DESIGNING A SPECTRUM ANALYZER USING PARALLEL PORT INTERFACING

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1. ABSTRACT

In this design of **Spectrum Analyzer**, we had implemented a hardware, which was controlled by associated software, for detecting the Fourier components (within a certain frequency range) of any input signal. *The theory behind such detection* [1] is based on comparing the input (unknown) signal with signals, generated locally using a numerically controlled oscillator (NCO), having frequencies within a definite range. With such comparison using necessary hardware, it became possible for us to detect each of the Fourier components of the input signal.

2. INTRODUCTION

The spectrum analyzer is lexically a device that can analyze any electrical signal [1], detects the frequency components present in that signal, finds out the relative ratios of amplitude of the frequency components, and finally shows the graph of *frequency vs. ratio of amplitude* for that input signal. In nutshell, it's a device that shows the Fourier transform of a signal given at its input. In our project, we tried to develop such a device, with of course some limitations. Of course, our device would not be feasible to use commercially but at least it's going to be a daunting task and boost up our ideas to develop a device from an algorithm or block diagram. Here we had come up with a *Spectrum Analyzer*, which can detect the signals having frequencies within a certain range.

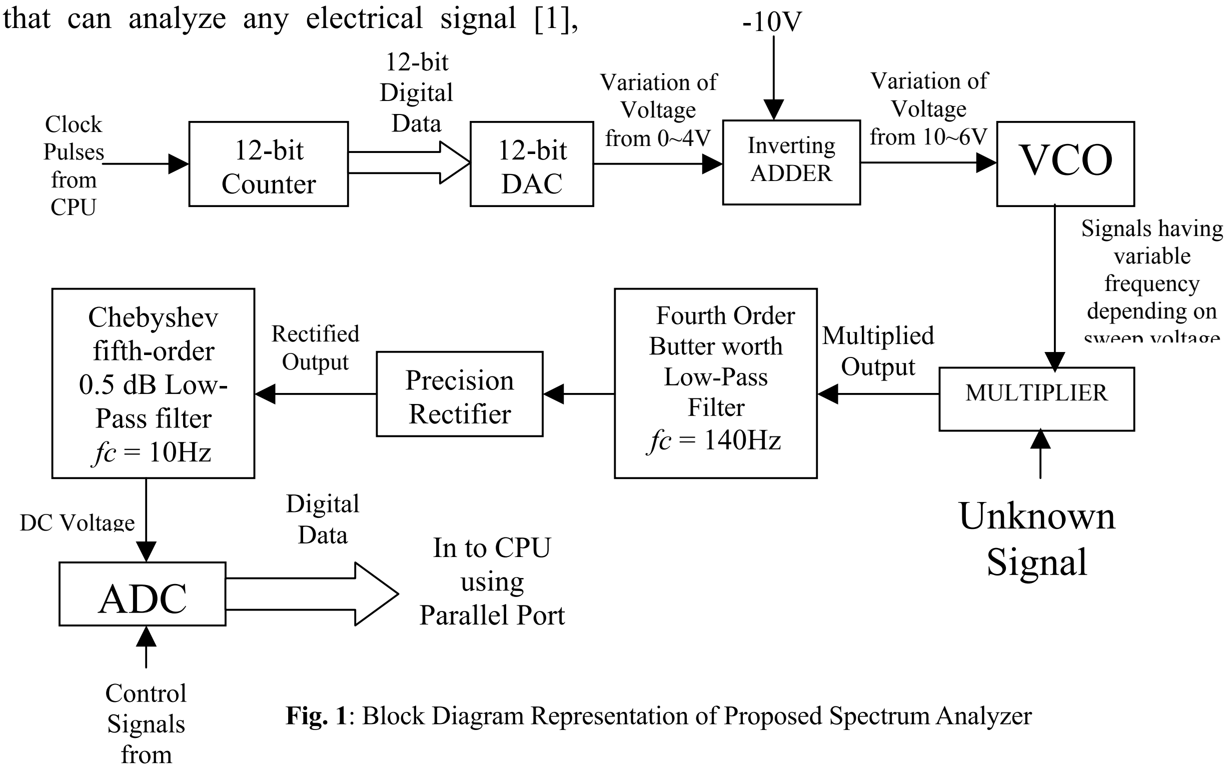


Fig. 1: Block Diagram Representation of Proposed Spectrum Analyzer

3. PROPOSED SCHEME

At first, the signal, whose frequency components are to be determined, should be fed to one of the Multiplier's input as shown in the design. Then the multiplier is switched at variable frequencies. The switching voltage is generated by a VCO and it's frequency is varied by varying the sweep voltage of the VCO [6] in a computer controlled manner using a Counter [5], a DAC [4] and an Adder [5].

Now, when a certain switching frequency comes quite close to any of the Fourier component frequency of the given signal, having both its frequency and amplitude within a certain range, a low frequency component will be present at the Multiplier's output. This low frequency component, if present at the output, will be filtered out by using a Low-pass filter ([2], [3]) having cut-off frequency, f_C = 140Hz. The amplitude of this low frequency component of the Multiplied output closely follows the amplitude of the Fourier component of the given signal under consideration. This filtered out low frequency signal is fed to a precision rectifier, for having the absolute value of this signal. Such full-wave rectified signal is futher passed through a sharp roll-off Low-pass filter with very low cut-off frequency, for extracting the DC component from it. The extracted DC component, whose magnitude corresponds to the amplitude of the Low-frequency signal (found at the multiplier's output) hence, to the amplitude of the Fourier component of the given signal (for which this DC value is obtained), is converted to digital form using an ADC [4], and is passed to computer using parallel port.

As, the switching frequency is varied, different Fourier components of the input signal can be detected in the above manner, and in each case, when the switching frequency comes quite close to the frequency of a Fourier component, a considerable DC voltage will be obtained at the output of final Low-pass filter; whereas, in other conditions there will be no DC value at that point.

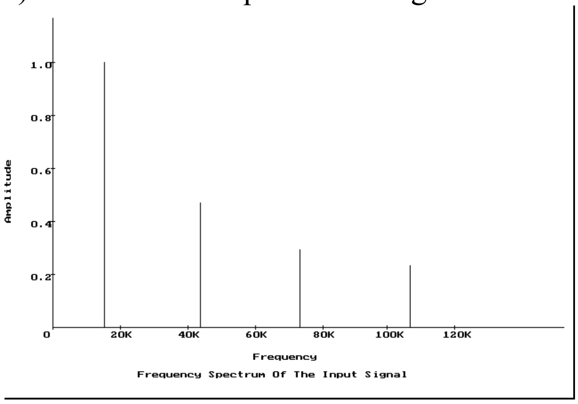
A computer is used to increase the switching frequnecy from a minimum to a maximum value, and in each case the digital-converted DC voltage (found at the final Low-pass filter output) is read by the PC. When a considerable DC voltage is sensed by the PC, it then records the corresponding frequency for which the DC voltage is obatined. This recorded frequency corresponds to the frequency of the Fourier component for which the DC value is obtained. This frequency contents along with its ratiometric amplitude (which is found by comparing the DC values obtained for different frequencies and then setting value of 1.0 for the frequency content whose amplitude is highest. The amplitude of the other frequency contents are shown as a fraction of that maximum DC value) are displayed properly in computer screen. And in this way, all the Fourier components of the input signal can be detected, and its amplitude can be measured in a ratiometric manner.

4. SOFTWARE ALGORITHM FOR IMPLEMENTING OUR SCHEME USING C++ LANGUAGE

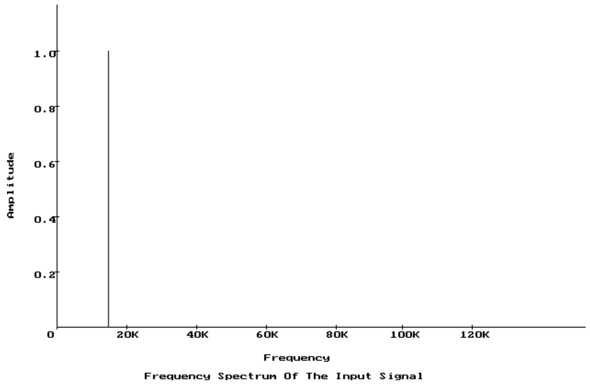
1. Initialize the graphics mode.
2. Reset the 12-bit Counter.
3. Send a clock pulse to the 12-bit Counter.
4. Wait for some time so that the circuit's output settles to a value.
5. Send conversion command to ADC.
6. Wait for conversion to complete.
7. Read ADC's converted data.
8. Check whether the Counter's counting has finished.
   if not, repeat Step 3; else go to Step 9.
9. Save all the scanning data in an array and normalize the data.
10. Plot the frequency vs. relative amplitude graph.

5. OBSERVED OUTPTUS WITH DIFFERENT INPUT SIGNALS

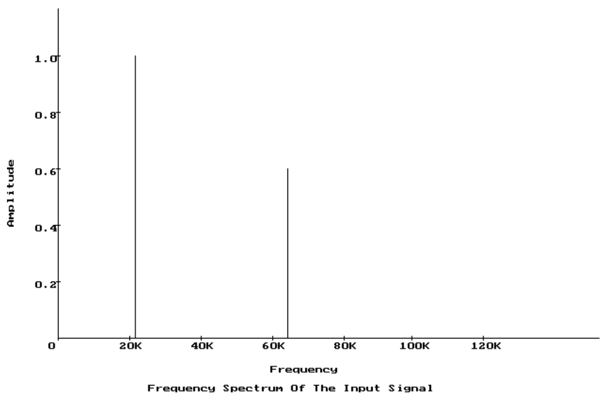
1) With 15KHz square wave signal:



2) With 15KHz Sinusoidal Signal:



3) With 22KHz Square Wave signal:



6. LIMITATIONS

All practically implemented measurements have got some limitations. Our project of *Spectrum Analyzer* is also not a exception from such limitations. Nevertheless, we tried our best to overcome these limitations using the knowledge we have got so far. The noteworthy limitations faced are given below:

- Our Analyzer's frequency range is limited by the frequency range of the VCO.
- Our frequency resolution is quite high and limited by the number of bits of Counter and DAC used.
- Out amplitude resolution is limited by the resolution of ADC.

7. SUGGESTIONS FOR INDUSTRIAL IMPLEMENTATION

For using such a spectrum analyzer in industrial purposes, the use of CPU for controlling our scheme can be avoided by introducing a microcontroller. And the Amplitude spectrum can be shown graphically using a Cathode Ray Tube (CRT), which is compatible enough for display of such spectrum.

8. CONCLUSION

Here we have presented an implementable scheme of *Spectrum Analyzer*. We convey our cordial acknowledgement to the individuals who helped us during this course of time, especially to Prof. Rezwan Khan and Mr.Aminul Haque for their support in implementing the scheme. Any counselling to develop the scheme further will always be welcomed. And finally, the whole project is dedicated to our successors for future developement.

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