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To:       Mark 5 Development Group

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Subject:   Simulation of phase cal and low fringe rate phase error using a polyphase filter bank

In order to preserve simplicity of a L.O. system without offset and compatibility with existing geodetic receivers I have simulated a polyphase filter band to obtain the errors introduced without L.O. offsets. I considered a 31 channel filter bank with 1024 Ms/s input rate along with white noise data and 1 MHz spaced phase calibration rails. I obtained the following results using the filter functions of memo #18:

A] Phase cal extraction

| Number taps per FIR subfilter | Number of taps per output interpolation filter | Location of phase cal MHz | Max-phase error (deg) |
|---|---|---|---|
| 8 | 16 | 8 | 0.5 |
| 8 | 16 | 4, 12 | 0.8 |
| 16 | 16 | 2, 14 | 1.5 |
| 16 | 32 | 2, 14 | 0.6 |
| 8 | 32 | 8 | 0.2 |

Comments:
1] 0.18 degrees = 1 ps in 500 MHz span
2] number of FIR taps mainly effects how close one can approach the bad edges. 16 taps are needed to get the 2 and 14 MHz phase calibration tones. The phase cal error is mainly controlled by the interpolation filter.
3] Phase error is sinusoidal with phase so that average errors is about $(2/\pi)$ times the max. error.
4] The errors are lowest for the phase cal tone in the band center.

B] Gaussian white noise

| Number of taps in FIR subfilter | Number of taps in output filter | Max-phase error (deg) |
|---|---|---|
| 8 | 16 | 0.6 |
| 16 | 16 | 0.4 |
| 16 | 32 | 0.15 |

Comments:
1] Both filters are important
2] The fringe phase errors will be reduced in the case of a non zero fringe rate.
3] When a fringe rate is present the power loss due to aliasing is about 0.4%. The added noise level increase due to the bandpass shape is about 2%.

Conclusions:

The performance of a polyphase filter bank is good enough that the addition of L.O. offsets are not needed. With a 16 tap FIR and a 16 tap interpolation filter the phase calibrated average group delay error with 500 MHz spanned bandwidth is about 2 ps at zero fringe rate. The instrumental errors are even smaller for wider spanned bandwidth. It has been assumed that the image of the first L.O. has been controlled by an image filter on the front end with more than 50 dB image rejection.