Zero-spacing interferometer for measurement of continuum spectrum of the low radio frequency background

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1. Introduction

We have developed an interferometer method for measurement of broad-band spectrum of the low radio frequency celestial radiation background, which is of importance in understanding the Epoch of Reionization, when the first stars and galaxies formed in the evolving universe. We have used two antennas in a short-spacing east-west interferometer mode, with a resistive semi-transparent screen in between. The system operates in the frequency range 87.5 to 175 MHz, suitable for probing the evolution in the state of the gas during cosmological epochs in the redshift range 7 – 15.

2. Description of the receiver system

The fat-dipole antennas forming the EW interferometer have been given sine-square profile to achieve broad-band performance over the frequency range of 87.5 – 175 MHz. The space beam splitter is placed vertically in between in a NS orientation and is realised as a resistive semi-transparent screen (Ref. Fig.1). It is expected to split the sky radiation incident on either side and the reflected/transmitted powers are received by the two antennas. The space beam splitter along with the antenna pair, forms a zero-spacing interferometer.

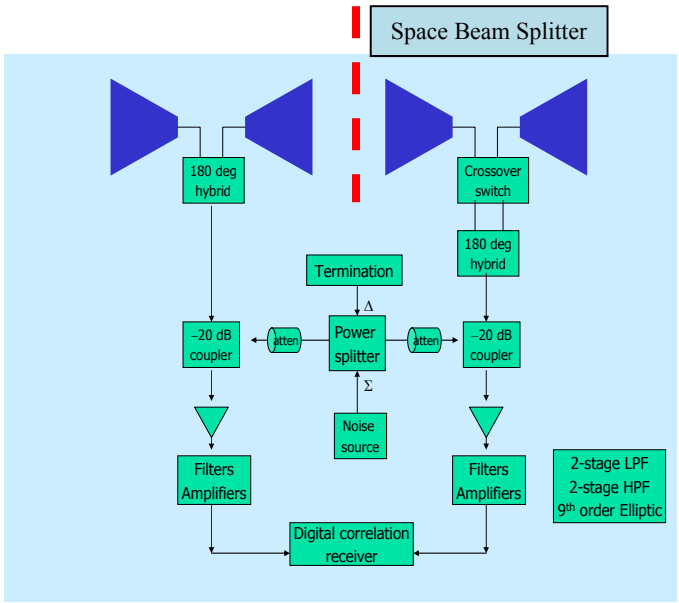

Fig. 1 System configuration

The analog receiver is low noise and includes a cascade of low and high pass elliptic approximation filters. Calibration of the bandpass as well as temporal gain variations, as also the absolute calibration, is based on noise sources that are switched into the signal paths via directional couplers. One antenna signal is phase-switched using a cross-over switch; this cancels the common mode signals entering the signal paths as well as the samplers.

The digital receiver, which follows the analog chain, is built as a 12- bit A/D converter and a correlator that is realized in a Virtex-5 Xilinx Field Programmable Gate Array (FPGA) chip. The sampling clock for the digitizer is disciplined to GPS signal for achieving the necessary temporal stability. The correlator output is read through an ethernet link and recorded in a computer for offline analysis.

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