ABSTRACT

Electrical power systems suffer in quality due to poor Power Factor (PF), harmonics, voltage swells, voltage sags, interruptions, flicker and transients. Harmonics in current are caused by nonlinear loads such as rectifiers, Switched Mode Power Supplies (SMPS), Uninterruptible Power Supplies (UPS), Variable Frequency Drives (VFD) etc. Harmonics produce many ill effects such as, high current and over-heating in neutral conductor in 3 phase- 4 wire systems, increase in neutral to ground voltage, overloading of transformers, failure of PF correction capacitors, malfunctioning of protective relays etc.

Considering all the ill effects caused by harmonics, utilities all over the world have started imposing penalty to the users who generate harmonics. It is necessary to measure and quantify the amount of harmonics at the Point of Common Coupling (PCC). Along with the energy meter, an affordable cost, effective, accurate and fast on-line harmonics measurement system is very much required at every electrical installation.

A given periodic, nonsinusoidal waveform can be resolved into a sum of many sine waves using Fourier series. The resolved components will have one sine wave which has the same frequency as that of the supply waveform (called the fundamental) and other sine waves whose frequencies are integer multiples of the fundamental. The components other than the...
fundamental are called harmonics. Harmonics in electrical power system are a complex phenomenon to detect, observe, capture and analyse. The specification given by International Electrotechnical Commission (IEC) Standard IEC-61000-4-7 for measuring harmonics requires 1000 samples to be acquired from 10 cycles of voltage or current waveforms for a 50 Hz system. One class of Artificial Neural Network (ANN) called Adaptive Linear Element (ADALINE) has been proposed by researchers for resolving a nonsinusoidal waveform into fundamental and harmonics.

In this thesis, a methodology for implementation of ADALINE, with real-time signal acquired from the current measuring circuit has been proposed. The proposed methodology has been tested for convergence on three different platforms namely (1) MATLAB (2) Digital Signal Processor (DSP) and (3) Field Programmable Gate Array (FPGA).

The ADALINE is implemented and verified using MATLAB running on a Personal Computer (PC). The ADALINE on MATLAB is tested with 100 samples obtained from a single cycle of the current waveform having a data acquisition time of 20ms. The accuracy of the results obtained from the proposed model is comparable with that of the FFT based Power Quality Analyser (PQA) model C.A 8332.

For the DSP implementation, the ADALINE algorithm is developed in programming language C using Code Composer Studio (CCS). From the load current waveform, 100 samples are acquired and fed to algorithm. Harmonic components up to 40th order are computed. The
measuring time using the proposed ADALINE algorithm on DSP is 21.157ms whereas the time taken by the FFT algorithm implemented on a DSP is 200.9ms.

In the FPGA implementation, the ADALINE algorithm is coded in Very high speed integrated circuit Hardware Description Language (VHDL). The model is simulated and verified using ModelSim. Using Xilinx ISE software, the VHDL code is converted and downloaded on a Xilinx Virtex –II FPGA. From the load current waveform, 100 discrete samples are obtained using an external Analog-to-Digital Converter (ADC). The sampled data are handled in integer format and hence the accuracy is slightly less in FPGA implementation. The measurement time in the proposed ADALINE algorithm on FPGA reduces to 20.08ms compared to 200.1024ms taken by FFT implemented on FPGA.

From the hardware point of view, the DSP implementation has an advantage of on-chip ADC needed for acquiring the data samples of the load current. The FPGA requires an external ADC and the associated interface circuit. From the results obtained, it is concluded that the ADALINE algorithm can be used in practice on DSP and FPGA as a stand alone measurement system to improve the measuring time requirements.