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POWER QUALITY

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Power quality problems can cause processes and equipment to malfunction or shut down. And the consequences can range from excessive energy costs to complete work stoppage. Obviously, power quality is critical. There are many ways in which a power feed can be poor quality, and so no single figure can completely quantify the quality of a power feed. In this paper we are going to present all definitions, classifications and problems related to power quality. Finally, we have done comparison between the practical measurements and standards related to power quality.

Keywords: power quality, standards, electrical power system, electric power grids
Cuvinte cheie: calitate de putere, standarde, sisteme de energie electrică, rețele de energie electrică

1. Introduction

The electrical energy is transferred from generation place to consumption directly without any tests or examinations, So that electricity must be able to fulfil their function properly without any problems and this is what is called the power quality.

An electrical power system is expected to deliver undistorted sinusoidal rated voltage and current continuously at rated frequency to the end users. Electric power quality has captured increasing attention in power engineering in recent years.

2. Definitions of power quality

Power Quality is defined as "any power problem manifested in voltage, current, and/or frequency deviations that results in the failure and/or mal-operation of end user's equipment. PQ is simply the interaction of electric power with electrical equipment [1, 2]. Figure 1 shows normal voltage signal and voltage signals with disturbances.

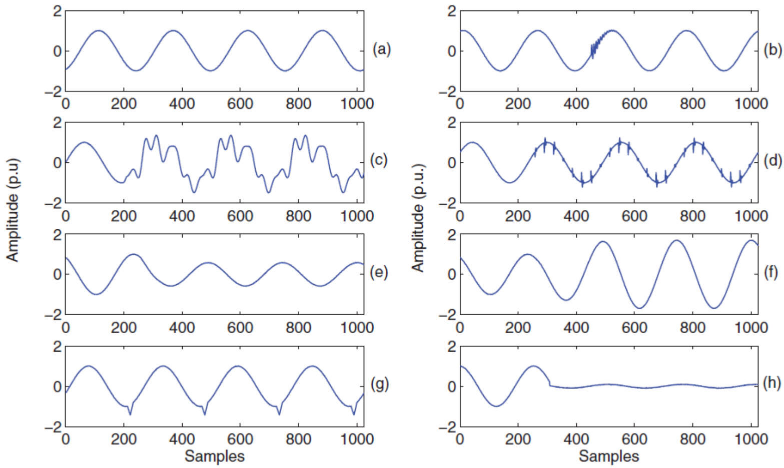

Fig. 1 Examples of voltage signals and disturbances: (a) nominal Voltage signal, (b) oscillatory transient, (c) harmonics, (d) notching, (e) Sag, (f) swell, (g) spikes and (h) outage

3. Classification of Poor Power Quality and Their Effects

Table 1 (Classification of the disturbances in different power Systems) illustrates a classification of the disturbances in different power Systems; main causes of them and corresponding impact on equipment [1], [3], [4]:

Table 1

category	**causes**	**impact**
Voltage dips	Local and remote faults Inductive loading Switch on of large loads	Tripping of sensitive equipment Resetting of control systems Motor stalling/tripping
Overvoltage	Load switching Capacitor switching	Problems with equipment that

	System voltage regulation	requires constant steady-state voltage
Harmonics	Industrial furnaces Non-linear loads Transformers/generators Rectifier equipment	Mal-operation of sensitive equipment and relays Capacitor fuse or capacitor failures Telephone interference
Power frequency variation	Loss of generation Extreme loading conditions	Negligible most of time Motors run slower De-tuning of harmonic filters
voltage fluctuation	AC motor drives Inter-harmonic current components Welding and arc furnaces	Flicker in: Fluorescent lamps Incandescent lamps
Voltage imbalance	Unbalanced loads Unbalanced impedances	Overheating in motors/generators Interruption of 3-phase operation
Transients	Lightning Capacitive switching Non –linear switching loads System voltage regulation	Control system resetting Damage to sensitive electronic components Damage to insulation

The typical phenomena related to wave amplitude, and its main characteristics are defined in table I, The table 2 (Power System Disturbances According to IEEE std 1159-1995 [4]) lists the limits given in standards IEEE std 1159 – 1995 [4] according to the classification of various power quality events [2], [6]:

Table 2

Disturbance Subtype	**Categories**	**Typical Duration**	**Typical Voltage Magnitude**
	1. Transients		
Oscillatory	- Low Frequency	0.3 -50 msec	0-4pu
	- Medium Frequency	20 μsec	0-8pu
	- High Frequency	5 μsec	0-4pu
	2. Short Duration Variations		
2.1. Instantaneous	- Interruption	0.5 -30	<0.1 Pu

		Cycles	
	- Sag	0.5 -30 Cycles	0.1 -0.9 Pu
	- Swell	0.5 -30 Cycles	1.1 -1.8 Pu
2.2.Temporary	- Interruption	3sec -1min	
	- Sag (Dip)	3sec -1min	
	- Swell	3sec -1min	
3. **Long duration variations**			
3.1.Interruption Sustained		>1min	0.0 Pu
3.2.Under-Voltages		>1min	0.8 -0.9 Pu
3.3.Over-Voltages		>1min	1.1 -1.2 Pu
4.Voltage Unbalance		Steady state	0.5 -2 %
5. Wave distortion			
5.1.Harmonics		Steady State	0 -20 %
5.2.Inter-Harmonics		Steady State	0-2%
5.3.Notching		Steady State	0.2 %
5.4.Noise		Steady State	0.1 %
6. Voltage Fluctuations		Intermittent	0.1-7%
7. Power frequency variations			
7.1.Slight Deviation		<10 S	49.5 Hz-50.5 Hz
7.2.Severe Deviation		<10 S	47.0Hz- 52.0 Hz

4. Analysing Power Quality Data by PC Applications Software (Power Acceptability Curve)

Power Acceptability Curves regulate the minimum PQ level that equipment should have to operate properly when the power supplied is within the standards. The most commonly used curves are CBEMA curve and ITIC Curve. On the CBEMA and ITIC, The height on the vertical axis shows the severity of the dip or swell relative to the nominal voltage, The horizontal position shows the duration of the dip or swell, see figure 2 And figure 3 [7], [8], [9]. These curves are divided into two regions [5], [7]:

- permitted zone: any voltage disturbance lie in that area should not cause malfunction at all.

- prohibited zone: any voltage disturbance lie in that area will cause malfunction.

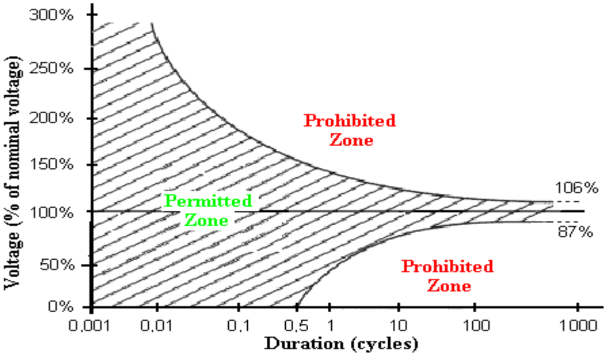

Fig. 2

CBEMA curve for equipment Susceptibility

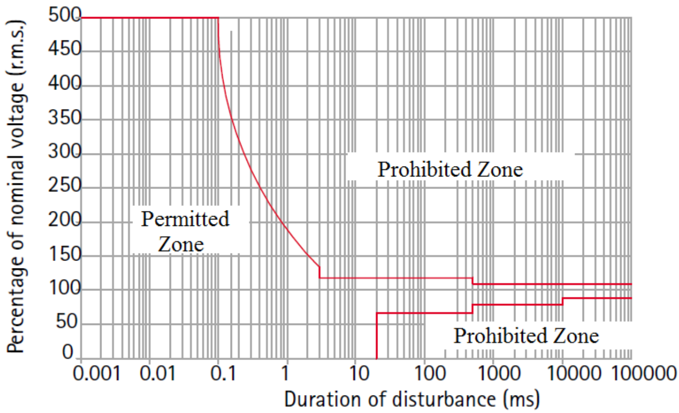

Fig. 3

ITI curve for equipment Susceptibility

5. Practical Measurements of power quality

We execute some measurements at BARAGAN Photovoltaic farm by using FLUKE SET for one week; we download the data by using Power Log software version 4.3.1. these measurements were recorded during the date from 12/12/2014 2:54:04 PM to 19/12/2014 9:44:04 AM.

Case 1 power frequency variations

Figure 4 shows frequency deviations, the maximum value of frequency is 50.039Hz, the minimum value is 49.952 Hz, and these values are within acceptable limits listed in the table 2.

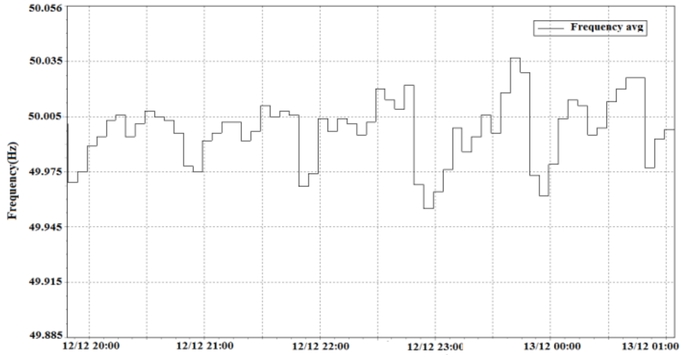

Fig. 4 frequency deviations

Case 2 voltage fluctuation

Figure 5 shows voltage fluctuations, the maximum value of voltage for three phases is 0.330 %, the minimum value is 0.125 %, and these values are within acceptable limits listed in the table 2.

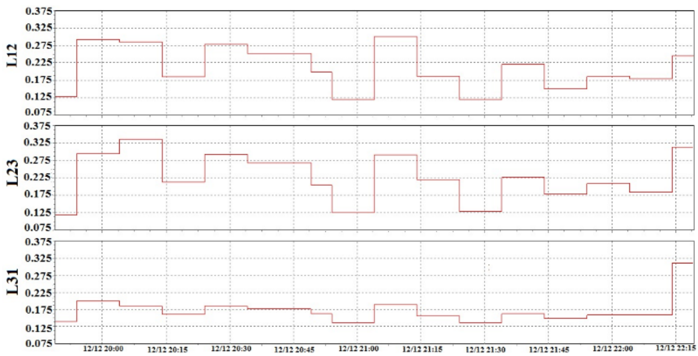

Fig. 5 voltage fluctuations (flickers)

Case 3 over voltage

Figure 6 shows recorded voltage waveform of duration 200 ms, we note that the maximum value of voltage is 20950V and this value is within limits mentioned in table 2.

Case 4 Harmonics

Figure 7 shows total harmonic distortion in percent (THD %). we note that the maximum value of total harmonic distortion is 3.7% and this value is within limits mentioned in table 2.

Case 5 Dips and Swells

Figure 8 shows dips points, we note that there are two dips points and that points located into permitted zone according to table 2, figure 2 and figure 3.

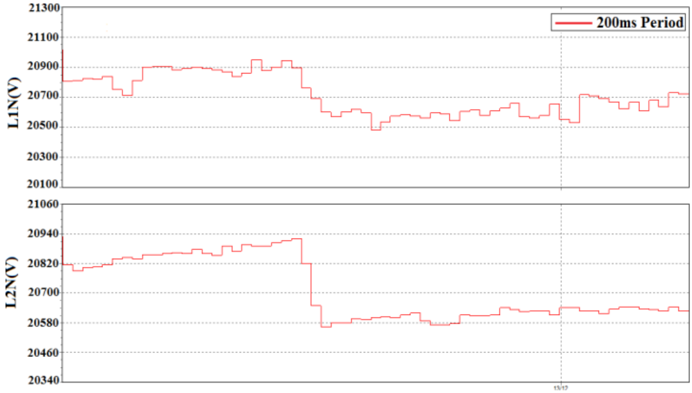

Fig. 6 over-voltage waveform

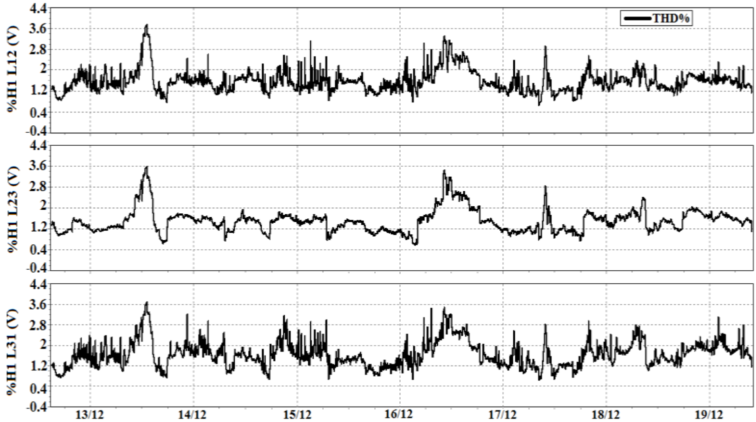

Fig. 7 Total Harmonic Distortion

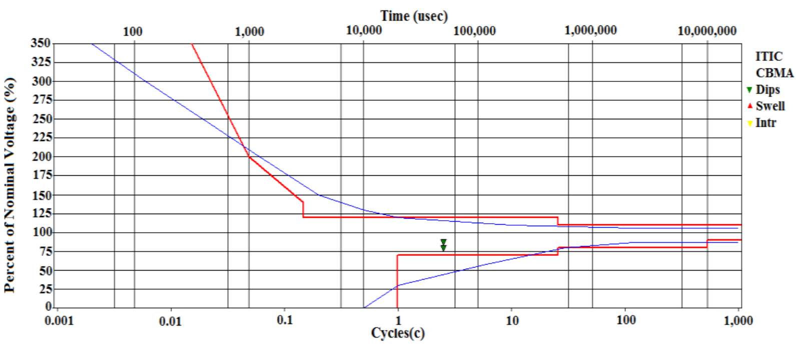

Fig. 8 shows dips points

6. Conclusion

■ On-going standards development should help make all parties more aware of power quality concerns and provide better tools and techniques for developing the optimum solutions to problems.

■ Equipment manufacturers must be able to provide information describing the sensitivity of their equipment to these variations.

■ On-going monitoring efforts and case studies will provide the information to characterize system performance and to understand the susceptibility of different types of customer systems.

■ Analytical tools will also benefit from the increased level of monitoring and characterization. Models should be improved and the tools themselves should become easier to use.

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