

SMART SECONDARY SUBSTATION MANAGEMENT DEVICE

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ABSTRACT

The aim of this paper is to describe a new device that will be installed into the smart secondary substations. It allows the full management of the substation and integrates control, protection, measurement and communication functionalities, on both sides, low voltage and medium voltage side. This device is integrated into a global architecture of automation network as an additional element and it communicates upstream with central systems and downstream with Smart meters installed in low voltage network that is supplied by the substation, managing their information and allowing remote operation on them. The device has been designed with a modular and scalable feature, in this way it provides a standard solution for different topologies of secondary substations.

INTRODUCTION

Gas Natural Fenosa is focused on innovation and technology to evolve and transform its current electricity distribution networks in order to face the new smart grid challenges and optimize grid management. In the recent past the smart grid has often been a synonym for a smart meter infrastructure, but now the vision must be wider. Smart grids will automate all the key components of the distribution networks. This automation will allow a diagnosis of the state of the different components of the grid, in addition to improving the quality of the service, which will lead to a better management of the grid and an efficient integration of new distributed energy resources.

Smart Secondary Substation is an important building block of the distribution smart grid. Through its services, it will be possible to obtain much more information on the operational state of the distribution grid, as well as to allow much greater control of the grid. Faster diagnostics and resolution of faults is made possible, and a much greater degree of distributed renewable energy sources and electric vehicles will be able to be integrated into the power grid.

As a result of the needs identified in the Research and Development project led by Gas Natural Fenosa called **ENERGOS**, the following features have been identified to be incorporated in the new Smart Secondary Substation.

- **Devices Design:** Compact, scalable and modular.

- **MV Protection:** Directional fault detector, supporting isolated neutral networks.
- **MV Control:** remote open-close switches using real time protocol, IEC 60870-5-104.
- **MV Metering:** Current, voltage, active and reactive power registers.
- **LV Protection:** fuses for short circuit and supervisor for other anomalies (open earthing neutral, open phase, high impedance short circuit, unbalanced loading ...)
- **LV Metering:** current, voltage, active and reactive power, active and reactive energy registers.
- **Events and alarms management:** related to **MV** and **LV** metering (overload, overvoltage, undervoltage, unbalanced,...) and related to installed equipment (anomalies, high transformer temperature, intrusion, fire, ..)
- **Metering data concentrator:** Managing readings of electricity meters installed downstream, in the low voltage circuits. Communication with these meters is performed by PLC, using PRIME/DLMS Protocol
- **Communication:** Integrating communication needs in a single pathway, supporting various technologies and security mechanisms.
- **Added functionality in developing:** on-line monitoring of partial discharge in medium voltage cables, LV loses control, connectivity LV client – Secondary substation, , Smart grid control algorithms...

To achieve the above objectives, a new device has been designed with a global perspective, providing intelligence to the secondary substation efficiently in terms of dimensions, cost and external communication needs. The device manages the substations and can be adaptable and scalable in terms of characterization: number of LV customers, substation type (rural, urban...), critical nature...

The real complexity is how to respond to all this variability with a standardized solution as simple as possible.

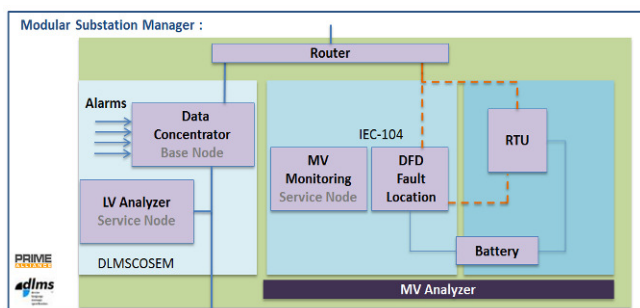


Figure 1. MSM scheme.

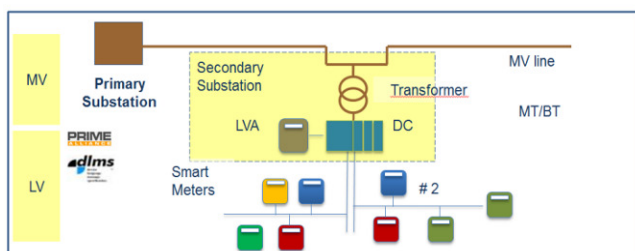


Figure 2. DC and LVA scheme.

MODULAR SUBSTATION MANAGER (MSM)

This device called MSM allows the remote management of functionality associated with the deployment of smart meters, low and medium grid supervision, and the MV remote control. The information we obtain from MSM facilitates real-time operation as well as backup office tasks:

Network Operation Center (Real Time)

- MV and LV monitoring
- Fault detection in MV
- LV feeder monitoring
- Events and Alarms in LV y MV grid.
- Automation and real-time control of the MV.

Network Operation Center (offline analysis)

- Quality of supply: undervoltage, overvoltage, harmonics and overload conditions
- LV and MV improved management: loss control, Imbalances, phase mapping, feeder-customer assignment.
- Asset Management
- Load flows Impact of electric vehicle
- Distributed Generation Impact
- Improved LV and MV network configuration

Metering System

- Remote reading of energy, power and quality parameters
- Remote Programming
- Remote synchronization with data concentrator
- Remote control power: connection and

- disconnection
- Load Management

The Smart Secondary Substation is a compact concept with a flexible balance between functionality and other synergies from the installation of numerous devices that can share information with other under the MSM framework to make a diagnosis and report to the control center, and even next substations.

For this purpose MSM uses public, open and non-proprietary protocols, prioritizing the information that must be sent using real time protocols. From the communication point of view it is working to ensure reliability, cost-efficiency, standardization, and cyber-security.

MSM MODULES

MSM device is composed of following modules:

- **Data Concentrator:** It integrates features associated with LV meters.
- **LV Analyzer:** It integrates features associated with LV side of secondary substation.
- **MV Analyzer:** It integrates features associated with MV side of secondary substation.
- **Communication Router:** it integrates into a single communication channel the communication needs of the other modules to the central systems

Data Concentrator

Its main function is to automatically obtain all information about measures and alarms associated with LV meters. This information is gathered and released to the central systems, either spontaneously, timely request of the Central System or on a schedule. It is also able to send commands, software and settings to meters. Its capacity management extends to 2,000 meters, each of them is able to generate up to 27 measures records and 53 events or alarms.

Communication used between Data Concentrator and LV meters is PLC, Data Concentrator also exchanges bidirectionally information with Central Systems through Web Services and FTP file transfer using TCP/IP communications (Ethernet port).

It can be equipped with distributed intelligence to perform global features associated with LV network: electric connection association, loss calculation, events filters...

It also has digital inputs to receive installing alarms (High temperature in transformer, flood, fire...)

Group Number	Sub-Group Number	Sub-group (Buffer name)	Minimum Entries	Description
1	10	Standard	100	Some standard events
	11	Power Contract	15	Power contract changed with values of new and former power contract
	12	Firmware	15	Firmware changed with values of new and former firmware version
	13	Synchronization	15	Clock synchronization with values of new and former date-time
2	20	Disconnect control	20	Related to connector
3	31	Power failures	15	Related to quality defined in RD1110/2007. Long Power failures
	32	Quality	15	related to quality defined in RD1110/2007. Voltage variations
4	40	Fraud	10	Related to fraud detection
5	50	Demand management	15	Related to demand management
6	60	Frequent occurrence-Common	100	Local and remote communications

Table 1. Events and alarms groups of LV meters.

All this automation is an effort of aggregation and use of complex algorithms that can analyze massive events consecutively. The existing operation centers SCADA & DMS systems need to be able to manage all the information of these secondary substations so it is necessary that some of the logic is decentralized and sent with an initial diagnosis. This allows making local decisions to ensure safety in the event of loss of communication with the operating center.

LV Analyzer

Each transformer has its LV analyzer to supervise its operation. LV Analyzer performs the same functions that LV client meters, but it also performs the following additional features:

- Logging for each phase of voltages, currents and active and reactive powers
- Generating of alarms and events associated with measures (overloads, over voltages, under voltages, phases unbalance...)

- Calculation of symmetrical components of voltages and currents for detecting network anomalies (open earthing neutral, open phase, short circuit with high impedance...)

LV Analyzer is connected and managed by the Data Concentrator in the same way that a client LV Meter.

All data of DC and LV Analyzer are communicated through standards reports to Central Systems.

Report	Content
S01	Instant data values (1 meter)
S02	Load Profile – Daily Incremental
S03	Daily absolute
S04	Monthly billing profile
S05	Daily billing values profile
S06	Meter Parameters
S07	Voltage Failure report
S08	Quality Power report
S09	Meter Events
S10	Intruder Equipment in PLC
S11	Base Node PLC Information
S12	Concentrator Parameters
S13	Meter spontaneous event
S14	Voltage and current profile
S15	Concentrator spontaneous event
S17	Concentrator events
S18	Cut/off confirmation
S19	Meter Firmware Update
S20	List of registered meters
S22	Concentrator Firmware Update confirmation
S23	Contract definition
S24	Table of meters present in the PLC network
S26	Instant data values on demand
S27	Instant register values on demand
G01	Report of hourly communication statistic with meters.
G02	Report of daily communication statistic with meters.
G03	Report of average curve (MED) of voltages, currents and powers.
G04	Report of maximum curve (MAX) of voltages, currents and powers.
G05	Report of minimum curve (MIN) of voltages, currents and powers.

Report	Content
G06	Report of instant value curve (MOM) of voltages, currents and powers.
G07	Report of average curve (MED) of unbalance and harmonics.
G08	Report of extended meter parameters
G09	Report of digital I/O parameters

Table 2. Standard reports

MV Analyzer

There is a MV Analyzer for each Secondary Substation and it integrates following features:

- Remote Terminal Unit (RTU) to remote control of the secondary substation.
- Directional Fault Detector.
- Logging for each phase of voltages, currents a, active and reactive powers...
- Generating of alarms and events associated with measures (overloads, overvoltages, undervoltages, phases unbalance...)

MV Analyzer is complemented with voltage and current sensors to capture the measures.

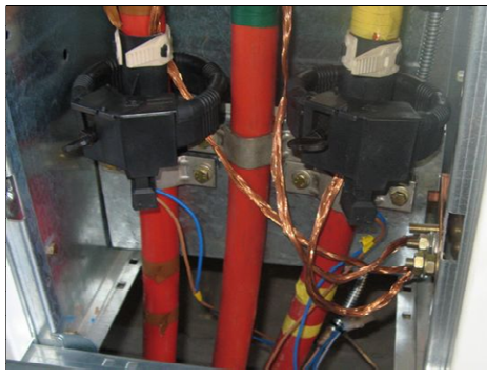


Figure 3. Current sensors in MV.

Communication Router

Communication router is connected in parallel with Data Concentrator and with Medium Voltage Analyzer through TCP/IP ports communicating with Central Systems. The communication channel may be GPRS, Optic-Fiber or PLC with broadband in Medium Voltage.

For this purpose MSM uses public, open and non-proprietary protocols, prioritizing the information that must be sent using real time protocols. From the communication point of view working is being developed to ensure reliability, cost-efficiency, standardization, and cyber-security.

Communications between meters/analyzers will be unicast type (with a specific meter/analyzer), broadcast type (every meters of network) and multicast type (with a specific group of meters/analyzers).



Figure 4. Overview of Smart Secondary Substation

TESTING AND PILOTING

Under the umbrella of several R&D and demonstration projects, MDM has been developed and piloted with satisfactory results. Currently several manufacturers already have MSM model that integrates communication router, Data Concentrator and LV Analyzer. These devices have been massively installed in more than 3.000 Secondary Substations. Throughout year 2013, MV module will be piloted for integration with the other modules.

CONCLUSIONS

The new MSM design allows transforming current secondary substations to Smart Secondary Substations adding new features required with proven technical and financial viability.

The use of open standards allows stimulating competitiveness among different manufacturers to optimize cost and to implement massively this solution in the MV and LV network.

The MSM design has been also conceived to be able to support additional functionalities that could be required in the future Smart Grid implementation.