On Multi-Channel Receivers with Arbitrary, Uncoupled Selection of Channel Spacing, Channel Bandwidth, and Channel Sample Rate.

fred harris
CUBIC Signal Processing Chair
Communication Systems and Signal Processing Institute
San Diego State University
fred.harris@sdsu.edu

Abstract: Multichannel receivers service and simultaneously down-convert numerous frequency division multiplexed (FDM) channels residing in a single sampled data signal stream. The polyphase filter bank has become the architecture of choice applied to this task. This architecture uses three interacting processes to perform the required channelization. These processes are an input commutator, a polyphase M-path filter, and a discrete Fourier transform.

The commutator performs an input sample rate reduction by commutating successive input samples to selected paths of the M-path filter. Sample rate reduction occurring prior to any signal processing causes spectral regions residing at multiples of the output sample rate to alias to base-band. This desired result allows us to replace the many down-converters of a standard channelizer, implemented with dual mixers, quadrature oscillators, and bandwidth reducing filters, with a collection of trivial aliasing operations.

The M-path filter performs the task of aligning the time origins of the offset sampled data sequences delivered by the input commutator to a single common output time origin. This is accomplished by the all-pass characteristics of the M-path filter sections that apply the required differential time delay to the individual input time series.

The DFT performs the equivalent of a beam forming operation; the coherent summation of signals at each input port with a selected phase profiles. The phase coherent summation of the outputs of the M-path filters separate the various aliases residing in each path by constructively summing the selected aliased frequency components located in each path, while simultaneously destructively canceling the remaining aliased spectral components.

In this paper, we present a technique to enhance the standard structure to permit decoupling between channel bandwidth, channel separation, and channel sample rate. An example of such a system, which we describe in this paper, performs 96-to-1 down sampling of a composite time series by a 128-path polyphase filter (and DFT). The process extracts one-hundred 128 kHz channels with 192 kHz channel spacing from a time series with input sample rate of 128*192 kHz to obtain an output channel sample rate of 2*128 kHz, or 2-samples per output symbol. This enhanced structure is accomplished by a shortened input commutator, path sub-commutators accessing path sub-weights, an output circular buffer, and a state machine controller to schedule the sub-commutator selection of sub weights and the shift parameter of the circular buffer. The enhanced capability multi-channel receiver requires no additional signal processing over that of a standard maximally decimated filter bank.