Design, Analysis and Study of 2x2 Rectangular Microstrip Antenna Array At 430 MHz for Wind Profiler RADAR"

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ABSTRACT

Wind profilers depend upon the scattering of electromagnetic energy by minor irregularities in the refractive index of air. The refractive index is a measure of the speed at which electromagnetic wave propagates through a medium. Atmosphere is the medium for wind profiling. Wind profiling radars operating in Doppler beam swinging mode needs to have large antenna array in order to have a narrow beam for wind direction accuracy. To meet the above requirement, in the present work an array with 4 elements configured in an 2X2 is designed. The antenna inserted is a co-axial probe (Probe feed) to the patch near its resonance in 'L' band is carried out. Principal plane 2-dimensional radiation patterns at 430MHz have been computed for single element and 2X2 linear array. The results of linearly polarized coaxial probe single element are generated using IE3D software. Using single element as basic building block, an 2X2 linear array was designed. In this paper Aluminum sheet is used as material for ground plate and patch, air is used as dielectric substrate. IE3D software is used to design and simulation of antenna array. The results obtained are presented succinctly. The inferences from the design of coaxial probe antenna are presented.

Keywords

Wind profile, Microstrip, Antenna Array, Dielectric, Patch, probe feed, IE3D.

1. INTRODUCTION

In the atmosphere, minor irregularities in the refractive index exist over a wide range of sizes in the troposphere and stratosphere. The refractive index depends primarily upon the temperature, pressure and humidity of the air. The radar depends on the scattering of EM wave energy of the air associated with clear air turbulence (CAT). The atmosphere minor irregularities in the index refraction exist over a wide range of refraction sizes.

The wind as it varies in direction or speed produce turbulent eddies (small whirling currents of air) .The turbulent eddies are created over a spectrum of sizes ranging from many tens of meters down to cm. Observations of wind velocity profiles are very important for studying meteorological phenomena, weather forecasting etc. Atmospheric radar (wind profiler) is one of the most suitable remote sensing instruments for observing height profiles of three components of wind velocity vector, including the vertical velocity, with high time and height resolutions without influence of weather conditions.

Propagation of radar signals through the atmosphere is strongly dependent on local meteorological conditions, especially in the atmospheric boundary layer. The wind profiling radar uses naturally occurring fluctuations in the radio refractive index and precipitation as targets. Due to their small aperture, UHF profilers are most suitable for measuring the winds in the boundary layer and lower troposphere regions. Unlike the VHF wind profiling radars, UHF radars are very sensitive for hydrometeors due to the small wavelength. Therefore these profilers are very much useful in studying convection, precipitation etc.

UHF radar is a potential tool to carry out research studies such as ABL Dynamics (Winds, Turbulence structure), Seasonal and Inter-annual variations, Interaction between the ABL and the free troposphere, Precipitating systems, Bright band Characterization, Rain/Cloud drop size distribution etc. It is also useful in the operational Mountain meteorology and civil aviation and identification of Atmospheric ducts. It also acts as a supplementary tool to large VHF MST radars by providing the atmospheric data in 0-5 km height range.

Several UHF radars are being operated across the globe either as research tools or as a part of wind profiler networks for operational meteorology. Atmospheric radars originally developed in 1970s for the research of mesosphere and stratosphere have been extensively applied to operational use for observations of the troposphere wind fields since 1990s as demonstrated by the Wind Profiler Demonstration Network. In Japan, more than ten profilers including the MU (middle and upper atmosphere) radar of Kyoto University have been operated for research use. Through the research and evaluation of profiler's data on the numerical weather prediction (NWP) models, JMA (Japan Meteorological Agency) established the operational wind profiler network and data acquisition system (WINDAS) for the enhancement of capability to watch and predict severe weather in Japan.

Microstrip antenna is printed type of antenna consisting of a dielectric substrate sandwiched in between a ground plane and a patch [1]. The concept of Micro strip antenna was first proposed in 1953, twenty years before the practical antennas were produced. Since the first practical antennas were developed in early 1970's, interest in this kind of antennas was held in New Mexico[6]. The microstrip antenna is physically very simple and flat, these are two of the reasons for the great interest in this type of antenna.

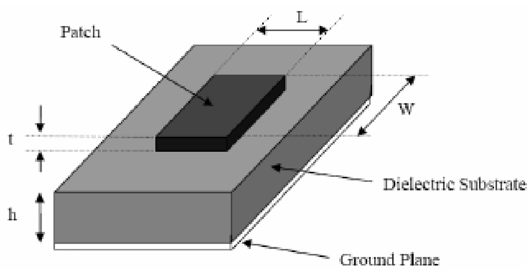
Microstrip antennas have several advantages compared to other bulky type of antennas. Some of the main advantages of the microstrip antennas are that it has low fabrication cost, its lightweight, low volume, and low profile configurations that it can be made conformal, it can be easily be mounted on rockets, missiles and satellites without major modifications and arrays of these antennas can simply be produced.

Observations of wind velocity profiles are very important for studying meteorological phenomena and weather forecasting. Atmospheric radar is one of the most suitable remote sensing instruments for observing height profiles of three components of wind velocity vector, including the vertical velocity with time and height resolutions without influence of weather conditions [1]. Propagation of radar signals through the atmosphere is strongly dependent on local meteorological conditions, especially in the atmospheric boundary layer [2] [3]. The wind profiling radar uses naturally occurring fluctuations in the radio refractive index and precipitation as targets. Due to their small apertures, UHF profilers operating around 900-1300 MHz [4][5] are most suitable for measuring the winds in the boundary layer and lower troposphere regions[6]. Unlike the VHF wind profiling radars, UHF radars are very sensitive for hydrometeors due to small wavelength [4]. Therefore these profilers are very much useful in studying convection, precipitation etc. UHF radar[4] is a potential tool to carry out research studies such as ABL Dynamics (Winds, Turbulence structure), seasonal and Inter-annual variations

Interaction between the ABL and the free troposphere, precipitating systems, Bright band characterization Rain/cloud drop size distribution etc. It is also useful in the operational Mountain meteorology and civil aviation and identification of atmospheric ducts. It also acts as a supplementary tool to large VHF MST radars by providing the atmospheric data in 0-5 Km height range [5]. Several UHF radars [4] are being operated across the globe either as research tools or as a part of wind profiler networks for operational meteorology.

2. DESIGN PROCEDURE

The designed antenna is an 1X8 linear array. The first step in the design is to specify the dimensions of a single microstrip patch antenna. The patch conductor can be assumed at any shape, but generally simple geometries are used, and this simplifies the analysis and performance prediction. Here, the half-wavelength rectangular patch element is chosen as the array element (as commonly used in microstrip antennas) [9]. Its characteristic parameters are the length L, the width w, and the thickness h, as shown in below Figure .



To meet the initial design requirements (operating frequency = 430 MHz, and beam width = 90) various analytical approximate approaches may be used. Here, the calculations are based on the transmission line model [7]. Although not critical, the width w of the radiating edge is specified first. In practice, the length L is slightly less than a half wavelength (in the dielectric). The length may also be specified by calculating the half wavelength value and then subtracting a small length to take into account the fringing fields [7-9]

In this paper Aluminum sheet is used as material for ground plate and patch, air is used as dielectric substrate. IE3D software is used to design and simulation of antenna array.

3. SIMULATED RESULT FOR 2X2 PATCH ANTEENA ARRAY

1. Return loss Measurement:

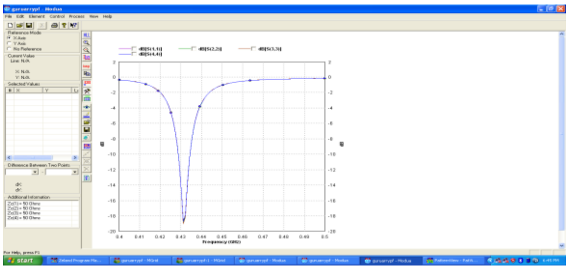


Figure: 1

From figure 1 The Return loss obtained at 430 MHZ is -19 dB and band width obtained at -10 dB is about 7 MHZ.

2. 2-Dimensional Radiation Pattern:

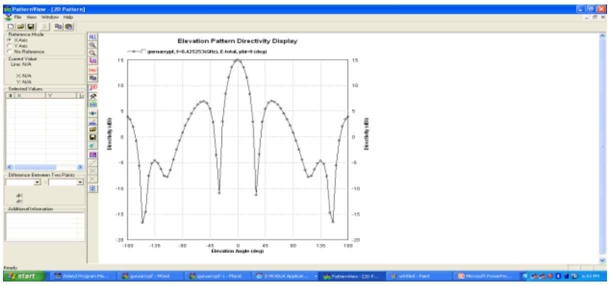


Figure 2

From figure 2, the 3 dB Beam Width obtained at pi=00 is 1050 and at 900 is 950

3 . VSWR Measurement:

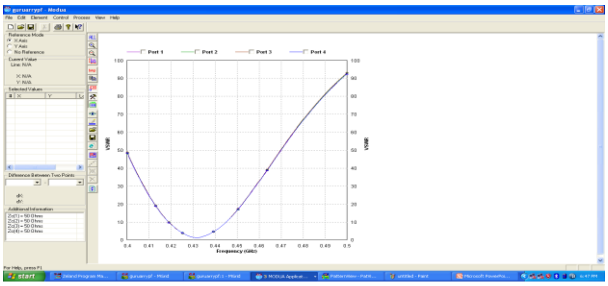


Figure 3

From the figure 3.the VSWR obtained at 430 MHZ is 1.25

4. Directivity vs. Frequency:

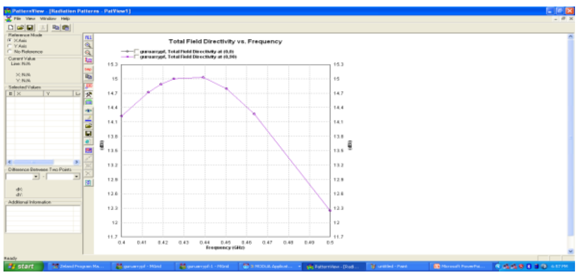


Figure 4

From the figure 4, gain obtained at 430 MHz is 15 dBi

5. Antenna Efficiency vs. Frequency:

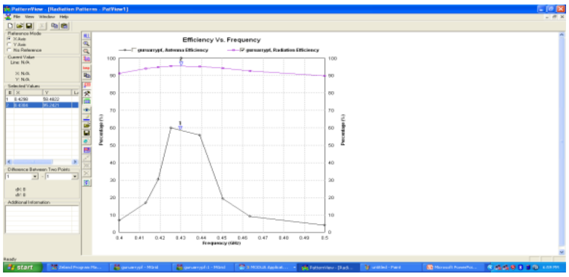


Figure 5

From the figure 5, the Antenna Efficiency is about 60% and radiation efficiency is about 90 %

6. Gain vs frequency:

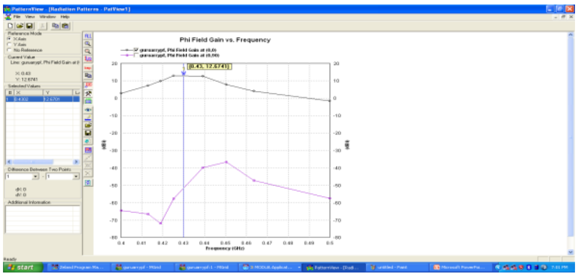


Figure 6

From the figure 6,Pi - field gain obtained at 430 MHz is 12.5 dBi

7. Radiation pattern(3-D) for 2x2arrays : E –theta pattern:

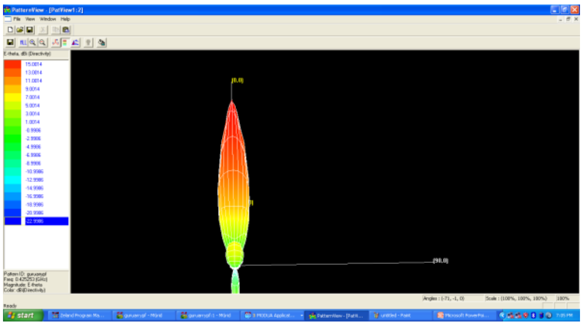
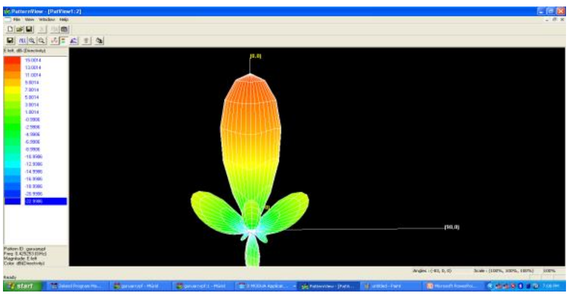


Figure 7

From figure 7, the Directivity of the 3-dimensional Radiation Pattern is 15 dBi

E- Left pattern:



4. CONCLUSION

Hence an 2X2 element array has been realized for wind profiling radars. Gain, Bandwidth and radiation patterns have been computed over a frequency at 430 MHz. From the data analysis, it has been pointed out that the side lobe level is the most critical factor, and thus determines the operating bandwidth. However, considering the impedance, gain and maximum side lobe at 430 MHz frequency, a 20 MHz bandwidth has been obtained. As demonstrated by the design 2x2 patch Antenna Array at 430 MHz has been successfully designed and simulated using IE3D.From the radiation pattern, it is observed that use of amplitude taper maintained the SLL within the maximum scan angle limit, which is an added advantage for Atmospheric Wind Profile Radar application. Using this 2x2 antenna array 15 dBi gain and 7 MHz bandwidth were obtained which is sufficient for data processing for the system. The future work of this Project is to extend the design to 1x8 Antenna Array and later 16x16 Antenna Array.

5. REFERENCES

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