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TMS320C6713 Based Harmonic Analyzer a Case Study

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ABSTRACT : ***Presence of harmonics in a power system is a major concern to power engineers for many years. With increasing use of nonlinear loads in power systems, the harmonic pollution becomes more serious. When the magnitudes and orders of harmonics are known, reconstructing the distorted waveform is simple. Adding the harmonics together, point by point, produces the distorted waveform. Decomposing a distorted waveform into its harmonic components is considerably more difficult. This process requires frequency analysis, which involves a fair amount of calculation. The wavelet transform (WT) relative to some basic wavelet, provides a flexible time-frequency window which automatically narrows when observing high-frequency phenomena and widens when studying low-frequency environments. A wavelet is a waveform of effectively limited duration that has an average value of zero. One of the widely used computation algorithm for harmonic analysis is Fast Fourier transform (FFT). This paper reports an attempt of implementation of TMS320C6713 based harmonic analyzer. First, the supply voltage is stepped down using a step-down transformer. The output of TMS320C6713 DSK is observed on oscilloscope.***

Keywards- FFT, DFT,CCS, WT,PF

1. INTRODUCTION

A harmonic is a sinusoidal component of a periodic wave having frequency integral multiple of fundamental frequency. The frequency contents present in the wave which are not integral multiple of fundamental frequency but greater than fundamental frequency are called ‘inter-harmonics’. The special category of inter-harmonics which are having frequency values less than fundamental frequencies are called as ‘sub-harmonics’.

The main sources of harmonic currents are the non-linear loads. The non-linear loads are those which have different current waveform than the supply voltage. The static power converters such as phase angle controlled rectifier, & inverters are the examples of sources of harmonic currents.The amount of harmonic voltage will often depends on the amount of harmonic currents being drawn by the load, source impedance which includes all the wiring and transformers back to the source of the electricity.[8]

Harmonic analysis is the process of finding the magnitudes and phases of fundamental frequency, and harmonics present in the waveform. The harmonic analysis also involves the study of non-stationary waveforms and transients come in the waveform due to various mechanisms in various operations.

This paper focuses on implementation of 240V, 50Hz power supply harmonic analysis based on DSK board using wavelet signal decomposition method. The organization of this paper is as follows: we described the need for the proposed system, the different techniques that were used, design requirements of DSK board and proposed algorithm.

2. NEED OF HARMONIC ANALYSIS

The harmonics present in the voltage and current not only affects the stiffness of power distribution system but also susceptibility of the equipment. This may cause economic loss.

The presence of harmonics in the signal cause reduction in power factor (PF) and it is given by-

$$PF = \frac{True\ power\ (Watts)}{Apparent\ power\ (VA)}$$

In solenoid coils and lighting ballasts some types of losses increases with the harmonic values such as skin effect and eddy current losses.

It causes overloads on the distribution systems due to the increase in the rms current. Overloads on neutral conductors due to the summing of third order harmonics created by single phase loads. It causes overloads, vibrations and premature ageing of generators, transformers, motors, etc.

Also it causes overloading and premature ageing of capacitors in power factor correction equipment. Distortion of supply voltage is capable of disturbing sensitive loads. It also causes disturbances on communications networks and telephone lines.

So, due to all above mentioned effects of harmonics present in the waveforms, it is essential to detect and suppress the harmonic contents present.

3. LITERATURE SURVEY

In early days, the harmonics are measured by using voltmeter with a tunes band pass filter (BPF) [7]-[9]. In this method, the dial has to be adjusted at desired frequency and voltage is to be read out from the voltmeter. The voltage values noted on the paper and the plot is drawn manually. For this a trained technician must be with equipment all times when harmonics were to be measured. The accuracy of this method was limited. The phase information cannot be obtained. [1]

To overcome the limitations of above mentioned method, a new method was invented. A spectrum analyzer and a noise measuring set are used to measure harmonics. A portable oscilloscope and multimeter are also required. The excellent results are possible with such a system. However, a technician must still adjust instruments and write results on paper for later analysis. Simultaneous data collection at several locations or long term data collection would be very expensive. [1]

Now, after the advancement in the spectrum analyzer the digital analyzers are developed based on recent technologies. Several algorithms are developed to measure

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harmonics such as Discrete Fourier Transform (DFT), and Wavelet Transform (WT) [10].

3.1 Discrete Fourier Transform

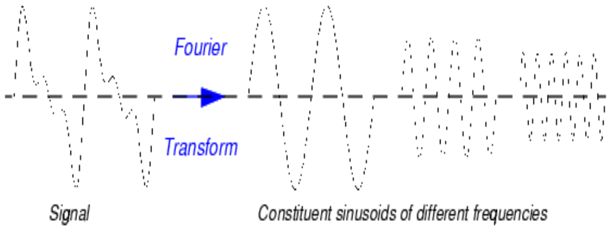

Fig. 1. Mechanism of Fourier Analysis

Fourier analysis is extremely useful for data analysis, as it breaks down a signal into constituent sinusoids of different frequencies as shown in fig 1. For sampled vector data, Fourier analysis is performed using the discrete Fourier transform (DFT). [2]

The discrete Fourier transform gives the representation of signal in frequency domain. Harmonics are the frequency components observed in the signal which are integral multiple of fundamental frequency. So by using DFT, the frequency representation of signal is obtained and one can find out the harmonics present in the signal.

The FFT is the algorithm which used to perform DFT. It is most efficient and less time consuming algorithm. The input signal x(n) having length N, FFT X(k) is given as-

$$X(k) = \sum_{n=1}^{N} x(n) e^{(-j*2\pi*(k-1)*(\frac{n-1}{N}))}$$

The signal whose FFT is to be calculated is assumed to be of finite duration which may cause the ‘spectral leakage’. Due to this weak signals in presence of strong signals or resolving a cluster of equal strength frequencies are lost.

To avoid the spectral leakage the ‘windows’ are used. Windows are smoothing functions that peak in the middle frequencies and decrease to zero at the edges, thus reducing the effects of the discontinuities as a result of finite duration.

Depending on the signal to be analyzed the window type, and different window parameters such as width of window, order are to be selected. Though this method gives the adequate information of the magnitude and phase of harmonics, it does not consider the time information while processing. Also this transform is not suitable for signals containing non-stationary events and abrupt changes. Thus we moved towards the different algorithm known as ‘Wavelet Transform’.

3.2 Wavelet Transform

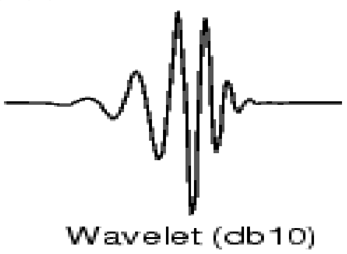

Fig 2. Basic Wavelet Daubecius

A wavelet is an oscillating and damped function as shown in fig 2. A wavelet is a waveform of effectively limited duration that has an average value of zero.[2]

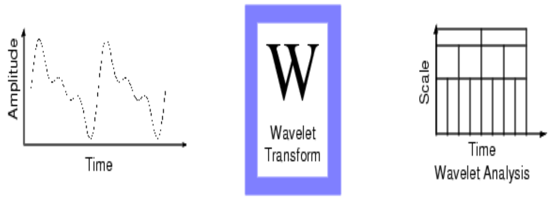

Fig 3. Mechanism of Wavelet Transform

The wavelet transform (WT) relative to some basic wavelet, provides a flexible time-frequency window which automatically narrows when observing high-frequency phenomena and widens when studying low-frequency environments. The basic mechanism of wavelet transform is shown in fig 3. [2]

There are two types of basic wavelets: father wavelet & mother wavelet. The mother wavelet is defined as

$$\int_{-\infty}^{\infty} \psi(t)\, dt = 0$$

The father wavelet is defined as-

$$\int_{-\infty}^{\infty} \psi(t)\, dt = 1$$

The continuous wavelet transform (CWT) of signal x(t) with the mother wavelet $\psi(t)$ is given as-

$$T(s,\tau) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} x(t)\, \psi^{*}\left(\frac{t-\tau}{s}\right) dt$$

The discrete wavelet transform (DWT) of signal x(n) is given as-

$$X(k,l) = a^{-\frac{k}{2}} \int_{-\infty}^{\infty} x(t) h(a^{-k}t - lT) dt$$

Where k represents frequency value and l represents time index.

The DWT analyzes the signal at different frequency bands with different resolutions by decomposing the signal into coarse approximation and detail information. DWT employs two sets of functions, called scaling functions and wavelet functions, which are associated with low pass and high pass filters, respectively. Fig 4 shows the mechanism of wavelet signal decomposition. [3]

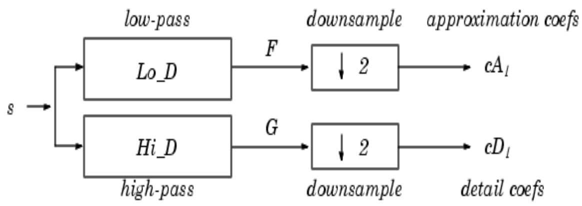

Fig 4. Mechanism of Wavelet signal decomposition

The decomposition of the signal into different frequency bands is simply obtained by successive high pass and low pass filtering of the time domain signal. The original signal x[n] is first passed through a half-band high pass filter g[n] and a low pass filter h[n]. After the filtering, half of the samples can be eliminated (according to the Nyquist’s rule) since the signal now has a highest frequency of fmax/2 radians instead of fmax. The signal can therefore be sub-sampled by 2, simply by discarding every other sample. [3]

The plot of detailed coefficient against scale and frequency is plotted called as ‘scalogram’. This gives information about harmonics contents present in signal.

4. PROPOSED METHOD

Proposed system implemented on TMS320C6713 DSK. The block diagram of proposed system is given shown in fig.5

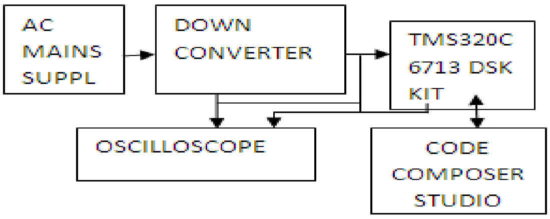

Fig.5 Block Diagram of System

In block diagram we firstly reduce the ac mains supply by using downconverter. The output of downconverter is given to the DSK kit. Code composer studio is used for the analysis of the output of system. The oscilloscope is used to display the comparison of the input and output of the DSK kit. In the below section the blocks of diagram are explained.

4.1 Downconverter

In this section input of system is reduced to 2.6 V by using the circuit given in fig.6.

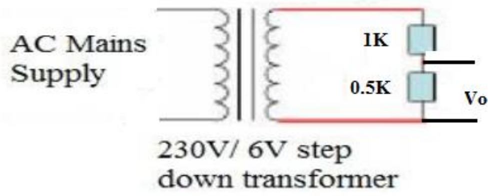

Fig.6 Circuit Of Downconverter

Transformer of the rating 6-0-6 V is used in the circuit. Using voltage divider rule, convert the output voltage to nearly about 2.6 V.

4.2 TM S320C6713 DSK Board

TMS320C6713 DSK developed by Texas Instrument with Spectrum digital, is a floating point digital signal processor (DSP) used as a low cost development platform. The sampling frequency of board is 32 kHz. The DSK board has an ADC/DAC build inside AIC codec with 16-bit resolution. The DSK board is connected to a computer for output display in Code Composer Studio (CCS) software. [4]

4.3 Proposed Algorithm

The algorithm used for the analysis of harmonics is wavelet signal decomposition. In the system for analysis, biorthogonal 3.9 wavelet transform is used.The signal is decomposed at 3 levels. The detailed and approximate coefficient obtained from signal decomposition are plotted which gives information about the harmonic content present in the signal [5]-[6].

5. CONCLUSION

A technique power supply harmonic analyzer in frequency domain using TMS320C6713 DSK was presented. The output from a step-down transformer gives a smooth/clean sine wave compare to the output from the other down converter techniques. The analysis using wavelet transform gives more accuracy as compared to the FFT analysis of system because of flexible window size . The wavelet transform analysis gives the inter harmonic analysis which is not given by the FFT method.

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