The architecture of the SMART T-STATION

NOWADAYS THERE ARE SEVERAL LARGE PROJECTS TO IMPLEMENT ADVANCED METER MANAGEMENT (AMM) SOLUTIONS. THESE PROJECTS ARE BEING DEVELOPED BY THE ELECTRICAL UTILITIES AND CONTEMPLATE THE ASPECTS OF REPLACEMENT OF METERS AND THE DEPLOYMENT OF THEIR ASSOCIATED COMMUNICATION. THE METERS ARE REPLACED BY 'SMART' METERS THAT AUTOMATE THE COLLECTION OF USAGE DATA. THE FOLLOWING PAPER, FROM JUAN ANTONIO AND HUGO BAROJA FROM ORMAZABAL, AND JAVIER ARRIOLA FROM IBERDROLA, WAS SUBMITTED AT A CIRED SEMINAR: SMARTGRIDS FOR DISTRIBUTION

THE COMMUNICATION of smart meters with a centralised system is carried out utilising different media, being the use of the power line communication in the low voltage network one of the most accepted. The information of all the meters associated to a MV/LV transformer is collected in the secondary transformer station. The information in each transformer station is exchanged with a central system in order to feed a general database of all the meters. There are different types of communication currently being used between the transformer stations and the central system; GPRS, PLC, Fibre Optics, etc.

Due to the infrastructure of communications that have to be deployed in this type of project, a great possibility to the implementation of other type of functions is opened, otherwise unaffordable economically in an individual way. Clear examples of these functions are the automation of the medium voltage networks, fault location, remote alarms indication, etc. The implementation of these functions is quite small in the distribution networks, because the communications of each simple installation is not viable most of the times.

Therefore, there is a real opportunity for smart grids in places where AMM projects are being deployed, which must ensure the implementations of future functions are conditioned by AMM system design. This paper looks at some critical aspects needed o clearly facilitate the implementation of future functions in a systematic and optimised way.

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Critical points

In general, the proposed systems for AMM functions in the projects carried out nowadays, introduce a main electronic device to be installed in the secondary transformer station.

This main electronic device communicates with the smart meters, via power line communication, concentrating all the information. The device is directly connected to the low voltage busbars. This information is sent to a central system via modem, which is commonly integrated inside the main device. Additionally, a set of digital and analogical inputs and outputs is incorporated with the purpose of manoeuvring the switches of the installation for distribution automation functions, measurements of current and voltage for load records, fault detection, etc. Therefore, all these functions are grouped in one electronic device initially oriented to AMM functions, taking advantage of its great digital processing capability in order to include possible future functions.

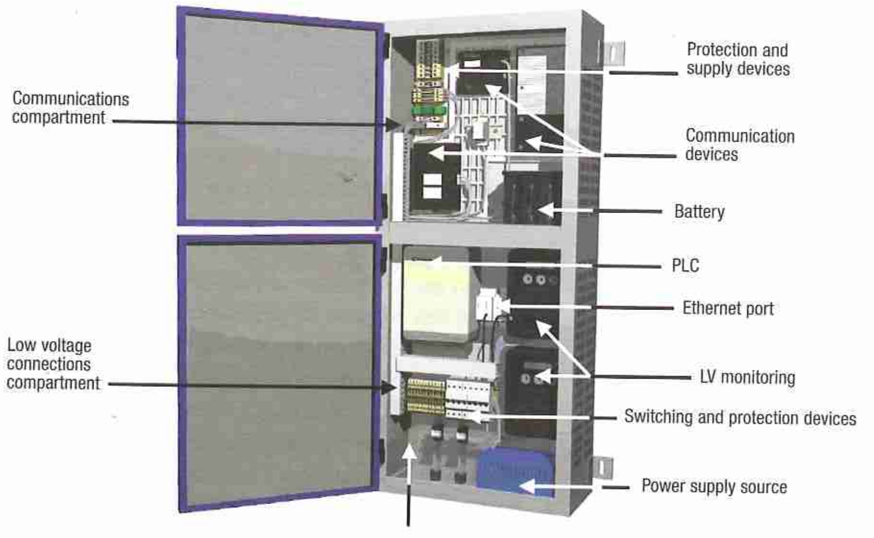
It may be observed in this type of installations that no in-depth reflection has been made on the real possibilities of utilisation of these additional functions. From a functional point of view all features seem operative, but when a practical deployment is undertaken, some critical points are detected and the use of the majority of these additional functions is not possible. Even the communications network that is deployed with the initial purpose of AMM functions may turn out to be useless for functions of automation, remote alarm indication, equipment auto-diagnostics, etc., or to incur in associated extra adaptation costs.

Transformer substation earthing systems

The first point to take into account in a secondary transformer MV/LV station, from the electrical point of view, is the earthing system. In summary, we could say there is a protection earthing system for safety aspects of the installation where all the accessible metallic envelopes of the equipment are directly connected. So, all accessible parts inside the installation have equal-potential, even under fault conditions. On the other hand, another earthing system is defined for the low voltage network and it is independent from the protection one. The low voltage earthing system is connected to the start point of the transformer in the low voltage side and it is the electrical potential reference to earth of the low voltage network. In general these earthing systems have to be independent in order not to transfer the overvoltage of the installation to the customers in case of a fault, with the consequent risks for people and goods. This detail has a clear reflection on the isolation voltages that are demanded for the different components connected to the low voltage network installed in transformer stations (LV side of the transformer, LV protection board, LV neutral interconnection, etc.).

This determining factor implies the equipment connected or referred to the electrical potentials of both earthing systems at the same time have to take into account the levels of isolation required. Otherwise, they become the most critical point for this type of overvoltage decreasing the levels of isolation, with the consequent risk for the integrity of all the installation (an example is internal arcs in the low voltage busbars where the PLC signals are connected).

Therefore, the practical application of the additional functions described previously of the devices oriented to AMM is not always possible. The main electronic device should include the levels of isolation of the installations in which it is integrated, that in some cases go up to 10kV.



ekorGID-Communications module

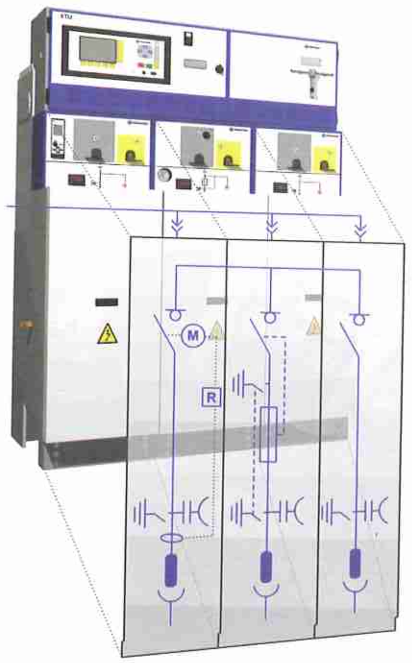
Reliable auxiliary supply

A reliable auxiliary supply is a critical point for some functions of smart grids. From an AMM functionality point of view, it is not necessary for the system to fully operate in the event of an outage in the low voltage network. In this case, there is no auxiliary supply from the low voltage side of the MV/LV transformer and the electronic equipment may not operate. The only consequence is there is no communication with the central system. No critical function has to be carried out using AMM functions during the absence of voltage period. In fact, in many of the AMM projects, it is assumed in the case of absence of voltage in the low voltage network, the smart meters and the main electronic equipment (concentrator) installed in the transformer station do not work during this period. This point is very different when automation functions are involved, where an outage in the medium voltage network is associated to an outage in the low voltage network, which implies no auxiliary supply. It is during this outage period the automation functions are more necessary. Therefore, it is necessary to have a reliable auxiliary power supply to provide energy to the control equipment, communications system and switching elements. In automated transformer stations the energy is usually stored in batteries. They operate mainly in stand-by mode and they contribute to supply the devices when an outage in low voltage occurs.

Therefore, reliable auxiliary supply is necessary in the electronic and the communications systems when automation functions are present.

Flexibility and scalability

The electrical distribution network presents a series of singularities according to the voltage level. In the lower voltage levels the number of installations is significantly higher, their complexity is drastically reduced and personnel involved in the work on site normally have no special skills. These factors have to be taken into



CGMCOSMOS ring main unit and ekorCCP remote terminal unit

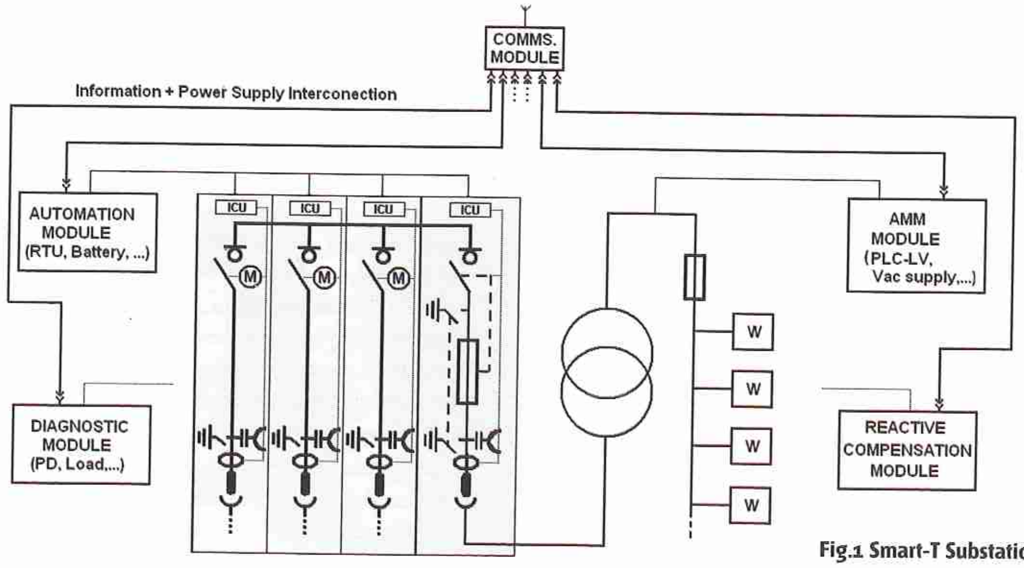


Fig.1 Smart-T Substation electric diagram

account when deploying a system concerning hundreds of thousands or more installations. The deployment of AMM projects have to include flexibility and scalability for the addition of new functions from the practical point of view of its implementation. This segmentation allows a practical deployment of different functions inside the same installation where the personnel, equipment and processes are clearly independent.

Smart grid functions are very different from a technical point of view and from the processes involved. Therefore different agents and different technologies are mixed in the same installations. For example, the evolution of network assets diagnostics like cables, transformers, circuit-breakers, etc. is a task that all the manufacturers of the equipment are affording, and this diagnostics are clearly related to the nature of each component. The diagnostics seem to be more effective if the data is processed at the component level and the final and useful elaborated information is transferred to a central system to be used local or remotely. Therefore, the installations have to be prepared not to limit the future individual functions in each component. They are in constant evolution and if they are included completely in the main device it will clearly limit the implementation of future features and this solution clearly presents disadvantages from the flexibility and scalability point of view.

Proposal of architecture

An answer to the critical points previously detailed is the modular architecture. This paper's proposal is to define the smart grid's functions from the point of view of its practical implementation. The modules are defined not only by their functionality but also by their physical implementation in the secondary transformer station. It allows the deployment to be separated into the different processes of communication, AMM, automation, alarm indication, asset diagnostics, etc. each of them independent and without interferences from one to another. Therefore, a massive installation could be carried out with different degrees of implementation which would not alter the final functionality. New modules may be added without the need to replace or modify exiting equipment and services.

A very important aspect of the proposal is the communication network is unique and may be used by the modules in an independent way.

In Fig.1 the proposed architecture is observed. The secondary transformer station is a node of an IP network and it is accessed by the corresponding physical medium. This is the WAN connection to the communication module. The IP network supports the different protocols of the modules in an independent way. This module includes the modems, information routeing and switching functions. It also includes an isolated auxiliary supply. Its function is to collect the information from the rest of the installation. It forms an ethernet network with the rest of the modules and the interconnection between them is logically and physically standardised including information interchange and auxiliary supply. This standardisation of the interconnection between modules allows the connection of every module to every port in the communication module in an independent way. This module is independent of the type of installation and the function initially implemented. It allows the physical and logical installation of the module with a systematic procedure and by specialised personnel in communication.

The AMM module includes the concentration of all the information of the smart meters and its associated functions. It is interconnected to the communication module in order to interchange the information and to supply the module. As described before, the interconnection is standardised physically and logically and is independent of the type of module.

The automation module includes the reliable auxiliary supply, the remote terminal unit, the interconnection to the switching elements, etc. and it is connected to the communication module by the standard interconnection described before.

The diagnostics module includes the partial discharge, temperature, current and voltage sensors, and the equipment to process the data. The useful elaborated information and the auxiliary supply are sent to the communication module via the standard interconnections.

Additionally, other modules may be considered to include a functionality of the smart grids, such us fault indication and location, alarm indication, reactive power compensation, etc. All of them will have the interconnection to the communication module in common, in order to interchange the information and to supply the module.

The practical implementation of the modules described before has to take into account the aspects related to security regulations for the protection of people and goods. More precisely, the physical implementation should not have to invade the places destined for maintenance and manoeuvre operations, as well as guarantee the correct accessibility. On the other hand, it is also important to define the systematic process of the installation and testing oriented to the personnel that really carry out this type of work in electrical distribution. In many cases, these tasks are carried out by small local businesses at low cost, but it has the inconvenience of a high rotation of people, poor skills, no specialisation and minimum technical resources.

A massive installation could be carried out with different degrees of implementation, which would not alter the final functionality

Conclusions

The deployment of large AMM projects in the electrical distribution networks is an opportunity like never before, to direct the process of change toward the smart grid. These projects are being deployed at a global level and they are of great interest for all of the electrical sector community. The problem shown in this paper is there has not been enough reflection on the steps to follow for the functions of the smart grid to become a reality and, to avoid that, these functions remain as a possible annotation for the future in the projects of AMM. TThis reflection intends to open the debate to solve the upcoming steps in the implementation of the functions much commented on but not massively implemented in electrical distribution networks such as automation, fault location, asset diagnostics and remote alarm indication. The proposed architecture is one of the possible examples of scalability and realistic gradual investment for an optimum and orderly massive deployment.

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