ABSTRACTS (PH D THESIS)

Development of software-defined multichannel receiver for Equatorial Atmosphere Radar (EAR)

**(Graduate School of Informatics,
Laboratory of Atmospheric Sensing and Diagnosis, RISH, Kyoto University)**

Nor Azlan bin Mohd Aris

Equatorial Atmosphere Radar (EAR) is a very high frequency (VHF) Doppler radar operated with an active phased-array antenna system, approximately 110 meters in diameter which consist of 560 three-element Yagi antennas, located at the equator in Kototabang, West Sumatra, Indonesia (0.20ºS, 100.32ºE, 865 m above sea level) [1]. Each antenna is driven by a solid state transmitter-receiver module (TR module). The array antenna is divided into 24 groups for ease of signal distribution and maintenance where each group consists of 24 antennas except for eight groups along the periphery which contain one to three fewer antennas. These design is purposely constructed to produce a quasi-circular array pattern as shown in Figure 1. It uses active phased-array system similar to the Middle and Upper atmosphere radar (MU radar) due to its fast beam steerability where phase shift and signal division and combination operations are carried out at a low signals level by electronic devices. The EAR had originally been equipped with a single receiving channel system. This research presents development of a multichannel receiver system for the EAR using a combination of the Universal Software Radio Peripheral X300 (USRP X300) and GNU Radio software. There are a number of advantages to have multichannel receiver system such as to enable spaced-antenna (SA) method and spatial domain interferometry.

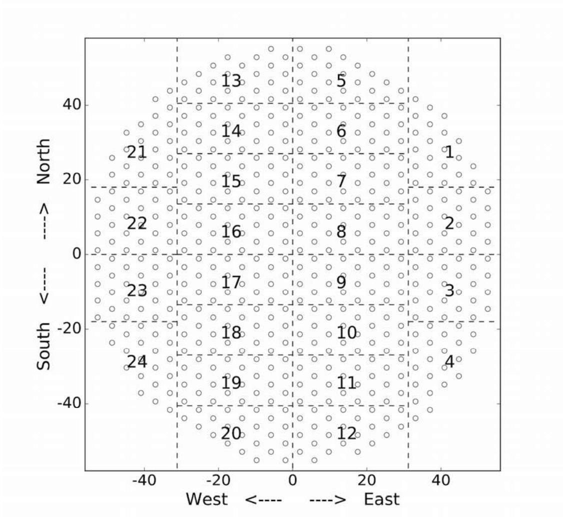

Figure 1. EAR antenna array

First test observation was conducted on November 2017 to analyze the system reliability, followed with subsequent tests in March and July 2018. The configuration of the test observation is shown in Figure 2 [2]. Two USRP X300 devices, corresponding to four receiving channels, were synchronized using 10 MHz reference clocks and a pulse per second (1 PPS) signal. The standard observation system of the EAR is retained by splitting the received echo signals through directional coupler which enabled simultaneous observation of the two different techniques,

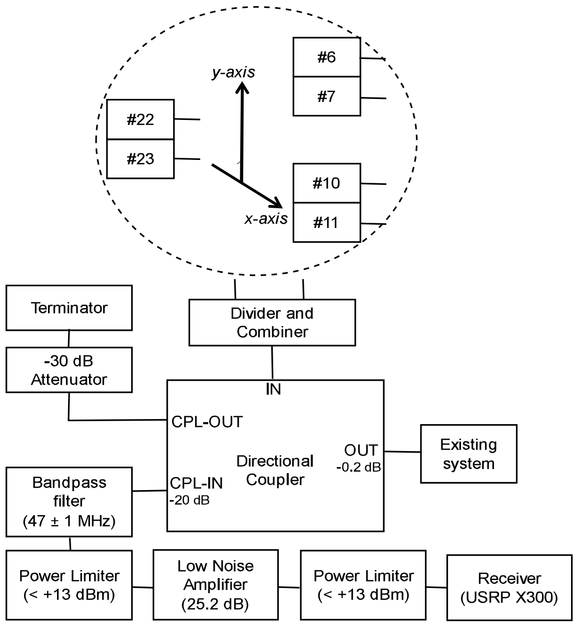

Figure 2. The configuration of the EAR multichannel receiver for test observation.

SA and Doppler beam swinging (DBS). Each receiving antennas for the EAR SA method formed by a combination of two antenna array groups (aperture size is approximately one twelfth of the whole EAR). The signal for SA application is fed to the USRP X300s for digital conversion, and then stored on a Hard Disk Drive (HDD). The ranging of the data is carried out by taking advantage of the leaked transmitted pulse [3], before demodulated and coherently integrated. The initial results show the existence of noticeable fluctuations in the estimated horizontal wind.

Further, performance analysis using multiple receiving antennas orientation for the application of SA method on the EAR has been carried out through multiple experiments over the duration between April 2019 and September 2019. Phase correction is applied to all channels for a single spectrum in the real time signal processing for improving the phase synchronization. Then, a comparison of the EAR SA performance using five different orientations taking into consideration the aperture size of receiving antenna and its separation distance has been presented, where the horizontal wind profiles using Full Correlation Analysis (FCA) were estimated and compared with the EAR standard observation data. Based on the results, the configuration with the largest aperture shows slight advantage over the other four configurations but with limited improvement [4].

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