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A DAQ card based mixed signal virtual oscilloscope

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Abstract

Complex signals find many applications in SONAR, RADAR, Echo Location Systems and for studying the resonant frequencies. Digital Storage Oscilloscopes (DSO) is used these days for acquisition and display of routine signals. This instrument, found in every measurement laboratory, though potent in displaying simple periodic waveforms like sinusoids fails when frequency-varying time signals are applied. This problem surfaces because the underlying technique of oscilloscope used to trigger the waveform does not acquiesce with complex signals like chirp. Ready solution to this problem is the mixed signal oscilloscope. This is a costly solution and small laboratories cannot afford to have the costly instruments. In this paper, a cost effective DAQ card based mixed signal virtual oscilloscope is proposed to study the complex signals. An intelligent technique, Weighted Hamming Distance (WHD) algorithm was used to accurately trigger the complex waveforms. Also for frequency domain analysis, Joint Time Frequency Analysis (JTFA) techniques were used. A LabVIEW^{TM} based virtual instrument was designed and developed with a capability to acquire, display and analyze the triggered signal. The integrated programming language LabVIEW^{TM} was chosen as it offers many simple ready to use functions. In a way the proposal offers a cost effective, fast and flexible solution to treat the complex signals. The need to create such solutions is the consequence of costly hardware systems. The deficiency of conventional hardware, scheme for the virtual oscilloscope for complex signals with some real time experimental results are presented in this work.

Keywords: Virtual instrumentation; Chirp signal; Data acquisition; Triggering; Complex signals; JTFA

1. Introduction

For the last two decades there has been a tremendous progress in computer technology. Measurement domain is no longer left unaffected. The way measurements are being done is totally revolutionized. Computer based measurement or say virtual instrumentation is gradually replacing the costly bench top instrumentation as it offers flexible, fast and cost effective solutions. Various classical instrumentation systems namely Oscilloscope, Multimeters and Spectrum analyzers, etc. are almost phased out by their counter part virtual instrumentation. Our research extends the trend and demonstrates the development of the computer based mixed signal digital oscilloscope. [9,10].

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Conventional signals such as the sinusoids have a constant frequency and the amplitude only varies with time throughout the signal definition. On the other hand, complex signals can be defined in this context as signals in which all the parameters vary. Fig. 1 shows a typical complex signal i.e. Linear Chirp.

Variation of amplitude and frequency with time can easily be understood by having a look at the signal. This requires a visually stable display of signal. The complex signal offers challenges for acquisition, display and analysis. Even the conventional modern age DSO is not capable of displaying and analyzing complex signals because these instruments employ simple triggering technique like level trigger. The conventional technique of voltage trigger apparently fails when complex signals like chirp are analyzed on DSO. This is due to the very fact that these instruments consider chirp as a conventional sine wave and trigger for each cycle of the sine wave instead of triggering for the complete chirp cycle. This analysis of the chirp signal as several sine waveforms of different frequencies leads the DSO to display them as sinusoids in quick succession. As this rapid change occurs at a very high rate and because of human eye not registering events occurring faster than 1/20th of a second the display appears as several overlapped sine waves. In the recent work [1], a new triggering technique was proposed for the complex signals based on WHD. Subsequent sections present the solution to the problem. For analysis of the complex signals in frequency domain JTFA technique is utilized and implemented [2–6].

DSO uses the level trigger to display the waveform applied to it. This leads to trigger interval and the number of samples for this trigger interval is computed and these numbers of samples are displayed. The DSO considers the interval as the fundamental time period of the whole waveform and thus takes that much samples from its buffer and starts displaying it in quick succession. With simple waveform like a sine wave, level trigger can achieve

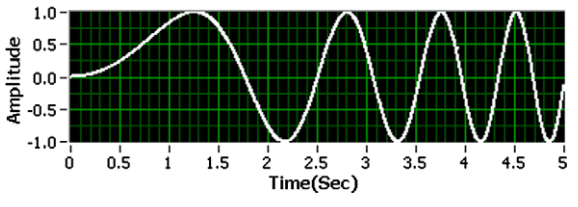

Fig. 1. Chirp waveform.

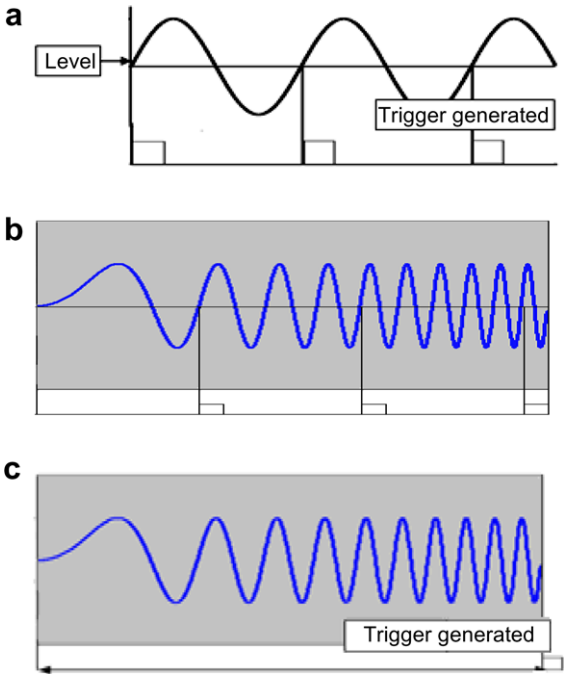

Fig. 2. (a) Level trigger on periodic sine wave. (b) Level trigger application on a chirp signal. (c) Correct trigger for a chirp signal.

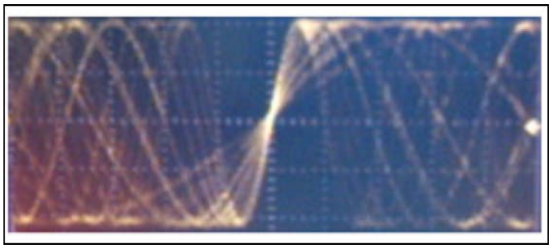

Fig. 3. Visually unstable display of Chirp on DSO.

stable display because trigger interval contains same number of cycles. This is shown in Fig. 2a.

Now for the complex signal as shown in Fig. 2b, level triggering produces a trigger interval having variable number of cycles for the same number of samples/time resulting in a visually unstable display.

The actual trigger interval should be one complete cycle for a chirp signal as indicated in Fig. 2c. Having done this the repeated chirp signal for this time duration will be displayed without any overlapping components as long as the entire time period is displayed.

To observe the shortcomings experimentally in display of complex signals on the oscilloscope, Tektronix dual channel signal generator AFG-3022 (250 MS/s, 25 MHz) was used to generate a chirp