IDENTIFICATION OF SAGS AND SWELLS USING PIC MICROCONTROLLER

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ABSTRACT

Power quality is a set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance. Power quality is a growing concern because today’s electricity consuming equipment ranging from personal computers to automated manufacturing process are much more susceptible to power quality problems. Power quality problems, typically, sags and swells are due to the natural events (e.g., lightning strikes, trees falling on the lines), utility activities (e.g., routine switching operations or human error). They last only for a fraction of a second, but they cause a great loss. For sensitive devices, momentary disturbances can cause the data to get scrambled, communication to get interrupted, a frozen mouse and equipment failure, etc.. Power quality issues can cause problems related in the business field. The identification of the voltage sags and swells is considered to be most important, since, voltage sags and swells cause severe damage in the power systems. This paper presents, the identification of voltage sags and swells using PIC microcontroller 16F877A. The identification system consists of the step down transformer, voltage sensing unit, PIC microcontroller 16F877A circuit and LCD to display the duration of occurrence of the voltage sags and swells.

Keywords – MPLAB IDE, PIC(Peripheral Interface Controller 16F877A, Power Quality, Voltage Sag, Voltage Swell.

1. INTRODUCTION

Electrical Power is generated, transmitted, distributed and mostly in the form of Alternating Current (AC). Electricity is generated far from the point of use and is fed to the grid synchronizing with the output of many generators. Then it is connected to the customers as per their requirements [1]. Quality power supply is the one which is made available, within voltage and frequency tolerances with a pure sinusoidal waveform. The Generated electricity is subjected to quality degradation, due to various load conditions. The variation in the voltage or frequency and distortion in the waveform is may cause problem in the power supply. Power quality is a set of electrical boundaries that allows an equipment to function in its intended manner without significant loss of its performance or life. There may be changes in the power quality due to some natural reasons or due to some fault in the operations. The changes in the power quality are common in the industrial fields, which include increases and decreases in voltage.

The poor power quality causes the equipment to malfunction. Thus the Power Quality is to be identified for the better performance of the equipment, which may increase the life time of the equipments. By identifying the type of disturbances, the cause and possible solution can be found. Power quality identification is the best way to detect and diagnose problems in electrical power system. It is advantageous to have a low cost solution for power quality identification. Identification of the power quality involves the setting of monitors and the gathering of data.

1.1 Power Quality Disturbances

According to the international standards power quality problems are classified as by duration, type and severity. Common power quality disturbances include surges, spikes, voltage sags, voltage swell and Harmonics on the power line. The typical voltage disturbance is shown in the Fig. 1.

The List of categories of power quality issues are:

1.1.1 Disturbances

A disturbance is a temporary deviation from the steady state waveform caused by faults of brief duration or by
sudden changes in the power system. The disturbances considered by the International Electro technical Commission (IEC) include voltage dips, voltage increases, brief interruptions and impulsive and oscillatory transients. The Institute of Electrical and Electronics Engineers (IEEE) has termed voltage dips as sags and voltage increases as swells.

1.1.1 Voltage Sags

According to the IEEE defined standard, IEEE Std. 1159, 1995 Voltage Sag is defined as a decrease of RMS voltage from 10% and 90% of nominal, for duration of 0.5 cycle to 1 minute. Decrease in the RMS value of the voltage ranging from a half cycle to a few seconds.

1.1.2 Voltage Swells

Voltage Swell is defined by IEEE 1159 as the increase in the RMS voltage level to 110% - 180% of nominal, at the power frequency for durations of 0.5 cycles to 1 minute. Increase in the RMS value of the voltage ranging from a half cycle to a few seconds.

1.1.3 Distortion

Distortion in the voltage or current waveform occurs when nonlinear loads are connected to the electrical system. Nonlinear loads draw currents in a non-sinusoidal manner though the supply voltage is sinusoidal.

1.1.4 Voltage fluctuations:

Continuous changes in the nominal value of the supply voltage are called voltage fluctuations.

1.1.5 Flicker

Flicker is described as the impression of unsteadiness of visual sensation induced by a light stimulus whose luminescence or spectral distribution fluctuates with time (IEEE 1995).

1.1.6 Noise

Noise is unwanted voltage or current superimposed on the power system voltage or current waveform.

1.1.7 Harmonics

Harmonics levels are increasing in the power systems due to proliferation of power converter circuits which are based on switched mode topologies [2]. Harmonics are as considered steady state events, where the 50 Hz waveform of voltage and/or current becomes distorted. Harmonics are not normally caused by the utility system itself. They are the result of non-linear loads. These loads can inject harmonic currents into the utility system and in severe cases cause problems for surrounding customers.

1.1.8 Surges

Surges are transient over voltages that usually last less than a few milliseconds. They are typically the result of lightning and equipment switching.

The Following factors are the quality of a typical electrical power system:

- Power Frequency Disturbances
- Electro Magnetic Interference(EMI)
- Power System Transients
- Electro Static Discharge(ESD)
- Power System Harmonics
- Power Factor(PF)
- Grounding and bonding.

PF deviation is mainly due to the inductive loads in the system. PF is defined as cosφ where φ is the electrical phase angle between voltage and current in a load. In a resistive circuit, since the phase angle between voltage and current is 0º, the PF is 1. In an inductive load, current lags the voltage and the PF is considered as lagging PF and it has a value between 0 and 1. A non-unity PF causes reactive power losses in the system. Voltage sags are caused by lightning strikes. Voltage sags are caused by faults in the electrical network.
Interruptions are caused by generator abnormalities. Flicker is caused by large fluctuating loads. Transients are caused by switching in or out heavy loads. Harmonics are generated by nonlinear loads. Voltage swells, voltage sags, interruptions and transients cause malfunction and premature failure of electrical and associated equipment. Flicker causes irritation and strain to the user. Harmonics produce many ill-effects which affect the entire electrical system and cause energy losses and failure of equipment. In a power system, voltage swells, voltage sags, interruptions and transients and flicker occur and persist for a short duration only.

1.2 Problem Identification

The term power quality is to describe the extent of variation of the voltage, current and frequency on the power system. The variation of voltage and current can either be in terms of magnitude or waveform shape/distortion. Any problem that results in failure or misoperation of customer equipment, itself is an economic burden to the user, or produce negative impacts on the environment. Power quality has become the main interest by the power systems research community. Voltage sags and swells are mainly causing severe damage and down time in the power systems. Power quality surveys shows that voltage sags are considered as the dominant factor affecting power quality. Monitoring is highly-effective means to detect, solve and even prevent problems. The best way to detect and diagnose the problems in electrical power system is called Power quality monitoring.

Benefits of Power Quality Monitoring

- Energy saving
- Reduced temperature raise
- Increased reliability / Life of equipment (e.g., Transformer, Motors, Capacitors…)
- Reduced Malfunction of Equipment

1.3 Need For Power Quality Monitoring

A properly installed and configured monitoring system is a valuable asset to almost any type of energy consumer. Energy consumers have a wide variety of considerations and concerns where energy usage is involved. This is largely due to the diversity of load types and requirements, energy consumption schedules. Studies of power quality phenomena have emerged as an important subject in recent years due to renewed interest in improving the quality of the electricity supply. Because the wide application of high-power electronics switchgear, problems of power quality are becoming more serious as each passing days.

1.4 Power Quality Problems

Power quality disturbance is such a big problem. The sensitivity of today’s electronic equipment makes it susceptible to power disturbances. Among the other power quality problems voltage sag and swell causes large damage, of which voltage sag causes serious effect. The reasons for the occurrences of the sag are

1.4.1 Utility Systems
Voltage sags can occur on utility systems both at distribution voltages and transmission voltages. Voltage sags that occur at higher voltages will normally spread through a utility system and will be transmitted to lower voltage systems via transformers.

1.4.2 Inside Industrial Plants
Voltage sags can be created within an industrial complex without any influence from the utility system. These sags are typically caused by starting large motors or by electrical faults inside the facility.

1.4.3 Bad Weather
Thunderstorms and lightning strikes cause a significant number of voltage sags. If lightning strikes a power line and continues to ground, this creates a line-to-ground fault. The line to ground fault in turn creates voltage sag and this reduced voltage can be seen over a wide area. High winds can blow tree branches into power lines. As the tree branch strikes the line, a line-to-ground fault occurs which creates a voltage sag. Broken branches landing on power lines cause phase-to-phase and phase-to-ground faults.

Factors Contributing to the Causes of Voltage Sags or Swells
1. Rural location remote from power source
2. Long distance from a distribution transformer with interposed loads
3. Unreliable grid system
4. Power distributor’s tolerances not suitable for voltage sensitive equipment
5. Switching of heavy loads
6. Unbalanced load on a three phase system
7. Equipment not suitable for local supply

Symptoms of Sags and Swells
1. Production rates fluctuates
2. Equipment does not operate correctly
3. Dimming of lighting systems
4. Relays and contactors drop out
5. Unreliable data in equipment test

If electrical equipment fails due to overloading, cable faults etc., protective equipment will operate at the sub-station and voltage sags will be seen on other feeder lines across the utility system.

1.4.4 Sources Of Power Quality Problems
Utility Sources, lightning PF correction equipment faults , Switching internal sources, individual Loads – lighting, elevators, coolers, arc welders, and other arc devices medical equipment, e.g. MRIs and X-Ray machines office equipment and computers.

2. METHODS TO DETECT THE POWER QUALITIES
Among the other power qualities, the voltage sags and voltage swells causes severe damages so the sags and swells are too identified.

In [4], Raj Naidoo proposed, that the sag detection can be done using the non linear adaptive filter techniques. The amplitude of the sag in real time is identified by using the filter. Algorithm is compared with the other techniques. In this method of detection, the algorithm detects the voltage sag quicker than the other method, but the voltage swell detection is slow.

The RMS method, Fourier Transform Method and Peak Voltage Method are used to identify the voltage sag and swell. RMS method is used to detect the sag before mitigation had started. The main disadvantage is that this method uses the historical data for the identification of the Voltage sags and voltage swells. So the detection of the sags and swells is slower.

In [5] and [6], sags are identified using the low pass filter and instantaneous reactive power. But these are unable to implement in the digital signal processor or microcontroller.

In [7], different methods had been discussed about the detection of the voltage sags and voltage swells at different operating conditions. In [8], mathematical models were developed and the voltage sags and voltage swells had been detected in the single phase power supply.

The Following Table 1 and 2 shows the Power Quality Definitions IEEE Categories Std 1159-1995

<table>
<thead>
<tr>
<th>SAG</th>
<th>DURATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantaneous Sag</td>
<td>0.5 – 30 cycles</td>
</tr>
<tr>
<td>Momentary Sag</td>
<td>30 cycles – 3 sec</td>
</tr>
<tr>
<td>Temporary Sag</td>
<td>3 Sec – 1min</td>
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</table>

3. PROPOSED METHOD
The hardware of the unit is composed of the step down Transformer, Voltage Sensing Unit, PIC Microcontroller unit, LCD. The AC supply for which the Voltage Sags and Voltage Swells are to be identified and the duration of the occurrence is displayed in the LCD. The Voltage Sensing Unit converts the ac to the true RMS value. The microcontroller is widely used in the industrial automation. A microcontroller based system is designed to identify the Voltage Sags and Voltage Swells. The system is compact, cost is lower and the designed hardware is not complex when comparing to the other system. The Microcontroller choice in this method is the PIC 16F877A low cost, low consumption, high speed, easy handling.

3.1 Voltage Sensing Unit
The Voltage Sensing Unit is that which consist of the RMS convertor. The True RMS to DC Converter is of low cost, small physical size of high accuracy. In contrast to measuring the average value, true RMS measurement is a universal language among waveforms, allowing the magnitudes of all types of voltage (or current) waveforms to be compared to one
another and to dc. True RMS converters are smart rectifiers; they provide an accurate RMS reading regardless of the type of waveform being measured.

3.2 Microcontroller Unit

The Microchip’s PIC 16F877A is used as a microcontroller and the program of the controller is written in Embedded C Program.

3.3 MPLAB IDE

MPLAB IDE is a software program that runs on a PC to develop applications for Microchip microcontrollers. It is called an Integrated Development Environment or IDE, because it provides a single integrated environment. To develop code for embedded microcontrollers, MPLAB IDE is a Windows-based Integrated Development Environment (IDE) for the PIC microcontroller (MCU) families. MPLAB IDE is used for writing, debugging, and optimizing PIC MCU applications for firmware product designs. MPLAB IDE includes a text editor for creating assembly language source code and an assembler to convert the source code into a form which can be programmed into the PIC microcontroller, simulator, and project manager. The most important component of the IDE is the integrated software simulator, which allows a designer to trace through their assembly code and watch the registers, RAM, ROM, and I/O ports.

3.4 LCD

LCD is an Electronic Visual Display, shown in Fig. 2. The LCD is a much more informative output device. The LCD that can easily show characters on its screen. LCD range in size, price and configuration, the LCD has a row of 8 pins to serve as its port. The pins that serve as its ports is D0, D1, D2, D3, D4, D5, D6 and D7.

These pins are generally used to pass information into the LCD, but it can also be set to pass information back to the microcontroller. The LCD used is the 2 × 16, for the display of the Time at which the Voltage Sags and Voltage Swells occur. The proposed method is that the voltage sags and swells are identified by using PIC microcontroller. The block diagram is shown in the Fig. 3. The AC main supply is given to the step down transformer. The step down voltage is then given as input to the voltage sensing unit.

3.5 Block Diagram

The voltage sensing unit is that which consist of the true RMS converter, the RMS converter is that which converts the AC to DC and the output is given to the PIC microcontroller. The PIC microcontroller is that which analyses the voltage amplitude and it then displays the Time at which the Voltage sags and Voltage swells occur. Then it also displays the duration that the Voltage Sags and Voltage Swells occur. The time period is displayed in the LCD. The flow chart is explained in the Fig. 4.
4. CONCLUSION

The proposed method identifies the voltage sags and voltage swells and the time at which they have occurred. Compared to very expensive Data Acquisition System the proposed method is cost effective. The identification helps in taking effective steps to mitigate the effects of voltage swells and sags.

REFERENCES