SMART POWER QUALITY MEASURMENT WITH MV RECLOSERS

Arne BERLIN
Pöyry Sweden AB – Sweden
arne.berlin@poyry.com

Niklas SIGFRIDSSON
Vattenfall Operations Nordic– Sweden
niklas.sigfridsson@vattenfall.com

ABSTRACT

The need to control the power quality is continuously increasing. This is partly due to the increment of the general requirements for power quality and partly to increasing volumes of distributed generation in the electricity grid.
The technical developments in communication systems and IT systems make it possible to implement smart solutions for power quality control in distribution grids.
This report examines the possibility of applying the power quality measurement through the protective relays ABB REF615 / RER615 which are designed for distribution networks 6-20 kV. Furthermore it gives the possibility to examine the integration of power quality measuring in SCADA / DMS environment. The study is part of the Smart Grid Gotland project, which also includes ABB Zone concept consisting of outlocated reclosers.
A strategy based on an A-B-alarm integrated in SCADA / DMS system is proposed. The system will act as a support system for system operators and not as a stand-alone measuring system for analysis. The study shows that the existing power quality functions need to be improved. The conclusion is that you already today can start to implement the concept.

INTRODUCTION

ABB introduced a number of power quality measurement functions of the protection relay 615 series in 2015. The fundamental issue was to figure out what the device could be used for and how to use the information. Another important question is whether this device can replace or complement the existing and traditional power quality measurement with power quality measurement instruments.
A general problem with traditional power quality measurement is that, in practice, it is limited to a number of measurement points in the electrical system and the ability to create communication with the measuring instrument. To measure in a high-voltage system requires access to VT:s and CT:s. Alternative points is to measure in the low voltage grid but it gives a very limited view of the power quality state of the grid. Optimal is to measure on the primary side of a secondary substation to obtain an overall view of the local grid.

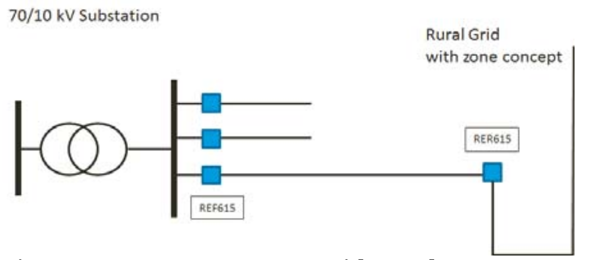

Figure 1: Zone concept with recloser. REF615 protection installed in the substation while RER615 is installed in the recloser.

A general problem with increasing the number of measurement points is that it requires an efficient measurement data collection and measurement analysis. Lack of power quality in distribution networks is also not a common phenomenon for an explicit measurement point. Therefore large volumes of data to confirm a good power quality is of no interest to analyse. The measuring system must be based on an alarm system that alerts you when something needs to be investigated or fixed. The nearest measuring point to the point of delivery (POD)is the most relevant to generate an alarm. But it will require a large number of measuring. An interesting compromise is to use the measurement points at the reclosers.

GENERAL PQ DEMANDS IN SWEDEN

In Sweden, the power quality is regulated by the Regulator Energimarknadsinspektionen. Power Quality parameters are divided into two main groups; interruptions and voltage quality. Interruptions are divided into two types; short interruptions and long interruptions. Long interruptions quantified in interruption time, minutes, while short interruptions quantified in number of interruption. The established systems are not able to quantify the short interruptions in time.
Voltage quality is regulated by the following quality parameters:
• Voltage variations
• Voltage Harmonics
• Voltage unbalance
• Voltage sag
• Voltage swell
• Rapid voltage change
For each power quality parameter is an unambiguous limit to demands for action. Many electrical grid owners have therefore developed planning levels for each power quality parameter to prevent that levels do not violate the prescribed limit. Thus, there is a basic structure of

unambiguous limits corresponding to two levels. An A level that corresponds to the regulatory limits and a B level corresponding planning levels limits.

Vattenfall Operations Nordic is working with power quality improvement through a systematic processing of customer complaints and the new connection of new customer installations such as wind farms. A continuous monitoring of voltage quality is currently limited to a number of major substations which are often near large industrial sites. There is a general problem to organize monitoring of power quality. Today's situation for electrical grid owners is that engineers who are working with power quality has no focus on monitoring, only analysis of power quality problems. Those who work with the monitoring of the power grid has no possibility to monitor the power quality. The long-term objective of power quality problems is to work preventively - ie detect the lack of quality before customers notice it. Fix the problem before it has any real effect on customers.

POWER QUALITY MEASURMENT WITH RER615

General application

Power quality measurement with the RER 615 is based on the same basic principles as protective functions; By setting a number of parameters formulate a condition for a function. Protection function results in a trip signal while measuring function results in an alarm signal.

There is no reference to the power quality measurement standard (IEC 61000-4-30) in ABB's documents, which means that measurement methods cannot be compared with ordinary class A measuring instrument. Measurement methods in 615 should thus be considered as indicative measurement. The protection also lacks the ability to save or deliver any measurement files corresponding PQDIF for analysis in a traditional power quality analysis system. The first conclusion will be that power quality measurement with the RER 615 cannot replace traditional power quality measurement of power quality instruments. The next question is then whether it can be a complement to the traditional power quality measurement.
Power quality measurement with the RER 615 has a number of structural advantages. The number of measurement points could be multiplied without any major additional costs. Integration of RER615 into the reclosers allows measuring points to come closer to the users of electricity (POD) and the reality that they are experiencing in their grid connection. The basic principle supports alarm management, which is essential if you substantially expand the number of measurement points in the grid. Protections alarm functions can be integrated into SCADA / DMS environment. You can both make use of existing technologies and methods used while handling the protection functions.
It is also possible to download the PQ values from the RER 615 to the SCADA/DMS. But compared to a power quality instrument, measurement information is very limited and insufficient for a power quality analysis. However, you can use the measurement data to visualize the power quality problem in order to clarify an alarm.

Power quality measurement involves an extended signal processing from the protection device which set new demands on the substation's communications. To put it simply, the mere management of digital alarm signals can apply the traditional technique by hard-wired but generally it is an advantage to using modern bus data technology (61850) between the device and the RTU. But if there is a need of downloading measured values it requires that the protection device is connected to a data bus system.

To be able to make a benefit from these power quality measurement techniques and in order to improve its working methods it requires modern communication technologies in the substation and a modern SCADA / DMS system on top.

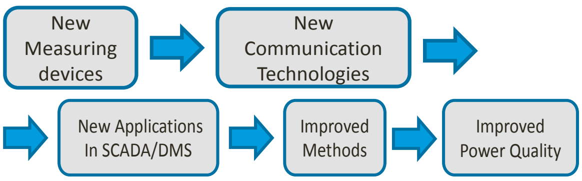

Figure 2: Preconditions to utilize new power quality measurement functions in RER615.

Available power quality functions

ABB defines the 615 series in power quality measurement functions that can be divided into three groups:

- Harmonics
- Short Voltage Change
- Unbalance

The basic parameter for voltage quality is voltage variations, but this defines by ABB as a measurement function in the 615 series. Defined measurement functions may also be added as power quality measurement functions:

- Voltage variations
- Overcurrent
- Frequency

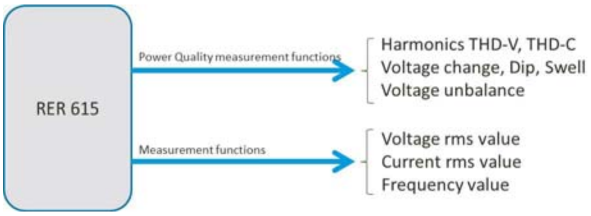

Figure 3: Avalable power quality functions

Harmonic measurement is limited to the Total Harmonic Distortion (THD) parameter but includes both voltage and current measurement. THD is sufficient to indicate harmonic problems in the network. The current harmonic gives a good indication of what causes the disturbance.

Short voltage changes can be divided into three parameters: The overvoltage (swell), undervoltage (sag) and interruption (outages). To define these parameters the relays use magnitude and duration. Outage registration would usually make use of circuit breaker functions - but to record short interruptions, it is difficult to define the time, why short breaks usually are recorded as the number of short interruptions. This power quality function provides a possibility to quantify short interruptions by duration.

Power quality function unbalance corresponding voltage unbalance but can be combined with the protective function of the current unbalance. The unbalance is defined as the ratio between the negative sequence and positive sequence. In Sweden there are always load currents symmetrical in MV system, which means that the detection of unbalance corresponds to a fault in the grid - any type of phase interruption. But at the same time, the unbalance creates total or partly outages in the low voltage grid.
Voltage variations are usually visualized in SCADA systems. But measured value is loaded from a special measurement value device. There is the possibility to use the voltage measurement directly from the IED protection. Measurement value device can thus be abolished in the future.

Overload is really no quality parameters, but a good indicator of the cause of power quality problem can be. Alarm management is based on the thermal load capacity.

Frequency measurement is primarily a responsibility of the Transmission System Operator (TSO) in a connected grid. But in an application of various types of island operation surveillance of the frequency becomes a very important function to maintaining a good power quality. The vision of the smart grid includes a clear vision of renewable production that create smaller island operation. An important part of operational monitoring in this case is monitoring of frequency.

It is important that all power quality measurement are based on the phase-phase voltage and not the phase-to-ground voltage. In MV Petersen-coil grounded systems there is a wide variation in the phase voltages, but at the same time this does not effect on the low-voltage side.

In the 615 series it is missing a power quality parameter that indicates the flicker problem. The simplest measurement function is RVC, Rapid Voltage Change.
It is also important in general that each measurement function supports at least two alarm levels.

Application of power quality measurement in the 615 series

Integration of power quality in the SCADA / DMS environment requires that the operators handle the information. An operators core business is to monitor, act and organize all the activities in the electricity grid. A SCADA / DMS system must support the operator in this work. Information that requires analysis should therefore not burden the operator. Integration of power quality measurement in the SCADA / DMS must apply the alarm functions in a way that each alarm corresponds to a need for action.

The difference between the traditional system of power quality instruments and power quality measurement, eg RER615 can be described as:
• **Analytical power quality measurement:** power quality measurement of power quality instruments designed to analyse measured values in order to clarify the condition in the power grid.
• **Operational power quality measurement:** The system must support the operators in any kind of action. The operational power quality measurement measures an analogue value which is converted to a digital alarm signal. The alarm has a defined importance for the condition of the power grid.

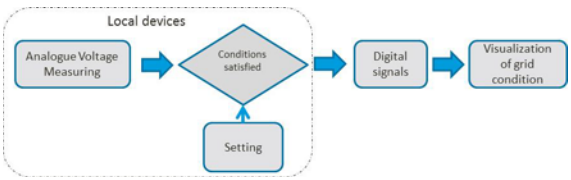

Figure 4: Operational power quality is characterized by a local setting of the device and a digital alarm function.

The operational power quality measurement is divided into two functions;
• Basic functions
• Complementary functions.
The basic functions correspond to the digital alarm signals

while the complementary functions correspond to visualization of measured values in SCADA/DMS. The visualization may involve numerical data or graphical information that aims to create a deeper understanding of the received alarms.

It should be noted that each outgoing bay has its own protection device which means that the same voltage is measured in all compartments. This can be perceived as unnecessarily when all units measuring from the same voltage transformer. Generally, it should be sufficient to measure the two outgoing bay in a substation. The current measurement is, however, important to measure CT in each bay.

Power quality alarm levels

Basic alarm management for power quality are based on the A- and B-alarms. A-alarm corresponds to the exceeding of regulations and should include some type of operational action plan. B alarms correspond to the exceeding of internal planning levels and operational plan is basically to create an investigative case, a PQ case. A PQ case has generally 1-20 weeks of investigation and therefore must be able to park a B-alarm so that it do not interfere with the daily operation monitoring. Even an A-alarm may take several days to troubleshoot why even an A-alarm should be temporarily parked to not interfere with the daily operation monitoring.

An example of application of the alarm levels of harmonics can be described as follows. A-alarm is selected THD 8% as this is a threshold according to the regulation. Harmonic THD levels above 4% in the MV grid are generally very rare. Obtained the exceeding of 8% means that a connected facility has broken by eg broken filter or connected equipment that has created a strong resonance in the power grid. New equipment connected to the distribution network often contains inverters of any kind - eg micro production. The network company generally lacks supervision of these facilities and the only way to discover that something is wrong is by the power quality. 4% THD could be grid companies planning level and will be set as B alarm. A B alarm could be a sign that the grid has too low short circuit impedance. A B- alarm should start a PQ case to investigate the problem with high THD level.

STRATEGY OF OPERATIONAL PQ MESURMENT

The strategy of operational power quality measurement can be summarized as:
- Introduce relay protection with power quality
- Apply A and B alarms in the system
- Supplement SCADA / DMS with PQ alarm management.
- Introduce modern data bus technology with 61850 in the substations
- The work with the PQ settings integrates with settings of the protection function.
- Develop and formulate a philosophy of setting for the PQ alarms.
- First establish the basic functions
- Secondly implement complementary functions.
- Develop visualization of the corresponding numerical measurements of SCADA / DMS.

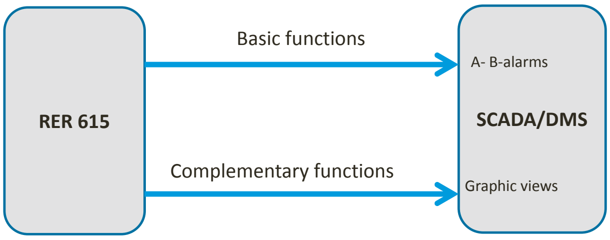

Figure 5: Strategy of operational PQ measurement.

The strategy assumes that some improvements to the existing power quality measurement functions are implemented.

Today micro-production and other small renewable electricity production is introduced in distribution networks. The structure of the distribution is not really built to handle production input. Installation of micro production is performed by private individuals, which makes it significantly more difficult to control the plant itself.

REFERENCES

[1] ABB Technical Manual RER615, 2015-03-06, Revision C, Product version 1.1. ID:757817 1MRS