1 Executive Summary

1.1 Siemens Power Systems Control - Meeting Future Energy Automation Challenges Today

A World Full of Energy Requires Efficient Grid Management

Be it in bustling cities or in developing regions, prosperity and progress in our modern society are inconceivable without energy. Energy is the driving force and lifeline of our civilization, in households as much as in industry, transportation, and healthcare.

One of the greatest challenges of the 21st century is to supply the required energy efficiently, economically, and with minimal impact on the environment. It is a challenge that involves the entire chain of energy logistics from generation to transportation and distribution.

In the coming decades, these efforts will be affected by four major factors, which are, worldwide growth in energy demand, increasing urbanization, dwindling fossil energy resources, and the effects of climate change.

Power grid operators around the globe are investing knowledge and capital to meet the new challenges. Success depends on a number of factors that include the optimized utilization of existing resources and networks, the further expansion of infrastructures, and the integration of power from distributed renewable sources.

Energy automation from Siemens plays an important role in this increasingly complex landscape. It facilitates improved energy management, more flexible responses to changing demands, and increased efficiency throughout the grids. Ultimately, this ensures a highly reliable energy supply at reduced cost.

Longstanding Experience

Siemens solutions for Energy Automation are based on Siemens’ long-standing experience, which is proven by more than 1,800 grid control systems installed all over the world. This number is quite impressive and so is the wide range of requirements these systems meet.

Be it for transmission, distribution, and generation companies, or for multi-utilities, independent system operators, and industrial companies, the control systems from Siemens meet extremely diverse requirements in all these areas.

The scope and comprehensiveness of Siemens solutions are determined entirely by the requirements of a project. The range of solutions spans from smallest all-in-one solutions to large distributed systems that comprise a huge set of different servers, and local or remote user interfaces. This flexibility is made possible by a comprehensive range of consistent components and solutions that can be matched to individual requirements.
Global Presence – Local Expertise

A multitude of factors need to be taken into account in the design of a grid control system. Siemens’ presence in about 90 countries ensures that any project’s specific requirements are known and perfectly understood. Customers from all over the world rely not only on Siemens’ expertise but also on a broad range of services that ensures reliable grid operation around the clock.

Innovation – for Advanced Development of Grid Control Systems

Today’s changing energy system requires new solutions. To meet the growing demand for power, the grids of today and tomorrow must integrate ever more renewable energy sources and ensure bi-directional power and communication flows. Smart Grids support the efficient and on-demand generation and consumption of power. Siemens meets these challenges head-on and provides support in this important area through continuous developments in all fields of energy automation. A global network of experts is working today on tomorrow’s technologies and solutions.

Innovation is, of course, unthinkable without sustainable investment protection. Siemens provides this protection through rigorous compliance with international standards and through setting technology trends.

Siemens also promotes development in power system control technology by participation in national and international committees (for example, IEEE, IEC, EPRI, DKE, CIGRE, and CIRED) and participation in Siemens User Groups.

Competitive throughout the Entire Life Cycle

Thus, Siemens is a reliable partner that helps increase a company’s long-term competitiveness throughout the entire life cycle of any system. This partnership spans from professional consulting for projects of any size to the configuration, installation, and commissioning of the solution as well as of its individual components. In addition, Siemens provides trainings that can take place at a customer’s facilities or in the Siemens training centers.

Siemens global service includes remote diagnosis as well as remote access and efficiently ensures highest system availability. Upgrades, expansions, and replacements of existing power control systems are also a part of the comprehensive range of offers.

Quality is Key to Success

The Siemens integrated management system is structured and certified in accordance with the international standards DIN EN ISO 9001 for quality, DIN EN ISO 14001 for environmental protection, and BS OHSAS 18001 for occupational health and safety. To ensure its suitability in a lasting manner, the management system is subjected to regular reviews.

Siemens delivers products, systems, and solutions with the required quality in correspondence with customer demands. Siemens ensures that product developments, products, and services are delivered at the contractually agreed times with innovative technology, and in the fulfillment of the specific quality standards. This makes consistent quality management possible in all processes. We ensure product and project quality with tests and inspections and guarantee quality in every individual process step.
1.2 Spectrum Power - Intelligent Control Center Solutions for Various Customer Segments

An intelligent control center is of crucial importance for the secure, economical, and reliable operation of any electric power system.

Spectrum Power covers all aspects of power management. Customized grid control systems are developed from a range of solutions based on proven and innovative components. Basic components for SCADA, communications, and data modeling are provided for grid control and monitoring. In addition, other applications for grid optimization and generation management are available. They span from analytical functions for distribution and transportation networks to forecasting and optimization applications, and all the way to scheduling applications for generation companies.

This successful concept makes Spectrum Power the intelligent control center solution for various customer segments as shown in the following figure.

![Figure 1: Spectrum Power - Intelligent Control Center Solutions for Various Customer Segments](image)

**Customized Solutions for all Requirements**

Spectrum Power 7 comes as a collection of application components that are configured into control center solutions for

- Microgrids
- Distribution
- Transmission

Spectrum Power application components are:

- Modular in nature
- Independent
- Self-contained
- Based on a common architecture

Selected Spectrum Power application components are equipped for being used in IT environments other than a Spectrum Power control center.

The modular structure of Spectrum Power enables the grid control systems to adapt fast to new conditions. The innovative Siemens technology concepts ensure that power control systems will continually meet any requirement.
In addition to its functional adaptation, the server hardware that runs Spectrum Power can also be customized. An all-in-one system, for instance, can be expanded step-by-step at any given time all the way to a redundant multi-server system.

**Spectrum Power – for the Right Decision in any Situation**

Spectrum Power provides operators with a fast and reliable overview of their system. This means that they can quickly assess its status and quickly reach the right decisions in order to avoid cost-intensive faults.

Intelligent user guidance also contributes to reliable and efficient operation. With its modern user interface and simple, consistent operational concepts, the network control system supports operational processes as well as the right reaction in critical situations.

**Secure Access to Information – Anytime and Anywhere**

A Web-based architecture with mobile online access to all data supports the decentralized operation of Spectrum Power, be it for mobile system administration, the fast restoration of power, or for the support of active participation in energy trading.

Maintenance employees receive any alarm messages as phone call or text message. This ensures the response from any location, for example, from outside the plant, from workstations outside the control center, and even from home.

**Reducing Grid Maintenance and Operating Costs – Increasing Grid Availability**

Economical grid operation benefits from reduced maintenance and operating costs. Spectrum Power contributes distinctly to such cost reductions by improving the assessment of the grid status and optimizing the use of resources.

Maintenance management enables to perform perfectly timed planned maintenance. Applications for fast fault localization and isolation support the correction of disturbances and outages. Power is restored as fast as possible through automated switching sequences. Planned actions and their effect on the grid can be examined without affecting real-time operations using the simulation mode.

**Outstanding Investment Protection**

The data of a control system is of highest importance and has to be preserved regardless of future developments of technologies and platforms. Hence the Spectrum Power product range relies on internationally valid standards, from data modeling that complies with IEC 61970 (CIM) to communications standards such as IEC 60870-5-101, -104, DNP, and ICCP.

Furthermore, as hardware platform industry-standard X86 servers can be applied.

**Integration into Enterprise Wide IT Environment**

Spectrum Power 7 adheres to the architectural paradigms of a Software Oriented Architecture (SOA).
The main advantages of this architecture are:

- Easy and seamless integration into an existing IT landscape.
- Easy change of the integrated solution.

This implies that the investments in software and hardware retain their utility and value well into the future.
1.3 Spectrum Power 7 Microgrid Management System (MGMS)

**Scalable, Flexible, Expandable**

Spectrum Power 7 MGMS makes use of all significant technical trends, whether it is the growing efficiency of workstations and servers, the ever more complex IT integration and network environment, relational databases or standardized interfaces.

The architecture of Spectrum Power 7 MGMS can be scaled to suit any size or configuration of a network control system and with all possible combinations of application programs.

Regardless of size or functionality requirement, a Spectrum Power 7 MGMS can expand or adapt readily to any changes. Spectrum Power 7 MGMS provides cutting-edge technology for your future requirements.

From database management to network applications, Spectrum Power 7 MGMS provides state-of-the-art functionality. Integrated in the data processing environment of your company, it supports all of your business processes. Spectrum Power 7 ensures maximum reliability and efficiency under all operating conditions.

**Reliable**

Servers with time-critical functions are supported by an appropriate backup computer (hot standby), while additional servers protect the less critical functions. This set-up ensures that all functions and system availability requirements are met.

Although Spectrum Power is inherently designed to recognize the possibility of the failure of critical processes, security best practices now call for not only robust and fault tolerant internal designs, but also for a level of independence in system monitoring of critical assets.

**Secure**

As a leading supplier to electric utilities, Siemens has developed a cohesive cyber security response program. The ongoing convergence of a number of trends over the past several years has led to a continuous elevation of the importance of cyber security in the systems that Siemens designs, develops, delivers, and supports. The security-related features of the Spectrum Power control system are based on international standards such as NERC CIP, ISO/IEC 15408 (Common Criteria), ISO/IEC 27002:2005, and BDEW.

**Straightforward Configuration**

A user can individually configure the graphic user interface as most suitable to the business working environment. Based on Web technology, this user interface runs on any hardware platform from multi-screen consoles to laptops and supports multiple-window displays, full pan and zoom functions. It also provides outstanding display call-up times.
Multi-site Operation of Spectrum Power – for even more Reliable and even more Economic Control Infrastructure

With the multi-site operation capability of Spectrum Power 7 MGMS, you are provided with a powerful tool for optimizing operation management. It is possible to transfer network management partially or completely from one control center to another. Such a capability provides for greater reliability of the system (emergency strategies), and makes a considerable contribution to cost reduction.

The multi-site control centers can be configured from two or more control centers and permit a very flexible and dynamic system. In the event of communication failures, each system continues to work autonomously; after recovery of the communication link, the data is automatically updated.

The Spectrum Power 7 Multi-site Operation of Control Centers concept provides the following benefits:

- Cooperative control of a power system through multiple control centers.
- Configuration and operation of redundant network control centers for splitting tasks, or as backup for emergency situations.
- Support for hierarchical or equally ranked control centre network configurations.
- Centralized maintenance of a uniform data model for all control centers of the network.
1.4 Subsystems of Spectrum Power 7 MGMS

1.4.1 Overview

Spectrum Power™ 7 MGMS has a modular structure in order to allow best fitting solutions for various customer types. The overall structure is made up of five domains each containing one or several subsystems.

These are the domains of Spectrum Power 7:

- Base System
- Communication
- Microgrid
- Distribution

Starting from a basic configuration that ensures successful system operation it is possible to add domains and subsystems to match various tasks of different customers.

The modular structure of Spectrum Power 7 facilitates the system to be expanded with only little effort, even subsequently. Modules are replaced or new components added to implement the
required modifications.

On the basis of the standard system open programming interfaces permit individual adaptation and subsequent expansions for new or existing customer-specific components.

A typical basic configuration could include, for example:

- **Base System** to ensure that basic functions are fulfilled (operational database, redundancy, data exchange, coordination of computers, multisite operation of control centers, and so on).
- **Data Engineering** (DE) for data entry and data amendment (facility data/network data, full-graphic descriptions), data import, and data export.
- **User Interface** (UI), a powerful and graphically oriented interface between the operator and the system.
- **Independent Front End System** (IFS) for interfacing the process through remote terminal units (RTUs) and IEDs.
- **SCADA Applications** for implementing the functions required for systems operation for signaling, measuring, controlling, and monitoring.
- **Historical Information System** (HIS) for storing, archiving, and subsequent reconstruction of process data.

In addition to these, the following subsystems are available for expanding the functionality from the beginning, or later-on as need arises:

- **Generation and Load Management** (GLM) for optimized control of distributed resources, including generation and load.
- **Forecast Applications** (FA) for forecasting load and renewable generation.
- **Optimization Applications** (OA) for optimizing the generation and use of energy, for economics, emissions and reliability.
- **Distribution Network Applications** (DNA) for increasing the observability of the distribution network, optimization, and automatic detection of faulty regions or elements followed by optimal supply restoration.
- **Service Oriented Architecture** (SOA) for easy-to-maintain integration of selected Spectrum Power 7 functionality with external IT systems by means of an Enterprise Service Bus (ESB) applying international standards.

1.4.2 Base System (BSS)

**Base System: General Services**

The Spectrum Power™ 7 base system contains various basic functions (services and systems) with fundamental functions required to operate a network management system.

Based on a Linux operating system and a relational database (ORACLE) these functions are used to organize data management, data exchange and communication between the modules installed on distributed computers for maximum performance and highest reliability.

**Functions**

- **Multi-computer system**
  Provides communication services for the different servers; hardware and software redundancy, multicomputer coordination, supervision, and monitoring services.
Softbus
The link between user programs, database, and system services using standardized interfaces. Softbus provides communication between individual program modules within a computer as well as communication between several computers (TCP/IP). Softbus represents layers five to seven of the ISO/OSI reference framework; for the transport layer (layer four), TCP/IP is utilized.

Database system
Consists of Operational Database (ODB) for real-time operation (process and application data) data, and ORACLE RDBMS for domain data and configuration data.

Study Mode
Allows performing planning studies in the SCADA area in parallel to process operation.

Features
- Redundancy features include LAN redundancy, server hot-standby redundancy (for example, SCADA), server spare redundancy (for example, TNA, HIS), ORACLE redundancy, and UI redundancy. Redundancy achieves high and scalable availability for continuous operation.
- Database system with a common data model for all shared data.
- Data consistency of Operational Database (ODB) in the distributed system; failover within seconds (hot-standby).
- Different operators at different consoles can simultaneously use Study Mode using different database copies; several study cases can be active at a single console.
- Study cases can be built from the current real-time situation (snapshot), from a save case, or from the archive (any time in the past).

Base System: Cyber Security
Typical Cyber Security principles are Confidentiality, Integrity, and Availability (CIA). Cyber security for power control systems changes the priorities to Availability, Integrity, and Confidentiality (AIC).

The Spectrum Power Control system has been designed and developed for meeting these requirements with features based on international standards (for example, NERC CIP, ISO/IEC 15408 Common Criteria, ISO/IEC 27002:2005, BDEW) such as:

- Cyber Vulnerability Assessment
  Periodic Cyber Vulnerability Assessments (CVAs) are performed on the Spectrum Power 7 system.

- Information Security Governance
  All Siemens employees who design, create, or review program code have successfully completed Siemens Secure Coding training.

- Security in Lifecycle
  Development stage: security tests mandatory in concept phase and system test. Implementation stage: FAT and SAT both include security tests.

- Access Control
  A Certificate Authority (CA) entity is provided to manage keys or Digital Certificates; secure data exchange between servers digital keys are applied.

- Cryptography
  Encryption is used where confidentiality is required to protect user credentials, and for data exchanged with user interface consoles.

- Security Architecture and Design
  Siemens provides a system blueprint and associated documentation for the Spectrum Power control system.

- Patch Management
Complete process established in the field from notification by third party vendor, through Siemens-internal testing, publishing in Bulletin, testing and releasing at customer site.

**Base System: Multisite**

The Multisite feature extends the capabilities of Spectrum Power so that multiple control centers (CC) cooperatively manage a power system. Some of the advantages achieved are:

- Reduced effort for data maintenance.
- Cost reduction from temporarily shifting grid control responsibility between CCs according to workload and available staff (for example, at night time, or during emergencies).
- Increased operational reliability from full and permanently available backup CC functionality. Multisite is a high-level application embedded in the message processing, independent of the lower levels like communication network. It deals with logical links and not with physical links.

**Functions**

- Maintains inter-control centers communication and responsibilities.
- Global availability of data.
- Globally effective manual inputs.
- Maintains, transmits, and distributes engineering data.
- Keeps the process images of all control centers up-to-date.
- Enables operators to control power system elements even when the operator CC does not have a direct process connection to that particular element.
- Supports **Main or Backup Configuration**, that is, two CCs control the entire power system. At any given point in time, only one of them controls the power system. The two CCs are directly connected to the power system RTUs.
- Supports **Main or Regional Configuration**, that is, each Regional CC (two or more) controls a separate portion of the power system; operators at the Main CC monitor and oversee the entire power system because - transparent to the operators at the centers - Multisite propagates real-time data received at the Regional CCs to the Main CC.

**Features**

- Areas of Responsibility are assigned to CCs; only if a technological area is assigned to a CC, responsibilities for this technological area are assigned to the CC consoles.
- Control centers communicate through Spectrum Power LAN or WAN using TCP/IP.
- Explicit operator action at the Backup CC initiates the switching of operational control from the Main CC to the Backup; this concept avoids intrinsic problems with automated failovers.
- Multisite transmits data between CCs transparent to other Spectrum Power functions; each CC stays autonomous, that is, it continues working in case of communication failures.
- Beyond the capabilities of standardized protocols, Multisite keeps the process images of all CCs (including Backup) fully up-to-date and distributes supervisory control commands, manual updates, notes, tagging, and alarm acknowledgments.

1.4.3 Data Engineering (DE)

The Data Engineering subsystem comprises all tools related to the provision of engineering and parameter data to the Spectrum Power system (during commissioning and subsequent
modifications/extensions). The main modules of Data Engineering are the Spectrum Power Information Model Management (IMM) component and the GIS Data Import Management (GDIM).

**Data Engineering: Information Model Manager (IMM)**

Engineering data consists of domain data like equipment, measurements and topology, as well as single-line displays and configuration data for the Spectrum Power control center system such as hardware and software deployment and application configuration.

**Functions**

- Editing and maintaining the domain data and topology automatically and simply during graphical network display construction.
- Complete, partial, and incremental import and export of engineering data provided through CIM-RDF and XDF formats based on the W3C standard XML.
- Job management enables working on different engineering tasks at the same time, without conflicts.
- The IMM model archive allows retrieving a historical model for any point in time.
- Job auditing provides means keeping track of who made data changes and when changes were made.
- Transferring incremental data changes online to the operational system without interrupting process control, and undo changes similarly.
- Quality Assurance System (QAS) allows testing data changes without any implication to the main system; QAS fulfills the NERC CIP requirement for a separate test system.
- The consolidation of data from different sources in the CIM-based Domain Object Model (DOM) is facilitated by the functionalities Support of Foreign Identifiers and Support of Catalogs (for creating new objects based on specified or foreign attributes).

**Features**

- Consistent, object-oriented full-graphic user interface for a consistent view for maintaining all engineering data tasks, including graphical data.
- Automatic updating of the database on graphic changes.
- Various data validation functions.
- No changes, of any kind, software, or data model can go into the production system directly; it has to be successfully tested on the QAS before.
- Adherence to international standards (for example, IEC 61970-301 EMS Application Program Interface and its extensions according to IEC 61968-11 System Interfaces for Distribution, and IEC 62325-301 Energy Market Communication).
- User authorization, user access rights, and instance level access rights.
- Based on an object-oriented data model using a Relational Database Management System (RDBMS).

**1.4.4 User Interface (UI)**

The User Interface provides ergonomic displays, as well as support for a video projection system. The Web-based user interface provides Spectrum Power access from Windows PCs as well as LINUX workstations with the same quality. It offers a common application for LAN, Intranet, and
Internet access (compressed and encrypted data transport).

The UI is started using Webstart technology. This assures minimum start-up times of the user interface and provides zero installation clients (no additional installation effort, automatic update of new client versions).
Functions

- List displays that allow sorting by columns, direct access to location in single-line diagram, and applications of freely definable filters.
- Curve displays for past, current, and estimated values with real-time trending, limit displaying, and capability of multiple y-axes.
- Tree-view based Station Explorer Display containing all technological addresses (digitals, analogs, accumulators) with filtering and sorting, allowing direct call-up of the corresponding single-line diagrams, controlling/manual updates of switches, or un-locking of selected values with value substitution.
- Definition of access rights (authority) for the operator console and for each operator based on user roles concept.
- Desktop Layout Management allows specifying and invoking the preferred arrangement of displays for the workplace – independent of the console device used.
- Free notes that can be added to a single-line diagram at any place.

Features

- Web technology provides a common look and feel for control center workplaces, offices, and remote workplaces.
- Support of a worldmap concept for displaying the network with different degrees of detail (panning, zooming, and decluttering).
- Seamless user interaction between applications, for example, viewing the location of an alarm in the network diagram using drag and drop or one-button click, or assigning a crew to an outage by simply dragging and dropping a crew on an outage.
- Dynamic coloring of network parts depending on their characteristics (for example, dead parts, island networks, and so on).
- Mechanisms for supporting situational awareness, for example, pie charts, power flow arrows, gauges, icons, and info boxes.
- Support for multi-screen operation using drag and drop (dragging objects across all screens without switching over).
- Clear distinction of real-time environment from study mode.
- Support of geospatial and schematic displays in the same viewer.
- Access rights and areas of control for each operator and operator consoles.
- Java Database Connectivity (JDBC) and Open Database Connectivity (ODBC) allowing the integration of any reporting tool, for example: Crystal Reports and Jasper Reports.

1.4.5 Independent Frontend System (IFS)

The Independent Front-End System (IFS) is a server-based process interface for coupling RTUs of different manufacturers to the Spectrum Power control system.

It uses off-the-shelf server hardware. For the reception and transmission of character-serial messages (RS232) off-the-shelf multi-port COM boards are connected and the data are processed by the protocol modules on the server.

IFS has a large variety of communication protocols implemented such as IEC60870-5-101 (Master/Slave), IEC60870-5-104 (Master/Slave), DNP 3.0/DNP3.0i (Master/Slave), and many more.

Functions
Data transmission in balanced or unbalanced transmission modes.

Numerous pre-processing functions reduce data flow into subsequent components and release them from routine processing.

Extensive communication diagnostic capability including monitoring and listening modes.

**Features**

- Several different communication functionalities are implemented, such as point-to-point (peer-to-peer), party-line, redundant connections to dual ported RTUs, dial-up connections, or multi-drop radio connections.
- High availability of the IFS achieved by hot-standby server failover, and Line Level Redundancy.
- Online activation of data changes.

**1.4.6 SCADA Applications**

SCADA applications provide the core functionality for managing any Energy Control System, that is, signaling, measuring, controlling, and monitoring based on analog, digital and accumulator values, in a secure, reliable, and efficient way. SCADA functions will support the switching required to go to and from Islanded and grid-connected modes.

**Functions**

- **Basic Data Processing**
  Starts from pre-processed data of the IFS; value changes are monitored, data distributed to other subsystems, and written to the Operational Database (ODB). Moreover calculations, logic operations, and special processing functions for special data types (for example, metered values) are performed. Values are checked against limits and alarms are issued as necessary.

- **Topology Analysis**
  For interactive topological path tracing and network coloring depending on the current state of the network (for example, grounded).

- **Supervisory Control**
  For testing (for example, interlocks), executing and monitoring switching operations (individual operations and pre-defined switching sequences).

- **Switching Procedure Management (SPM)**
  Used to prepare, study, and execute specific sequences of switching operations for clearance, improvement of fault conditions, restoration of power following a fault, and for the optimization of the network operation.

- **Tags**
  Represent special types of network data, controlled using the Spectrum Power supervisory control function, for example, when checking interlocking conditions. Tags displayed in single-line displays call the operator’s attention to exceptional network status reports.

- **Redundant Data Sources**
  Support both digitals and analogs; analogs are allowed to have up to four redundant data sources.

- **Load Shedding**
  Enables an operator to shed or restore a list of load control elements. An operator can shed to a specified MW load curtailment within a list. The under frequency relay monitoring function monitors and reports the status of the under-frequency relays,
Features

- Excellent situational awareness thanks to graphical indication of critical situations, topological coloring and tracing.
- Secure network operation due to granular access rights by function and area of responsibility.
- Online adaptations of interlock conditions and safety features permit network expansions without interrupting operation (preliminary test in study mode).
- Simulation of the effect of a switching procedure (that is, set-up through SPM) to determine network elements that would get (de-)energized after execution.
- Execution of switching procedure actions by stepping through individual actions, or by requesting that an entire switching procedure is automatically executed in the precise order as built.
- Complex switching operations such as busbar changeover and line switching permit reduced switching times and therefore fast execution of the switching operations (‘pre-defined switching sequences’).
- Multi-phase presentation and control.
- Export of tabular displays to charts (for example, Microsoft Excel).
- Study context for analysis of past and future operations (for example, using real-time snapshots as base case).
- Easy engineering thanks to type based definition of alarming behavior, display behavior, and so on, of equipment.
- Load Shedding allows shedding and restoring all loads in a list with one single command.

1.4.7 Generation and Load Management

The Generation & Load Management (GLM) subsystem enables the integrated management of distributed generation and load resources. Operation and safety-related restrictions are taken into account. Different factors (efficiency, fuel costs, reserve power capacity, and so on) can be matched in an optimum fashion which leads to considerable cost reduction.

To address the particular constraints of a Microgrid, the lack of inertia as well as the variety of distributed resources are taken into account. The operation of the Microgrid in both islanded as well as grid-connected modes are supported.

Functions

- **Load Frequency Control (LFC)**
  Controls the power output of the generating units in a way to maintain system frequency and/or Control Zone Net Interchange at their desired values. Virtual Unit Groups handle the logical control of an aggregated plant, for example, Combined Cycle Units. Controls dispatchable load and Demand Response resources as part of the overall balance.

- **Economic Dispatch (ED)**
  Allocates generation in an optimal manner among the committed units to minimize production cost while respecting reserve requirements and technical constraints. ED cooperates closely with LFC to satisfy system economic and regulating requirements in the most economic manner consistent with the operating capabilities of the units.

- **Reserve Monitor (RM)**
  Provides tools for the definition of active and reactive reserve requirements; RM periodically calculates active and reactive reserves, compares the reserves to the requirements, and alarms insufficiencies.

- **Automatic Voltage Control (AVC)**
  Uses Available voltage controls to control the voltage in the Microgrid within acceptable levels,
computing controls in real-time in response to telemetered voltage values.

**Features**

- Modelling of renewable resources such as photovoltaics, wind generation, as well as energy storage and demand response resources. By means of Virtual Unit Groups LFC and handle the logical control and dispatch of an aggregated plant consisting of many real generators.
- LFC provides a fully compensated area controller with separated small and large signal handling for both utmost stability and fast response.
- ED provides three different dispatch calculations to meet real-time dispatch requirements (that is, tertiary control) and also advisory and schedule requirements.
- RM supports up to five reserve classes and various reserve calculation modules for a wide range of reserve elements.

**1.4.8 Forecast Applications (FA)**

The Load Forecast application calculates the load for the future hours and days. This quantity is the basis for planning sufficient generation, spinning reserve, and standby reserve for future time instances.

Renewable Generation Forecast has modules to calculate the output of solar photovoltaics given the weather forecast. A second module calculates the output of any wind generation.

**Functions**

- Correction of historical load
- This manual user activity improves the data quality and closes gaps of historical data.
- Rescaling of weather
- For example, considering time delay between outdoor and indoor temperature caused by thermal capacity and the smoothing factor caused by the isolating capability of the houses.
- Data analysis
- For the automatic load forecast function, the historical data is analyzed using Multiple Regression Analysis, or Adaptive Regression Analysis (Kalman Filter).
- Automatic load forecast
- Activated periodically at defined time steps, after each run of the analysis program, or on operator request, for example, after entering/importing weather forecast.
- Very Short Term Load Forecast
- Provides forecast correction based on deviations between predicted load values and measured load values of the last few hours thus considerably improving the forecast results up to 3 hours ahead.
- Manual load forecast
- Available means include single manual entries, rescaling of daily forecasts to assumed peak load or energy demand, weather sensitive pattern matching algorithm, and more.
- Similar day forecast
- Similar day forecast is based on predefined non-weather sensitive load patterns and weather increment patterns; the operator enters the predicted weather for each forecast day: hot (H), normal (N), or cold (C).
After the fact error analysis

Provides information concerning the accuracy of the load forecast by comparing the current measured load with the forecasted load, for example, Mean Absolute Deviation (MAD).

Features

- Forecast load up to seven (7) days ahead.
- Long term generation forecast for photovoltaics
- Incorporates very short term forecast of photovoltaic generation based on sky scanners
- Support for multiple forecast areas (geographical areas or logical areas such as groups of customers)
- Multiple users (Real-Time User, Study Users)
- Web-based UI
- Commercial RDBMS

1.4.9 Optimization Applications (OA)

The Optimization Applications calculate the optimal mix of generation, interchange and load to meet economic, environmental and reliability requirements. This includes taking into account utility demand charges, time-of-use pricing, real-time pricing and the cost of generation within the Microgrid, including fuel mixes, optimization of combined cycle or multi-stage generation. The Optimization Application will also take into account scheduling of loads and demand response resources.

Functions

- Scheduling of Generation and Load in 15 minute to 1 hour intervals for up to a day ahead
- Optimization to meet economic objectives (minimize cost of energy) or environmental concerns (reduce emissions)
- Prepare cost and capacity-based bids for energy and ancillary services

Features

- Highly flexible optimization engine
- Uses standard Mixed Integer Programming libraries (IBM ILOG CPLEX, Gurobi)
- Allows determination of best mix of local generation, interchange and any load shifting if needed
1.4.10 Historical Information System (HIS)

The Historical Information System (HIS) component of Spectrum Power™ 7 provides the functionality to collect, archive, and analyze all power system related process information.

Functions

- HIS calculates and stores aggregated values persistent for configurable time periods (for example, 15 minutes); such value aggregation is configured on a data point level for optimal support of utilities' reporting or analysis use cases.
- HIS calculates aggregated values on the fly for a user-specified time period for utmost flexibility.
- Historical values can be manually updated (for example, corrected) and dependent persistent aggregations are automatically recalculated; logs are provided for audit trail.
- HIS provides predefined formulas including conditional arithmetic, trigonometry functions, and MVA calculation; user defined formulas can be defined with the formula editor.
- Archived data (switch statuses, tap positions, analog measurements) can be replayed in single-line diagrams.
- Support of offline area/long term archive by moving data to tape, DVD, and so on, and reloading on demand.
- Replay allows the user to display historical data using a single-line diagram for a specified time range and playback periodicity. The single-line diagram to be used for the playback can be chosen from snapshots of SCADA single-line diagrams that HIS has saved periodically.

Features

- RDBMS-based archive, using standard Oracle technology.
- Scalable architecture to process very large volumes of data.
- Data collection and storage both periodic and by exception; spontaneous archiving of real-time values.
- Data collection for HIS can be configured as a hot-standby component; it buffers the collected data during a temporary down period of the HIS database to ensure that no data is lost.
- Web User Interface for accessibility from any client with access permission.
- Easy access for data reporting and evaluation in the office environment using open interfaces, for example, integration with ODBC/JDBC-based tools (such as Microsoft Excel).
- Export to Excel and CSV Format.
- Temporary buffering for redundant data collection using Hot-Standy technology of Spectrum Power 7.
- Corporate users archive using HIS replica in demilitarized zone (DMZ).
- SOA Interfaces for easy integration with external applications using an Enterprise Service Bus (ESB).

HIS: Energy Accounting (EA)

HIS Energy Accounting (EA) is the separate accounting routine on top of the HIS.

Functions

- Collects and stores generation, interchange, and load energy values.
- Energy values are accumulated over selectable time ranges, for example, to calculate daily energy.
- Energy calculation per Tariff period.
1.4.11 Distribution Network Applications (DNA)

The successful management of smart distribution grids increasingly requires tools to simplify and improve the analysis of situations in the grid and provide more reliable networks status information. The Spectrum Power Distribution Network Applications (DNA) form a critical component in the Smart Grid transformation of the electrical distribution network.

- It increases the observability of the distribution network and provides the user with a fast and complete real-time view of the current network status (monitoring).
- It provides optimization of the distribution network control in closed loop operation. DNA implements dynamic optimization of the distribution network.
- It automatically detects the faulty region or elements and implements an optimal restoration of de-energized areas.

Functions

DNA is divided into various applications. Applications can be added to match the tasks and the structure of the system and to improve the observability of the network. With this modular structure, the system can be expanded with little effort to meet the diverse and growing needs of the utility.

DNA provides Smart Grid tools for analysis of the network with:

- Distribution System Power Flow (DSPF)
  - Calculates the network status under different load conditions and configurations including look-ahead. Potential limit violations are detected. The results are also used for further analysis (for example, what if scenarios) and further optimization processes.
- Distribution System State Estimator (DSSE)
  - Provides a solution for real-time monitoring, control, and optimization of the network. Unlike DSPF, it utilizes available current magnitude and measured power values. It consistently corrects incoming mismatched information during the estimation process, including topology analysis, load data, and measured values. The adaptation of loads uses an optimization process which minimizes the deviation between measured and calculated values. DSSE integrates this optimization process together with a power flow engine to calculate all nodal voltages and branch flows.
- Short-Term Load Scheduler (STLS)
  - Maintains scheduled active and reactive power consumption of system loads for a short time range (for example, one week - hourly) using the existing values, and continuously adjusting to the latest DSSE results. In addition, information from automated meter reading can be used as input to improve the quality of STLS results.

DNA provides Smart Grid tools for fault management with:

- Fault Location (FLOC)
  - Localizes the faulty section as closely as possible by using remotely controlled and manually updated information from, for example, protection devices, fault indicators, and impedance measurements.
- Fault Isolation and Service Restoration (FISR)
  - Determines a set of switching operations to isolate an area of the network and to restore service to de-energized areas of the network while making sure there is no violation of substation transformer capacities and other constraints.
- Short Circuit Calculation (SCC)
  - SCC is used to calculate currents that are results of a short circuit. It solves symmetric or asymmetric faults. SCC is used to determine the maximum short-circuit current which
determines the rating of electrical equipment, or the minimum short-circuit current which can be a basis for the protection sensitivity checking or fuses selection.

DNA provides Smart Grid tools for optimization of the network operation with:

- Volt-VAr Control (VVC)
- Determines control actions of transformers with on-load tap changer, phase-to-phase voltage controllers and/or shunt capacitor banks to improve network operations, for example, loss minimization. VVC provides both open-loop and closed-loop operating modes.
- Optimal Feeder Reconfiguration (OFR)
- Determines switching plans and multiple options for the optimal radial distribution network configuration and the specification of the normally open switches, according to the selected objective function, for example, active power loss minimization, accounting for equipment loading limits and voltage limits. The Large Area Restoration (LAR) sub-function determines the restoration plan for supplying of large parts of the distribution network, which are de-energized after a fault occurrence or maintenance work.

**Features**

- Automatic verification of quality and completeness of relevant data.
- Use of Advanced Metering Infrastructure (AMI) information to increase the load calculation accuracy.
- Complete and consistent calculation of the current state of the distribution network.
- Detection of erroneous measurements.
- Calculation of optimal resource settings to optimize the state of the network.
- Automated fault detection and service restoration.
- Operation in different modes (open loop, closed loop, and study mode).
- All applications are designed and developed to take into account the characteristics of distribution networks (very large radial and weakly meshed structure, symmetrical and asymmetrical, balanced and unbalanced)
- Data Validation Tool (DV) that verifies in an automated way quality and completeness of the data necessary to execute all DNA functions.

**1.4.12 Service Oriented Architecture (SOA)**

The Siemens Service-Oriented Architecture (SOA) Framework enables loosely coupled communication between Spectrum Power components and external Business Service Components (BSCs) and thus provides advantages such as:

- Modular and decoupled architecture, which leverages open industry standards to allow disparate applications exchange data.
- Flexibility to add and modify services with minimal impact on operations.
- Configuration driven framework, that is, easy to maintain.
- Support for secured Web services communications.

In a fully SOA enabled enterprise environment, service enabled BSCs are typically interconnected by an Enterprise Service Bus (ESB), which provides the communications back-bone to enable loosely coupled system components to exchange data. The Siemens SOA Adapter is built upon standards and as such is ESB vendor agnostic. Furthermore, Siemens SOA adapters do not mandate the use of an ESB system.

**Functions**

- The **Siemens SOA Adapter Framework** (SAF) provides Web services-based APIs and
configurable patterns to Spectrum Power 7 components and other applications which can be used to transmit and receive data using the ESB.

- SAF can be deployed within a J2EE Application Server such as JBoss or within a Service Container Architecture (SCA) compliant Managed Container.
- SAF provides Transport level security and Message level security to make secured webservice communication between the applications. These are configurable features and can be setup for each message. The SAF leverages the WS-Security1 v1.0 standard.

**Features**

- Enables RDBMS and non-RDBMS applications.
- Scalable and flexible deployment
  - In an ESB-based enterprise environment.
  - In a J2EE based environment such as JBoss (point-to-point Web services).
- Includes configurable SOA patterns with ability to extend as needed.
- Supports Web Services standards such as MTOM, SOAP, WSDL, and so on.
- Supports secure communications over TLS.
- Can enable HTTP(S) and JMS to send and receive data.
- IEC 61970 CIM based dynamic data interfaces.