COMPACT METERING SOLUTION WITHSTANDS HARSH ENVIRONMENT

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ABSTRACT

The purpose of this paper is to describe a technical solution able to improve the MV tariff metering system with benefits in terms of size and robustness.
In the smart grid context the billing and the quality measurement are crucial issues and the MV metering unit is one of the main steps to be "smart grid ready".
Thanks to the use of instrument transformers optimized for digital meters and to screened insulation technology it is now possible to propose very compact metering solution.
The specification of metering units should reflect this technology improvement, moving away from individually specified components to a more functional specification.

INTRODUCTION

Public distribution networks as well as industrial MV networks usually include metering Units in MV/LV substations [Figure 1].

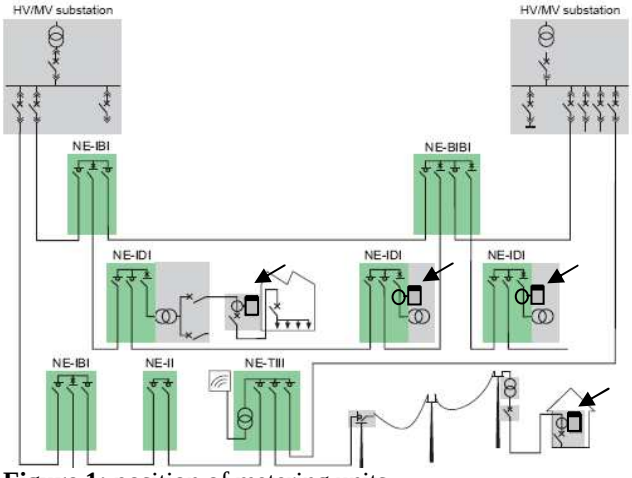


Figure 1: position of metering units

In these substations, MV or LV metering units bill the energy to private customers, buildings or industrial plants.

MV metering is generally preferred to LV metering when the installation requires one MV/LV transformer above a certain level of power or more than one MV/LV transformer. For instance, the MV metering is used when the power exceeds 1000kVA in France or 250kVA in Italy.

MORE CONSTRAINTS ON FOOTPRINT

In the past, the electricity MV tariff metering of industrial sites was located in a large cubicle part of the MV panel. This solution was simple and cost-effective.
The width stood by the metering cubicle was not a big issue because MV metering was dedicated to a small number of customers like large industrial sites with further MV/LV transformer and most of the other customers had a tariff meter on the LV side. The large width of the MV metering cubicle was also an advantage for maintenance and replacement of the MV sensors.
Nowadays, due to the lack of space available and its cost, the global trend is to reduce the size of equipment. It is the reason why new compact RMU have been developed while the metering unit remained the same for years. It is now time to reconsider new solutions for metering applications. For example, the meter devices based on microprocessor technology require very low power signal enable reducing the MV sensors size and giving the possibility to increase strongly the range of use of the sensors.

INCREASING DEMAND IN METERING EQUIPMENT

In the last recent years, due to the smart grids and the deployment of distributed generation, the number of electrical substations with MV tariff metering and sub-metering has continuously increased.
A higher level of measurement is required to combine more functions than the tariff metering. Now the smart meters are used to supply data:

- To monitor the energy quality provided by the supplier (Voltage dips, Voltages profiles)
- To manage the Volt VAR of the network by the utilities and the customers

The trend is also to offer new services to the customers to improve energy efficiency of industrial buildings, with a multiplied number of metering and sub-metering units to analyse and to bill the energy at the right level of consumer. For example, the consumers load curves will be used with the French Linky smart-meters [1] to build day-after curves. This will open new applications for:

- Optimizing the set of transformers,
- Reducing losses. Balancing the three phase currents and reducing neutral current will reduce losses,

- Monitoring the transformers and tap changers. [2] Disturbance waveforms showing the birth of faults.

MAINTENANCE ISSUES OF THE METERING CUBICLE

More and more, the utilities require solutions able to better withstand harsh environments to increase the availability of the grid and to limit the maintenance.
However the traditional metering cubicle is often a weak point of the electrical substation.

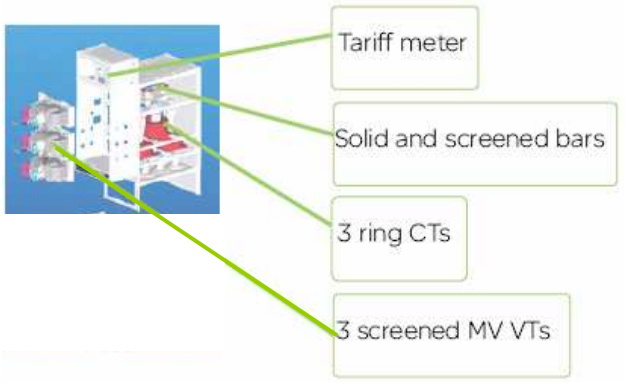
The metering units comprise MV busbars with current transformers (CTs), voltage transformers (VTs) and optional HV fuses into a cubicle with a conventional air insulated system (AIS). The VTs are fragile and must be disconnected for most of the maintenance operations. Certain ferro resonance problems can appear and above all the necessity of disconnecting the VTs for the cables or the cubicle power frequency tests is a strong weakness for maintenance operators.
With pollution and humidity, a corona discharge can be revealed with an accelerate ageing of the metering unit. A cleaning service is then mandatory and this operation is delicate due to the forms of the CTs , VTs and fuses.

Some manufacturers have developed airtight with high level of protection or waterproof cubicles to face against harsh environment but this technical approach brings an important additional cost to the cubicle.

NEW TECHNOLOGY FOR METERING UNIT

The technology proposed is totally insulated and screened design, composed of:

- Solid and screened bus riser,
- Three phase to earth VTs, solid and screened,
- Three ring type CTs, solid insulated



Voltage transformers

The VTs are located on front for easy access for maintenance and easy disconnection without HV fusing but with removable links for commissioning and replacement.

Thanks to insulated and screened design of all the components, they are insensitive to harsh environments and may be located in a compact cubicle without risk of partial discharge.
The VTs are compliant with class 0,2 according to IEC 60044-2 standard [3].

Current transformers

The CTs are traditional ring type, insensitive to harsh environments thanks to insulated and screened bus riser.
The CTs are compliant with class 0,2 according to IEC 60044-1 standard for 100/5 until 600/5 transformation ratio and class 0,5S for 50/5. [4]

BENEFICES OF A SCREENED SOLID INSULATION

The Screened Solid Insulation System (2SIS), means that the entire main circuit is solid insulated and earth screened, meeting the requirements of the “accidentally touchable” protection grade defined by IEC 62271-201. No live part of the main circuit, of the CTs and VTs are exposed to free air.
A double insulation occurs everywhere between user and the MV circuit: by the conventional protection of the earthed metal cubicle plus the earth-screened solid insulation of main circuit and components
This technology gives two advantages to the metering unit.
At first the insensitivity to harsh environments is greatly improved:

- The metering unit is not affected by climate, temperature, condensation, dust, etc.
- No more cleaning servicing
- Extended life expectancy (designed for 40 years)

Secondly the risk of internal arcing is reduced as the design includes phase per phase screened insulation over the entire MV path.

BENEFICES OF A COMPACT AND PRE-ENGINEERED METERING UNIT

Optimized size

The 2SIS technology combined with the choice of ring CTs and pre-engineering VTs allows reducing the distances between the devices (CTs, VTs, bus) as there is no electric field between them.
It is now possible to optimize the size in a reduced footprint of a 375 mm width, a 900 mm depth and a height of 900 mm, with a significant breakthrough reducing by 2 or 3 the width of the traditional metering unit while keeping an easy accessibility to the instrument transformers.

Figure 3: size of the metering unit can be reduced to 375 X 900 X900 mm

Versatile architecture

This technology allows a versatile architecture where the VTs can be placed upstream or downstream the CTs and the bus bar can be connected at the top or below the sensors.

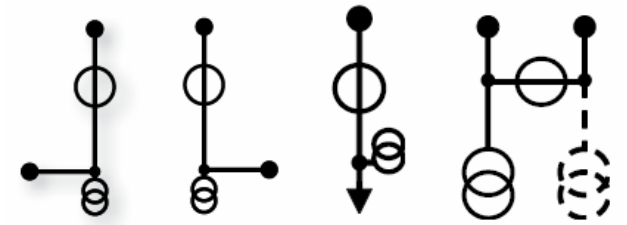


Figure 4: versatile arrangements

No more HV fused VTs

Voltage transformers are often fuse-protected in air isolated systems (AIS), however using fuses at this level brings problems. As some UK or French Electrical Utilities, many utilities do not recommend fused VTs in Gas isolated System (GIS) and with the 2SIS technology, fuses aren't useful:

- The probability to have a fault is drastically reduced compare to AIS technology because the VT is insensitive to harsh environments.
- The corrective maintenance is easier because the damage caused by a fault in the cubicle is limited. The risk of a phase to phase fault is reduced and all the faults which could occur inside the VTs turn in earth fault.
- The reliability of the VT is better than the fuse system including its connections. Using fuse gives a lower availability while not improving the protection of the installation.

Suitable for most applications

Unlike the traditional metering large MV metering, a pre-engineered solution cannot cover all the applications and performances which are specified by DNOs.
As examples:

- Some utilities require to install there own CTs or VTs in order to optimize the replacement operation of faulty sensors with a dedicated stock.
- Some utilities require high level of accuracy for very low rated current: i.e. 20/5 ratio with 0,2S class is equivalent to require an accuracy of +/-1,5 mA at 0,2A.
- High level of power for VTs :30 MVA

These specifications are patterns for the past and leads to huge measurement transformers and big sizes of the tariff metering cubicle. A global specification, including accuracy of the sensors and the meters should be addressed to better optimize the system. As an example, it is not useful to choose a CT with a ratio of 20/5 which is much bigger than with a ratio of 100/5 and doesn't allow future increase of the customer loads. The 100/5 CT class 0,2S allows to measure from 120A to 1A with accuracy and remains enough accurate until 0,1A (with a starting measurement of 0,1%× I_n) which is convenient for most of the applications.
The usual performances are illustrated in [Figure 5&6].

Single secondary metering VT (KV/V)				
Rated voltage (V) / Power frequency withstand				
7.2/20/60	7.2/32/60	7.2/28/75	12/42/75	17.5/42/75
3/√3 to 6.6/√3 kV	6/√3 kV	6/√3 to 11/√3 kV	10/√3 kV	10/√3 to 15/√3 kV
100/√3 V 110/√3 V	100/√3 V	100/√3 V 110/√3 V	100/√3 V	100/√3 V 110/√3 V
Power and precision class				
5VA to 15 VA cl 0.2				
5VA to 30 VA cl 0.5				

Figure 5: usual VTs characteristics

Transformation ratio	50/5	100/5	150/5	200/5	300/5	400/5	600/5
Power (VA) with cl 0.2S Fs<5	n/a	2.5VA to 5VA	2.5VA to 10VA	2.5VA to 15VA			
Power (VA) with cl 0.2, Fs<5	n/a	2.5VA to 5VA	2.5VA to 10VA	2.5VA to 15VA			
Power (VA) with cl 0.5s, Fs<5	2.5VA to 5VA	2.5VA to 10VA		2.5VA to 15VA			

cl: accuracy class - Fs: Safety factor

Figure 6: usual CTs characteristics

Solution, including the smart meter

The proposed solution is flexible. Standard outputs of the CTs and VTs complying with international standards [3], [4] are usable. The architecture is open to digital meters used by the DNOs as well as various models of meters depending on the applications.
A global solution may be proposed with a meter complying with any part of the IEC 62053-xx series, including power quality features. [5]

CONCLUSION

Unlike conventional metering solutions which are air insulated (AIS technology) and larger, the concept of a metering cubicle fully solid insulated and screened (2SIS technology) gives a more compact metering unit, and harsh environment withstand.

This design reduces by 2 or 3 the width of the metering unit and offers a pre-engineered solution including all the sensors and pre-tested connections.

The metering unit has been designed to adapt easily a smart meter, but a more global solution can be provide, including power quality monitoring compliant with IEC 61000-4-30 Class A. [6] and tariff metering which are accepted by the European DNOs [5] .

As with most systems utilized by electric utilities, the PQ system has grown and will grow over time.
The monitors are ION7650 or ION8800 devices provided by Schneider Electric. Revenue data is also utilized for billing and SCADA purposes. For example, in the Distribution substation, a device will use IEC60870-5-104 over Ethernet to communicate with SCADA while allowing a MODEM connection to the billing software, and a GPRS connection to the Power Quality Analysis software.

REFERENCES

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[4] IEC 60044-1,"Instrument transformers – Part 1: Current transformers"
[5] IEC 62053, "Electricity metering equipment"
[6] IEC 61000-4-30, "Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques –Power quality measurement methods" 2008 Ed 2.0