POWER EVACUATION & SMART METERING

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MODERN ELECTRICITY SYSTEM
POWER EVACUATION

- Stage wise power evacuation
  - Phase I, Phase II and ........Phase N
- Connecting the power plant to
  - Existing grid substation
  - Nearby substation of another Company/Industry
- Power evacuated under normal conditions
- Power evacuated during Contingency conditions.
- Power plant in the nearby location
- Clear understanding of power system planning in that area/utility
- Plan in sync with utility plans
- Feeder outages
TYPICAL SLD OF PV PLANT

Grid

VCB

I VCB ACB DC/AC Inverter

I VCB ACB DC/AC Inverter

I VCB ACB DC/AC Inverter
COMPONENTS OF POWER EVACUATION

- Transformer
- Circuit breaker
- Current Transformer
- Potential Transformer
- Lightning Arrestors
- Cables & Conductors
- Isolator
- Energy Meter
## Cables

<table>
<thead>
<tr>
<th>Cross sectional area (sq mm)</th>
<th>Approx overall diameter (mm)</th>
<th>Current rating (ground) (A)</th>
<th>Current rating (Air) (A)</th>
<th>Short circuit current (kA)</th>
<th>Short Circuit MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x150</td>
<td>66</td>
<td>240</td>
<td>285</td>
<td>14.1</td>
<td>268</td>
</tr>
<tr>
<td>3x240</td>
<td>76</td>
<td>315</td>
<td>385</td>
<td>22.6</td>
<td>430</td>
</tr>
<tr>
<td>3x300</td>
<td>82</td>
<td>355</td>
<td>440</td>
<td>28.2</td>
<td>537</td>
</tr>
<tr>
<td>3x400</td>
<td>90</td>
<td>405</td>
<td>510</td>
<td>37.6</td>
<td>716</td>
</tr>
</tbody>
</table>

- Duration of short circuit – 1 sec
- Maximum allowable temp during short circuit – 250°C
## Conductors

<table>
<thead>
<tr>
<th>Standard Nominal copper (Sq. mm)</th>
<th>Code Word</th>
<th>Diameter (mm)</th>
<th>Current in Ampere (30°C) (A)</th>
<th>Current in Ampere (50°C) (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Squirrel</td>
<td>6.33</td>
<td>70</td>
<td>97</td>
</tr>
<tr>
<td>20</td>
<td>Weasel</td>
<td>7.77</td>
<td>100</td>
<td>123</td>
</tr>
<tr>
<td>30</td>
<td>Rabbit</td>
<td>10.05</td>
<td>148</td>
<td>183</td>
</tr>
<tr>
<td>55</td>
<td>Cat</td>
<td>13.5</td>
<td>229</td>
<td>285</td>
</tr>
</tbody>
</table>
LOAD FLOW ANALYSIS

- Most efficient technique to determine the behavior of the system under steady state conditions
- Provides information regarding
  - Bus voltage at different load points
  - Real and reactive power flows
  - Circuit overloads
  - System losses
- Operating procedures can be analyzed
  - Contingency conditions
    - Loss of generator, transmission line, transformer or load
- It is performed to determine the optimum evacuation scheme from proposed plant both
  - Normal
  - Contingency condition
- Base case is critical
ANALYSIS OF LOAD FLOW RESULTS

- Options for power evacuation
- Line over loadings because of power evacuation
- Line over loadings during contingency
- Possibility of Microgrids?
SHORT CIRCUIT STUDY

- To compute the magnitude of the currents flowing through the power system after a fault occurs
- Design an adequate protective system
- Capacity of the interrupting requirements for the circuit breakers
- Recognize faults and initiate circuit breaker operation to disconnect faulted facilities
- Types of fault
  - Three phase
  - Phase to phase
  - Double phase to ground
- Select fuses, breakers, switch gear ratings in addition to setting of protective relays and checking their coordination
OVERVIEW OF IEC 61850

Standard Communication with TCP/IP (Ethernet Standard)
Communication between bay devices

Protection and Control
Metering & SCADA
Remote monitoring and fault diagnosis

Integration of innovative sensor and switch technologies
Automated dispatch and control;
Asset management;

Fault records and time synchronization
Condition monitoring and diagnosis.
Utility Automation – IEC 61850

- Highly flexible and Scalable
- Protection and Control
- Uses main stream technologies like Object modeling, XML and TCP/IP
- Reduces operation, engineering and maintenance costs;
- Availability in market
- Interoperable and Interchangeable
## Architecture - Substations

<table>
<thead>
<tr>
<th>Yesterday</th>
<th>Today</th>
<th>Tomorrow</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA conventional MMI / Control Board</td>
<td>SA with Interbay bus</td>
<td>SA with interbay &amp; process bus</td>
<td>Direct Access for Network Control</td>
</tr>
</tbody>
</table>

### Diagram Description
- **Yesterday**:
  - SCADA: distribution, metering
  - Event recording protection
  - Copper cables
  - Bay cubicle

- **Today**:
  - Gateway / Protocol Conv.
  - SAS
  - Serial communication to other bays
  - Copper cables
  - Bay cubicle

- **Tomorrow**:
  - Gateway / Protocol Conv.
  - SAS
  - Serial communication to other bays
  - Sensors & actuators
  - Copper cables
  - Bay cubicle

- **Future**:
  - Router / Switch
  - SAS
  - Serial communication to other bays
  - Sensors & actuators
  - Copper cables
  - Bay cubicle
SMART METERING
Advanced Metering Infrastructure
AUTOMATED METERING INFRASTRUCTURE - SMART METERS

Outage management System

Pre-Payment

SMART METER

Active Load Control

Revenue Protection

Sub-Metering
NET METERING

- It is an electricity policy for consumers who own renewable energy facilities or V2G electric vehicles.
- Net = What remains after deductions
- Demand Response
- PV Inverter for reactive power support using smart PV inverters

Source: http://en.wikipedia.org/
SMART METERING

- Digitally capture or record when power is consumed/produced
- Two way communication
  - Transmit the information to a central server
  - Receive commands/information from central server and take appropriate action.
- Control
FUNCTIONAL COMPONENTS

- Voltage and Current Inputs
- Communication modules
  - Zigbee, RF, PLCC, GSM/GPRS etc.
- Power Supply
- Core Processor
- LCD Display
- RS 232 port
COMPONENTS

- Power Supply
- Voltage
- Current

Source: http://www.ti.com/
HOW THEY OPERATE?

INTERNET

GSM/GPRS

DCU

Local Mesh Network
HOW THEY OPERATE?
Tasks

- Measure, Observe
- Smart Meter
- Communicate
- Control
**Tasks**

- Measure, Observe & Display
  - Three Phase voltages
  - Three Phase currents
  - Power factor
  - Power flow direction
  - Outages
  - Theft
  - Maximum demand information
  - Tariff rate information
  - Total money/kWh spent/earned
  - Carbon credits
  - Time of use tariff
COMMUNICATION

Various communication modes
  • Application specific
  • Radio Frequency
  • GSM/GPRS
  • Zigbee
  • Wimax
  • Power Line Communication
COMMUNICATION - POSSIBLE OPTIONS

- Direct GSM/GPRS
  - Low density Area
- Local mesh (zigbee) and GPRS
  - High density Area
- Local mesh (RF) and GPRS
  - High Density Area
- Local mesh (PLC) and GPRS
  - High Density Area
CONTROL

- Connect/disconnect in case of pre-paid type meters
- Disconnect in case of
  - Power theft
  - Tampering
- Any other control requirement as per utility
SPECIFICATIONS

- Support the regular features that a standard static meter
- Shall comply with the requirements of IS 13779.
- The connection/disconnection relay shall be as per IS 15884
- In addition it will support communication interface for data exchange between data concentrator unit and utility.
- The meter can have a GPRS modem in case when it connects to the network management system directly for spread out locations.
- Dense locations - RF mesh module (frequency band of 865-867 MHz) → Data Concentrator Unit → WAN using GPRS.
- Any other de-licensed band which suits the application can also be utilized.
## What Makes it SMART?

<table>
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<th>Conventional Meter</th>
<th>Smart Meter</th>
</tr>
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<tbody>
<tr>
<td>Only electricity consumption (kWh)</td>
<td>Voltage, Hourly kWh data, power quality measurements</td>
</tr>
<tr>
<td>No communication capability</td>
<td>Integrated two-way communication between the utility and meter</td>
</tr>
<tr>
<td>No outage detection</td>
<td>Automated outage detection and notification</td>
</tr>
<tr>
<td>No tamper detection</td>
<td>Automated meter tamper alarms</td>
</tr>
<tr>
<td>Manual on-site meter reading Manual meter connects and disconnects</td>
<td>Remote meter connect and disconnects Automated and on-demand meter readings</td>
</tr>
<tr>
<td>Consumption feedback and cost estimate is done after every month (typical reading time)</td>
<td>Real time feedback provided to customer</td>
</tr>
</tbody>
</table>
REFERENCES