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Abstract

Power quality issues in South America: Present reality and future opportunities



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The objective of this paper is to present an overview of the power quality industry and issues in South America. An attempt is made to focus on the present needs and future opportunities for R&D and international cooperation. The paper reveals aspects of the trends, efforts, solutions and insights progressing in South American countries coping with power quality in the context of political, economical and organizational structures. From the impact of pioneering transmission access on power quality, to developing instrumentation and standards, to national surveys, a broad spectrum of experience is presented in this paper.

1. Introduction

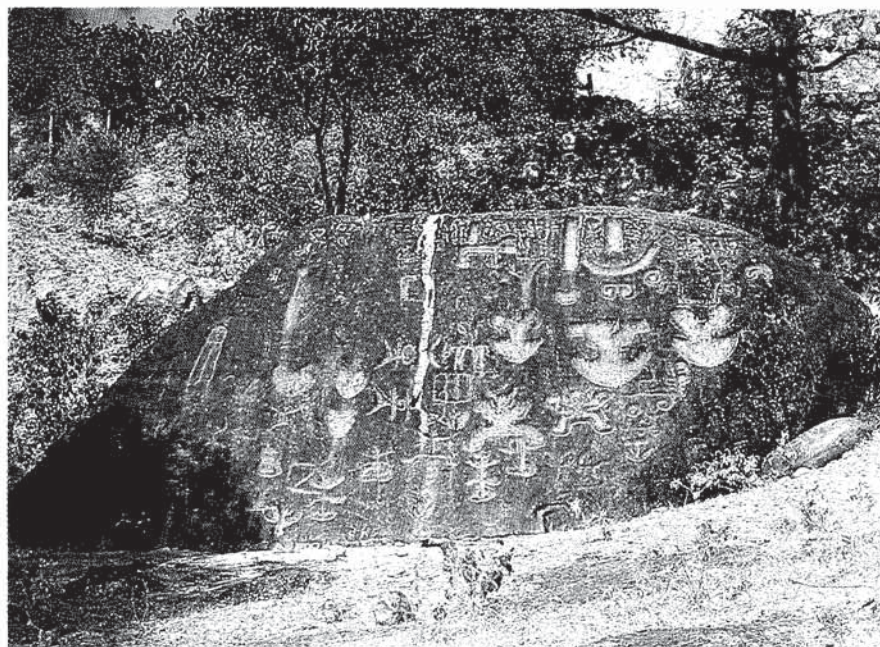
Although countries in South America are socially, politically and economically very different from the developed nations, power quality problems experienced in these worlds apart are quite similar. The global technological village is a reality regarding power quality disturbances. Sensitive electronics do not take into account anthropological factors. Voltage

sags, harmonic distortions, etc. are increasingly causing the same kind of inconvenience for the user of sensitive electronic equipment connected to a

power system either in Manhattan or an Amazon village. The following aspects are among the topics reported in this paper regarding power quality in South America: economical/political background, past efforts, problems being presently experienced, monitoring and measuring instrumentation utilized and developed, standards and methodologies used, present efforts, cost estimation of power quality problems, political, economical, administrative issues, and future plans.

2. Argentina

Since 1975 Argentinean utilities have been monitoring and analyzing voltage deviations problems such as flicker, harmonics, voltage sags, unbalances, etc. The experience has been reported by several documents produced by the Institute of Technological Investigations for Electrical Power Systems centered at the University of La Plata, and private electrical companies. Several power quality monitoring instruments were designed and built at the University of La Plata. Also extensive site measurements have been carried out since 1975 together with the development of computational tools for modeling and simulation of static compensators, harmonic filters, etc.



Until two years ago however, electromagnetic compatibility, power quality, and quality service problems were analyzed case by case when some form of litigation happened between the utility and the customer. Only few specialists at the large power utilities were looking at the problem on an occasional basis. The CIGRE WG 36.05 was the only forum in the country for discussion and debate of this subject.

However, coincidentally with the changes that have happened in the last couple of years in the electric sector in Argentina the theme of power quality has become a high priority in the power sector. Besides the increased awareness of the end-user of sensitive electronics the federal government has fixed regulations to control the effect of voltage quality.

The new political and economical and economic structures will certainly cooperate for a more efficient way to handle power quality issues in Argentina. In the new structure an important role will be played by ENRE (National Electricity Regulator) which will control and interpret the law and regulations on behalf of the federal government as it applies to the relations between electrical utilities and customers.

The responsibility of the power utility will be to provide adequate quality to its customers in terms of both voltage (quality and

reliability) and service (customer satisfaction, etc.). For the private distribution companies serving large metropolitan areas clear regulations of quality and strategy of application have been set.

Thus, the future looks very promising for the power quality business in Argentina as the changes in the structure of the electric sector start to produce the desired results.

3. Brazil

The Brazilian power sector has been concerned with power disturbances issues since the middle of the seventies. Considerable work was carried out by technical working groups coordinated by Eletrobras. Attempts to establish regulations and limits for harmonic distortions, voltage flicker, etc. were made since the last seventies. During the early eighties until now CIGRE WG 36.05 provided an alternative forum for wider discussions which allowed the participation of industrial customers, manufacturers, consultants, and researchers. The nature of the Brazilian electric network, long radial and weak transmission systems was one of the causes for anticipation of the concerns and problems experienced with sensitive loads, and which has emerged more recently and more significantly in the industrialized world.

As in most countries the earlier work was fragmented in several distinct voltage deviation problems such as harmonics, flicker, unbalances, and sags. Just recently the concept of power quality (or energy quality and service as preferred in Brazil) has received considerable attention. The cost of disturbances has reached unprecedented proportions and the industrial sector is very motivated to reduce cost of disturbance and solutions. The utilities are trying very hard to maintain the quality of supply but the economic situation has made things difficult.

In order to keep track of system electrical quality and investigate the impact on the system equipment extensive system monitoring has been carried out by several federal utilities since the early eighties. Several power quality monitoring instruments and specialized computational tools were developed by several universities and utilities. Right now all federal and some state owned utilities have established power quality programs. The operation of many programs though has been jeopardized by financial cuts. A creative alternative has been envisaged by developing international joint projects with the industrialized world in which experienced and financial responsibility are shared between partners. In this context, a joint power quality research project between EPRI and Eletrobras was recently established and is being carried out at the moment in the South of Brazil.

Regarding the development of the power quality engineering recommendations, the power sector, through different technical working groups, has tried since the late seventies to establish a "Made in Brazil" standard. But the inherent technical complications of the subject, the complexity of the utility / customer / manufacturer relationship and complex organizational structure of past governments made the task very difficult. In the late eighties, however, the CIGRE 36.05 with the cooperation with several utilities, industrial customers, manufacturers, and other technical groups initiated a comprehensive debate. A national and comprehensive survey on power quality issues was to follow (Ribeiro, 1990). This debate and survey proved essential to make the standards in preparation more meaningful and realistic. These events were also crucial in bringing for the first time to the table of negotiation all interested parts and has led to approval recently of a consensus engineering recommendation which will serve as the basis for a legislative document.



Another aspect that is presently affecting and will continue to impact power quality issues is the new legislation for power factor correction in term of level of reference and forms of measurements. A reference minimum power factor of 0.92 based on hourly evaluation will certainly impact the assessment of the state of the system regarding power quality disturbances.

More recently and significantly however, has been the impact of the economic and political situation of the past five years on power quality issues. Whereas the problems have increased drastically in the past very little has been done to address and mitigate problems. The cost of power quality has reached enormous proportions in Brazil. The EPRI/Electrobras project has estimated an average annual loss of one million dollars per customer participating in the project.

The future approach to power quality in Brazil will depend on the evolution of political, economical and organizational changes in the power sector over the next few years. For example the continuation of the process of privatization of the power sector is dependent on the results of the up-coming presidential election in 1995. The impact on "electric energy business" and in particular power quality issues and approaches can not be predicted at this point in time. However, tremendous opportunities and challenges remain to be addressed regarding PQ issues in Brazil.

4. Chile

Due to the geographical conditions existing in the country (aproximately, three thousands miles long) and also due to the

economical development of each of the main cities. The Chilean electrical system sector is formed by four independent interconnected networks. As early as 1980 Chile became one of the first countries in the world to privatize the whole electrical system, the Quality of Electrical Service becomes a major topic of interest among Generation, Transmission and Distribution utilities. Power quality issues, previous and after privatization have focused in assessing mainly "voltage and frequency regulation" parameter and frequency and duration of interruptions. However, most of these indices do not take -directly- into consideration or don not reflect



properly the effect of interruptions on the number of customers. Therefore, during the last four years the Chilean utilities are beginning to consider new indices where the number of customers affected by interruptions is a key aspect. Other technical parameters wich are important in definig the quality of electricity "product" such as level of harmonic distortion, voltage fluctuation (flicker), voltage unbalances, etc., have not received previously enough attention by utilities, end users and

government authorities. However, due to the large growth of the Chilean econoy and electric demands in the last two decades, several technical problems related to the above mentioned parameters have started to emerge. As a result few years ago, government authorities started a program to asses the quality of supply.

The Chilean national energy commission is now in the process of updating the "National Code of Operation of the Electrical Sector" and one of the most important issues being developed and included in the code is the "Quality of Electrical Service". Three

important elements are being considered within the topic of Quality of Electrical Service at Generation, Transmission, Distribution and End User level: 1) The quality of electricity "product" which is defined by a set of technical parameters, together with teh corresponding procedures to measuring and control the quality of the electriciy product at utility level 1) The quality of the commercial services provided to customers. It is accepted that during 1995 this new code of Operation of the Electrical Sector will start to operate.

A national survey was recently performed among Distribution Utilities

(DU) and large Customers (LC) about the Quality of Electrical Service provided by Chilean main Transmission Utility. 95% of the distribution utilities responded the survey. The number of Large Custoers which replied to the survey were 12 and they are among the ones with the largest electric demand, and several of them with more than one interconnection busbar with the transmission system. In general, Distribution Utilities (DU) and Large Customers (LC) are not receiving

enough interconnection busbars. In addition, they are not controlling or planning to control the quality of the voltage provided by the Transmission utility. These two aspects reflect in some way the primitive status of Quality of Service issues and the need of new developments and investments. However, DU and LC do not complain about frequency and duration of the interruptions. In fact both DU and LC ranked the quality of the service provided by Transmission utilities as good.

Some specific questions and results of the survey are presented below: What is customer level of satisfaction regarding voltage regulation parameter? The annual average qualification of the service provided by the transmission system was 67 from a maximum of 100.

What is the customer view on the maximum range of voltage regulation parameter at the interconnection busbar with the transmission network? The average value was 3%. The maximum and minimum values were 5% and 1.5%, respectively.

Are there accidental interruptions detected by special monitoring equipment? What is the maximum number of interruptions per year which would be acceptable?

Most of the D. U. detect and register accidental interruptions via manual methods. The annual average number of accidental interruptions which D. U. are expecting for the next years is 5 interruptions.

What are the harmonic voltage/current levels at the interconnection busbar with the transmission network?

No harmonic measurements have been performed by any of the D.U.. Only 30% of the L.C. surveyed have performed harmonic measurements. The instrumentation used corresponds to old designs.

Power quality are being addressed by the power sector. The private

structure of the electric sector is very favorable to an objective and efficient approach to solving power quality problems. Opportunities in education, continuous monitoring using modern instrumentation and simulation tools are among the tasks to be tackled in the near future.

5. Colombia

The Electric Power Sector in Colombia is very concerned about power quality problems. Colombian utilities and universities have integrated a working group on Power Quality so called National Quality Committee, which is identifying PQ issues and developing standards and procedures to handle PQ problems. This working group and utilities are being motivated by the World Bank, which grants loans to utilities involved in programs to improve customer services and service quality.

One of the biggest problems in power distribution in Colombia is service interruption due to electrical problems in distribution networks. Origin of interruptions may be either external sources such as lightning, rain, trees, etc., or internal sources such as maintenance, overloading, protective schemes, etc. Therefore, power quality in Colombia includes voltage quality and reliability problems.

Utilities, governments, manufacturers and customers around the world are concerned about power quality, which has been defined by EPRI as "Any power problem manifested in voltage, current, or frequency deviations that result in failure or mis-operation of customer equipment." However, in a developing country as Colombia, main issues in power quality include other items that are of less or not interest in developed countries. These items are mainly, steady state voltage regulation and service interruptions. Nevertheless, all utilities in Colombia are experiencing all voltage quality



problems, such as harmonics, voltage dips and sags, and flickers, no matter how small are their distribution systems. However, many utilities do not recognize all problems in power quality and they just think about voltage regulation as main problem.

The University of the Andes conducted a national survey (Torres 93) among utilities and large industrial customers to help detecting existing level of power quality problems in Colombia. Twenty-one utilities and twenty-six industrial customers responded the survey. The results show that power quality problems affect customers and that they have invested in UPS and self-generation to reduce the economical effect of outages, service interruptions and voltage quality problems.

The survey also showed types of power quality problems that have affected selected industrial customers. We can observe that service reliability problem, such as

short and long term interruptions are the main concern of customers at this time. Customers do not recognize harmonics as one of the biggest problem. However, this may be because of lack of knowledge about the effects of harmonics on equipment. Harmonics may be the cause of many equipment damages attributed to voltage fluctuations.

To know the severity of the problem of power distribution reliability we conducted a survey among several utilities. By using three wide known indices we may have an idea of distribution system reliability. These reliability indices permit one to compare the relative performance of systems. Fig. 3 shows reliability indices for six utilities in Colombia and an average of about hundred utilities in USA as reported in Ref. 2 (Herst, 91). The relative low number of total customers and the high number of interruptions including large number of customers produce large values for the defined indices.

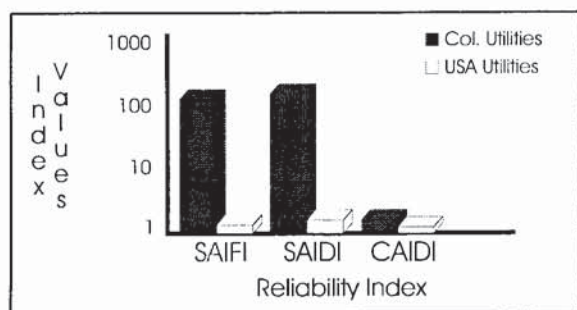


Fig. 1 - Reliability indices comparison for colombian utilities. (Taken from Ref 1)

In Fig. 1 reliability indices are defined as follows:

SAIFI= System average interruption frequency index

SAIDI= System average interruption duration index (hours)

CAIDI= Customer average interruption duration index (hours)

Regarding power quality measurements, we do not have executed enough measurements to completely evaluate the state of power quality in the country.

However, the National Quality Committee has sponsored two small programs of measurements on harmonics and steady state voltage drop on distribution system at medium voltage and low voltage levels respectively. Fig. 4 and Fig. 5 show some of the results. From these measurements and results we may conclude that harmonics are present in some circuits as expected and that voltage regulation is an issue in power quality. However, the extremely small numbers of measurements on the systems do not permit to get definite conclusions about the severity and extension of power quality problems.

Utilities are concerned about the results of measurements and customer claims about PQ. The National Quality Committee is conducting a national program for standardization taking into consideration international standards and recommendations such as IEEE-519, IEC-555 and others. The University of Los Andes is

working in simulation of PQ problems and modeling of power system and power electronics components to characterize their behavior and effect on voltage quality. PQ problem in Colombia includes short and long term interruption of service and steady state voltage regulation, so PQ is called Service Quality as a wide sense definition of power quality. The PQ research group at the University of Los Andes has done intensive work in modeling and simulation with the main goal of providing the power industry with analytical and computational tools. This work should be a support for standardization and provides a methodology for PQ problem analysis.

Work on PQ in Colombia is just beginning. Several utilities have conformed the National Quality Committee to work coordinately in this subject. Steps have been taken

in the direction of producing a national standard. However, more work is necessary in terms of measurements, and simulations to obtain sufficient data and background for standardization and to establish procedures for PQ analysis. Future work includes a national workshop in PQ to familiarize utilities engineers and customers about these problems.

4. Conclusions

Several countries in South America are starting to systematically monitor the disturbances and to establish power quality programs. Economic difficulties delay action, but the severity of the problems and the financial losses experienced by utilities and customers cannot be overlooked any longer. Although similar in nature, peculiarities regarding system characteristics, power industry legal and economic structure, customer system accessibility, etc. create unique PQ problems in South America. This overview may help the international power quality community to have a better appreciation for the multidimensional character of the problems and more objectively address the solutions.

This paper has focused on the dominant power quality issues in four countries in South America. Among the topics covered were the most common types of problems encountered, utility/customer relationship and economic-political-organization aspects.

Despite the structural difficulties, countries in South America are addressing power quality issues. The problems and challenges remain considerable and the industrialized world remain a much needed reality. This cooperation should provide much insight and enrich our understanding on how to address power quality issues with a broader perspective.

7. References

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Biographies

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PROGRAMA EXPERTO PARA EL DIAGNOSTICO DE ERRORES INNATOS DEL METABOLISMO

Resumen del trabajo presentado en el Segundo Congreso latinoamericano de genética realizado el 25 de septiembre en Puerto Vallarta, México.

Los EIM comprenden cerca de 350 enfermedades, para muchas de las cuales sólo se han identificado unos pocos casos en el mundo, pero que en conjunto afectan aproximadamente el 1% de la población. Su comprobación se hace midiendo la actividad de la proteína o enzima deficiente. Entre los escollos que se encuentran para la identificación, diagnóstico, tratamiento e investigación de estas enfermedades, podemos mencionar entre otros: el poco conocimiento de estos desórdenes entre el cuerpo médico en general, atribuible en parte a la poca frecuencia de aparición, a la falta de suficientes laboratorios que se dediquen a su estudio, y en ocasiones a la insuficiente formación de los médicos en bioquímica. Para ayudar en el diagnóstico y

selección de las pruebas de laboratorio y en el entrenamiento de médicos e investigadores, se elaboró un Programa Experto de Computador. El programa consta de una base de datos que incluye los grupos de enfermedades metabólicas, las características clínicas y de laboratorio de cada una de las enfermedades, las pruebas que usan para su identificación. El usuario puede ingresar la sintomatología, historia genética y nutricional de pacientes, y a partir de estos datos, el computador suministra la lista de posibles diagnósticos, recomienda los exámenes que se debe realizar para ubicar el paciente en un grupo determinado y luego exámenes más específicos, hasta llegar al que da el diagnóstico definitivo. Permite además, consultar listados de enfermedades que presentan un síntoma, el grupo al que pertenece determina enfermedad, frecuencia

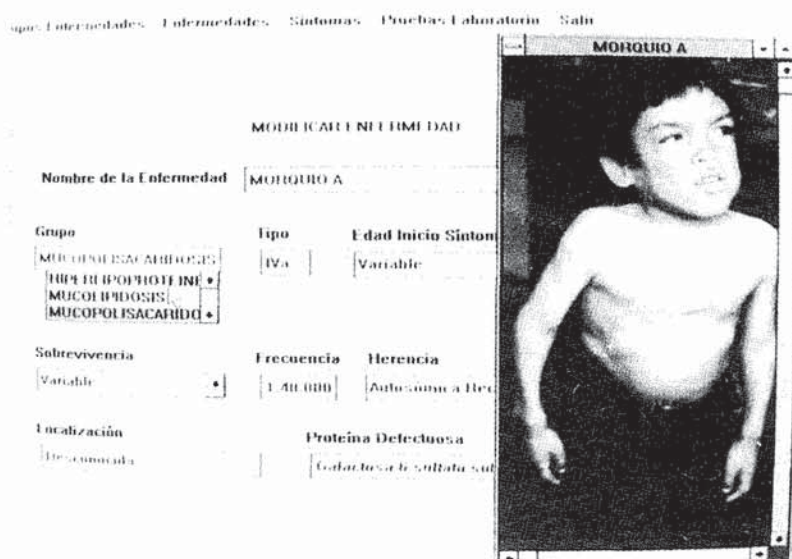
de aparición, tipo de herencia, localización cromosómica, sintomatología propia de cada uno de los desórdenes metabólicos. Una versión original del programa,



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se elaboró en turbo pascal; a pesar de sus méritos presenta dificultad en el ingreso de la información y en la manipulación del programa; la nueva versión en ambiente windows es más amigable y tiene características novedosas, como manejo de historias clínicas de los pacientes, elaboración de reportes más específicos y refinamiento del algoritmo de diagnóstico. Requiere un computador con procesador 80386, windows 3.1, por lo menos 4 megas de memoria principal y seis en disco.



- Este proyecto surgió como una tesis de pregrado del Departamento de Ingeniería de Sistemas y computación, asesorada por el Ingeniero Jaime Bohorquez a quien agradecemos especialmente su colaboración.