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# A Survey on Sidelobe Reduction Techniques in Antenna Array for Wind Profiler Radars

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**ABSTRACT:** Wind profiler radars are used to measure windspeeds and direction in the atmosphere. They measure the echoes from radar emitted electromagnetic radiation, rejected from tiny changes in the refractive index of air. Low sidelobes have long been of interest to antenna designers, with high sidelobe levels are unacceptable for most military and satellite communications. This paper carries a literature survey of different techniques using various methods from the view point of reducing antenna array sidelobe levels.

**KEYWORDS:** Antenna array, Clutter fence, Lower atmospheric application, HFSS, Sidelobe level, Return loss, Gain.

## I. INTRODUCTION

The atmosphere that covers the earth is roughly divided into four layers, starting from the earth's surface is troposphere, stratosphere, mesosphere and thermosphere. As a result of complicated atmospheric motion, various weather changes are caused, such as localized torrential downpour, wind shear, and so on. The weather observation instruments that can observe the air motion of the atmosphere with high degrees of accuracy and time resolution has been developed in various countries, especially in European countries, the US and Japan, due to the remarkable progress of the remote sensing technology in recent years. Among such instruments, wind profiler radar (WPR), which can provide the three-dimensional structures of wind velocities and wind directions of each layer of atmosphere in real time, has become indispensable to the world today.

Wind profiler radars are used to measure wind speeds and directions in the atmosphere. They measure the echoes from radar-emitted electromagnetic radiation, rejected from tiny changes in the refractive index of air. Modular Wind profilers can be used to study a wide array of phenomenon ranging from surface-atmosphere exchange, precipitation, boundary layer evolution, air quality, airflow in complex terrain, pollution level and many other topics. It is also referred as Lower Atmospheric Wind Profiler (LAWP) because it is used to probe the lower part of the atmosphere (up to about 5 Km) [1]. Many lower atmospheric wind profilers have been developed in recent past by research and commercial groups for meteorological application.

## II. RELATED WORK

Fence shaping of the substrate – integrated electric dipole antenna operating at 5G high-band frequencies was carried out. In this work, the concept of fence shaping and tapering was discussed with the aid of V-shaped, U-shaped fence dipole antenna for which the performance was compared with the conventional rectangular fence dipole antenna. The via fence was employed around dipoles to suppress back radiation, where by varying the geometric shape of the fence, the radiation characteristic could be controlled. By fence shaping for substrate integrated electric dipole antennas, it was able to achieve a gain and HPBW of about 12.6 dBi and 104° from 4x1 array respectively. The proposed model could achieve an excellent and stable radiation performance over a wide frequency bandwidth, making it suitable for multiple high band applications [2].

A Substrate Integrated Waveguide Longitudinal Slotted Array Antenna (SIWLSAA), which is loaded with metal fences exhibited high isolation across VHF/UHF bands was demonstrated. A SIWLSAA used for this purpose, consisted of 3x6 slotted arrays, which is designed on the front and back sides of FR-4 lossy dielectric substrate. It had an isolation of -63dB between its radiation slots. An improvement was shown by using metal fence between each row of slotted arrays. The resulting isolation was shown to be better than -83dB across 200 MHz to 1.0 GHz. The gain was 1.5dBi, and sidelobe reduced to 40dB. The advantage is that, the proposed SIWLSAA was compact and was used in Multiple Input Multiple Output (MIMO) and radar system applications [3].

The Invasive Weed Optimization (IWO) algorithm was used to solve the beam pattern synthesis issues of the Linear Antenna Array (LAA) and the Circular Array Antenna (CAA). In this design process, an optimization problem was formulated and IWO was used as optimizer to identify set of optimal excitation currents to get a desired result. Samples of 8, 16 and 32 element LAAs and CAAs were performed to cross check the optimization process of sidelobe level (SLL) reduction and proved that SLLs can be effectively suppressed by IWO, from the simulation results. Advantage of this technique was that, IWO showed better performance in accuracy, convergence rate and stability. The EM simulation showed results got from IWO, were effective in most antenna array for practical conditions [4].

Sidelobe reduction of an antenna array pattern for suppressing effects of ground and sea clutter of zenith- looking Wind Profiler Radar was demonstrated. Here, simulation was performed for various shapes of clutter fence for 915 MHz Doppler Radar and 449 MHz Interferometric Radar. This work showed a low-cost modification in the hardware design, would allow SLL reduction. With 915 MHz radar, it exhibited SLL reduction up to 5 DB. Also, for 449MHz Interferometric Radar, it was simulated on a single array and extended to triple hexagonal array. The clutter fence shield surrounded the antenna array which consisted of metal coated panels. It also used edge treatment with parallel quarter wave deep corrugations. Advantage of this technique is that, it allowed a compact clutter fence, for a portable and easily deployable radar [5].

A microstrip patch antenna array was designed with 16 circular patches for reducing SLLs. Due to effects of mutual coupling between elements, reflection within substrate material, fabrication tolerance and also due to surface wave effects, it is difficult to design an antenna array with SLL lower than -25dB. While in this work design, for reducing effects of surface wave, air core below each circular patch, within the substrate was used. To mitigate the effects of mutual coupling, it uses the simple narrow fence strip between each element. The Chebyshev amplitude distribution was used to feed 16 circular patch antennas. It was observed that, an improvement in SLL by 4.2 dB and 1.2 dB with the use of air core and narrow strip respectively. It used HFSS and CST simulation software to verify the results [6].

A study of ground clutter prevention fences for boundary layer radars (BLRs) was carried out. A low elevation algorithm on sidelobe suppression, based on uniform physical theory of diffraction (PTD) was developed. Sidelobe suppression is the difference of the highest sidelobe in lowest elevation region between in the cases of absence and presence of the fence. The study used 2 rectangular arrays mounted on metallic reflected plates, each with 24 rows of ECCD- electromagnetically coupled coaxial dipole. There are metallic circular pipes of ECCD, which acted as radiation dipoles, are arranged in collinear manner in vertical directions. This in-phase excitation was observed to give a line array performance. To suppress ground clutter, the radiating elements were placed 20cm over the ground surface, with reflecting metal plates with holes, were 0.25 wavelength below antennas. They could steer the beam in various direction, only by controlling the phase of phase shifters [7].

Adaptive antenna technique as a powerful means for clutter rejection is show cased. The main antenna beam pattern was not altered as the target region is identified by its shape. The loss of antenna gain was kept no more than 0.5 dB, to maintain the high sensitivity of system. An adaptive sidelobe suppression algorithm was developed for a high gain antenna to actual data taken by the middle and upper atmospheric radar, without effecting the desired echoes from turbulence [8].

Operation of Mobile Wind Profiler in severe clutter environment was studied. In this work, the improvement profiler technologies had made in possible to measure horizontal wind profiles in severe clutter environment. A digital receiver for radar design resulted in 105dB of linear dynamic range. It allowed the profiler to operate in higher clutter locations without use of fences. Clutter contamination, was removed by employing wavelet filters. This helped in spectral leakage in Doppler spectrum, which allowed overlapping of Doppler peaks. The success in the prototype showed accurate wind profiles which could be measured in severe clutter environment [9].

### III. PROPOSED METHODOLOGY

The goal of this project is to design a clutter fence for antenna array of wind profiler radar, to mitigate effects of sidelobes. The key feature of the proposed design is modularity. In order to obtain a portable and easily deployable radar, it is of interest to design a compact fence model to suppress sidelobe level. The design is carried with High Frequency Simulation Software (HFSS) software. The reduction of sidelobe level is important for reducing radar returns and is usually carried out with 3-D metallic ground planes. The work flow for designing process is shown in the Fig (1).

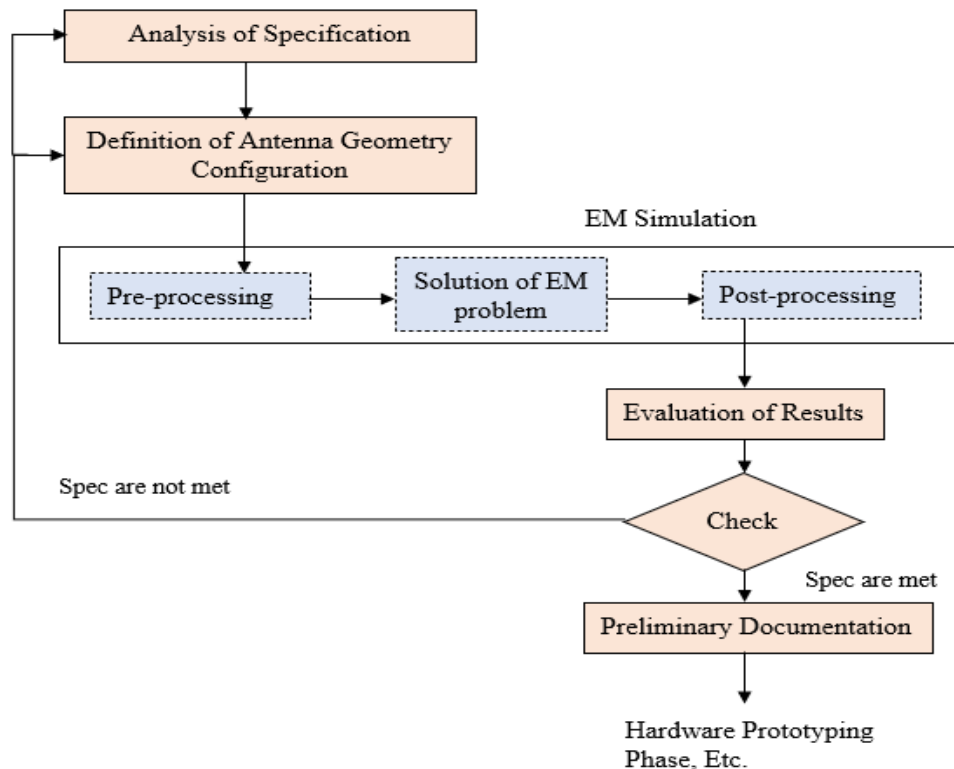


FIG 1: DESIGN WORKFLOW

#### IV. TOOLS USED

We choose High Frequency Simulation Software (HFSS), to explain the antenna designing process, while keeping complexity level at a minimum. It uses a Finite Element Method (FEM) solver technique. HFSS has a powerful antenna design function, it can calculate the antenna parameters. It is the industry standard for simulating high frequency electromagnetic fields. It offers state of the art solver technologies based on finite elements, integral equations, asymptotic and advanced hybrid methods to solve a wide range of microwave, RF and highspeed digital application.

#### V. CONCLUSION

Wind Profiler Radars measure the echoes from radar emitted electromagnetic radiation, rejected from tiny changes in refractive index of air. The project mainly concentrated on improving the sidelobe level. The literature survey is carried out considering various methods applied to improve the gain of modular wind profiler. Key features of proposed wind profiler system are modularity, better return loss.

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