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Switched Beam through Parasatic Antenna Array for Radio Direction Finding Using I/Q Samples

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Abstract An electronically controlled parasitic antenna array consisting of one active element connected to a software defined radio (SDR) receiver and four passive parasitic elements used to design and construct affordable radio direction finding system. The directivity of the antenna array achieved by increasing/degreasing the electrical length of the parasitic elements. The design based on a central active monopole and an array of four parasitic monopoles equidistantly from the central element by 0.20 λ, placed on ground plane to provide the 360 degree azimuthal coverage without any moving parts, provides excellent directional resolution. The system is controlled by using Arduino to switch between regions (0-90),(90-180),(180-270) or (270-360) and analysed by using a newly developed method based on I/Q samples to extract the amplitude and phase of the desired signal to find the exact direction in that region. The antenna design, its application to determine the direction finding, the new algorithm are presented below.

Keywords: *RDF, AoA, parasitic monopoles*

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1. Introduction

This paper presents a new method of determination of an angle of arrival (AoA) and hence radio signal direction finder (RDF) by using electronic beam steering of an antenna array system based on one active element and four switched parasitic elements.

The antenna system is a circular array of quarter wavelength dipoles, with four parasitic elements positioned equidistantly, surrounding one active central element. All parasitic elements are assumed to be electronically switched between short-circuit by inductor termination or open circuit by capacitor termination states to change their resonant length.

This technique allows the short-circuited parasitic elements to act as a reflector, whereas other parasitic elements act as directors when they are open-circuited.

For and for most, the direction of maximum gain is being controlled by open - and short-circuiting the relative parasitic elements with respect to the four quarters of the circular antenna, a set of radiation patterns is formed covering the horizontal plane at 0°, 90°, 180°, and/or 270°.

Furthermore a new algorithm is developed using amalgamation of a SDR#, Matlab and Visual Studio to extract the exact direction of the signal (AoA) by analyzing the stored I/Q data.

2. Methodology

A steel plate, one meter in diameter, reinforced by rectangular frame of wood, as shown in Figure 1 below, as ground plane where the five monopoles antenna elements that with magnetic base are placed and the Cartesian coordinates is being marked where the active element at the origin and ANT 1 and ANT 3 represent the Y-axis and ANT 2 and ANT 4 represent the X-axis and ANT 1 and ANT 2 represent the first quarter and ANT 3 and ANT 4 represent the fourth quarter. The gain of the antennas is equal to 2.15dBi.

Figure 1. The RDF setup

The electronic antenna switching system is done by eight relays that are controlled by Arduino and ULN 2803 IC as a relay driver.

HackRF One, software defined radio, and SDR# driver represent the receiving unit used for the DF setup to capture and store the I/Q, in phase/ quadrature, signal of concern where by using Matlab amalgamated with Visual Studio is being processed and analyzed to determine the (AoA).

3. Results and Discussions

The following results are obtained using SDR# software as the switching action was done manually:

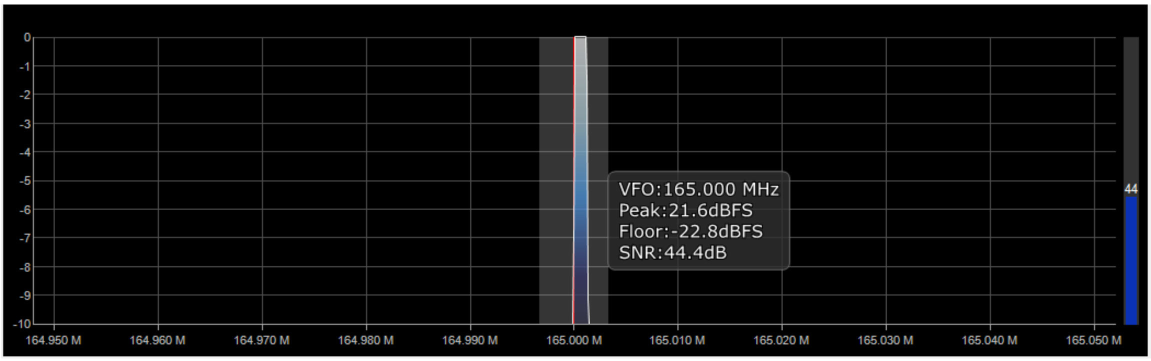

Figure 2. Signal strength when the transmitter facing the opposite side of the parasitic element that is shorted by inductor

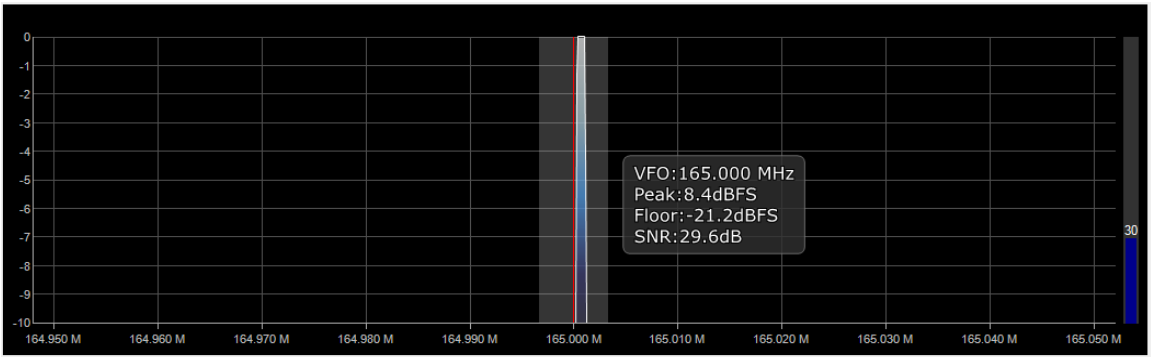

Figure 3. Figure Signal strength when the transmitter facing the parasitic element shorted by inductor

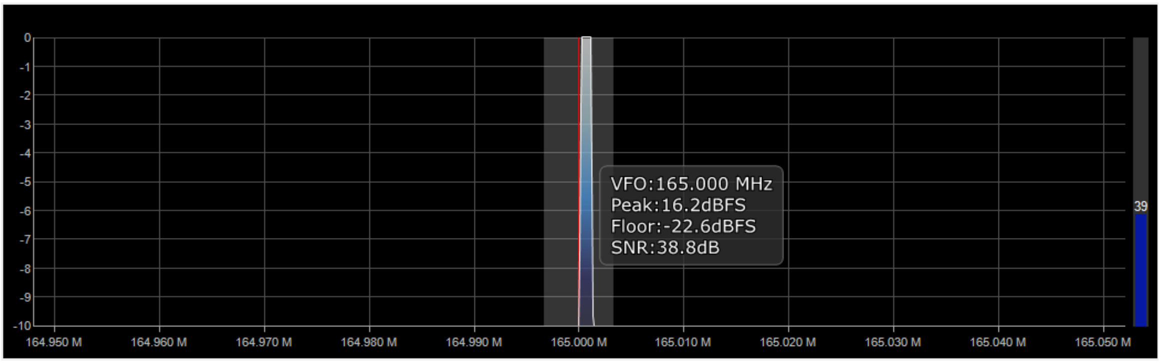

Figure 4. Signal strength when the transmitter facing the left parasitic element shorted by capacitor

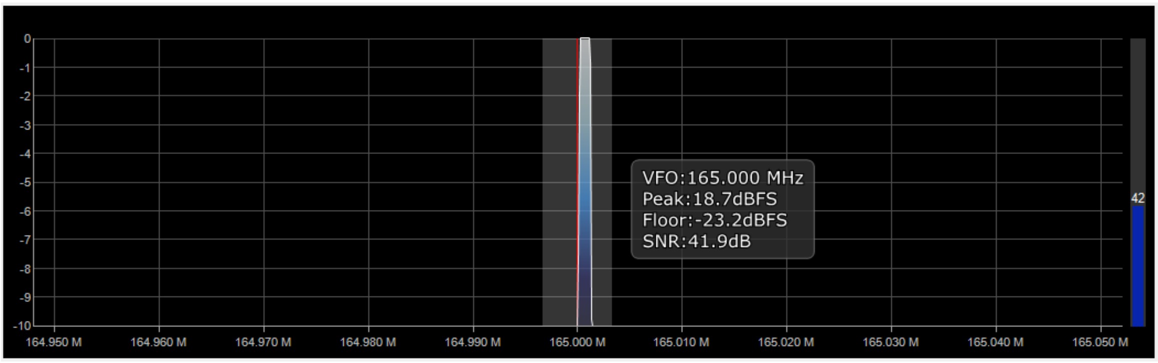

Figure 5. Signal strength when the transmitter facing the right parasitic element shorted by capacitor

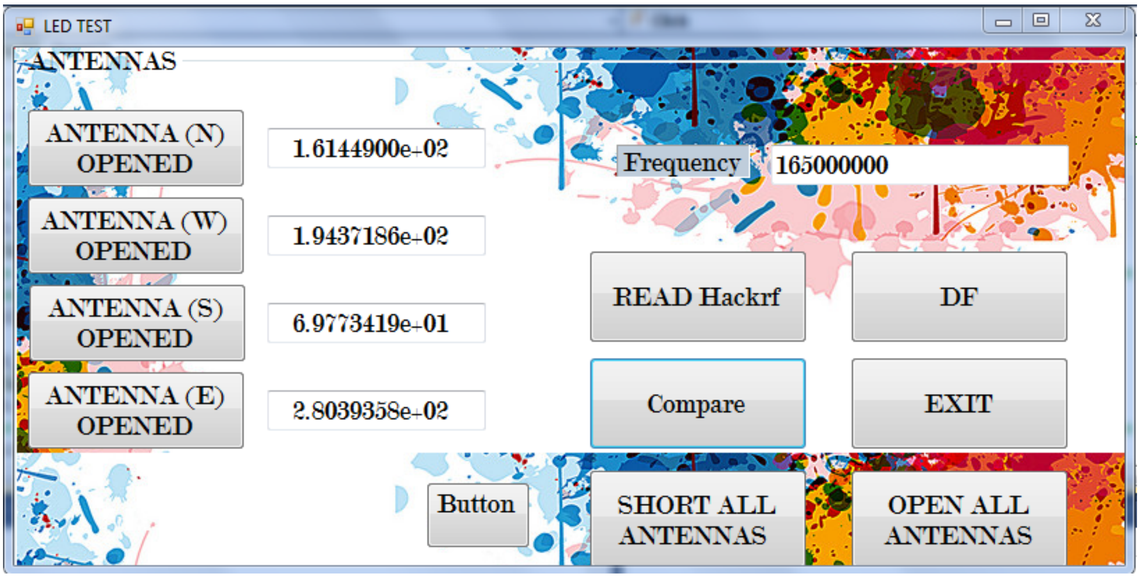

Figure 6. RDF interface and signals amplitude

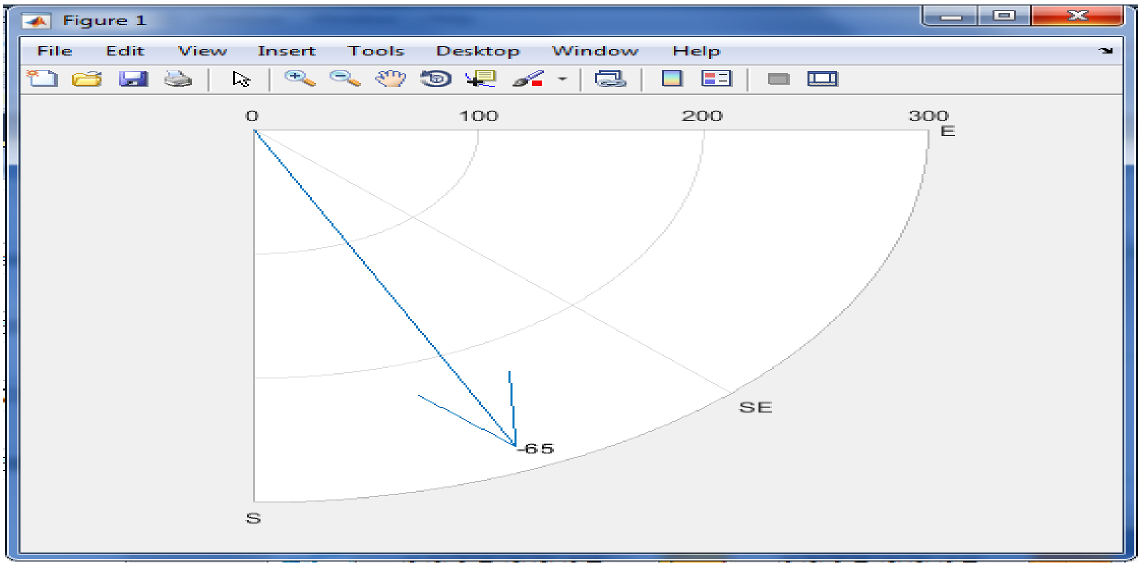

Figure 7. Direction of the captured signal

4. Conclusion

The switching of the beam was achieved through the termination of parasitic elements by capacitors and an inductor combination and from the maximum signal strength the direction of the target was established using the captured I/Q samples.

5. Future Work

One of the most important we'll do is using the raspberry pi 3 with the RDF setup and run the pi 3 as a server in order to get the data from anywhere we are in without any physical connection to the computer.

It is also very important to increase the number of parasitic elements in order to narrow down the region of target thus increasing the accuracy.

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