

POWER QUALITY MONITORING INSTRUMENT FOR ENERGY DISTRIBUTION FEEDER

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Abstract – This paper reports a power quality monitoring instrument to be integrated in the electric energy distribution network of CELPA, the electric utility of Belem – Para – Brazil. The instrument, based on a 68HC11 microcontroller collects data at customer service entrance locations on the feeder, recording both triggered and sampled data voltage signal, which are processed by a Real Time Executive that manages several tasks, enabling the calculation of ANEEL (Brazilian Electricity Regulatory Agency) continuity and conformity indicators. The utility has evaluated the monitoring instrument in a pilot project with good results, assuring low cost, high performance, reliability and capability of integration with the Energy Distribution Control Center.

Keywords – Power Quality – Energy Distribution – Monitoring Instrument – Quality Indicators.

1. INTRODUCTION

In today Brazilian scenario considering the influence of new aspects as privatization, competition and different relationships among new agents, improving power quality is one of the most important actions utilities can take [1].

The concern over power quality arises from the customer's need for continuous operation of manufacturing processes, the continuing increase in overall electronic load sensibility, crossing over from computers and control instrumentation to equipment used in industrial applications. Troubleshooting electric problems often led to disrupted or failed equipment [2].

Identifying these problems involves the use of expensive, specialized portable monitoring equipment or even bringing in a consultant in power quality troubleshooting. Today, customers typically work with their local utility to resolve power quality issues.

It is not clear if this arrangement will continue to work in a deregulated electric market.

Power providers use a variety of voltage recorders to monitor steady-state voltage variations on distribution systems [3]. Today portable power quality monitors are no longer the only options for power quality troubleshooting.

Some permanently installed distribution network monitors can also do the job, serving two roles: One, is a highly accurate digital meter; the other is a monitor watching for voltage quality problems, alarming on occurrence and capturing waveforms and other data useful for getting to the root cause of a problem, with the goal of supplying solutions to power quality problems.

Several power quality research and development groups focused on improving the reliability of electricity distribution system and its compatibility, with customer equipment by monitoring, analyzing and solving power quality problems [4].

With goal of supplying solutions to its power quality problems, CELPA, the electric utility of Belem and the NESC.- Supervision and Control System Group, Electrical Engineering Department, University of Para, Brazil; conducted a technological research project, to installing a real time power quality monitoring network at customers service entrance, as shown in fig. 1.

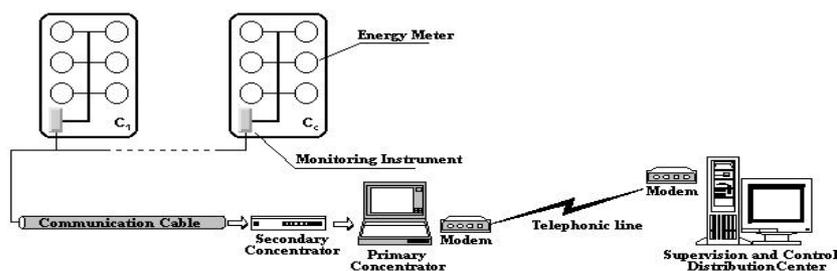


Fig. 1 – Power quality monitoring instrument at customer service entrance

The objective of this paper is to report in their different sections the hardware and software of instrument and experimental results obtained in field tests.

2. MONITORING INSTRUMENT DESCRIPTION

Advanced metering technology was required to adequately detect and record steady-state power quality disturbances at the customers-utility interfaces. The instrument hardware, based on 68HC11 microcontroller consist of 4 modules:

- Voltage Signal Conditioning Module – which conditions the secondary distribution network voltage for acceptable levels by microcontroller.
- Processing Module – corresponds to the microcontroller CPU, responsible for tasks management through a Real Time Executive Technique.
- Memory Module – Stores the management program and tasks routines in a nonvolatile memory (EEPROM) and occurrences recorders in a volatile memory (Static RAM).
- Analog/Digital Converters Module – Formed by 68HC11 internal A/D converter, transforms analog signal samples for a digital signal in the 00_{HEX} to FF_{HEX} (0_{DEC} to 255_{DEC}) band.

Fig. 2 shows the block diagram of monitoring instrument.

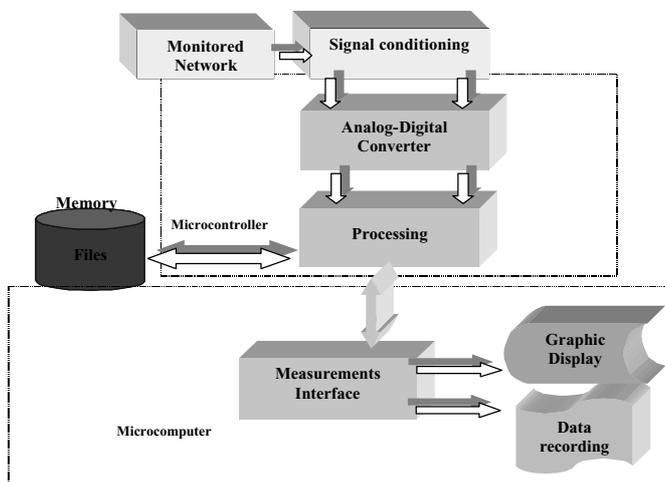


Fig. 2 –Block diagram of the monitoring unit

A microcomputer linked to monitoring unit through a RS-485 communication or dial-up modem can correlate power quality events with their effects and share information with customers. It can choose the information it wants to monitor, including harmonic data.

Two programs compose the monitoring instrument: PQAnalyzer Software and Softcom.

The PQAnalyzer is a program developed in Assembly language of the microcontroller, stored in EPROM with the purpose of analyzing and register possible voltage quality problems occurrences.

A Real Time Executive manages the data acquisition system performing the following tasks:

Task 1 – Calculate the True RMS voltage value.

Task 2 – Detect sustained interruptions for time period that exceed 1 minute.

Task 3 – Detect sustained voltage level violations

Task 4 – Sample the signal voltage to calculate total harmonic voltage distortion.

The flowchart of the Real Time Executive is show in fig.

3

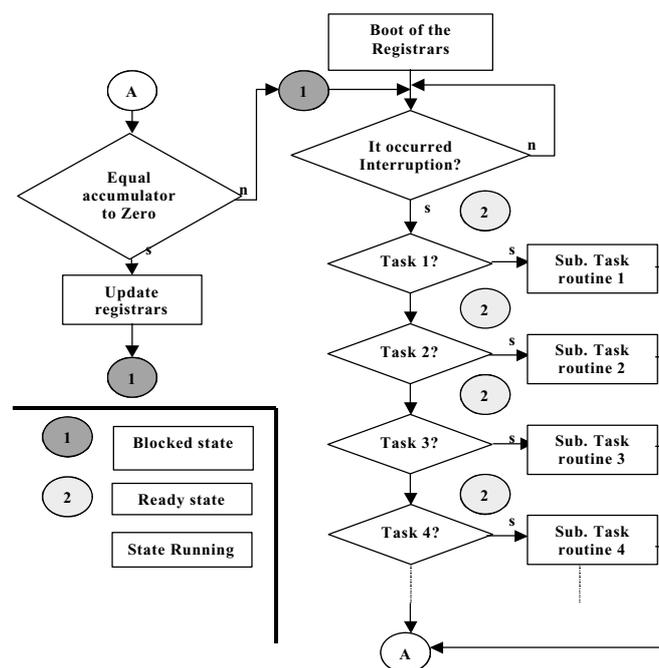


Fig. 3 - Real time executive flowchart

The data collected by the monitoring instrument is extremely valuable to obtaining continuity indicators, in accordance with the requirements imposed by ANEEL 024/2000 Regulation expressed as follows [1]:

$$DEC = \frac{\sum_{i=1}^n C_a(i) \cdot t(i)}{C_c} \quad (1)$$

$$FEC = \frac{\sum_{i=1}^n C_a(i)}{C_c} \quad (2)$$

$$DIC = \sum_{i=1}^n t(i) \quad (3)$$

$$FIC = n \quad (4)$$

$$DMIC = T_{\max} \quad (5)$$

where,

- DEC: Weighted average interruption duration;
- FEC: Weighted average interruption frequency;
- DIC: Individual interruption duration for each end-user;
- FIC: Individual interruption frequency for each end-user;
- DMIC: Maximum duration of continuous interruption for each end-user;
- $C_a(i)$: Number of customers in the considered group that are affected by the interruption i during a certain period of observation ;
- $t(i)$: Duration of the interruption i in the considered set, during a certain period of observation;
- C_c : Total number of customers in the considered group, during a certain period of observation;

- n : Number of interruptions during a certain period of time;
- t_{\max} : Maximum duration of a continuous interruption during a certain period of observation.

The data also allows obtaining conformity indicators concerning voltage levels and harmonic voltage distortion in the distribution network. Target indices concerning voltage conformity until today were not yet defined by ANEEL.

3. EXPERIMENTAL RESULTS

The performance of the monitoring instrument was validated through tests of all their basic functions realized using an experimental setup simulating three customers under voltage quality problems, such as interruptions and voltage level violations.

Fig. 4 shows the monitoring instrument diagram experimental setup circuit.

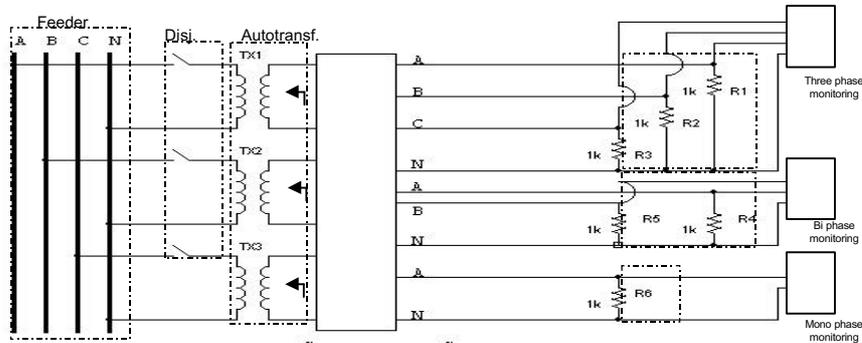


Fig. 4 – Circuit diagram for monitoring instrument experimental tests

The communication between monitoring instrument and a master station to test the software SOFTCOM was realized using the experimental arrangement of figure 5.

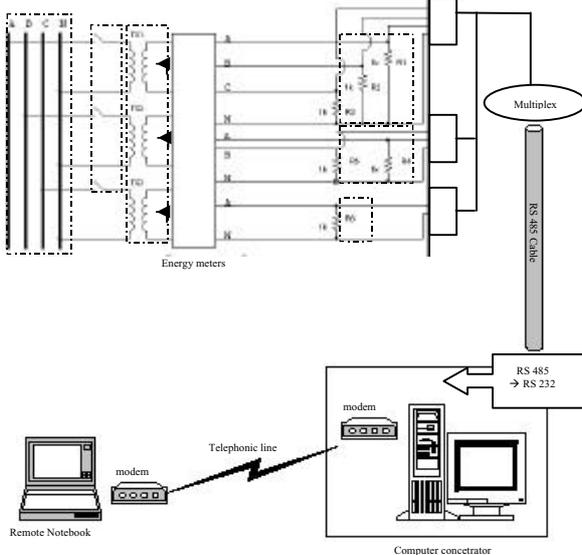


Fig. 5 – Complete layout of instrument arrangement test.

Fig. 6 show the occurrence table registering voltage violations and interruptions at a customers site.

	Data	Hora	Tipo	Duração	Fase	Valor
1	13/10/2000	17:10:31	Sobretensão	00:02:01	A	140,5907
2	13/10/2000	17:30:39	Sobretensão	00:02:23	A	103,071
3	13/10/2000	17:48:14	Sobretensão	00:02:20	A	71,4248
4	13/10/2000	17:53:09	Interrupção	00:02:18	A	0
5	13/10/2000	18:10:21	Sobretensão	00:03:03	A	135,453
6	13/10/2000	18:19:56	Sobretensão	00:02:39	A	92,40902
7	13/10/2000	18:27:04	Interrupção	00:02:24	A	0
8	13/10/2000	18:35:55	Sobretensão	00:21:04	A	145,68
9	13/10/2000	18:09:10	Sobretensão	00:03:42	A	144,1142
10	13/10/2000	19:12:06	Sobretensão	00:04:14	A	142,4113

Summary: DEC: 00:18:25, FIC: 7, DMIC: 0,06

Fig. 6 - Occurrence table at a customers site

4. CONCLUSIONS

Power quality monitoring systems are getting more powerful every day. Permanent monitoring systems are used to track ongoing system performance and watch for potential power quality problems, also providing a wealth of information for utility and customers to review when there is a disturbance. The monitoring instrument developed in this technological project initiated by NESC and CELPA undergoes a series of laboratory and field tests that ensure lower cost and ease of use, has proven reliable and effective in a pilot project of the utility. It can effectively monitor and record voltage troubleshooting and so, problem sources can be pinpointed and resulting corrective actions can be taken. Data acquired along a monitoring period may constitute a

powerful analysis tool for planning, operating and designing distribution energy systems

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