

SMT IF System Considerations

R. W. Freund
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Introduction:

The current architecture of the SMT IF system is overly complex, convoluted, and difficult to configure and support. Simply stated, it is a mess. There are three basic spectrometer types in use, a wideband filter bank system, two different types of acousto-optic spectrometers (AOS), and a chirp spectrometer. Due to different system requirements at the time of their design, all have different input frequency ranges. Also, there are two different IF frequency ranges in use by facility receivers. To accommodate these different passbands, various additional IF processing hardware has been installed to translate one passband to another to provide maximum flexibility. This additional signal path electronics cannot be an improvement to the overall system stability. Now is the time to reconsider what the "standard" IF frequency interface range should be between receivers and spectrometers.

Foundation:

The performance of all receivers systems would be improved and the operational complexity would be reduced by a careful selection of a new standard IF interface frequency range. The standard would provide a sensible interface between both existing and new receivers to the existing complement of spectrometers. This would be achieved by reducing the number of IF signal systems and by reducing the amount of IF processing circuitry used within a spectral translator thus improving the stability and reducing signal distortion.

While analyzing the IF interface frequency range, the current and future spectrometer bandwidth requirements must also be considered. With the trend in receiver design toward wider IF bandwidths and higher frequency operation, increased spectrometer coverage must follow. At one time, a coverage of 256 MHz was sufficient, now a 2 GHz spectrometer is marginal. The future will surely see spectrometers and systems with multiple octave GHz bandwidth capabilities.

An early 10-meter spectrometer interface provided frequency covered over the 3 to 4 GHz frequency range. At a time when receiver IF bandwidths were less than 1000 MHz, this specification was very reasonable. But now, with IF passbands covering multiple GHz and future bandwidths covering more, this specification is inadequate. For example, the current ARO 1.3 mm / 2 mm SIS JT receiver provides an IF passband at the dewar from 4 to 8 GHz. Even now, there is a disparity between the IF compatibility of the receiver IF coverage with the analysis range of the widest spectrometer.

Recommendations:

The 4 to 6 GHz input band of the new ARO filter bank spectrometer forms the basis for a new spectrometer passband interface standard. A wider input band might be chosen, but this 2 GHz wide input bandwidth provides an excellent starting point. The question now is whether this bandwidth is sufficient as the next generation standard. As pointed out earlier, with an ARO receiver already providing IF frequency coverage from 4 to 8 GHz, and with mixers currently being designed with similar or larger IF bandwidths, the new ARO standard IF interface should be changed to support these current radiometer systems. Also, the large scope of the ALMA Project will be a ready source of high performance devices, mixers and state of the art receiver components. The narrowest IF bandwidth permitted by the ALMA Project covers this same 4 GHz band, 4 GHz to 8 GHz. The new ARO standard IF interface should be 4 to 8 GHz.

What is required by this accepting the new standard? All future receiver initiatives must provide passbands that either span the entire frequency range or fall entirely within this band. New spectrometers will either cover the entire 4 GHz band or provide capabilities to select a portion from this band from anywhere within the band.

General Plan:

The way this standard effects the situation with the current suite of receivers and spectrometers is to mandate compliance as soon as practical. For ARO spectrometers, the 1 MHz and 250 KHz resolution filter banks and the chirp spectrometer almost satisfy the new standard. They already provide coverage across half the band and can select any segment from this sub-band. For now, this partial compliance is acceptable. But, there are two hardware options available to bring the filter banks into full compliance and are described below.

The first option results in the simplest architecture, is conceptually the simplest, and requires the least amount of additional hardware but is the most expensive. Twelve local oscillator synthesizers in the each of the current filter bank IF processors would be changed to support a wider tuning range. Currently, the design provides for input tuning only across the 4 GHz to 6 GHz band. These synthesizers would be replaced with 12 new ones that cover the full 4 GHz wide band.

The second option adds additional hardware to the IF signal path but uses some existing parts and is less expensive. By replacing 4 components in two excess 12-meter 8-beam IF processor modules, a tunable IF converter could be obtained that tunes the full 4 GHz wide IF band. To complete the assembly, a housing, multiple power supplies, a fixed frequency local oscillator, and control circuitry would be needed.

The three acousto-optic spectrometers, AOS-A, AOS-B, and the narrower AOS-C, can become fully compliant by upgrading their IF processor modules. Their current fixed frequency or narrow range local oscillator sources would need to be replaced with ones that permit selecting

a band segment from anywhere within the full IF band. Also, the IF signal paths within the SMT facility might need to be modified to better support signals in the 4 to 8 GHz range.

Major portions of the 1.3 mm / 2 mm dual band SIS receiver are in complete compliance with the standard. A narrow band IF filter in each channel of its "Total Power Monitor" chassis needs to be replaced. The two remaining facility receivers, the MPIfR 870 micron dual polarization receiver and the SORAL single polarization 650 micron receiver both provide a 1 GHz wide IF band centered at 1.5 GHz. Modifications are needed to the IF system to convert the 1 to 2 GHz passband to somewhere in the 4 to 8 GHz band. The current TP/IF Chassis performs a similar conversion action by translating the receiver's IF passband to 3 to 4 GHz. It also is the interface into the site's total power system.

In the short term, the SMT continuum system is most effected by the adoption of the new standard. The present continuum system is physically located within the dual passband converters for the legacy receivers. To implement the proposed standard IF, the two different functions implemented by this chassis would be separated and re-packaged. One function, probably the Total Power System, would remain in its present location, while the IF converter system would be upgraded and re-packaged.

Conclusion:

The current SMT IF system is a relic of previous times. Its basic architecture needs an overhaul to effectively and efficiently support our current and future radiometer designs. The time to reconsider a new IF frequency interface range standard is now. The past standard was based on a 3 to 4 GHz passband. This frequency range doesn't support any of the current receivers or spectrometers.

The new IF bandwidth standard should be the full octave from 4 GHz to 8 GHz. This specification provides full support for the newest ARO 1.3 mm / 2mm SIS facility receiver without restriction and provides support for the next generation of receiver designs. Systems utilizing ALMA Project components would also benefit from this bandwidth choice.

The general near term upgrade path involves modifying two 12-meter 8-beam IF modules, replacing three local oscillator synthesizers in the IF processors of the AOS spectrometers, changing the up-converter electronics used with the legacy receivers, changing the Total Power System, and upgrading the cable infrastructure.

These recommendations can be implemented quickly and with a modest budget resulting in enhanced capabilities that can be exploited in the short term. The most ambitious aspect of the new IF standard involves changes to the Total Power System.