USE OF INFORMATION PROVIDED BY AMR SYSTEMS TO EVALUATE PQ INDICES IN DISTRIBUTION NETWORKS

Dorel STANESCU, Electrica S.A., Romania[1]
Iacob BLAGU, Electrica S.A.,Romania[2]

SUMMARY

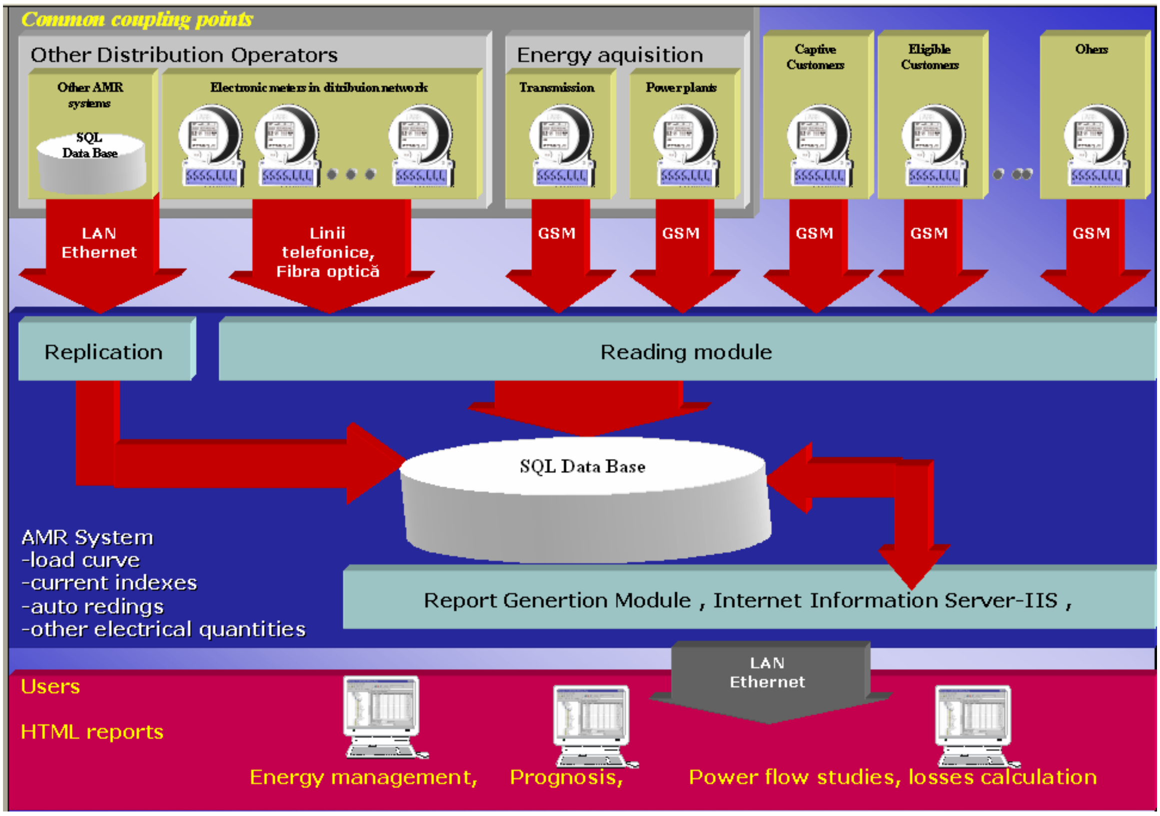
Recent developments of liberalised energy market promoted Automat Meter Reading systems as the principal instrument for metering operators. Over the past years few years information gathered from field energy meters accumulated in very large databases.
Digital meters used in today's energy market have, beside basic functions such as indexes for energy and load curves, extended functions wich permit assessment of some Power Quality indices. This paper present results of an analyse conducted with use of that extended functions disponible for meters included in an Automatic Meter Reading system implemented at a distribution subsidiary. Even the measurements are not executed acording EN 50160 standard, some relevant conclusions about the PQ problems in a distribution network can be outlined. This measurements can be combined with those obtained from dedicated PQ analyzers installed in certain nodes of distribution network in order to make a proper evaluation of PQ indices.
This solution has the advantage of using existing equipments and communication channels to search and locate sources of perturbations in the network. Because digital meters are installed at different voltage levels snapshots of PQ indices over the entire network are obtained at the same time.
Key words: power quality, harmonic distortion, distribution network

---

[1] str. Uzinei, nr. 1-7, Sibiu,Romania, telefon: 0269 205830, e-mail: dorel.stanescu@electricats.ro;
[2]str. Uzinei, nr. 1-7, Sibiu,Romania, telefon: 0269 205700, e-mail: iacob.blagu@electricats.ro;

AUTOMATIC METER READING SYSTEMS

Automatic Meter Reading (AMR) Systems are widely used today to aquire information from remote energy meters installed in common coupling points. This information is stored in relational databases, procesed and used to establish energy exchanges on the market.
Present day electronic meters can be considered Intelligent Electronic Devices (IED) since they perform aquisition and measurements of electric quantities in network nodes and store them in internal memory. Usualy the measurements are accesed from a remote control center using digital communications and downloaded according a predefined schedule. In figure 1 is presented the information flow from field meters to final users.
The arhitecture of AMR systems resembles one of a SCADA system. The main difference is that SCADA systems performs ON-LINE data aquisition and bi-directional communications instead of data download on request as is the case for AMR systems. Still we can recognize the communication infrastructure, the central database stored on a powerfull server and the computer network used to provide users with different reports according access rigths.



Figurea 1 Information flow for AMR system

Measuremens presented in this paper were obtained using the AMR system developed in recent years in a romanian distribution branch. This system manages electronic meters installed in:

- 110/20kV distribution substations for each overhead 110kV line and on each power transformer high and medium voltge side.
- common coupling points with other partners such as tranmission operator and hidro power plants.
- Energy measurement installations for eligible cusomers.

Equipmets used to develop present AMR system are:

- Electronic meters ALPHA A1RLQ+ and A1R-l type
- Communication equipments (analog and GSM modems, multipexing units and a wide range of converters
- Servers, computers and other pheripherals at central headquarters

In order to be integrated in the AMR system the electronic meters need to be able to measure the active received and delivered as well as the reactive energy in the 4 quadrants highlighting the inductive and the capacitive components. Those meters are storing the information regarding the electrical power received and delivered using 4 chanels for the load curve. The period when the load curve is stored depends on the size of the storing interval and on the number of chosed chanels.

DISTORSIONS IN 110kV DISTRIBUTION NETWORKS

As it was proved by a number of mesurements and analyses done in the last period of time, the distribution network functions under an unbalanced regim. The unbalanced regim indices can be meassued using specific measurement and recording equipments, genericaly named network analysers. Because those equipments are expensive, they are used localy and only for limited periods of time.

In order to estimate how the unbalanced regime influences the power losses in the the distribution network, is necesary to spead the area of measurements. This approach involves simultaneous meassurements in different network nodes using a time frame that will allow to extrapolate the results to the usual time intervals for power loss calculation, quarterly or yearly. A possible solution can be to develop dedicated systems that will be able to analyse the power quality on the whole distribution network. This approach has the advantage to meet all the requests for a continuous monitoring of the power quality indicators, but has high costs and requires time to be implemented.

Another possibility is to use the data aquisitions provided by the inteligent electronic devices IED that are already instaled in the network wich have the capacity to determine a part of the power quality indicators. We can name here the RTU equipments which have the capacity to record separately informations about the voltages and currents from the network nodes they are supervising. This information can then be accesed in the data base containing the history and evolution of the measurements and can be used to determine the unbalanced regime indices.

Another example are the actual energy meters which provide the electrical power consumption and a vide range of real time measurements. As a result of the energy market development, the number of electronic meters provided endowed with extra facilities for example, the possibility to record the load curves increased to several hundreds in recent years. Those meters are ussualy installed in network nodes where other data aquistion IED do not exist or there is no justification for their presence. The possibility to follow up the electrical power consumption recorded every hour in more network nodes hepls to improve the methods and the results of powerflow analysis. A part of the electronic meters have special functions. They can measure the active and reactive power, the voltages, the currents, the harmonic distorssion coefficients, can record those measurements and send them to a distant location based on a scheduler. Furthere analysis of those records allows a better monitoring of the power quality parameters and help validate the mathematic formulas used in software applications.

During 2006, the real time measurement data aquisitions from the electronic meters from the measurement groups of the 110kV network were used to identify the asimetrical and unbalanced regims on the 110kV overhead line with the higest load in Sibiu distribution network. This line is named OHL 110kV Sibiu North-Copsa Mica. In order to obtain a complete image, there were used the real time values measured using the meters from the measurement groups connected with OHL 110 kV Sibiu South-Sibiu North, OHL 110kV Sibiu North-Copsa Mica, the meters installed in Sibiu and Copsa Mica 110/20kV substations and the metter from the main customer connected at 110kV level, suplied directly from Copsa Mica substation trought its own transformator.

a) THD_U % OHL 110kV Sibiu Sud – Sibiu Nord.

b) THD_U % OHL 110kV Sibiu Nord – Copşa.

c) THD_U % Trafo1 110/20kv Copşa.

d) THD_U % OHL 110kV Copşa - Mediaş.

Figure 2 THD_U values recorded on OHL110kV Sibiu Sud-Sibiu Nord-Copşa-Mediaş

During 15-17 iulie 2006

During one week, the informations were recorded each hour using the AMR system.We need to mention that the values were the real time values for the moment of interogation.

Because the data aquisition system can interogate only one meter at the time, the streams of values obtained from the 5 measurement groups are not perfectly syncronised, but the individual values for each of the 5 measurements are included in a 10 minutes interval, needed to examine all meters. Also, the priorities in the communication protocols established in the AMR system did not allow access to real time data aquistitions in certain time intervals (especially between 02:00 and 04:00 when the meters are automaticaly read).

Those aspects make the stream of values to be discontinous. But even under those circoumstances, enough data for a concludent analysis were obtained.

The majority of examined metters use three wires connection. For this reason, the recorded values for V_R and V_T showed in the chart need to be considred actually the line voltages U_{RS} and U_{TS} .

The results presented in chart 3 a)....d) are in a condensed form . Only the values for the voltage total harmonic distorsion factor THD_U.have been used. It can be noticed that in all three cases, the total harmonic distorsion for line voltage U_{TS} has constantly values over the treshold limit (3%).
An analysis of therecords leads to the following conclussions:

- Simultan measurements in different points of the network allow a comparative evaluation of the indicators and the validation of the results.
- Similar results for diferent network nodes, reduce the possibility that higher values for THD_U and THD_I are exclusively caused by errors introduced in the measurement chain by measurement transformers.
- The recorded values of THD_U for U_{TS} are high in all the measurements. This indicator's value is constantly over the 3% limit.
- Different values of THD_U for U_{RS} and U_{TS} are noticed in all the monitorised nodes. In the same time, the THD_I values recoded on different phases in the consumption nodes have aproximatively the same values. Those observations lead to the conclusion that the perturbations are generated outside the analysed area.
- The most probable sources of perturbations are the power suply substations Micasasa and Dumbraveni for the electrical powered railway transportation. Because in those substations the meters do not provide real time measurements, is necesary to analyse their functioning regim with dedicated equipments.

DISTORSIONS IN 20kV DISTRIBUTION NETWORKS

The results showing that the total harmonic distorsion for line voltage THD_U for the 110kV network has diferent values on each phase lead to an extension of the measurements to the 20kV network. A number of consumers suplied by the medium voltage network and equiped with electronic meters were selected. During a month, those meters were interogated on every hour. For each point of consumption, the RMS values of the voltage and curents on each pahse,as well as the total harmonic distortion factor for currents and voltages, on each phase were recorded. The analysis was done on a 20kV network following the power flow from the supply to the customer.
The studied area is presented in fig 3 and can offer us an whole picture on the analysed indicators. The red circles represent the measurement groups used for data aquisition. Then for each of the network nodes included in the study we prepared graphical representation for the load curve and the recorded values of THD_U for U_{RS} and U_{TS} and THD_I on each phase.Also, on the chart representing the THD_U evolution the 3% limit was indicated.

Figure 4 shows the raports obtained for THD_U on the power suply rute from transmision substation 400/110kV Sibiu South to the final consumer suplied at Medium Voltage and fig 5 shows the reports generated directly by AMR system for the consumers connected to Medium Voltage.

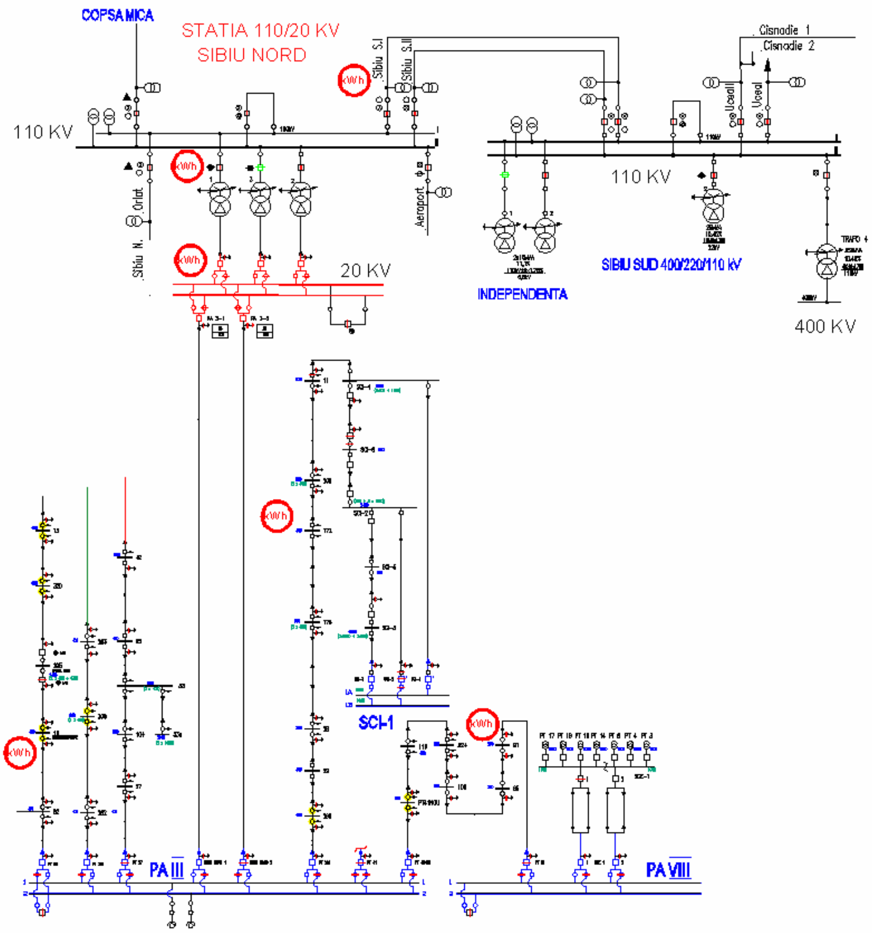


Figure 3. The analysed area of 110 and 20 kV network , indicating measurement groups used in the study

a) THD_U %

OHL 110kV Sibiu Sud – Sibiu Nord

b) THD_U %

TRAFO1 110/20kV Sibiu Nord

c) THD_U % recorded to the end customer

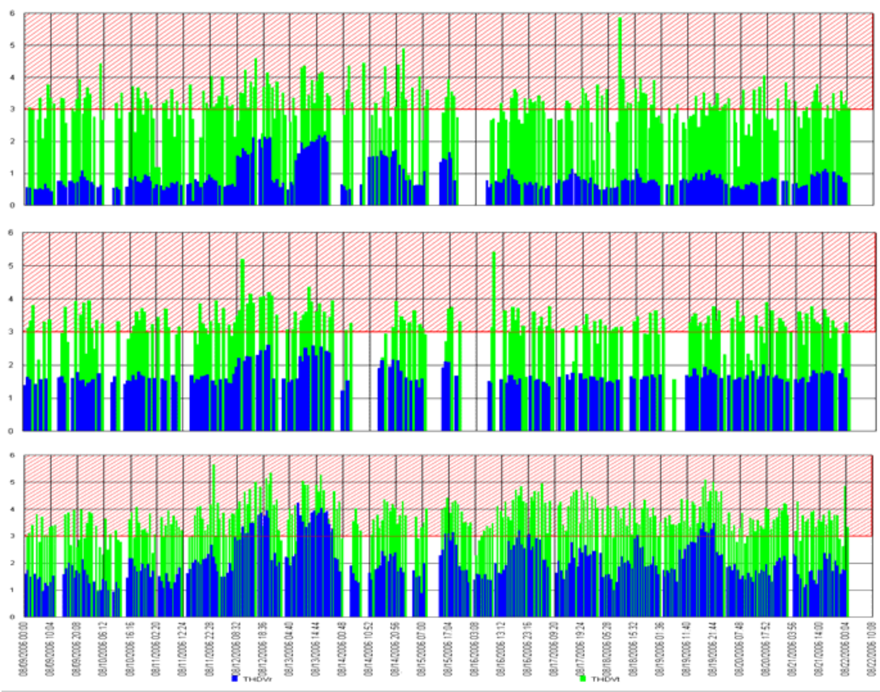


Figure 4 THDU records along suply path

Figure 5 AMR reports for one big comercial center

The charts for the other customers present the same particularities as the examples presented in fig 5:

- There are important diferences between THD_U for U_{RS} and THD_U for U_{TS}.
- For U_{TS} the real time value of THD_U is constantly is higher than the 3% limit.This characteristic is noticed in all the analysed network nodes
- The measurements on this case lead to similar results with the former analysis done only at the 110kV level.
- The high level of the total harmonic distorsion factor for U_{TS} is transmited from the 110kV network to the Medium Voltage distribution network.
- The main conclusionis is that the unbalance in the distribution networks is a reality that can not be neglected

CONCLUSIONS

The unbalanced regime causes suplimentar looses in the network on one side and leads to higher errors in the measurements of the electric power consumption on the other side. Both aspects influence the actual mode of determining the commercial looses in a negative way and their influence increases when the power quality indicators depreciate.

The methods and algorithms usually used to determine the losses in the distribution networks are based on the premise that the networks are functioning in the ideal regime. One of reason leading to this approach was the fact that before the intelligent electronic devices became available, the unbalanced regime indicators were practically impossible to detect.

Using information provided by the AMR system is possible to determine a part of those indicators. As an example first is presented the analysis of an 110kV network and then the analysis of a distribution network containing both 110kV and 20kV lines, all the way to the final customer.

In both cases the data were recorded for over a week. The results were analyzed and used presented into a graphic form.

The main conclusion of the study is that in the analyzed network SDEE the voltage harmonics level is very high and this phenomenon is visible in the whole network.

In order to determine the exact source of the perturbations, it is necessary to continue the study using dedicated equipments for the determination of the power quality indicators.

BIBLIOGRAPHY

[1] Albert H., Mihăilescu A. „Pierderi de putere şi energie în reţelele electrice” Editura Tehnică, Bucureşti, 1997

[2] Georgescu G., Gavrilaş M., Rădăşanu D. -„Calculul şi reducerea pierderilor de putere şi energie în reţele electrice” - Editura “Gh. Asachi”, Iaşi, 1997

[3] * * * Manual Tehnic Contoare ALPHA