Low Power Instruments Transformers: Drivers, considerations and future trends

The change in the electrical distribution business due to the appearance of new loads as electrical vehicles and the charging stations, distributed storage and renewable energy sources connected to the MV/LV[1] distribution network, new regulations driven factors like the wide use of smart meters and expectations to increase power quality and continuity of service, increases the need of DSOs[2] to know and control this main part of the electrical power system, closer to the end-consumer.

DSOs have wide experience in system tele-control.

Up to now, the key point for tele-control was communication costs.

Nowadays, DSOs have the need to implement a communications network "in parallel" with the distribution network. They need to communicate end-consumer´s smart meters with DSO to manage and report smart meter data and get advantage with the analysis of these data.

The development of communications technologies (PLC, GSM, GPRS, 3G, 4G, FO, digital Radio, etc.) makes it possible even in the most remote places.

Some technologies, like the use of PLC couplers, allow the use of MV network not only as energy supply network but communication network, making this technology very valuable in some cases, to reduce future operative costs.

The communication network for smart grid applications will be a combination of different technologies who gives effective cost solution in each situation. The solution will be different to communicate an underground transformer substation comparing with a LBS[3] installed in middle of a remote forest.

Once we have the communications issue solved, the implementation of different equipment along the MV network is more affordable and significant, taking information of different points of the system and reporting it to the DSO, to manage the distribution system more efficiently.

What kind of information would be interesting to manage?

Not so long ago, the information of the MV network came from end-consumer that called utility because of an outage or because the voltage level is not high enough for powering the pumps at the end of the line; or because of the indication of the Earth Fault Indicators that inform of fault passage;…

DSO needs to manage the system with real time information of the state of the network if they would like to manage the network more efficiently and improve the service to their end-consumers. They need to know the behavior of the system to reconfigure it when needed, as quick as possible without negative impacts.

The use of well-known measuring technologies like resistor/capacitor dividers, Rogowski coils or low power current transformers to be connected with IEDs[4], helps DSOs do cost effective deployments to

[1] MV/LV: Medium Voltage/Low Voltage
[2] DSO: Distribution System Operator
[3] LBS: Load Break Switch
[4] IED: Intelligent Electronic Devices

take the information from the network, analyzing it and managing the alarms that all these elements can report.

These IEDs have high impedance analog inputs also called LEA[5] inputs, which requires almost no energy. The design of this LEA inputs standardizes voltage and current analog inputs due to the fact that both manage millivolts secondary signals instead of amps or volts.

It is very important to know the value of this impedance to define correctly the correspondent sensor (rated burden) to guarantee accuracy required.

The result is more efficient and cost effective management of the MV network and an improvement of the quality of the service for the final end-consumer.

Voltage and current sensors, or as they are defined in the new IEC 61869-6, IEC 61869-10 and IEC 61869-11 standards, low power passive instrument transformers, are a good option to measure real time voltage and current parameters in important points of the network, becoming key components to manage the behavior of the network, where the power can go upstream because of the distributed generation, or it can be subject to peaks of demand of energy because of the quick charge of EVs[6].

There are several characteristics that make sensors the best solution for these big deployments:

- Solutions for overhead lines and GIS[7] or AIS[8] underground installations (secondary transformer substations) are available.



- Reduced dimensions and weight.
- Easy to install, because of the design.

[5] LEA inputs: Low Energy Analog inputs
[6] EV: Electric vehicle
[7] GIS: Gas Insulated Switchgear
[8] AIS: Air Insulated Switchgear

Mechanical Characteristics		
Materials	Insulation	Resin
	Circuitry	RoHS compliant 2002/95/EC
Weight	1,4 kg.	

DIMENSIONS

- ➔ No field adjustment or calibration required (plug and measure).
- ➔ No need of fuses in secondary circuits of voltage sensors.
- ➔ Secondary circuit of voltage and current sensors can be left open or short-circuited, making them safer than conventional ITs[9].
- ➔ Linear characteristics that make them suitable to be used for both protection and metering.
- ➔ They can be used in a wide range of primary values.
- ➔ Several manufacturers and new international standard (IEC 61869) that guarantee good market offering and interoperability.

Their reduced dimensions are one of the principal reasons why these solutions have been taken into account for secondary transformer substations.

The alternative was to use conventional instrument transformers for measuring voltage, with a big space requirement, which makes this solution not feasible.

The design of MV equipment, principally RMU[10], has been strongly stressed to reduce dimensions for several reasons.

The main reason is the cost of urban land.

The T-connectors used to wire MV cables in these underground lines also has been reduced from the first symmetrical T-connectors to asymmetrical designs in order to save space.

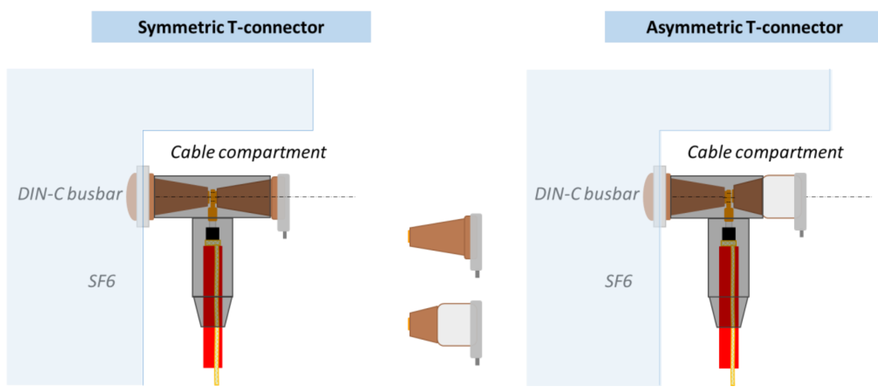
[9] IT: conventional Instrument Transformer
[10] RMU: Ring Main Units or compact SF6 transformer substations

The issue now is that the DSO needs to install new high accuracy measuring sensors for smart grid applications in this compact equipment where there is not much room.

In this scenario two aspects are important to be considered:

- ➔ the easy installation of the devices,
- ➔ the space available for them.

That is why the dimension of the sensors is a relevant issue to take in consideration. In a first look, choosing an asymmetric T-connector seems the best solution for saving space. But we must to plug the voltage sensor in the rear part of the connector, so the dimension we must consider is the total length of sensor+connector.



Both solutions have the same or very similar dimensions. That is why we must consider other reasons before choosing the optimal solution.

If we also take in to account the easy installation and the advantage of using a universal solution, then the alternative of using a standard solution versus a non-standard one helps to make fast and big deployments of smart grid systems.

If we analyze the asymmetrical solutions we see that they have different designs for different manufacturers of asymmetrical T-connector.

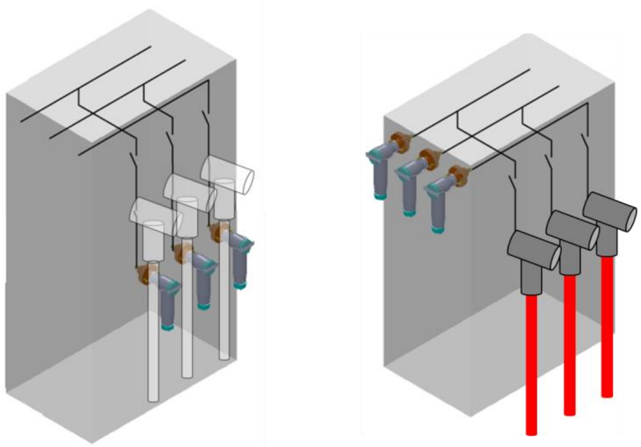
This means that we must know in advance what asymmetric T-connector we have installed or what kind of connector we are going to use in order to choose the suitable sensor.

If we use different asymmetric T-connectors in our MV network, we must install different plug sensors, adding difficulty to the deployment, which normally considers a considerable quantity of installations. Managing different sensor references also adds difficulty.

Nevertheless, the symmetrical T-connector is completely standard. All connector manufacturers design them to make possible to plug DIN-C cones in both parts of the connector, front and rear part. It is a solution with a good market offering, not only looking at the number of different manufacturers that offers this kind of connector but also considering the number of voltage sensor manufacturers that offers DIN-C cone voltage sensors.

We find this issue in retrofit projects. We need to control currently existing network so we need new solutions for old installations.

The need of installing new measuring devices (voltage sensors mainly) in overhead or underground switchgears, makes necessary to think of redefining these equipment for the next future. It is necessary to define if this measurement equipment must be integrated in the switchgear or if it must be “plugged” in order to allow access to it.



This redesign allows sending switchgear completely wired and tested from factory, avoiding wiring problems in installation, making it easier.

Another important issue that DSO must to evaluate is the technical characteristics they need for their smart grid expectations.

Voltage ratio, accuracy rated burden, etc., can be defined clearly with the new IEC standard, in similar way as we are used to do with conventional instrument transformers.

New standards **IEC 61869-10**, Additional requirements for low-power passive current transformers and **IEC 61869-11**, *Additional requirements for low-power passive voltage transformers* are helpful tools to define correctly the sensor we need.

These standards cancel and replace first edition of IEC 60044-8 and IEC 60044-7.

The LPIT[11] technical requirements are completed together with **IEC 61869-1**, *General requirements* and **61869-6**, *Additional general requirements for low-power instrument transformers*.

PRODUCT FAMILY STANDARDS		PRODUCT STANDARD	PRODUCTS	OLD STANDARD
IEC 61869-1 GENERAL REQUIREMENTS		IEC 61869-2	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS	IEC 60044-1 IEC 60044-6
		IEC 61869-3	ADDITIONAL REQUIREMENTS FOR INDUCTIVE VOLTAGE TRANSFORMERS	IEC 60044-2
		IEC 61869-4	ADDITIONAL REQUIREMENTS FOR COMBINED TRANSFORMERS	IEC 60044-3
		IEC 61869-5	ADDITIONAL REQUIREMENTS FOR CAPACITIVE VOLTAGE TRANSFORMERS	IEC 60044-5
	IEC 61869-6 ADDITIONAL GENERAL REQUIREMENTS FOR LOW-POWER INSTRUMENT TRANSFORMERS	IEC 61869-7	ADDITIONAL REQUIREMENTS FOR ELECTRONIC VOLTAGE TRANSFORMERS	IEC 60044-7
		IEC 61869-8	SPECIFIC REQUIREMENTS FOR ELECTRONIC CURRENT TRANSFORMERS	IEC 60044-8
		IEC 61869-9	DIGITAL INTERFACE FOR INSTRUMENT TRANSFORMERS	
		IEC 61869-10	ADDITIONAL REQUIREMENTS FOR LOW-POWER PASSIVE CURRENT TRANSFORMERS	
		IEC 61869-11	ADDITIONAL REQUIREMENTS FOR LOW-POWER PASSIVE VOLTAGE TRANSFORMERS	IEC 60044-7
		IEC 61869-12	ADDITIONAL REQUIREMENTS FOR COMBINED ELECTRONIC INSTRUMENT TRANSFORMER OR COMBINED LOW-POWER PASSIVE INSTRUMENT TRANSFORMERS	
		IEC 61869-13	STAND-ALONE MERGING UNIT	
		IEC 61869-14	ADDITIONAL REQUIREMENTS FOR CURRENT TRANSFORMERS FOR DC APPLICATIONS	
		IEC 61869-15	ADDITIONAL REQUIREMENTS FOR VOLTAGE TRANSFORMERS FOR DC APPLICATIONS	

All these considerations and standards will help us in the definition of the optimal solution for becoming a smart distribution grid.

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[11] LPIT: Low Power Instrument Transformers
[12] RTU: Remote Terminal Unit