Variable Dielectric Delay Lines in Liquid Crystals for Phased Array Feeds

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Abstract

In this project we seek to exploit a novel liquid crystal (LC) technology, which allows a controllable true time delay (TTD) to be applied to an RF signal of frequencies up to tens of Giga-Hertz. The basic technology has already been demonstrated and has a wide variety of applications. We now intend to use this technology to construct a real astronomical demonstration system for delay lines and show that these can be integrated into the beam-forming module of an existing Phased Array Feed (PAF) instrument, dramatically improving its capabilities.

PAFs are an essential next step for radio astronomy. They offer the possibility of increasing a telescope's Field-of-View (FoV), of improved calibration and of allowing operation up to high frequency. PAFs have been implemented in instruments such as PHased Arrays for Reflector Observing Systems (PHAROS) and can achieve these goals, but over a narrow bandwidth due to the use of phase shifters in the beam-former hardware. In this project we seek to implement a TTD beam-former, which will allow the whole available bandwidth to be used. This will make use of novel technology — LC stripline whose dielectric constant can be varied by application of an AC voltage. We propose a two year programme during which we will produce a PAF module using a set of TTD units that will be tested within the PHAROS receiver, which is available for use on this project and will make an ideal test-bed. Our focus is on demonstrating the Technology Readiness Level (TRL) of these delay lines in the context of a prototype instrument, thereby addressing integration issues as well as pure technology development.

The objective of this project is to realise the potential of a TTD signal module implemented by a controllable dielectric constant LC through construction of the hardware for a PAF. Achieving this will develop this promising LC technology from TRL 4 to TRL 7. To this end, in this project we will: develop a unit and its associated control hardware which can apply a TTD to a 4–8 GHz signal; produce a set of 13 (plus 2 spares) of these units; and demonstrate that these units when incorporated into one module of the PHAROS receiver can be used to form a single steerable broad-band beam.