CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

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Project Number

S1002

Project Title

Optimal Phased Array Antenna Systems for Radio Astronomy

Abstract

Objectives

Collecting cosmic data to understand the universe and its beginnings is very time-consuming and expensive. Current radio stations require vast areas of isolated space and expensive hardware which must be manually modified, making the design costly and laborious while simultaneously limiting the number of telescopes to the number of analogue paths and land available. The goal of this project is to develop an innovative system design for radio stations that increases efficiency and optimizes data collection via the creation of a radio station with eight subsystems that each contain 64 phased array receivers.

Methods

The project consisted of two parts: designing efficacious arrangements of antenna arrays and formulating techniques to correlate the subsystems images. For each array, original programs in MATLAB were written to compute both the sidelobe suppression and the Half-Power-Beamwidth (HPBW) angle which determines the selectivity of the array. Subsequently, additional MATLAB programs were created to combine data from each subsystem to generate an image with a greater Signal-to-Noise-Ratio (SNR).

Results

The research discovered that a concentric circle array design produces the greatest sidelobe suppression, increasing the SNR to 44.67 compared to the standard rectangular array which possesses a SNR of 39.61. Furthermore, the other models, a line, circle, triangle, pentagon, modified circle, and spiral, contained SNRs of 19.25, 17.69, 10.51, 17.65, 18.24, and 43.52 respectively. The HPBW of the concentric circle array increased to 0.05783 radians compared to a rectangular array which contains a HPBW of 0.05236 radians. Moreover, the new MATLAB correlation programs increased the SNR from 1.72 to 13.8 when correlating the data from 8 subsystems, decreasing the average noise by approximately 86%.

Conclusions

Compared to the standard rectangular array used by current radio stations, the SNR increase for a concentric circle phased array allows for shorter integration times for data collection at each subsystem. Also, the correlation of images from each phased array subsystem results in much less time needed for the production of a high-resolution image, thereby dramatically diminishing the total time, cost, and power required to produce cosmic images. Thus, the implementation of a concentric circle array design would offer great benefits for modern radio stations.

Summary Statement

I designed an innovative model for radio stations using original phased array design patterns to optimize the cost, efficiency, and area needed to generate high-quality cosmic images.

Help Received

None. I designed the receiver array patterns and developed the MATLAB programs by myself.