Combination of Periodic and Alias-free Non-uniform Signal Sampling for Wideband Signal Digitizing and Compressed Transmitting Based on Picosecond-Resolution Event Timing

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Abstract—Method for high precision analog input signal digitizing and compressive transmitting based on obtaining and processing timing information by a picosecond resolution Event Timer is presented. While it has significant advantages, application of this type of systems is limited as the highest frequency of the input signals cannot exceed half the repetition rate of the involved periodic representative events formed and timed by the Event Timer. **An approach to eliminating this limitation by using deliberately randomized non-uniform sampling of the input signals and specific reference function is proposed, described and discussed.**

Keywords—event timing, timing information, pulse width modulation

Event timing system A033-ET so far has been mostly used in the Satellite Laser Ranging (SLR) systems and currently about half of active SLR stations use this Event Timer for time measurements. It represents also an effective tool for proper analog input signal digitizing and transmission.
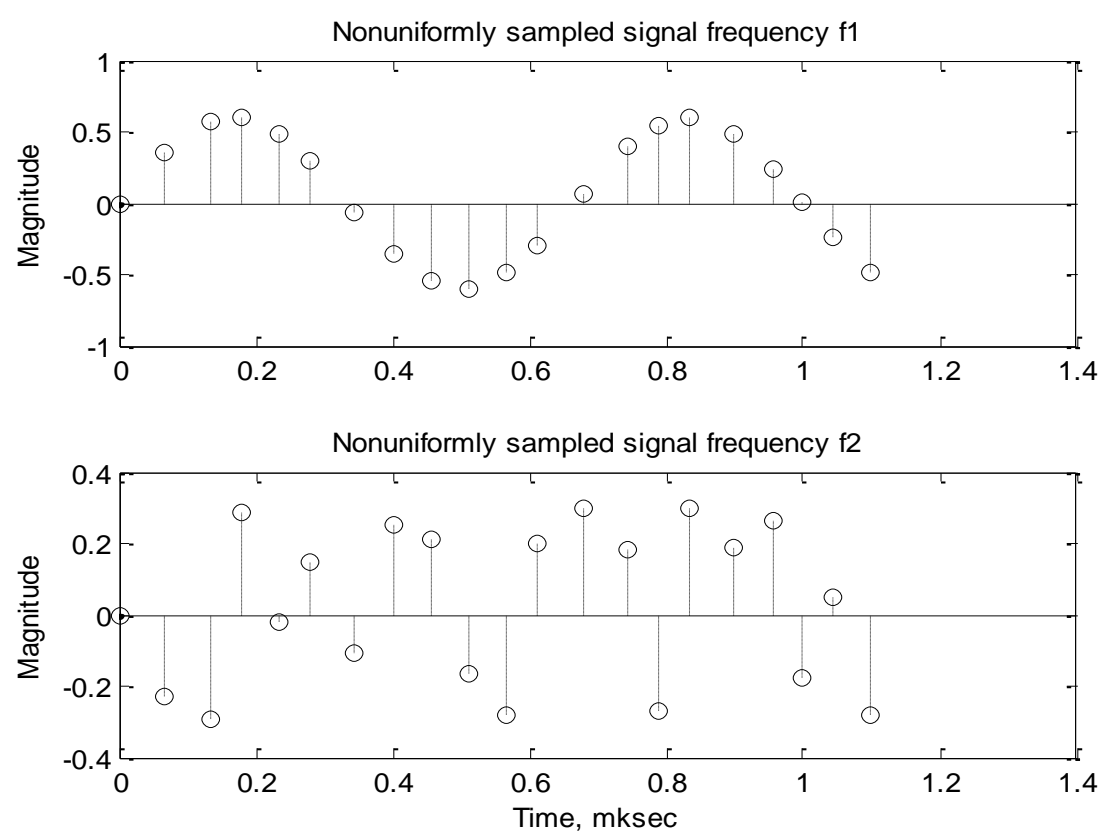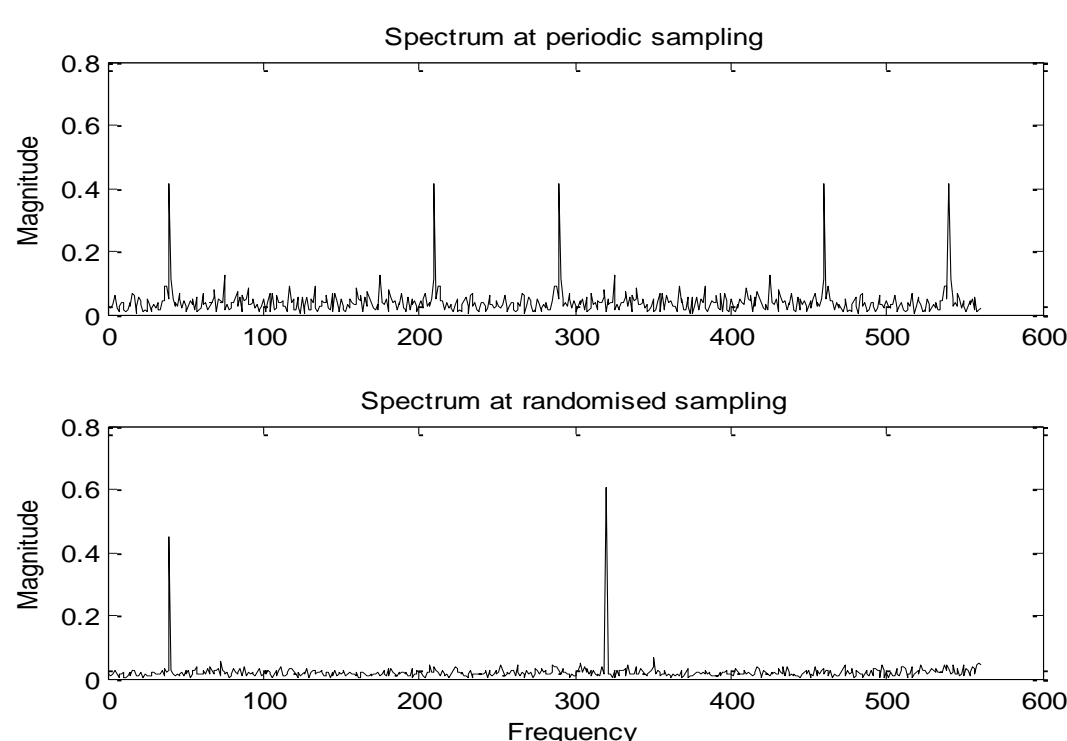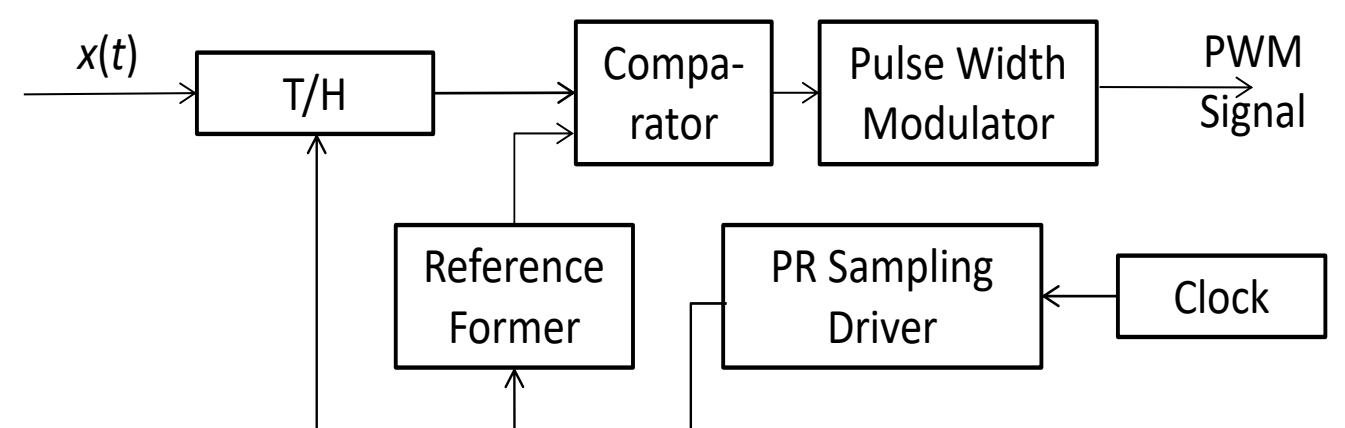

Illustration of the typical signal sample value sequences obtained in result of randomized additive non-uniform sampling of the respective signals. Frequency f2 in this case is 10 times higher than frequency f1.
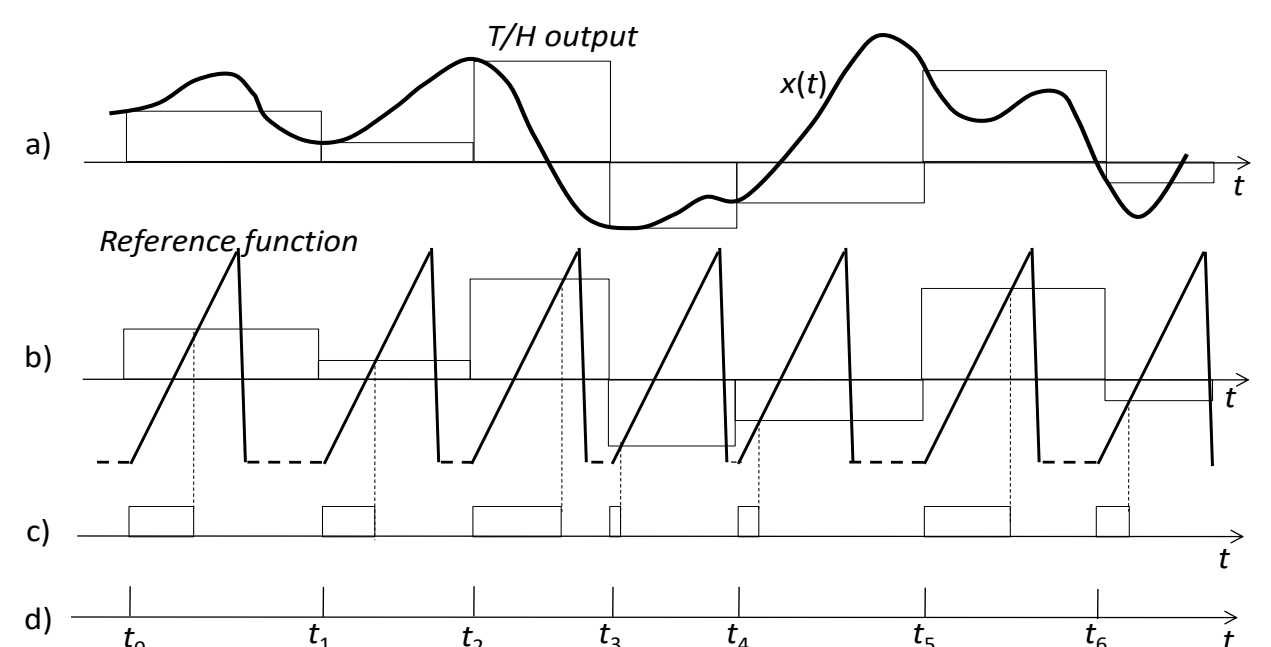

Spectra of a signal with two components at frequencies f_1=40 and f_2=320 at using periodic (upper Spectrum) and randomized sampling (lower Spectrum) performed at the same mean sampling rate 250.

The sampling model, taking into account fluctuation or jitter of the sampling time instants, is defined as: $t_k = kT + \tau_k$, $k = 0, 1, 2, \ldots$ where T is the duration of a constant time interval and τ_k is a random variable.
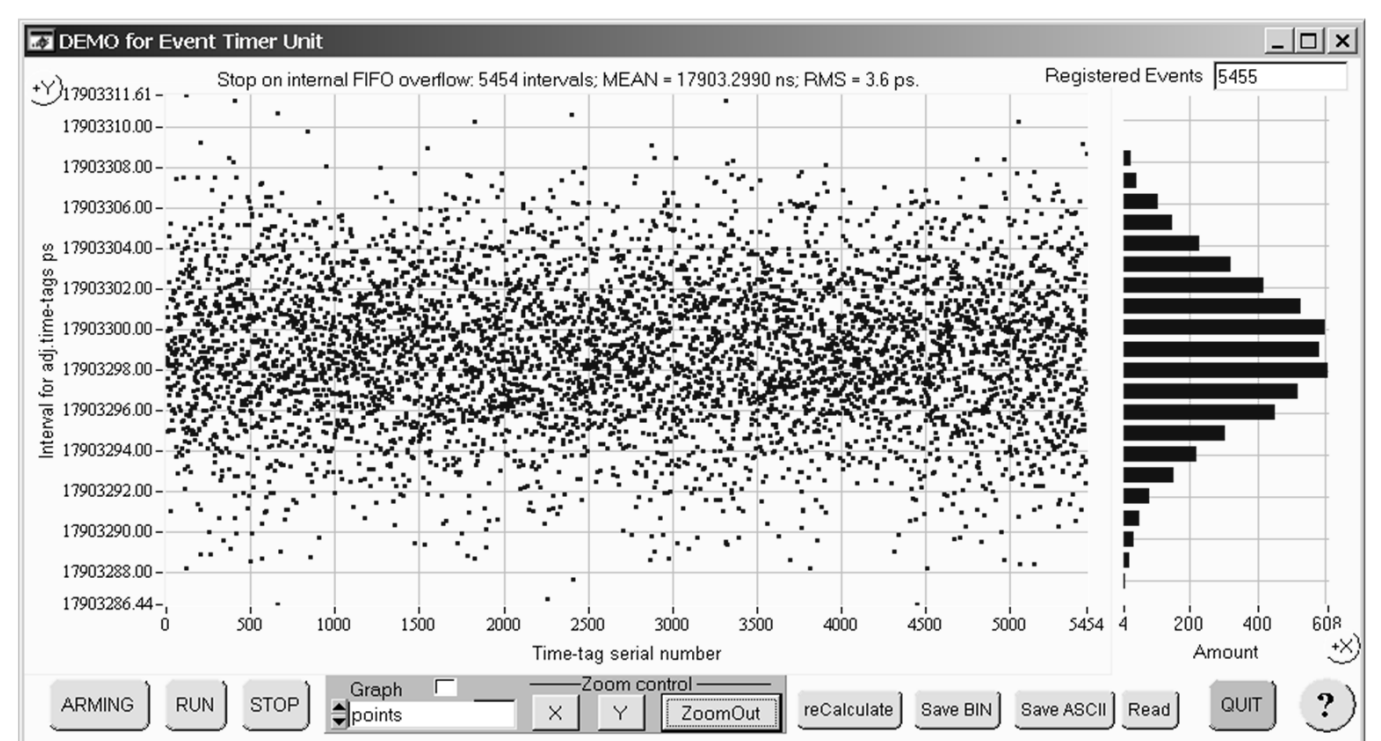
Sampling time instants are generated by pseudo-random PR Sampling Driver on the basis of the following equation: $\tau_k = (\mu \pm \alpha_k)T_c$, $k = 0, 1, 2, \ldots$ where μT_c is the mean value of t_k ; α_k is a pseudo-random number provided by the Pseudo Random Number Generator included into the structure of the PR Sampling Driver and T_c is period of the pulse train generated by Clock.

Block diagram of the transmitter forming PWM signals from the wideband analog input signals based on combining periodic and randomized sampling.

Time diagrams illustrating basic functions of the Analog-to-PWM Converter.

Histogram of the measured time intervals showing their deviation. RMS error of measuring these time intervals is 3.6 ps and it means that the single shot event timing precision is 2.5 ps.

CONCLUSIONS

- The described using of the pseudo-randomised additive non-uniform sampling for widening the frequency range of the Analog-to-Event-to-Digital Converters significantly increase the application potential of the wideband analog signal digitizing and transmitting systems based on picosecond resolution Event Timers.

- Specifics of composing the periodic and deliberately pseudo-randomised sampling processes at the input signal digitizing and transmitting are described. In this case the representative crossing events are formed by using specific piecewise linear reference-function rather than the sine-wave reference function.

- As the input signal sample values are taken at pseudo-random time instants, these instants are pre-determined and that information is used also by the receiver at reconstruction of the transmitted signal sample values. Consequently, only these sample values have to be transmitted over the transmission line by using the Pulse Width Modulation.

- The high performance Event Timer is used for high precision reconstruction of the transmitted signal sample values and for correcting the errors due to the distortions of the used piecewise linear reference-function.