DESIGN AND IMPLEMENTATION OF MULTIPURPOSE WAVEFORM ANALYZER

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Abstract:

Waveform analysis has found increasing application in the design and maintenance of electronic systems. Much of these requirements are served at the moment by CROs mainly high performance types which are expensive. This project outlines an alternative approach to this problem, a "Multi purpose waveform analyzer". This is a PC based system incorporating an external microcontroller to capture up to 6 channels of analogue inputs and display and analyze them simultaneously. Each channel observed is separately processable for waveform quality indicators.

Introduction:

Analogue inputs are fed to the PC through an external system. The heart of the system is ADC (Analogue to digital converter) and Brain of the system is the microcontroller. In addition there are several auxiliary components.

System overview:

Total number of input channels is 6, so that it can be configured for one, two, three or six channels. The total sampling rate is 180 kilo samples per second. Therefore sampling rate per channel is given by

$$\frac{\text{Total sampling rate}}{\text{No. of Channels}}$$

For an example, when we configure it to 6 channels, then sampling rate would be 30ksps. Obviously we can increase the rate by decreasing the number of channels.

This can display the waveforms similar to CRO. While displaying, we can zoom and pan the picture. Each channel can be displayed with different colors and if you want unnecessary channels can be hidden.

If the signal is periodic it can find the fundamental frequency and its harmonics (up to 21st harmonic). It can display the spectral components similar to spectrum analyzer.

Our instrument can work as a power analyzer (calculate single phase power, three phase power, total RMS power, power due to fundamental component and power due to harmonics etc.)

It can display 'Power quality indicators" such as

- Displacement factor (DF)
- Distortion factor (DisF)
- Power Factor (PF)
- Total Harmonic Distortion (THD)

Symmetrical components of an unbalanced three phase system can be found and displayed.

Captured Waveforms can be saved as files in the computer and later they can be retrieved for further analysis.

System Design:

System design can be shown in a schematic diagram as follows.

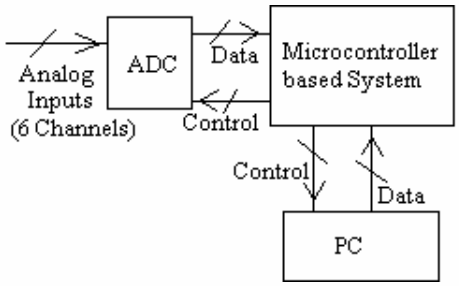

Fig. 1 - schematic diagram

The ADC we used is MAX 118 CPI. It has a resolution of 8 bit and 8 input channels. For our task, we use only 6 channels. The microcontroller configures the device according to the computer's command. (I.e. as 1 channel, 2 channels, 3 channels or 6 channels).The waveform is sampled (the sampling rate is 180 kSPS) and digitized by the ADC. Then that waveform is fed to the computer through the parallel port. That data is stored in memory as an integer array. Then these data can be analyzed by the computer.

Our microcontroller is DS80C320 manufactured by "Dallas Semiconductor". It is a member of famous 8051 family. But it is much advanced compared to original Intel 8051. Assembly language was used to program the microcontroller. This microcontroller doesn't have a built in program memory. Therefore we used 27C256-Q EPROM to store the device firmware.

To operate the system, we have developed GUI based software. The GUI is shown in Fig. 2. This was developed with Visual Basic. But, some critical and long subroutines (Which consume much time to process data) were implemented with Visual C++. We created DLLs including those subroutines and called them in main program. Similarly we created a DLL to access the Parallel Port too, since VB doesn't have direct hardware accessing facility.

Operation and Results:

Figure 3 to 8 shows some results of the system.

Fig. 3 is a waveform of a sinusoidal signal. If you observe the picture, you can see that there are two channels and second channel is hidden to see the channel 1 clearly.

Fig. 4 shows the symmetrical components of a **highly unbalanced** three phase system. (The reason for selecting a very highly unbalanced system instead of slightly unbalanced system is to show all components clearly. Otherwise Negative sequence and Zero sequence components would not be seen clearly since their magnitude is low compared with that of Positive sequence).

Fig. 5 shows harmonic components of a square waveform. We know that there are no "Even Harmonics" in a square waveform and magnitude of "n^{th} odd harmonic" is 1/n of its fundamental. By observing the picture, we can clearly see this result.

Fig. 6 shows the spectral components of the above square wave signal. This is somewhat similar to a "Spectrum Analyzer".

Fig. 7 shows results of three phase power analysis. Total power, fundamental power, harmonic power, contribution of each phase and total results is clearly and separately displayed.

Fig. 8 shows power quality indicators of above three phase system. Displacement factor,(DF) Distortion factor(DisF), Power factor(PF) and Total Harmonic Distortion(THD) is given.

Conclusion:

Now we have completely implemented both hardware and software for this project. The project covers all areas of

- Microcontroller based system designing and programming (assembly)
- Digital Electronic circuits designing
- Printed Circuit Board (PCB) designing
- Computer interfacing and programming (Visual C++) and
- Application Software developing (Visual Basic).

This project increased our knowledge, experience and confidence to do even a large project of this nature.

This system can be built for about 4000.00 Rupees. (Neglecting the cost of a computer, since it is becoming an ordinary home appliance like TVs and Radios).

There is another thing that must be mentioned. By modifying the software and very slightly modifying the hardware, we can convert this to a Synchronizer (which is used to synchronize a generator with national grid). But we didn't implement that part and that additional time was spent to make the software more attractive.

Finally, we should be grateful to Dr. J.P. Karunadasa for his guidance.

References:

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- "Intel 8051 Microcontroller" - Open university, Sri Lanka
- www.ti.com (commercial web site of "Texas Instrument Corporation")
- www.maxim-ic.com (Commercial web site of "Maxim/Dallas Semiconductor")