

LOW COST HARMONIC MEASUREMENT USING ARDUINO UNO

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Abstract: In recent years, the use of a non-linear power system loads have increased. So accordingly, the harmonic pollution to power line quality is growing. Due to the current technological advances, and the convenience of life and livelihood equipment increasing, this also increases power consumption, so that the frequency changes are quite common. The degree of change varies depending on load characteristics and design of the power supply system. In the power line system operation, when the frequency is lower than the nominal value, the system is under the overloaded condition. If the frequency is higher than the reduction value, it shows the oversupply of the power line. Various harmonics in power systems are measured typically by the heterodyne receiver in analog techniques or the FFT (fast Fourier transform) analyser in digital methods. The role of frequency represents whether the power line reaches a state of equilibrium between supply and demand, so frequency is a very important indicator for the reliability, safety and economy of the power line system. Arduino is used to build a low-cost data capture card combined with mobile devices to build a portable power line frequency detection platform. By observing changes in the frequency, we can immediately detect the situation of the power line system operation, and the interference of power line quality can also be monitored simultaneously. The input signal is processed by the quantisation and sampling for the harmonics measurement, and hence the total harmonic distortion in the input signal is easily detected by using Arduino FFT implementation.

Keywords

Arduino, Harmonics, Transformer, THD, FFT.

1. INTRODUCTION

In electrical power system the impact of non-linear loads has been increasing during the last decades. Presently, power system and power quality have been concerned about harmonic pollution generated by modern electronic devices such as adjustable speed drivers, controlled rectifier etc. In ideal situation, the

electric power in a network is supplied at a constant system frequency, and at specified voltage magnitudes known as the fundamental frequency, however, in practice under different circumstances the frequency and voltages are deviated from their designated values. The deviation of a wave form from its perfect sinusoid is generally expressed in terms of harmonics. Harmonics in power systems is nothing but the existence of signals, super imposed on the fundamental signal, whose frequencies are integer numbers of the fundamental frequency. The presence of harmonics in the voltage or current waveform leads to a distorted signal for voltage or current, and the signal becomes non-sinusoidal signal which causes malfunctions or damage on load. Harmonic measurement is one of the well-known aspects of power quality monitoring and control. Quite a lot of algorithms have been proposed on harmonic analysis. Among them Fast Fourier transform (FFT) is the most widely used computation algorithm. FFT is a competent algorithm used to Figure out Discrete Fourier transform (DFT). For analysis of these harmonics which are relatively stationary compared to other power quality disturbances, the signals should be from the time domain to the frequency domain. This is done by means of the discrete Fourier transform (DFT), which can be implemented well by the fast Fourier transform (FFT).

2. RELATED WORKS

The design, computational aspects and implementation of an iterative technique for measuring power system frequency is explained by the Abu-El-Haija [2014]. The technique provides accurate estimates to a resolution of 0.01-0.02 Hz for near- nominal, nominal and off-nominal frequencies in about 20 ms. Computation requirements are modest and the technique has been implemented on a modern digital signal processor. The proposed technique was extensively tested using voltage signals obtained from a dynamic frequency source and from a power system.

Milenko B. [2005] proposed the three new techniques for frequency measurement are proposed in

the paper. The first is a modified zero crossing method using curve fitting of voltage samples. The second method is based on polynomial fitting of the DFT quasi-stationary phasor data for calculation of the rate of change of the positive sequence phase angle. The third method operates on a complex signal obtained by the standard technique of quadrature demodulation. All three methods are characterized by immunity to reasonable amounts of noise and harmonics in power systems. The performance of the proposed techniques is illustrated on several scenarios by computer simulation.

Kamwa and Grondin [2000] proposed the real-time measurements of voltage phasor and local frequency deviation find applications in computer-based relaying, static state estimation, disturbance monitoring and control. This paper proposes two learning schemes for fast estimation of these basic quantities.

Power quality (PQ) is an issue that is becoming increasingly important to electricity consumers at all levels of usage. Improvement of PQ has a positive impact on sustain profitability of the distribution utility on the one hand and customer satisfaction on the other explained by Bollen [2006].

The electric spring (ES) was originally proposed as a distributed demand-side management technology for making noncritical loads adaptive to the availability of intermittent renewable power generation by Yan, Tan [2017].

Moore [2004] proposed a new numerical technique for evaluating power system frequency from either a voltage or current signal is presented. The technique uses discrete time values of the input signal, taken at a fixed sampling rate, to provide an estimate of power system frequency accurate to within typically 0.001 Hz.

2.1 EFFECTS OF HARMONCS

2.1.1 Overheating of Electrical Equipment

It is common to refer to heating as I²R losses. Electrical equipment can be overheated by distorted load current that cause higher eddy current losses inside the equipment. Other results of heating are:

- a) Overheating of generators, motors, transformers, and power cables that lead to early equipment failures
- b) Excessive losses
- c) Overheating of neutral conductors, and other electrical distribution equipment

- d) Capacitor failures, tripping of circuit breakers and loss of synchronization on timing circuits.

3. NEED OF FAST AND ACCURATE IDENTIFICATION OF FUNDAMENTAL AND HARMONIC QUANTITIES

In industrial and commercial power system fast and accurate identification of the signal is required for evaluation of initial and future system performance. It is also essential to study system reliability and finding its ability to grow with production for operating requirements. It is also required to ensure whether the system will operate safely, economically, and efficiently over the expected life of the system or not depending on following:

a) Power Quantities: In a power system, different measures of power quantities such as power frequency 60/50 Hz or fundamental of active, reactive, and apparent powers are defined these three basic quantities are the quintessence of power flow in electrical networks and should be calculated based on the information embedded in voltage and current signals.

b) Detection of fundamental frequency: A power signal when distorted is consists of fundamental and one or more harmonics. Fundamental voltage and current components should be properly detected to get fundamental power, harmonic and unbalanced quantities in many applications.

c) Analysis and power Quality Monitoring: A distorted wave consists of 5th and 7th harmonic and several other higher harmonics. In certain complex condition it consists of inter harmonics and sub harmonics in such cases the energy of the signal at each constituting component is required for analysis and quality monitoring of the system.

3.1 Importance of Harmonic Measurement

Harmonic measurements are an important part of the overall investigation for a number of reasons. Most importantly, the measurements must be used to characterize the level of harmonic generation for the existing nonlinear loads as it provide a means for verifying the harmonic model.

4. BLOCK DIAGRAM

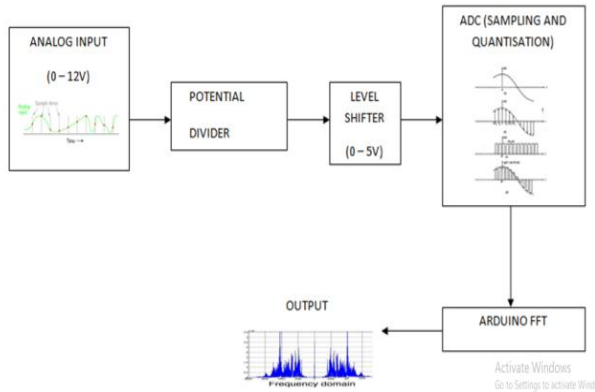


Figure 1 Block Diagram

4.1 Potential Divider

Potential or voltage dividers for high voltage Impulse Voltage Measurements, high frequency a.c. measurements, or for fast rising transient voltage measurements are usually either resistive or capacitive or mixed element type. The low voltage arm of the divider is usually connected to a fast recording oscillography or a peak reading instrument through a delay cable. A schematic diagram of a potential divider with its terminating equipment is given in Figure 2. Z1 is usually a resistor or a series of resistors in case of a resistance potential divider, or a single or a number of capacitors in case of a capacitance divider. It can also be a combination of both resistors and capacitors. Z2 will be a resistor or a capacitor or an R-C impedance depending upon the type of the divider.

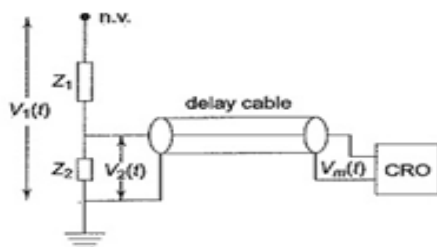


Figure 2 Potential Divider using CRO

Each element in the divider, in case of high voltage dividers, has a self-resistance or capacitance. In addition, the resistive elements have residual inductances, a terminal stray capacitance to ground, and terminal to terminal capacitances.

5. SAMPLING AND QUANTISATION

The system shown in Figure 3 is a real-time system, i.e., the signal to the ADC is continuously sampled at a rate equal to f_s , and the ADC presents a new sample to the DSP at this rate. In order to maintain real-time operation, the DSP must perform all its required computation within the sampling interval, $1/f_s$, and present an output sample to the DAC before arrival of the next sample from the ADC. An example of a typical DSP function would be a digital filter.

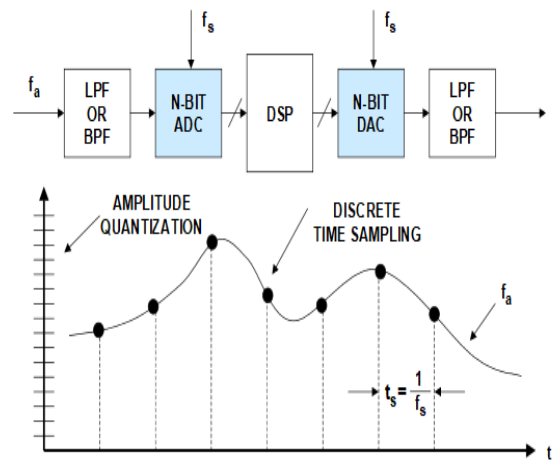


Figure 3 Sampled data system

5.1 Arduino UNO

An Arduino board consists of an Atmel 8-bit AVR microcontroller with complementary components to facilitate programming and incorporation into other circuits which is shown in Figure 4. An important aspect of the Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable add-on modules known as shields. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²C serial bus, allowing many shields to be stacked and used in parallel. Official Arduinos have used the mega AVR series of chips, specifically the ATmega8, ATmega168, ATmega328, ATmega1280, and ATmega2560. A handful of other processors have been used by Arduino compatibles. Most boards include a 5 volt linear regulator and a 16 MHz crystal oscillator (or ceramic resonator in some variants). Although some designs such as the Lily Pad run at 8 MHz and dispense with the on-board voltage regulator due to specific form-factor restrictions.

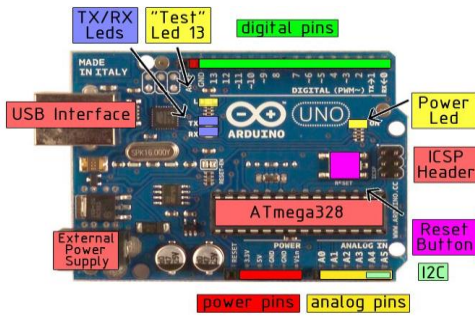


Figure 4 Arduino Hardware

5.2 IEEE-519 Evaluations of Harmonic Distortion and Recommended Harmonic Limit

The following chart Table 1 indicates the limits for harmonic current distortion imposed by this standard. The limits are based up on ratio of available short circuits current (I_{sc}) at PCC to maximum demand load current (I_L) The analysis is generally performed at the point of where facility power is connected to utility.

Voltage Distortion limits

IEEE 519 standard propose limits of current harmonic injection from end user / customer to supply grid so that voltage harmonic levels on overall power system remains within acceptable limit.

Table 1 Voltage Distortion Limits

Bus Voltage at PCC (V_n)	Individual Harmonic Voltage Distortion (%)	Total Voltage Distortion THD V_n (%)
$V_n < 69KV$	3.0	5.0

6. SIMULATION RESULTS

PLX-DAQ enables a more complex interaction with Excel. It can take the cell values from Excel, it can read and write check box PLX-DAQ takes commands in uppercase and every data row have to end with, because it derives from Parallax world a 'carriage return'. The serial port speed required by PLX-DAQ is particular in any case the rate is from 9600 bit/sec to 128.000 bit/sec. The speed of 128.000 bit/sec works fine in the Arduino. The software is made by a competitor of Arduino,

Parallax, and the company that sells the Boe-Bot and the Propeller, which are in direct competition with Arduino. The software is called PLX-DAQ and it is free software.

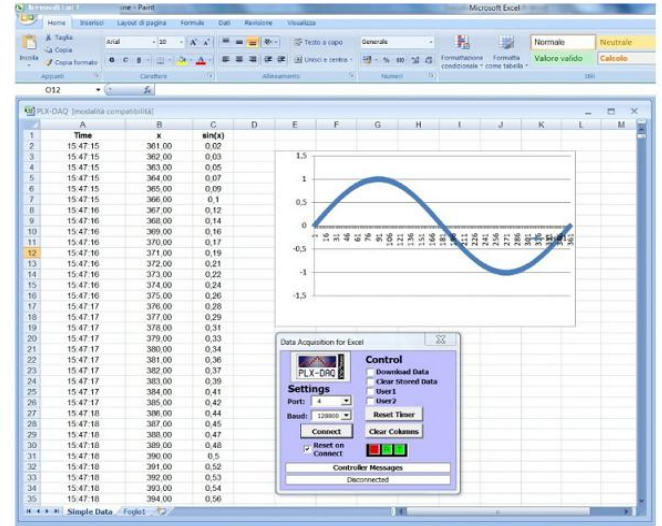


Figure 6 Simulation Result

7. CONCLUSION

The various harmonic mitigation strategies adopted in the last three decades have been reviewed. Based on this survey a new methodology to control harmonic distortion in power system is introduced. In the proposed method harmonics get detected using Arduino. The benefits of the proposed optimization method are: 1. Detection of harmonics in easier way 2. Correct measurement of harmonics and THD. Non-linear loads result in harmonic distortions in the power system and the associated problems were discussed briefly.

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