Power System SCADA – Part II
(EMS,DMS)

Dr. Sasidharan Sreedharan
www.sasidharan.webs.com
Contents

- Energy Management System (EMS)
  - AGC
  - Energy Pricing (ABT)

- Distribution Management System (DMS)
  - Distribution Automation
  - SS Automation

- Case Studies (SCADA With Distribution Automation)
# Syllabus Update

## AIT/SCADA - Day 4

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<td>09:00-10:00</td>
<td>Opening Ceremony &amp; Break (09:30 - 11:00)</td>
<td>SCADA Functional Requirements and Components</td>
<td>Power Systems SCADA and SCADA in Power System Automation</td>
<td>EMS, DMS, AGC DA, SSA</td>
<td>Smart Grid Micro Grid</td>
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<td>10:00 - 10:30</td>
<td>Introduction to Supervisory Control and Data Acquisition</td>
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<td>General features, Functions &amp; Applications Benefits</td>
<td>Power Systems SCADA and SCADA in Power System Automation (cont’d)</td>
<td>DA, Remote Metering Renewable Integration SCADA</td>
<td>Structure of SCADA Communication Protocols</td>
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SCADA/EMS/DMS Architecture

- **SCADA**
  - Data points: 100 – 1,000,000
  - Sub stations: 1 – 10,000
  - High load events per second: 10 – 10,000
  - Updated analogs per second: 10 – 10,000

- **EMS**
  - Data points: 10,000 – 100,000
  - Sub stations: 100 – 10,000

- **DMS**
  - Data points: 10,000 – 1,000,000
  - Sub stations: 1,000 – 100,000
## EMS/DMS Functions

### EMS
- Network Configuration / Topology Processor
- State Estimation
- Contingency Analysis
- Three Phase Balanced Power Flow
- Optimal Power Flow

### DMS
- Voltage Reduction
- Load Management
- Power Factor Control
- Two-Way Distribution Communications
- Short-Term Load Forecasting
- Fault Identification / Fault Isolation / Service
- Restoration
- Interface to Intelligent Electronic Devices (IEDs)

### Load Forecast
- Every hour for a period of 1-7 days
- LFC: Every few seconds
- ED: Every few minutes
EMS Detailed Function

- **System load forecast** :

- **Unit Commitment** : Start up & shut down times for most economic operation of thermal units for each hour.

- **Fuel Scheduling** : Economic choice, fuel purchase contracts.

- **Transaction evaluation** : Purchase & sale of energy with neighboring companies.

- **Transmission loss minimization** : Controller actions for minimization of loss.

- **Security constrained dispatch** : Ensuring eco dispatch without violating network security.

- **Production cost calculation** : Actual & economical for each generated unit on hourly basis.
Power System Action Time Frames

- Transient stability
- Generator/excitation dynamics
- Mechanical
- Switched cap’s
- Under-voltage load shedding
- SVC, DC
- SCADA
- Relaying, incl. under-frequency load shedding
- Long-term stability
- LTCs & dist. voltage reg.
- Excitation limiting
- Line/transformer overload
- System operator

Time - Seconds

0.1 1 10 100 1000 10000
Grid Management

- **Unit commitment** – which works on a scale of days
- **Scheduling** needed on a day upon day basis
- **Load** following which has a time scale of minutes to hours
- **Regulation** which happen over seconds to minutes
Load Dispatch Centre - Functions

- Load Generation Balance (LGB) preparation
- Demand Forecasting
- Scheduling of Central share
- Power Purchase
- Outage Planning
- Preparation of Daily System Statistics
Load Generation Balance (LGB)

Ensuring availability of generation to meet the ever-changing demand in the most optimal way

• **Real time**
  – The actual demand has to be met with power availability

• **Long term (Control period)**
  – Energy requirement for the control period is to be met
    
    • Stable and Secure grid operation
    • Effective utilization of available resources
Factors affecting LGB

- Major loss of generation / Central grid station (CGS) outage
- Transmission line outage
- Climatic condition
- Price signal from power market
- Spill threat
- Conservation requirement
Preparation of LGB

Factors considered

1. Demand forecast

2. Generation schedule
   - KSEB
     » Hydel
     » Thermal
   - IPPs

3. Availability of CGS Share

4. Power Purchase
Demand Forecast

➢ Forecast to be made for **day ahead demand and energy requirement.**

➢ Demand forecast is divided into segments like

  • Night-off peak (22:00hr to 05:00hr)
  • Morning peak (05:00hr to 08:00hr)
  • Day peak (08:00hr to 18:00hr)
  • Evening peak (18:00hr to 22:00hr)

➢ Availability to be ensured for each segments
Factors affecting demand

- Climatic condition
- Festivals
- Major holidays
- Major sports events and Political developments
- Social disturbances and strikes
Typical Demand Curve
Power Purchase

Power is purchased from

i. Central Electricity Regulatory Commission approved Traders and

ii. Power Exchanges
Availability Based Tariff

• Introduced in Southern Region with effect from 1-1-2003
• Tariff promotes grid discipline with its inherent commercial mechanism
• Consists of three parts:
  ✓ Fixed charge or Capacity charge
  ✓ Variable charge or Energy charge
  ✓ UI (Unscheduled Interchange) charge

www.srldc.org
Tariff Structure

• ABT is a three part tariff
  – Capacity charges (Fixed cost)
  – Energy charges (Variable cost)
  – UI charges

❖ Capacity charges and energy charges are settled monthly as per the Regional energy Account.

❖ UI charges are settled weekly

❖ Energy accounts are prepared and issued by the Southern Regional Power Committee Secretariat
Major problems existed in grid operation prior to the implementation of ABT

- Low frequency during peak load hours - 48.0-48.5 Hz
- High frequency during off peak hours - 50.5 to 51 Hz
- Rapid and wide changes in frequency – 1 Hz in 5 to 10 minutes.
- Very frequent grid disturbances, causing tripping of generating stations, interruption of supply to large blocks of consumers, and disintegration of the regional grids.

One important reason attributed to the situation was the absence of direct incentives or penalties for the individual utilities responsible for the problems.
Beneficiary UI

-UI

Drawal Schedule by RLDC

Actual drawal by beneficiary

+UI
What is UI?

- **UI** – *Unscheduled interchange*
- Demand of the grid is not constant
- Frequency of the grid is not constant
- Depending on various conditions, the tie line flow varies from instant to instant
- Thus UI is unavoidable in an integrated network
- UI can be harnessed effectively to the advantage of the constituents if system permits
- The UI is the difference between the schedule and the actual draw up / generation.

- **Rate depends on frequency**
- CERC finalizes Inter state UI rate
VAR Rates

- **Payable @10 ps/KVARH For**
  - VAR injection at Voltages above 103% of rated voltage
  - VAR drawal at Voltages below 97% of rated voltage

- **Receivable @10 ps/KVARH For**
  - VAR drawal at Voltages above 103% of rated voltage
  - VAR injection at Voltages below 97% of rated voltage
ADVANTAGE ABT.

• MAXIMISATION OF GENERATION AVAILABILITY
  – MEET MORE CONSUMER DEMAND
• ECONOMY IN OPERATION
  – REDUCE COSTS
• RESULT :-
  – IMPROVED QUALITY OF SUPPLY.
  – UNUTILISED CAPACITY HARNESSSED.
  – MERIT ORDER IN GENERATION.
  – GRID DISCIPLINE
## Kerala System

### Generation

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DEREGULATION & COMPETITION

Deregulation driving actions of most utilities

Major driving forces:

- Improved power quality and service reliability
- New energy related services and business areas
- Lower cost of service
- Information needed for improved decision making

SA: A proactive response to these forces
Why Needed? Why Now?

DEVELOPMENT OF IEDs

Rapid development and deployment of Intelligent Electronic Devices (IEDs)

- Protective relays
- Meters
- Equipment condition monitors

IEDs have become an integral part of Substation Automation systems

Technological developments have made SA systems less expensive and more powerful
Automatic Load Restoration: “Intelligent” Bus Failover

• Nature of Problem
  – When a transformer failure occurs, “simple” bus failover scheme transfers load to healthy transformer
  – “Simple” failover scheme may overload healthy transformer, especially during peak load
  – Some schemes have been disabled because of this.
  – Substation firm capacity limited by amount of load that can be carried if a transformer fault occurs.
Automatic Load Restoration: “Intelligent” Bus Failover

• Objectives
  – Transfer as much load as possible to 2\textsuperscript{nd} substation transformer
  – If necessary, transfer portion of load to alternate substation
  – Shed portion of load if necessary
“Intelligent” Bus Failover: How It Works
“Intelligent” Bus Failover: How It Works
“Intelligent” Bus Failover: How It Works
“Intelligent” Bus Failover: How It Works

Bus Transfer Scheme Operates
“Intelligent” Bus Failover: How It Works
“Intelligent” Bus Failover: How It Works

To Adjacent Substation

Restore Load Using Feeder Automation
Supply Line Sectionalizing

![Diagram of supply line sectionalizing](image-url)
Supply Line Sectionalizing

Permanent Fault Occurs

SA System
Supply Line Sectionalizing
Supply Line Sectionalizing
Supply Line Sectionalizing

SA System Opens Appropriate device

SA System
Supply Line Sectionalizing

SA System Sends Reclose Signal
Equipment Condition Monitoring

• **Continuous On-line Diagnosis of SS Equipment (HV breakers, Transformers)**

• Main objectives
  – Find/fix problems earlier
  – Avoid forced (unscheduled) outages
  – Reduce maintenance costs

• Role of SA
  – Monitor specialized sensors
  – Perform “expert system” analysis
  – Inform engineers or dispatchers of possible problems

Monitoring Devices

• Dissolved Gas in Oil Monitors/Samples
• Moisture Detectors
• Load Tap Changer Monitors
• Partial Discharge/Acoustic Monitors
• Bushing Monitors
• Circuit Breaker Monitors (GIS and OCB)
• Battery Monitors
• Expert System Analyzers
Adaptive Relaying

- Process of **automatically altering settings on protective relay IEDs based on system conditions**

- **Special Protection Schemes**
  - SA system can play a role in implementing bulk power **Special Protection Schemes (SPS)**
  - Example: tripping of critical generating unit requires new settings on a line that may become very heavily loaded under this condition.

- **Benefit**
  - Avoid need to implement custom hardwired logic to accomplish this functionality
Intelligent Alarm Processing

– Prioritize alarm information
– Eliminate duplicate & nuisance alarms
– Route alarm info to appropriate party
– “Expert” alarm processing
  • provides more informative and useful alarm messages
Power Quality Monitoring

– SA System and IEDs able to detect power quality events and report the following information:
  • Harmonic content of the voltage waveform
  • Total harmonic distortion
  • Oscillographic data (waveforms)
Real-Time Equipment Rating

– *Base equipment ratings on actual conditions rather than conservative assumptions*
– *Squeeze more capacity out of existing equipment*
– *Example: Transformer “Hot Spot” Monitoring*
  • Monitor the true winding hot spot temperature
  • Derive loadability from the results
  • 10% average additional loading can be achieved
Support for Feeder Automation

• SA is an “Enabling Technology” for Feeder Automation functions
  • *Integrated volt VAR control*
  • *Feeder reconfiguration*

• Requirements for Feeder Automation:
  • *Monitoring of 3 phase quantities at substation end of feeder*
  • *Load Tap Changer set point control*
Monitoring of Switched Feeder Capacitor Banks

– Switched feeder cap banks forced out due to blown fuses, mechanical control failure, etc.
  
  • 20% failure at one utility

– Banks out of service months before being discovered

– VAR flow monitoring quickly detects failed cap banks
Integrated Protection Functions

• **Objective:**
  Incorporate protection functions in the SA System
  – Basic protection units (IEDs) exchange current/voltage data via high speed LAN
  – Relay trip signals exchanged over LAN

• **Examples:**
  – Automatic reclosing
  – Breaker failure
  – Bus differential

• **Benefit:**
  – Avoid cost of separate protective relays
  – Potential for improved performance and reliability
Hyderabad Integrated SCADA Project
The Hyderabad SCADA project involves networking of all the substations in and around Hyderabad city for:

- Data collection from all substation equipment to the central Computer system for analysis,
- Control and monitoring of the distribution system by issuing commands to the remote stations

The Electricity Distribution system for Hyderabad city spans over an area of 1555 sq km.

Over one million consumers are served by APCPDCL.

The system covers 13 nos. 132 / 33 kV stations and 93 nos. 33/11 kV stations.

APCPDCL: Andhra Pradesh Central Power Distribution Company Ltd
http://www.apcentralpower.com/
• **Aim of the Project** - **Effective Load Management of Distribution system in Hyderabad** to improve the reliability of the electricity supplies

• **SCADA (Supervisory Control & Data Acquisition System)** is integrated with Distribution Automation Functionalities for better utilization
  - Load Control
  - Automatic Meter Reading
  - Emergency Load Shedding
  - Integrated Volt/Var Control
  - Feeder SCADA-Fault Localization
  - Trouble Call Management
  - Facilities Management
Project Benefits

- Efficient Distribution Management
- Fault analysis easier and quicker due to availability of real time information
- Prompt and quicker restoration of supply in case of outages
- Malfunctioning equipment can be identified and action can be taken for rectifying the same early
- Historical data up to a period of 2 years can be stored for future analysis
- Stations can be operated as unmanned substation
- Close monitoring of supply status for essential services and VIP functions
- Load shedding can be programmed in a systematic manner during shortages or exigencies
Project Finance

- Project is financed by DFID under AP Energy Efficiency Project (APEEP)
- DFID has so far released Rs 32 crores (4.8 million UKP) for this project
The Hyderabad SCADA system comprises of the following subsystems

- Control Center Equipment (Computer System)
- Application Software - SCADA
- Distribution Management Functions Software
- Microwave Communication system
- Field data Acquisition system (Remote Terminal Unit)
- UPS, Power Supplies, Towers etc.,
Distribution Control Center Hyderabad
Communication Towers
Historical Data Processing

Archiving features:
- Cyclic or time of day
- Data with quality codes
- Successive mean value calculation
- Backup value

Avanti DBMS

Real time data

Time tagged data

Future

Past

Long term archiving

AIT/SCADA - Day 4
Historical Data Presentation

Time tagged data

Reports

Plans

Duration curves

Curves

Single line diagram

Historical Data Presentation

Time tagged data

Reports

Plans

Duration curves

Curves

Single line diagram

Historical Data Presentation

Time tagged data

Reports

Plans

Duration curves

Curves

Single line diagram
Spread sheet integration

Avanti DBMS

Real time data
Past
Future

Time tagged data

Quality code inheritance

Commercial spread sheet

Spread sheet interaction

- Tables
- Histograms
- Pie charts
- Three dimensional diagrams
Disturbance Data Archiving - Post Mortem Review

RTU

Storing

Master Station

Storing

Archive

Presentation

Triggering

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Common Billing System

Billing
- LT Billing
- HT Billing

Revenue Collection
- e-Seva
  - LT Billing
  - HT Billing
  - e-Seva

New Customer Accounting
- ERO-Offices
  - Web enabled Collections (Online Collections)

- Citi Bank Online
- Electronic Clearing System
- Credit Cards
- ATMs of Banks
- e-Collection on Box
- KIOSKS of Banks
- Payment Through Telephone (IVRS)
Regards,

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