Broad band front ends and feeds for eMERLIN

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Engineers at Jodrell Bank Observatory (JBO), assisted by an engineer from NAOC in Beijing and researchers at Birmingham University's Emerging Device Technology group, have developed a new broad band cryogenic front end, together with new feed systems, for the MERLIN radio telescopes. MERLIN, operated by Jodrell Bank Observatory, is the Multi-Element Radio Linked Interferometer Network, an array of 7 radio telescopes distributed around England, with separations of up to 217km. C band frequency coverage of MERLIN has been increased almost six times to include the octave band 4 to 8 GHz.

For many years the MERLIN array of radio telescopes has operated C band receivers covering the frequency band 4.5 to 5.2 GHz. Microwave radio links have relayed 16 MHz wide sections of this band (left and right hand circular polarisation components of the received energy) to JBO for correlation and map making. Currently the MERLIN system is in the process of being substantially upgraded to eMERLIN: dedicated optical fibre links will allow instantaneous bandwidths up to 2 GHz to be relayed to JBO, thus hugely increasing the sensitivity of the observations. This has resulted in the need to develop a broad band C band receiver system capable of exploiting the increased available bandwidth.

This paper describes the design of the 4 to 8 GHz cryogenic receiver front end and associated feed horns. The front end includes an in-house designed quad-ridge ortho-mode transducer (OMT), which is used with a high temperature superconducting hybrid coupler to discriminate dual circular polarisation. Closed-cycle helium refrigeration is used to cool the polarisation components and low noise amplifiers (LNAs) to around 20 kelvins. The LNAs each include a lattice-matched indium phosphide high electron mobility transistor (HEMT) in the first stage to give excellent noise performance.

As the MERLIN array uses five different designs of radio telescope antenna it was necessary to design several new feed horns; fortunately two of the telescopes, the MkII telescope at JBO and the Defford telescope, have virtually identical F/D ratio, and hence the same design could be used for both. The requirement, in each case, for good return loss and constant beam width across an octave band, presents a set of difficult challenges. Two types of prime focus feed designs have been completed: one dielectric loaded design for the Lovell Telescope at JBO (F/D = 0.3), and one more conventional scalar feed for the MkII and Defford telescopes (F/D = 0.45). Two other feed designs have been completed: for the Cambridge 32 metre and the three E-Systems cassegrain telescopes (Knockin, Darnhall and Pickmere). All feeds have been tested both in the laboratory and on the telescopes with the exception of the Cambridge feed, which will be installed in summer 2005. Performance of the E-Systems feeds has been disappointing, owing to an oversight in the design and mechanical constraints. Phase correcting lenses are currently under design to correct the problem.