PC BASED SPECTRUM ANALYZER

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I dedicate this to my beloved parents,
my whole family, and to all my friends
who have stood by me throughout these 4 years my studying at UTeM.

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ABSTRACT

PC based Spectrum Analyzer is a project which is developed by using Digital Signal Processing (DSP) technology. Today, most of people want a latest and sophisticated technology but at the same time having a function and quality that equal to the real hardware part. There are many spectrum analyzers at the market, but the price is expensive. At university, spectrum analyzer is only used by student at laboratory to do so some experiment related to the signal analysis. Therefore, university or students are not capable to buy this equipment. So, the equipment is limited and some experiment can't be carrying out. That is why, PC based Spectrum Analyzer is developed. Using the low cost and advantages of TMS320C6713 DSP board, the spectrum analyzer can produce a signal similar to real hardware output result. The signal can capture in real time from DSP processor and display it through to personal computer monitor. With the external hardware such as voltage transducer, the signal is step down until 1.5 V before entering to DSP board. After that, the signal will be transfer from DSP board to personal computer by using software. The operation software interface is written using Visual Basic software. This software utilizes a Graphical User Interface (GUI) which is more efficient in producing the output. Therefore, the GUI is designed specifically to give user more friendly operation. This PC based Spectrum Analyzer is a useful tool in education, particularly doing experiments and help students or learners in digital signal processing field.

ABSTRAK

Penganalisis Spektrum berpandukan Komputer Peribadi adalah sebuah projek yang telah dibangunkan dengan mengunakan teknologi Pemprosesan Isyarat Digit (DSP). Pada masa sekarang, kebanyakan orang mahukan teknologi yang baru dan canggih tetapi pada masa yang sama mempunyai fungsi dan kualiti sama seperti bahagian perkakasan sebenar. Terdapat banyak penganalisis spektrum di pasaran, tetapi harganya mahal. Di universiti, penganalisis spektrum hanya digunakan oleh graduan di makmal untuk melakukan beberapa ujikaji yang berkaitan dengan analisis isyarat. Oleh sebab itu, universiti dan graduan tidak mampu untuk membeli peralatan ini. Oleh itu, peralatan ini adalah terhad dan beberapa uijikaji tidak dapat dilaksanakan. Oleh yang demikian, penganalisis spektrum berpandukan komputer peribadi telah dicipta. Dengan hanya menggunakan kos yang rendah dan kelebihan TMS320C6713, iaitu papan Pemprosesan Isyarat Digit (DSP), penganalisis spektrum boleh menghasilkan isyarat sama seperti keputusan keluaran perkakasan sebenar. Dengan perkakasan luar seperti alat penerima gelombang voltan, isyarat tersebut akan dijatuhkan sehingga 1.5 volt sebelum memasuki papan Pemprosesan Isyarat Digit (DSP). Selepas itu, isyarat tersebut akan dipindahkan dari papan Pemprosesan Isyarat Digit (DSP) ke komputer peribadi dengan menggunakan perisian. Paparan operasi perisian ini telah dibuat mengunakan perisian Visual Basic. Perisian ini mengunakan Paparan Pengguna Grafik (GUI) di mana ia lebih cekap dalam penghasilan keluaran. Oleh sebab itu, GUI telah direka dengan teliti untuk memudahkan pengguna mengunakan perisian ini. Spektrum berpandukan komputer peribadi ini sangat berguna dalam pendidikan, terutamanya dalam melaksanakan ujikaji dan dapat membantu graduan atau orang yang belajar dalam bidang Pemprosesan Isyarat Digit (DSP).

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LIST OF ABBREVIATIONS

ADC	-	Analog Digital Converter
BOM	-	Bill of Materials
CCS	-	Code Composer Studio
COFF	-	Common Object File Format
CONJ	-	Conjugate
DAC	-	Digital Analog Converter
DFT	-	Discrete Fourier Transform
DSK	-	DSP Starter Kit
DSL	-	Digital Subscriber Line
DSP	-	Digital Signal Processor
EMIF	-	External Memory Interface
EVM	-	Evaluation Module
FFT	-	Fast Fourier Transform
GUI	-	Graphical User Interfaces
HDTV	-	High-Definition Television
IDE	-	Integrated Development Environment
ISR	-	Interrupt Service Routine
LED	-	Light Emitter Diode
McBSPs	-	Multi-channel Buffered Serial Ports
MHz	-	Mega Hertz
OLE	-	Object Linking and Embedding
PC	-	Personal Computer
RTDX	-	Real Time Data Exchange
RTSA	-	Real Time Spectrum Analyzer
TI	-	Texas Instruments
VLIW	-	Very-Long-Instruction-Word
VLSI	-	Very Large Scale Integrated

CHAPTER I

INTRODUCTION

1.1 Overview

Most of people are used to observing signals in the time domain with an analog oscilloscope. However, most analog oscilloscopes don't have the frequency domain to see spectrum signals. In addition, it didn't much help in determining what a signal looks like in the frequency domain. This is where spectrum analyzers come in. After that, the evolution is coming with new fresh idea. The PC Based Spectrum Analyzer was developing to faces the innovative technology. PC Based Spectrum Analyzer is controlled with easy to use windows software. This allows for more organized data display and increased screen size. With friendly graphical user interface (GUI), PC based Spectrum Analyzer also have data management like saving data and picture, loading, screen capture and control wave in real time .This project connect to PC's by using USB port. This chapter will discuss about the objectives of the project, scope of work, problem statements and thesis outline which included in this project.

1.2 Objectives

The objectives of this project is to develop a system that can measured real time input signal by using DSP processor and monitor the output through the Personal Computer (PC) screen. This system displays the waveform and its spectrum in real time by using DSP technology. The signal was captured the signal parameter and its frequency value automatically to computer by using a software. This software was developed using the Microsoft Visual Basic programming language. It also can be analyze the FFT and frequency contents of the input signal given.

1.3 Scope of Work

There are many kinds of method that can be used to develop this system but for this project, the scopes of work are describes as follow:

1. Implement using TMS320C6713 DSP evaluating board (Digital Starter Kit).
2. Voltage transducer with input range 0 – 240V, specific to 0V until 24V.
3. Frequency input that can be measure (0 - 4000 Hz).
4. Sampling Frequency – 8000Hz.
5. Measure real-time voltage and FFT of the signal.
6. Visual Basic will be used for GUI in PC.

1.4 Problem Statement

Currently, signal spectrum analyzer is designed by hardware are very costly. Universities and students usually do not have ability to provide these spectrum analyzers at lab, so some experiments can not be carried out. Beside that, the hardware spectrum analyzer have a small monitor to monitoring the waveform and the data could not be save in text when the data is needed to analysis or comparison . Therefore, by using a low cost spectrum analyzer based mainly on DSP processor and Visual Basic graphical user interfaces (GUI), PC based Spectrum Analyzer is developed. The main feature is to improve the education level.

1.5 Project Flow

The first and second stage of this project is more focusing on literature study of basic concept DSP and also understanding the fundamental of Digital Signal Processing. The third process is designing the structure voltage transducer for implement the hardware. By using MULTISIM software, the circuit was design. In general, a transducer is a device which converts a signal from one form to another. Most electronics circuits use both input and output transducers.

Then the next process is simulation MATLAB software using DSP algorithm. MATLAB are choice because it contains trigonometric function that can be used to generate a sinusoidal signal. A cosine signal of amplitude A and frequency f1 can be obtained by using the MATLAB command. Then using Code Composer Studio software, we implement FFT on hardware device. Code Composer Studio is TI's flagship development tool. It consists of an assembler, a C compiler, an integrated development environment (IDE), the graphical interface to the tools and numerous support utilities like a hex format conversion tool. The DSK includes a special version of Code Composer specially tailored to features on the 6713DSK board.

After that, we are developing software. The purpose of this software is being design Graphical User Interfaces (GUI) using Visual Basic. In this software development, Rapid Prototyping was choice because it's a software development process that involves iterative development and the construction of prototypes. A program is developing from computer (host) to display the real-time monitoring of signal and its spectrum using Visual Basic.

The next process is field testing and troubleshooting. A few tests are done to make sure that the hardware and software are work properly. If any error is detecting, the process is return to previous stage. The last process is writing a report. This report must include overall of this project documentation which explain briefly about PC Based Spectrum Analyzer.

1.6 Thesis Outline

This thesis represent by five chapters. The following is the outline of the PC based Spectrum Analyzer project in chapter by chapter.

Chapter I is discuss the brief overview about the project such as introduction, objectives, scope of the project, problem statement and project flow.

Chapter II covers theories and equations that are being used in order to complete this project. It also describe about spectrum analyzer and TMS320C6713 DSK board. The available techniques are being covered in this chapter and the better methods have been chosen for this project.

Chapter III is about the project methodology. Project methodology is about what processes are being done to complete the project. It emphasizes the details on the processes that are used. All these methodology should be followed for a better performance.

Chapter IV shows about the result and discussion such as project finding and analysis of PC based Spectrum Analyzer. The result consist figures with some explanation and covers the output for this project.

Chapter V is discuss about conclusion overall of this project. It also includes suggestion for the future modification and development.

CHAPTER II

LITERATURE REVIEW

2.1 Overview

Nowadays, all relatively inexpensive computers designed for an individual user. In medium price, personal computers range anywhere .All are based on the microprocessor technology that enables manufacturers to put an entire CPU on one chip. For education like university student, they used personal computer as reference to get knowledge or information, doing the task for assignment and also made technology experiment to improve their understanding. In the other word, personal computer is a medium of new technology to step forward for give human a good culture live.

In this section, it will be discussing about the theory and concepts that is accordingly to the project in details. Also, it will inform about the perspective and method that have been using in this project. The theory that will be discussed is about the Spectrum analyzer, DSP processor, TMS320C6713 DSK, DSP and programming language and software. It also include about spectrum analyzer technology which is very expensive to be developed. Using the advantages of personal computer, the spectrum analyzer software is developing to give something new or preference idea for this project.

2.2 Fundamentals of Spectrum Analyzer

Figure 2.0: Spectrum Analyzer

Spectrum analyzer is used to sweep over a band of frequencies to determine what frequencies are being produced by a specific circuit under test, and then the amplitude of each frequency component. An accurate interpretation of the display will allow you to determine the efficiency of the equipment being tested. Figure 2.0 illustrate the physical of Spectrum Analyzer.

A spectrum is a collection of sine waves that, when combined properly to produce the time-domain signal under examination. Figure 2.1(a) shows the waveform of a complex signal. Suppose that hoping to see a sine wave. Although the waveform certainly shows the signal is not a pure sinusoid, it does not give a definitive indication of the reason why. Figure 2.1(b) shows the complex signal in both the time and frequency domains. The frequency- domain display plots the amplitude versus the frequency of each sine wave in the spectrum. As shown, the spectrum in this case comprises just two sine waves. Now, it knows why original waveform was not a pure sine wave.

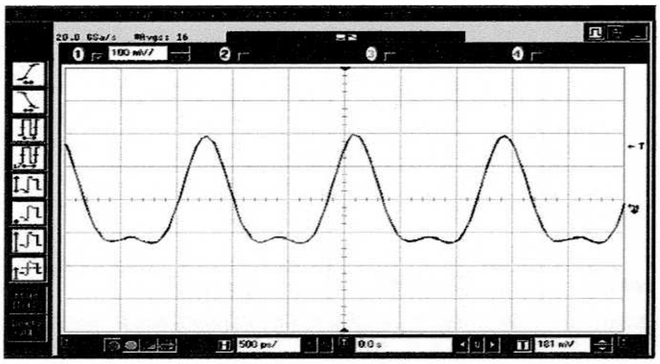

Figure 2.1(a): Waveform of complex signal

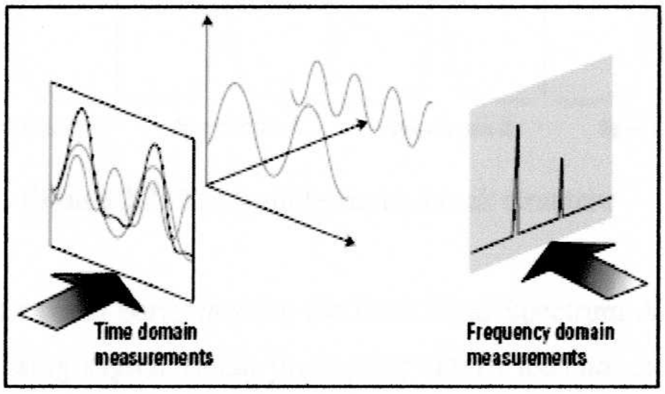

Figure 2.1(b): Complex signal in both time and frequency domain

2.2.1 Concepts of Real-Time Spectrum

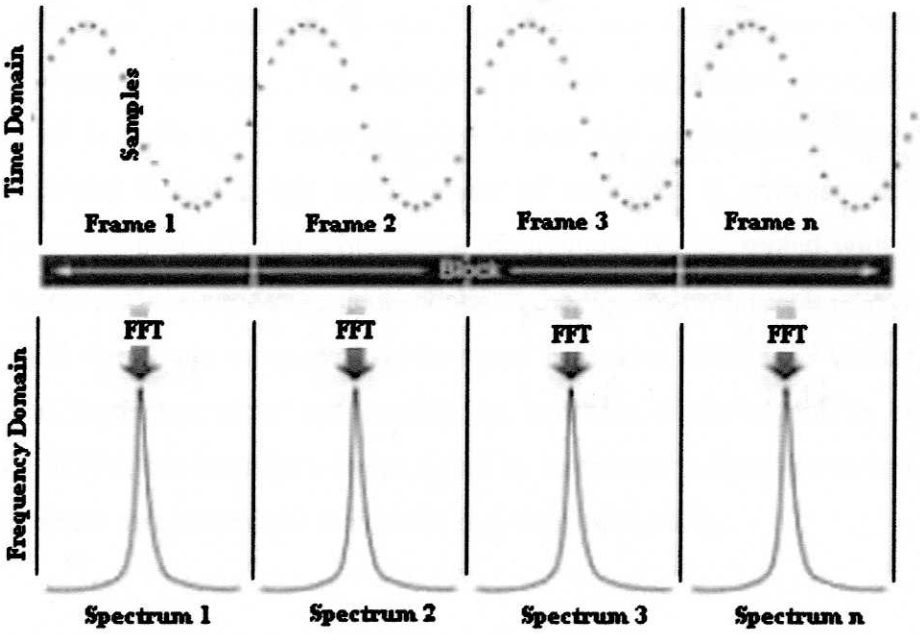

Figure 2.2: The sample-frame-block structure

The measurements performed by the Real Time Spectrum Analyzer (RTSA) are implemented using digital signal processing (DSP) techniques. To understand how the signal can be analyzed in the time, frequency, and modulation domains, it is first necessary to examine how the instrument acquires and stores the signal. After it is digitized by the ADC, the signal is represented by time domain data, from which all frequency and modulation parameters can be calculated using DSP. These concepts have three terms. They are samples, frames, and blocks. It used to describe the hierarchy of data stored when a real time Spectrum Analyzer seamlessly captures a signal using real-time acquisition. Figure 2.2 illustrates the sample-frame-block structure.

The lowest level of the hierarchy of data is the sample, which represents a discrete time-domain data point. This construct is familiar from other applications of digital sampling, such as a real-time oscilloscopes and PC-based digitizers. The effective sample rate which determines the time interval between adjacent samples depends on the selected span. In the RTSA, each sample is stored in memory as an I/Q pair containing magnitude and phase information. The next step up is the frame.

A frame consists of an integer number of contiguous samples and is the basic unit to which the Fast Fourier Transform (FFT) can be applied to convert time domain data into the frequency domain. In this process, each frame yields one frequency domain spectrum. The highest level in the acquisition hierarchy is the block, which is made up of many adjacent frames that are captured seamlessly in time. The block length is the total amount of time that is represented by one continuous acquisition. Within a block, the input signal is represented with no gaps in time. In the real-time measurement modes of the RTSA, each block is seamlessly acquired and stored into memory. It is then post processed using DSP techniques to analyze the frequency, time, and modulation behavior of the signal. In standard modes, the RTSA can emulate a swept signal by stepping the signal front end across frequency spans that exceed the maximum real-time bandwidth.

2.2.2 Fast Fourier Transform Analysis

The Fast Fourier Transform (FFT) is very important in the real-time spectrum analyzer. In the spectrum analyzer, FFT algorithms are generally employed to transform time-domain signals into frequency-domain spectra. Conceptually, FFT processing can be considered as passing a signal through a bank of parallel filters with equal frequency resolution and bandwidth. The FFT output is generally complex–valued. For spectrum analysis, the amplitude of the complex result is usually of most interest. The FFT process starts with properly decimated and filtered baseband I and Q components, which form the complex representation of the signal with I as its real part and Q as its imaginary part.

In FFT processing, a set of samples of the complex I and Q signals are processed at the same time. This set of samples is called the FFT frame. The FFT acts on a sampled time signal and produces a sampled frequency function with the same length. The number of samples in the FFT, generally a power of 2, is also called the FFT size. For example, 1024 point FFT can transform 1024 I and 1024 Q samples into 1024 complex frequency-domain points. FFT Properties The amount of time represented by the set of samples upon which the FFT is performed is called the frame length in the RTSA. The frame length is the product of the FFT size and the sample period. Since the calculated spectrum is the frequency representation of the signal over the duration of the frame length, temporal events cannot be resolved within the frame length from the corresponding spectrum. Therefore, the frame length is the time resolution of the FFT process.

The frequency domain points of FFT processing are often called FFT bins. Therefore, the FFT size is equal to the number of bins in one FFT frame. All bins are spaced equally in frequency. Two spectral lines closer than the bin width cannot be resolved. The FFT frequency resolution is therefore the width of each frequency bin, which is equal to the sample frequency divided by the FFT size. Given the same sample frequency, a larger FFT size yields finer frequency resolution. For a spectrum analyzer with a sample rate of 25.6 MHz and an FFT size of 1024, the frequency resolution is 25 kHz. Frequency resolution can be improved by increasing the FFT size or by reducing the sampling frequency.