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Topic – Intelligent Oscilloscope Triggering Schemes

ABSTRACT

Digital Signal Oscilloscope (DSO) is commonly used these days in every instrumentation and measurement laboratory for graphical presentation of time varying signals and their basic measurements. The key to the oscilloscope's value for viewing rapidly varying signals is synchronization of the horizontal sweep with the input signal, which is called triggering of the sweep. For a stable continuous display, the horizontal sweep must begin at exactly the same instant within the signal's period. The instant at which the horizontal sweep begins is normally determined by the signal crossing a set triggering voltage level in specified direction. Once the sweep is completed, the trigger circuit waits for the next trigger instant determined by the signal again crossing the set trigger level. This technique works well if the epoch in the signal can be uniquely decided by its voltage amplitude level, where the horizontal sweep can be periodically initiated. However, when the signal contains many faster asynchronous pulses embedded in a signal with a much larger repetition period; or has multiple crossings of the desired trigger voltage level within one period, then this simple method results in unstable triggering. Modern digital oscilloscopes offer facilities such as digital delay for zooming in on the region of interest within the waveform. However, all existing techniques have significant limitations in generating repetitive trigger signals locked to a complex input waveform.

In order to become the candidate for advance and generic oscilloscope triggering, weighted hamming distance (*Whd*) based and autocorrelation based triggering scheme are discussed. These techniques also have wider applicability in addition to being accurate, robust and fast. The fast algorithm is the most desired feature of the triggering algorithm as it has a direct impact on the oscilloscope bandwidth. In these two advanced triggering methods based on similarity measure, the waveform is correlated with a pre-stored reference pattern and the trigger status for every new sample acquired is checked, based on the minimum value and maximum value between the reference and the test pattern. These methods enhance the capability of the oscilloscope for catering to wide variety of waveform types. But these two techniques have not been tested on variety of complex waveforms, and their performance has not been compared when they are subjected to noisy signals. The above mentioned issues, related to amplitude based advanced triggering techniques, are addressed in the thesis.

For success of both the amplitude based advanced schemes, it is required that the captured reference waveform must contain at least one base period of the target signal and it is very difficult to ensure the same. A frequency based triggering scheme is proposed in this thesis which circumvents the above mentioned limitations associated with the reported advanced techniques. In this technique, frequency of all harmonics present in test signal is retrieved using FFT and the base repetition rate of the signal is found by selecting the frequency of lowest harmonics present. For stable display of a signal in an oscilloscope, it must be triggered at its fundamental frequency.

The robustness of the proposed method is evaluated by simulated addition of random noise to test signal and has been compared with other efficient methods like *Whd* and autocorrelation based methods of triggering. All the techniques are implemented in real time using LabVIEW® software and NI-PCI - 6221 DAQ card. Robustness results are analyzed using MATLAB® software. Finally, Tektronix TDS-210 digital oscilloscope is successfully triggered externally in real time. It is found that the proposed technique is equally effective in producing stable triggering for simple as well as for complex waveforms and unlike other advanced techniques it is free from reference waveform requirement. Further, the proposed method is less sensitive to signal noise in comparison to its amplitude based counterparts.