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Design Digital Filter of Harmonic Elimination in Power System

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Abstract - *With increasing use of power electronic systems and time variant nonlinear loads in industry, the generated power harmonics/interharmonics have resulted in serious power-line pollution. Power supply quality is therefore aggravated harmonics are found to have negative effects on power system equipment's including transformers, capacitor banks, rotating machines, scanner, PC, printer, TV and protective relays. These transformers and motors may experience increased losses and excessive heating. Harmonic voltage and currents in an electric power system are a result of nonlinear electric loads. These harmonic related losses reduce system efficiency, cause apparatus overheating, and increase power and air conditioning costs. Hence, reduction of harmonics is considered desirable for analyzing power supply quality. Designing of digital filter is the techniques to improve power quality in delivering electrical power to the customer. Digital filter is the effective method mostly used for harmonics elimination in AC signal processing applications. In this work, a digital FIR/IIR filter is implemented on PIC18C452 Microcontroller for removing 50/60Hz signal harmonics. Digital filters are efficient for harmonics elimination in low as well as high frequency signals. This project presents the assessment of digital filter design and harmonic analysis to the system.*

Key Words: Nonlinear load, harmonics, power system, digital FIR/IIR filter, PIC18C452 controller, harmonics analysis.

1.INTRODUCTION

Recently, the electrical harmonic pollution is getting more and more serious with the increasing use of nonlinear components in electronic devices. The presence of harmonics in power system is a major concern to power engineers for many years. Harmonics lead to industrial plant downtimes and power losses. Harmonic is the signal whose frequency is a multiple integer of the fundamental frequency. The highly nonlinear devices are the sources of harmonics. Harmonic analysis is used to calculate the impact of harmonic producing loads on a power system [1]. The effect of harmonics on power system can be in the form of power efficiency decreasing, wire overheating, ageing of electrical systems, etc. [2].

Several algorithms have been projected on harmonic analysis and we can conclude from previous work done that Fast Fourier transform (FFT) is the most commonly used computation algorithm. FFT is a proficient algorithm used to compute discrete fourier transform (DFT). DFT gives a finite set of discrete-frequency magnitude spectrum values [4] [5].

Nowadays, DSP is become an important tool and have shown fast development in various field following the expressive advances on digital technology, image processing, robotics, circuits fabrication, VLSI applications. Filters is a device which removes unwanted components from signal. Filter classified into analog filter and digital filter. The digital filters are progressive, gives better, faster, minimum disturbances in the output. Digital filters are able to accomplish various operations that world, at best, be highly difficult to follow with analog filters. The types of digital filters are IIR and FIR filter [7][8]. In FIR filter is non-recursive and have linear phase response. In IIR filter has feedback and gives better response with less compatible price. IIR filter is suitable for lower order filter and found more targeted than FIR. In designing the IIR filter the main hurdle is to set the lowest order for the purpose of magnitude response and linear phase response. There are various methods exist to design digital filters, like frequency sampling or windowing methods is most popular and very much in use. In the previous papers, digital filter is implemented on general purpose DSP's, FPGAs, and ARM platform [8]. While each type has advantages and disadvantages like low cost, size, precision, power consumption etc.

2.LITERATURE SURVEY

In this section we briefly review the most relevant literature of design digital filter for noise elimination in power system.

Jeena Joy [2] have proposed a power supply harmonic analysis using FFT technique is being implemented on ARM7 core processor LPC2138. In this V_{supply} 230V, 50Hz is stepped down to 6V using a voltage divider to match the power rating of the processor input and output is displayed on a graphic LCD and harmonic analyzer is analyzing harmonics in a single phase supply.

Jaipreet Kaur Bhatti [3] have proposed a harmonic meter using a microcontroller. The meter is built with a microcontroller and the full wave rectifier front end circuit. The input signal to the 10-bit ADC is full wave rectified. The software performs DFT calculation to finding the amplitude of the fundamental frequency and the 3rd harmonic. The distortion is calculated by the ratio of the amplitude of the 3rd harmonic to the fundamental frequency.

Manish Kansal [7] have implemented digital IIR/FIR filter for removal power supply noise. Author first designed digital filter in MATLAB to check feasibility of specifications. Then the filter was designed in VHDL and simulated in Modelsim software. In this, Parks McClellan Algorithm is used to calculate the coefficients.

Rakhi Thakur [8] have implemented digital FIR filter on FPGA and compare with traditional DSP. The FPGA solution provides complete flexibility in the design. By reducing chip count, it improves the overall reliability of the system, provides less area, low power and high-speed implementation of FIR filters. It also reduces filter latency. The advantages of the FPGA approach are higher sampling rates, lower cost and more flexibility.

Tochukwu Chiagunye [10] have designed Microcontroller based LPF, HPF and BPF digital filter with op-amp. In this, author implemented digital filter in PIC 16F877A controller. In this, analog signal generated by tone generator (555 IC).

Mukherjee [17] have implemented digital FIR filter on DSP and FPGA platform. In this, simple moving average (SMA) and exponentially weighted moving average (EWMA) based signal filtering techniques are applied on corrupted signal with different SNR to filter out noise from a discretely sampled signal.

Dr. Kamal Aboutabikh [11] have implemented digital notch filter for eliminating power line interference by FPGA chips which is based on development and education board DE2-70. This algorithm also used in all ECG, EGG and EMG devices.

3.PROPOSED SYSTEM

The block diagram of system contains sine wave generator (using DAC), mixer, local oscillator, low pass filter and microcontroller.

Here we use PIC18C452 as the microcontroller. The whole section can be divided into three main sections, Pure sinewave generation using DAC, Harmonics analysis and digital filter design section. If the harmonics signal is detecting, then it will be showed on graphical LCD. It shows the percentage of total harmonic distortion (THD) or we can see on spectrum analyzer.

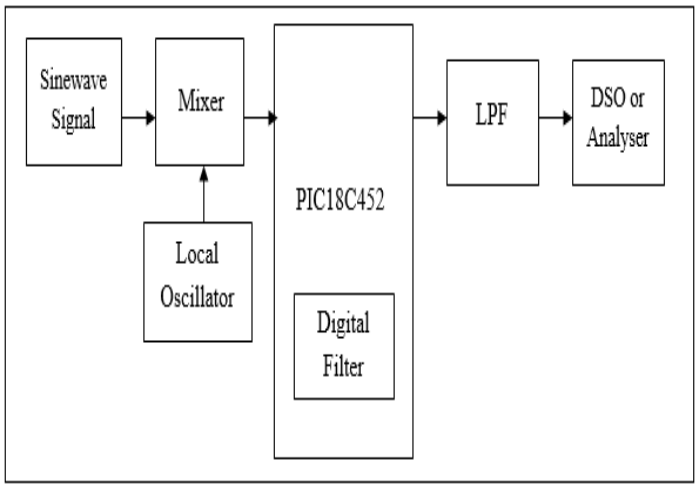

Fig -1: Block diagram of proposed system

The basic idea here is to generate or synthesize a sine wave by passing a digitally generated PWM through a filter. This technique can be also used to generate other waveforms like sawtooth, square, etc. Generally, lookup tables are used to make it easier and faster. Also by changing the lookup table we can change the wave form. The sinewave LUT equation (1) shown below

LUT [Y]= rint (100 + 100 * sin (Angle_Step_Rate * Y))
...Equation (1)

Where, Y is no of division

3.1 Oscillator Circuit

The wien bridge oscillator is used to generate 100Hz frequency. This frequency will add with the fundamental frequency by using mixer circuit.

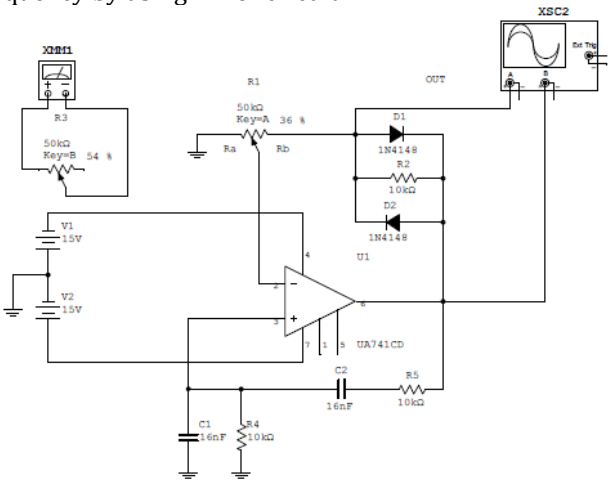

Fig -2: Block diagram of wien bridge oscillator circuit

3.2 Mixer Circuit

In order to generate distorted signal i.e. harmonics signal we are required simple adder or mixer circuit. This mixer will add the fundamental frequency (50Hz) and other frequency (100Hz) signal generated by wien bridge oscillator. The output of mixer circuit is distorted signal i.e. we called it as harmonics.

3.3 Digital Filter

In this project we are more focus on digital filter. There are two basic types of digital filter, Finite impulse response (FIR) and Infinite impulse response (IIR) filter. Design and implementation of digital filter, first select the type of filter such as LPF, HPF, BPF, BSF etc., select sampling frequency (Fs), pass band (Wp), stopband frequency (Ws), passband ripple, decide the filter order (N) and coefficients (a_k) of the filter. Implementing filter operation using proper hardware and software. In this project PIC18C452 Microcontroller or dsPIC is used for digital filter design.

4.HARDWARE IMPLEMENTATION

4.1 Flow Chart

The flow chart of digital filter design steps and proposed system are shown below.

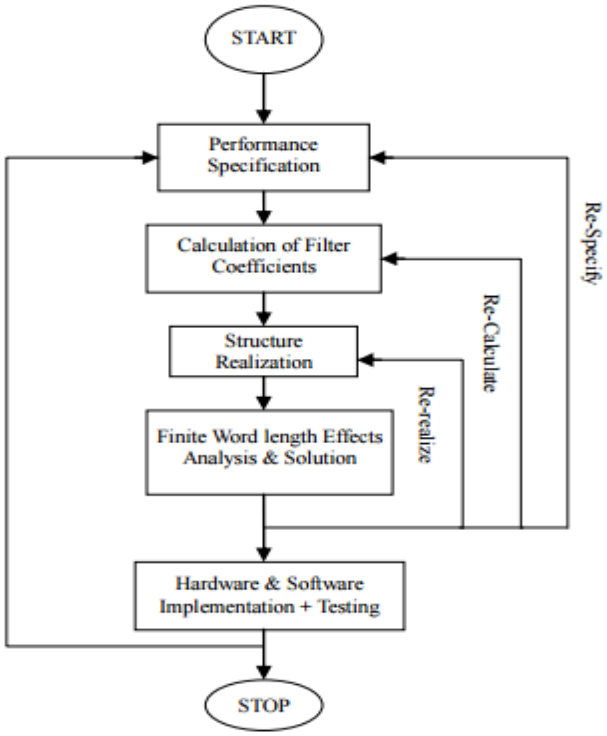

Fig -3: Flow chart of digital filter design

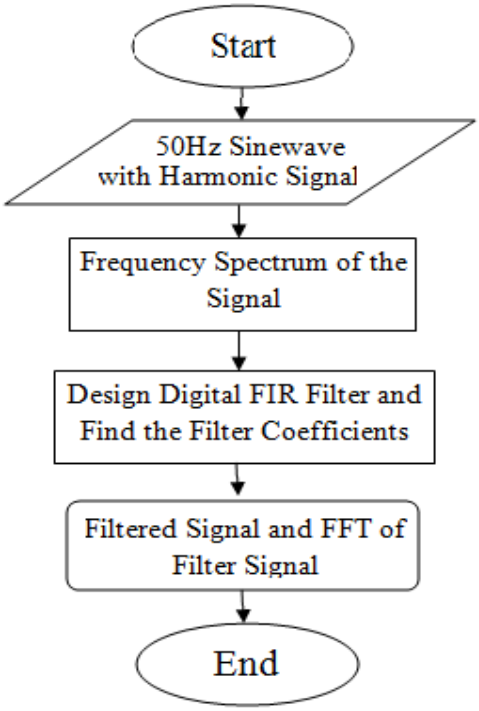

Fig -4: Flow chart of proposed system

4.2 Project Hardware

Fig -5: Experimental Setup

Project contains hardware and software part. In software we will generate pure sinewave signal having 50/60Hz frequency using PWM method through ARM7 LPC2478 microcontroller and given to the mixer circuit. The another input for mixer is from local oscillator (i.e. 400Hz). Mixer will add both the signals i.e. fundamental frequency and other frequency generated by local oscillator and produces new frequency which we called as harmonics signal. The output of mixer circuit is display on graphical LCD. It will show the percentage of THD. We will measure parameter of distorted signal using harmonic meter, provided by Motwane Pvt Ltd.

This distorted signal given to PIC18C452 microcontroller. After that we are design digital FIR/IIR filter by selecting proper type, coefficient, taps, accumulator, multiplier, sampling frequency, passband, stopband etc. then transfer code on PIC18C452 microcontroller. Then DAC is convert digital samples into analog signal and feed to LPF (low pass filter). Here R-2R ladder network is used for convert digital signal into analog form. The LPF is design using R and C component with op-amp 741. So the output of LPF is sinewave signal i.e. filtered output, observed on DSO.

5.RESULTS

The hardware is tested in Motwane Manufacturing Industry., and also tested in our college.

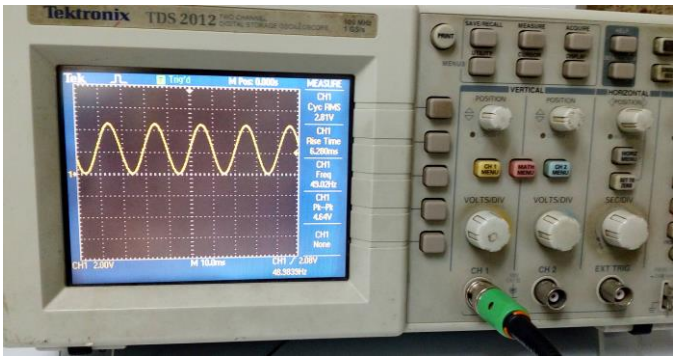

Fig. -6: Pure sinewave signal (50Hz)

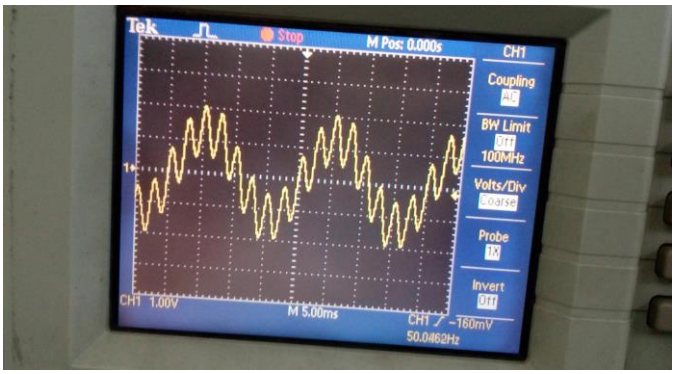

Fig. -7: Distorted signal (400Hz + 50Hz)

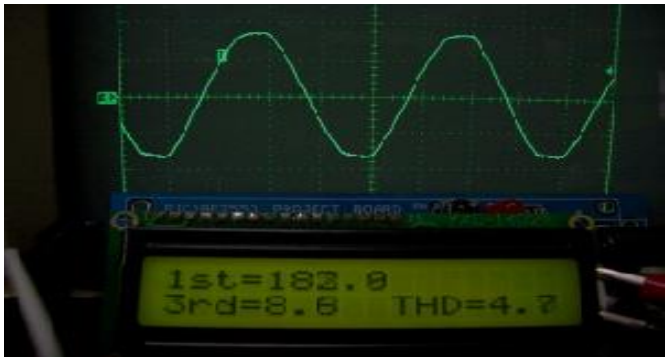

Fig. -9: Detecting 3rd harmonics

6.CONCLUSIONS

In this work, harmonics and power quality are analyzed. High pass filter used to suppress the high frequency harmonics component. The fundamental frequency of the system is 50/60 Hz and the harmonics are generated with the multiple integer of fundamental frequency. The amplitude of the harmonics is smaller than the fundamental frequency but the harmonics frequency is greater than the fundamental frequency. Therefore, result shows that high pass filter is used to suppress the high frequency component. The harmonics are found to have negative effects on power system equipment's. Hence the losses in the system are generated by distortions or harmonics in the electrical power system. Economical impact of the electrical power system can be decreased by mitigating or reducing harmonics and distortions and to increase the power quality of the system.

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