
c) Report modification and creation	d) Software configuration and system generation.

A complete scan of all status data from the RTU is made in every 10 minutes and any discrepancies between field status and Control Centre database is immediately reported by an alarm message. Analog data is periodically updated at Control Centre from RTUs. Periodicity of data acquisition is configured by user, initially 5 seconds and upto 30 seconds. And if valid data cannot be acquired from one of the RTUs, the Control Centre System automatically triggers to the backup Communication channel.

3.2 Data Exchange

The SCADA system provides web services that allow multiple applications to exchange any real time data points including alarms and events.

SCADA System have inbuilt OPC Server functionality so that OPC Client is able to interact with SCADA server using a defined OPC interface.

IV. HARDWARE USED

In order to provide reliable power supply to control centre equipment a UPS and other auxiliary equipments are provided as a part of WRLDC System. Components wise details of equipments is as following:-

4.1 Uninterruptible Power Supply (UPS)

The UPS primarily uses the inverter subsystem to deliver AC power to the critical loads. In case of UPS failure the Static Bypass provides an alternate path to ensure continuous AC power supply to critical loads. It is designed to provide continuous-duty, on-line, solid-state power supply system power conditioning and uninterrupted power supply to the loads. The critical loads to be served by the UPS includes the Computer System of WRLDC including SCADA/EMS system computers, emergency lighting, and other critical loads at control centre necessary to sustain the operation.

Normally two UPS systems runs in parallel mode, however it is possible to run each UPS in independently. The necessary hardware and software including cabling & interfaces required for the parallel operation is installed. Each UPS system consists of various sub-systems such as rectifier/charger, batteries, solid state Pulse Width Modulation (PWM) based inverter, static bypass switch, manual maintenance bypass switch, load transformer, panels, cables and accessories etc as required in accordance with this Specification. Control panel is provided at each facility to manually control the UPS. However in the event of a loss of Input primary AC source, the UPS system provides power to the critical loads from the output of the inverter subsystems through batteries uninterruptedly.

Necessary other components for complete and proper operation of the UPS are:-

Table 3: Component details

a) Rectifier/charger unit	(b) Low Voltage disconnect feature to disconnect Battery bank
(c) Inverter	(d) Manual maintenance bypass switch
(e) Static bypass switch	(f) Load transformer and required filters
(g) Control panel, automatic controls and protection	(h) All necessary cables, **MCCB**s / **MCB**s / switches / fuses and other support hardware.

The UPS design is capable to isolate any failed piece of equipment *viz. Rectifier/charger unit, inverter and battery* for maintenance. Further it considers the following important electrical parameters:-

- UPS equipment comply with IEC 62040 or equivalent EN/BS standards for design, performance and EMC requirements.
- The input mains AC supply to the UPS is 415 volt AC, 3-phase, 4-wire, 50 Hz. The input supply voltage may vary +10% to -15% from nominal and the frequency may vary from 47.5 to 52.5 Hertz.

4.1.1 Rectifier/Charger Unit

The rectifier/charger units are installed in a single enclosure along with the UPS system electronics. Each rectifier/charger unit output voltage matches the characteristics of the connected-supplied batteries and inverter. Its Input current limit of 125 % of the nominal full load input current. Batteries

have capacity to recharge upto 90% State of Charge from fully discharged state (i.e. ECV of 1.75 V) within 8 hrs while carrying full load where battery charging current is considered as at least 20% of Battery AH capacity.

4.1.2 Inverter

The inverter includes two winding/phase load transformer of one to one ratio with electrostatic shielding. This load transformer can be either internal or external to UPS panel. It is capable to operate at-least 80% of the nominal capacity at the rated power factor and is also capable of operation with loads ranging from the rated power factor through unity power factor.

Inverter is suitable to accept 100% load at crest factor of at least 3:1 for Switching Mode Power Supply (**SMPS**) of computer system equipments without derating. The inverters are provided with interrupter switch to isolate the unit from the load on failure of the inverter unit. The interrupter switch is rated to carry full continuous load and to interrupt the inverter under full fault load conditions.

4.1.3 Static Bypass Switches

The bypass switches is static, high speed devices rated to transfer and carry full rated load continuously. The static bypass switches is provided to protect/prevent out of phase transfers. The switching speed of the static bypass switches is less than 1 millisecond. During the changeover, the output voltage does not fall below 205 V A.C., 50 Hz +5%., in order to avoid any disruption to computer load supply. An automatic transfer back to the inverter subsystems occur if the transfer from the inverter subsystems was caused by a temporary overload and the load has returned to normal or by a temporary over/under voltage condition on inverters output and the voltage has returned to normal

4.2 Battery Requirements

Maintenance free Valve Regulated Lead Acid (VRLA) Battery is deployed with each UPS. Battery is capable of being recharged to 90% State of Charge (SOC) from the fully discharged condition (1.75 V/cell) within 8 hrs. In all cases, the battery is normally not allowed to discharge beyond 80% of rated capacity (80% DOD) at 10 hours rate of discharge.

The battery is capable of giving more than 1200 charge/discharge cycles at 80% DOD [2] at an average temperature of 27º Celsius. The battery set have a minimum expected operational life of 5 years at normal operating conditions or 1200 charge/discharge cycles (whichever is early).

4.3 AC Distribution Boards

AC power distribution boards (ACDBs) consists of 'Input ACDB' and one no. 'Output ACDB'. The 'Input ACDB' is provided with 4 nos. of Four (4) Pole type MCCBs which conforms to IS 13947-2/IEC 60947-2. All the MCCBs are provided with over-current, short circuit protection and is programmed for the overload and short-circuit tripping of the MCCBs/MCBs with upstream and downstream switchgear.

The 'Output ACDB' is provided with one number of 4-pole Bus section MCCB of requisite rating which is normally kept in closed (NC) condition when both UPS are running in parallel.

4.4 Diesel Electric Generator

The generator set consist of a diesel engine directly coupled to an electric generator, together with the necessary switchgear, controls, battery etc and accessories to provide continuous electric power for the duration of any failure of the normal AC source.

The generator set engines are full diesel compression ignition, four-stroke cycle, air-cooled type. The rated horsepower of the engine, at the generator synchronous speed, with all accessories attached and is not be less than that required to produce the rated power.

4.5 Power Cables

All external power cables are stranded Aluminum conductor, armoured XLPE/PVC insulated and sheathed, 1100V grade as per IS 1554 Part-I. The conductor for the Neutral connection from UPS to Output ACDB are sized 1.8 times the size of the Phase conductors to take care of the non-linear loads. However, the cable between UPS and Battery bank are of stranded copper conductor (armoured type).

Cable marking and labeling complies with the requirements of the applicable standards. Also each cable is identified at both ends with appropriate color for identification of each phase/neutral/ground along with the cable number indicated at the near-end and far-end destination.

Entire network is earthed through a copper bus bar, braid or cable inside enclosures. The safety earth network is terminated at two/more studs for connecting with the earthing grid. Safety earthing cables between equipment and enclosure grounding bus bars have minimum size 6 mm^2, stranded copper conductors, rated at 300 volts. All hinged doors are earthed through flexible earthing braid.

V. CONCLUSION

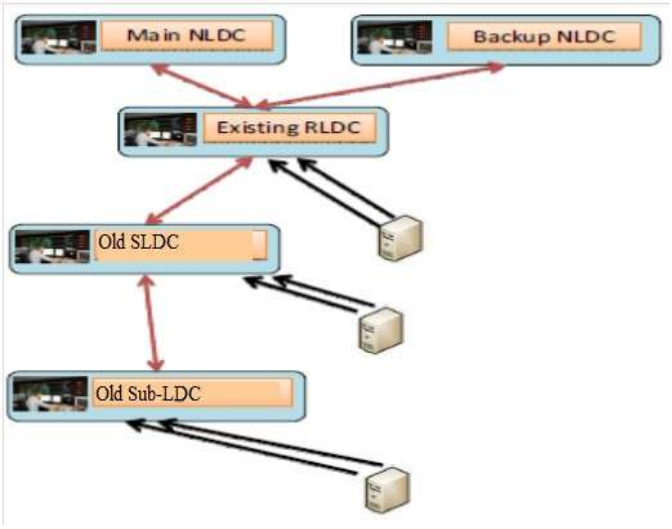
SCADA implementation has helped in comprehensive preventive & break down maintenance and has also been useful in taking back up of data at SLDC/NLDC, etc. Intent of this study is to expand / upgrade the (SCADA/EMS) of Western Regional Load Dispatch Centre and State Load Dispatch Centers of Madhya Pradesh (MPPTCL), Gujarat (GETCO), Chhattisgarh (CSPTCL) and Goa (GSED).

Existing system had entire load of information exchange and communication of NLDC, individual existing RLDC and

[2] *DOD (Depth of Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery on discharge to its rated capacity*

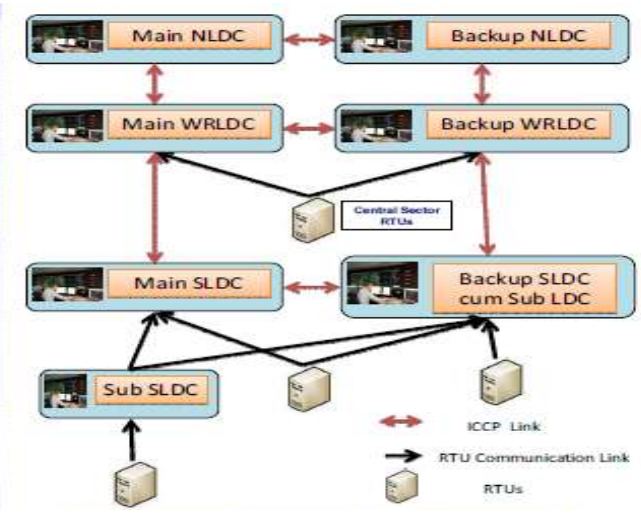
SLDC respectively and back up had limited communication with inter-regional LDC. Detailed flow chart of existing system is depicted below (refer Fig: 2)

Figure 2: Old system Flowchart



But New system had upgraded SCADA interface to streamline information exchange and data back-up both at NLDC and Regional *(WRLDC, ERLDC, etc)* along with State LDC. Further these back up units at NLDC and Regional LDC are enabled with ICCP link which has helped in strengthening the Inter-Control Center Communications Protocol between the dispatch centers. Besides this, the sub-LDC had been established effective RTU communication link with back-up SLDC and Main SLDC. Detailed flow chart of upgraded new system is depicted below (refer Fig:3)

Figure 3: New system Flowchart



Integration of existing RTUs and Control unit with new system does not require any modification in the existing system. It would be beneficial for integrating Renewable Energy Control Centers with Main and Backup Control Centers.

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ABBREVIATIONS

AH	Ampere Hour
ACDBs	AC power distribution boards
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CSPTCL	Chhattisgarh State Power Transmission Corporation Ltd
CFE	Communication Front-Ends
CPSU's	Central Public Sector Undertakings
DDS	Database Development System
DDED	Daman Diu Electricity Department
DNHED	Dadra Nagar Haveli Electricity Department
Dept	Department
DISCOM	Distribution Companies *(under flagship of State Government's)*
DTS	Dispatcher Training Simulator
DOD	Depth of discharge
DC	Direct Current
ECV	End Cell Voltage
EMS	Energy Management System
GW	Giga Watt
GoI	Government of India
GSED	Goa State Electricity Department
GETCO	Gujarat Electricity Transmission Corporation Ltd
HVDC	High Voltage Direct Current
ICCP	Inter-Control Centres Communications Protocol
ISR	Information Storage and Retrieval function
IEC	International Eletro technical

	Commission
kWh	Kilo Watt Hours
kV	Kilo Volts
V	Volts
MSETCL	Maharashtra State Electricity Transmission Company
MPPTCL	Madhya Pradesh Power Transmission Company Limited
MWH	Mega Watt Hours
MCCB	Molded Case Circuit Breaker
MCB	Miniature Circuit Breaker
NTPC	National Thermal Power Cooperation Limited (Undertaking of GoI)
NLDC	National Load Dispatch Centre
PLC	Programmable Logic Controller
POSCO	Power System Operation Corporation Ltd
PLF	Plant Load Factor
%	Percentage
PGCIL	Power Grid Corporation of India (Undertaking of GoI)
PVC	Polyvinyl Chloride
RLDC	Regional Load Dispatch Centre
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SLDCs	State Load Dispatch Centre
SOC	State of Charge
SMPS	Switching Mode Power Supply
T&D	Transmission & Distribution
UPS	Uninterruptible Power Supply
VRLA	Valve Regulated Lead Acid
WB	World Bank
WRLDC	Western Regional Load Dispatch Centre
WAN	Wide Area Network
XLPE	Cross-linked polyethylene