A Design Concept for the IIP Radiometer

Steven W. Ellingson
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This note describes a design concept for the IIP L-band radiometer front-end, capable of 100 MHz effective bandwidth. The design, shown in Figure 1, uses a single downconversion to move two 50-MHz bands from L-band to analog IFs at 50 MHz and 150 MHz, each of which is digitized at 200 MSPS. These 50 MHz bands undergo independent processing and are then recombined to form a single complex signal of a little less than 100 MHz bandwidth digitized at 100 MSPS.

The analog section section consists of a high-pass image rejection filter followed by a mixer. The LO frequency is variable, but for design purposes is nominally 1270 MHz. Band "A" is defined as 1295–1345 MHz (center: 1320 MHz), which is shifted to a center frequency of 50 MHz. Band "B" is defined as 1395–1445 MHz (center: 1420 MHz), which is shifted to a center frequency of 150 MHz. Proposed image rejection requirements for this downconversion are −0.1 dB at 1295 MHz, −40 dB at 1245 MHz, and −60 dB at 1145 MHz; this amounts to a transition bandwidth of 3%, which is aggressive, but not unreasonable.

The output of the mixer is split in two to accomodate independent processing of Bands A and B. Each band is filtered for anti-aliasing purposes using a filter with about 80 MHz bandwidth. Since the proposed sample rate is 200 MSPS, excellent alias rejection is easily achieved using a relatively low-order filter. Also, the ultimate bandwidth of interest of 50 MHz should fall well within the 1 dB points of the filter, so the bandpass should be completely defined by the digital filtering, with relatively little contribution from IF filter shape. This should result in a very repeatable and temperature-stable design.

The Band A ADC digitizes it's IF in it's first Nyquist zone, whereas the Band B ADC digitizes it's IF in it's second Nyquist zone. This results in a spectrum reversal for Band B which, if desired, is easily correctly later in the signal path. To reduce the design risk in subsequent (digital) processing, it is desired to dumultiplex each ADC output into two paths of 100 MSPS each. Two suitable ADCs for this design are the AD9054 and the SPT7720. Both are 8 bits.

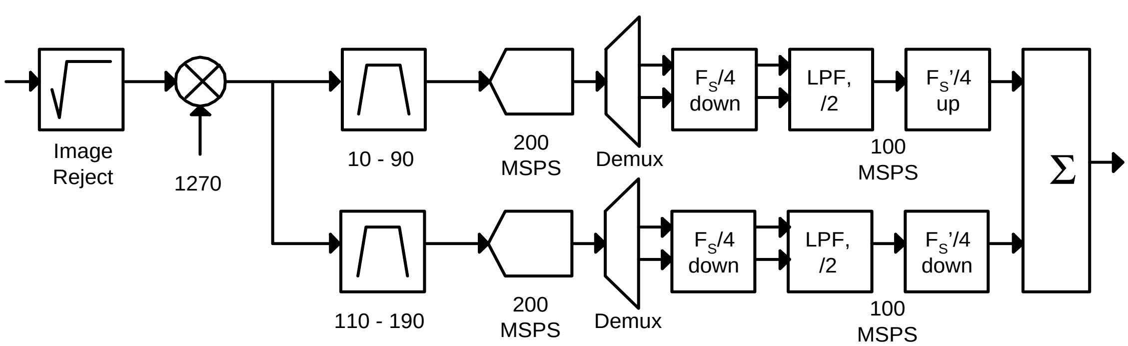

Fig. 1. Design Concept.

The output of the Band A ADC undergoes an $F_S/4$ downconversion, which shifts the center of the band from 50 MHz to zero and simultaneously generates the associated complex-valued signal. To reject the displaced sideband and set the ultimate bandwidth, it is necessary to apply a lowpass filter (LPF). The cutoff frequency of this filter is just under 25 MHz, resulting in a little less than 50 MHz bandwidth. Thus, the sample rate can be reduced to 100 MSPS. Using polyphase techniques, the $F_S/4$, lowpass filter, and decimation can probably be very efficiently implemented even for a large effective (not actual) number of filter taps, which makes me optimistic that we can achieve a very sharp transition bandwidth. (This is how the HSP43216 does it.) Next, the signal is *upconverted* by $F_S'/4$ at the new sample rate $F_S' = 100$ MSPS, which centers the 50 MHz bandpass at 25 MHz. The processing for Band B is identical, except that the last step is to *downconvert* by $F_S/4$, which centers the bandpass at -25 MHz.

The final step is simply to add the 100 MSPS output streams from Bands A and B, resulting in a single 100 MSPS complex data stream containing close to 100 MHz bandwidth.

As a final note, the really compelling aspect of this architecture in my opinion is that it gives most of the signal processing work to the polyphase filters, where it can be handled very efficiently. In fact, it may be possible to simplify the $F_S/4$-LPF-$F_S'/4$ processing chain into a single polyphase filter. In addition to sideband rejection and bandlimiting, the LPFs can be used for calibration, notch filtering, and fine delay control (anticipating interferometer use) by manipulating the filter coefficients.