A Novel Method for Suppression of Aliasing Ghosts

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ABSTRACT. This paper proposes a "half-sample delay switching" to suppress aliasing ghosts caused by finite frequency sampling without the clumsiness of a sharp anti-aliasing filter.

Nyquist theorem says that signals beyond $R_s/2$ will be overlayed over in-band signals, where R_s is the sampling rate. Any anti-aliasing filter leaks undesired out-band supurious signals. And "good" sharp-cut filters are usually big and not simple. Are there no ways to suppress aliasing-ghosts without the clumsiness of big anti-aliasing filters? Yes. It is "delay switching".

Consider a cross-power spectrum analyzer for a two-element interferrometer, and assume stationary signals and complex-samplers (Figure). When we put a delay δ before one of the samplers, there is phase shift $\Delta\phi$ in the output phase spectrum which is proportional to the input frequency. When the delay δ is a half of the sampling period $1/f_s$, the phase shifts have a difference of 180° between two signals which are:

(1). In-band signal of frequency f.

(2). Aliasing signal of frequency f_a, where $f_a = f + f_s$.

$$\Delta\phi\ (f) = 2\pi f \delta = \pi f/f_s.$$

$$\Delta\phi\ (f_a) = 2\pi f_a \delta = \pi(f+f_s)/f_s = \Delta\phi(f) + \pi.$$

The 180° phase shift difference $\Delta\phi\ (f_a) - \Delta\phi(f)$ is not affected by delay compensation of phase slope $\exp(-\pi i\ f/f_s)$ at the output of the analyzer, because both in- and out-band signals appear in the same frequency channel. Therefore, by adding the compensated output of the delay-on state to the output of delay-off state, we get aliasing-free spectrum. To get precise suppression, put half-sample clock skew circuit (0° /180° switching of sampling clock, Figure) instead of analog half-sample delay in the signal path. Then we have:

(1). Precise half-sample delay by simple circuit in any sampling frequency.

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(2). No gain/phase change between on- and off-state of the delay switch.

Half-sample delay switching does not discriminate the aliasing ghost whose frequency is separated from the in-band signal by $k \times f_s$ where k is an even number. These ghosts can be discriminated by m/n sample delay switching, for an example, 0/3-1/3-2/3 sample delay switching.

Ghost caused by unbalance in a pair of real- and imaginary-part ADC is an aliasing ghost from the negative frequency band. Therefore it can also be suppressed by the delay switching. In the extreme case of the unbalance, aliasing in a case of real-sampling can also be suppressed by the delay switching.

New ADC system of the Nobeyama FX will have this half-sample clock skew switching facilities in 1987.

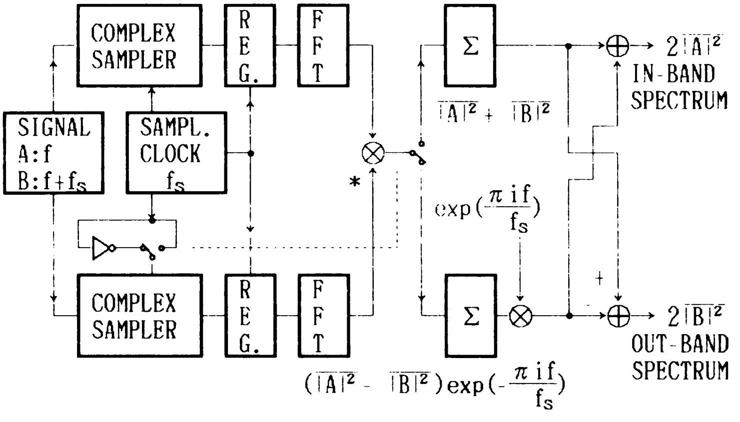

Figure. Block diagram of the half-sample delay ($1/2\ f_s$) switching to eliminate aliased out-band spectrum.

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