Phase and Delay parameters in fourfit

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delay_offs – this parameter allows offsets (in ns) to be made on a per-channel basis, similar to the normal pc_phases correction. If there are two polarizations, the same offset is applied to both. The principal effect of this parameter is to adjust the cross-power spectrum per channel, in order to line up the single band delays of all channels that are to be coherently fit together.

pc_delay_l
pc_delay_r – In the block diagram in Figure 2, which depicts the VLBI2010 system, it can be seen that the pcal only imperfectly corrects for instrumental phase and delay effects. It is injected prior to the low-noise amplifier in the front-end, and in principle everything that happens to the signal after that point can be corrected by examining the embedded pcal information. However there are differerent pathways for the two linear polarizations from the feed to the injection point. Also, the pcal signal is split, and follows different paths to the injection point.

The pc_delay_l and pc_delay_r parameters are designed to correct for this uncalibrated portion of signal path. The baseline pcal phase difference is corrected appropriately for each of the four Stokes polarization products. For example, the LxR product phase is corrected by

$$(\tau^{R}_{rem} - \tau^{L}_{ref}) \times (f - f_r)$$

where f_r is the reference frequency. These two delay values, which are specified in ns, can be determined once by looking at strong fringes on an unpolarized source (with good coordinates); the values should then be relatively stable unless the frontend setup is changed.

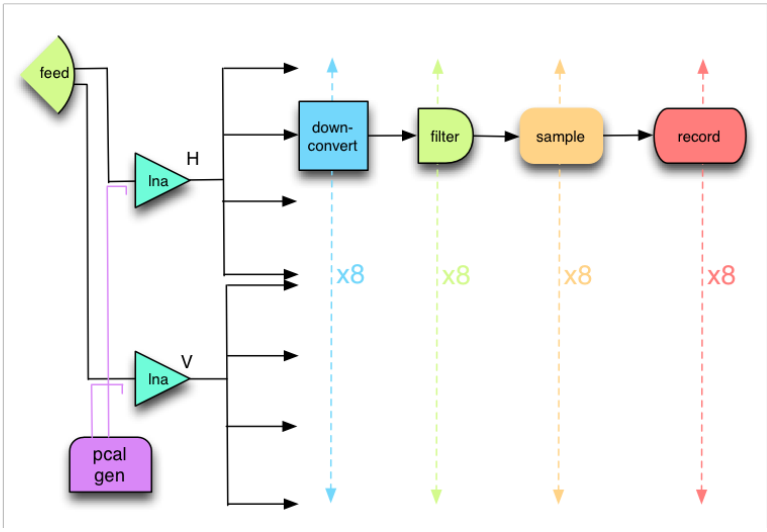

Figure 1 Block diagram of VLBI2010 signal paths

pc_phases – pcal additive phase adjustments in degrees, for each of the specified frequency channels. These offset phases are added to the underlying model, as specified by pc_mode. If 2 polarizations are present, the same values are applied to both polarizations.

pc_phases_l
pc_phases_r – normally manual or additive pc phases are done on a per-channel basis, using the *pc_phases* keyword. In the presence of dual polarization, though, this level of control is not fine enough, since the LCP signal will likely follow a different processing path than the RCP signal. This vector parameter allows phases to be specified individually for the L (= X or H) and R (=Y or V) channels, using a syntax analogous to *pc_phases*.

***Note** that there is only one set of pc_phase registers internally within fourfit, so that specifying pc_phases is incompatible with pc_phases_l (or r). In some sense, pc_phases is just a short hand for setting both pc_phases_l and pc_phases_r at the same time, to the same value.*

station_delay – approximate a priori delay difference (in ns) between two signal paths: 1) from the maser up to the receiver, and down to the inputs of the digitizers, 2) from the maser to the clock circuits of the digitizers. This delay is used to determine an absolute delay from the pcal values (in multitone mode), which have an ambiguity of 1 us (for 1 MHz rails), or 200 ns (for 5 MHz rails). The station_delay parameter sets, in essence, the center of a window of +/- half the ambiguity spacing, in which the peak is found.

Having the correct absolute delay is important because the cross-power spectra are corrected (in multitone mode) point-by-point across the spectrum by the difference in extracted pcal delays at the two stations. If one of the stations is on

the wrong ambiguity then the coherent summed amplitude is affected. This parameter is used primarily for VLBI2010, where the cable delays of hundreds of ns may be large compared to the 200 ns ambiguity spacing. There is a default value of 150 ns, which would result in multitone fit delays in the range from 50—250 ns.

Note that the delay that comes from the multitone fit is the difference of path 1) minus path 2), which is not the same as the path traversed by the incoming radio signal, which only goes from the receiver down to the digitizer. The presumption is that the upward 5 MHz signal and path 2) contribute equally to delays at all frequencies, so that the channel-to-channel delay differences will be strongly dominated by the downward path, and thus the code uses the full delay difference to adjust the channels.

Delay offsets are applied for all pcal modes, but of course the multitone-extracted delays are only applied when multitone is enabled at both sites. An additional requirement for the application of multitone delays is that sampler pools be defined.