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High Frequency LNA Considerations for Future Highly Integrated Receivers

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In radio astronomy receivers it is common for all of the components to be manufactured into individual, independent blocks, even in the case of the most state-of-the-art receivers such as the recent ALMA Band 2 prototype receiver [1]. This approach has several benefits, primarily that it allows for different suppliers for each of the components, allowing for specialist manufacture, and also allows for the best of the available units to be selected for each receiver. However, the drawback of this approach is that the size of the components is rarely a concern to the design of the receivers, aside from trying to minimize the overall size and mass of the receiver. This approach also requires the use of predetermined, standardized interfaces between the components, that may add to the size of the components and introduce extra losses to the receiver.

As the application space of radio astronomy develops with technological capability and the increasing needs and desires from the astronomy community, larger arrays of telescopes and more complex receiver architectures (for example focal plane arrays and phased array feeds) are becoming more prevalent. In both scenarios the numbers of components needed are increasing dramatically, increasing the time and complexity of the projects. In these receivers the size of the components can become extremely critical due to the need for precise placement of the components to achieve the required receiver performance.

The Advanced Radio Instrumentation group at the University of Manchester have a track record of delivering high performance LNAs at millimeter and sub-millimeter wave frequencies [1, 2, 3], including for the ALMA observatory and more recently for a 67-116 GHz sixteen-pixel focal plane array receiver. The development of this receiver has required pushing the design of the components to the physical limits in order to ensure that the receiver chain of each pixel will fit within the cross-sectional area of the feedhorn, and so allow for optimum pixel placement in the final receiver. In the case of the LNAs we are close to reaching the limits of what is practically possible while still using a standard waveguide flange. In this presentation we will discuss the aspects of the LNA design related to highly integrated receivers, potential strategies for further, future miniaturization and integration, and the effect of design choices on the testing and measurement process.

Testing, characterization, and optimization of the LNAs for modern receiver systems is also an increasingly labour intensive and time-consuming task. In total, projects at ARIG have required well over one hundred LNAs to be fabricated and measured within a short time frame. To be able to characterize these LNAs and assess their optimum bias point within the available project timelines, we have developed a three-channel cryogenic noise measurement system, including custom control and analysis software in order to automate the measurement process and increase the throughput of LNA measurements. In this presentation we will also discuss the development of this measurement system and the process of measurement automation to increase the throughput of LNA measurements to meet the needs for future generations of radio astronomy instrumentation.

References

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