URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Recent Centimetre Band Receiver Development at CSIRO Australia

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We present three recent receiver designs and the challenges in their development: a phased array feed (PAF), a multibeam system for FAST and an "ultra-wideband" feed for the Parkes telescope. A significant driver in the development of these receivers is the radio astronomy focus on surveys. In general terms

$$Survey\ Speed = Sensitivty^2 \times Bandwidth \times Field\ of\ View \quad (1)$$

In the area of sensitivity, there are diminishing returns for LNA development in the centimetre band but the demand for wider bandwidths and changing transistor and foundry availability requires ongoing attention. Our recent receivers have increased the bandwidths over previous designs. The signal processing is also moving toward digitizing and recording the entire bandwidth available from the feeds. The multibeam and PAF receivers maximize the utilization of the reflector field of view.

Ultra-wideband receiver for the Parkes 64m telescope

This receiver covers 700 to 4030MHz (Figure 1). The feed horn is a dual polarized quad-ridged feed horn with an outer corrugated skirt and a central dielectric insert incorporating three concentric layers. The dielectric insert and quad-ridged horn are attached to the 70 K stage of the system with a fiberglass foam sandwich providing the vacuum window. Four probes at the base of the feed connect LNAs which in turn are combined in a differential amplifier – all at the 20 K stage. The signal path is split into three sub-octave bands to minimize the effects of intermodulation distortion. These bands are fed to three 12 bit 4Gs/s digitizers per polarization. The digitizers are located in a cabinet adjacent to the receiver with careful shielding to prevent them adding to the RFI. The receiver was installed in an interim state in May 2018. At the time of writing the receiver is undergoing refinements and it is to be reinstalled in October 2018.

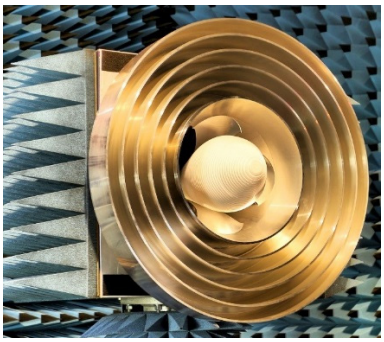

Figure 1. Ultrawideband Feed

Multibeam receiver for the Five hundred metre Aperture Spherical Telescope

This receiver provides 19 dual polarized beams over 1050 to 1450 MHz (Figure 2). The stepped horn feeds have a single choke ring to improve pattern symmetry, reduce sidelobes and reduce feed to feed coupling. A smooth spline quad-ridge ortho-mode transducer (OMT) is used. The LNAs utilize commercial bare-die GaAs-HEMTs (gallium arsenide high electron mobility transistors). The OMTs are cooled to 70 K and the LNAs to 20 K. This receiver has the largest cryostat we have developed and required three Gifford-McMahon cryo-coolers. This receiver was installed in May 2018 and is operating as the main receiver for FAST.

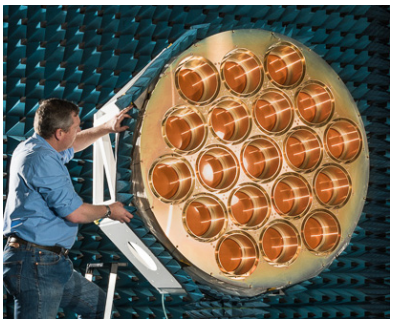

Figure 2. Multibeam Feed

"Rocket" PAF

A PAF prototype based on solid of revolution investigated with a 40 element prototype (20 in each polarization) (Figure 3). The elements present 180 Ω to differential ambient temperature LNAs. Measurements have shown 15 to 20 K receiver noise temperature over 600 to 1800 MHz. This work has formed the basis for plans for a full sized (~200 element) PAF for the Parkes 64m telescope.

Figure 3. "Rocket" PAF prototype