SIEMENS

Spectrum Power™ MGMS

Microgrid Management System

Application Sheet

1 Spectrum Power MGMS (Microgrid Management System)

The Siemens Spectrum Power MGMS (Microgrid Management System) is an advanced software solution for optimal microgrid management and control. MGMS is based on our world renowned utility grid control center platform Spectrum Power 7, ensuring the power and performance to handle any microgrid application.

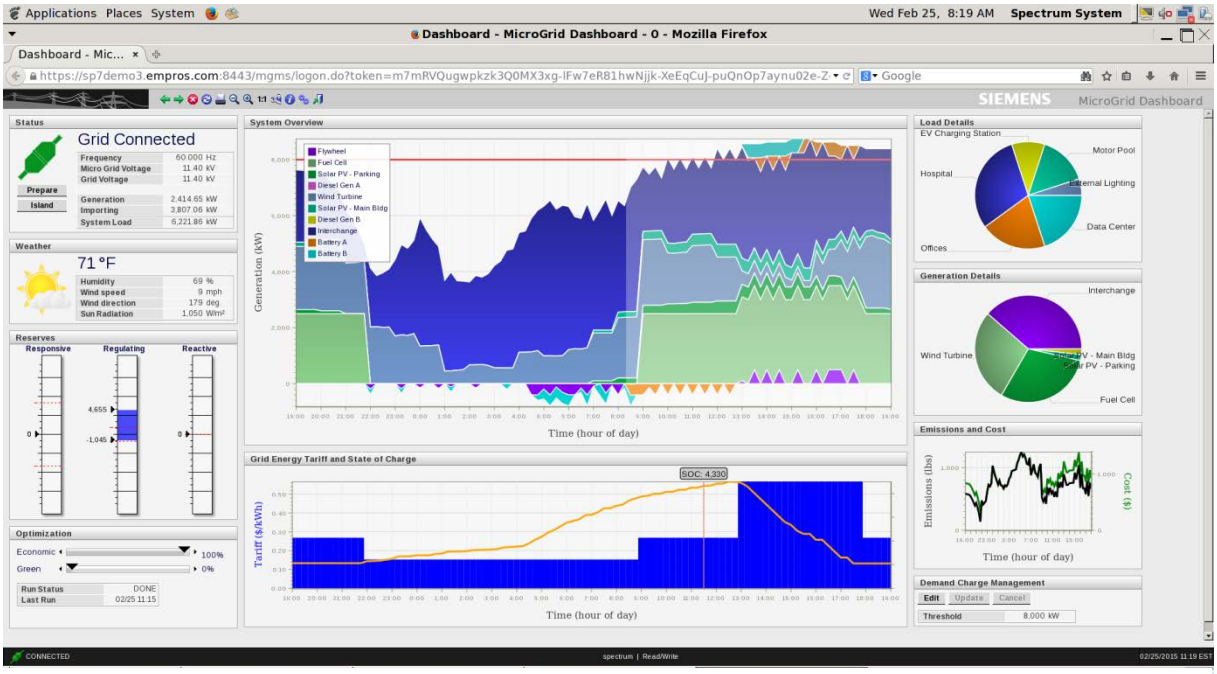

Figure 1 MGMS Dashboard

The MGMS Dashboard

MGMS dashboard provides a comprehensive overview and complete situational awareness about the microgrid.

Along with the current status, mode, the operating status of all microgrid resources in immediate past and near future is displayed in such a way that a quick look at the dashboard is enough to assess the situation.

The dashboard in above figure is showing the microgrid operating in grid connected and economic mode of operation.

Figure 2 MGMS Dashboard

Scalable, Flexible, Expandable

Spectrum Power MGMS is built on the highly scalable, flexible, and expandable Siemens Spectrum Power 7 platform.

Reliable

The Spectrum Power 7 platform has built in support for redundancy of varying degree to support stringent reliability requirements.

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

Spectrum Power IMM (Information Model Manager) provides one central place to fully configure the MGMS system. User can enter network model data, resource characteristics and other parameterization using user friendly user interface and/or importing CIM-RDF and XDF formatted files.

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.

Unmanned/Autonomous Operation

Spectrum Power MGMS can be configured to operate without need of frequent user interaction. If situation requiring user attention develops, MGMS can send alarms or alerts via text messaging or email.

2 Subsystems of Spectrum Power MGMS

2.1 Overview

Spectrum Power 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:

- Microgrid
- Base System
- Communications

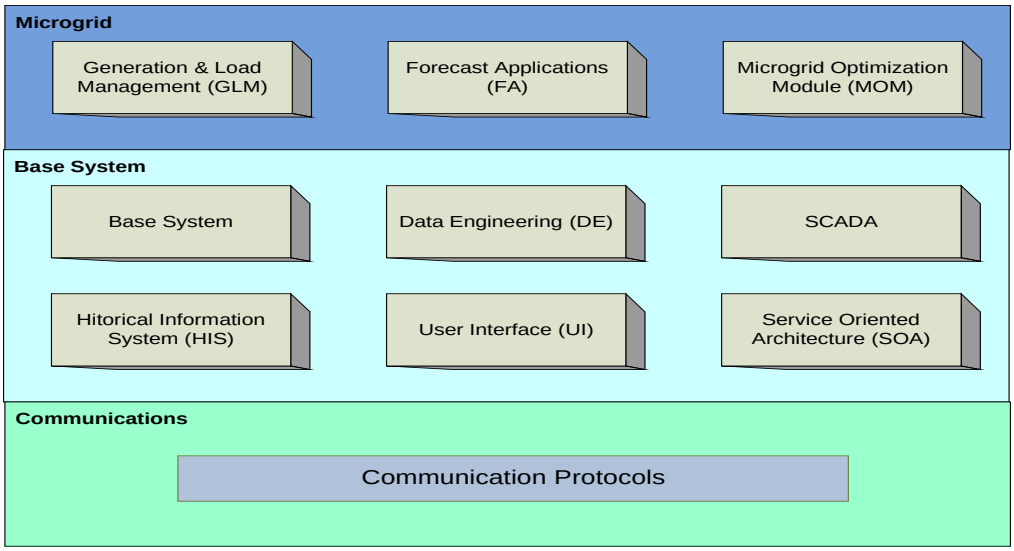

Figure 3 Domains and Subsystems of Spectrum Power 7

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 MGMS facilitates the system to be expanded with only little effort, even subsequently. Modules are replaced or new components added to implement the required modifications.

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, 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.
- **Communication Protocols** 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 generation and load shed.
- **Forecast Applications** (FA) for forecasting load and renewable generation.
- **Microgrid Optimization Module** (MOM) for optimizing the generation, storage and grid supply, for economics and emissions (green mode).
- **Service Oriented Architecture** (SOA) for easy-to-maintain integration of selected Spectrum Power functionality with external IT systems by means of an Enterprise Service Bus (ESB) applying international standards.

2.2 Generation and Load Management

The Generation & Load Management (GLM) subsystem is the most important microgrid application. It enables management of distributed generation, energy storage 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.

Variety of distributed resources is taken into account. The operation of the microgrid in both islanded as well as grid-connected modes is supported.

The GLM is designed to be operated autonomously without user interaction. The user objectives and constraints can be preconfigured and the GLM operates autonomously within those bounds.

The GLM can accept and implement commands from remote systems up in the hierarchy – such as the Market Management System or a DMS.

Functions

Generation Management (GM)

GM controls ON/OFF statuses, active and reactive power of the distributed resources that include distributed generation and storage. The distributed generation can be renewable (e.g. solar, wind) or non-renewable (e.g. micro turbines, fuel cells, diesel generators).

The active power control strategy is primarily determined by the Microgrid Optimization Module (MOM) based on the operating objective provided by the user.

The reactive power control strategies can be predetermined for grid connected and islanded mode of operation by the user.

The GM can take actions such as increasing or decreasing generation autonomously in response to abnormal situations like low or high voltage violations in the network.

The GM can be parameterized to support various active and reactive power control modes of various types of distributed resources.

In islanded mode of operation the GM can provide automatic voltage control in the microgrid.

If configured, the GM can calculate regulation and control the import/export with the main grid in connected mode of operation; while in islanded mode it can provide frequency regulation.

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. The RM also triggers Optimization Applications in response to violation of reserves in order to mitigate the situation by causing new dispatch to execute that takes into account the reserve requirements.

Automatic Voltage Control (AVC)

Automatic voltage control can be enabled or disabled separately for grid connected and islanded mode of operation. The AVC controls the reactive power output of the distributed resources that can be controlled and are configured to participate in the reactive power control.

The AVC kicks in upon voltage violation in the microgrid. The acceptable normal voltage range is defined by the user.

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.

The loads can be grouped or sub-grouped and be assigned priority (criticality). The load shedding function sheds or restores the loads considering the assigned priorities.

Load Shedding allows shedding and restoring all loads in a list with one single command.

2.3 Microgrid Optimization Module (MOM)

The MOM are the brains of the microgrid. MOM takes load and generation forecast, resource characteristics, constraints, import/export price or the Time of Use tariff for duration of dispatch horizon and computes optimal operating strategy for the microgrid for the duration of dispatch. The optimization objective can be to minimize the cost of supplying microgrid load (Economic Mode) or to minimize emission to supply the microgrid load (Green Mode). The dispatch horizon and time interval are configurable from one through seven days and from 15 minutes through one hour respectively. The dispatch is calculated at configurable periodic interval, or triggered by an event such as change in microgrid configuration (islanded to grid connected etc.), or on demand from user.

The MOM function can help prepare the energy or ancillary service bids for the unused resource capacities over the dispatch horizon.

Functions

- Scheduling of Generation and storage in 15 minute to 1 hour intervals for up to seven days ahead
- Optimization to meet economic objectives (minimize cost of energy) or environmental concerns (green mode)
- 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
- Supports Green Mode and Economic Mode of optimization
- Accepts Time of Use tariff for grid supply

2.4 Forecast Applications (FA)

The Forecast Applications predicts the values for loads and renewable generation for future hours and days. These predictions are the basis for planning sufficient generation, and import/export from/to the main grid.

Renewable Generation Forecast calculates the output of solar photovoltaic, and wind generation given the weather forecast.

All schedules including the generation and load forecast schedules are stored in a central schedule repository called Current Operating Plan (COP). COP provides easy to use APIs and UI to read and write the schedules.

Functions

- Correction of historical load
- 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.
- For the automatic load forecast function, the historical data is analyzed using Multiple Regression Analysis, or Adaptive Regression Analysis (Kalman Filter).
- Activated periodically at defined time steps, after each run of the analysis program, or on operator request, for example, after entering/importing weather 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
- 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 photovoltaic and wind generation
- 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

2.5 Base System

Base System: General Services

The Spectrum Power MGMS base system “general services” has components that make the system scalable and performance intensive.

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.

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) .

The above described capability around Cyber Security positions the Spectrum Power MGMS for expedited certification under other industry segment certification programs (e.g. US military).

2.6 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, equipment characteristics as well as single-line displays and configuration data for the Spectrum Power MGMS control center.

The IMM provides a central place where all of the data is entered and maintained.

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.
- 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.
- 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.
- 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.

2.7 User Interface (UI)

The Web-based user interface provides Spectrum Power MGMS 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)

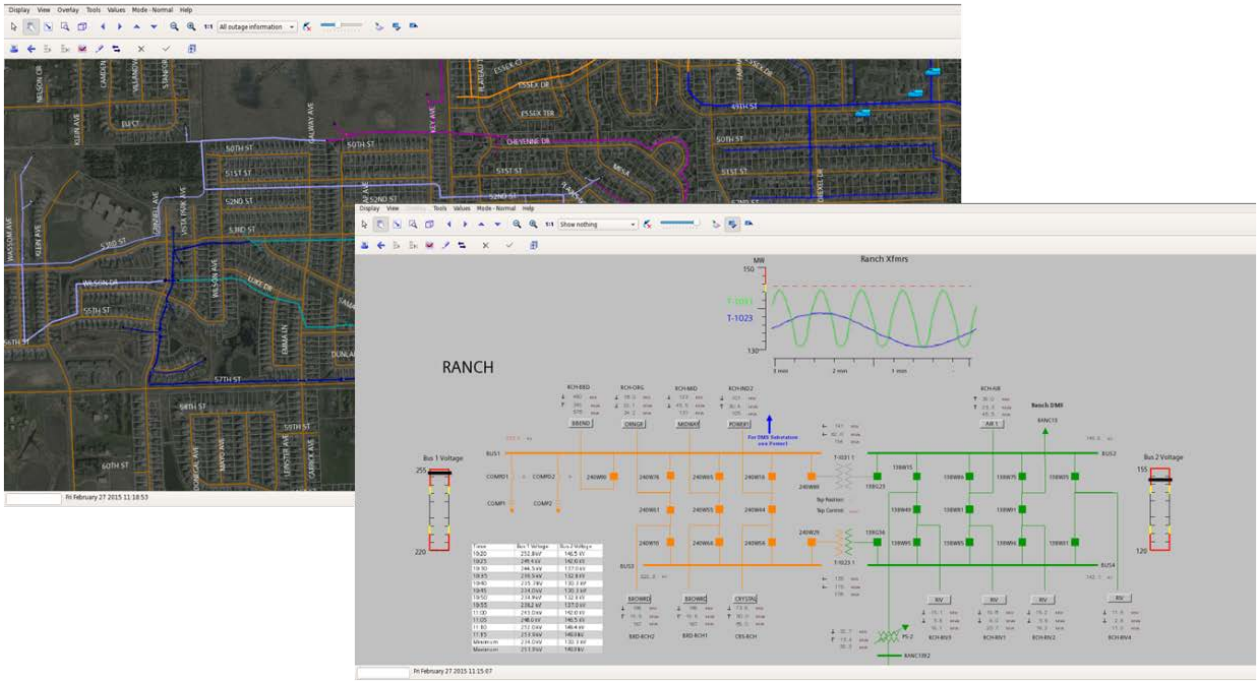

Figure 4 Switching between Geospatial and Schematic Displays

MGMS Dashboard

The MGMS dashboard provides overview of the microgrid. It is designed to provide overall situational awareness quickly.

Figure 5 MGMS Dashboard

MGMS Dashboard provides following information:

- Current Status of microgrid:
  - Operating Status (Grid Connected/Islanded)
  - Current Weather
  - Current Reserves
- Operating Mode
  - Economic – Minimize the cost of production
  - Green Mode – Minimize the emission
- Past and Future Generation, Import/Export from each generating, storage resource and grid
  - A color coded stacked line chart shows generation level for each resource for 12 hours in the past and 12 hours in future
  - User can choose any point of time on the chart and see details load and generation mix in color coded pie-chart adjacent to the stacked line chart
- Time of Use (ToU) tariff and State of Charge (SoC)
  - This chart shows the grid ToU tariff and total SoC of the storage devices for past 12 hours and future 12 hours
- Cost and Emission line charts
  - The cost and emission line charts show fifteen minutes or hourly cost and emission data for past 12 hours and future 12 hours
- Demand Charge Management
  - The demand charge management section allows user to specify a demand charge threshold so that the grid import will be capped at the desired value
- Optimization
  - Optimization section allows user to select “Economic Mode” or “Green Mode” or mix of both modes.

Functions

- 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.
- Free notes that can be added to a single-line diagram at any place.
- The MGMS Dashboard provides a comprehensive overview of the microgrid including current status, future outlook and a peek into immediate past.

Features

- Web technology provides a common look and feel for control center workplaces, offices, and remote workplaces.
- Support of a world map concept for displaying the network with different degrees of detail (panning, zooming, and decluttering).
- Seamless user interaction between applications

- 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, gauges, icons, and info boxes.
- Support for multi-screen operation using drag and drop (dragging objects across all screens without switching over).
- Support of geospatial and schematic displays in the same viewer.
- Access rights and areas of control for each operator and operator consoles.

2.8 Communication

Spectrum Power MGMS 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.

2.9 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.

2.10 Historical Information System (HIS)

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

2.11 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.

The Siemens SOA framework can be used to interface with Energy Market to submit bids for various commodities and receive settlements.